SERVICE & INSTALLATION

T-SERIES POSITIVE ROTARY PUMPS

TSR MODEL

CONTENTS

INTRODUCTION

General

This manual contains installation, operation, cleaning, and repair instructions, with parts lists, for the TSR T-Series Positive Displacement Pumps as provided by Tri-Clover Inc., of Kenosha, Wisconsin. It also provides a trouble shooting chart to aid in determining pump malfunctions.

SAFETY

Safety is very important!

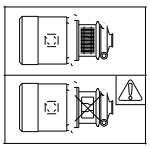
Included throughout this manual is the safety alert symbol you see to the left. When you see this symbol be alert to the potential for personal injury.

SIGNAL WORDS: Like DANGER, WARNING, or CAUTION are used with a safety alert symbol. DANGER-Immediate hazard which WILL result in personal injury or death. WARNING-Hazards or unsafe practices which COULD result in personal injury or death. CAUTION-Hazards or unsafe practices which COULD result in minor personal injury or product damage.

DO NOT attempt to modify any Tri-Clover product. To do so could create unsafe conditions and void all warranties. ***DO NOT place any Tri-Clover product in an application where general product service ratings are exceeded.***

SAFETY LABELS below are placed on every pump. Do not remove any labeling on any Tri-Clover product. Immediately replace any label that is missing.

Part Number 38-241



Part Number 38-309

HANDLING

Attention must be given to the safe handling of all items. Where pumps, mounted units or individual components weigh in excess of 44 lbs (22 kg), it is recommended that suitable lifting tackle be used. *Table one* lists the bareshaft weights of all the pumps in the TSR range. In cases where the pump is part of a mounted unit (e.g. pump and primary drive), the baseplate should always be used for lifting. Correctly positioned slings should be used for all lifting purposes.

Warning:
It should be noted that pump units complete with drives and baseplates will weigh considerably more than the bareshaft weights shown in *table one*.

Table One

Model	Weight (S)*		Weight (F)*	
	lbs	kg	lbs	kg
TSR1/N/S_	29	13	31	14
TSR1/N/L_	31	14	33	15
TSR1/W/S_	33	15	35	16
TSR1/W/L_	35	16	37	17
TSR2/N/S_	58	26	62	28
TSR2/N/L_	61	27	64	29
TSR2/W/S_	62	28	66	30
TSR2/W/L_	64	29	68	31
TSR3/N/S_	112	51	117	53
TSR3/N/L_	121	55	126	57
TSR3/W/S_	110	50	121	55
TSR3/W/L_	128	58	139	63
TSR4/N/S_	180	81	192	87
TSR4/N/L_	216	98	227	103
TSR4/W/S_	192	87	205	93
TSR4/W/L_	228	103	241	110
TSR5/N/S_	235	106	248	113
TSR5/N/L_	275	152	348	158
TSR5/W/S_	284	129	302	137
TSR5/W/L_	353	160	370	168
TSR6/N/S_	434	197	452	205
TSR6/N/L_	573	260	591	268
TSR6/W/S_	516	234	538	244
TSR6/W/L_	584	265	606	275

* S = Tri-Clamp® and Bevel Seat Connections
F = Flanged Connections

INSTALLATION

Unpacking Equipment

Check the contents and all wrapping when unpacking your equipment. Inspect all parts for damage that may have occurred during shipping.

Note:
If the plastic pump port covers have been broken or disturbed in shipment, dismantle fluid head to make sure it is free of all foreign materials before placing pump in service.

Initial Lubrication

The pump unit is designed for either grease or oil lubrication. Grease lubricated units are filled at the factory prior to shipping and will require no additional lubrication until after the pump is put into service. Oil lubricated pumps that are shipped without oil, and are tagged as such, must be filled prior to putting pump into service. (See ***Lubrication.)*** Oil lubricated pumps can be identified by the presence of sight glass(es) on the side of the power frame and vent/filler plug(s) on the top of the power frame. Grease filled units lack sight glass(es) and vent/filler plug(s).

Location

The pump unit should be located as near as possible to the liquid source, and in a position where the suction piping can be short and direct with a minimum number of elbows and fittings. It should also be readily accessible for inspection.

Flexible Couplings

The purpose of a flexible coupling is to compensate for temperature changes and allow end movement of the pump and motor shafts without interference with each other while transmitting power from the motor to the pump. A flexible coupling should not be used to compensate for shaft misalignment.

When properly aligned, the flexible couplings should appear as shown in *figure one*.

The faces of the coupling halves should be far enough apart so that they do not touch each other when the motor shaft is moved toward the pump.

The tools required for checking flexible coupling alignment are a straightedge and a taper gauge or set of feeler gauges.

Figure One

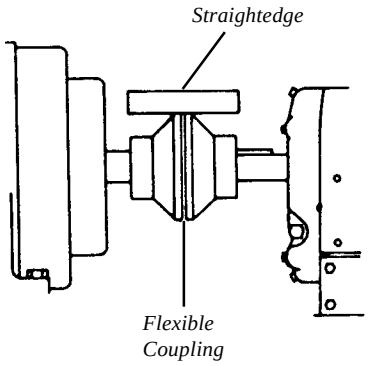


Figure Two

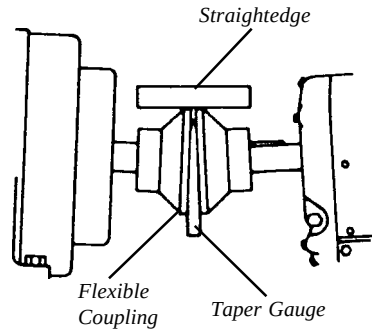
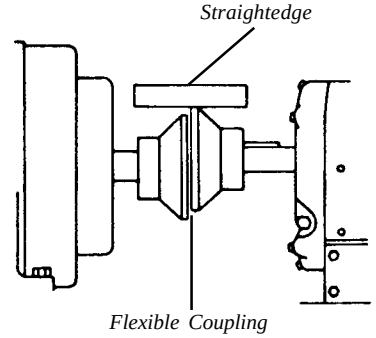


Figure Three



Flexible Coupling Alignment

There are two types of misalignment encountered with flexible couplings: angular misalignment and parallel misalignment. To check for angular misalignment, (see *figure two*), insert a taper gauge or feeler gauge at four places located 90° degrees apart around the coupling as shown. Coupling halves will be aligned when the measurements are the same at all check points.

To check parallel misalignment, (see *figure three*), place a straightedge across the coupling half rims at the top, bottom, and both sides, making sure that the straightedge is parallel to the motor and pump shafts. The coupling will be properly aligned when the straightedge rests evenly on the coupling rims at all check points.

Correct alignment is obtained by use of shims under the motor mounting feet. It must be remembered that adjustment made in one direction may affect alignment in another direction. Therefore several checks of both angular and parallel alignment should be made.

Note:
Your T-Series Pumps are designed for either clockwise or counterclockwise rotation.

Connect the flexible coupling, start the pump and operate it until temperatures are stabilized. The unit should then be shut down, and the alignment immediately rechecked.

Note:
If corrections in alignment are necessary at this time, be sure to check in all directions after making adjustments.

PIPING HINTS

General

This section provides some do's and don'ts of piping which will aid in obtaining the maximum efficiency and service from your pump.

Piping should be independently supported at both the suction inlet and discharge outlet. Care should be taken that piping is properly aligned and does not put any strain on the pump casing. The piping should have as few bends as possible.

Suction Piping

The suction piping should be short and follow a direct route with a minimum number of elbows and fittings. Elbows should not be used at the suction inlet as friction loss would be greatly increased. Excessive friction losses in the suction line could result in pump cavitation, causing poor performance, noise, vibration, damage to equipment, and possible damage to product. Whenever practical the diameter of the inlet piping should be the same as or larger than the pump connection size. If a reducer is required at the pump inlet, an eccentric tapered reducer should be used in lieu of a straight concentric tapered reducer to prevent air pockets from forming and impairing pump efficiency.

A horizontal suction pipe must have a gradual rise to the pump. A high point in the suction line will form an air pocket and prevent proper pump operation. All joints in the suction line should be air tight, to prevent air leakage which can reduce pump capacity and efficiency.

Discharge Piping

The discharge piping should be short and direct with a minimum number of elbows and fittings. It is advisable to increase the pipe diameter at the discharge outlet to minimize head loss.

OPERATING CONDITIONS

TSR pumps should only be used for the duty for which they have been specified by Tri-Clover Inc. or their authorized distributors. The operating pressure and temperature limits for individual pumps must not be exceeded.

The temperature and pressure limits of a pump are determined by the pump head clearances. Clearances are spaces provided between the rotating and stationary elements in the pump head (see ***Clearances***) and are necessary to avoid contact. The size of the clearances is related to the operating temperature and pressure of the pump.

The pump clearances are selected from a standard set of clearances and are chosen at the pump selection stage to suit the given duty conditions. Thus, the temperature and pressure limitations are those imposed by the clearances and are not related to pump life or design.

If the operating pressure and temperature limits are exceeded, the pump may be irreparably damaged.

Pump Orientations

TSR pumps have been built to operate in the upright position unless specified otherwise and must not be used in any other orientation without the correct modifications.

Table Two

Rotor Material	Metal		Rubber			
Duty	Continuous		Continuous		Intermittents	
	deg C	deg F	deg C	deg F	deg C	deg F
Temperatures up to :	70 130 200	158 266 392	70	158	100	212

If the pump is required to be side mounted, or inverted, then this must be stated at the time of order. Alternatively, if the orientation of an existing pump is to be changed, the Tri-Clover Inc. must be contacted for details of the necessary modifications.

Operating Temperature Limit

The operating temperature limit of the pump is governed by clearances engineered into the pump head during manufacture. There are three different clearance bands for metal rotors (hence three temperature ratings), and one for rubber rotors, see *table two*. The temperature rating of individual pumps is selected to suit the duty conditions and is stated on the original order documentation, if this is not available, consult Tri-Clover Inc. or their authorized distributor quoting the following information:

(i) the Pump Model Code
and, (ii) the Pump Serial Number.

Note:
If a Cleaning In Place (CIP) is to be used or retrospectively installed, confirm that this will not exceed the pump temperature or pressure operating limits.

Note:
If the pump is operated during the CIP cycle, it is essential that rapid temperature changes do not occur otherwise damage due to thermal shock will occur.

Table Three

Pump Code	Differential Pressure		Maximum Speed	Liters/	IMP.gal	US.gal
	Bar	PSI	RPM	rev	100 rev	100 rev
TSR1/N/SS or LD	8	115	1000	.053	1.17	1.40
TSR1/N/SD	15	215	1000	.053	1.17	1.40
TSR2/N/SD	15	215	1000	.128	2.82	3.38
TSR3/W/SD	15	215	1000	.384	8.45	10.15
TSR4/W/LD	15	215	1000	.790	17.38	20.87
TSR1/W/SS or LD	5	75	1000	.085	1.87	2.25
TSR1/W/SD	12	175	1000	.085	1.87	2.25
TSR2/W/SD	12	175	1000	.181	3.98	4.78
TSR2/N/SS or LS	10	145	1000	.128	2.82	3.38
TSR3/N/SS or LS	10	145	1000	.266	5.85	7.03
TSR4/N/SS or LS	10	145	1000	.554	12.19	14.64
TSR2/W/SS or LS	7	100	1000	.181	3.98	4.78
TSR3/W/SS or LS	7	100	1000	.384	8.45	10.15
TSR4/W/SS or LS	7	100	1000	.790	17.38	20.87
TSR3/N/SD	20	290	1000	.266	5.85	7.03
TSR4/N/LD	20	290	1000	.554	12.19	14.64
TSR5/W/LD	15	215	600	1.680	36.95	44.39
TSR6/W/LD	15	215	500	3.530	77.65	93.26
TSR5/N/SS or LS	10	145	600	1.160	25.52	30.65
TSR6/N/SS or LS	10	145	500	2.460	54.11	64.99
TSR5/W/SS or LS	7	100	600	1.680	36.95	44.39
TSR6/W/SS or LS	7	100	500	3.530	77.65	93.26
TSR5/N/LD	20	290	600	1.160	25.52	30.65
TSR6/N/LD	20	290	500	2.460	54.11	64.99

Pump Maximum Speed

The maximum operating speeds for the TSR pumps are all listed on *table three*. It is important to remember that the values quoted are due to design considerations, and in practice the recommended maximum pump speed may be limited for one or more of the following reasons:

- ✓ **Product viscosity**
- ✓ **Product rheology**
- ✓ **Product type (solids, abrasive, etc.)**
- ✓ **Pump suction (cavitation, NPSH required, etc.)**
- ✓ **Pump wear**
- ✓ **Noise level**

Tri-Clover Inc. or an authorized distributor should be consulted when proposing to modify a pumping system, especially when any of the above parameters are significantly different to the original design for which the pump was selected.

SYSTEM DESIGN AND INSTALLATION

Note:
When designing a pumping system it is good practice where possible, to have a short straight suction line avoiding bends tees and any restrictions.

At the system design stage, consideration must be given to:

1. Access to the pump and driver, and where applicable, to oil filler, level and drain plugs, and flush seal connections.
2. Isolating valves should be provided on each side of pump.
3. All pipe work should be independently supported.
4. Care should be take to exclude foreign bodies from entering pump head.
5. Pump and drives should be mounted on common baseplates.
6. Transmission
   - ✓ If the pump is supplied bareshaft, flexible couplings should be correctly aligned within the coupling manufacturer's limits for misalignment. If the pump is supplied mounted on a baseplate, refer to ***Coupling Misalignment***. Couplings of a non flexible type should not be used.
   - ✓ Vee-belts should be properly aligned and tensioned to prevent excessive belt wear and power loss. Provision must be made to permit belt tension adjustment.

