

Hydraulic Starting Product Manual

Supplied by: Industrial Power Units Ltd
Churchbridge, Oldbury, UK, B69 2AS

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2003/372



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1. INTRODUCTION

Into the new millennium, Powerstart is able to stay at the fore front of non-electric starting with the offering of new components and the streamlining of existing offerings.

The Powerstart manual has been updated to include all the new and improved products as well as to ensure that dimensions, weights, pressures and all other measurements are in dual formats (metric as well as imperial).

The engine cross reference table has grown immensely and is continuously updated to include any new applications.

Accumulators are now offered with ABS (American Bureau of Shipping) certification as an option. The Lloyd's certification is still standard but has been uprated to the revised PD5500:2006 standard.

Pressure gauges are now available with either metric or imperial markings.

The selection of pinions gears and flanges has been extended to include more information on the flanges which will help customers and distributors to establish configurations with greater ease. Powerstart now offers over 40 different pinion gear configurations and over 30 flange configurations. Most of these pinions can be cut to fit either the small, medium or large starters in steel or beryllium copper.

We hope that this manual proves to be useful and we always welcome constructive ideas and suggestions.

The Powerstart technical team.

APPLICATION ENQUIRY FORM

General

Customer: Date:

Contact: Machine:

Tel. No.: Model:

Fax. No.: Order no.:

Engine Specifications

Make: Model:

Power (kW): Displacement: (litres):

Break away torque: Running torque (Nm):

Parasitic load (Nm):

Min. cranking speed (rpm): Crank duration (s):

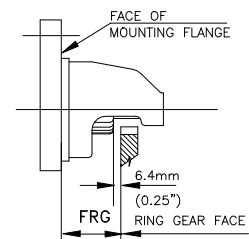
Will the load be disconnected from the engine during cranking (Y or N):

Starter Mounting Arrangement

Flange type (SAE 1 or 2 or 3 or 4):

Flange to ring gear (FRG) in mm:

For any special mounting arrangement please supply drawing.



Pinion Gear Information

Pinion gear no. teeth: Ring gear no. teeth:

Pressure angle 15° or 20°: Diam. Pitch or module:

Outside diameter (mm): P.C.D. (mm):

Rotation (CW or CCW): Is a non-sparking pinion required (Y or N):

Existing Starter Motor

Make/model: Power (kW):

Max. overall diameter (mm): Total length (mm):

Specifications are subject to change without prior notice due to product improvements.

SYSTEM SELECTION CALCULATION

1. Starter Motor

1.1 Gear ratio = $\frac{\text{Ring gear no. of teeth}}{\text{Pinion gear no. of teeth}} = \frac{\text{[]}}{\text{[]}} = \text{[]} : 1$

1.2 Torque required at pinion = $\frac{\text{Engine breakaway torque (inclusive parasitic load)}}{\text{Gear ratio (from 1.1)}} = \frac{\text{[]}}{\text{[]}} = \text{[] Nm}$

1.3 Torque required (at starter) = $\text{Torque at pinion (from 1.2 above)} \times 1.15 = \text{[]} \times 1.15 = \text{[] Nm}$

Select a starter from the table below which supplies a torque equal to or greater than the torque arrived at in 1.3 above

Starter motor	M10	M16	M22	M28	M38A	M66A
Maximum torque in Nm at 21 MPa (3000 PSI)	30	48	66	84	124	216

1.4 Minimum oil pressure = $\frac{\text{Torque req'd (from 1.3)} \times \text{System press. (21 MPa)}}{\text{Maximum starter torque in Nm}} = \frac{\text{[]} \times 21}{\text{[]}} = \text{[] MPa}$

2. Accumulator

2.1 Starter spd. = $\text{Min. engine cranking speed} \times \text{Gear ratio (from 1.1)} = \text{[]} \times \text{[]} = \text{[] rpm}$

2.2 Starter revs = $\frac{\text{Crank duration (sec)}}{60} \times \text{Starter spd (2.1)} = \frac{\text{[]}}{60} \times \text{[]} = \text{[] revs}$

2.3 Min. oil vol. required = $\text{Starter revs (from 2.2)} \times \text{Starter displacement (cc)} = \text{[]} \times \text{[]} = \text{[] cc}$

2.4 Accumulator minimum size = $\frac{\text{Minimum oil vol required (from 2.3)}}{\text{Chart value}} = \frac{\text{[]}}{\text{[]}} = \text{[] ltr.}$

Note: Chart value is obtained from accumulator calculation sheet on section 3, page 3-10 at the intersection of "Maximum system pressure" (recommended 21MPa) and the greater of "Minimum oil pressure" (from 1.4) or the accumulator gas pre-charge pressure of 10MPa

3. Conclusion

3.1 Starter motor model: see page 12-2 **M** ___ - **D** ___

3.2 Accumulator model: see page 12-1 **A** ___ **SC**

Specifications are subject to change without prior notice due to product improvements.

2.3 ENGINE CROSS REFERENCE TABLE

Engine Model	Cyl.	Capacity (cc)	Hydraulic Starter	Turbine Starter	Remarks
ADE					
152	3	2510	M22-D318	L05MR-_318	
236	4	3860	M22-D318	L05MR-_318	
354/365	6	5810	M22-D318	L05MR-_318	
364	4	3970	M22-D5DS	L05MR-_5DS	
366	6	5960	M22-D5DS	L05MR-_5DS	
442	V8	15060	M22-D4BS	L05MR-_4BS	
447/407	6	11960	M22-D4BS	L05MR-_4BS	
449	5	9970	M22-D4BS	L05MR-_4BS	
Baudoin					
12P15	V12	82200	M38A-D63S		
6P15	6	20550	M38A-D63S		
DNP4	4	9140	M22-D63S		
DNP5	5	14275	M22-D63S		
Bukh					
DV036			M10-DWZ46		
Caterpillar					
3054	4	4400	M22-D318	L05MR-_318	
3024	4	2200	M10-DFZ76		Same as Perkins 404-C22
3056	6	5805	M22-D318		Similar to Perkins 1006
3114			M22-D21S		
3116			M22-D21S		
3126			M22-D21S		
3204	4	5200	M22-D31S		
3304	4	6970	M28-D23S	R06MR-P23S	
3306	6	10463	M38A-D23S	R06MR-P23S	
3406	6	14600	M38A-D13S	R06MR-P13S	
3408	8	18000	M66A-D73S	R06MR-P73S	
3412	12	27000	M66A-D73S		
3508	8	34500	M66A-D73S		
3512	12	51800	M66A-D73S		
3516	16	69000	M66A-D73S		
C4.4	4	4400	M22-DCY18	L05MR-DCY18-G	
C6.6		6600		L05MR-_63S-G	
C7		7000	M28-D21S/M38A-D21SX1	L05MR-_21S	
C9			M28-D13S		
C18	6	18100	M66A-D73S	R14MR-P73S-G	
C32	V12	32100	M66A-D73S	R14MR-P73S-G	

Specifications are subject to change without prior notice due to product improvements.

Engine Model	Cyl.	Capacity (cc)	Hydraulic Starter	Turbine Starter	Remarks
Cummins					
4B	4	3900	M22-DE1S		
6B	6	5900	M22-DE1S		
6CTA8.3	6	8300	M28-D229		Check bellhousing
B3.3 (forklift)		3300	M10-DWG6		
KTA19/28/38/50			M66A-D73S		
NTA855			M38A-D73S		
QSB 6.7			M22-DSZKS	L05MR-PSZKS	
QSK23			M66A-D13S		
QSC 8.3		8300		L05MR-PSZCYS-G	
QSX 15		15000		R10MR-P13S-G	
QSK60					
QSL9	6	9000	M22-DSZCYS		
A2300			M10-DA41X1		
QSM11				R06MR-P13S-G	
QSK99			M66A-D73SX1		

Daedong					
TD1400-S1				L05MR-?R44-G	

David Brown					
580GTLB			M22-D3C1		

Deutz					
BF4M1013E	4		M22-D518		
BF6M1013E	6		M22-D518		
F5L413FRW	5	7977	M22-D5AS		
F6L413	V6	9572	M22-D41S		
F8L413	V8	12763	M22-D41S		
F10L413	V10	15953	M22-D41S		
F12L413	V12	19144	M22-D41S		
F3L912	3	2827	M22-D518		
F4L912	4	3770	M22-D518		
F5L912	5	4712	M22-D518		
F6L912	6	5655	M22-D518		
F6L914	6	6000	M22-D518		
BF4L1011F			M22-D5W6		
BF2L1011F			M22-D5W6		
F2L2011F			M22-D5W6		
BF4M2012	4	3200	M22-D518		

Daewoo					
310			M10-DLP9		

Fiat					
8210			M22-D4F4		

Specifications are subject to change without prior notice due to product improvements.

Engine Model	Cyl.	Capacity (cc)	Hydraulic Starter	Turbine Starter	Remarks
FORD					
2700			M22-D3		
4500			M10-D3C4XSE		
6000			M22-D3C4		
GENISIS	6		M22-D3C4		
Gardener					
6L			M22-D23S		
Hatz					
M40/2/3/4			M10-D444		
Z790			M10-D644		
1D81/1D90			M10-DG85		
2M41/2L41			M10-D444X1		
Isuzu					
2.2 LTR	4	2200	M10-D9G6		
6BD1	6	5785	M10-D4P9		
C240	4		M10-D9GAXSE		
6HK				L05MR-P4AYS-G	
4JJ1T			M10-D431SX1		
6WG1				R10MR-PXGYS-G	
3CB1-GZG01			M10-DFZBY6		Same eng. As Yanmar 3TNV
Iveco					
8041/8061			M22-D5X1		
8210	6		M16-D5F8		
8281 SRi 10	V8	17200	M38A-DHRS		
N67			M22-D311	L05MR-P311-G	
7675i			M22-DWX1		
Cursor C13	6	12800	M28-DSZ3S		
JCB					
444N2				L05MR-PJZ16-G-E4	
TCA-85			M22-DJZD6X1		
John Deere					
6068			M22-D31S		
6081			M22-DBZ1S		
Kubota					
EB300			M10-DGL1		
2200			M10-D4E1X		Gehl loader (replaces M10-D5L1)
v3800			M22-DR41X1		
V2203			M10-D61S		
V2607			M10-DR41X1		

Specifications are subject to change without prior notice due to product improvements.

Engine Model	Cyl.	Capacity (cc)	Hydraulic Starter	Turbine Starter	Remarks
Lister					
HL6	6		M22-D21S		
PETTER LP3	3		M10-D3M1		Lug may foul on 2 cylinder
PETTER LPW2/3	2/3		M10-D3M1		
PETTER PH1&2			M10-DLC8XL		
STW-2			M10-D318		
TS2/3			M10-D318		
Man					
D0226 M,MT,ML			M22-DD18		
D2840 T,L,LX,LY			M22-D537		
D2842 T,L,LX,LY			M22-D537		
D2848 T,L,LX,LY			M22-D537		
D2866 T,L,LX,LY			M22-D537		
Mercedes					
OM441A			M22-D53S		
MTU					
183	V6		M28-D43S		
12V2000	V12		M66A-D73S		
16V2000	V16		M66A-D73S		
18V2000	V18		M66A-D73SX1		
MWM					
916-6			M22-D544		
D232-V12	V12	17600	M22-DAZ1S		
D232-V8	V8	11760	M28-DAZ1S		
Mitsubishi					
S6R			M38A-DLZYSX1	Similar to Volvo D25	
S4S			L05MR_DT4-G		
S6B3/S6A3				R10MR-PLZYS-G	
S12R/S16R			M66A-DSHSX1	R14MR-PSHS-G	
S12A2			M66A-DKZYSX1		
S4E			M22-D446		
S4Q			M22-DDY6X		
6D24	6	12000	M38A-DYZE		
Paxman					
VP185			M66A-DEZ3S		
Perkins					
1004			M22-D3A8		
1006	6	5805	M22-D318		Same as Cat 3056
3012 TAG 3A	12	25000	M38A-D63S		
4-108	4	1755	M10-D61S		
4-236	4	3870	M10-D318		

Specifications are subject to change without prior notice due to product improvements.

Engine Model	Cyl.	Capacity (cc)	Hydraulic Starter	Turbine Starter	Remarks
4-248	4		M22-D3A4		
1306	6	6700			
404-C22		2200	M10-DFZ76X		Same as Cat 3024
403-D15		1500	M10-DFZ76X		
1103			M22-D318		
1300			M28-D23S		
M50 (w/ SAE1 offset)			M10-D3FY8		

SABB					
M4/LB	4	2950	M10-D544XL		

Scania					
DS1-14			M22-D43S		
D19			M22-D51S		

Toyota					
2ZII			M10-DVSCXS		
1Z			M10-D4S6		

VM					
D704LT			M22-D546		
D754 TE2		3000	M22-D546		
4105TE2		4000	M22-D546		

Volvo					
1010/1210 SERIES		10-12000	M22-D4AS		
1620 SERIES		16000	M38A-D2AS		
610/710 SERIES		1862890	M22-D5AS		
PENTA 2040			M10-DF46		
D25			M3A-DLZYSX1		
TD950				R06MR-PDY1S-G	

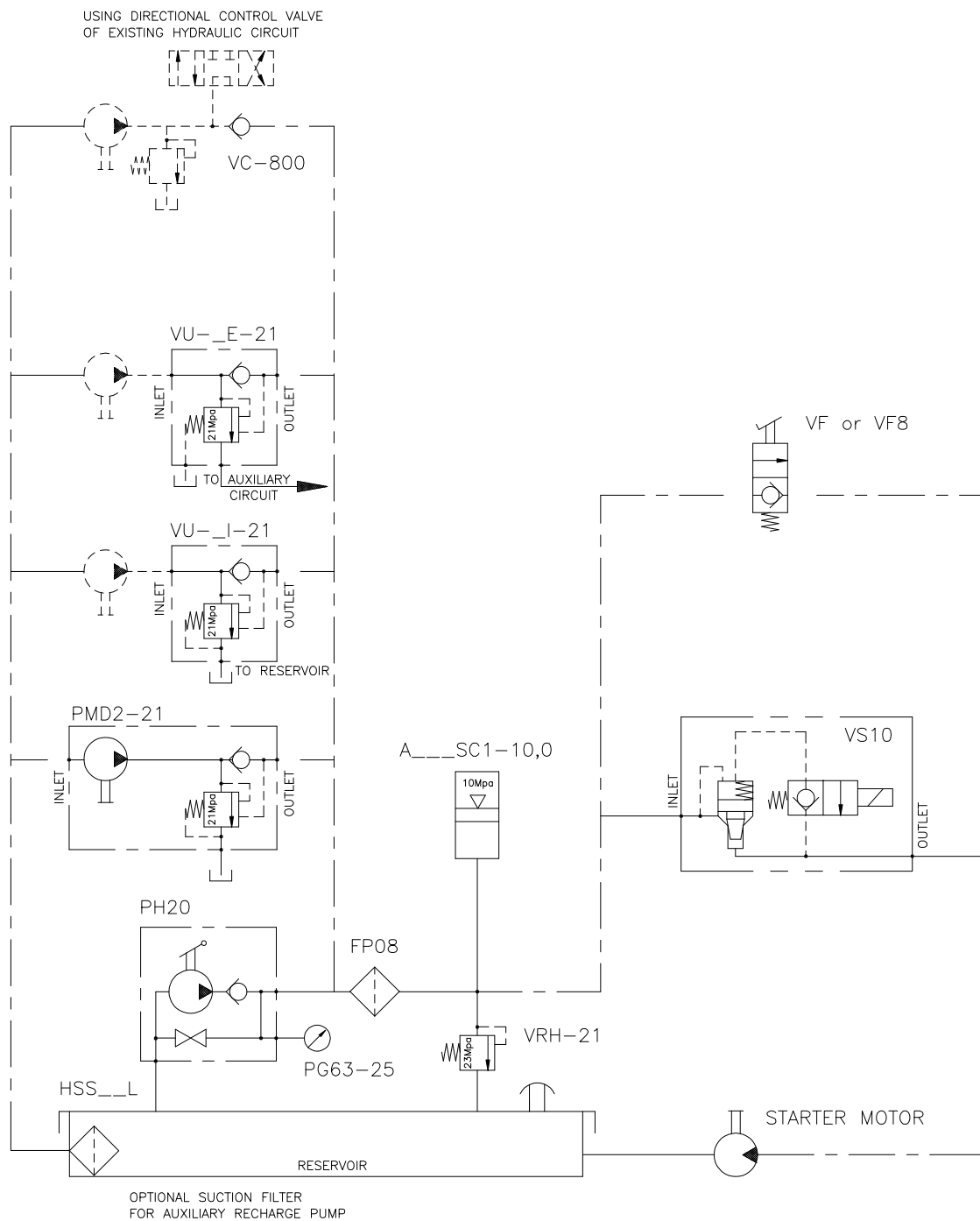
Yanmar					
4TNE84T-JS	4	2500	M16-DTV4		
4TNV88			M10-DAG4		
4TNV98-VNS			M10-DWG6		

Specifications are subject to change without prior notice due to product improvements.

2.4 START VALVE AND RECHARGING SYSTEM DIAGRAMS

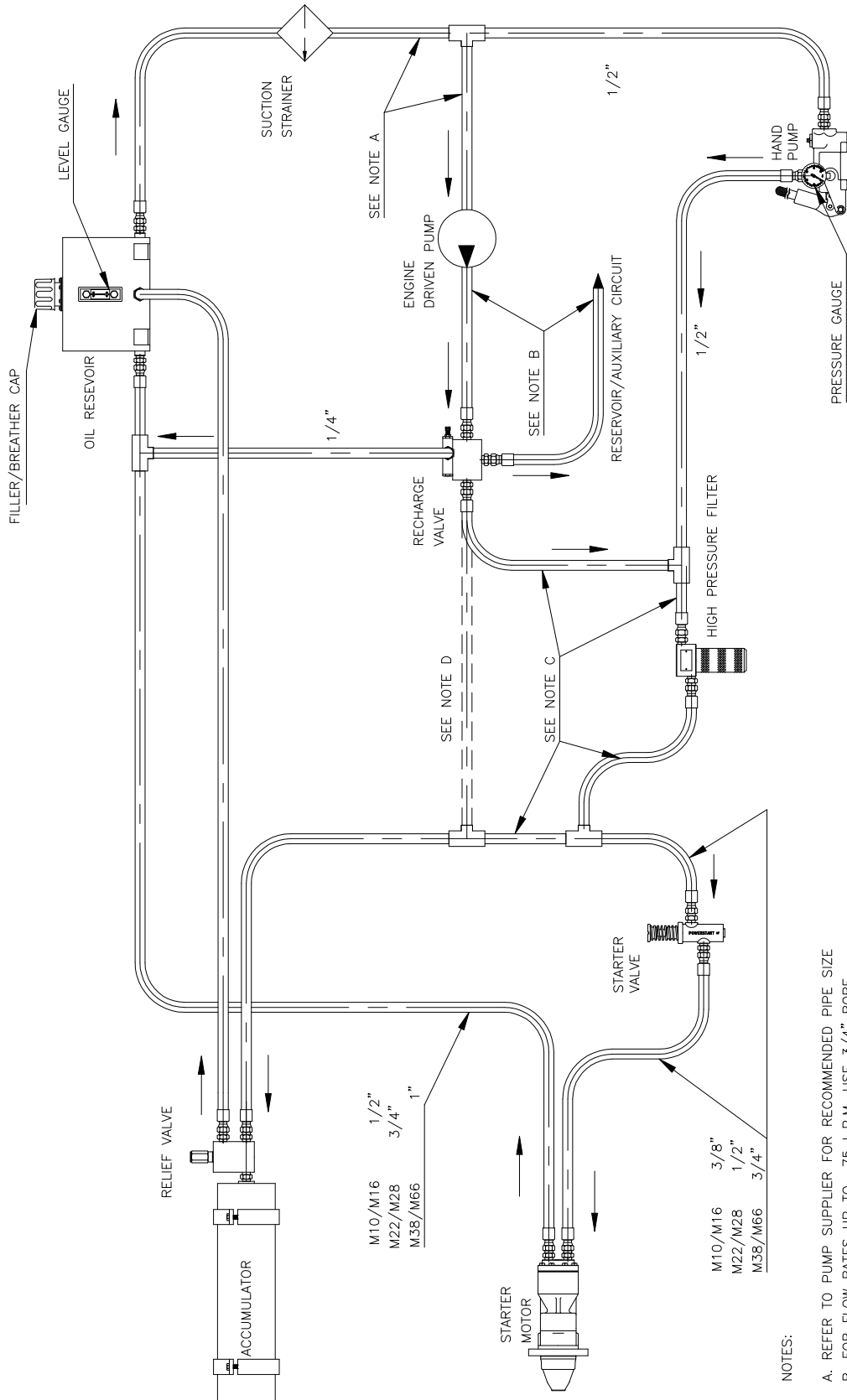
OPTIONAL MECHANISED RECHARGING SYSTEMS

START VALVE OPTIONS



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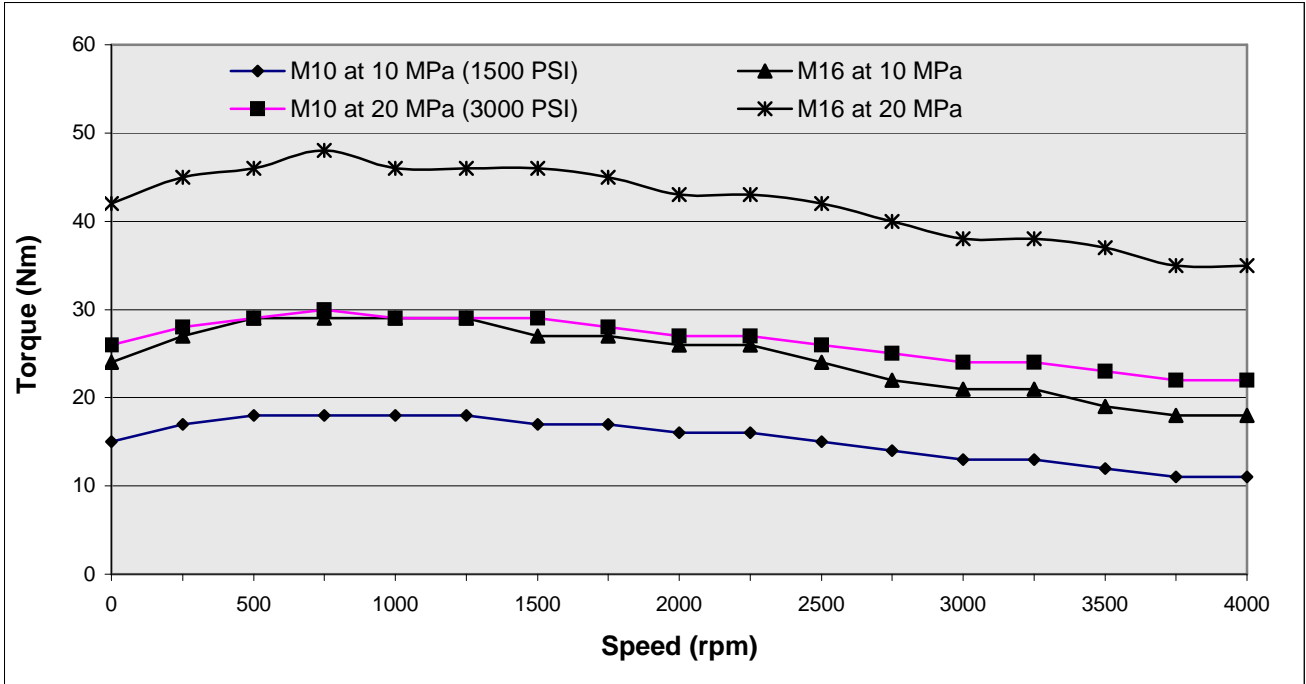
2.5 HYDRAULIC PIPING AND FITTINGS DIAGRAM



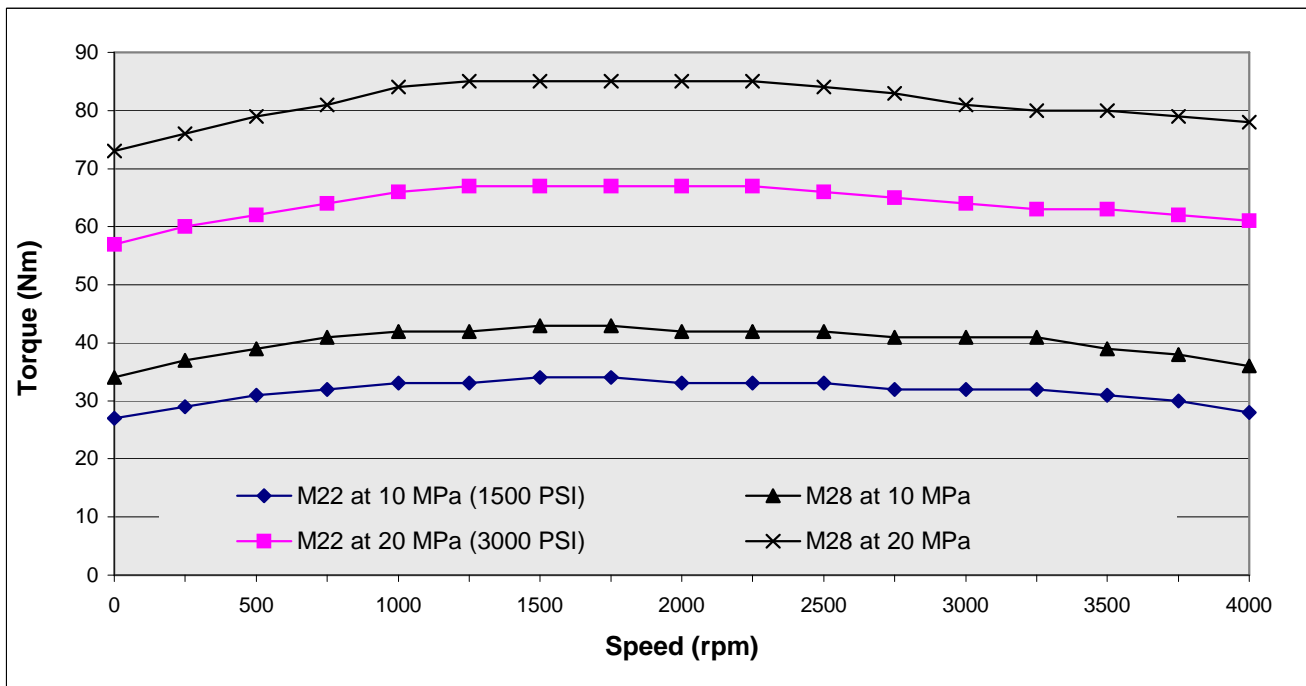
Specifications are subject to change without prior notice due to product improvements.

2.6 POWERSTART STARTER PERFORMANCE CURVES

2.6.1 M10 AND M16 STARTER TORQUE CURVES

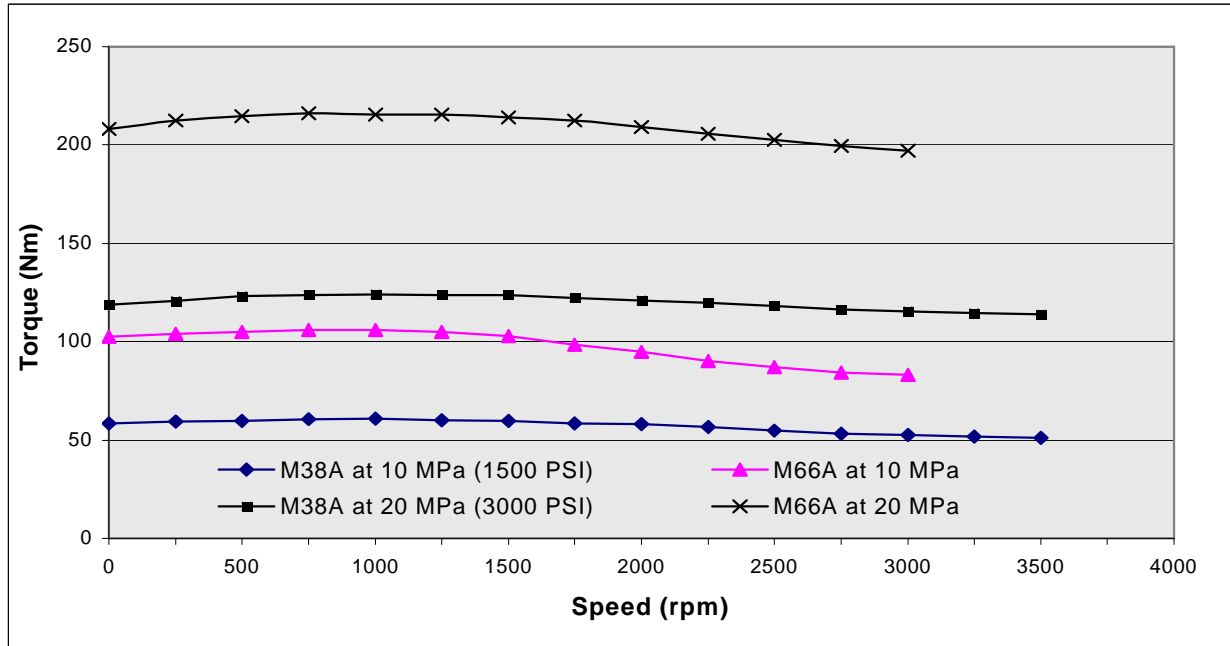


2.6.2 M22 AND M28 STARTER TORQUE CURVES



Specifications are subject to change without prior notice due to product improvements.

2.6.3 M38A AND M66A STARTER TORQUE CURVES



Specifications are subject to change without prior notice due to product improvements.

3. INSTALLATION, SERVICE AND MAINTENANCE

3.1 INSTALLATION GUIDELINES

3.1.1 APPLICATION

Ensure the use of the correct equipment as requested on the application enquiry sheet and the subsequent parts list viz.:

- Motor size, mounting flange, pinion gear and direction of rotation.
- Accumulator nominal volume and gas pre-charge pressure.
- Unloading valve flow capacity and pilot drain (internal or external).
- Filter element rating (micron) and flow capacity.
- Reservoir capacity.
- Hose sizes and lengths.
- Starting valve type and options such as engine interlock and transmission interlock.

3.1.2 EQUIPMENT POSITIONING

Keep the system as compact as possible. Keep hoses and piping as short as possible. Affix all equipment properly and effectively to achieve minimal system failure. Items must be easily accessible for maintenance and testing purposes. Do not mount equipment in close proximity to high temperatures (e.g. exhaust manifolds etc.).

- **ACCUMULATOR** can be mounted vertically or horizontally. Keep clear of direct engine and exhaust heat to avoid gas pre-charge variations. Provide a minimum of 100mm (4") clearance at gas end to permit easy application of test and charge kits. Secure the accumulator safely to avoid sudden recoil movement in the unlikely event of hose failure.
- **HAND PUMP** can be mounted up to 3m (9.8 ft) above reservoir oil level (at sea level altitude). If the pressure gauge is fitted directly to the pump, protect it from accidental damage. Apply ergonomic principles for easy handle operation.
- **FILTER** should be mounted vertically with the bowl facing downwards to avoid excessive oil spillage while replacing element.
- **START VALVE** to be positioned for convenient actuation by the operator.
- **UNLOADING VALVE** must be easily accessible for maintenance inspection.
- **RELIEF VALVE** should be mounted close to the accumulator oil end cap with no other valve or component in between.

Specifications are subject to change without prior notice due to product improvements.

3.1.3 SYSTEM INSTALLATION

MOTOR with M10, M16, M22 and M28 starters the starter drive is supplied with the **pinion gear in the extended (engaged) position. The gear will retract after the first start.** Do not tamper with the starter drive assembly. To ensure the correct engagement depth, turn the pinion gear counter-clockwise to extend the gear to its utmost. Measure the distance from the motor mounting flange to the face of the pinion gear. Deduct 13mm (1/2") from that and the resultant value should equal the bellhousing flange to ring gear distance (FRG). This should provide, in the disengaged mode, a clearance between ring gear and pinion of approximately 6mm (1/4"). Apply marking blue on the gear teeth so that after the first start the gear mesh can be inspected for accuracy. Clean flange faces to permit flush mounting of the motor. Check for interference with engine parts and ring gear. The pinion housing may be indexed in 90° increments (for M10, M16, M22, M28) and 60° increments (for M38A, M66A) with respect to the starter motor housing.

ACCUMULATOR to be affixed securely with recommended Powerstart mounting brackets (part no. AC-17).

HAND PUMP is to be mounted on a flat surface and shimmed if necessary to avoid body distortion and ensure full movement of lever and handle. The pump handle may not be left in the pump and must be stored separately.