Note:
Always apply anti-seize to shaft ends before fitting pulleys/flexible couplings.

7. Baseplates should be secured to a flat level surface to avoid distortion.

Note:
After installation, the transmission alignment should be checked, and where necessary readjusted.

8. Check the electrical supply is compatible with that of the electric motor , and that the unit is wired for the correct direction of rotation.
9. Check that all nuts and bolts are tight.
10. Ensure that all moving parts are provided with suitable guards to comply with Health and Safety Legislation.

11. To protect the pump and piping system against excessive pressure, a pipeline relief valve should be installed.

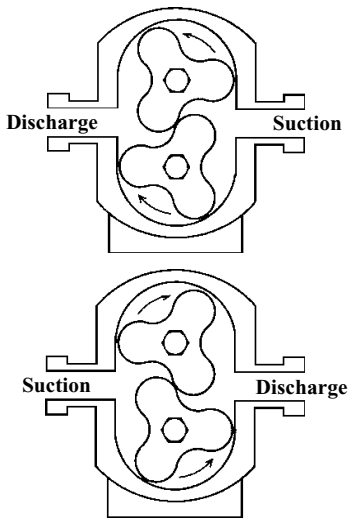
START-UP PROCEDURE

1. When the pump is received, before putting it into service the suction and discharge port covers should be removed, and the flanges or threads cleaned with solvent.
2. The direction of rotation of the pump drive shaft dictates the suction and discharge direction of the pump. See *figure four*.
3. Check that all connections and joints are tight and leak-free. Where possible check the system with a compatible nonhazardous liquid.
4. **Check lubrication of both pump and driver.** See ***Initial Lubrication.***

> **Note:**
> Ensure that both the pump gearcase chambers and the driver gearcase are filled with the appropriate lubricant before starting the pump.

5. Check all guards are installed and secure.
6. Check packed glands.
   (a) Supply flushing fluid, if specified, see ***Flushed Seal Arrangements***.
   (b) Leave gland packing and followers loose on start-up, adjusting as directed in ***Adjusting the Packing Gland***.
7. Check mechanical seals.
   (a) If specified, ensure all flushing connections are correctly fitted, tight and leak-free, see ***Flushed Seal Arrangements.***
   (b) If specified, check that recommended flushing fluid is at correct pressure and flow rate, see ***Flushed Seal Arrangements***.
   If in doubt about flushing flow rate or pressure, consult Tri-Clover Inc.
8. The Tri-Clover Rotary Lobe Pump is a Positive Displacement Pump, therefore open all valves in the system and check there are no obstructions in the pipe work before starting the pump. Turn the pump over by hand to ensure there are no obstructions in the pump head.
9. Start/stop pump and check direction of rotation.
10. Check that liquid is being pumped. If pumping does not occur, refer to ***Trouble Shooting.***

Figure Four

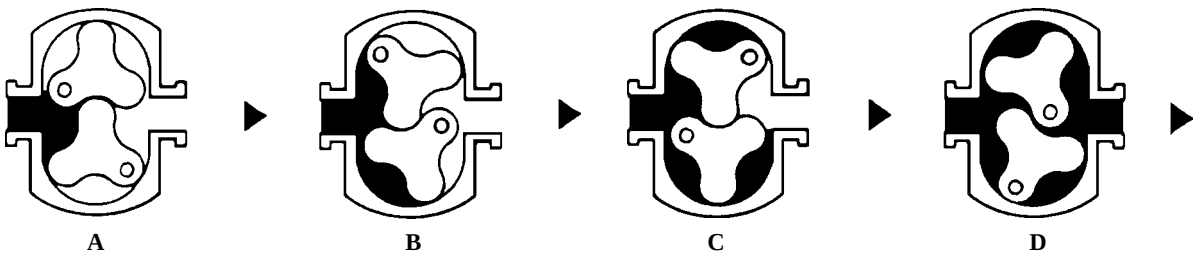


Pump Rotation

The pumping principal is best explained with reference to *figure five* (a-d). In (a) the contra-rotating rotors have just come out of mesh creating a reduction in pressure which is then filled with product. In (b) and (c) the product is trapped in the chambers and transferred around the outside of the rotorcase to the discharge. In (d) the rotors go into mesh and the product is discharged.

The rotors are synchronized by the timing gears, and mesh without contact occurring, thus when sealing system permits, dry running is possible. Pumps can be run in either direction of rotation.

Figure Five



Reversing the direction of rotation of the drive shaft will also reverse the flow direction. For a given direction of drive shaft rotation, top and bottom drive shaft pumps have opposite flow directions as illustrated in *figure four*.

ROTOR RETENTION

The TSR range of pumps uses two distinct methods of rotor retention. TSR1 to TSR5 pumps employ a Flanged Hexagon Nut, see *figure six*, and TSR6 rotors are retained by Torque Locking Assemblies (TLA), see *figure seven*. In some cases Flanged hexagon nuts, or TLA rotor retention are available, though this is only to special order. Both methods permit the pumps to be run in either direction when tightened to the recommended torque values, see *tables four* and *five*.

Flanged Nut Rotor Retention

All of the pumps using flanged nut rotor retention are fitted with o-rings which seal the rotors. This arrangement is detailed in *figure six*.

When removing and replacing the rotor nuts, the o-rings should be inspected for damage and replaced if necessary. When refitting, the rotor nuts should be tightened to the correct torque value as shown in *table four*.

Torque Locking Assembly (TLA) Rotor Retention

TSR6 pumps always use TLA rotor retention. The cavity in which the TLA is situated is sealed with flanged nut and o-ring. Where TSR4 and TSR5 pumps use TLA retention, this cavity is sealed with a rotor cap, two o-rings, and a screw. See *figure eight.* The following sections on TLA's are applicable to both.

Torque Locking Assemblies (TLA) - Mounting Instructions

When fitting a TLA it is recommended that:

1. The TLA is lightly oiled on all surfaces to assist in achieving the correct torque value. This will also aid its release when removing.
2. Once installed into its working position, and before tightening, a temporary clamp, supplied with the pump, should be used to ensure that the rotor with TLA is positively abutted against the shaft shoulder. This will ensure that the clearances on both the front and rear faces of the rotor are maintained.
   Figure nine shows the rotor clamp in use. With the rotor correctly positioned on the shaft and the TLA in place, special clamp nut is put through the center hole in the clamp and tightened onto the end of the shaft. This will hold the rotor in place, and the TLA screws may now be tightened through the access slots in the clamp.
3. With the rotor clamp secured in place, the TLA screws can be torqued up to the correct settings, see *table six*. To obtain best results it is recommended that the screws are tightened in a diametrically opposed pattern, repeating until correctly set.

Torque Locking Assemblies (TLA) - Release Instructions

1. **TSR6 ONLY:** Using a 36 mm socket spanner, remove the flanged rotor nut, ensuring the sealing o-ring is not lost (see *figure seven).*
   TSR 4 and TSR5 ONLY: Loosen the socket head cap screw, and remove the rotor cap, ensuring that the two sealing o-rings are not lost. See *figure eight*. If the rotor cap does not release easily, it can be removed by gently screwing a suitable screw into the thread in the center hole of the rotor cap.
2. Loosen the TLA in several stages and in a diametrically opposite sequence. The loosened TLA can now be removed.
3. To extract the TLA from the rotor, only remove the two screws which are fitted with washers. Carefully screw 8 mm x 50 mm bolts into the holes (these holes have only 3-5 threads, do not tighten) and pull out the TLA.

Figure Six

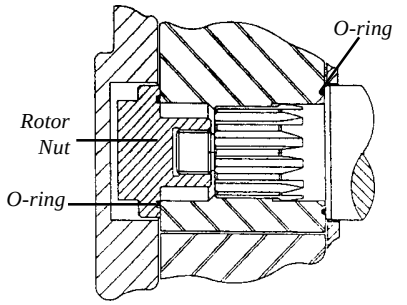


Figure Seven

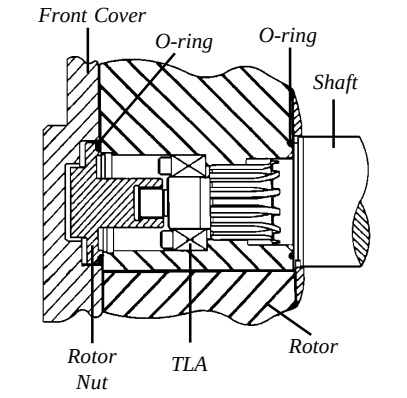


Table Four

Rotor Retention

Model Code	Torque (ftlb)	Torque (Nm)	Wrench Size (mm)
TSR1	10	14	17
TSR2	57	77	24
TSR3	89	120	24
TSR4 to 6	119	160	36

Table Five

Model Code	Type of Rotor Retention	Shaft Spline Sealing
TSR1	Hex Nut	O-Rings
TSR2	Hex Nut	O-Rings
TSR3	Hex Nut	O-Rings
TSR4	Hex Nut or TLA	O-Rings
TSR5	Hex Nut or TLA	O-Rings
TSR6	TLA	O-Rings

GENERAL MAINTENANCE

Figure Eight

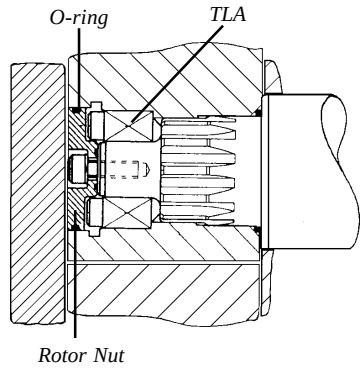
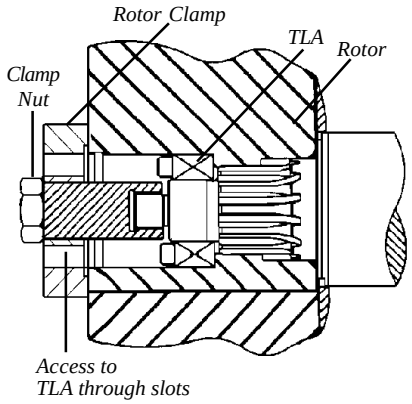


Figure Nine



Removing the Rotors

1. Before starting to dismantle the pump, isolate the driver/pump from all power and control supplies, purge the system if any hazardous products have been pumped.
2. Ensure isolating valves to the pump are closed.
3. Carefully loosen the front cover retaining nuts, there may still be residual pressure in the system.
4. Remove the front cover retaining nuts and take off the cover.
5. At this point, it may be advisable to flush out the pump head before continuing.
6. Loosen the rotor retaining nuts and remove them. For TSR6 pumps, the torque locking assemblies should now be removed, see ***Torque Locking Assemblies (TLA) - Release Instructions***.
7. Extract the rotors which should slide out from the splines.
8. Inspect front cover, rotor, rotor nut o-rings and replace as necessary.

Removing the Rotorcase

1. Remove rotor as described in ***Removing the Rotors.***
2. Disconnect the suction and discharge piping.
3. If the pump is fitted with a packed gland seal, loosen the gland followers. If the pump is fitted with a double mechanical seal arrangement, remove the housing retaining nuts and ease the housing away from the rotorcase.
4. Remove the frame nuts.
5. The rotorcase can now be tapped forward with a soft mallet until it clears the locating dowels. If the pump is fitted with mechanical seals, care must be taken to support the rotorcase as it comes off the dowels, otherwise the seals may be damaged.
6. Once the rotorcase is removed, the seals can be examined.

Installing and Shimming the Rotorcase

When installing a casing, correct shimming is critical. Shim packs fastened onto the casing are used between the casing and frame to control the clearances between the rotor and casing. Plastic color coded shims are used under the plate on pumps rated up to 266°F and metal shims on pumps with 392°F specifications. If the pump has previously been shimmed, the old shims may be reused, provided they are not removed or mismatched from underneath the shim plates. It is essential that identical shimming is used both top and bottom of the casing to ensure that equal clearances are maintained across the rotor faces.

To reinstall the casing, the following step by step procedure should be used.

Note:
Care should be taken when sliding the casing over the shafts not to damage the mechanical seals, if installed. When installing the shims, ensure that similar clearances are achieved both on the top and on the bottom of the casing.

Figure Ten

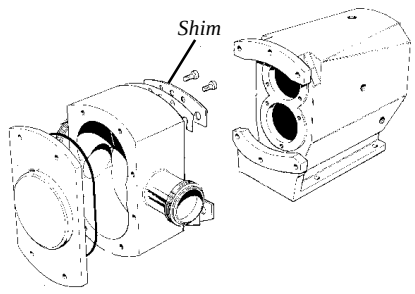


Table Six

Rotor TLA

Model Code	Torque (ftlb)	Torque (Nm)	Key (mm)	Rotor Cap Type	Retention Torque
TSR4	3.0	4.1	3	M5 screw	n/a
TSR5	6.3	8.5	4	M6 screw	n/a
TSR6	10.3	14.0	5	36mm hex nut	118 ftlb

1. Check that the seals are correctly installed.
2. If new shims are to be installed, use the following procedure. Remove the casing from the frame. Insert the thinnest shim between the casing and shim retainer at both top and bottom, and tighten the shim retainer screw to the required torque, see ***Technical Specification Chart***. Reinstall the rotors. The back clearances, i.e. the gap between the back surface of the rotors and back wall of the casing cavity, can now be measured to determine the additional shimming required to bring the clearance within tolerance. See ***Clearances*** sections for specific dimensions
3. Install the additional shims, and recheck the clearances. If necessary, repeat the above exercise until the clearances come within tolerance.
4. Tighten casing retaining nuts to the specified torque, see ***Technical Specification Chart***.

Reinstalling the Rotors

1. Rotors used on TSR pumps have sealing o-rings. Check the condition of the o-rings, and fit new rings if necessary.

Tri-Lobe Rotors (see *figure eleven*)
TSR tri-lobe rotors are fully interchangeable, and the master lobe in each case is identified by a machined dimple. When installing the rotors, correct timing is achieved by ensuring that the master lobes on each rotor are in line with each other. The recommended fitting procedure is as follows:

- ✓ Rotate the drive shaft until the keyway is uppermost (not essential).
- ✓ Install the bottom rotor with the master lobe in the twelve o'clock position.
- ✓ Install the top rotor with the master lobe also in the twelve o'clock position.

Bi-Lobe Rotors (see *figure twelve*)
TSR bi-lobe rotors are fully interchangeable, and only the master lobe of the master rotor is identified by a machined dimple. Correct timing is achieved by ensuring that the rotors are perpendicular to one another. Bi-lobes can be assembled and timed as follows:

- ✓ Insert either rotor on to either shaft and rotate it so that either lobe is vertical.
- ✓ Insert the other rotor so that the lobes are horizontal.
- ✓ It is important to check by rotating the assembly by hand, since some sizes can be fitted "one spline out". Any reference to the drive shaft keyway, dimple on the rotor, etc. is unnecessary. The major reason for the dimple is to differentiate between the two rotor orientations, i.e. the different relationship between the splines and the rotor profile.

Note:
Prior to restarting the pump, the pump shaft should be turned by hand to ensure free rotation without contact taking place between the rotors.

2. Replace the rotor nuts, and tighten to the recommended torque. For rotors which are retained by torque assemblies, see ***Rotor Retention***.
3. Before installing the front cover, examine the o-ring and replace if damaged. Install front cover, and tighten the nuts to the recommended torque values, see ***Technical Specification Chart***.

Figure Eleven

Rotors

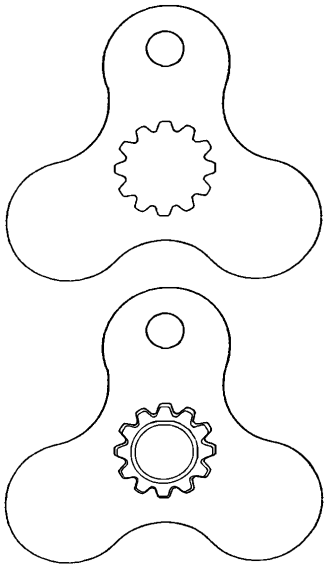
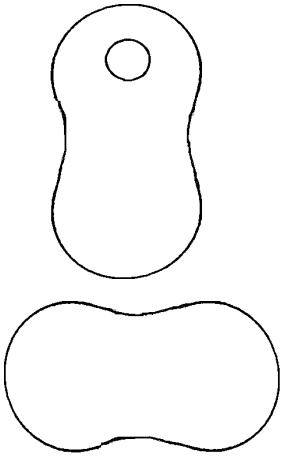


Figure Twelve

Rotors



MECHANICAL SEALS

The TSR range may be fitted with a single or double mechanical seal, see *figure thirteen.*

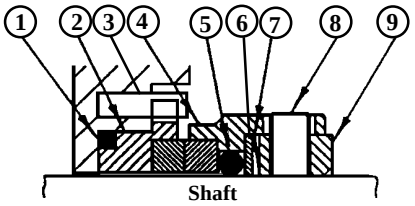
Table Seven

Seal Settings

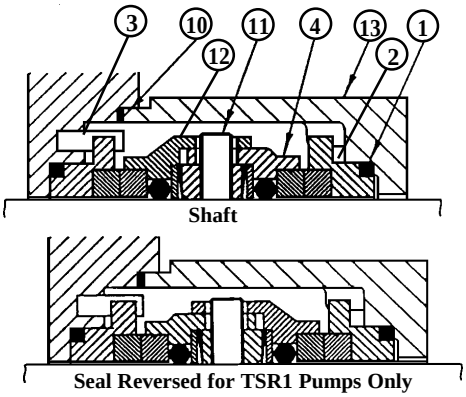
Pump Code	Setting Dimensions MM	Inches
TSR1	33.6	1 5/16
TSR2	35.6	1 13/32
TSR3	38.1	1 1/2
TSR4	39.6	1 9/16
TSR5	47.6	1 7/8
TSR6	50.7	2

Figure Thirteen

Single Mechanical Seal



Double Mechanical Seal



Item	Description
1	Seat O-Ring
2	Stationary Seat
3	Anti-Rotation Pins
4	Rotary Face (Single)
5	Shaft/Seal O-Ring
6	Washer
7	Wave Spring
8	Set Screw (Single)
9	Drive Ring
10	Gasket
11	Set Screw (Double)
12	Rotary Face (Double)
13	Seal Housing

The single mechanical seal is comprised of a stationary seat (2) and rotary assembly. The stationary seat (2) is pressed into the rotorcase and sealed by an o-ring (1). The seat is kept from rotating by three anti-rotation pins (3). The rotary assembly is comprised of a drive ring (9), three cup pointed set screws (8), a wave spring (7), a washer (6), an o-ring (5), and a rotary face member (4). The set screws project radially from the drive ring and engage with slots in the face member, thus providing drive, while at the same time holding the assembly together.

The double mechanical seal is comprised of two stationary seats (2) and a rotary assembly. The stationary seats are located in the rotorcase and seal housing (13) and each is sealed by an o-ring (1). The rotary assembly for the double mechanical seal consists of the same components as the single mechanical rotary assembly with the substitution of item 11 for item 8, and the addition of an outboard rotary face member (12), another washer (6), o-ring (5) and spring (7).

Handling the Mechanical Seal

When removing or replacing any mechanical seal, it should be remembered that all seals of this type rely on

- ✓ Their precision Lapped Faces.
- ✓ The internal and external o-rings.
- ✓ The working length.

When removing or installing mechanical seals to the pump, care must be taken handling the seal faces (items 2, 4, and 12 on *figure thirteen*). They must not be placed face down since any damage such as scratches or chips will almost certainly result in leakage. Similar care should be taken to protect the o-rings (items 1 and 5 on *figure thirteen*).

Preparation Prior to Seal Installation

1. All leading edges of the shaft over which the o-ring must pass should be chamfered.
2. Ensure the shaft diameter onto which the seal is to be fitted is clean and smooth.
3. Remove all sharp edges and burrs over which the seat o-ring must pass.
4. Check that the eccentricity between the bore of the seat housing and the shaft is within .005" full indicated movement.
5. Thoroughly clean the shaft and rotorcase counterbore which will hold the seal seat.

Seal Setting

The working length of the single seal is critical, and on some TSR models, designed for arduous working conditions, there will be an abutment spacer on the shaft. *Table seven* gives the setting dimensions for those pumps which do not have an abutment spacer.

The double seal is retained in a housing of predetermined size, therefore adjustment of the setting length is not required.

Installing the Single Mechanical Seal/Single Mechanical Seal with Flush

1. Carefully remove the protective packaging from the seal. Faces and seats are brittle materials, care must be taken during installation not to scratch or chip these components.
2. Using a clean soft cloth, wipe the lapped surface of the seat (item 2 on f*igure thirteen*) and the face (item 4) perfectly clean.
3. When using solid or PTFE Encapsulated o-rings (items 1 and 5) soak them in hot water at 140°F to promote flexibility.

4. Before locating the seat o-ring (1) onto the seat (2), place the seat to the back of the rotorcase to ensure that the drive scallops on the perimeter of the seat line up with the three anti-rotation pins.
5. Lubricate the o-ring (item 1) with Tri-Clover L-1011A spray lubricant (i.e. silicone grease), and firmly press onto the seat (item 2) until the o-ring is fully seated.
6. Lubricate the outside diameter of the o-ring, and firmly press the seat complete with o-ring into the rotorcase counterbore by hand.
7. Lubricate the rotary assembly o-ring (item 5), and fit into rotary assembly.
8. To enable the rotary assembly to be set to its correct working length when a seal spacer is not used, it is advisable to mark the shaft where the back of the seal locates. See *table seven* and *figure fourteen*.
9. Lubricate the shaft with Tri-Clover L-1011A spray lubricant (i.e. silicone grease).
10. Where applicable: lubricate seal spacer o-ring, and install the o-ring into the seal spacer. Slide seal spacer onto the shaft with the end of the spacer containing the o-ring positioned closest to the rotor end of the shaft.
11. Ensure that the set screws do not protrude into the bore of the drive ring (item 9). Fit rotary assembly over shaft.
12. Gently slide the rotary assembly along the shaft until it reaches its correct working position. Lightly tighten the set screws (item 8) until the drive ring (item 9) is centralized on the shaft. The set screws can then be fully tightened progressively. If the pump has a flushed mechanical seal, skip to step 14.
13. Install rotorcase, refer to ***Installing and Shimming the Rotorcase*** and ***Reinstalling the Rotorcase.***

Single Mechanical Seal with Flush (See *figure sixteen*)

14. Press the lip seals into the seal housings.
15. Place the seal housing gasket into the casing bore.
16. Draw the seal housing front face against the gasket by lightly tightening the retaining nuts.
17. Install the rotorcase, taking care not to damage lip seals. Refer to ***Installing and Shimming the Rotorcase*** and ***Reinstalling the Rotorcase.***
18. Equally and alternatively tighten the housing retaining nuts until the face of the housing is snugly seated against the housing gasket.

Note:
The rotary assembly should be correctly assembled by ensuring the chamfer of the drive ring is always on the gearcase side of the rotary assembly. See *figure fifteen*.

Installing the Double Mechanical Seal (See *figure seventeen*)

1. Carefully remove the protective packaging from the seal. Faces and seats are brittle materials, care must be taken when installing not to chip these components.
2. Wipe the lapped surface of the seats (item 2) and the faces (item 5) and (item 10) perfectly clean.
3. When using FEP Encapsulated or solid PTFE o-rings (items 1 and 5), soak them in hot water at 140° F to promote flexibility.

Note:
As the set screw is not centrally positioned across the length of the drive ring, it is important to refer to the drawing for the correct orientation of the drive ring. See *figure fifteen* for chamfer location.

Figure Fourteen

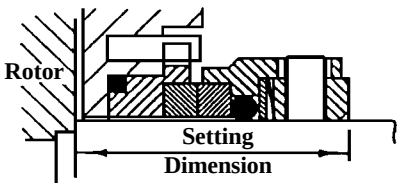


Figure Fifteen

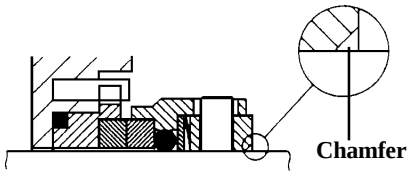
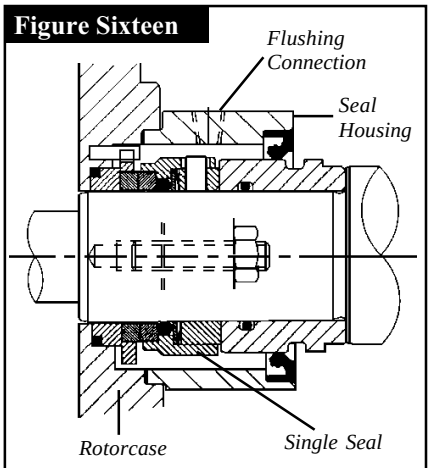
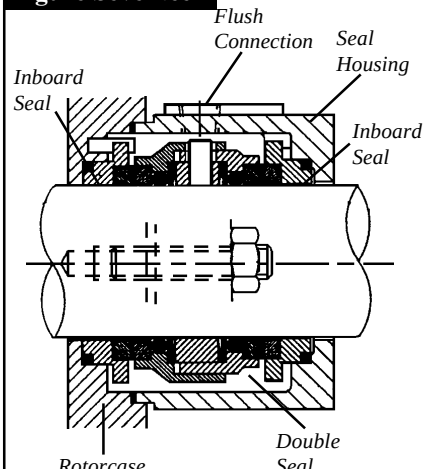


Figure Sixteen



Single Seal with Mechanical Flush

Figure Seventeen



Double Mechanical Seal

4. Before locating the seat o-rings (item 1) onto the seats (item 2), place the seat to the back of the rotorcase to ensure that the drive scallops on the perimeter of the seat line up with the three anti-rotation pins and the lugs in the seal housing.
5. Lubricate the o-rings (items 1) with Tri-Clover L-1011A spray lubricant (i.e. silicon grease), and firmly press onto the seats (items 2) until the o-rings are fully seated.
6. Lubricate the outside diameter of the o-rings, and firmly press the seats complete with o-rings into their housings until they bottom out.
7. Fit the seal housing to the shafts.
8. Lubricate the rotary assembly o-rings (item 5), and fit into rotary assembly.
9. Lubricate the shaft with Tri-Clover L-1011A spray lubricant (i.e. silicone grease).
10. Ensure that the set screws do not protrude into the bore of the drive ring. Fit rotary assembly over shaft.
11. Install a new gasket (item 10) into casing counterbore.
12. Gently slide the seal along the shaft until it abuts against the seal housing (13) making certain that the assembly is correctly oriented. See *figure thirteen*
13. Install rotorcase, refer to ***Installing and Shimming the Rotorcase*** and ***Reinstalling the Rotors***.
14. The seal housing is then secured in position by two nuts, which must be evenly tightened to ensure the gasket is leak tight, but must not be over tightened so as to transmit distortion to the seal seats which may reduce the seal life or cause irreversible damage to the seal.
15. The set screws can now be accessed through the flushing holes, and should be tightened progressively to ensure that the drive ring is located centrally on the shaft.