FILTER is to be mounted on a flat surface, using the two M10 threaded holes in the filter head. Make sure filter bowl faces down to minimise oil spillage during element replacement.

FLOW CONTROL

RELIEF VALVE, unloading valve and accumulator pre-charge are factory pre-set and are not to be tampered with.

HOSES and fittings have to be rated at 35 MPa (5000 psi) (accumulator test pressure). Installation has to be undertaken as per hose and fitting supplier's specification and recommendations. As a rule of thumb the bend radius should be 12 times the nominal hose size. Avoid straight hose lines as the length can vary by ±3% when pressurised. Remain within laminar velocity by avoiding erratic flow directional changes. Between accumulator, start valve, motor and reservoir use only straight adapters, through lines in T-pieces (if required) and 90° hose ends to attain lowest flow restrictions.

Hose size for:	M10, M16	M22, M28	M38A, M66A
Pressure Lines:	3/8"	3/8"	3/4"
Motor Return Lines:	1/2"	1/2"	1"

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3.1.4 INSTALLATION PARAMETERS

	Model	Pressure Ports	Suction, Return line	Gauge, Drain, Pilot line	Mounting Bolts	Qty
Starter Motor	M10, M16	3/8" NPT	3/8" NPT		As per engine	
Starter Motor	M22, M28	3/8" NPT	1/2" NPT		As per engine	
Starter Motor	M38, M66	SAE 12	SAE 12		As per engine	
Port Adapters	M38, M66	1/2" NPT	1-1/6" JIC		As per engine	
Accumulator	SC	3/4" NPT			use AC-17 bracket	2 sets
Acc. Bracket	AC-17				M10 or 3/8"	2
Handpump	PH20	3/8" NPT	3/8" NPT	1/4" NPT	M10 or 3/8"	4
Filter	FP08	1/2" NPT			M10	2
Foot valve	VF	3/8" NPT			M8 or 5/16"	2
Foot valve	VF8	1/2" NPT			M8 or 5/16"	2
Relief valve	VRH	3/4" NPT	1/2" NPT	1/4" NPT	M8 or 5/16"	2
Unloading Valve	VU-2	3/4" NPT	3/4" NPT	1/4" NPT	M8 or 5/16"	2

3.1.5 COMMISSIONING OF SYSTEM

On prototypes and first off system installations, note the following for your records:

- Equipment compliance to the recommended specification.
- Equipment accessibility.
- Hose sizes and lengths.

3.1.6 PRIMING OF SYSTEM

- Fill reservoir with recommended mineral oil within ISO 32 to 46 (SUS 140 - 230).
- Actuate hand pump and expel air by loosening outlet connection on the pump. Retighten connection.
- Bleed the system via the hand pump by loosening the fittings at the start valve inlet. Retighten all fittings when oil escaping is free from air (no bubbles).
- Charge the system by means of the hand pump. Resistance will be built rapidly as the oil pressure (shown on the pressure gauge) reaches the accumulator gas pre-charge pressure. This should correspond with the pre-charge indicated on the accumulator nameplate. Continue pumping until the system pressure of 21 MPa (3000 psi) is reached.
- Check all connections for leaks. **CAUTION:** If any leaks are found do not attempt to tighten fittings under pressure. Release pressure via the bleed screw on the hand pump. Once satisfied that no pressure remains, replace thread sealant and/or tighten fitting and again pump by hand until the system pressure is reached.
- When using a minipak, ensure that the reservoir is filled until it just registers at the bottom of the sight glass **when the system is fully discharged.**

3.1.7 STARTING PROCEDURE

- Ensure engine is in a serviceable condition (oil level, fuel supply, coolant, etc.). **Fuel system must be primed.**

Specifications are subject to change without prior notice due to product improvements.

- Disconnect engine from load. Alternatively if load cannot be disconnected, ensure that it is safe to drive the load once the engine rotates and / or fires.
- Activate starter valve.
- If engine fails to start, recharge accumulator with hand pump and repeat above step.
- Release starter valve as soon as the engine has started.
- Repeat the starting procedure a number of times to completely purge the system of air.
- If the system is equipped with an automatic recharge valve check that it is charging the accumulator to system pressure of 21 MPa (3000 psi).

If the engine turns rapidly for approximately 3 - 5 seconds and does not start, the problem is not with the starting system. If oil emerges from the starter motor check that the inlet and outlet connections are correctly connected to the pressure and return lines.

If a flow control valve is used, this must be carefully set as follows: Screw the adjustment knob all the way in and then back out by two turns. Have someone actuate the start valve and determine whether the engine starts. It should not start due to slow cranking. Open the adjustment knob until the engine cranks faster and just starts. Recharge the system and try the process again. Finally, open the knob by half a turn and lock it using the lock nut below the adjuster.

On prototype installations record the return line backpressure approximately 50mm from the starter motor outlet. Insert the pressure gauge on the T-piece branch line only. The backpressure must not exceed 500 kPa (75 psi). Whilst cranking the engine take care to avoid personal injury.

Hydraulic starting systems require virtually no maintenance apart from replacing the filter element and a periodic check of the gas pre-charge pressure and the system pressure. Before undertaking any repair work ensure that the hydraulic system pressure is released. If in doubt, do not loosen anything and call for professional advice.

Provided that the above points are observed, a hydraulic starting system can be expected to give years of trouble free life, but remember never try to overcome an engine or fuel problem by operating the hydraulic starter above its design pressure (usually indicated by a red sector on the pressure gauge).

When having equipment repaired ensure that the work is carried out by an approved workshop equipped to test all components involved. This is particularly important with the accumulator which must be subjected to a rigorous inspection, be pressure tested under controlled conditions and have a test certificate issued on satisfactory completion of inspection and testing.

3.2 MAINTENANCE

To ensure economic and trouble free starting cycles, the basic preventative maintenance principles have to be adhered to. If any problems arise during the routine checks please refer to “3.5 TROUBLESHOOTING” on page 3-12. Undertake inspections when the machine is at ambient temperature to ensure correct pressure readings.

3.2.1 DAILY

- Check system pressure at the pressure gauge which should read 21MPa (3000 psi) as standard when the system is fully charged.
- As the system cools down it is normal for the pressure to drop slightly, however this should stabilise. If it continues to drop inspect for leaks or refer to the troubleshooting guidelines on page 3-12

3.2.2 WEEKLY

- Check oil level, which should be at the low-level mark when accumulator is at system pressure. A sudden drop of the oil level with no signs of external leakage in the system could indicate the loss of the accumulator gas pre-charge pressure.
- Visually inspect all hydraulic connections and hoses for leaks and retighten if necessary. This should never be done with the system under pressure. First release system pressure by loosening the bleed screw on top of the hand pump. Once you are satisfied that no pressure remains, retighten the fitting or replace the damaged hose or component. Retighten the bleed screw on the hand pump. Pump the system up to 21 MPa (3000 psi). Inspect that the leak has been eliminated.
- In the unlikely event that a leak should develop between the motor body and port plate, retighten the 8 bolts for starter motors as follows:

M10, M16, M22, M28	to 10 Nm (7.3 lb.ft.)
M38A, M66A	to 30 Nm (22.1 lb.ft.)

3.2.3 QUARTERLY

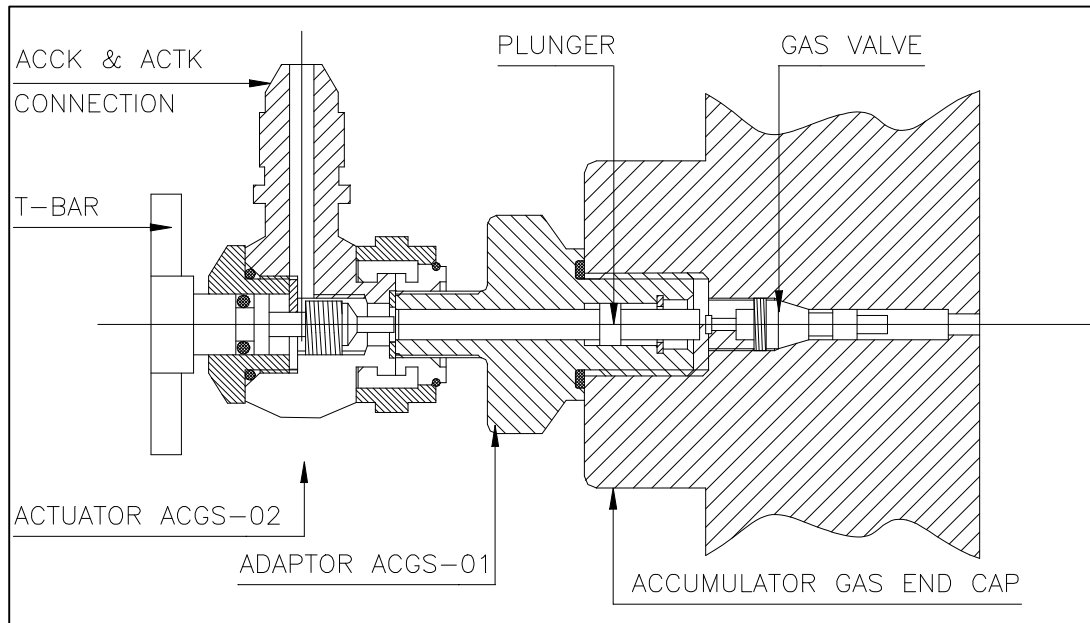
- Check accumulator pre-charge. This can be done as described in “3.3.2 TESTING OF GAS PRE-CHARGE” on page 3-7. However, a far simpler method is to shut the engine off, release system pressure via the bleed screw on top of the hand pump then retighten the bleed screw and actuate the hand pump. The pressure will rapidly rise and then stabilise. This pressure corresponds with the accumulator gas pre-charge. If, however, this pressure rapidly rises to 21 MPa (3000 psi), it indicates that the accumulator has lost part or all of its gas charge.
- To check the unloading valve integrity the engine has to be running. The cut out pressure of 21 MPa (3000 psi) is confirmed at the daily inspection (see above). Open the hand pump bleed screw to reduce the system pressure slowly. Note the pressure reading as the mechanised pump starts to recharge the starting system. This pressure should read between 16.8MPa (2400 psi) and 18.9 MPa (2700 psi) depending on the recharge ratio 80% std. (90%optional). Retighten the bleed valve. The pressure should rise to 21 MPa (3000 psi) at which point the valve should unload.

Specifications are subject to change without prior notice due to product improvements.

3.2.4 SIX MONTHLY

Or every 2000 engine running hours (approximately 1500 starts) the filter element (part no: FP08-08-40) has to be replaced. Very dusty environments may require more frequent replacement.

3.3 ACCUMULATOR GAS SERVICE



3.3.1 GENERAL

THE MACHINE MUST BE STOPPED, SWITCHED OFF AND ISOLATED PRIOR TO ANY ACTION

By turning the T-bar clockwise the adapter plunger moves forward lifting the gas valve poppet off the seat, thereby opening a passage connecting the accumulator gas chamber to the outlet.

Pressure testing and recharging of accumulators must be undertaken with care and should be carried out at ambient temperature. Refer to “3.4.2 *RESSURE / TEMPERATURE COMPENSATION*” on page 3-11 for a table showing the effect of different temperatures on the gas precharge.

3.3.2 TESTING OF GAS PRE-CHARGE

NOTE: In order to obtain a correct reading, the accumulator should be at ambient temperature. Furthermore, if the accumulator is connected up to a hydraulic system, all oil must first be discharged from the accumulator. If the temperature exceeds 40°C (104°F) please refer to “3.4.2 *RESSURE / TEMPERATURE COMPENSATION*” on page 3-11.

- Clean the gas end cap of the accumulator by wiping all dirt away from around the gas valve protector plug.
- Remove the gas valve protector plug, using a 6mm A/F allen key and clean the seal area, ensuring that no dirt enters the threaded hole
- Screw in adapter ACGS-01 and hand tighten.
- Turn T-bar of actuator ACGS-02 clockwise until it is fully retracted.
- Assemble actuator ACGS-02 onto adapter ACGS-01 and tighten lightly (17mm A/F spanner).

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- Turn actuator T-bar clockwise to open the gas valve in the accumulator end cap.
- CAUTION: Excessive force used in tightening the T-bar will bend the actuator pin in the gas valve and cause it to malfunction.
- If any pressure is present in the accumulator it will be registered on the gauge (PG63-25). If this reading is substantially higher than the pre-charge pressure indicated on the accumulator label, verify that all of the oil has been discharged from the accumulator. Also see note above if temperature exceeds 40°C (104°F), prior to reducing pressure.
- Turn T-bar anti-clockwise until it is fully retracted.
- Unscrew actuator ACGS-02 from adapter ACGS-01 and remove adapter from accumulator.
- Inspect seal of gas valve protector plug and replace if necessary.
- Screw the gas valve protector plug into accumulator and tighten to 22 Nm (16 lb. ft.).

3.3.3 GAS CHARGING PROCEDURE

WARNING: Only use dry nitrogen when charging hydraulic accumulators. The use of other gasses is highly dangerous and could result in an explosion with the risk of serious personal injury or death.

If the standard nut ACCK-04 (3/4" BSP) is not compatible with your nitrogen bottle connection, kindly purchase the correct nut from your gas supplier. In order to obtain a correct reading, the accumulator should be at ambient temperature. Furthermore, if the accumulator is connected up to a hydraulic system, all oil must first be discharged from the accumulator. If the temperature exceeds 40°C (104°F) please refer to "3.4.2 PRESSURE / TEMPERATURE COMPENSATION" on page 3-11.

- Clean the outlet of the nitrogen bottle before assembly. Connect the bottle adapter incorporating the recharge valve to the nitrogen bottle.
- Clean the gas end cap of the accumulator by wiping all dirt away from around the gas valve protector plug.
- Remove the gas valve protector plug, using a 6mm allen key and clean the seal area, ensuring that no dirt enters the threaded hole.
- Ensure that the actuator pin is fully retracted, i.e. the T-handle should be unscrewed all the way
- Screw in adapter ACGS-01 and hand tighten.
- If not already done, assemble actuator ACGS-02 onto adapter ACGS-01, tightening lightly (17mm A/F spanner).
- Turn actuator T-bar clockwise to open the gas valve in the accumulator end cap.
- CAUTION: Excessive force used in tightening the T-bar will bend the actuator pin in the gas valve and cause it to malfunction.
- If any pressure is present in the accumulator it will be registered on the gauge (PG63-25). If this reading is substantially higher than the pre-charge pressure indicated on the accumulator label, verify that all of the oil has been discharged from the accumulator. Also see note above if temperature exceeds 40°C (104°F), prior to reducing the pressure.
- To increase the pressure, slowly open the valve on the nitrogen bottle. Rapid filling of an accumulator is undesirable since this causes temperature variations, resulting in incorrect readings.
- When the desired pressure has been reached, close the gas valve on the nitrogen bottle. Allow the temperature to stabilise for 3 - 4 minutes and check the pressure. If need be, adjust as dictated by reading on the pressure gauge.

Specifications are subject to change without prior notice due to product improvements.

- To reduce the pressure, turn the bleed valve knob - see "5.7 ACCUMULATOR CHARGE KIT" on page 5-7, anti-clockwise for a short while, closing it every now and then to obtain a correct pressure reading.
- Ensure gas valve on the nitrogen bottle is closed.
- Turn T-bar on adapter ACGS-02 anti-clockwise until fully retracted.
- Release pressure trapped in hose by turning the bleed valve knob anti-clockwise.
- Unscrew actuator ACGS-02 from adapter ACGS-01 and remove adapter from accumulator.
- Inspect seal of gas valve protector plug and replace if necessary.
- Screw gas valve protector plug into accumulator and tighten to 22 Nm (16 lbf. ft.).

Specifications are subject to change without prior notice due to product improvements.

3.4 ACCUMULATOR GAS CALCULATIONS

3.4.1 ACCUMULATOR FLUID VOLUME CALCULATION

		SYSTEM PRESSURE IN MPa																					
		30	28	26	24	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	
GAS PRECHARGE PRESSURE IN MPa	20	333	286	231	167	91	48	0															
	19	367	321	269	208	136	95	50	0														
	18	400	357	308	250	182	143	100	53	0													
	17	433	392	345	292	227	190	150	105	55	0												
	16	467	429	385	333	273	238	200	158	111	59	0											
	15	500	464	423	375	318	286	250	211	167	118	63	0										
	14	533	500	462	417	364	333	300	263	222	176	125	67	0									
	13	567	536	500	458	409	381	350	316	278	235	188	133	71	0								
	12	600	571	538	500	455	429	400	368	333	294	250	200	143	77	0							
	11	633	607	577	542	500	476	450	421	389	353	313	267	214	154	83	0						
	10	667	643	615	583	545	524	500	474	444	412	375	333	286	231	167	91	0					
	9	700	679	654	625	591	571	550	526	500	471	438	400	357	308	250	182	100	0				
	8	733	714	692	667	636	619	600	579	556	529	500	467	429	385	333	273	200	111	0			
	7	767	750	731	708	682	667	650	632	611	588	563	533	500	462	417	364	300	222	125	0		
	6	800	786	769	750	727	714	700	684	667	647	625	600	571	538	500	455	400	333	250	143	0	
	5	833	821	808	792	773	762	750	737	722	706	688	667	643	615	583	545	500	444	375	286	167	
	4	867	857	846	833	818	810	800	789	778	765	750	733	714	692	667	636	600	556	500	429	333	
	3	900	893	885	875	864	857	850	842	833	824	813	800	786	769	750	727	700	667	625	571	500	
	2	933	929	923	917	909	905	900	895	889	882	875	867	857	846	833	818	800	778	750	714	667	
1	967	964	961	958	955	952	950	947	944	941	938	933	929	923	917	909	900	889	875	857	833		
0.5	983	982	981	979	977	976	975	974	972	971	969	967	964	962	958	955	950	944	938	929	917		

(Assuming isothermal gas expansion).

Note: The difference between the accumulator nominal volume and the available fluid volume must never be less than 400cc.

$$\text{AVAILABLE FLUID VOLUME (in cubic centimetres)} = \text{CHART VALUE} \times \text{ACCUMULATOR NOMINAL VOLUME (in litres)}$$

Calculation Example

- Given: A starter system with a 5.5 ltr. accumulator pre-charged to 10 MPa and a system pressure of 21 MPa.
- Solution: At intersection of pre-charge pressure “10 MPa” and system pressure of “21 MPa”, the selected chart value of “524” is multiplied by the accumulator nominal volume of 5.5 ltr. to arrive at the available fluid volume of 2882 cc.

Specifications are subject to change without prior notice due to product improvements.

3.4.2 RESSURE / TEMPERATURE COMPENSATION

Gas Temp in °C	Gas Pre-charge Pressure in MPa at 15°C										
	5	6	7	8	9	10	11	12	13	14	15
20	5,0	6,0	7,0	8,1	9,1	10,1	11,2	12,3	13,3	14,4	15,6
30	5,2	6,2	7,3	8,4	9,5	10,5	11,6	12,8	13,9	15,1	16,3
40	5,4	6,5	7,6	8,7	9,8	11,0	12,1	13,3	14,5	15,7	17,0
50	5,6	6,7	7,9	9,0	10,2	11,4	12,6	13,8	15,1	16,4	17,7
60	5,8	7,0	8,2	9,4	10,6	11,8	13,0	14,4	15,7	17,0	18,5
70	6,0	7,2	8,5	9,7	11,0	12,2	13,5	15,0	16,3	17,7	19,4
80	6,2	7,5	8,8	10,0	11,3	12,7	14,0	15,5	17,0	18,5	20,3

The above table shows, for example, that when an accumulator is recharged to 14 MPa whilst the hydraulic oil is at a working temperature of 40°C and the oil temperature drops during the night to ambient of 15°C, the accumulator pressure would have reduced by (15.7 - 14) = 1.7 MPa due to contraction of the gas.

3.4.3 GAS PRESSURE LOSS

When checking the accumulator pressure with the Powerstart test kit ACTK, an inevitable slight loss of pressure occurs. The approximate pre-charge pressure drop per test in percent equals 0.5 divided by the accumulator nominal value. The use of a charging kit with a hose results in a far greater pressure loss and is therefore not recommended.

$$\text{PRESSURE LOSS (as a percentage of pre-charge pressure)} = \frac{0.5}{\text{ACCUMULATOR NOMINAL VOLUME (in litres)}}$$

Example

An accumulator with a nominal volume of 5.5 ltr. would lose $0.5 / 5.5 = 0,09\%$ of pre-charge pressure for each test. If the pre-charge pressure was 6500 kPa prior to testing, the pressure loss is 0.09% of 6500 kPa, i.e. 5.85 kPa. The remaining gas charge pressure would then be $6500 - 5.85 = 6494$ kPa.

3.5 TROUBLESHOOTING

Frequently system components are removed unnecessarily when in actual fact the problem for the engine not starting lies elsewhere. If the engine turns at a fairly high speed (200 rpm plus) for a reasonable period of time (3-5 seconds) and the engine does not start check the engine for fuel at the injectors, faulty protection system, blocked air intake (filter or butterfly valve), correct compression, etc. If the enclosed maintenance schedule is adhered to, any problems arising should be identified in time and therefore avoid costly breakdowns.

Always ascertain that the correct equipment is installed (e.g. accumulator and motor size) and that the test equipment, especially the pressure gauges, are in good working order. The equipment has been inspected at installation and subsequent replacements must match the original parts.

3.5.1 ENGINE DOES NOT TURN

- Verify that system pressure is at 21 MPa (3000 psi).
- When the starter valve is actuated, observe if system pressure drops. If pressure is constant, it indicates a seizure. This could be in the engine and caused by mechanical failure such as overheating or hydraulic lock, either by a leaking cylinder head gasket or cracked cylinder head, or by leaking fuel injectors. Refer to engine manufacturer's handbook. If system pressure drops inspect for leaks. If none are apparent, the failure is most likely within the starter motor. Remove the motor and inspect the drive. If the pinion teeth are damaged inspect the engine ring gear for damage, before rotating the engine to another position. Do not under any circumstances attempt to actuate the starter either with it lying loose in the engine compartment or by holding it. The reactionary torque is violent and damage to equipment or personal injury could result. In addition, the drive spins at high speed and is unprotected when removed from the engine. Replace with a new motor or one known to be in good working order.
- If the hydraulic accumulator has lost its gas charge. It is possible to build up full system pressure of 21 MPa (3000 psi) to check, release pressure by loosening the bleed screw on top of the hand pump. Pressure will drop to zero immediately. Now retighten the bleed screw of the hand pump and start pumping. After a few strokes of the hand pump, appreciable resistance will be felt, and the pressure will immediately climb to 21 MPa (3000 psi). If this happens, replace the accumulator. In multiple accumulator systems, each accumulator must be checked individually. (A short cranking cycle indicates failure of one accumulator, refer to section 3.5.3 hereunder).

3.5.2 SLOW CRANKING OF ENGINE

If the cranking cycle is slow and extended indicating starter motor overload, check for engine problems e.g. wrong lubricant viscosity, partial seizure of engine or excessive parasitic load which could be caused by transmission or main hydraulic circuit failure (e.g. pump, off-loading valves, the failure of the components driven by the engine including auxiliary hydraulic pumps, generators, etc.).

- Ensure hydraulic fluid viscosity is within ISO 32 to 46 (SUS 140-230).
- Inspect piping for correct sizes, refer to "3.1.3 SYSTEM INSTALLATION" on page 3-2 under "HOSES". Check for hose damage, deformed hoses or piping or obstructions inside the hoses. Occasionally the inner lining of the hose may collapse and restrict the flow of oil.
- Ensure correct system pressure and pre-charge pressure as shown in test instructions "3.3.2 TESTING OF GAS PRE-CHARGE" on page 3-7. As a quick check, release system pressure at the hand pump bleed valve and retighten screw. Once the hand pump is primed commence pumping by

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hand. The pressure indicated on the gauge should increase rapidly until the accumulator gas pre-charge is reached after which the rise in pressure should be gradual. If this pressure is higher or lower than 9 to 11 MPa (1290 psi to 1570 psi) refer to "3.3.3 GAS CHARGING PROCEDURE" on page 3-8. If the pressure rises rapidly to 21 MPa (3000 psi) (system pressure) it indicates that no gas charge is present at the accumulator and the piston is "dead ended".

- Replace start valve with a new unit or one known to be in good working order.

3.5.3 SHORT STARTING CYCLE

- Ascertain correct accumulator and motor size.
- Test accumulator gas pre-charge as described in section 3.5.1 above in the last paragraph. If the system is equipped with more than one accumulator, refer to "3.3.2 TESTING OF GAS PRE-CHARGE" on page 3-7.
- If the parasitic load is excessive, it can also cause a short cranking cycle. What happens is that initially the full system pressure is sufficient to rotate the load, but as the pressure drops the output torque of the starter drops to the point where it can no longer rotate the load. The starter then stalls, resulting in a short cranking cycle. Refer to "3.5.2 SLOW CRANKING OF ENGINE" above.
- Replace starter with a new unit or one known to be in good working order.

3.5.4 PRESSURE LOSS (system will not hold pressure)

Visually inspect all system connections and piping for external leaks. If no external leaks are present, this indicates leakage is taking place internally. It is a simple matter to isolate the faulty component. To ensure the safety of the maintenance personnel the following tests must be carried out with the engine shut off and system pressure at zero by loosening the bleed screw on top of the hand pump. After each component has been tested, it is necessary to bleed off all pressure before removing the next line.

- Remove the return line from the starter motor to the reservoir. After the initial flow of oil, operate the hand pump to build up 10 - 12 MPa (1500 – 1800 psi). If oil continues to flow from the motors return line, replace the start valve. Reconnect the starter return line.
- If the system is equipped with an unloading valve disconnect the inlet from the engine driven pump, the return/power-beyond line and the 1/4" external drain line if fitted. Operate the hand pump as described in 2. above. If valve leaks replace it.
- Disconnect the return line from the relief valve to the reservoir. Powerstart relief valves are zero leak valves. If valve leaks, replace it.
- If no leaks are detected after testing the above components, replace the hand pump. CAUTION: do not attempt to test the hand pump since this must be done under pressure by trained personnel.

3.5.5 HAND PUMP MALFUNCTION

The hand pump is double acting and a correctly functioning hand pump must have a pumping action in both directions viz. there should be very little free play in the pumping action.

- Check for mechanical wear in the link holes in both the pump plunger and pivot lever.
- Check for excessive wear between the pivot pin and pivot lever.
- Check for excessive wear between the pivot pin and pump body.
- Check for excessive wear between pump handle and pivot lever.

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If excessive wear is present above replace the pump. If no signs of excessive wear are detected and pump action feels sloppy, proceed as follows:

Pull the handle rapidly in one direction for its full travel and observe if handle tends to spring back. If it does, repeat above procedure and pause for a few seconds at the end of the stroke. If the pump no longer springs back, this indicates a restriction in the supply line to the pump, which must be cleared. If pump handle continues to spring all the way back, this indicates a malfunctioning suction valve which could either be contaminated or damaged. If handle is loose in both directions, this indicates the delivery valve is contaminated or damaged. A contaminated oil reservoir will cause a pump to malfunction and should be drained, flushed and refilled with clean oil. If pumping action is "spongy", this indicates air in the system. Check oil level and ensure that there are no suction leaks.

3.5.6 GENERAL

If fluid emerges from the reservoir during cranking, check that it has not been overfilled. Powerstart reservoirs have been sized so as not to overflow if the reservoir is filled up to the upper mark of the level gauge whilst the accumulators are empty. Another reason for oil emerging from the top of the reservoir during cranking could be a reservoir manufactured by a third party where no baffle plate has been provided or where the return connection is situated in close proximity to the breather cap. It is recommended that horizontal baffle plates be fitted to small capacity reservoirs, with ports below the baffle.

If there are signs of oil inside a dry fly wheel housing, remove the starter motor and inspect for leakage from the shaft seal before stripping the flywheel housing.

If the starter motor appears to leak between the pinion housing and the starter or at the starter motor nameplate, check if the flywheel housing is a wet housing. This is common on forklift trucks, and the problem can be overcome by sealing the pinion housing to starter face and nameplate to starter face with a silicone sealer. Use a conventional gasket between the starter motor and flywheel mounting face.

**IF THE ABOVE GUIDELINES HAVE NOT RESOLVED THE PROBLEM PLEASE CALL
POWERSTART OR THEIR DISTRIBUTOR FOR FURTHER ASSISTANCE**

Specifications are subject to change without prior notice due to product improvements.

3.6 WARRANTY STATEMENT

Powerstart equipment purchased new is warranted against defects in material and workmanship for a period of one year from the date of purchase. Should any piece of equipment be suspected to be faulty, it should be immediately returned with a Warranty Claim Form (found in the following page) to the place of purchase so that it may be inspected and tested by Powerstart or their nearest authorised representative.

The conditions of this warranty are: (a) That Powerstart is notified within this period by means of the attached Warranty Claim Form and that such product is returned to Powerstart or its authorised distributor or dealer, transportation prepaid by such user; (b) That product has been installed and used according to Powerstart's specifications; (c) That product has not been misused, abused, modified or improperly maintained by the user; (d) That the defect is not the result of normal wear and tear, and (e) that such product has only been repaired by authorised Powerstart service centres and with original Powerstart spare parts.

Powerstart shall, at its option, either replace or repair, without charge, any such starter product found upon Powerstart's examination to be so defective. Repairs or replacements under this warranty are warranted for the remainder of the original warranty period.

Powerstart makes no other warranty, and implied warranties, including any warranty or merchantability or fitness for a particular purpose are hereby disclaimed.

This warranty constitutes the entire obligation of Powerstart relating to the sale and use of this product, and Powerstart's maximum liability is limited to the purchase price of such product at the date of purchase. In no event shall Powerstart be liable for incidental, indirect, consequential or special damages of any nature arising from the sale or use of such engine starter product.

Powerstart products repaired by the manufacturer out of warranty carry a 3 month warranty on workmanship and parts replaced.

The warranty does not cover freight or customs charges and these are for the account of the customer.

Specifications are subject to change without prior notice due to product improvements.

WARRANTY CLAIM FORM

General

Customer: Date:

Contact person:

Tel. No.: Fax. No.:

Distributor:

Installation Details

Starter: Serial no.:

Engine: Installation date:

No. of starts: Failure date:

Parasitic load (Nm):

Installed by:

Failure Details:

Failed components:

Remarks:

For internal use only:

Claim assessed by: Accepted/rejected:

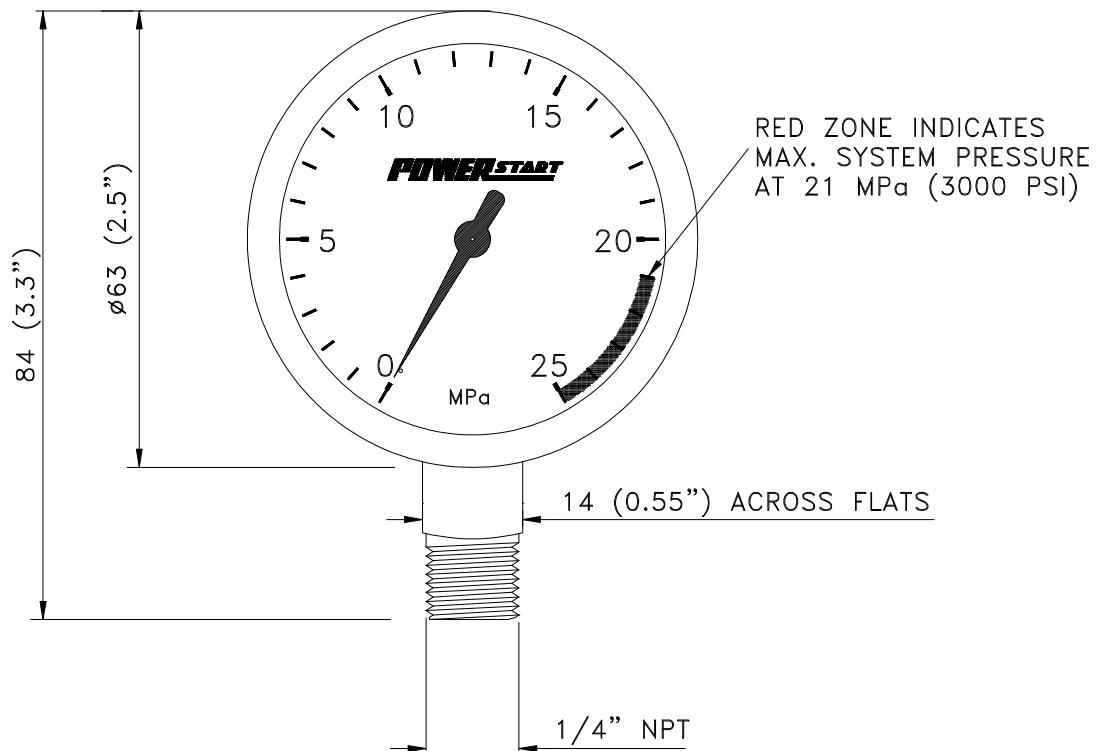
Repair/supply new: Job no. or inv. no.:

Cause of failure/remarks:

Specifications are subject to change without prior notice due to product improvements.