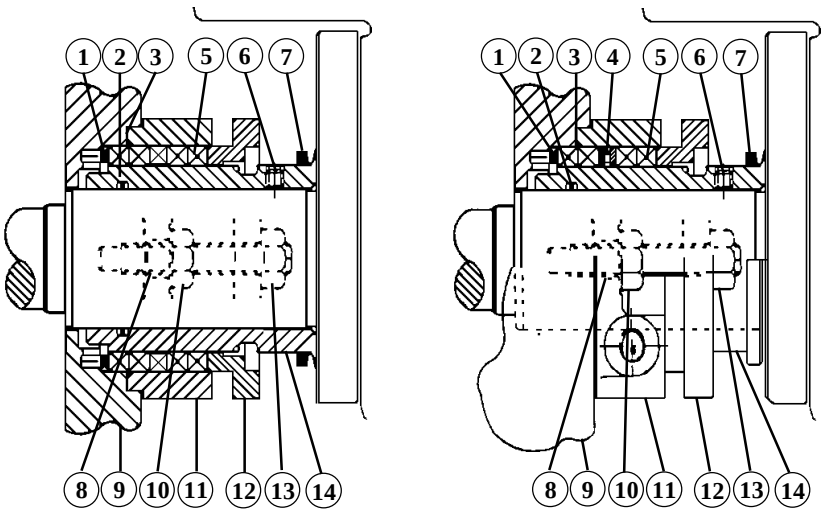
PACKED GLANDS

A typical packed gland assembly for the TSR pump is shown in *figure eighteen*. When correctly assembled and adjusted, a slight loss of product should occur so as to lubricate the packing and shaft sleeve.

The two most popular packed gland arrangements are shown in *figure eighteen* Part A and Part B. Part A shows the standard option, while part B shows the flushed packed gland with lantern ring and the liquid flush connections.

Figure Eighteen

1 Spader Gland
2 O-Ring
3 Gasket
4 Lantern Ring
5 Gland Packing
6 Set Screw
7 Ring Slinger
8 Stud
9 Rotorcase
10 Nut
11 Gland Housing
12 Gland Follower
13 Adjusting Nut
14 Shaft Sleeve



The shaft sleeves are retained by three hexagon set screws and are sealed to the shaft by an internal o-ring which should be replaced if new sleeves are fitted. The tightening torques for the hexagon set screws are given in *table eight*.

Table Eight

Model Code	Torque Nm	Torque ftlb	Key mm
TSR1	3.0	2.2	2.5
TSR2	4.0	2.9	3.0
TSR3	4.0	2.9	3.0
TSR4	4.0	2.9	3.0
TSR5	14.0	10.3	4.0
TSR6	14.0	10.3	4.0

Preparation Prior to Packing Glands

When the gland needs repacking, the following points should be noted.

1. Ensure that the packing you are installing is the correct size, and the correct number of rings are available. If lantern rings are used, check that they are in the correct sequence for the lantern ring to align with the flushing holes. (Preformed packing rings with scarf joints are used as standard).
2. Ensure that the gland housing is in a good and clean condition. The gland housing bore can easily be damaged by over tightening the packing which can spin with the shaft causing undercuts in the housing. This will make adjusting new packing almost impossible.
3. The shaft sleeve (which is replaceable) should also be carefully examined before fitting new packing, and if grooved, should be replaced as the gland will not seal to an acceptable level.

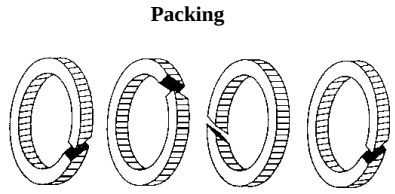
Note:
On non-food applications apply anti-seize to the shaft sleeve area before reinstalling the shaft sleeve.

Repacking the Gland

The easiest way to repack the gland is in a number of progressive steps. Old packing rings are removed from the front of the gland housing, and new rings inserted in the back of the gland housing. The gland follower can then be used to push the packing forward thus making more old packing accessible at the front of the gland housing. This is described in more detail as follows.

1. Ensure the pump head has been drained.
2. Release and remove gland follower nuts, and pull back the gland housing.
3. Release and screw back the gland housing nuts, and pull back the gland housing.
4. At this point, the gasket should be inspected for damage and replaced if necessary.
5. Two packing rings should now be visible. These should be removed. An appropriate tool will be required to pick out the packing.
6. Push the gland housing forward and tighten the nuts.
7. Insert the first new packing ring into the gland housing.
8. Push the gland follower forward, replace the gland follower adjuster nuts and tighten. This will push the old and new packing forward. Release and remove gland follower nuts, and pull back gland followers.
9. Insert the second new packing ring into the gland housing. The new packing rings should be fitted with the joint 120° apart.
10. Push the gland follower forward, reinstall the gland follower adjuster nuts and tighten. This will push the old and new packing forward. Release and remove gland follower nuts, and pull back gland followers.
11. Release and screw back the gland housing nuts, and pull back the gland housing.
12. The next two old pieces of packing will now be visible. These should be removed.
13. This process should be repeated until all old packing has been pushed forward and removed from the front of the gland housing, and new packing has been installed. Where the seal is flushed, the lantern ring should be removed and replaced as part of this process. Care should be taken to ensure that the lantern ring is reinstalled in the correct sequence. The new packing rings (and lantern ring where applicable) should always be installed at the back of the gland housing.

Figure Nineteen



Adjusting the Packed Gland

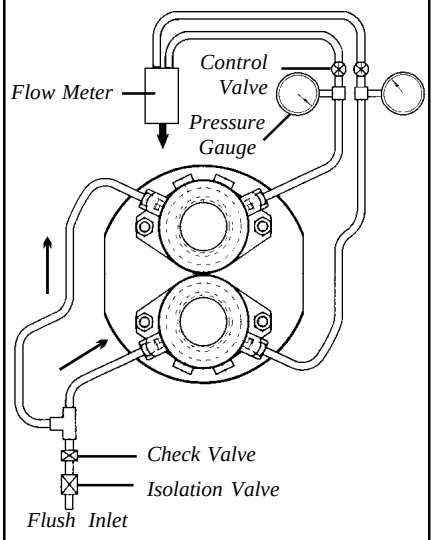
A little care when first adjusting will result in optimum packing life.

1. Ensure that the gland follower is square against the last ring of packing, lightly tighten remembering that the gland **must** weep to lubricate the packing rings. Care taken on adjustment will dictate the packing life.
2. Open suction and discharge valves if equipped, and flood the pump head. If the leakage is unacceptable, steadily tighten the packing until the leakage is reduced to an acceptable rate.
3. Start pump and allow to run for ten minutes while keeping a check on the gland housing temperature. If the housing becomes significantly hotter than the surrounding casing, then the gland has been over tightened, stop the pump and allow it to cool. Repeat the procedure ensuring the gland is still weeping.
4. Once the pump is running without the gland overheating for approximately ten minutes, the gland follower nuts can be tightened by $^1/_6$ of a turn at ten minute intervals until the leak is at an acceptable rate. Drip leakage is essential to prevent overheating of the gland area which will cause seal failure.

Table Nine

Pump	Connection
TSR1 TSR2 TSR3	$^1/_8$" NPT
TSR4 TSR5 TSR6	$^1/_4$" NPT

Figure Twenty



Pipework & fittings not supplied with pump

Note: This arrangement is for double mechanical seals or packed glands. If the pump is installed with single mechanical seals, the pressure gauge and control valve should be installed on the inlet side of the system.

FLUSHED SEAL ARRANGEMENTS

Many seal arrangements rely on the circulation of a flushing fluid around the seal area. This is done for one or more of the following reasons:

- ✓ To carry away product or unwanted product residue.
- ✓ To cool the seal area.
- ✓ To provide a product barrier.

It is therefore important that;

- ✓ The flush is correctly connected.
- ✓ A suitable flushing fluid is used.
- ✓ The fluid is supplied at the correct pressure and flow rate.
- ✓ The flush is turned on prior to starting the pump.

Connecting the Flush

The recommended method of connecting the flush for double mechanical or packed gland seals is detailed in *figure twenty*. The outlet side of the flushing circuit should include a control valve and pressure gauge. This will enable the correct flushing pressure to be obtained and monitored. If the pump is installed with single mechanical seals, the pressure gauge and control valve should be installed on the inlet side of the flush system.

Suitable fittings should be used to connect to the housings, the housing connection sizes are given in *table nine*. Both the pipe and fittings must be able to withstand the required flushing pressure. The fittings may be of any material that is of the correct pressure rating.

In addition, the following equipment is shown in *figure twenty*. While these are not essential, their use is strongly recommended.

- ✓ Isolation valve and check valve. These will enable the flush to be turned off, and stop any unwanted substances flowing in the wrong direction.
- ✓ A system that will act as a visible indication of flow. (In this case a flow meter is shown.)

Where the pump is installed with a gland guard, the guard must be modified to suit the flushing pipe work and reinstalled.

Flushing Pressure and Flow Rate

To enable the flush to operate correctly, the flushing fluid must be supplied at the correct pressure. This pressure is dependent upon the pumping pressure.

The following is a guide to the correct flushing pressure.

- ✓ **Single Mechanical Seal:** Flushing pressure should be 5 psi max.
- ✓ **Double Mechanical Seal, and Packed Gland Seal:** Flushing pressure should be 5 psi over discharge pressure.
- ✓ **Steam Flushing:** The above pressures and flow rates may not be applicable to Steam Flushing, Tri-Clover Inc. should be contacted for advice.

Flushing Fluid

The flushing fluid is dependent upon the product pumped and will vary from pump to pump. For advice on selecting a suitable flushing fluid, please contact Tri-Clover Inc.

REMOVAL OF REAR GEARCASE COVER AND REPLACEMENT OF SEAL

1. Isolate the motor, remove any coupling or V-belt guards.
2. If the pump is direct coupled, it will be necessary to disconnect the coupling and remove the pump from the baseplate to gain access to the rear oil seal.
3. If the pump is belt driven, release the tension on the belts and remove them, remove the pulley and drive key.
4. If the pump is oil lubricated, drain the oil. (From the bottom chamber only on pump sizes 4 through 6). See ***Lubrication*** section.
5. For grease lubricated pumps, the easiest way to perform this operation is with the pump resting on its front cover and drive shaft vertical. If this is not possible and the pump remains horizontal, provision should be made to collect the grease that leaks out when the gearcase cover is removed. It is important to catch all the grease that leaks out, since the quantity must be measured and the identical amount put back into the pump. If a clean tray is used, the grease can be reused.
6. As the cover is sealed to the gearcase with a liquid gasket, it may require a sharp tap with a mallet and punch to break the seal.
7. Remove the cover and press out the oil seal, and replace with a new seal.
8. Clean the faces of both the gearcase and the end cover, coat the faces with suitable liquid gasket, and reinstall. Make sure pump drive shaft is clean and smooth and free of nicks and burrs that might damage the oil lip seal. Replace the retaining screws, then centralize the lip seal on the shaft before tightening to the recommended torque value, see ***Technical Specifications Chart***.
8. If a clean tray has been used to catch the drained lubricant, the lubricant can be reused. Otherwise, if oil filled, top up to the center line of the sight glasses, and if grease filled use the holes provided to add a quantity identical to that which has drained out of the pump, see ***Lubrication*** section.

Figure Twenty-One

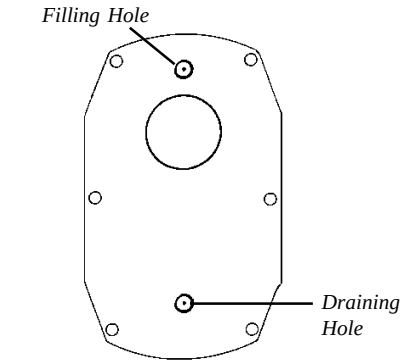


Figure Twenty-Two

Torque Locking Elements

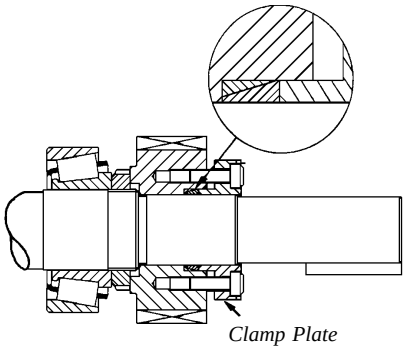
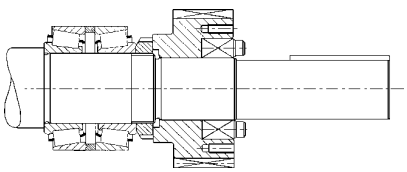


Figure Twenty-Three

Torque Locking Assembly (TLA)



TIMING GEARS

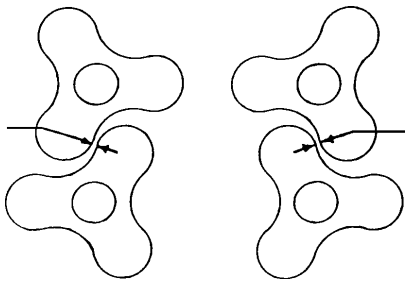
Each pump has a pair of timing gears. These are located in the rear of the gearcase and ensure sychronization of the rotors, such that under normal working conditions the rotors will not contact one another.

Within the TSR Range, two methods of gear retention are used. TSR1 to TSR3 pumps use torque locking elements, and pump models TSR4 to TSR6 employ torque locking assemblies (TLA's) (see *figures twenty-two* and *twenty-three*).

Table Ten

Pump Model	Torque (ftlb)	Keysize (mm)
TSR1	9	5
TSR2	12.5	5
TSR3	9	5
TSR4	10	5
TSR5	26	6
TSR6	26	6

Figure Twenty-Four



Gear Retention

Pumps TSR1 to TSR3 - Torque Locking Elements

The gears in TSR1, TSR2, and TSR3 pumps are retained with torque locking elements, see *figure twenty-two*. The axial load to the locking elements is applied through a clamp plate which is retained by three or six socket head screws. When installing the torque locking elements, they must be oiled (not greased) on all surfaces. The screws should be tightened to the torque values shown in *table ten*.

When timing the pump, the clamp screws must be loosened before moving the locking elements. The elements should not be forced. If the elements are made to slip, then the whole assembly should be released, and the above procedure repeated.

Pumps TSR4 to TSR6 - Torque Locking Assembly (TLA)

The gears in TSR4, TSR5, and TSR6 pumps are retained with torque locking assemblies (TLA's), see *figure twenty-three*. These are similar to the ones used to retain the rotors, and thus the same method for installing should be used. This is explained in ***Torque Locking Assembly (TLA) - Mounting Instructions***. When tightening the TLA's, the screws should be tightened to the torque values shown in *table ten*.

Timing Adjustment

The rotor timing (sychronization) is set in the factory. If the rotors become unsynchronized, they may be retimed using the following procedure.

Note:
The cause of the fault should be established and eliminated before proceeding.

To adjust the timing of the rotors, first remove the gearcase end cover, see ***Removal of Rear Gearcase Cover and Replacement of Seal***. Once the cover is removed the timing gears will be exposed.

To retime the rotors, only one of the timing gear retainers need be released enough to allow the rotors to be tapped into a position where they are synchronized. The rotors are correctly synchronized when the clearances at the measurement points are equal, see *figure twenty-four*.

Use feeler gauges to measure the clearances at the positions illustrated in figure *twenty-four*, and adjust until equal. The pump is then correctly timed. Tighten the screws for the gear retention. See *figure twenty-two* for TSR1 to TSR3 and figure *twenty-three* for TSR4 to TSR6. Replace the gearcase cover, see ***Removal of Rear Gearcase Cover and Replacement of Seal***.

Timing Gear Removal

The bore of the timing gear is a transitional fit on the shaft diameter. In some cases, therefore, interference will occur, and an extractor tool may be required to pull the gear off. Threaded holes are provided on all gears for fitting extractor tools.

To remove the timing gears, the following procedure is recommended.

1. Remove the rear gearcase cover, see ***Removal of Rear Gearcase Cover and Replacement of Seal***.
2. Release torque locking element or assembly.
3. An extractor tool should be used to pull the gear off. If the gearcase has twin lubrication chambers, lubricant may drain out when the top gear is removed.

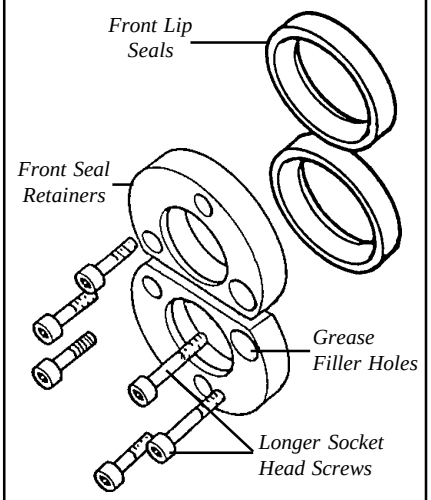
Lip Seal - Removal and Reinstallation

The bearing lip seal is only installed to gearcases with twin lubrication chambers and fits behind the top shaft rear bearing housing. The lip seal runs on a boss at the back of the timing gears, and prevents the top chamber lubricant from draining into the bottom chamber. If the lip seal is to be reused, care should be taken when extracting it not to damage the sealing edge, otherwise a new lip seal should be installed. To reinstall a seal, it should be pressed evenly into the bore, and a flat plate or dolly used to seat it.

Replacing the Front Frame Grease Seals

1. Remove rotorcase front cover, rotors and rotorcase, see ***General Maintenance***.
2. Remove the mechanical seal, see ***Mechanical Seals***, or the shaft sleeve if a packed gland is installed, see ***Packed Glands***.
3. Three socket head screws retain the seal carrier, once removed the carrier can be extracted. As silicone sealant or a gasket is used to seal the faces, the carrier may have to be eased off carefully with a lever.
4. Once the carriers are removed from the pump, the seals can be pressed out, and replacements pressed in using a suitable dolly.
5. Ensure the surface area which the seal will run on is free from scratches. If the surface is scratched, clean up damaged area with a fine grade abrasive cloth. Ensure that all traces of abrasive material are cleaned away before reinstalling the new oil seals.
6. Before replacing the seal carriers, see *figure twenty-five*, clean the old silicon sealant (if used) from the rear face of the carrier and from the front face of the gearcase. Coat the rear face of the carrier with new silicone sealant, or install a new gasket, slide into position and replace the three socket head screws. It must be noted that one of the three screws is longer, this should be inserted in the hole which aligns with the largest hole in the gearcase, see *figure twenty-five*. Tighten the screws evenly to the recommended torque value, see ***Technical Specifications Chart***.
7. Reassemble the seals and rotorcase, see ***General Maintenance*** for setting dimensions and reinstallation procedures.

Figure Twenty-Five



Installing the Timing Gears

1. Install the rotors to the shafts to establish the timing.
2. If the gearcase has double lubrication chambers, check that the bearing lip seal is installed. Check that the boss on the back of the gear is smooth, and smear some lubricant onto it.
3. Slide on the gears. They may require heating up. Use an induction heater or hot oil bath up to 230° (TSR1, 2 and 3 are heated to 284°F). Where gears are marked as pairs, they should be reinstalled with the timing marks in alignment.
4. Install the timing gear locking elements or assemblies, and tighten one gear up, see ***Gear Retention***. Check the timing, see ***Timing Adjustment***, before tightening up the last gear.

GEARCASE DISASSEMBLY

Shaft Removal

1. Remove rotorcase front cover, rotors and rotorcase, see ***General Maintenance***.
2. Remove product seals, see ***Mechanical Seals*** and ***Packed Glands***.
3. Remove the gearcase rear cover, timing gears and drain lubricant, see ***Removal of Rear Gearcase Cover and Replacement of Seal***.
4. Remove the gearcase front seal retainers and seals, lubricant will drain from top chamber if grease filled, see ***Replacing the Front Gearcase Seals***.
5. The shaft assemblies can now be removed through the front end of the gearcase, a soft faced mallet may be used to tap them out. Where the pump has double lubrication chambers, the top chamber can now be completely drained. Ensure that the spacer located in one of the bottom shaft bearing bores is retained for reinstallation.

Bearings - General

The TSR range of pumps utilize taper roller bearings which are arranged in one of the following ways:

- ✓ single front and back bearings separated by a large spacer
  or

Figure Twenty-Six

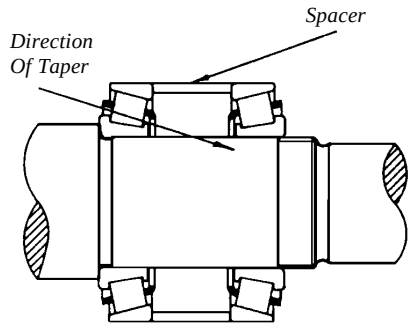
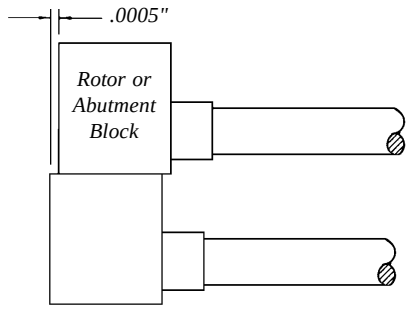


Figure Twenty-Seven



- ✓ two sets of double bearings front and back, assembled with individual spacers.

Bearing Removal

To remove the bearings, loosen the notched bearing nut using a C-spanner, the bearing assembly can now be dismantled. The bearing cones are shrunk onto the shaft and will require pressing off.

Installing Bearings to Shaft

Single Bearing Assemblies

1. Load shaft into vice in a vertical position, and apply anti-seize compound to the bearing diameters.
2. Use an induction heater or oil bath to heat the front bearing cone to 230° F (TSR1, 2 and 3 are heated to 284° F). Pass the bearing over the rear bearing diameter, and ensure a positive fit on the front bearing diameter against the shaft shoulder. The bearing taper should be towards the gear end of the shaft, see *figure twenty-six*.
3. Locate outer race of bearing onto the cone just installed.
4. Locate bearing spacer onto race just installed.
5. Locate rear outer bearing race onto the spacer.
6. Heat rear bearing cone to 230° F (TSR1, 2 and 3 are heated to 284° F), and install to bearing diameter. The taper should be towards the rotor end of the shaft, see *figure twenty-six*.
7. Allow bearings to cool.
8. Locate shaft in vice in horizontal position taking care not to damage seal and bearing surfaces.
9. Apply Permabond grade 145 sealant or equivalent to the shaft lock nut thread, and screw lock nut onto the shaft. While continuously rotating both bearings and spacer, torque up the bearing lock nut until the spacer cannot be moved radially (off the shaft center line) by finger pressure alone, but can be moved with a light blow of a mallet.

Double Bearing Assemblies

1. Follow the above procedure for the front set of bearings.
2. Repeat the above procedure for the rear set of bearings, but in this case torque up the lock nut until the spacer can be just moved by finger pressure alone.

Shaft Replacement

Gearcases are assembled with the top shaft bearing locating against a machined surface in the bearing housing, and the bottom shaft bearings butting against a spacer found in the bearing bore. When a new gearcase is being built, this spacer is initially oversized, such that the axial displacement in the rotor abutment shoulders can be measured and the appropriate spacer fitted, or the existing spacer ground to suit, see *figure twenty-seven*. When rebuilding a used gearcase the axial displacement should be checked; however, it will normally be within tolerance, 0.012 mm or 0.0005".

Replacing Single Bearing Shaft Assemblies

1. Replace shaft abutment spacer into bottom rear bearing bore of the gearcase.
2. Install auxiliary shaft into gearcase.
3. Install drive shaft into gearcase.
4. Apply light smear of oil to front oil seals, and press into front seal retainers.
5. Install seal retainers to the gearcase without silicone sealant or a gasket at this stage, and torque the cap screws to their recommended value, see ***Technical Specification Chart***.
6. Fit rotors or shaft abutment blocks to the shafts, and torque rotor nuts to the recommended value, see ***Technical Specification Chart***.

7. Using a depth micrometer, measure from the front face of the bottom rotor to the front face of the top rotor, and record the axial displacement of the rotor abutment shoulders. When measuring off a pair of rotors, it is important to compensate for any small differences there may be in the rotor lengths.
8. The axial displacement should be less than 0.012mm (0.0005"), otherwise, the bottom shaft should be removed, and the spacer ground or an appropriate spacer installed to give an axial displacement of not greater than 0.012mm (0.0005").
9. Once both shaft shoulders are within tolerance of each other, remove both seal retainers, apply silicone sealant or install a gasket, replace and tighten retainer screws to specifications, see ***Technical Specifications Chart*** for torque values. Recheck to ensure alignment.
10. With the shafts installed, the timing gears and front end of the pump can now be installed, and the pump timed. See ***Timing Adjustments***.

Replacing Double Bearing Shaft Assemblies

The installation procedure is similar to that for the single bearing shafts, except that the abutment spacer is located into the bottom front bearing bore, between the front bearing and the housing.

LUBRICATION

The TSR gearcases have single and double lubricant chambers dependent on pump size; the units are grease or oil filled dependent on duty.

Note:
Ensure that any drive and gearcase units are filled with lubricant and serviced in accordance with manufacturer's instructions.

Lubrication Arrangements

Single Lubrication Chambers

These are used on series 1, 2 and 3 pumps, which have plain gearcases for grease lubrication, but have one filler/breather plug, oil level sight glass and drain plug for oil lubrication.

Double Lubrication Chambers

These are used on the series 4, 5 and 6 pumps, which have plain gearcases for grease lubrication, but have two filler/breather plugs, oil level sight glasses and drain plugs for oil lubrication.

Grease Filled Gearcases

Grease lubricated gearcases are filled prior to shipment.

When the pump units are operating at full pressure and speed, the grease should be changed every two years. This interval may be extended under normal operating conditions, (e.g. moderate pressure and speed) but should not exceed five years.

When the pump units are operating in arduous environmental conditions, (e.g. dust, high humidity accompanied by high daily temperature changes etc.), the grease should be changed more frequently, alternatively gearcase should be oil filled.

Draining Grease From Gearcase

Single Lubrication Chambers

These gearcases may be drained by removing the gearcase end cover, see ***Removal of Rear Gearcase Cover and Replacement of Seal***.

Double Lubrication Chambers

To drain the bottom chamber, remove the gearcase end cover, see ***Removal of Rear Gearcase Cover and Replacement of Seal***, and allow to drain.

To drain the top chamber involves the removal of the top shaft, see section ***Shaft Removal***. The shaft can now be reinstalled, refer to ***Shaft Replacement***, and the gears reinstalled, see ***Installing the Timing Gears***.

Refilling With Grease

Single Lubrication Chamber

Stand the pump on its front cover, and with the gearcase cover removed, fill the gearcase with the specified amount of grease, see *table twelve*, and reinstall the gearcase end cover.