4. ACCESSORIES

4.1 PRESSURE GAUGE SPECIFICATIONS



Part numbers:

- PG63-25** – Gauge with metric (MPa) markings
- PG63-25-U** – Gauge with imperial (psi) markings

Features:

- Glycerine filled casing.
- Plexiglas safety front.
- Snubber screw.
- Safety blow out plug.

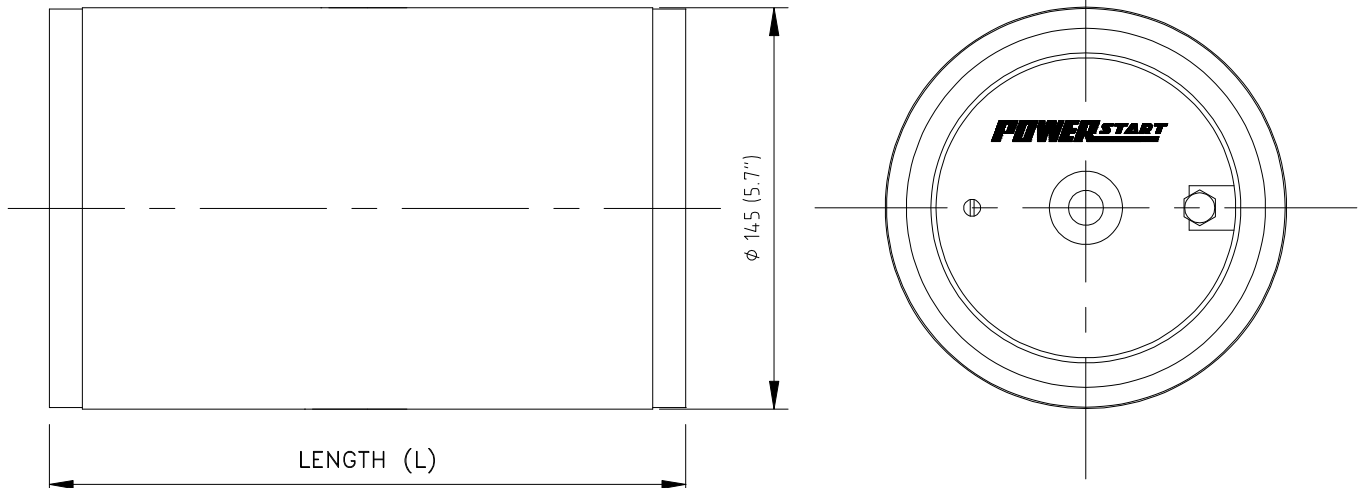
Specifications:

Mass	325 grams (0.7 lbs)
Construction	One piece forged brass case and stem
Working pressure	0 – 25 MPa (0 – 3600 psi)
Temperature range	Ambient -20°C to +60°C (-4°F to +140°F) Fluid media -20°C to +100°C (-4°F to +212°F)

Specifications are subject to change without prior notice due to product improvements.

5. ACCUMULATORS

5.1 ACCUMULATOR SPECIFICATIONS



Features:

- During severe over pressurisation seals extrude to vent gas pressure prior to structural failure.
- End cap retention design prevents disassembly if accumulator is pressurised.
- Protector plug quick exhaust slot safeguards operator during disassembly in the unlikely event of the valve core failing.
- Pre-charge valve is protected from damage.
- Unique piston T-seal cannot roll.
- Accumulators conform to PD5500:2006 and are certified by Lloyd's Register of Shipping as standard
- Powerstart accumulator design is approved by the American Bureau of Shipping and accumulators may be ABS type approved as an added-cost option.

Specifications:

Construction	Certified steel tube - seamless to DIN 2391 (part 2)
Working pressure / Test pressure	21 MPa (3000 psi) / 31.5 MPa (4560 psi)
Design pressure	25 MPa (3600 psi)
Average burst pressure	120 MPa (17400 psi)
Pre-charge pressure	10 MPa (1450 psi) standard (different pressures on request)
Safety ratio	In excess of 4:1
Fluid media	Mineral oil
Viscosity range	ISO 32 to 46 (SUS 140 to 230)
Temperature range	-30°C to +100°C (-22°F to +212°F)
Seals	Nitrile (std.), Viton (optional)
Gas valve assembly	Stainless steel tamper resistant
Gas seal	Twin - bubble tight

Model	Capacity		Length "L"		Mass	
	ltr.	USG	mm	in.	kg	lbs.
A010SC	1.0	0.25	230	9.0	15.5	34
A025SC	2.5	0.66	350	13.8	19.5	43
A040SC	4.0	1.06	475	18.7	24.0	53
A055SC	5.5	1.50	600	24.0	28.0	62

Model	Capacity		Length "L"		Mass	
	ltr.	USG	mm	in.	kg	lbs.
A075SC	7.5	1.95	740	29.0	34.5	76
A100SC	10.0	2.60	965	38.0	40.5	89
A120SC	12.0	3.20	1125	44.0	46.0	101
A160SC	16.0	4.20	1450	57.0	57.0	125

Specifications are subject to change without prior notice due to product improvements.

5.2 LLOYD'S APPROVAL CERTIFICATE



Type Approval Certificate Extension

This is to certify that Certificate No. 93/00020(E3) for the undernoted products is extended and renumbered as shown.

This certificate is issued to:

PRODUCER	Powerstart (Pty) Ltd
PLACE OF PRODUCTION	27, Bushbuck Close Corporate Park South 1385 Midrand South Africa
DESCRIPTION	Hydraulic accumulators of fabricated Carbon Steel.
TYPE	SC, SR, SS.
APPLICATION	Marine, offshore, industrial and mining use in hydraulic systems, and steering gears.
SPECIFIED STANDARDS	Lloyd's Register of Rules and Regulations for Ships, Part 5, Chapter 11: July 201; PD5500:2009 including up to Amendment No. 3:2011; ASME Section VIII Division 2: 2010 including and up to 2011 Addenda.
RATINGS	Sizes: A10, A25, A40, A55, A100, A120 & A160 Max. working pressure (MPa): Steering gears: 16.77 Hydraulic systems: 21 Temperature range (°C): -40 to +100 Factor of safety: 4:1

Certificate No.	93/00020(E4)
Issue Date	23 January 2012
Expiry Date	22 January 2017
Sheet	1 of 2

P.F. Moysey
London Design Support Office
Lloyd's Register EMEA

Lloyd's Register EMEA
71 Fenchurch Street, London EC3M 4BS

Lloyd's Register, its affiliates and subsidiaries and their respective officers, employees or agents are, individually and collectively, referred to in this clause as the 'Lloyd's Register Group'. The Lloyd's Register Group assumes no responsibility and shall not be liable to any person for any loss, damage or expense caused by reliance on the information or advice in this document or howsoever provided, unless that person has signed a contract with the relevant Lloyd's Register Group entity for the provision of this information or advice and in that case any responsibility or liability is exclusively on the terms and conditions set out in that contract.

Specifications are subject to change without prior notice due to product improvements.

5.3 ABS APPROVAL CERTIFICATE



CERTIFICATE NUMBER

04-HS407816/1-PDA

DATE

26 January 2009

ABS TECHNICAL OFFICE

Houston SED - Ship Equipment

CERTIFICATE OF Design Assessment

This is to Certify that a representative of this Bureau did, at the request of
Powerstart (Pty) Ltd. - Rivonia

assess design plans and data for the below listed product. This assessment is a representation by the Bureau as to the degree of compliance the design exhibits with applicable sections of the Rules. This assessment does not waive unit certification or classification procedures required by ABS Rules for products to be installed in ABS classed vessels or facilities. This certificate, by itself, does not reflect that the product is Type Approved. The scope and limitations of this assessment are detailed on the pages attached to this certificate. It will remain valid as noted below or until the Rules or specifications used in the assessment are revised (whichever occurs first).

PRODUCT: Accumulator, Hydraulic Fluid
MODEL: A010SC, A025SC, A040SC, A055SC, A075SC, A100SC, A120SC, A160SC
ABS RULE: 2009 Steel Vessels Rules 1-1-4/7.7, 4-4-1, 4-4-1A1, and 4-6-7/3.5.4
OTHER STANDARD: None;

AMERICAN BUREAU OF SHIPPING

Hans P. Haendler
Engineering Type Approval Co-ordinator

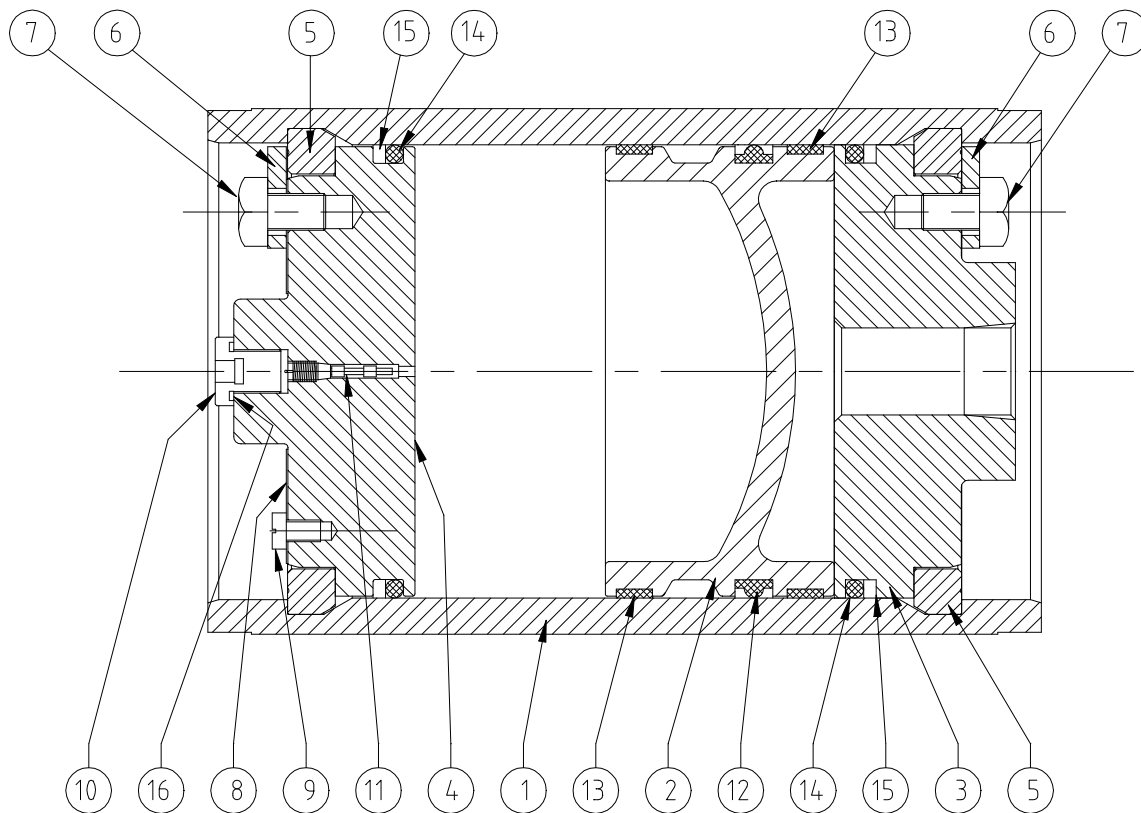
AB258(07/03)

NOTE: This certificate evidences compliance with one or more of the Rules, Guides, standards or other criteria of American Bureau of Shipping or a statutory, industrial or manufacturer's standard and is issued solely for the use of the Bureau, its committees, its clients or other authorized entities. Any significant changes to the aforementioned product without ABS approval will result in this certificate becoming null and void. This certificate is governed by the terms and conditions on the reverse side hereof.

TX 05/08 8168
LTA 1000

Specifications are subject to change without prior notice due to product improvements.

5.4 ACCUMULATOR PARTS LIST



Item	Description	Qty	Part no.
1	Barrel	1	AC-01-□
2	Piston	1	AC-02
3	Oil end cap	1	AC-03-□
4	Gas end cap	1	AC-04
5	Retaining ring (set)	2	AC-05
6	Retaining washer	2	AC-06
7	Retaining bolt	2	AC-07
8	Nameplate	1	AC-08
9	Screw	1	AC-09
10	Gas plug	1	AC-10
11	Valve core	1	AC-11
12	Piston seal (including backup)	1	AC-12
13	Wear strip	2	AC-13
14	O-ring (endcap)	2	AC-14
15	Backup ring (endcap)	2	AC-15
16	Plug seal	1	AC-16

Nominal volume

010	-	1.0 ltr. (0.25 gal.)
025	-	2.5 ltr. (0.66 gal.)
040	-	4.0 ltr. (1.06 gal.)
055	-	5.5 ltr. (1.50 gal.)
075	-	7.5 ltr. (1.95 gal.)
100	-	10.0 ltr. (1.95 gal.)
120	-	12.0 ltr. (2.60 gal.)
160	-	16.0 ltr. (4.20 gal.)

Fluid connection

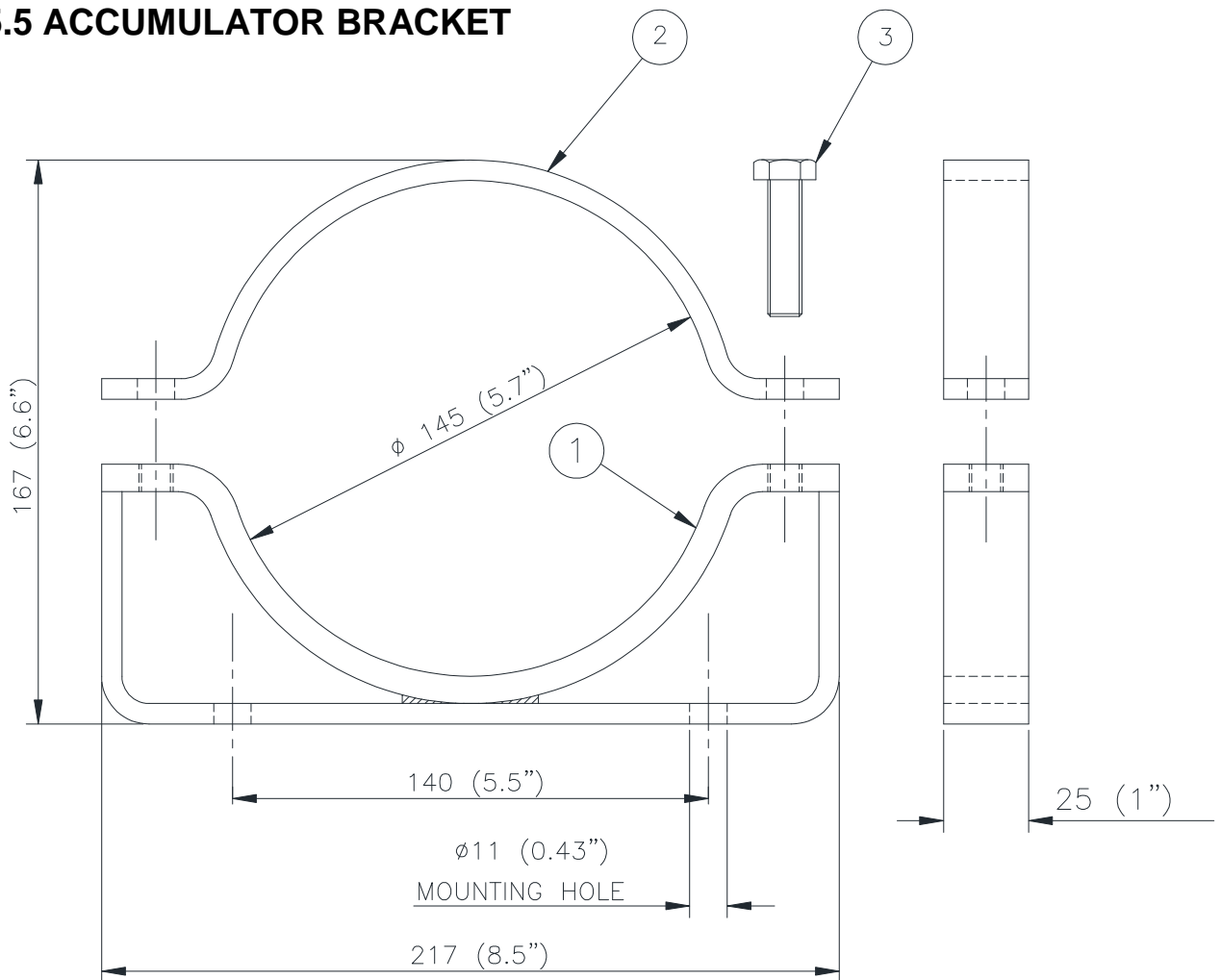
1	-	¾" NPT (std.)
2	-	1" NPT
3	-	1 ¼" NPT
4	-	¾" BSPF
5	-	1" BSPF
6	-	1 ¾" BSPF
7	-	1 ¼" BSPT
8	-	SAE-12

Repair kit includes items 11-16	AC-RK
Seal kit includes items 12-16	AC-SK

Please note: Fluid connections other than ¾" NPT are not ex-stock and will therefore take longer to

Specifications are subject to change without prior notice due to product improvements.

5.5 ACCUMULATOR BRACKET



Part number:

AC-17

Specifications:

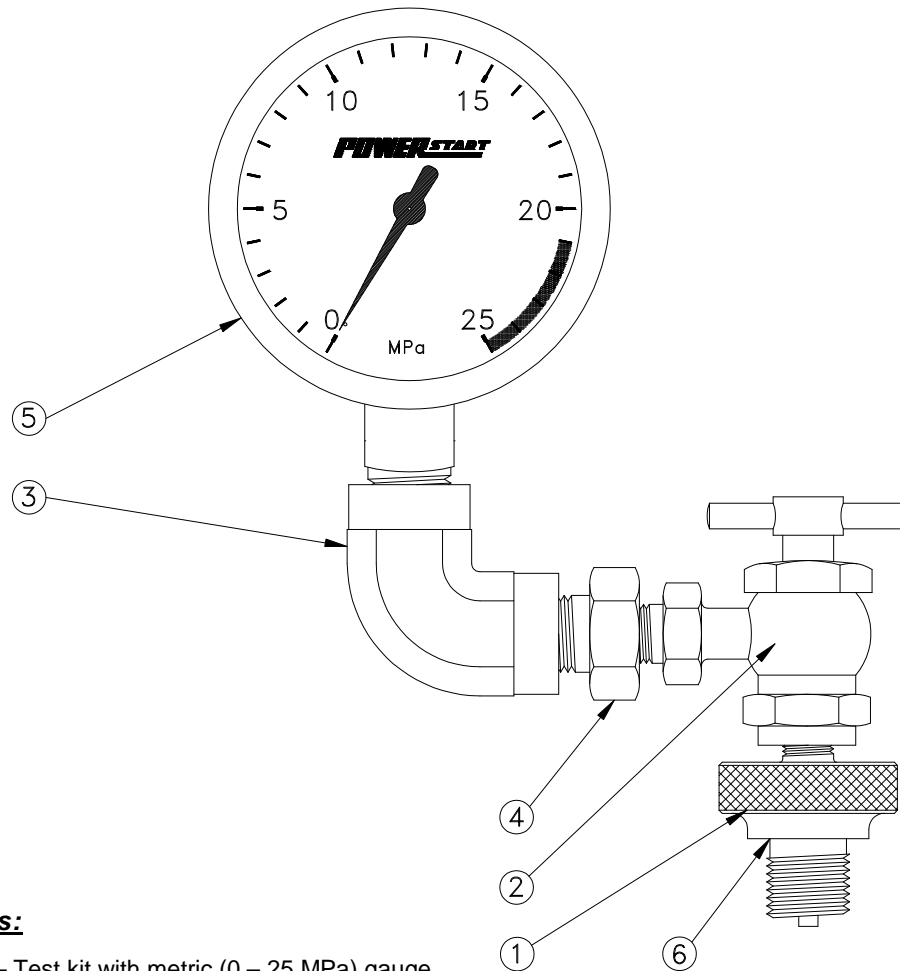
Mass	1.1 kg (2.4 lbs)
Construction	Mild steel
Finish	Zinc plated and yellow passivated
Clamp size	145mm (5.7") Diameter tube

Item	Description	Qty	Part no.
1	Base	1	AC-17-1
2	Clamp	1	AC-17-2
3	Bolt	2	AC-17-3

Note: The part number AC-17 refers to one bracket (i.e. one bracket top, one bracket bottom and two bolts). For most installations, two brackets will be required.

Specifications are subject to change without prior notice due to product improvements.

5.6 ACCUMULATOR TEST KIT



Part numbers:

- ACTK** – Test kit with metric (0 – 25 MPa) gauge
- ACTK-U** – Test kit with imperial (0 – 3000 psi) gauge

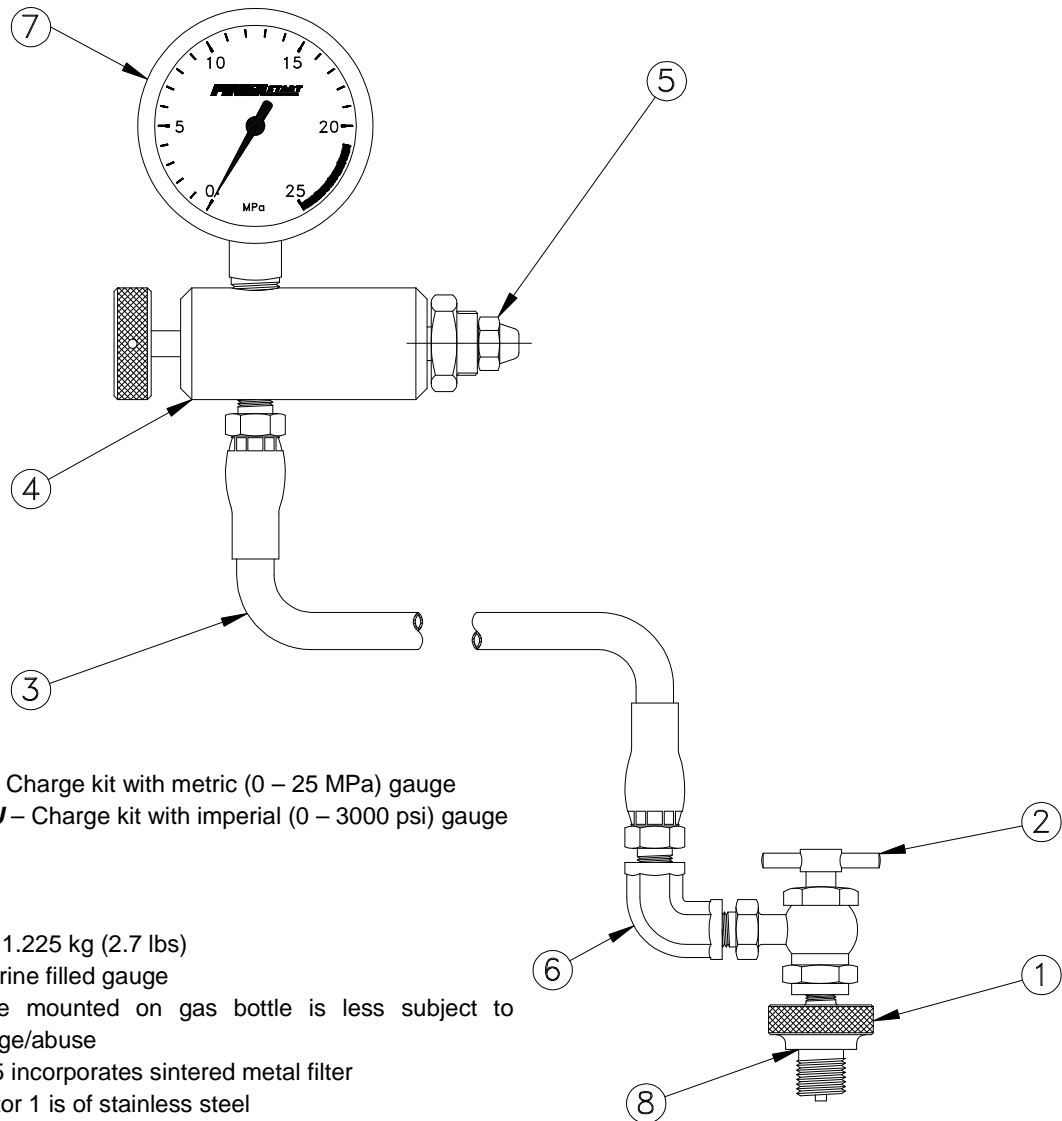
Features:

- Mass 550 grams (1.2 lbs)
- Compact light weight glycerine filled gauge
- Adaptor 1 is of stainless steel
- Design minimises gas loss when checking pre-charge pressure
- One piece forged brass gauge and stem

Item	Description	Qty	Part no.
1	Adaptor	1	ACGS-01
2	Actuator	1	ACGS-02
3	Elbow	1	ACTK-01
4	Reducer	1	ACTK-02
5	Pressure gauge (metric MPa markings)	1	PG63-25
5	Pressure gauge (imperial psi markings)	1	PG63-25-U
6	Seal	1	AC-16

Specifications are subject to change without prior notice due to product improvements.

5.7 ACCUMULATOR CHARGE KIT



Part number:

ACCK – Charge kit with metric (0 – 25 MPa) gauge

ACCK-U – Charge kit with imperial (0 – 3000 psi) gauge

Features:

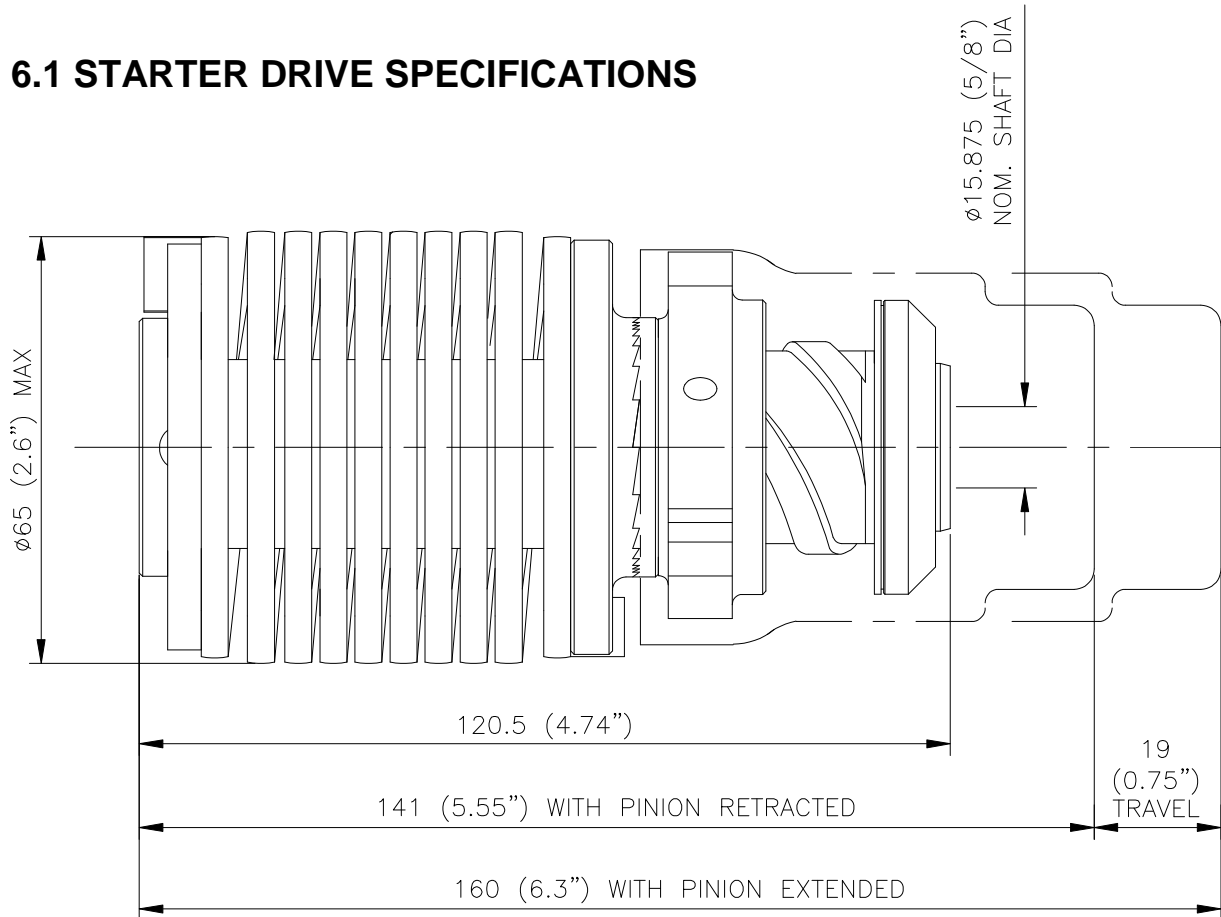
- Mass 1.225 kg (2.7 lbs)
- Glycerine filled gauge
- Gauge mounted on gas bottle is less subject to damage/abuse
- Item 5 incorporates sintered metal filter
- Adaptor 1 is of stainless steel
- One piece forged brass gauge case and stem
- 3/4" BSPF thread to fit standard nitrogen bottles

Item	Description	Qty	Part no.
1	Adaptor	1	ACGS-01
2	Actuator	1	ACGS-02
3	Hose	1	ACCK-01
4	Pre-charge valve	1	ACCK-02
5	Bottle adapter	1	ACCK-04
6	Elbow	1	ACCK-05
7	Pressure gauge (metric MPa markings)	1	PG63-25
7	Pressure gauge (imperial psi markings)	1	PG63-25-U
8	Seal	1	AC-16

Specifications are subject to change without prior notice due to product improvements.

6. STARTER DRIVE

6.1 STARTER DRIVE SPECIFICATIONS



Part number:

M22-23 (Bare starter drive with no pinion gear)

See "PINION GEAR DETAILS AND DIMENSIONS" on page 12-8 for part numbers for a starter drive with pinion gear and circlip.

Features:

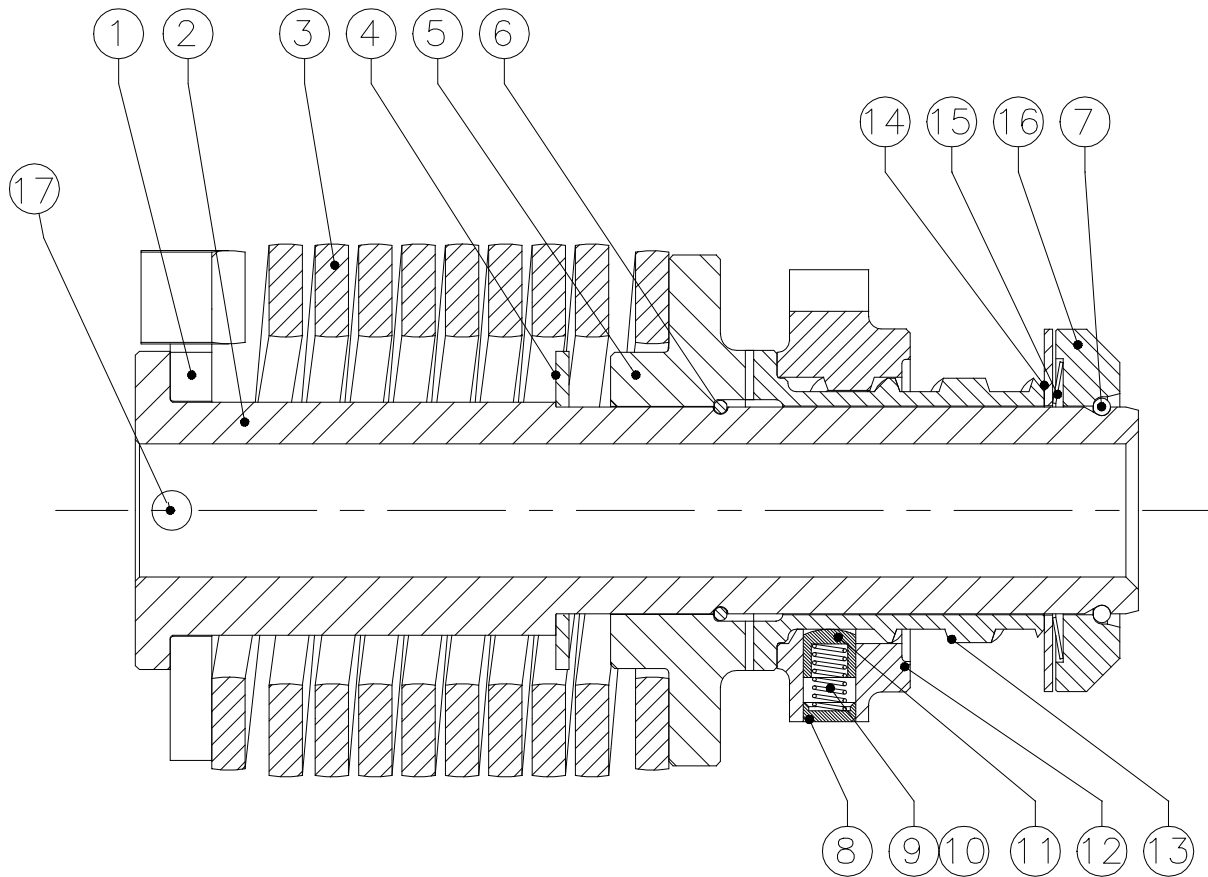
- Robust construction
- Repairable
- Non-sparking, beryllium copper pinions available in marinised anti-corrosion option

Specifications:

Mass	1.43 kg (3.1 lbs)
Construction	Alloy steel
Speed range	0-7000 rpm
Disengagement speed	3500-3900 rpm
Rotation	CW (standard)
Shaft attachment	Keyed
Pinion options	See data sheet on page 12-8

Specifications are subject to change without prior notice due to product improvements.

6.2 STARTER DRIVE PARTS LIST



Item	Description	Qty	Part no.
1	Drive washer	1	M22-23-01
2	Spindle	1	M22-23-02
3	Torsion spring	1	M22-23-03
4	Thrust washer	1	M22-23-04
5	Clutch	1	M22-23-05
6	Retaining ring	1	M22-23-06
7	Retaining ring	1	M22-23-07
8	Plug	2	M22-23-08
9	Anti-drift spring	1	M22-23-09

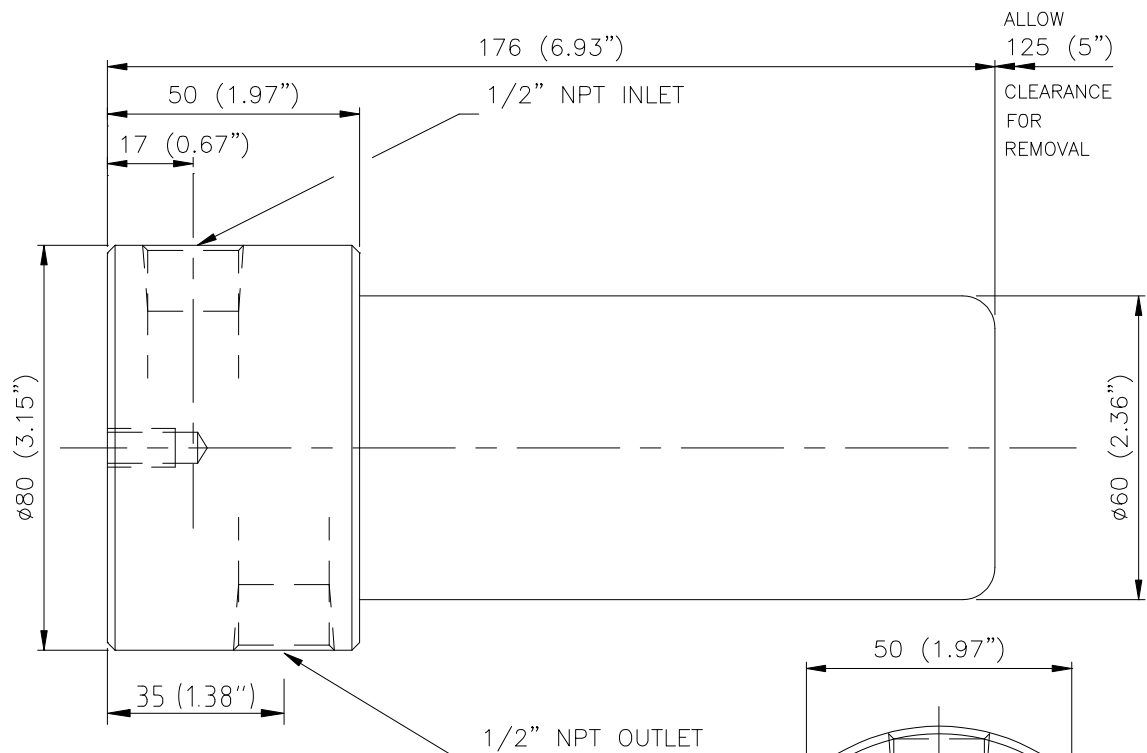
Item	Description	Qty	Part no.
10	Detent spring	1	M22-23-10
11	Plunger	2	M22-23-11
12	Helix nut	1	M22-23-12
13	Helix shaft	1	M22-23-13
14	Thrust washer	1	M22-23-14
15	Bevel washer	1	M22-23-15
16	Stop ring	1	M22-23-16
17	Locating screw	1	M22-23-17

Due to the need to test the disengagement speed with specialised equipment, it is not recommended that starter drives be dismantled or attempted to be repaired by anyone other than Powerstart. Spares are not sold individually for this reason.

Specifications are subject to change without prior notice due to product improvements.

7. FILTERS

7.1 PRESSURE FILTER SPECIFICATIONS



Part number:

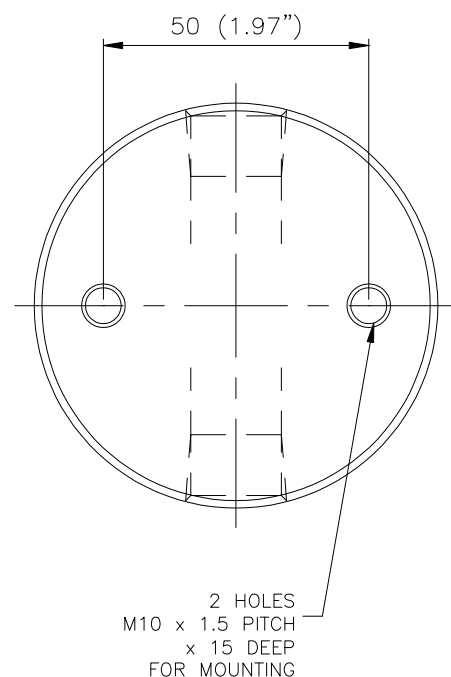
FP08

Features:

- Integral bypass valve
- Mounting holes provided
- Plug bonded to filter element
- Bypass valve components retained during disassembly

Specifications:

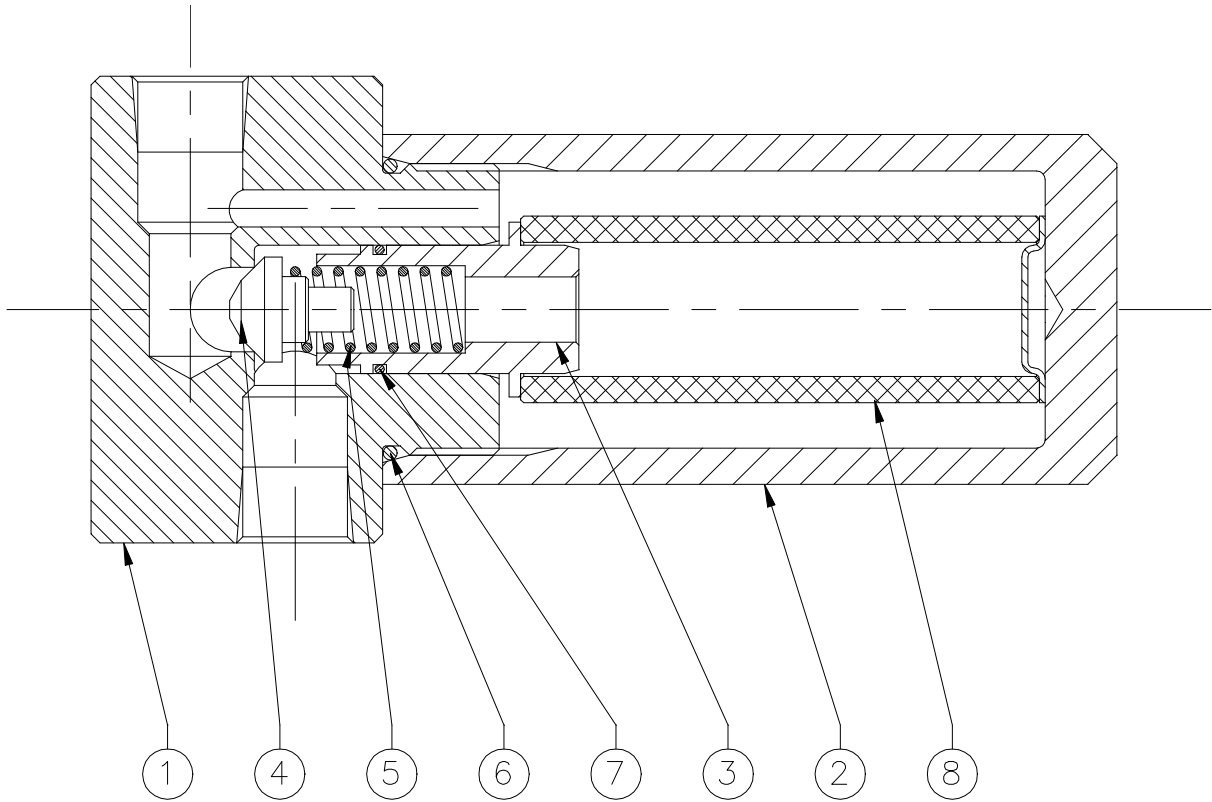
Weight	3.2 kg (7.04 lbs)
Construction and finish	All steel, black oxide
Maximum working pressure	21 MPa (3000 psi)
Design pressure	25 MPa (3600 psi)
Fluid media	Mineral oil
Viscosity range	ISO 32 to 46 (SUS 140-230)
Temperature range	-30°C to +100°C (-22°F to +212°F)
Flow rates	80 l/min (21 usgpm) at 40 micron
Bypass cracking pressure	750 kPa (108 psi)



Warning: Drop system pressure to zero before replacing filter element. Only hand-tighten filter body.

Specifications are subject to change without prior notice due to product improvements.

7.2 PRESSURE FILTER PARTS LIST



Item	Description	Qty	Part no.
1	Filter head	1	FP08-01
2	Filter body	1	FP08-02
3	Standpipe	1	FP08-03
4	Poppet	1	FP08-04
5	Spring	1	FP08-05
6	O-ring (body)	1	FP08-06
7	O-ring (standpipe)	1	FP08-07
8	Filter element 40 micron (standard)	1	FP08-08-40

Specifications are subject to change without prior notice due to product improvements.

8. MOTORS

8.1 M10 TO M66A MOTOR SPECIFICATIONS & DIMENSION TABLE

		INERTIA DRIVE						PRE-ENGAGED
		M10	M16	M22	M28	M38A	M66A	M22-P
	Weight	9.5 kg (20.9 lbs)		11 kg (24.3 lbs)		21.5kg (47.4 lbs)		14.5kg (31.9 lbs)
	Construction	Cast iron (ductile iron)						
	Max. working pressure	21 MPa (3000 psi)						
	Design pressure	25 Mpa (3600 psi)						
	Fluid media	Mineral oil						
	Viscosity range	ISO 32 to 46 (SUS 140-230)						
	Temperature range	-40°C to +100°C (-40°F to +212°F)						
	Speed range	0-4000 rpm				0-3000 rpm		
	Rotation	CW - Standard (CCW - Optional)						
	Duty cycle	Intermittent						
	Overall volumetric efficiency	95% (minimum)						
	Displacement	9.98cc (0.6 cu.in.)	15.59cc (0.95 cu.in.)	22.1 cc (1.35 cu.in.)	28 cc (1.71 cu.in.)	38 cc (2.32 cu.in.)	66 cc (4 cu.in.)	22.1 cc (1.35 cu.in.)
Max. torque at 21 MPa (3000 psi)	30 Nm (22 lbf.ft.)	48 Nm (35 lbf.ft.)	66 Nm (49 lbf.ft.)	84 Nm (62 lbf.ft.)	124 Nm (92 lbf.ft.)	216 Nm (160 lbf.ft.)	66 Nm (49 lbf.ft.)	
Dimensions in mm)	Overall length	A	293mm (11.5")	328.5mm (12.9")		441mm (17.4")		
	Max. motor length	B	225mm (8.9")	260mm (10.2")		328mm (12.9")		
	Motor diameter	C	89.5mm (3.5")	101.5mm (4")		130mm (5.1")		
	Dist. between ports	D	41.3mm (1.63")	47.6mm (1.87")		65mm (2.6")		
	Inlet port	E	3/8" NPT	3/8" NPT		SAE 12		
	Outlet port	F	3/8" NPT	1/2" NPT		SAE 12		
	Flange thickness	G	Depends upon configuration				21mm (0.83")	
	Pinion hsg. Length	H					113mm (4.5")	
	Mounting flange						SAE 3	
	Flange to ring gear (FRG)						50.8mm (2")	

Part numbers:

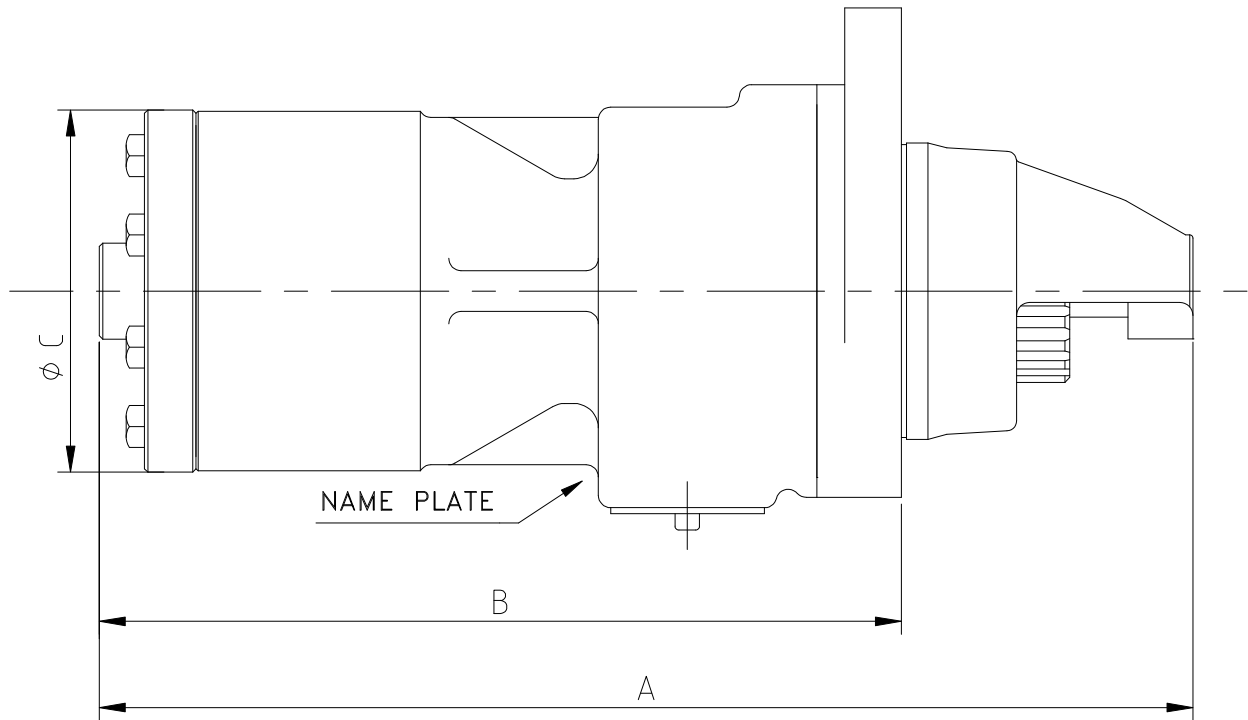
See "STARTER MOTOR ORDERING CODE" on page 12-4

Features:

- Light weight yet aluminium free.
- Rugged, long life construction.
- Reduced internal case pressure.
- Improved seal design.
- Non-sparking, beryllium copper drives and marinised anti-corrosion models available.

Specifications are subject to change without prior notice due to product improvements.

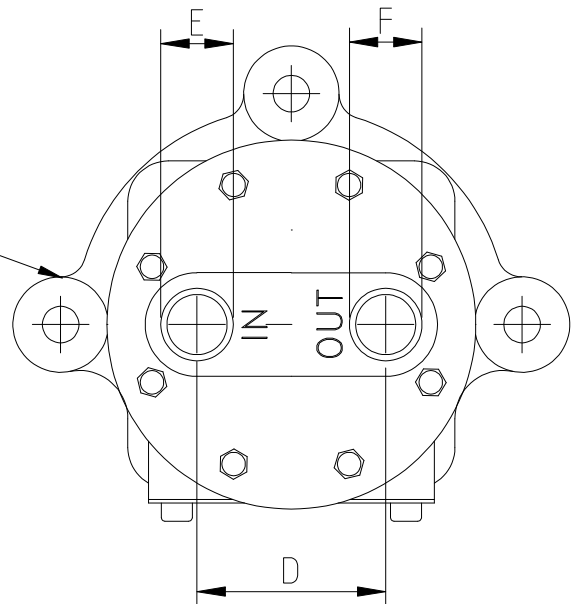
8.2 M10 TO M28 MOTOR DIMENSIONS



FOR MOUNTING DIMENSIONS
REFER TO MODEL TYPE

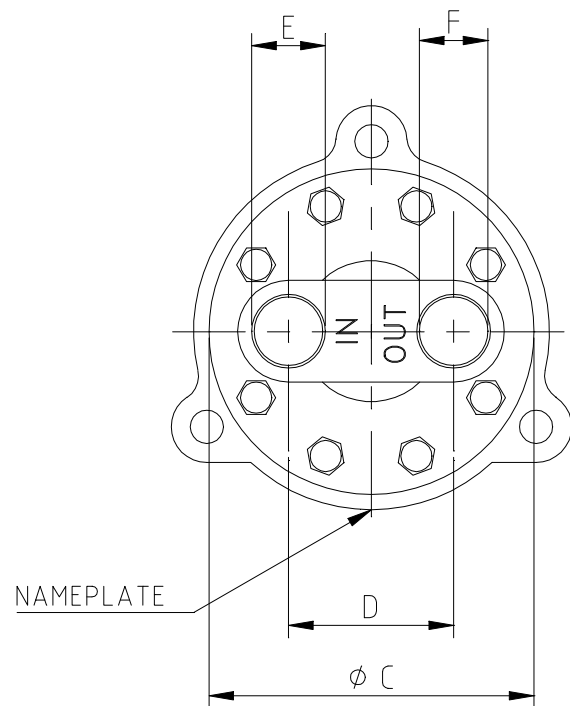
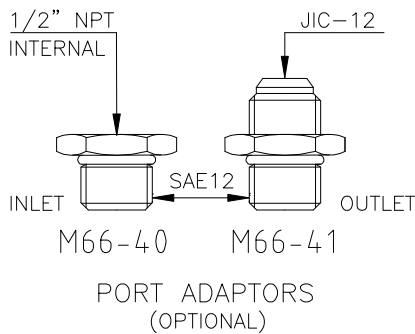
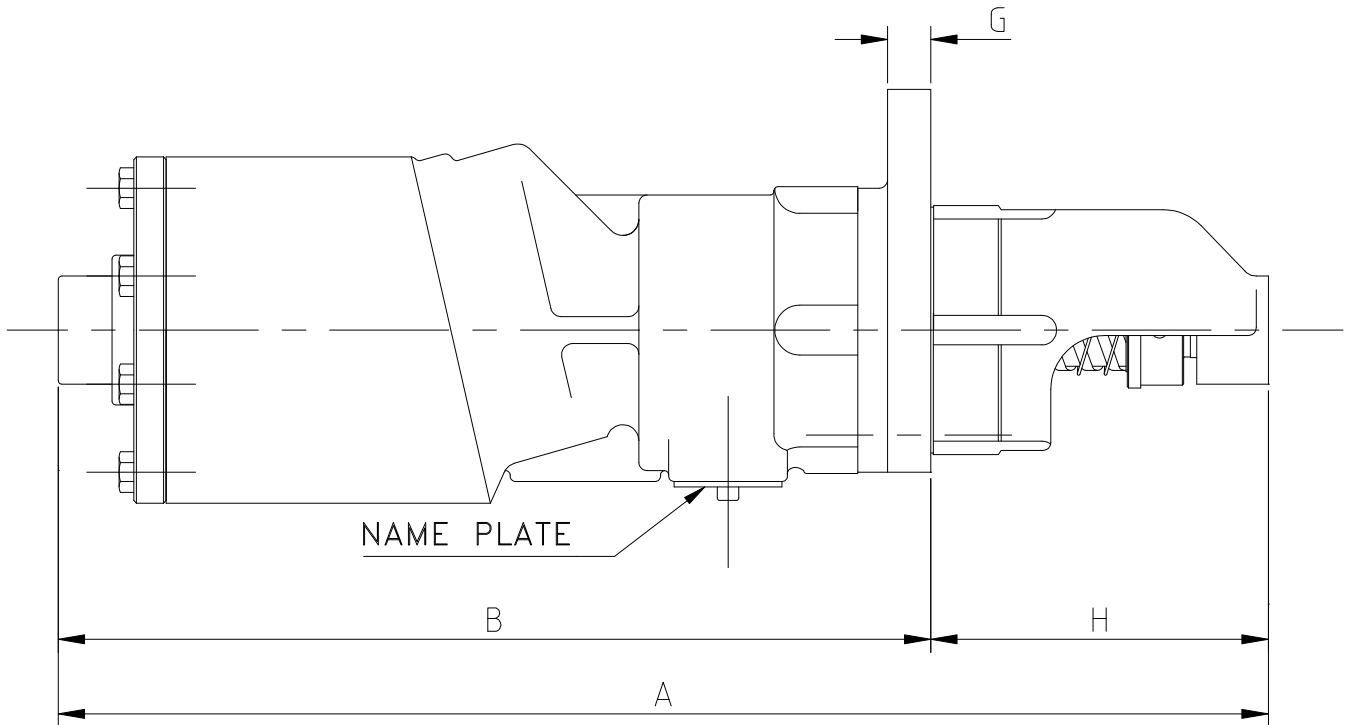
- For clockwise rotation orientate port plate as shown.
- For counter clockwise rotation, orientate port plate 180° and ensure that CCW drive is used.

For model variations see "STARTER MOTOR ORDERING CODE" on page 12-4.



Specifications are subject to change without prior notice due to product improvements.

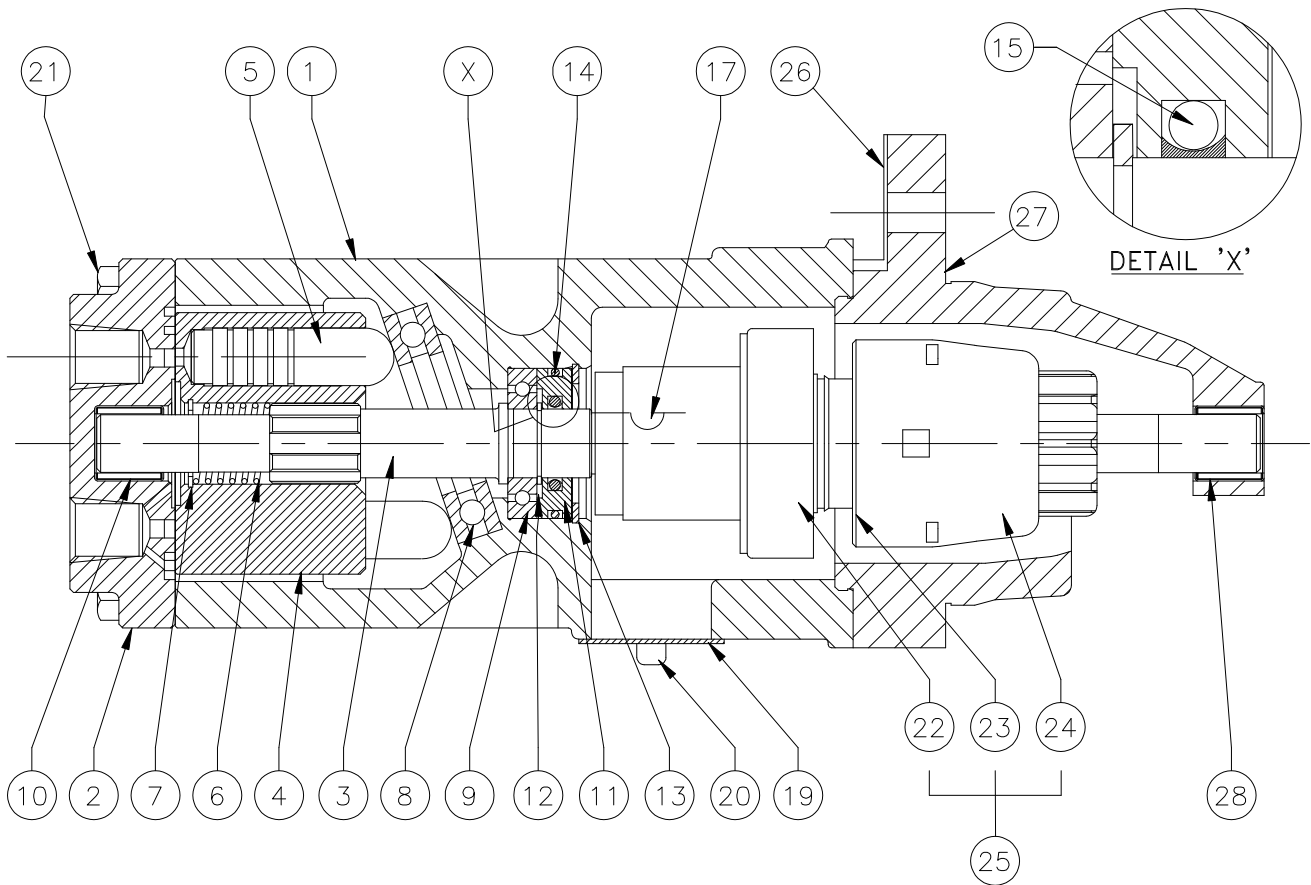
8.3 M38A TO M66A MOTOR DIMENSIONS



- For clockwise rotation orientate port plate as shown.
- For counter clockwise rotation, orientate port plate 180° and ensure that CCW drive is used.
- For model variations see "STARTER MOTOR ORDERING CODE" on page 12-4.
- Please note that port adaptors are sold separately and must therefore be ordered extra

Specifications are subject to change without prior notice due to product improvements.

8.4 M10 AND M16 MOTOR PARTS LIST



Item	Description	Qty	Part no.
1	Motor housing	1	M10-01
2	Port plate	1	M10-02
3	Shaft	1	M10-03
4	Barrel	1	M□□-04
5	Piston	7	M□□-05
6	Spring	1	M10-06
7	Circlip (barrel)	1	M10-07
8	Thrust bearing	1	M10-08
9	Centre bearing	1	M22-09
10	Bearing (port plate)	1	M10-10
11	Seal holder	1	M22-11
12	Circlip (bearing)	1	M22-12
13	Circlip (holder)	1	M22-13
14	O-ring (holder)	1	M22-14

Item	Description	Qty	Part no.
15	Shaft seal assembly	1	M22-15/16
17	Key	1	M22-17
19	Nameplate	1	M22-19
20	Screw	2	M22-20
21	Bolt	8	M10-21
22	Drive (excl. 23 and 24)	1	M10-23
23	Circlip (gear)	1	M22-24
24	Pinion gear	1	M22-25- □
25	Drive assembly	1	M10-B □
26	Pinion housing	1	M22-H□
27	Bolt (pinion housing)	4	M22-28- □
28	Bearing (pinion hsg.)	1	M22-10

Bolt length

1 – 30mm

2 – 40mm

3 – 55mm

Motor size

10 or 16

See ordering code on section 12

Pages 12-5 to 12-8

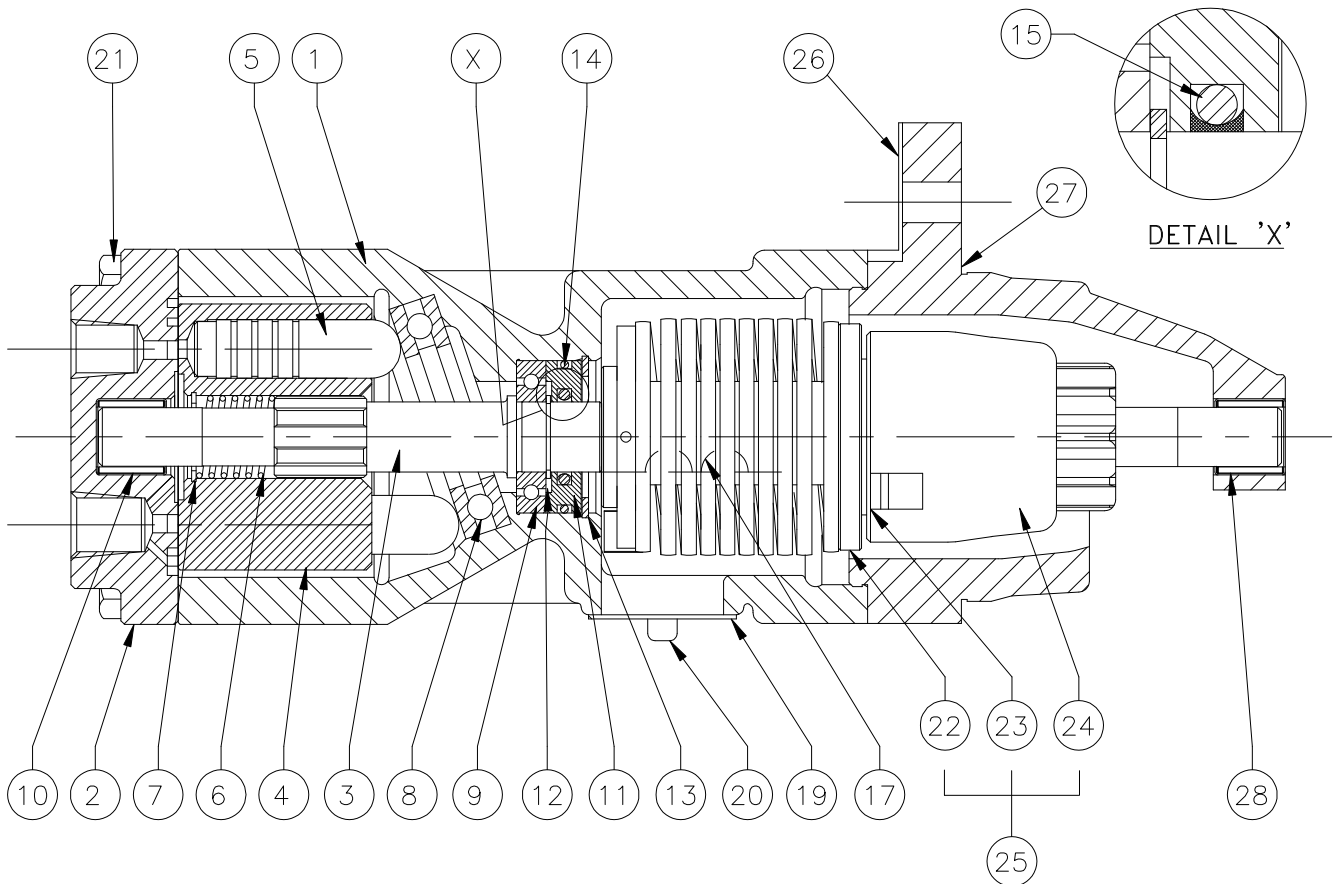
Items 11-17 and 28 included in seal kit M10-SK

Items 9-17 and 28 included in repair kit M10-RK

Items 22-24 comprise drive assembly (item 25)

Specifications are subject to change without prior notice due to product improvements.