Double Lubrication Chamber

With the shaft reinstalled into the gearcase, inject the specified amount of grease, see *table twelve*, into the top chamber through the top right seal retainer screw hole, as viewed from the front, which is counter drilled 1/4" BSP to take a grease nipple. Replace the seal retainer, see ***Replacing the Front Gearcase Seals***, and repeat the procedure for the lower chamber. Reinstall the seals, followed by the rotorcase, then the rotors and rotorcase cover, see ***Installing and Shimming the Rotorcase*** and ***Reinstalling the Rotors***.

Table Eleven

Lubricants

Grease Filled (-61°F to +266°F)	
Shell Tivela Compound A	
Oil Filled (-68°F to +176°F)	
BP	Energol GR-XP150
Castrol	Alpa SP120
Esso	Spartan EP150
Mobil	SHC 630
Shell	Omata 150
Texaco	Meropa 150
Jax	SynGear 220

Oil Filled Gearcases

Oil lubricated gearcases are typically dispatched without lubricant.

Before starting up, remove the oil filler plug(s), and fill gearcase chamber(s) with the recommended grade of oil (see *table eleven*) until it reaches the center of the oil level sight glass(es). Allow the oil to settle, and top up if necessary. Replace oil filler plug(s).

Note:
Do not over fill with oil, and ensure the oil breather is clear at all times.

After the first month or 250 working hours, whichever is sooner, drain the oil, clean out any sludge, and refill with new oil. It is recommended that, thereafter, the oil is replaced on an annual basis. When the pump units are operating in arduous environmental conditions, (e.g. dust, high humidity, etc.) the oil should be changed more frequently, and six month intervals are recommended.

If these grades are not readily available, any equivalent high quality gear lubricant of similar viscosity and characteristics may be used.

Note:
It is important when reassembling the pump to always replace the grease with new grease. Do not mix different types of grease.

Table Twelve *All measurements are in ounces*

Model Code	Top Chamber	Bottom Chamber	Total
TSR1/___/S_	Single	Chamber	6.0
TSR1/___/L_	Single	Chamber	8.5
TSR2/___/S_	Single	Chamber	14.5
TSR2/___/L_	Single	Chamber	17.0
TSR3/___/S_	Single	Chamber	29.0
TSR3/___/L_	Single	Chamber	39.0
TSR4/___/S_	9.5	17.5	27.0
TSR4/___/L_	12.0	25.5	37.5
TSR5/___/S_	13.5	37.0	50.5
TSR5/___/L_	21.0	46.5	67.5
TSR6/___/S_	27.0	61.0	88.0
TSR6/___/L_	44.0	78.0	122.0

RELIEF VALVES

The TSR pump range can be supplied, or retrofitted, with a relief valve. The relief valve is designed to protect the pump from damage that can be caused by over-pressurization.

Relief valve setting is achieved by tightening the notched nut/lock nuts. This increases the pressure at which the valve will be relieved, i.e. the point when the hydraulic piston moves forward and allows a free flow of product, around the front of the rotors.

WARNING! Over pressurization will occur if:

a) A valve is closed against the pump discharge.
b) The product viscosity in the system is increased significantly.
c) The pump speed is increased.

Figure Twenty-Eight

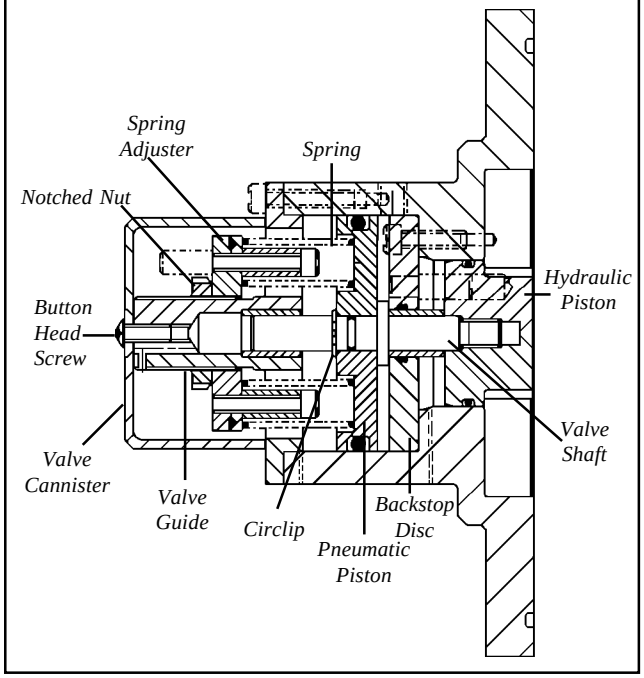
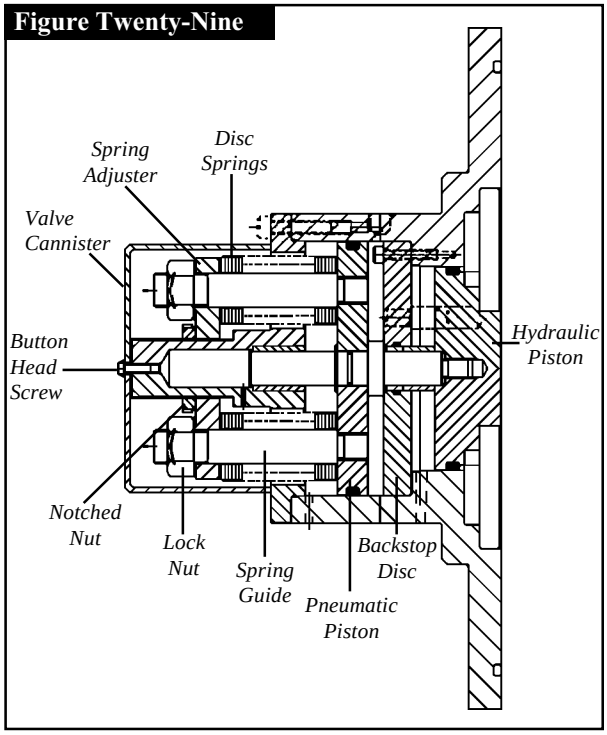


Figure Twenty-Nine



There are two relief valve styles, one for the TSR1-TSR5 (see *figure twenty-eight*) pump range and the other for TSR6 pumps only (see *figure twenty-nine*).

Air Operation

The relief valve may be released by supplying air through the air connection, which makes it ideal for a CIP system. Air supplies must be clean and dry and supplied between 60 psi and 120 psi.

The air connection is positioned on the outside of the valve housing and will be threaded according to the pump size shown in *table thirteen*.

The connections must be made via a standard instrument valve which vents the air from the chamber if no air is being supplied.

Table Thirteen

Pump	Connection
TSR1 TSR2 TSR3	1/8" BSPT or NPT
TSR4 TSR5 TSR6	1/4" BSPT or NPT

Checking the Air Operation of the Relief Valve

It is possible to check the air operation of the valve with the pump operating, but this should only be done when there is no pressure in the pump and system, the pump may therefore require stopping. To check if the valve is correctly operating using air, the following procedure should be adopted.

1. Remove the button head screw followed by the valve cannister.
2. Insert a thin rod through the button screw hole onto the end of the piston shaft, and mark the rod at the end of the valve guide.
3. Open the air supply to the valve, and push the rod onto the new position of the piston shaft, marking the rod as before.
4. Close the air supply and check that the piston has moved back to its original position by noting the position of the first mark on the rod.

Table Fourteen

Valve Type	Pump	Pressure Range PSI
Standard	TSR1-TSR6	101-276
Lever Operated	TSR1-TSR5	101-145
	TSR6	101

Valve Pressure Ranges

Table fourteen indicates the pressure ranges for the TSR pumps with standard or lever operated valves.

Adjusting the Relief Valve

Prior to dispatch the relief valve is tested on water to the customer's specified maximum working pressure. After testing, the valve springs are then released.

If the maximum system pressure, pump speed or product viscosity is changed, the valve will require resetting and valve springs may have to be changed.

Warning:
The relief valve will require setting to suit the site conditions.

The following details the procedure for adjusting the relief valve. Before continuing, ensure that the pump is not operating.

TSR1-TSR5 Relief Valve

1. To ensure accurate adjustment of the relief valve, a pressure gauge should be installed into the pumping system close to the discharge side of the pump.
2. Remove the button head socket screw, and remove the valve cannister.
3. Ensure the notched nut is released, so that no springs are being compressed.
4. Insert a thin rod through the button screw hole onto the end of the piston shaft and mark the rod by the valve guide.
5. Restart the pump and note the pressure of the system when the rod starts to move, i.e. the valve is beginning to open and the pressure is dropping slightly.
6. Tighten the notched nut inwards by fine adjustments until the correct system pressure is achieved and therefore, any increase in system pressure will activate the valve.
7. To ensure no further movement of the valve it is recommended that a commercial thread locking adhesive is applied to the thread/notched nut.

TSR6 Relief Valve

1. To ensure accurate adjustment of the relief valve, a pressure gauge should be installed onto the pumping system close to the discharge side of the pump.
2. Remove the button head socket screw and the valve cannister.
3. With the pump stopped, insert a thin rod through the button screw hole onto the end of the valve shaft and mark the rod by the valve guide.
4. Tighten the notched nut up to the spring adjuster as far as possible, using finger pressure only.
5. Restart the pump and note the pressure of the system when the rod starts to move, i.e. the valve is beginning to open and the pressure is dropping slightly.
6. Tighten the notched nut inwards by fine adjustments until the correct system pressure is achieved; and therefore, any increase in system pressure will activate the valve.

Note:
After each fine adjustment of the notched nut, the four lock nuts should be evenly tightened.

7. To ensure no further movement of the valve, it is recommended that a commercial thread locking adhesive is applied to the thread/notched nut.
8. The lock nuts should now be released by one complete turn, and if their self-locking properties have diminished, then thread locking adhesive should again be applied.

Valve Disassembly

Note:
It should only be necessary to completely dismantle the valve if o-rings are to be inspected and replaced, or springs are to be replaced for a different pressure rating.

1. Remove the button head screw followed by the valve cannister at the front of the valve assembly.

2. Release and remove the notched nut which retains the spring adjuster, followed by the valve nuts (TSR6 only).
3. Take off the spring adjuster and springs (disc springs TSR6 only). Release the socket head cap screws and remove the valve guide.
4. Access to the pneumatic piston and o-rings is achieved by releasing the circlip, which locates in the valve shaft, and carefully pulling the pneumatic piston out.
5. The valve backstop disc is retained by socket head cap screws, which screw into the valve front cover. These should be removed so that the backstop disc and hydraulic piston may be lifted out of the front cover using the valve shaft.
6. Unscrew the hydraulic piston from the valve shaft so that the backstop disc may be removed and access to its o-rings is achieved.
7. Inspect all o-rings, and replace as necessary.

Valve Assembly

Refer to relief valve drawings in *figures twenty-eight* and *twenty-nine*, and follow the assembly procedure to ensure correct assembly is achieved.

1. Locate the backstop disc with its o-ring, against the threaded side of the valve shaft shoulder.
2. Install the o-ring onto the hydraulic piston, and screw the piston onto the valve shaft.
3. Push the assembly into the front cover, and tighten the backstop disc socket head cap screws.
4. Locate the piston o-rings, and push the assembly onto and up to the valve shaft shoulder. The circlip may now be installed (TSR6 only). Install the springs.
5. Each spring guide (TSR6 only) should carry the same amount of disc springs. Take care in positioning them in the correct orientation.

Note:
The number of disc springs are selected to suit the duty conditions. If the duty conditions change, contact Tri-Clover for reselection.

6. Place the valve guide over the spring guides (TSR6 only), and tighten the socket head cap screws into the front cover.
7. Install the spring adjuster, lock nuts and notched nut followed by the valve housing and button head screw.
8. See ***Adjusting the Relief Valve*** to set the valve for the correct site conditions.

TROUBLE SHOOTING

Tri-Clover pumps are relatively maintenance free with the exception of sanitizing and lubrication. Like any piece of machinery, however, occasional problems can arise. The trouble shooting chart provides a means of determining and correcting most of your pump problems. The motor manufacturer should be contacted for specific repair instructions on the motor.

The trouble shooting chart has been prepared on the basis that the pump as installed has been properly suited to its application. Should problems arise when the remedies listed in the trouble shooting chart do not cure the situation, pump cavitation may be the problem. Symptoms of pump cavitation, such as noisy operation, insufficient discharge and vibration, can result when a pump is not properly applied. If these conditions are present, check the system and re-evaluate the application. If assistance is required, contact Tri-Clover at (414) 694-5511.