8.5 M22 AND M28 MOTOR PARTS LIST



Item	Description	Qty	Part no.
1	Motor housing	1	M22-01
2	Port plate	1	M22-02
3	Shaft	1	M22-03
4	Barrel	1	M□□-04
5	Piston	7	M□□-05
6	Spring	1	M22-06
7	Circlip (barrel)	1	M22-07
8	Thrust bearing	1	M22-08
9	Centre bearing	1	M22-09
10	Bearing (port plate)	1	M22-10
11	Seal holder	1	M22-11
12	Circlip (bearing)	1	M22-12
13	Circlip (holder)	1	M22-13
14	O-ring (holder)	1	M22-14

Item	Description	Qty	Part no.
15	Shaft seal assembly	1	M22-15/16
17	Key	2	M22-17
19	Nameplate	1	M22-19
20	Screw	2	M22-20
21	Bolt (port plate)	8	M22-21
22	Drive (excl. 23 and 24)	1	M22-23
23	Circlip (gear)	1	M22-24
24	Pinion gear	1	M22-25-□
25	Drive assembly	1	M22-B □
26	Pinion housing	1	M22-H □
27	Bolt (not illustrated)	4	M22-28-□
28	Bearing (pinion hsg.)	1	M22-10

Bolt length

- 1 – 30mm
- 2 – 40mm
- 3 – 55mm

Motor size

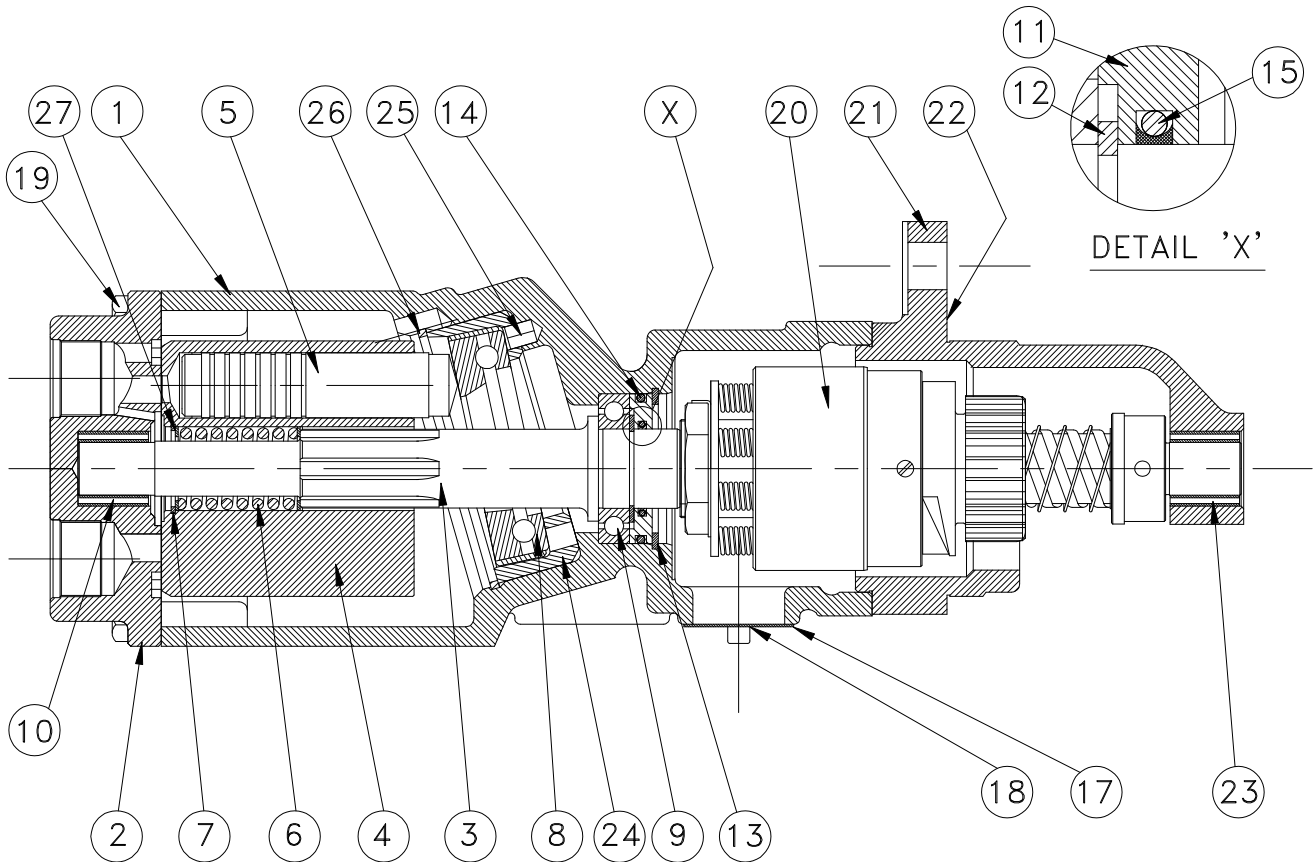
22 or 28

See ordering code on section 12
Pages 12-5 to 12-8

Items 11-17 and 28 included in seal kit M22-SK
Items 9-17 and 28 included in repair kit M22-RK
Items 22-24 comprise drive assembly

Specifications are subject to change without prior notice due to product improvements.

8.6 M38A MOTOR PARTS LIST



Item	Description	Qty	Part no.
1	Motor housing	1	M66-01
2	Port plate	1	M66-02
3	Shaft	1	M38A-03
4	Barrel	1	M66-04
5	Piston	7	M66-05
6	Spring	1	M66-06
7	Circlip (barrel)	1	M66-07
8	Thrust bearing	1	M66-08
9	Centre bearing	1	M66-09
10	Bearing (port plate)	1	M66-10
11	Seal holder	1	M66-11
12	Circlip (bearing)	1	M66-12
13	Circlip (holder)	1	M66-13
14	O-ring (holder)	1	M66-14

Item	Description	Qty	Part no.
15	Shaft seal assembly	1	M66-15/16
17	Nameplate	1	M22-19
18	Screw	2	M22-20
19	Bolt	8	M66-21
20	Drive assembly	1	M38A-B □
21	Pinion housing	1	M38A-H3S
22	Bolt (not illustrated)	6	M66-28
23	Bearing (pinion hsg.)	1	M38A-29
24	Displacement insert	1	M66-30
25	Spring pin	1	M66-31
26	Circlip (insert)	1	M66-32
27	Washer (barrel)	1	M66-33

28	Inlet reducer	1	M66-40
29	Outlet adaptor	1	M66-41

Optional port adaptors not shown

Items 11-15 and 23 included in seal kit M38A-SK

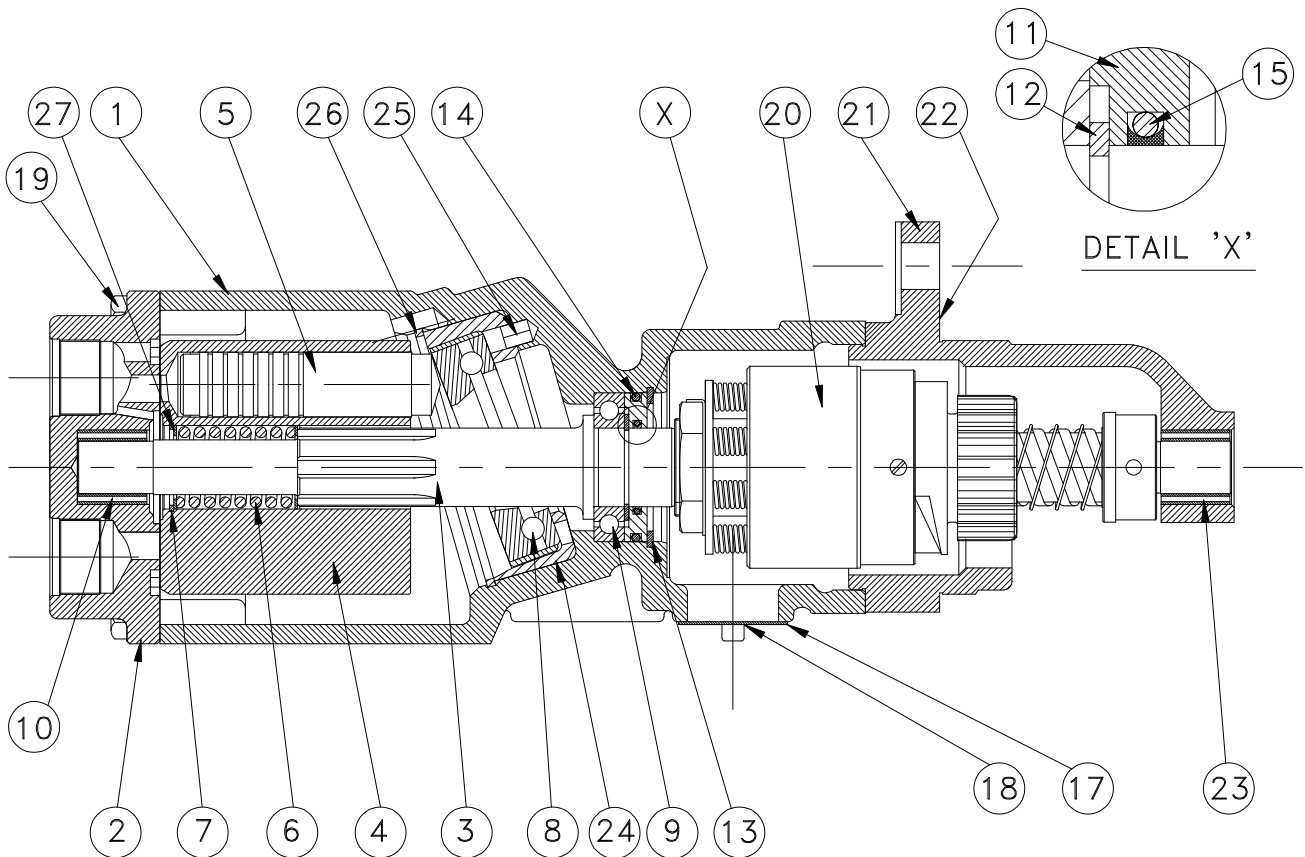
Items 9-15 and 23 included in repair kit M38A-RK

See ordering code on section 12

Page 12-8

Specifications are subject to change without prior notice due to product improvements.

8.7 M66A MOTOR PARTS LIST



Item	Description	Qty	Part no.
1	Motor housing	1	M66-01
2	Port plate	1	M66-02
3	Shaft	1	M38A-03
4	Barrel	1	M66-04
5	Piston	7	M66-05
6	Spring	1	M66-06
7	Circlip (barrel)	1	M66-07
8	Thrust bearing	1	M66-08
9	Centre bearing	1	M66-09
10	Bearing (port plate)	1	M66-10
11	Seal holder	1	M66-11
12	Circlip (bearing)	1	M66-12
13	Circlip (holder)	1	M66-13
14	O-ring (holder)	1	M66-14

Item	Description	Qty	Part no.
15	Shaft seal assembly	1	M66-15/16
17	Nameplate	1	M22-19
18	Screw	2	M22-20
19	Bolt	8	M66-21
20	Drive assembly	1	M38A-B□
21	Pinion housing	1	M38A-H3S
22	Bolt (not illustrated)	6	M66-28
23	Bearing (pinion hsg.)	1	M38A-29
24	Displacement insert	1	M66-30
25	Spring pin	1	M66-31
26	Circlip (insert)	1	M66-32
27	Washer (barrel)	1	M66-33

28	Inlet reducer	1	M66-40
29	Outlet adaptor	1	M66-41

Optional port adaptors not shown

Items 11-15 and 23 included in seal kit M38A-SK

Items 9-15 and 23 included in repair kit M38A-RK

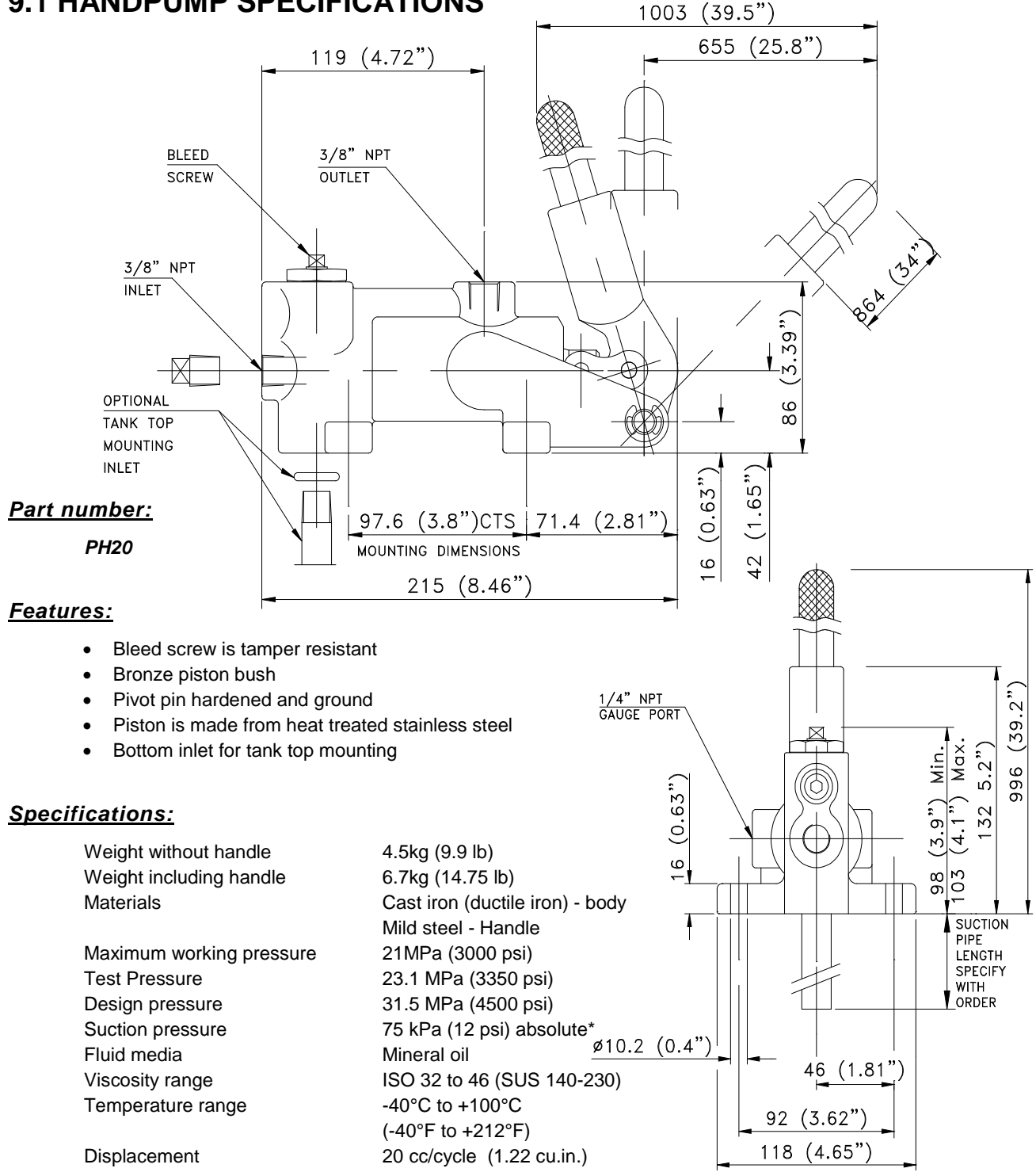
See ordering code on section 12

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Specifications are subject to change without prior notice due to product improvements.

9. HAND OPERATED PUMPS

9.1 HANDPUMP SPECIFICATIONS



Part number:

PH20

Features:

- Bleed screw is tamper resistant
- Bronze piston bush
- Pivot pin hardened and ground
- Piston is made from heat treated stainless steel
- Bottom inlet for tank top mounting

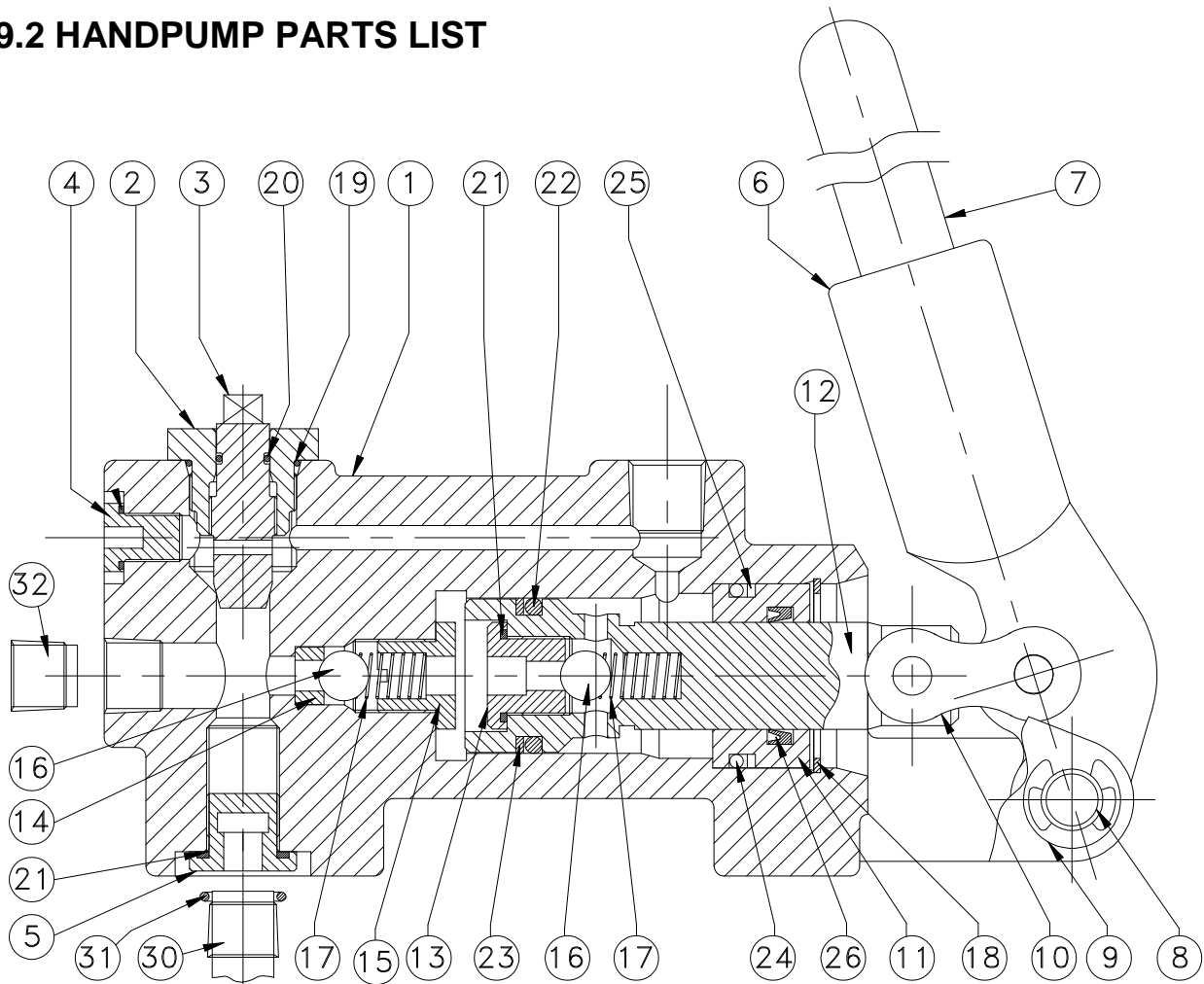
Specifications:

Weight without handle	4.5kg (9.9 lb)
Weight including handle	6.7kg (14.75 lb)
Materials	Cast iron (ductile iron) - body Mild steel - Handle
Maximum working pressure	21MPa (3000 psi)
Test Pressure	23.1 MPa (3350 psi)
Design pressure	31.5 MPa (4500 psi)
Suction pressure	75 kPa (12 psi) absolute*
Fluid media	Mineral oil
Viscosity range	ISO 32 to 46 (SUS 140-230)
Temperature range	-40°C to +100°C (-40°F to +212°F)
Displacement	20 cc/cycle (1.22 cu.in.)
Force on handle	210N (48 lb.) at 21 MPa (3000 psi)
Bypass	Manual

*This equates to the pump operating (priming) 3m (9.8 ft) above oil level at sea level altitude.

Specifications are subject to change without prior notice due to product improvements.

9.2 HANDPUMP PARTS LIST



Item	Description	Qty	Part no.
1	Pump body	1	PH20-01
2	Guide bush	1	PH20-02
3	Bleed screw	1	PH20-03
4	Bleed plug	1	PH20-04
5	Tank top plug	1	PH20-05
6	Pivot lever	1	PH20-06
7	Handle	1	PH20-07
8	Pivot pin	1	PH20-08
9	Circlip	2	PH20-09
10	Connecting link	1	PH20-10
11	Piston bush	1	PH20-11
12	Piston	1	PH20-12
13	Outlet valve seat	1	PH20-13
14	Inlet valve seat	1	PH20-14
15	Inlet spring retainer	1	PH20-15

Item	Description	Qty	Part no.
16	Valve ball	2	PH20-16
17	Valve spring	2	PH20-17
18	Circlip (piston bush)	1	PH20-18
19	O-ring (guide bush)	1	PH20-19
20	O-ring (bleed screw)	1	PH20-20
21	Seal (outlet valve seat)	2	PH20-21
22	O-ring (piston)	1	PH20-22
23	Backup ring (piston)	1	PH20-23
24	O-ring (bush)	1	PH20-24
25	Backup ring (bush)	1	PH20-25
26	U-seal	1	PH20-26
30	Standpipe (optional)	1	PH20-30
31	O-ring (standpipe)	1	PH20-31
32	Plug	1	PH20-32

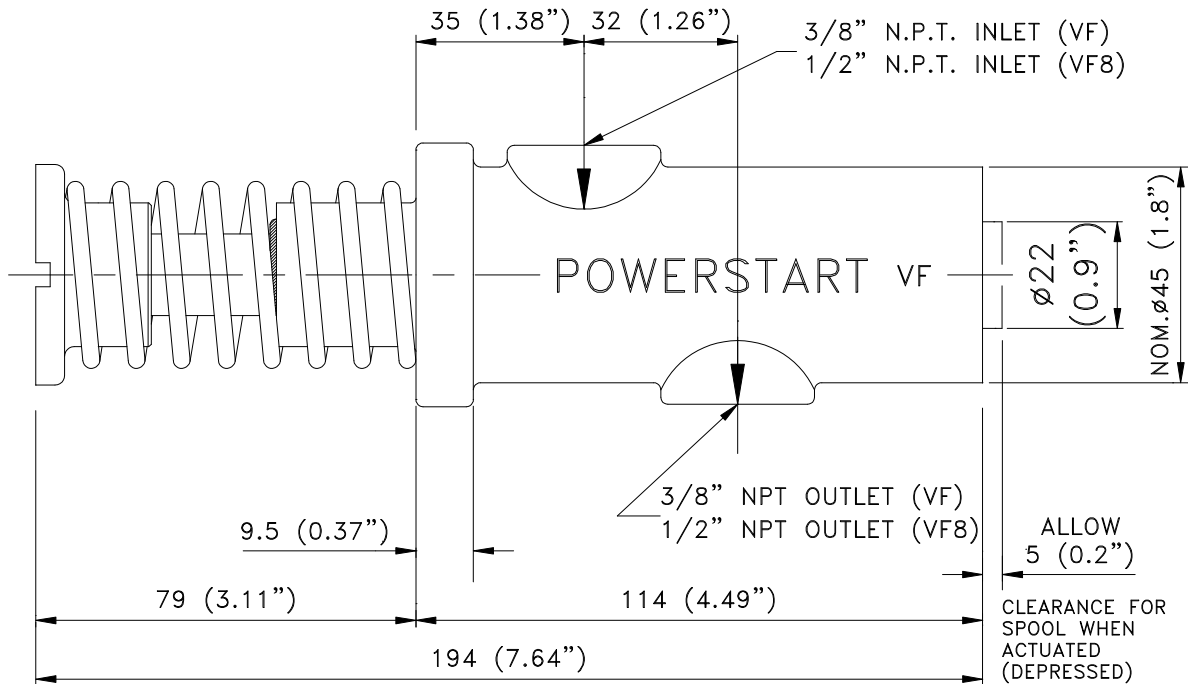
Items 17 to 26 included in seal kit PH20-SK

Items 16 to 26 included in repair kit PH20-RK

Specifications are subject to change without prior notice due to product improvements.

10. STARTING VALVES

10.1 FOOT VALVE SPECIFICATIONS



Part number:

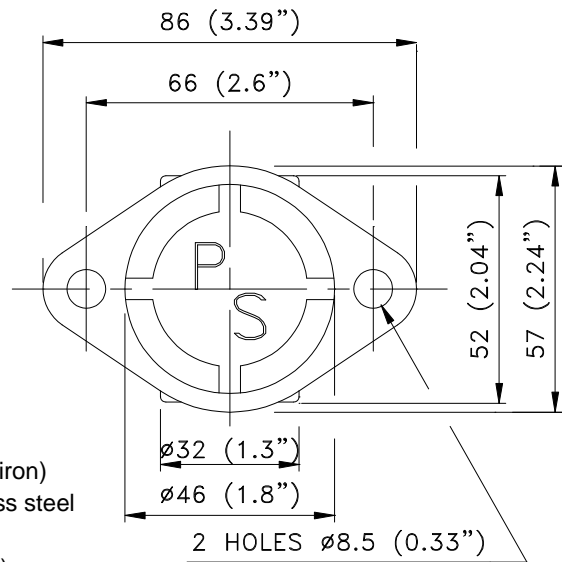
- VF – Foot valve with 3/8" NPT ports
- VF8 – Foot valve with 1/2" NPT ports

Features:

- Top wiper seal to prevent ingress of dirt
- Extended guide bush
- Safety plug gives access to bore of valve spool

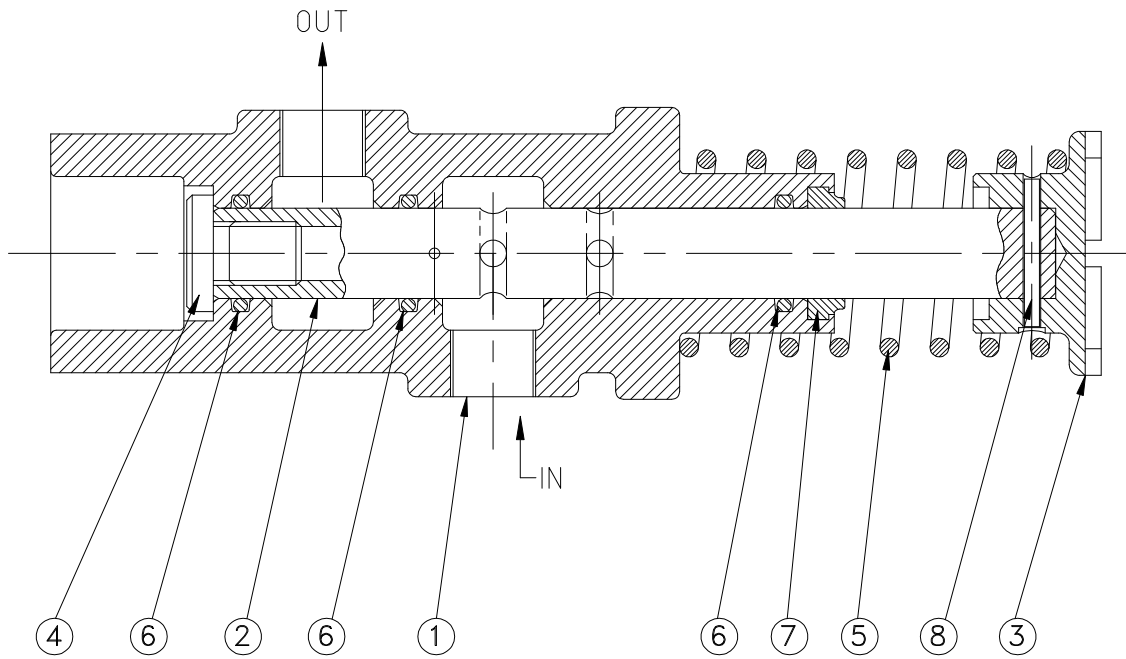
Specifications:

Weight	1.5kg (3.3 lbs)
Body and knob construction	Cast iron (ductile iron)
Spool	Hardened stainless steel
Spring	Cadmium plated
Maximum working pressure	21 MPa (3000 psi)
Design pressure	25 MPa (3600 psi)
Fluid media	Mineral oil
Viscosity range	ISO 32 to 46 (SUS 140-230)
Temperature range	-30°C to +100°C (-22°F to +212°F)
Flow rates (max.)	Model VF (3/8" NPT ports) - 75 l/min (20 usgpm) Model VF8 (1/2" NPT ports) - 120 l/min (31 usgpm)
Force to open	270N (60 lbf.) at 21 MPa (3000 psi)



Specifications are subject to change without prior notice due to product improvements.

10.2 FOOTVALVE PARTS LIST



Item	Description	Qty	Part no.
1	Valve body	1	VF-01
2	Valve spool	1	VF-02
3	Knob	1	VF-03
4	Plug	1	VF-04
5	Spring	1	VF-05
6	O-ring	3	VF-06
7	Wiper seal	1	VF-07
8	Lock pin	1	VF-08

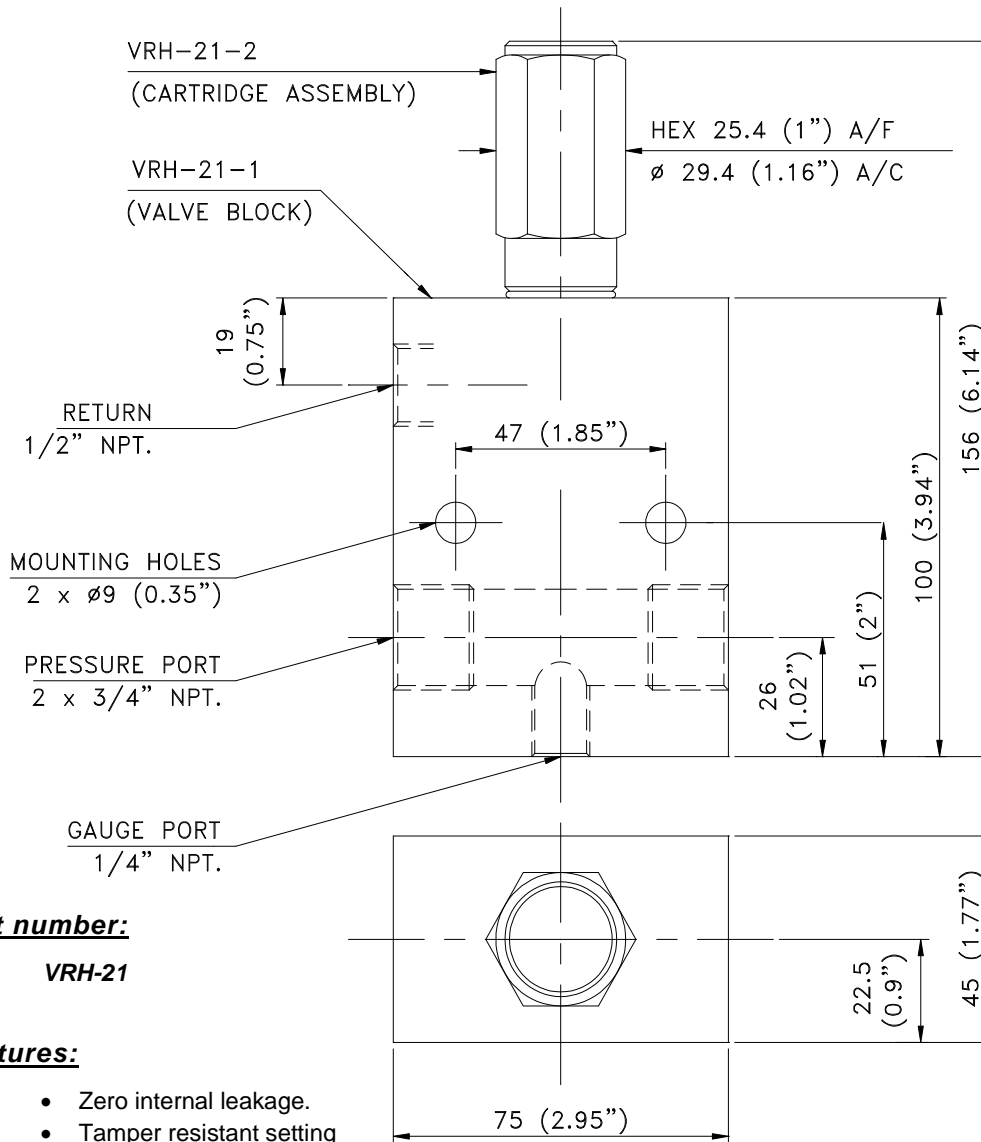
Items 6, 7 and 8 included in repair kit VF-RK

Items 6 and 7 included in seal kit VF-SK

Specifications are subject to change without prior notice due to product improvements.

11. PRESSURE CONTROL VALVES

11.1 RELIEF VALVE SPECIFICATIONS

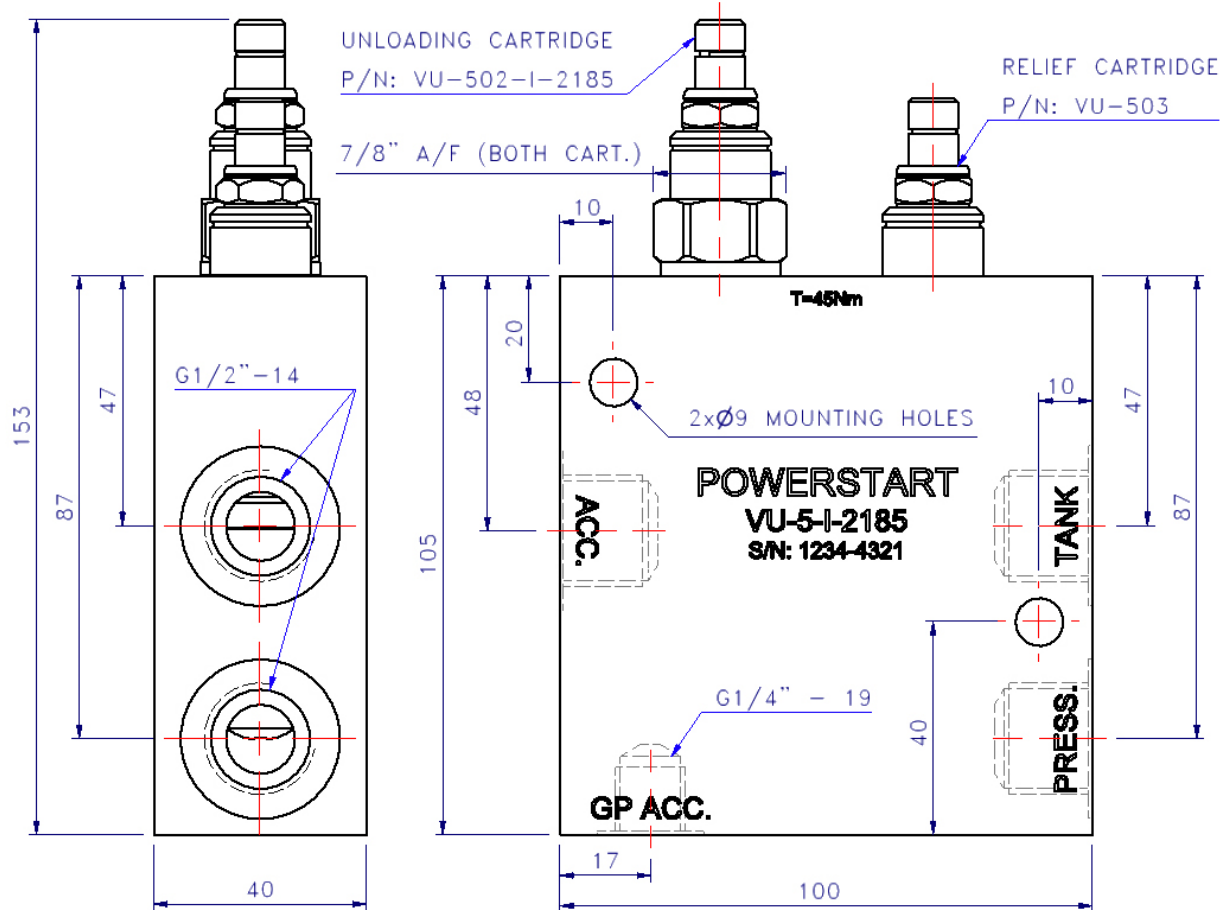


Specifications:

Weight	2.4 kg (5.3 lbs)
Construction	All steel
Maximum working pressure	23MPa (3300 psi) factory preset Other settings available on request
Design pressure	25 MPa (3600 psi)
Fluid media	Mineral oil
Viscosity range	ISO 32 to 46 (SUS 140-230)
Temperature range	-30°C to +100°C (-22°F to +212°F)

Specifications are subject to change without prior notice due to product improvements.

11.2 CARTRIDGE UNLOADING VALVE (60 LPM) - Fully sealed with integral relief



Part number:

VU-5-I-2185

Features:

- Replaceable unloading and relief cartridges without removing block
- Gauge port for accumulator pressure
- Available in stainless steel as an option
- Integral relief valve

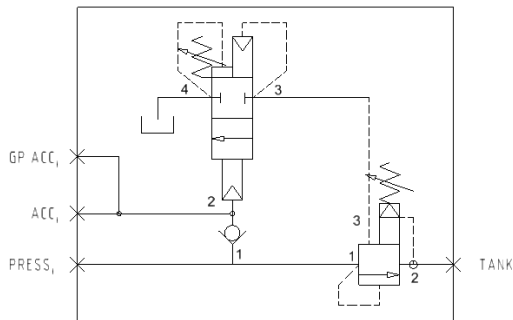
Specifications:

Weight	3.0 kg (6.6 lbs)
Construction	All steel cadmium plated
Maximum working pressure	23MPa (3400 psi)
Design pressure	35 MPa (5000 psi)
Unloading pressure	21 MPa (3000 psi)
Relief pressure	23 MPa (3300 psi)

Specifications are subject to change without prior notice due to product improvements.

Rated Flow	60 litres/min (16 US GPM)
Fluid media	Mineral oil
Viscosity range	5 to 500 cSt
Temperature range	-20°C to +90°C (-4°F to +194°F)
Pressure differential	15%
Seals	Nitrile

Schematic diagram

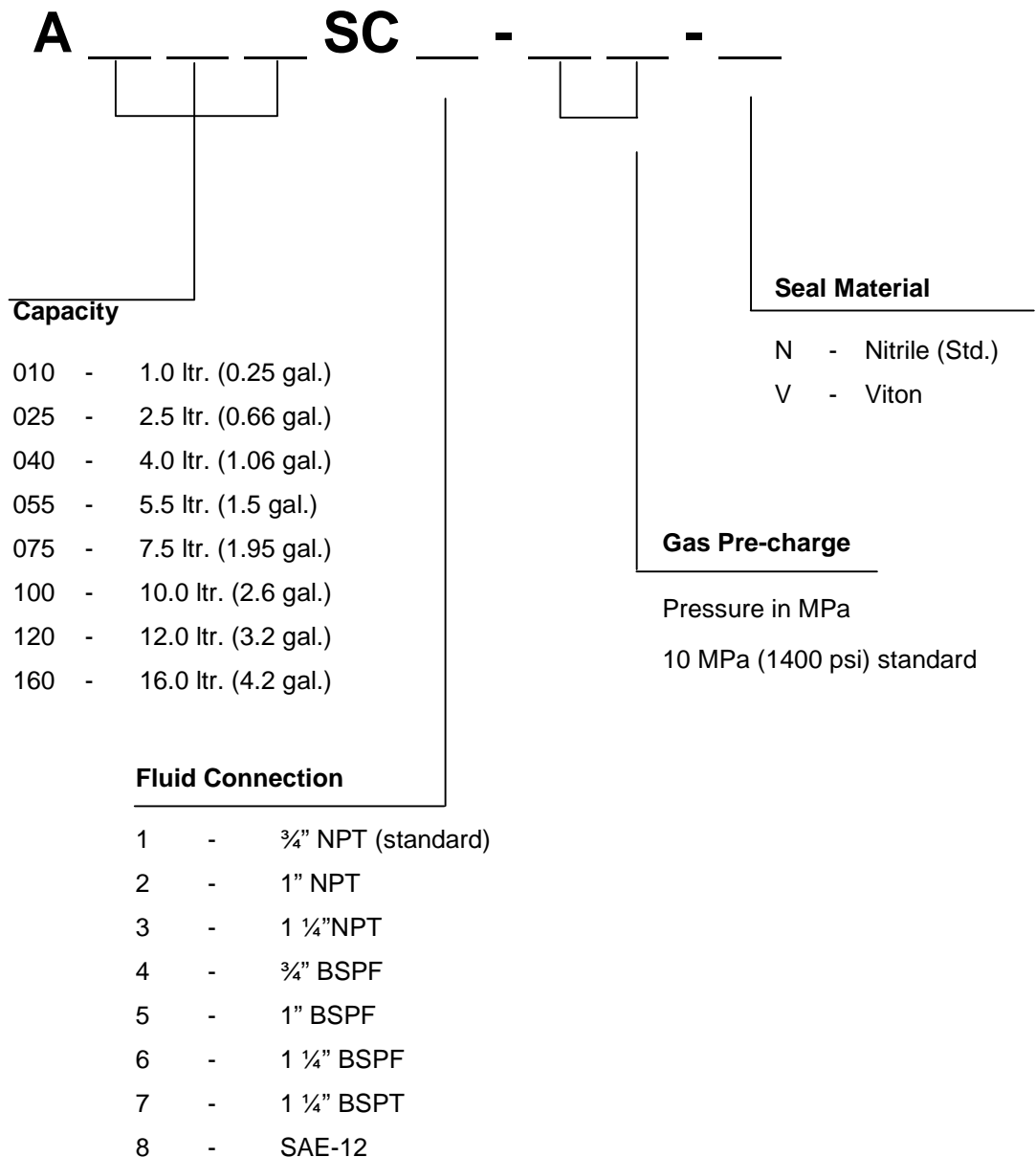


Specifications are subject to change without prior notice due to product improvements.

12. ACCUMULATOR, MOTOR AND SYSTEM ORDER CODES

12.1 ACCUMULATOR ORDERING CODE

Accumulator Model:



Note: Fluid connection, gas pre-charge and seal material may be left out of part number for standard configurations.

Specifications are subject to change without prior notice due to product improvements.

12.2 STARTER MOTOR ORDERING CODE

Starter model: **M** _____ - _____

Displacement

- 10 - 10cc (0.6 cu.in)
- 16 - 16cc (0.95 cu.in.)
- 22 - 22cc (1.35 cu.in.)
- 28 - 28cc (1.7 cu.in.)
- 38 - 38cc (2.32 cu.in.)
- 66 - 66cc (4.0 cu.in.)

Drive Type

- D - Inertia
- P - Pre-engaged

Pinion Gear

Refer to "PINION GEAR DETAILS AND DIMENSIONS" on page 12-8 for code

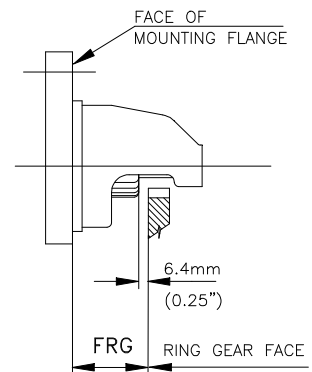
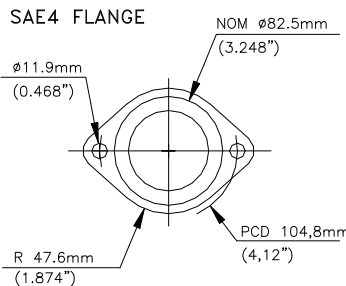
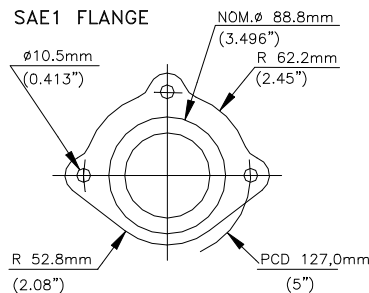
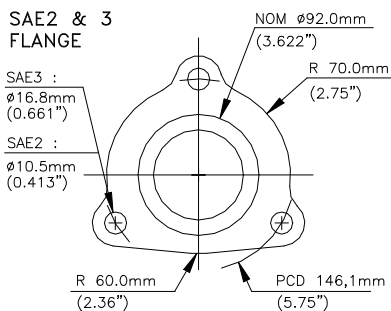
Flange Type

- 1 - SAE 1
- 2 - SAE 2
- 3 - SAE 3
- 4 - SAE 4

Numerous specials are available from Powerstart

FRG (Flange to ring gear)

Refer to "FLANGE DETAILS" on page 12-6 for code



Specifications are subject to change without prior notice due to product improvements.

12.3 PINION HOUSING ORDERING CODE

Pinion Housing	Nosecone	Flange	Spacer	FRG in mm	See assy instr.	Remarks
M22-H18	(M22-N2)	(M22-F1)	(M22-S1)	31		Available as one piece casting
M22-H1S	(M22-N2)	(M22-F1)		51		Available as one piece casting
M22-H37	M22-N2	M22-F3		55	Yes	
M22-H3S	M22-N1	M22-F3		51		For M22-25-1 and 2
M22-H3S	M22-N2	M22-F3		51		For smaller pinions
M22-H44	M22-N3	M22-F4		25		
M22-H46	M22-N3	M22-F4		23	Yes	
M22-H48	M22-N3	M22-F4		31.5		
M22-HA4	M22-N2	M22-FA	M22-S1&6	25		
M22-HAS	M22-N2	M22-FA		51	Yes	
M22-HAS3	M22-N2	M22-FA		51	Yes	
M22-HAS4	M22-N2	M22-FA		51	Yes	
M22-HBS	M22-N3	M22-FB		51		
M22-HC1	M22-N2	M22-FC	M22-S3	29		
M22-HC4	M22-N2	M22-FC	M22-S1	25		
M22-HD3	M22-N2	M22-FD	M22-S2	31		
M22-HDS	M22-N2	M22-FD		51		
M22-HF4	M22-N2	M22-FF	M22-S1	25		
M22-HF9	M22-N3	M22-FF		45		
M22-HG4	M22-N3	M22-FG		25	Yes	
M22-HG6	M22-N3	M22-FG		23	Yes	
M22-HGA	M22-N2	M22-FG		13	Yes	
M22-HJ9	M22-N3	M22-FJ		45		
M22-HK4	M22-N3	M22-FK		25		
M22-HL1	M22-N3	M22-FL		29	Yes	
M22-HM1	M22-N3	M22-FM		29	Yes	
M22-HNB	M22-N2	M22-FN		36		
M22-HP9	M22-N3	M22-FP	M22-S6	45		
M22-HQS	M22-N2	M22-FQ		51		
M22-HRC	M22-N2	M22-FR		19		
M22-HS6	M22-N3	M22-FS		21		Toyota forklift
M22-HT6	M22-N3XLD	M22-FT		23		Mitsubishi S4S

Specifications are subject to change without prior notice due to product improvements.

12.4 FLANGE DETAILS

Mounting Flange	No. of Holes	Dia. Of Holes	Angle Bet. Holes	PCD of Holes	Spigot Dia.	Remarks	Width
M22-F1	3	10.5	90°	127	89	SAE 1, 3 Holes, at 90°	16
M22-F2	3	10.5	120°	146	92	SAE 2	16
M22-F3	3	16.8	120°	146	92	SAE 3	16
M22-F4	2	12	180°	105	82.5	SAE 4	43
M22-F6	2	slots		138	103.5	Special Ford application	10
M22-FA	3	10.5	90°	127	89	SAE 1 Offset 22° CCW	16
M22-FB	3	16.8	120°	146	92	SAE 3 Offset 3.3mm	16
M22-FC	3	12	90°	146	92	SAE 1 on SAE 3 PCD	23
M22-FD	3	10.5	90°	127	89	SAE 1 Offset 22° CW	16
M22-FE	2	12	180°	105	82.5	Special stepped flange for Kubota	10
M22-FF	3	15	90°	146	115	M22-FC with dia. 115 Spigot	23
M22-FG	2	13	180°	120	95	F4 Type with dia. 95 spigot on 120 PCD	10
M22-FJ	3	16.5	90°	144	92	FC Type with 144 PCD	23
M22-FL	2	12	180°	105	82.5	SAE4 with profiled bottom edge	10
M22-FM	2	M10	180°	127	89	F4 Type with dia. 89 spigot on 127 PCD	10
M22-FN	2	15	180°	153	105	F4 Type with dia. 105 spigot on 153 PCD	10
M22-FO	3	10.5	90°	127	89	SAE1 Type with 3.3mm and 23° offset	16
M22-FP	3	13	N/A	140	105	Special	16
M22-FQ	3	10.5	90°	127	89	SAE 1 Offset 3.3mm and 23°	16
M22-FR	3	10.5	90°	127	100	SAE 1 Offset 3.3mm and 13° with 100 spgt	10
M22-FS	2	13	180°	113 cntrs	89	2 Hole flange 10mm offset dia. 90 spigot	12
M22-FT	2	13	180°	115	82.5	SAE4 Type with dia. 82.5 spigot	10
M22-FU	3	12	90°	127	89	SAE 1 Offset 3.3mm	16
M22-FV	2	13	180°	120	95	2 Hole flange 2mm Offset	10
M22-FW	2	13	180°	99.7 cntrs	82.5	2 Hole flange offset 13.4mm	10
M22-FX	3	10.5	90°	146	110	SAE 1 Type	16
M22-FY	2	10.5	180°	115	82.5	Similar to M22-FT but with 10.5mm holes	10
M22-FZ	3	10.5	90°	127	89	SAE 1 Type with offset	16

All dimensions above are in mm

Specifications are subject to change without prior notice due to product improvements.

12.5 NOSECONE, SPACER AND FRG DETAILS

Spacer Details

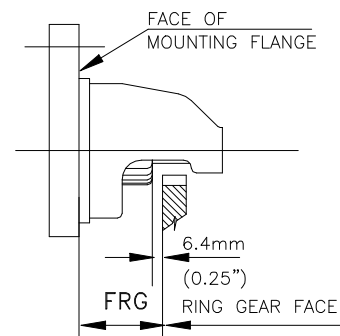
Spacer	Width in mm	Colour
M22-S0	as cast	Red oxide
M22-S1	18.5	Orange
M22-S2	21.0	White
M22-S3	14.5	Yellow
M22-S4	13.0	Grey
M22-S5	9.0	Blue
M22-S6	6.0	Green

Nosecone Details

Nose Cone	Outside dia. in mm
M22-N1	85.6
M22-N2	85.6
M22-N3	78
M22-N4	78.0 Offset 1.7mm

Flange to Ring Gear Code Table

FRG Code	Distance in mm	Distance in inches
S	50.8	2.00
1	29.0	1.14
4	25.5	1.00
5	42.0	1.65
6	23.0	0.91
7	55.0	2.17
8	31.5	1.24
9	45.0	1.77
A	13.0	0.51
C	19.0	0.75
D	16.0	0.63
E	74.0	2.91
F	38.1	1.50
G	68.0	2.68
H	34.0	1.34



Specifications are subject to change without prior notice due to product improvements.

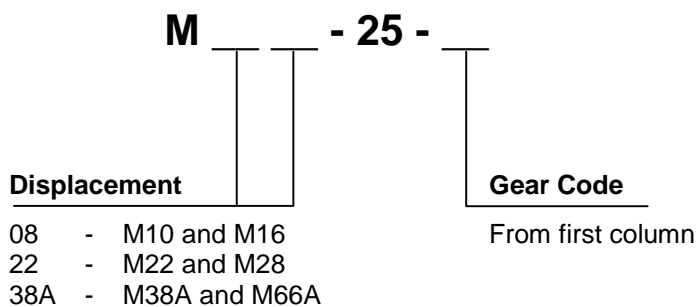
12.6 PINION GEAR DETAILS AND DIMENSIONS

Gear Code	Teeth	D/P Mod	Press Angle	OD	PCD	Root Dia.	Over 2 Teeth	Correction	Remarks
1	11	6/8	20	57.1	46.6	43.6	20.6	+1 Tooth	
2	12	8/10	20	46.4	38.1	35.5	15.6	+1 Tooth	
3	10	8/10	20	40.0	31.8	29.2	15.5	+1 Tooth	
4	11	3	15	41.1	33.0	28.1	14.3	+2/3 Mod	
5	9	3	15	34.5	27.0	21.5	14.1	+0.5 Mod	
6	13	8/10	20	46.4	41.3	35.0	14.6	Std.	
7	12	6/8	20	57.1	50.8	43.5	19.4	Std.	
8	11	8/10	20	44.0	34.9	31.2	15.6	+1.5 Add.	
9	9	2.75	15	33.0	24.8	21.3	13.3	+1 Mod.	PRQ 5-26183
A	15	10	20	44.4	38.1	33.3	12.1	+0.5 Tooth	
B	11	3	15	41.9	33.0	29.1	14.5	+1 Tooth	Mitsubishi (Premier)
C	14	10/12	20	41.9	35.6	32.8	12.5	+1 Tooth	
D	10	3	15	38.1	30.0	25.1	14.3	+2/3 Mod.	MAN (Gali) PRQ 5-26057
E	10	10/12	20	32.2	25.4	20.9	12.4	+1 Tooth	
F	20	10/12	20	58.1	50.8	46.8	13.0	+1.5 Add.	Volvo 2040 (Matla)
G	9	2.5	15	30.0	22.5	20.0	12.1	+1 Tooth	Kubota EB300
H	13	3	20	47.0	39.0	34.0	14.5	1.5 Add.	Iveco 8281sr110
J	12	7	20	54.5	43.5	39.2	17.8	+1 Tooth	MTU 8v396t833
K	9	8/10	20	36.8	28.6	25.8	15.5	+1 Tooth	
L	11	8/10	20	40.0	35.0	28.6	14.5	Std.	Lister PH1&2
M	10	12/14	20	26.9	21.2	18.7	10.0	+1 Tooth	
N	11	10/12	20	34.7	28.0	25.2	12.7	+1 Tooth	PRQ 5-26176
P	11	2.5	15	35.0	27.5	23.8	12.0	+1 Mod.	Deutz 1011 PRQ 5-26184
R	9	3	20	36.0	27.0	23.6	14.9	+1 Tooth	
S	15	4	15	70.6	60.0	52.6	19.2	+2/3 Mod.	
T	13	10/12	20	39.8	33.0	30.6	12.5		Yanmar. PRQ 6-4081193
U	13	10/12	20	38.7	36.1	29.4	12.4		
V	11	3	15	40.0	33.0	26.4	14.1	+1mm	Toyota 2ZII
W	9	3	20	35.0	27.0	22.5	14.7	+1 Tooth	Iveco 8041
X	11	3.5	15	48.2	38.5	32.5	16.9		Mitsubishi S6R
Y	13	3.5	15	56.4	45.5	41.0	17.3	2.1 mm Add.	
Z	10	12/14		27.9	21.2	19.6			
AZ	13	3	15	48.4	42.4	34.9	23.9 (3T)		MWM Engine
BZ	11	8	20	40.5	34.9	28.5	14.5	-0.04mm Add.	PRQ 6-4081157
CZ	15.0	3.5	15.0	61.9	54.9	46.7		+0.7 Tooth	
DZ	9	12/14	12	25.8	19.1	17.8	10.5	+0.5 Tooth	Special ford
EZ	13	3.5	15	57.8	45.5	42.4	17.4	+1.5 Tooth	
FZ	9	10/12	20	29.6	22.9	20.3	12.4	+1 Tooth	PRQ 5-26179

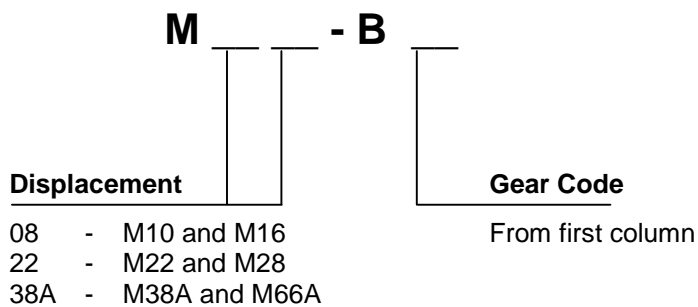
Specifications are subject to change without prior notice due to product improvements.

12.7 PINION GEAR AND DRIVE ORDERING CODES

Pinion Gear Ordering Code

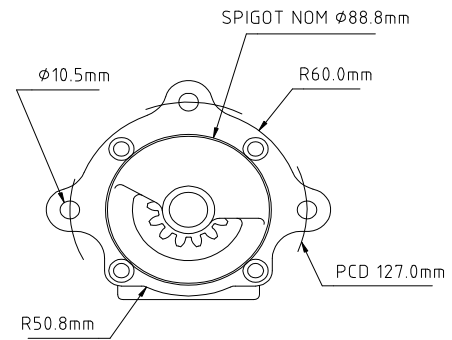
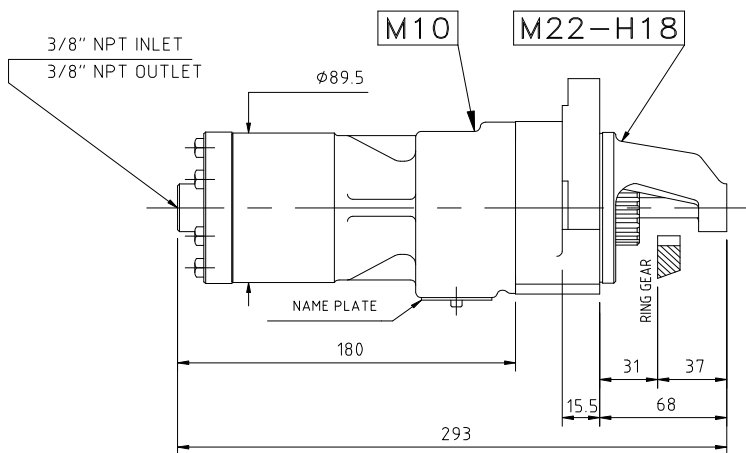


Starter Drive Ordering Code

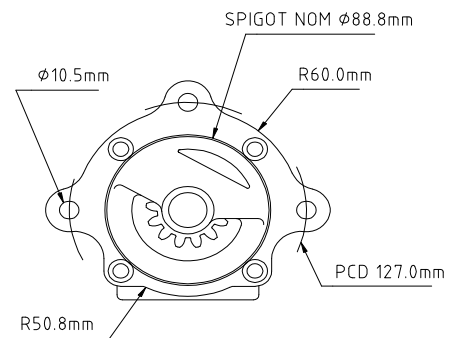
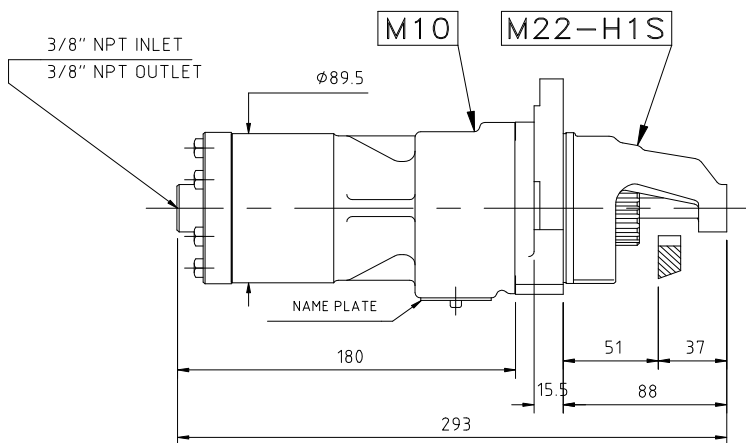


Specifications are subject to change without prior notice due to product improvements.

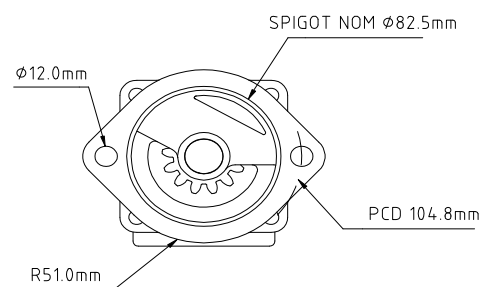
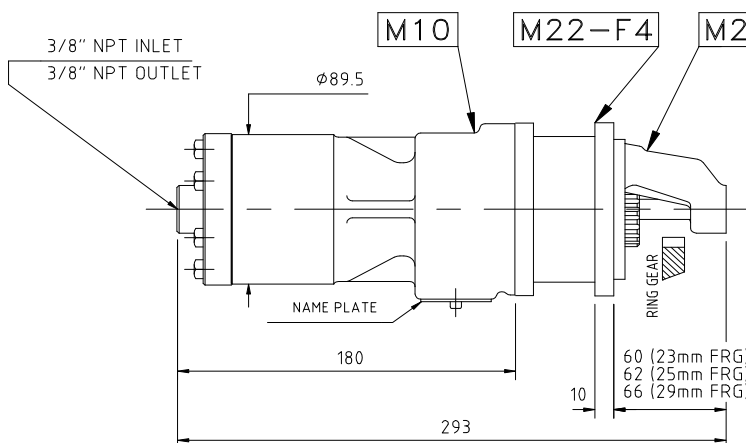
12.8 M10 PRODUCT RANGE



M10-D_18 for FRG 31mm



M10-D_1S for FRG 51mm

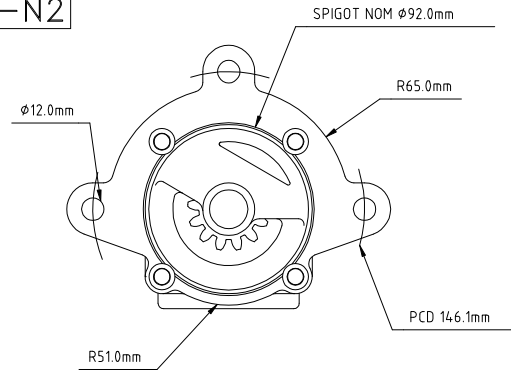
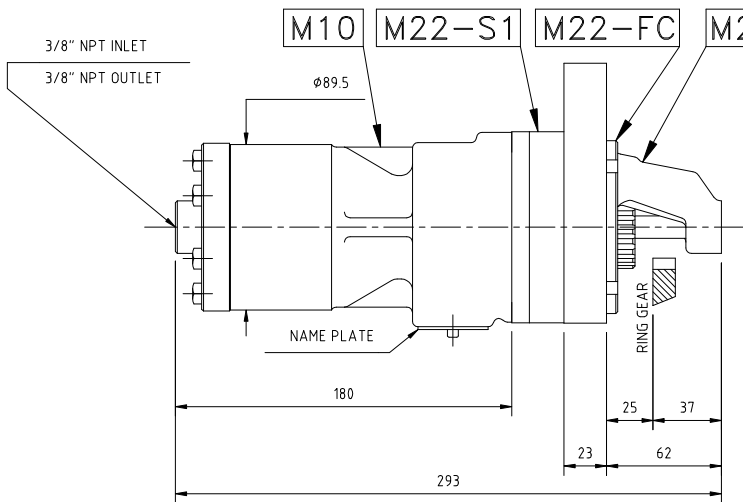


M10-D_46 for FRG 23mm

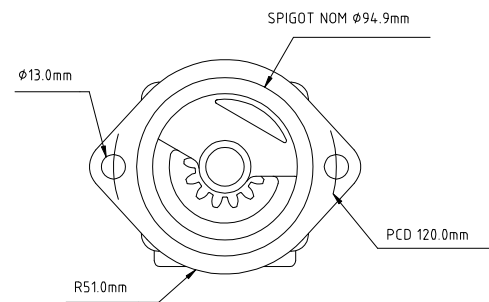
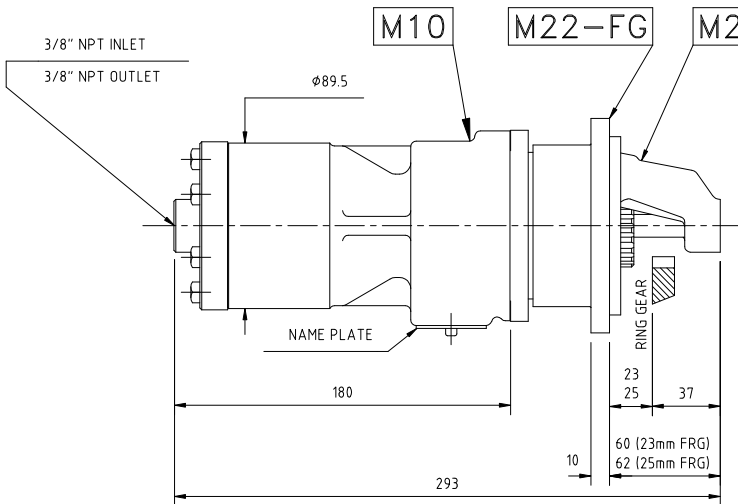
M10-D_44 for FRG 25mm

M10-D_41 for FRG 29mm

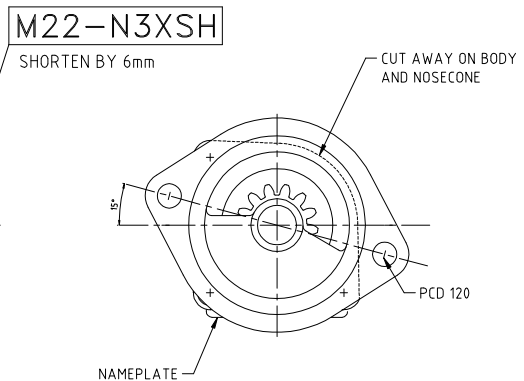
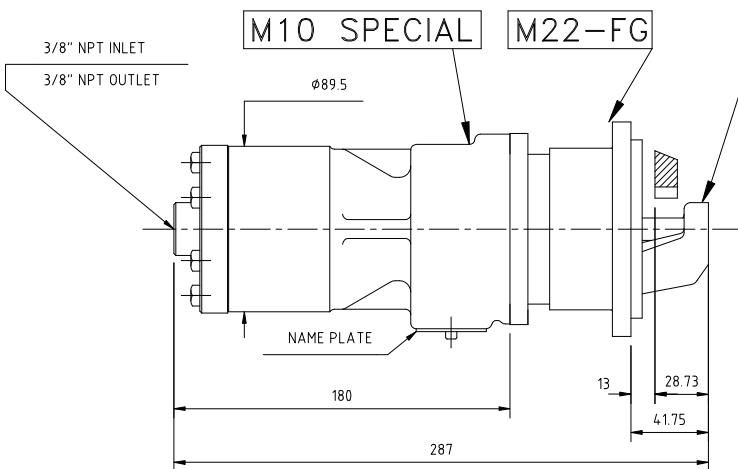
Specifications are subject to change without prior notice due to product improvements.