Problem	Possible Causes	Possible Solutions
1. No discharge	a. Incorrect direction of rotation.	a. Reverse Motor.
	b. Pump un-primed.	b. Expel gas from supply line and pumping chamber and introduce liquid.
	c. Insufficient NPSH available.	c. Increase supply line diameter. Increase static suction head. Simplify supply line configuration and reduce length. Reduce speed. Decrease product temperature-check effect of increased viscosity on available and permitted power inputs.
	d. Gas in supply line.	d. Expel gas from supply line.
	e. Foot valve strainer obstructed or blocked.	e. Service fittings.
	f. Front cover relief valve leakage.	f. Check pressure setting and readjust if necessary. Examine and clean seating surfaces. Replace worn parts.
2. Under Capacity	a. Insufficient NPSH available.	a. See 1.c. above.
	b. Product vaporising in supply line.	b. See 1.c. above.
	c. Air entering supply line.	c. Remake pipework joints. Adjust or repack gland.
	d. Gas in supply line.	d. See 1.d. above.
	e. Insufficient head above supply line.	e. Raise product level. Lower outlet position. Increase submergence of supply line.
	f. Foot valve strainer obstructed or blocked.	f. See 1.e. above.
	g. Product viscosity below rated figure.	g. Increase pump speed. Decrease product temperature.
	h. Product temperature above rated figure.	h. Cool the product / pumping chamber.
	i. Delivery pressure above rated figure.	i. Check for obstructions. Service system and reverse to prevent problem recurring. Simplify delivery line.
	j. Loose gland.	j. Tighten gland. See notes on packed glands.
	k. Pump speed below rated figure.	k. Increase pump speed.
	l. Belt drive slipping.	l. Re-tighten to maker's recommendations.
	m. Worn pump parts.	m. Install new components.
	n. Front cover relief valve leakage.	n. See 1.f. above.
	o. Relief valve chatter.	o. Check for wear of sealing surfaces, guides, etc. replace as necessary.
	p. Relief valve incorrectly set.	p. Readjust spring compression. Valve should lift about 10% above duty pressure.
3. Irregular Discharge	a. Insufficient NPSH available.	a. See 1.c. above.
	b. Product vaporising in supply line.	b. See 1.c. above.
	c. Air entering supply line.	c. See 2.c. above.
	d. Gas entering in supply line.	d. See 1.d. above.
	e. Insufficient head above supply line.	e. See 2.e. above.
	f. Foot valve strainer obstructed or blocked.	f. See 1.e. above.
	g. Loose gland.	g. See 2.j. above.
	h. Pump speed above rated figure.	h. Decrease pump speed

Problem	Possible Causes	Possible Solutions
4. Prime Lost After Starting	a. Insufficient NPSH available.	a. See 1.c. above.
	b. Product vaporising in supply line.	b. See 1.c. above.
	c. Air entering supply line.	c. See 2.c. above.
	d. Gas entering in supply line.	d. See 1.d. above.
	e. Insufficient head above supply line.	e. See 2.e. above.
	f. Foot valve strainer obstructed or blocked.	f. See 1.e. above.
	g. Product viscosity above rated figure.	g. Decrease pump speed. Increase product temperature.
	h. Loose gland.	h. See 2.j. above.
	i. Pump speed above rated figure.	i. See 3.h. above.
5. Pump Stalls When Starting	a. Product viscosity above rated figure.	a. See 4.g. above
	b. Product temperature below rated figure.	b. Heat the product / pumping chamber. Check with pump maker.
	c. Delivery pressure above rated figure.	c. See 2.i.
	d. Worn unsynchronized timing gears.	d. Refer to pump maker for advice and replacement parts.
	e. Metal-to-metal contact of pumping parts.	e. Check rated and duty pressures. Refer to pump maker.
6. Pump Overheats	a. Product viscosity aboved rated figure.	a. See 4.g. above.
	b. Product temperature above rated figure.	b. See 2.h. above.
	c. Delivery pressure above rated figure.	c. See 2.i. above.
	d. Gland over-tightened.	d. Loosen and readjust gland.
	e. Casing strained by pipework.	e. Check alignment of pipes. Install flexible pipes or expansion fittings. Support pipework.
	f. Flexible coupling misaligned.	f. Check flange alignment and adjust mountings accordingly.
	g. Shaft bearing wear or failure.	g. Refer to pump maker for advice and replacement parts.
	h. Worn unsynchronized timing gears.	h. See 5.d. above.
	i. Grease quantity/quality incorrect.	i. Refer to pump maker's instructions.
	j. Metal-to-metal contact of pumping parts.	j. See 5.e. above.
	k. Front cover relief valve leakage.	k. See 1.f. above.
7. Motor Overheats	a. Product viscosity above rated figure.	a. See 4.g. above.
	b. Product temperature below rated figure.	b. See 5.b. above.
	c. Delivery pressure above rated figure.	c. See 2.i. above.
	d. Gland over-tightened.	d. See 6.d. above.
	e. Pump speed above rated figure.	e. See 3.h. above.
	f. Casing strained by pipework.	f. See 6.e. above.
	g. Flexible coupling misaligned.	g. See 6.f. above.
	h. Shaft bearing wear or failure.	h. See 6.g. above.
	i. Worn unsynchronized timing gears.	i. See 5.d. above.
	j. Grease quantity/quality incorrect.	j. See 6.i. above.
	k. Metal-to-metal contact of pumping parts.	k. See 5.e. above.
8. Excessive Power Absorbed	a. Product viscosity above rated figure	a. See 4.g. above.
	b. Product temperature below rated figure	b. See 5.b. above.
	c. Delivery pressure above rated figure	c. See 2.i. above.
	d. Gland over-tightened	d. See 6.d. above.
	e. Pump speed above rated figure	e. See 3.h. above.
	f. Casing strained by pipework	f. See 6.e. above.
	g. Flexible coupling misaligned	g. See 6.f. above.
	h. Shaft bearing wear or failure	h. See 6.g. above.
	i. Worn unsynchronized timing gears	i. See 5.d. above.
	j. Grease quantity/quality incorrect	j. See 6.i. above.
	k. Metal-to-metal contact of pumping parts	k. See 5.e. above.

Problem	Possible Causes	Possible Solutions
9. Noise and Vibration	a. Insufficient NPSH available.	a. See 1.c. above.
	b. Product vaporising in supply line.	b. See 1.c. above.
	c. Air entering supply line.	c. See 2.c. above.
	d. Gas entering in supply line.	d. See 1.d. above.
	e. Insufficient head above supply line.	e. See 2.e. above.
	f. Foot valve strainer obstructed or blocked.	f. See 1.e. above.
	g. Product viscosity above rated figure.	g. See 4.g. above.
	h. Product temperature above rated figure.	h. See 2.h. above.
	i. Unexpected solids in product.	i. Clean the system. Install stainer to supply line.
	j. Delivery pressure above rated figure.	j. See 2.g. above.
	k. Loose gland.	k. See 2.j. above.
	l. Pump speed above rated figure.	l. See 3.h. above.
	m. Casing strained by pipework.	m. See 6.e. above.
	n. Flexible coupling misaligned.	n. See 6.f. above.
	o. Loose pump drive mountings.	o. Install lock washers to loosen fasteners and retighten.
	p. Shaft bearing wear or failure.	p. See 6.g. above.
	q. Worn unsynchronized timing gears.	q. See 5.d. above.
	r. Grease quantity/quality incorrect.	r. See 6.i. above.
	s. Metal-to-metal contact of pumping parts	s. See 5.e. above.
	t. Relief valve chatter.	t. See 2.o. above.
	u. Relief valve incorrectly set.	u. See 2.p. above.
10. Excessive Wear	a. Product temperature above rated figure.	a. See 2.h. above.
	b. Unexpected solids in product.	b. See 9.i. above.
	c. Delivery pressure above rated figure.	c. See 2.i. above.
	d. Casing strained by pipework.	d. See 6.e. above.
	e. Shaft bearing wear or failure.	e. See 6.g. above.
	f. Worn unsynchronized timing gears.	f. See 5.d. above.
	g. Metal-to-metal contact of pumping parts	g. See 5.e. above.
11. Pump Lockup	a. Product temperature above rated figure.	a. See 2.h. above.
	b. Unexpected solids in product.	b. See 9.i. above.
	c. Delivery pressure above rated figure.	c. See 2.i. above.
	d. Gland over-tightened.	d. See 6.d. above.
	e. Casing strained by pipework.	e. See 6.e. above.
	f. Shaft bearing wear or failure.	f. See 6.g. above.
	g. Worn unsynchronized timing gears.	g. See 5.d. above.
	h. Grease quantity/quality incorrect.	h. See 6.i. above.
	i. Metal-to-metal contact of pumping parts	i. See 5.e. above.
12. Excessive Gland Seal Wear	a. Unexpected solids in product.	a. See 9.i. above.
	b. Gland over-tightened.	b. See 6.d. above.
	c. Gland flushing inadequate.	c. Check that fluid flows freely into gland. Increase flow rate.
13. Product Loss Through Gland	a. Unexpected solids in product.	a. See 9.i. above
	b. Loose gland.	b. See 2.j. above.
	c. Gland flushing inadequate.	c. See 12.c. above.

FRONT SEAL CARRIERS AND REAR COVER SPECIFICATIONS

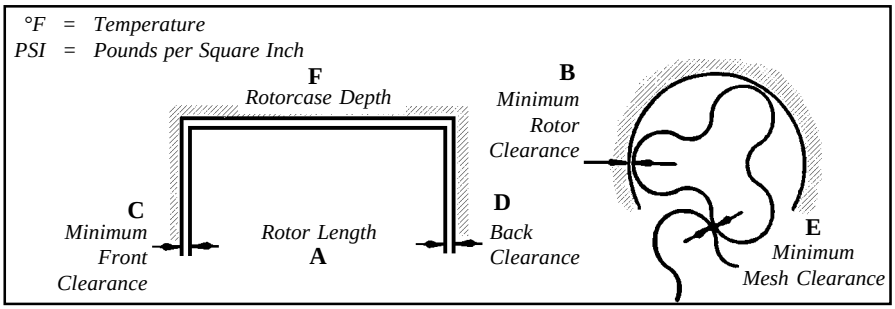
	Torque		Key Size
	Nm	ftlb	mm
TSR1 to TSR3	10	7	5
TSR4 to TSR6	25	19	6

TECHNICAL SPECIFICATION CHART

Model Code	Tightening Torques								Key or Wrench Size			
	Front Cover Nuts		Rotor Nuts		Gearcase Nuts		Timing Gear Screws		Front Cover Nuts	Rotor Nuts	Casing Frame Nuts	Gearcase Screws
	Nm	ftlb	Nm	ftlb	Nm	ftlb	Nm	ftlb	mm	mm	mm	mm
TSR1	20	15	14	10	20	15	12	9	13	17	13	5
TSR2	39	29	77	56	40	30	17	12.5	17	24	17	5
TSR3	39	29	120	88	40	30	12	9	17	24	17	5
TSR4	39	29	161	120	64	47	14	10	17	36	19	5
TSR5	39	29	161	120	64	47	35	26	17	36	19	6
TSR6	105	77	161	120	175	129	35	26	19	36	24	6

CLEARANCES - TSR1 MODELS

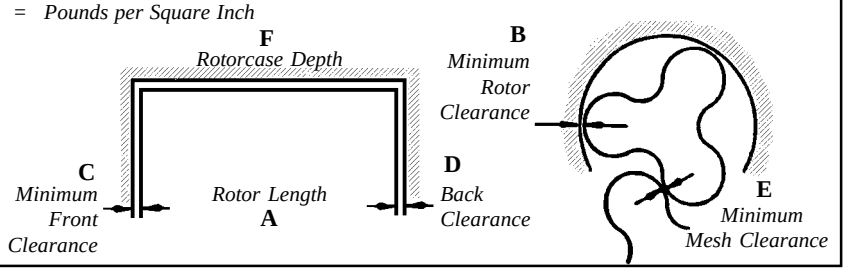
°F = Temperature
PSI = Pounds per Square Inch



Rotor Size & Type	Tri-Clover Part No.	PSI	oF	A	B	C	D	E	F
TSR1 NSD	TSR1-02A-002	217	158	0.653 0.652	min. 0.006	min. 0.005	0.004 0.006	min. 0.005	0.664 0.663
	TSR1-02A-006		266	0.652 0.651	min. 0.006	min. 0.006			
	TSR1-02A-010		392	0.652 0.650	min. 0.006	min. 0.006			
TSR1 NLD	TSR1-02A-002	116	158	0.653 0.652	min. 0.006	min. 0.005	0.004 0.006	min. 0.005	0.664 0.663
	TSR1-02A-006		266	0.652 0.651	min. 0.006	min. 0.006			
	TSR1-02A-010		392	0.652 0.650	min. 0.006	min. 0.006			
TSR1 WSD	TSR1-02A-004	174	158	1.046 1.045	min. 0.006	min. 0.006	0.004 0.006	min. 0.005	1.058 1.057
	TSR1-02A-008		266	1.045 1.044	min. 0.007	min. 0.006			
	TSR1-02A-012		392	1.044 1.043	min. 0.007	min. 0.007			
TSR1 WLD	TSR1-02A-004	72.5	158	1.046 1.045	min. 0.006	min. 0.006	0.004 0.006	min. 0.005	1.058 1.057
	TSR1-02A-008		266	1.045 1.044	min. 0.007	min. 0.006			
	TSR1-02A-012		392	1.044 1.043	min. 0.007	min. 0.007			