M10-D_C4 for FRG 25mm

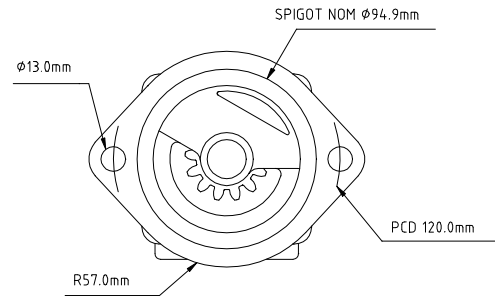
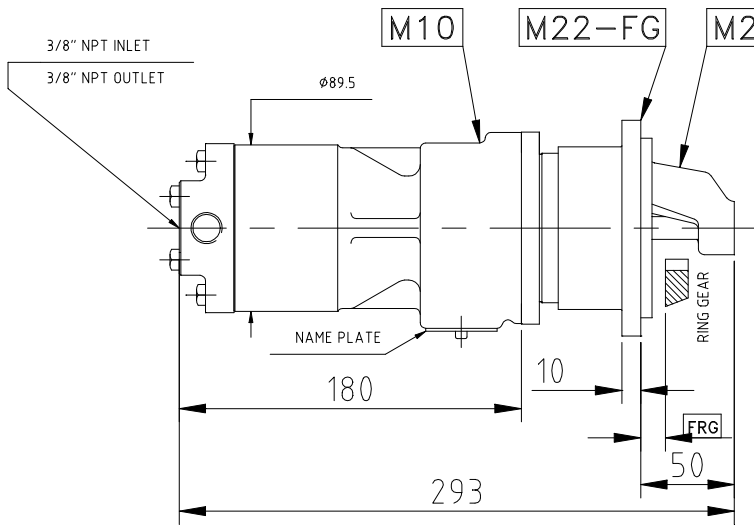


M10-D_G4 for FRG 25mm
M10-D_G6 for FRG 23mm

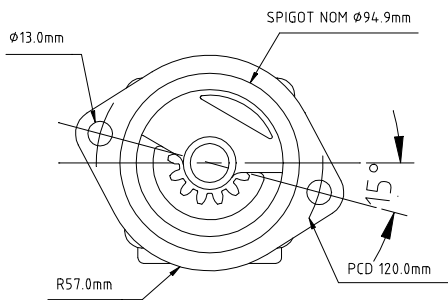


M10-D_GAXS for FRG 13mm

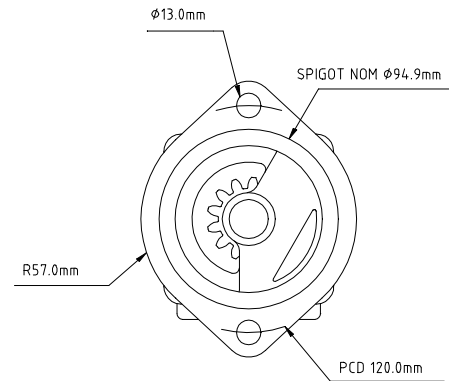
Specifications are subject to change without prior notice due to product improvements.



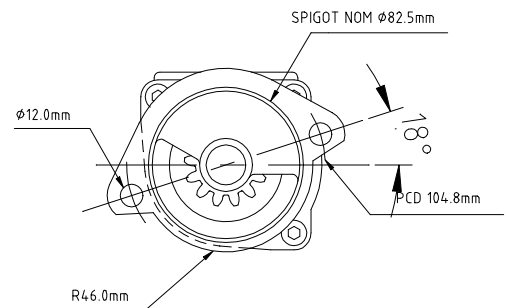
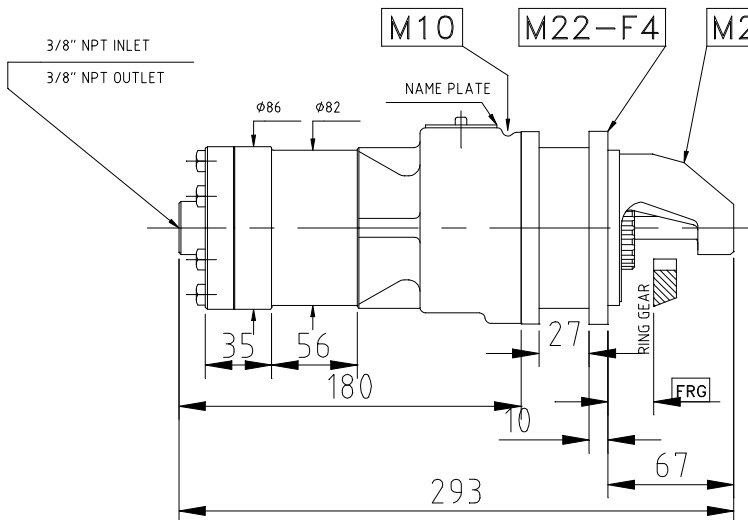
M10-D_GAXSE
for FRG 13mm



M10-D9GA2XSE
for FRG 13mm

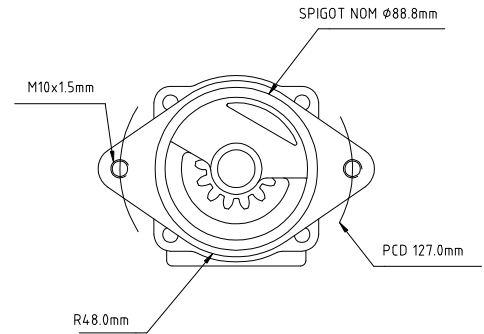
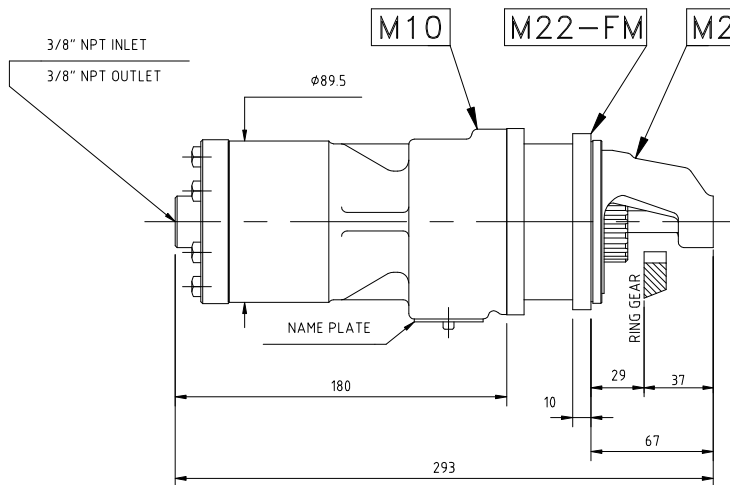


M10-D9GA3
for FRG 13mm

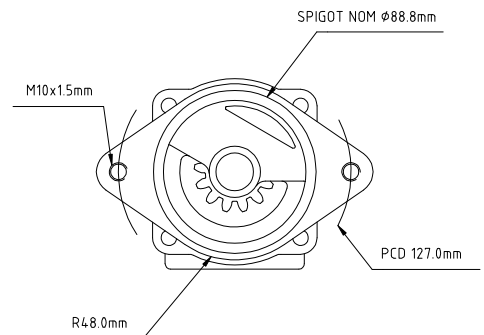
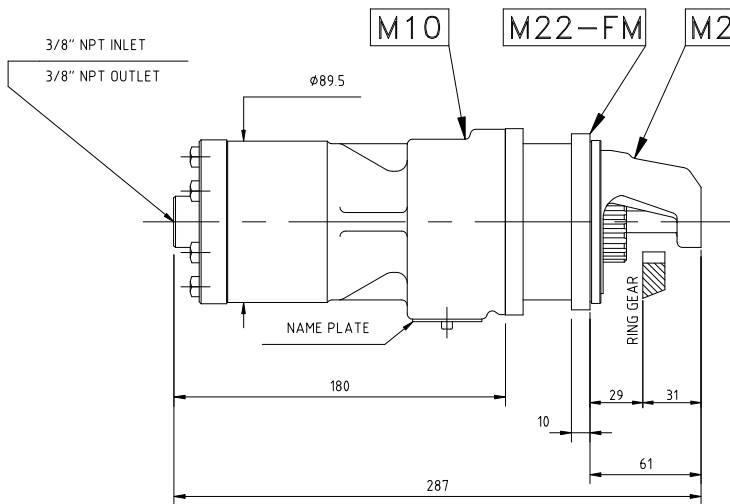


M10-D5L1
for FRG 29mm

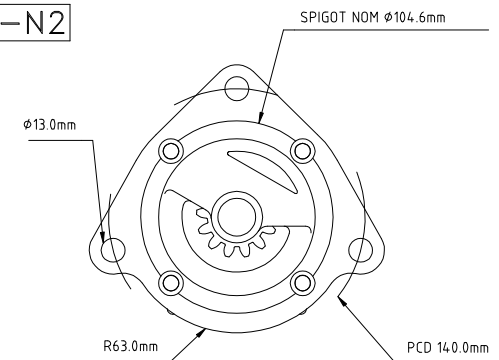
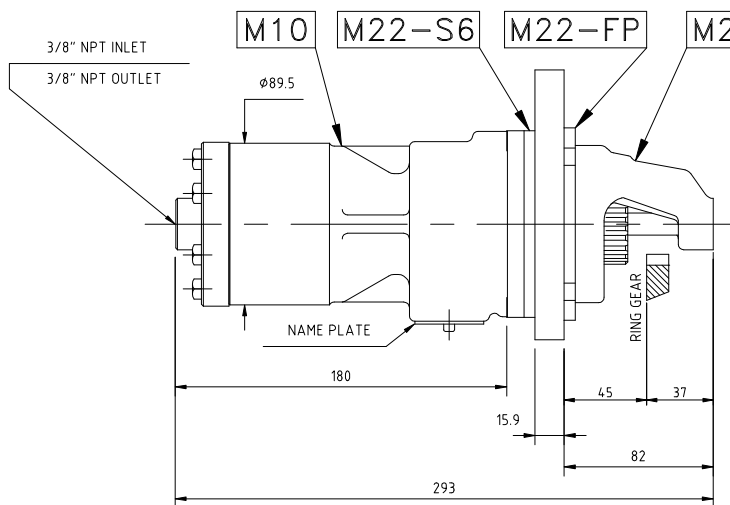
Specifications are subject to change without prior notice due to product improvements.



M10-D_M1
for FRG 29mm

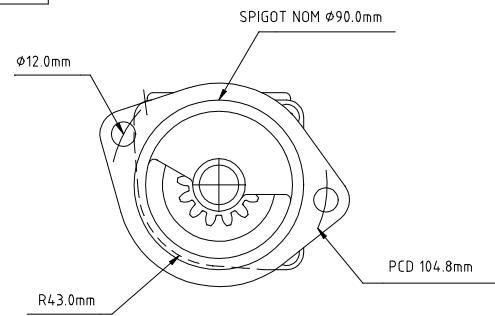
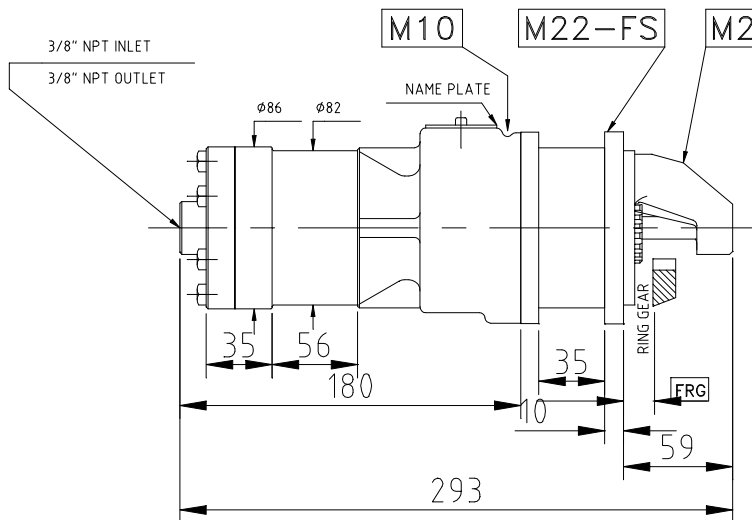


M10-D3M1XSH
for FRG 29mm

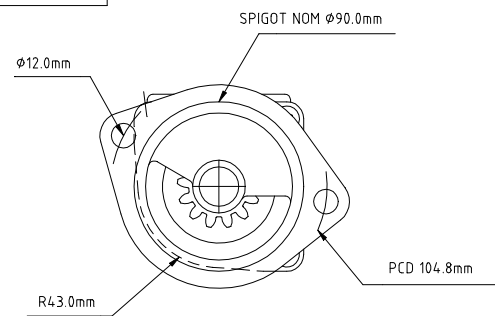
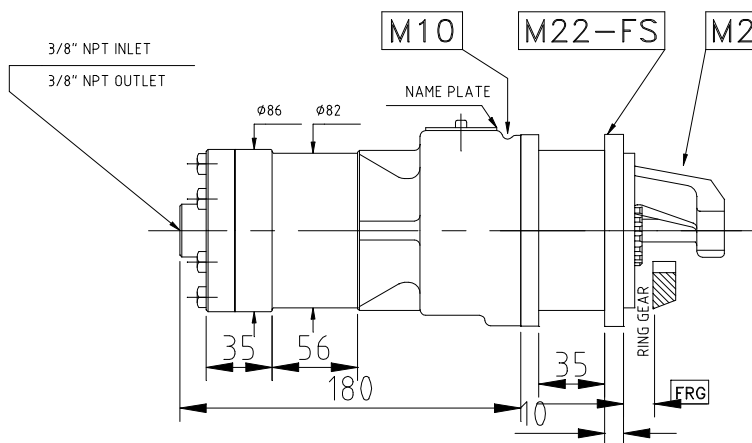


M10-D_P9
for FRG 45mm

Specifications are subject to change without prior notice due to product improvements.



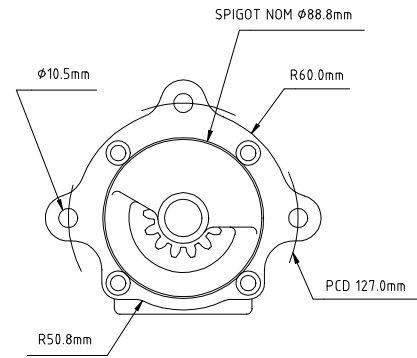
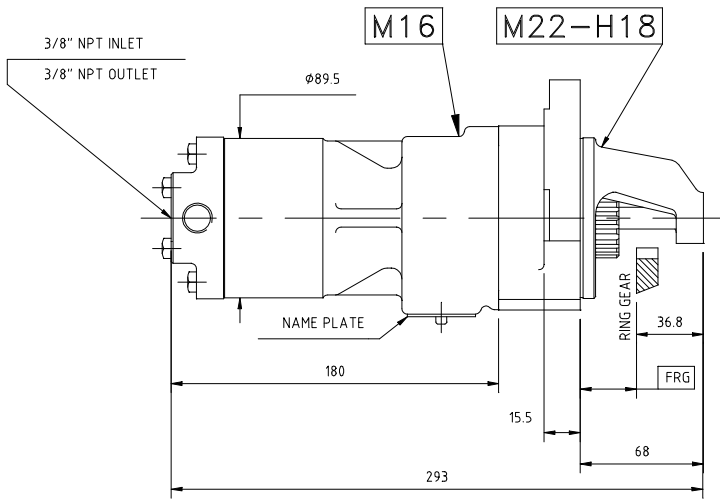
M10-D4S6
for FRG 21mm



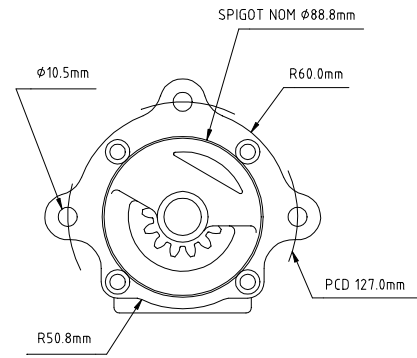
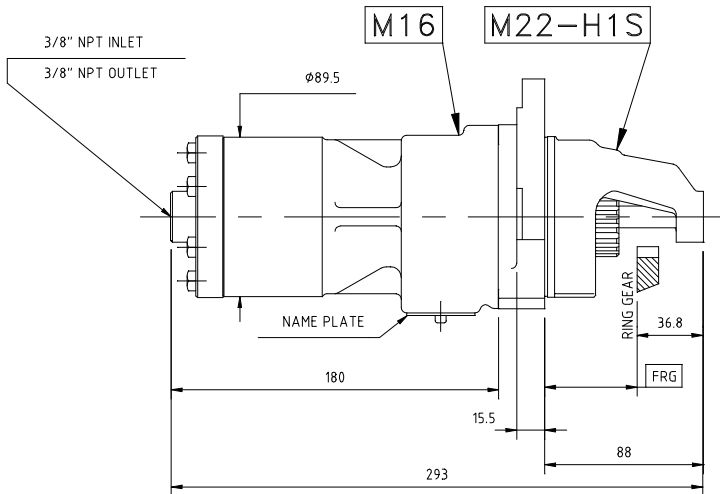
M10-D4S6XSE
for FRG 21mm

Specifications are subject to change without prior notice due to product improvements.

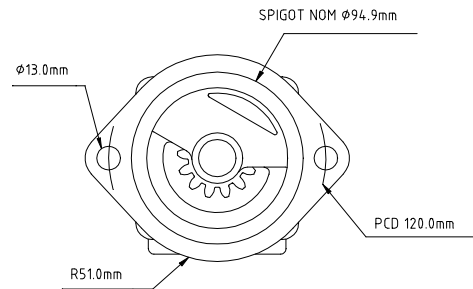
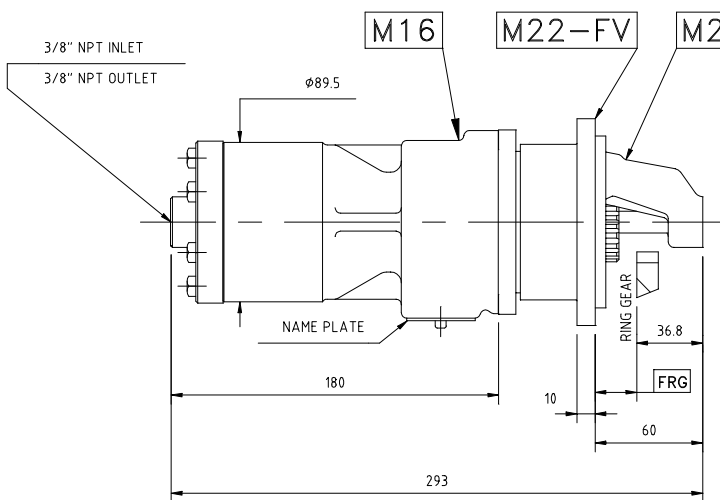
12.9 M16 PRODUCT RANGE



M16-D_18XSE
for FRG 31mm



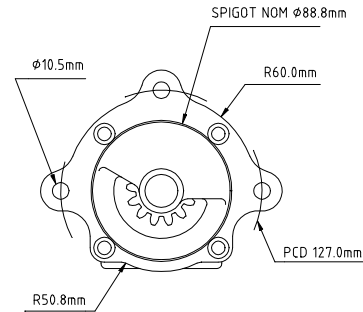
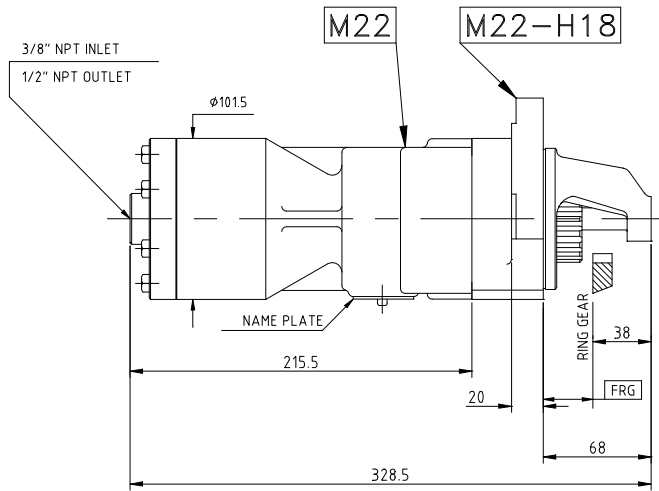
M16-D_1S for FRG 51mm



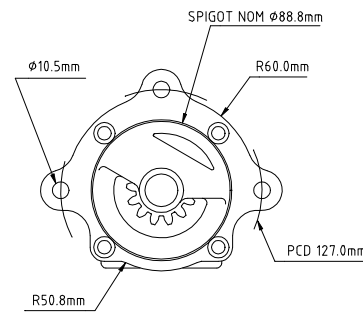
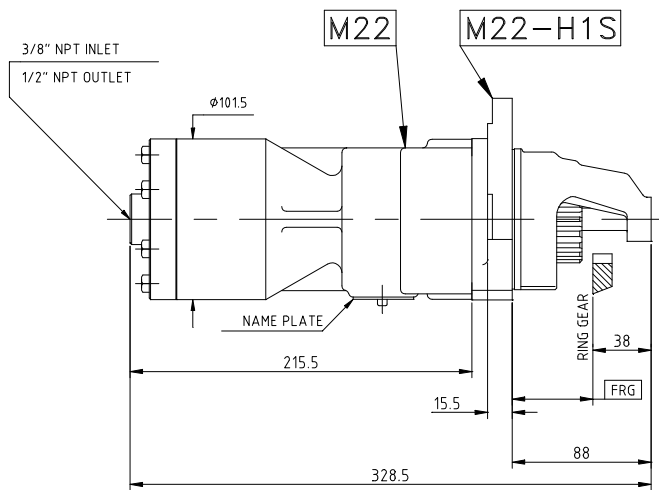
M16-D_V6 for FRG 23mm

Specifications are subject to change without prior notice due to product improvements.

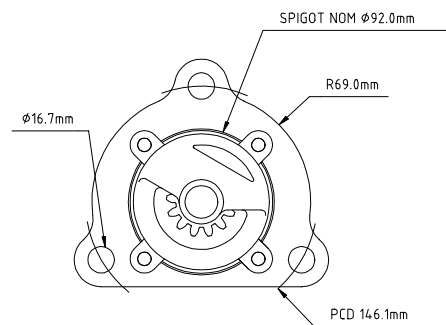
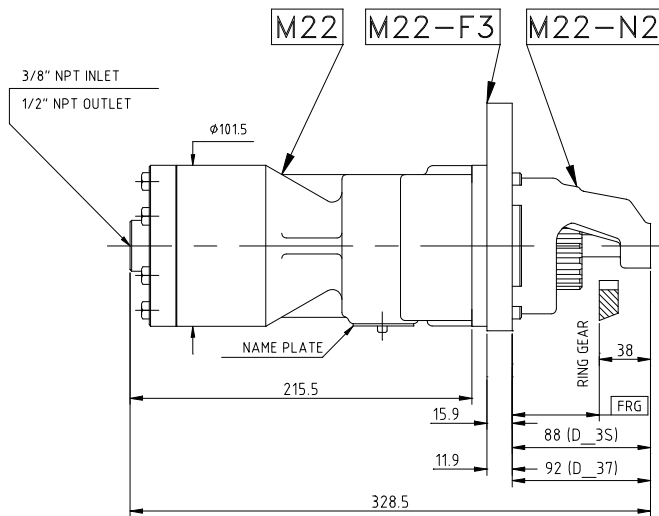
12.10 M22 PRODUCT RANGE



M22-D_18 for FRG 31mm



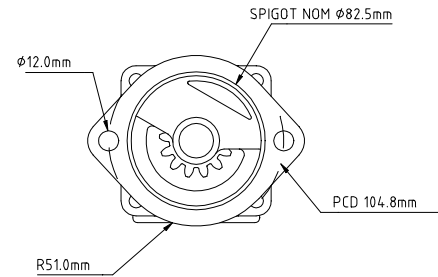
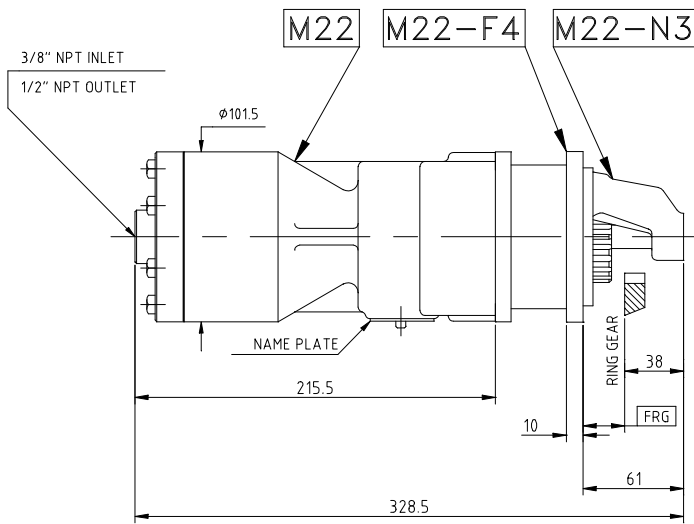
M22-D_1S for FRG 51mm



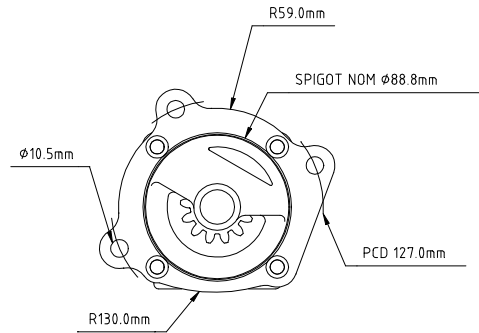
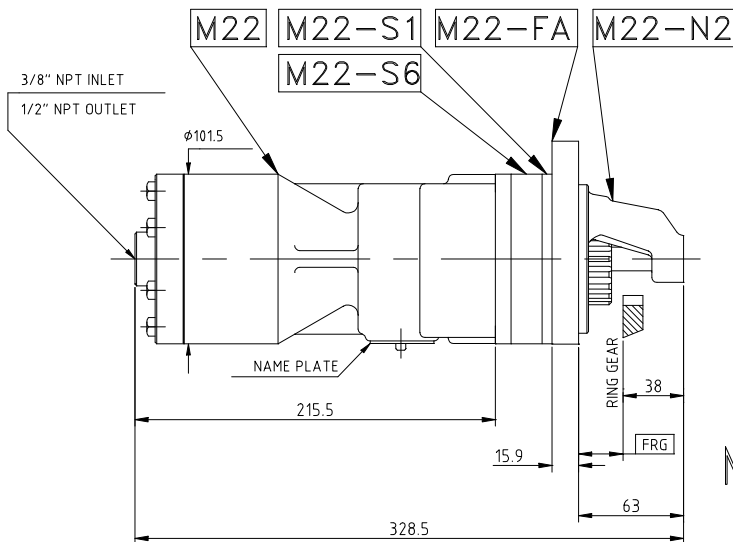
M22-D_37 for FRG 55mm

M22-D_3S for FRG 51mm

Specifications are subject to change without prior notice due to product improvements.

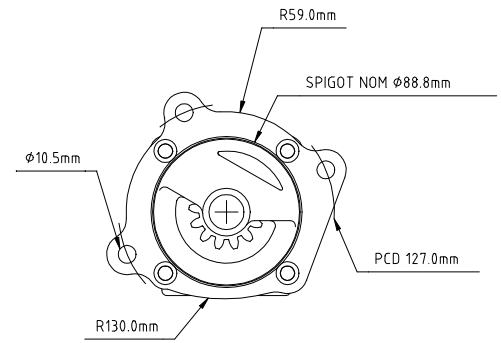
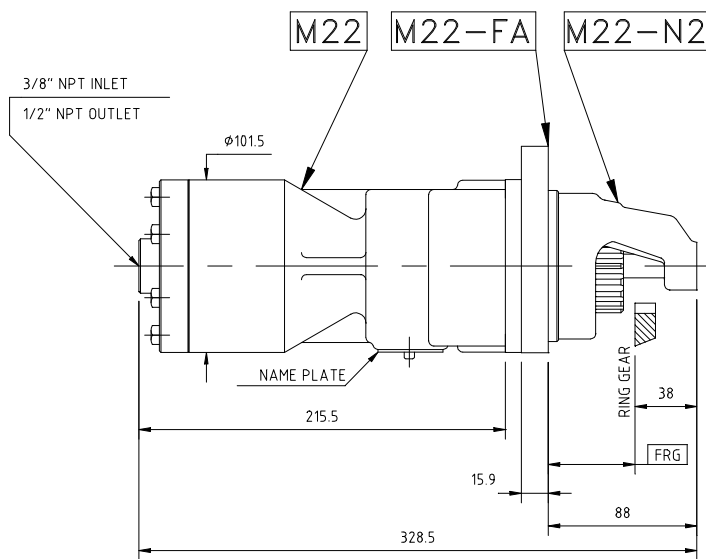


M22-D_44 for FRG 25mm

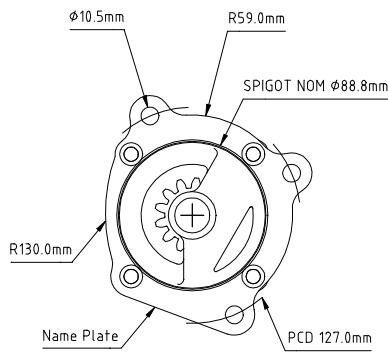


M22-D_A4 for FRG 25mm

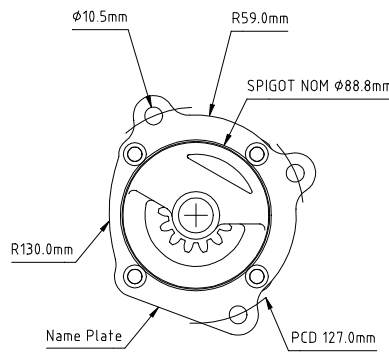
Specifications are subject to change without prior notice due to product improvements.



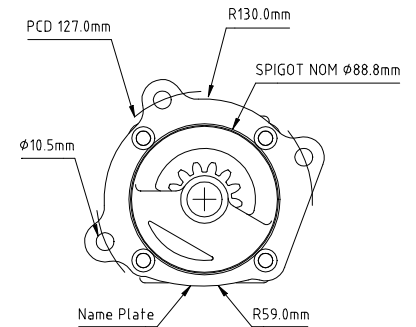
M22-D_AS for FRG 51mr



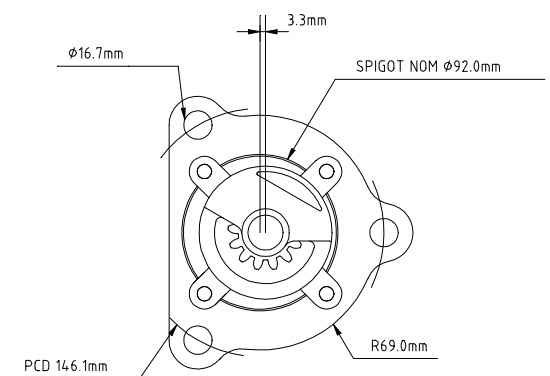
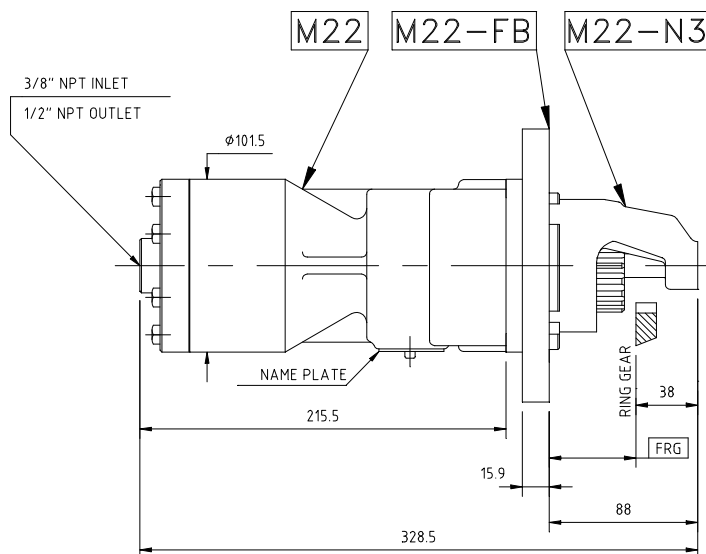
M22-D_AS2
for FRG 51mm



M22-D_AS3
for FRG 51mm

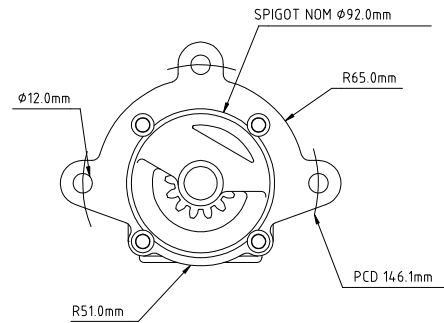
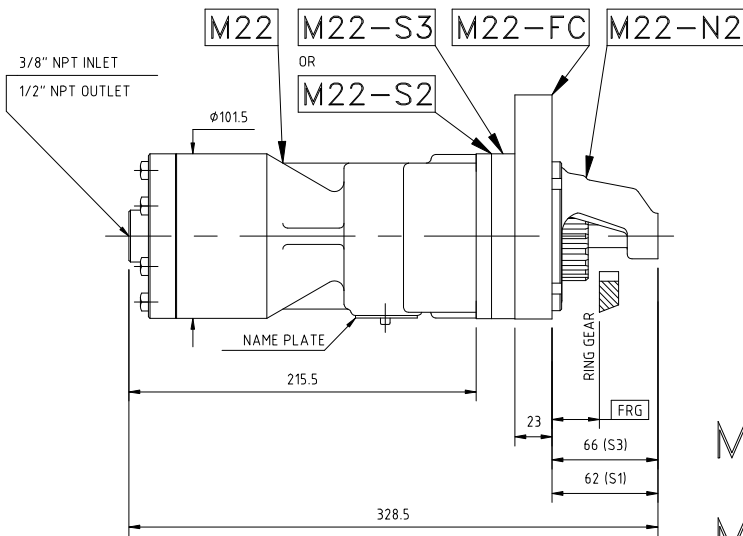


M22-D_AS4
for FRG 51mm



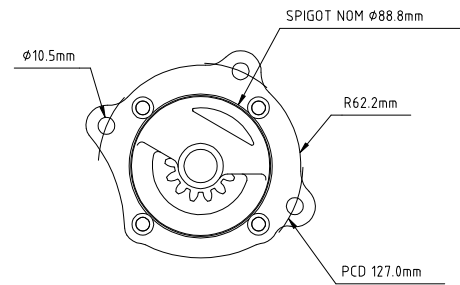
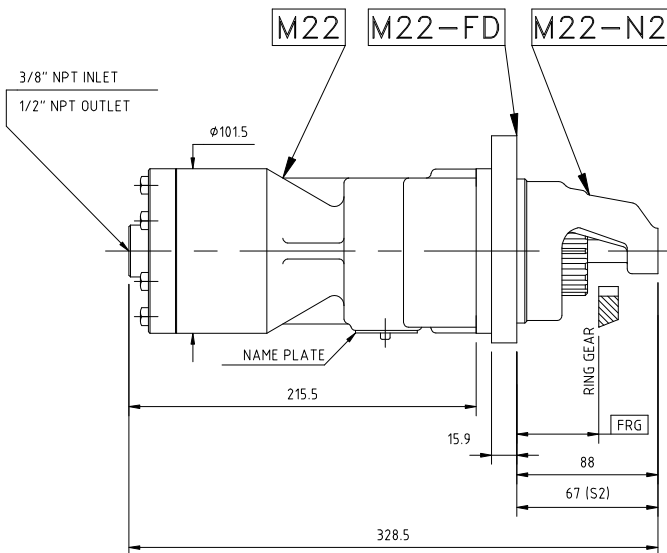
M22-D_BS
for FRG 51mm

Specifications are subject to change without prior notice due to product improvements.



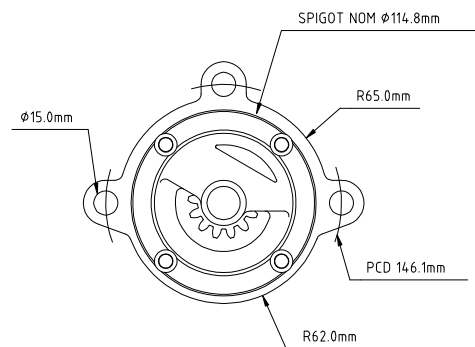
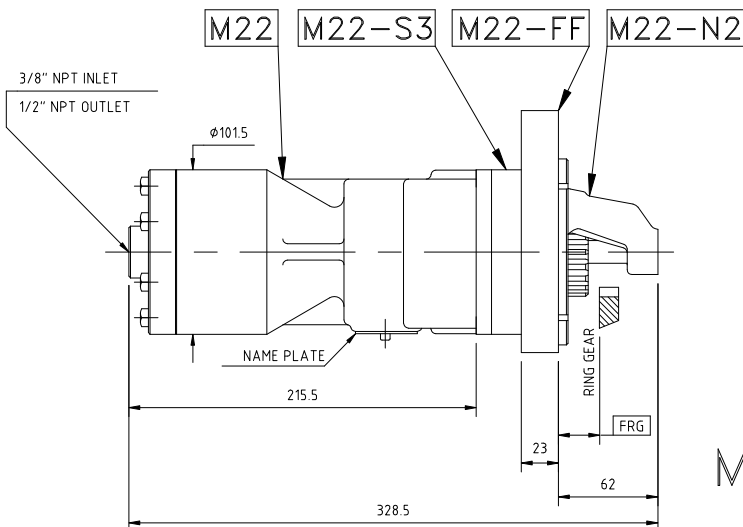
M22-D_C1 for FRG 29mm with M22-S3

M22-D_C4 for FRG 27mm with M22-S2



M22-D_DS for FRG 51mm

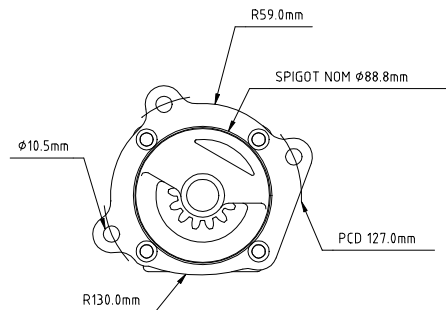
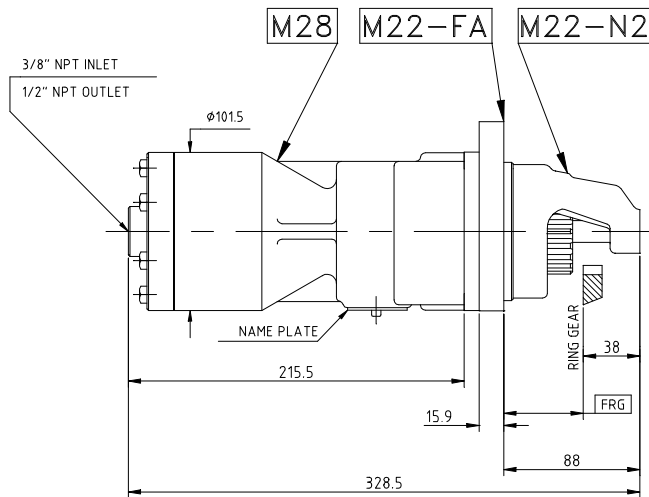
M22-D_D3 for FRG 31mm with M22-S2



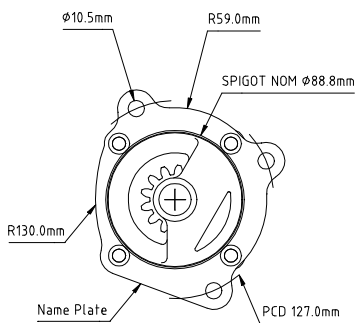
M22-D_F4 for FRG 25mm

Specifications are subject to change without prior notice due to product improvements.

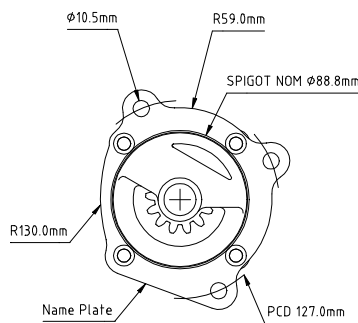
12.11 M28 PRODUCT RANGE



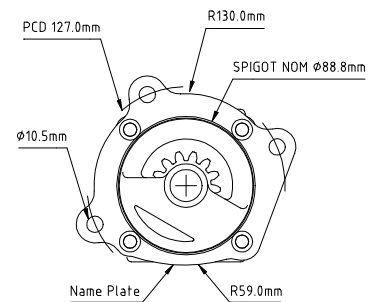
M28-D_AS for FRG 51mm



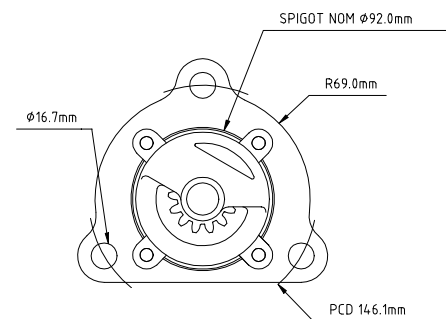
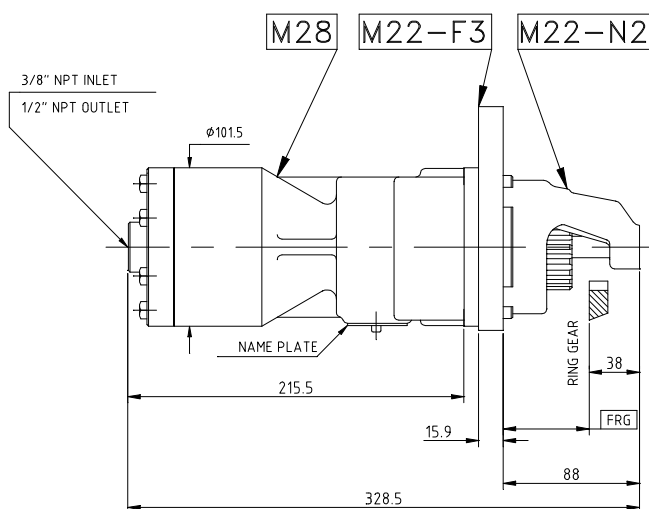
M28-D_AS2
for FRG 51mm



M28-D_AS3
for FRG 51mm

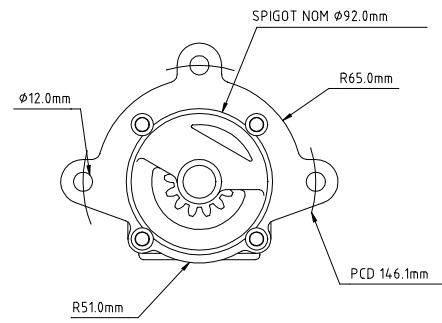
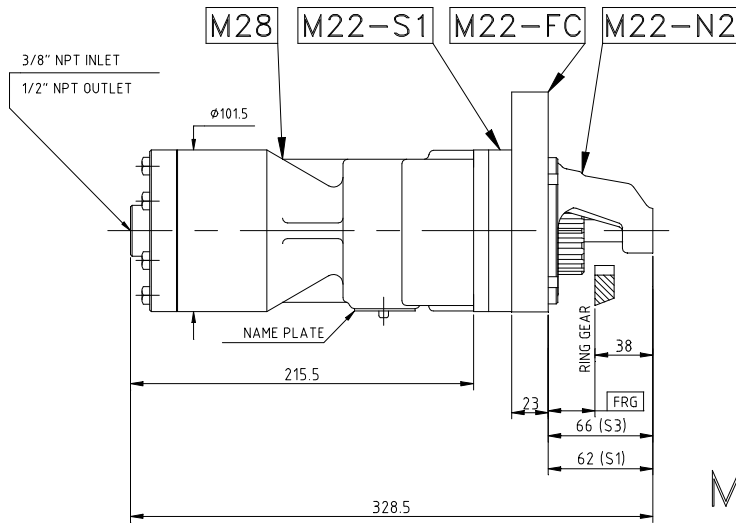


M28-D_AS4
for FRG 51mm



M28-D_3S for FRG 51mm

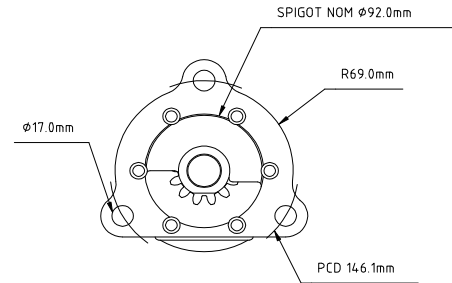
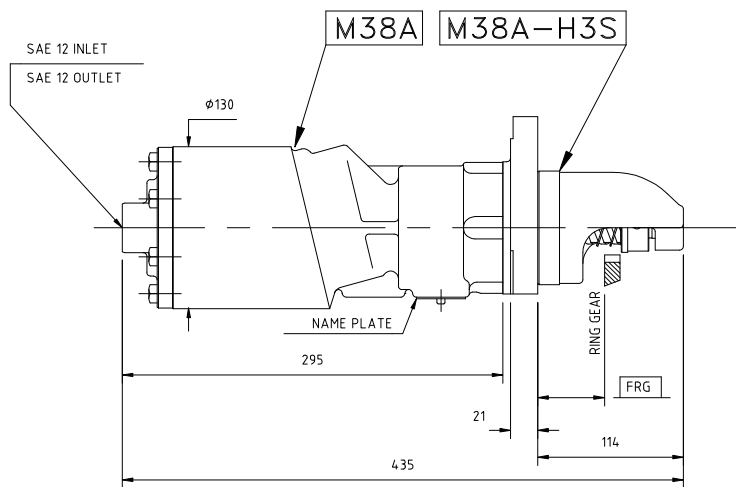
Specifications are subject to change without prior notice due to product improvements.



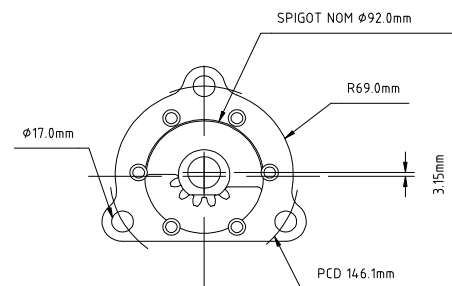
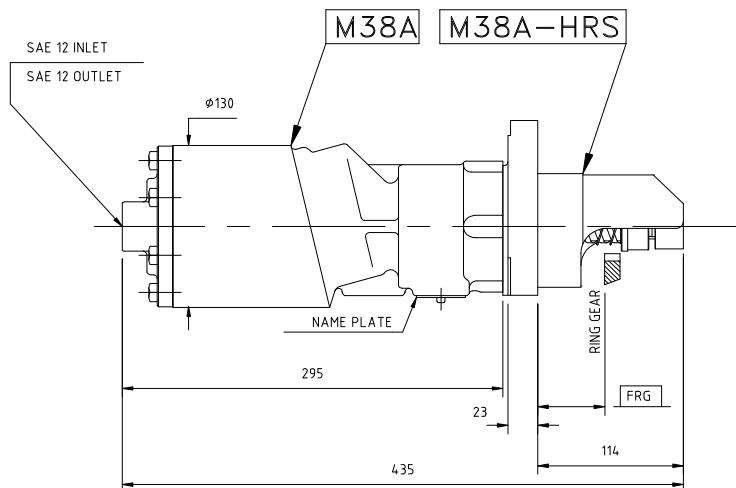
M28-D_C4 for FRG 25mm

Specifications are subject to change without prior notice due to product improvements.

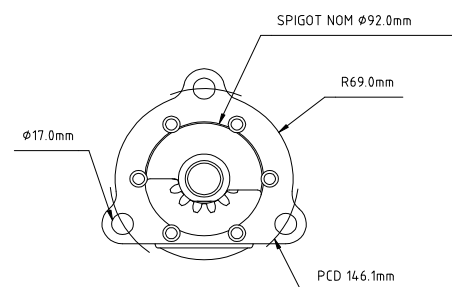
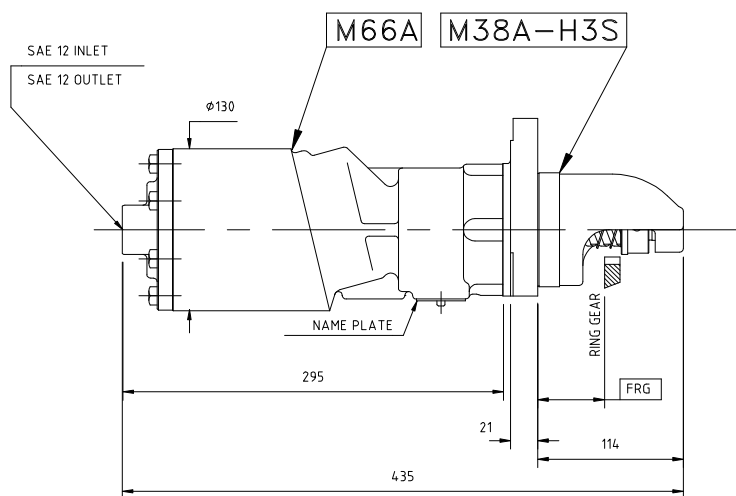
12.12 M38A/M66A PRODUCT RANGE



M38A-D_3S
for FRG 51mm



M38A-D_RS
for FRG 51mm



M66A-D_3S
for FRG 51mm

Specifications are subject to change without prior notice due to product improvements.

13. COMPLETE MINI-PAK STARTING SYSTEMS

13.1 MINI-PAK ORDERING CODES

Pump-Pak part number:

M P - P F 1 0

Minipak part number:

M P 1 0 - - - F 1 0 1 8

Starter Size

10	-	10cc (0.6 cu.in.)
16	-	16cc (0.95 cu.in.)
22	-	22cc (1.35 cu.in.)
28	-	28cc (1.7 cu.in.)

Starter Drive

Pinion gear, flange type
and FRG distance
Refer to pages 12-3 to 12-5

Accumulator

10	-	1.0 ltr. (0.25 gal.)
25	-	2.5 ltr. (0.66 gal.)
40	-	4.0 ltr. (1.06 gal.)
55	-	5.5 ltr. (1.5 gal.)
100	-	10.0 ltr. (2.6 gal.)
120	-	12.0 ltr. (3.2 gal.)
160	-	16.0 ltr. 4.20 gal.)

Hose Length

18 - 1.8m (6 ft.) (std).

Start Valve

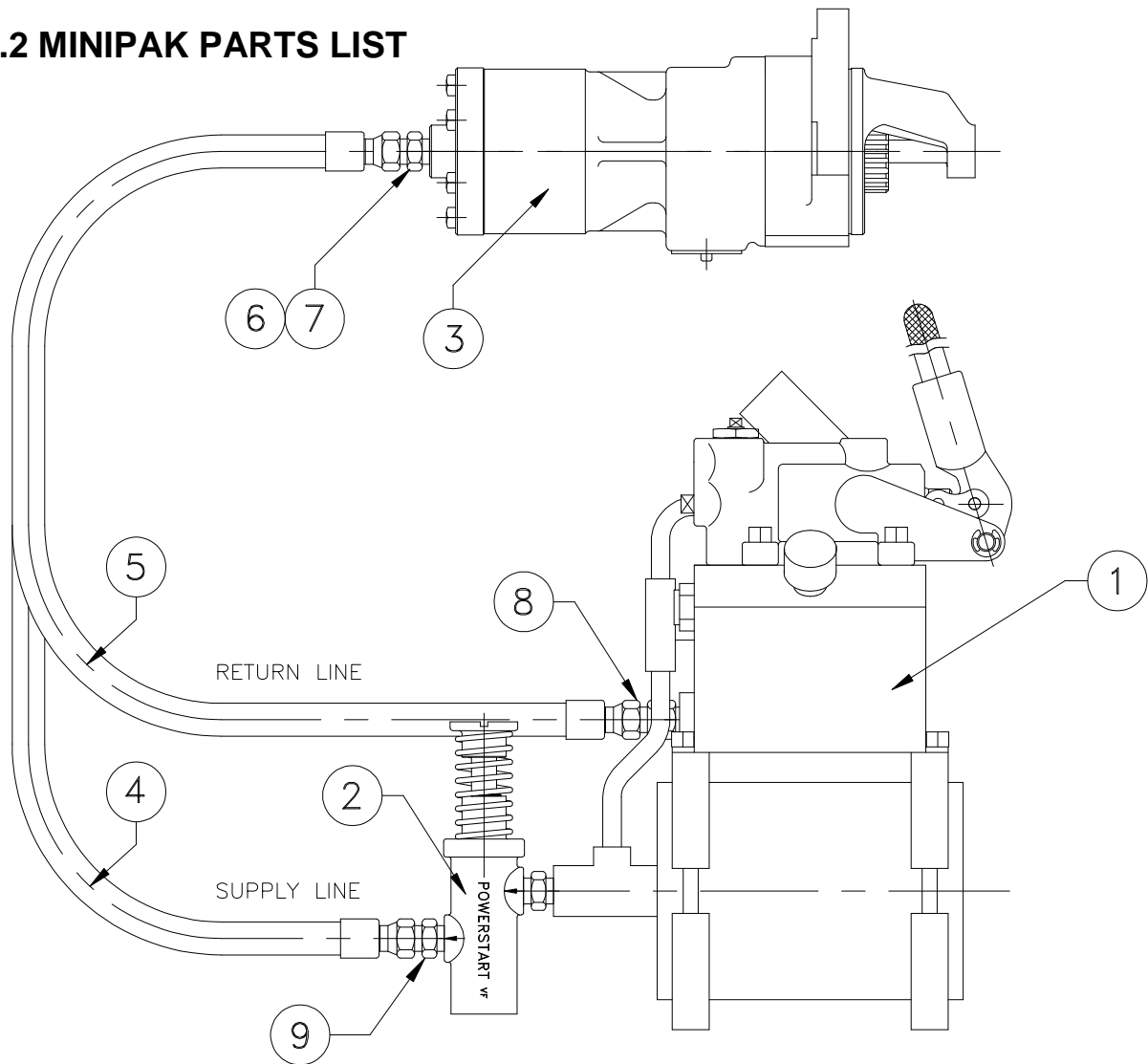
0	-	None
F	-	Foot valve (std.)
S	-	24V DC Solenoid valve

Features:

- One piece bolt-on pre-assembled solution to a complete starting system
- Pump-paks comprise an accumulator, oil reservoir, filler breather, hand pump, relief valve and foot valve
- Mini-paks comprise of a pump-pak, a return hose, a supply hose, adaptors and a starter motor
- All steel construction
- Integrated relief valve

Specifications are subject to change without prior notice due to product improvements.

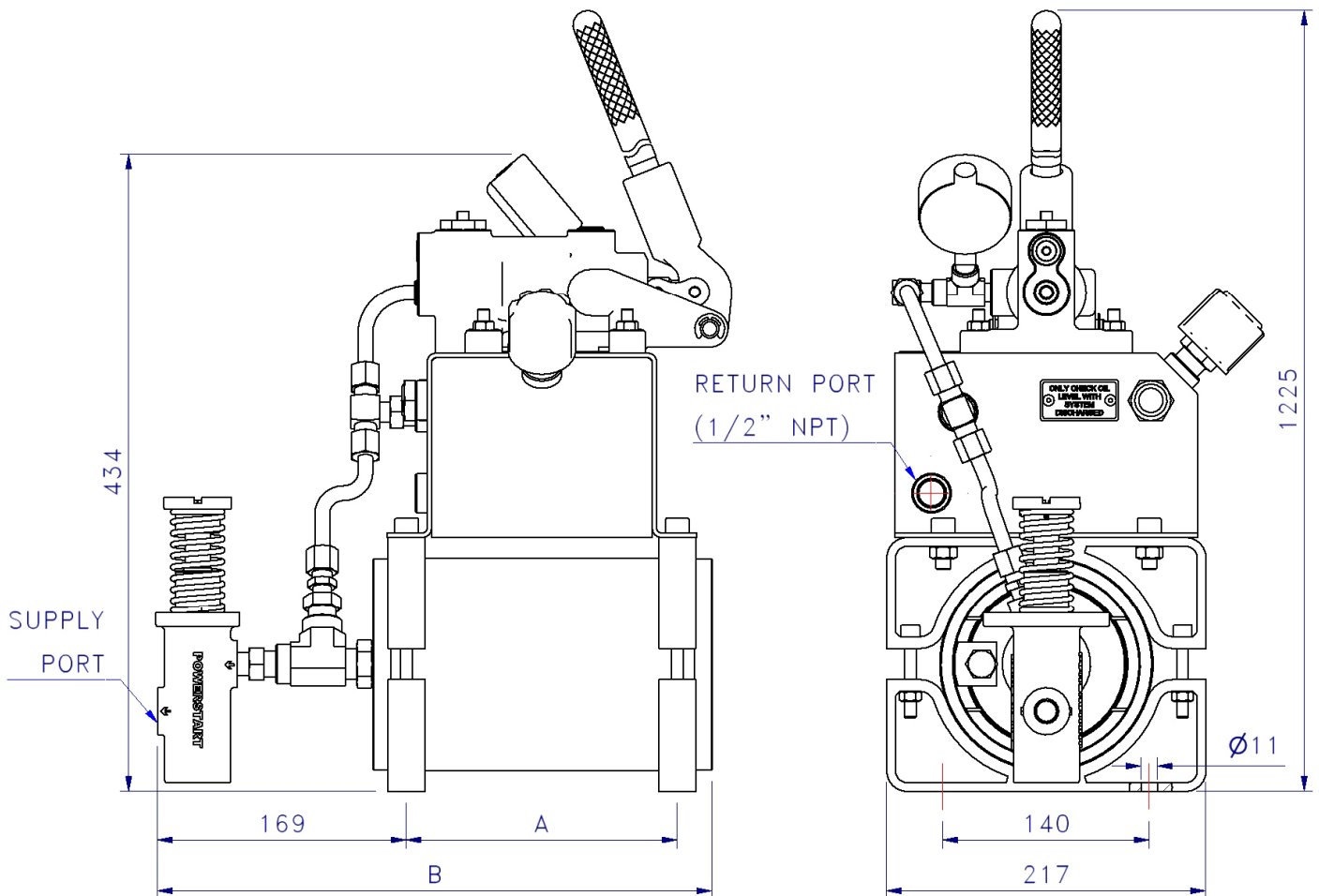
13.2 MINIPAK PARTS LIST



Item	Description	Qty	Part no.		Remarks
			Small minipaks	Large minipaks	
1	Pump-pak	1			
2	Start valve	1	Depends on configuration		Part of pump pak
3	Starter motor	1			
4	Pressure hose	1	HS08-18	HS10-18	1.8m long Standard
5	Return hose	1	HR10-18	HR12-18	1.8m long Standard
6	Motor inlet port adaptor M10-M28	1	HS-01		
6	Motor inlet port adaptor M38A/M66A	1		HR-01	
7	Motor outlet port adaptor M10/M16	1	HR-02		
7	Motor outlet port adaptor M22/M28	1	HR-01		
7	Motor outlet port adaptor M38A/M66A	1		Not required	M66-41 included with motor
8	Tank return adaptor M10-M28	1	HR-01	HR-04	
8	Tank return adaptor M38A/M66A	1		HR-03	
9	Footvalve adaptor M10-M28	1	HS-01	HS-02	
9	Footvalve adaptor M38A/M66A	1		HR-01	

Specifications are subject to change without prior notice due to product improvements.

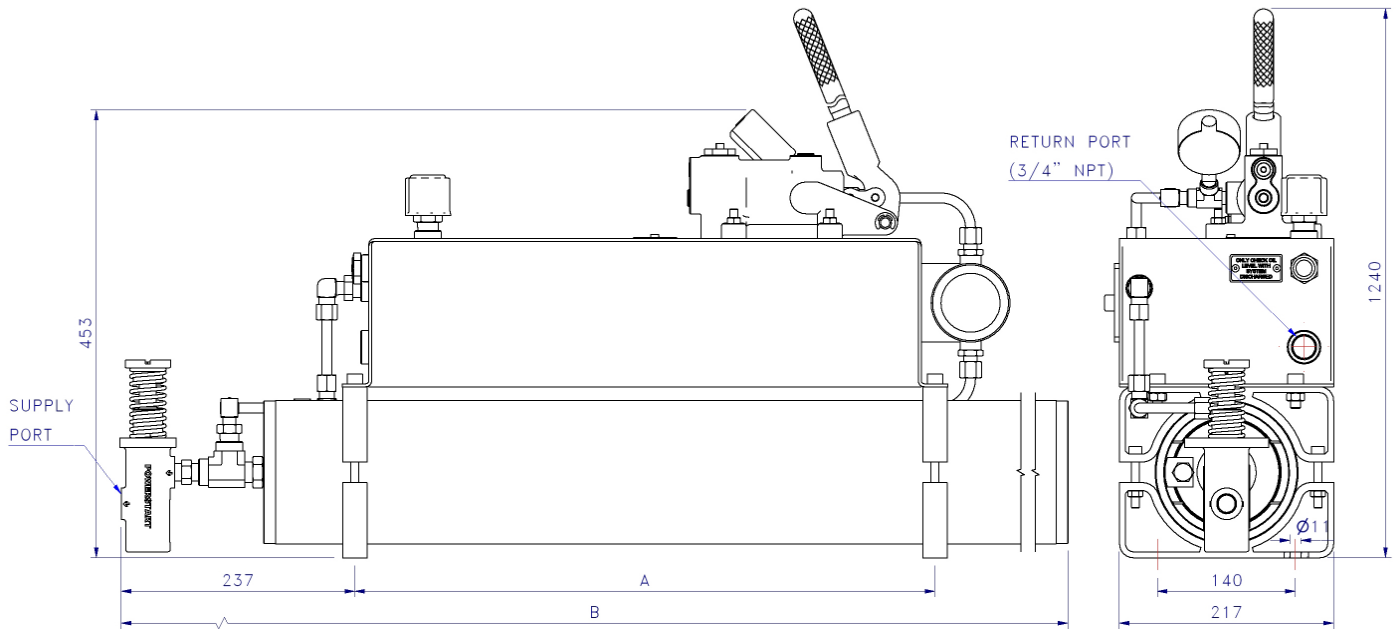
13.3 SMALL PUMP-PAK DIMENSIONS



Part no.	Acc. size ltr. (gal.)	Tank size ltr. (gal.)	Dimensions in mm (in)		Supply Port (NPTF)	Return Port (NPTF)	Dry weight kg (lbs.)
			A	B			
MP-PF10	1.0 (0.25)	3.0 (0.8)	184 (7.2)	376 (14.8)	3/8"	1/2"	35 (77)
MP-PF25	2.5 (0.66)	5.0 (1.3)	309 (12.2)	496 (19.5)	3/8"	1/2"	42 (92)
MP-PF40	4.0 (1.06)	5.0 (1.3)	309 (12.2)	621 (24.4)	3/8"	1/2"	45 (99)
MP-PF55	5.5 (1.50)	5.0 (1.3)	309 (12.2)	746 (29.4)	3/8"	1/2"	50 (110)

Specifications are subject to change without prior notice due to product improvements.

13.4 LARGE PUMP-PAK DIMENSIONS



Part no.	Acc. size ltr. (gal.)	Tank size ltr. (gal.)	Dimensions in mm (in)		Supply Port (NPTF)	Return Port (NPTF)	Dry weight kg (lbs.)
			A	B			
MP-PF100	10.0 (2.60)	15.0 (3.9)	588 (23.1)	1109 (43.7)	1/2"	3/4"	73 (160)
MP-PF120	12.0 (3.20)	15.0 (3.9)	588 (23.1)	1269 (50.0)	1/2"	3/4"	78 (172)
MP-PF160	16.0 (4.20)	15.0 (3.9)	588 (23.1)	1594 (62.8)	1/2"	3/4"	90 (198)

Specifications are subject to change without prior notice due to product improvements.