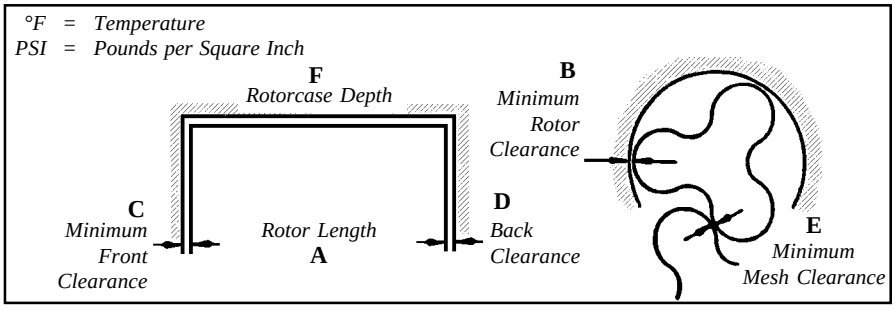
CLEARANCES - TSR2 MODELS

°F = Temperature
PSI = Pounds per Square Inch



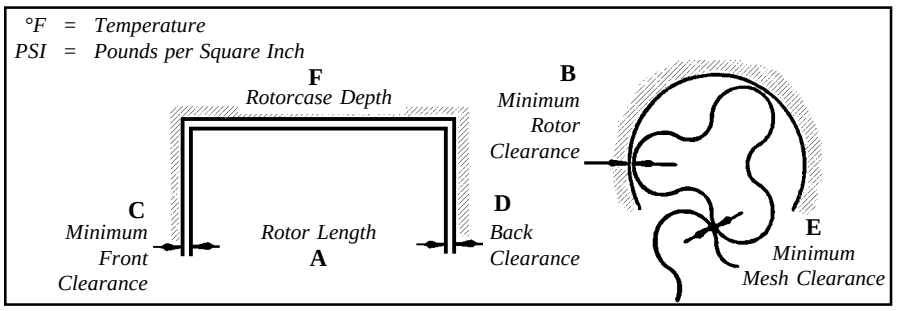
Rotor Size & Type	Tri-Clover Part No.	PSI	°F	A	B	C	D	E	F
TSR2 NLS	TSR2-02A-101	145	158	0.891 0.890	min. 0.006	min. 0.006	0.005 0.003	min. 0.003	0.902 0.900
	TSR2-02A-105		266	0.887 0.885	min. 0.007	min. 0.009	0.006 0.004		
	TSR2-02A-109		392	0.880 0.879	min. 0.008	min. 0.013	0.009 0.007		
TSR2 NLD	TSR2-02A-002	217	158	0.887 0.886	min. 0.007	min. 0.008	0.006 0.004	min. 0.004	0.902 0.900
	TSR2-02A-006		266	0.885 0.884	min. 0.008	min. 0.009	0.007 0.005		
	TSR2-02A-010		392	0.880 0.878	min. 0.009	min. 0.012	0.010 0.008		
TSR2 WLS	TSR2-02A-103	102	158	1.261 1.259	min. 0.007	min. 0.006	0.005 0.003	min. 0.003	1.272 1.270
	TSR2-02A-107		266	1.256 1.255	min. 0.008	min. 0.009	0.006 0.004		
	TSR2-02A-111		392	1.249 1.248	min. 0.009	min. 0.014	0.009 0.007		
TSR2 WLD	TSR2-02A-004	145	158	1.258 1.257	min. 0.008	min. 0.007	0.006 0.004	min. 0.004	1.272 1.270
	TSR2-02A-008		266	1.256 1.255	min. 0.009	min. 0.008	0.007 0.005		
	TSR2-02A-012		392	1.253 1.252	min. 0.011	min. 0.009	0.010 0.008		

CLEARANCES - TSR3 MODELS



Rotor Size & Type	Tri-Clover Part No.	PSI	°F	A	B	C	D	E	F
TSR3 NLS	TSR3-02A-101	145	158	1.186 1.224	min. 0.008	min. 0.006	0.006 0.004	min. 0.005	1.999 1.198
	TSR3-02A-105		266	1.181 1.180	min. 0.009	min. 0.011	0.007 0.005		
	TSR3-02A-109		392	1.173 1.172	min. 0.011	min. 0.015	0.010 0.008		
TSR3 NLD	TSR3-02A-002	217	158	1.184 1.183	min. 0.013	min. 0.007	0.007 0.005	min. 0.007	1.199 1.198
	TSR3-02A-006		266	1.182 1.181	min. 0.014	min. 0.009	0.008 0.006		
	TSR3-02A-010		392	1.178 1.177	min. 0.015	min. 0.010	0.011 0.009		
TSR3 WLS	TSR3-02A-103	102	158	1.698 1.697	min. 0.010	min. 0.007	0.006 0.004	min. 0.005	1.711 1.170
	TSR3-02A-107		266	1.693 1.692	min. 0.013	min. 0.011	0.007 0.005		
	TSR3-02A-111		392	1.685 1.683	min. 0.015	min. 0.017	0.010 0.008		
TSR3 WLD	TSR3-02A-004	145	158	1.696 1.695	min. 0.015	min. 0.008	0.007 0.005	min. 0.007	1.711 1.170
	TSR3-02A-008		266	1.694 1.693	min. 0.015	min. 0.009	0.008 0.006		
	TSR3-02A-012		392	1.690 1.689	min. 0.016	min. 0.011	0.011 0.009		

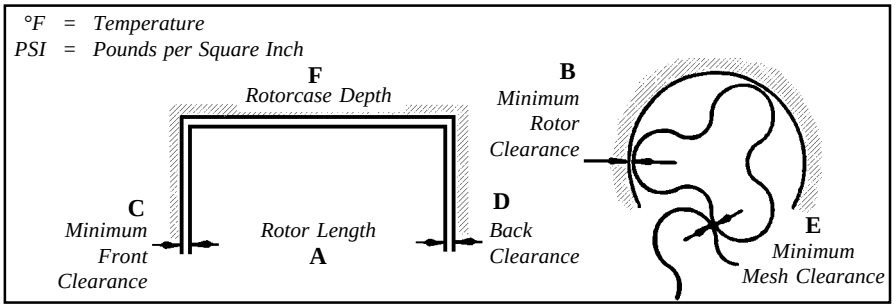
CLEARANCES - TSR4 MODELS



Rotor Size & Type	Tri-Clover Part No.	PSI	°F	A	B	C	D	E	F
TSR4 NLS	TSR4-02A-001	145	158	1.504 1.503	min. 0.007	min. 0.007	0.006 0.004	min. 0.006	1.517 1.516
	TSR4-02A-005		266	1.499 1.498	min. 0.009	min. 0.010			
	TSR4-02A-009		392	1.497 1.496	min. 0.011	min. 0.011			
TSR4 NLD	TSR4-02A-002	290	158	1.500 1.499	min. 0.013	min. 0.008	0.008 0.006	min. 0.008	1.517 1.516
	TSR4-02A-006		266	1.499 1.498	min. 0.015	min. 0.010			
	TSR4-02A-010		392	1.497 1.496	min. 0.017	min. 0.011			
TSR4 WLS	TSR4-02A-003	102	158	2.165 2.164	min. 0.012	min. 0.008	0.007 0.005	min. 0.006	2.180 2.179
	TSR4-02A-007		266	2.161 2.159	min. 0.015	min. 0.012			
	TSR4-02A-011		392	2.156 2.154	min. 0.018	min. 0.017			
TSR4 WLD	TSR4-02A-004	217	158	2.158 2.157	min. 0.018	min. 0.013	0.009 0.007	min. 0.008	2.180 2.179
	TSR4-02A-008		266	2.156 2.155	min. 0.021	min. 0.014			
	TSR4-02A-012		392	2.155 2.154	min. 0.024	min. 0.016			

CLEARANCES - TSR5 MODELS

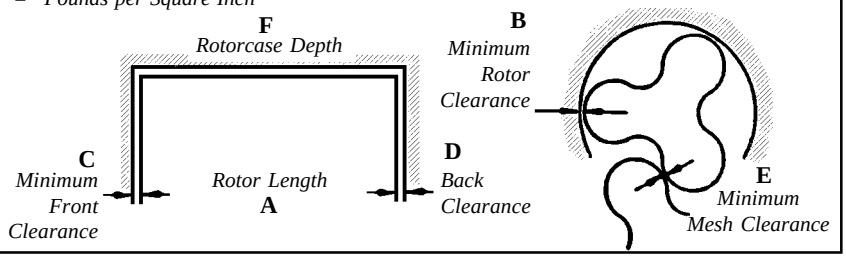
°F = Temperature
PSI = Pounds per Square Inch



Rotor Size & Type	Tri-Clover Part No.	PSI	°F	A	B	C	D	E	F
TSR5 NLS	TSR5-02A-001	145	158	2.011 2.010	min. 0.011	min. 0.010	0.007 0.005	min. 0.008	2.029 2.028
	TSR5-02A-005		266	2.007 2.006	min. 0.013	min. 0.015			
	TSR5-02A-009		392	2.001 2.000	min. 0.016	min. 0.020			
TSR5 NLD	TSR5-02A-002	290	158	2.009 2.008	min. 0.018	min. 0.011	0.008 0.006	min. 0.010	2.029 2.028
	TSR5-02A-006		266	2.007 2.006	min. 0.020	min. 0.013			
	TSR5-02A-010		392	2.006 2.004	min. 0.023	min. 0.015			
TSR5 WLS	TSR5-02A-003	102	158	2.916 2.915	min. 0.017	min. 0.012	0.008 0.006	min. 0.010	2.936 2.935
	TSR5-02A-007		266	2.911 2.909	min. 0.021	min. 0.017			
	TSR5-02A-011		392	2.905 2.904	min. 0.025	min. 0.022			
TSR5 WLD	TSR5-02A-004	217	158	2.910 2.909	min. 0.023	min. 0.015	0.011 0.009	min. 0.012	2.936 2.935
	TSR5-02A-008		266	2.908 2.907	min. 0.027	min. 0.017			
	TSR5-02A-012		392	2.906 2.905	min. 0.031	min. 0.019			

CLEARANCES - TSR6 MODELS

°F = Temperature
PSI = Pounds per Square Inch

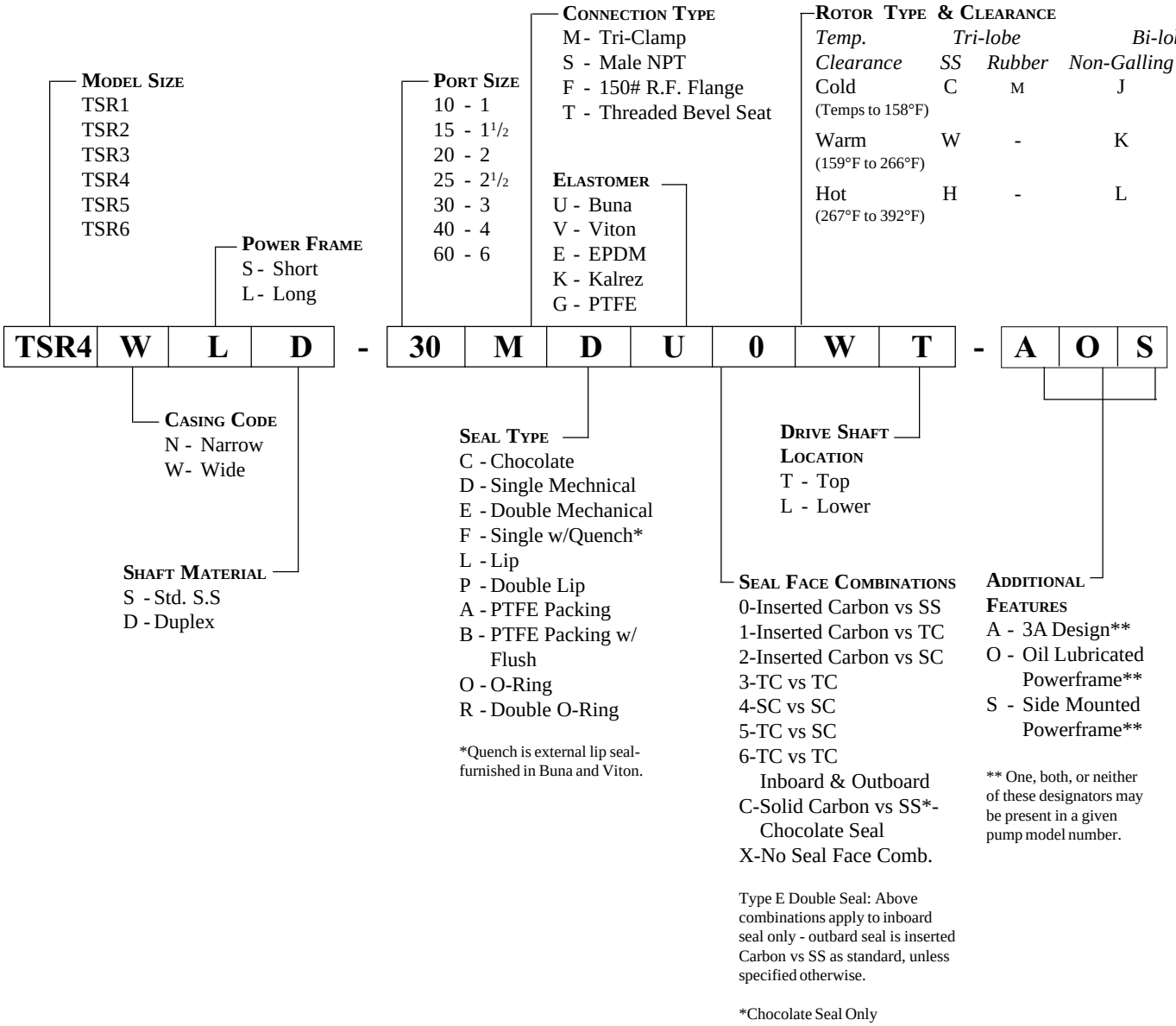


Rotor Size & Type	Tri-Clover Part No.	PSI	°F	A	B	C	D	E	F
TSR6 NLS	TSR6-02A-001	145	158	3.122 3.121	min. 0.015	min. 0.014	0.009 0.007	min. 0.012	3.146 3.144
	TSR6-02A-005		266	3.116 3.115	min. 0.018	min. 0.020			
	TSR6-02A-009		392	3.109 3.108	min. 0.021	min. 0.027			
TSR6 NLD	TSR6-02A-002	290	158	3.115 3.114	min. 0.021	min. 0.016	0.014 0.012	min. 0.014	3.146 3.144
	TSR6-02A-006		266	3.113 3.112	min. 0.024	min. 0.018			
	TSR6-02A-010		392	3.111 3.110	min. 0.027	min. 0.020			
TSR6 WLS	TSR6-02A-003	102	158	4.478 4.476	min. 0.019	min. 0.016	0.010 0.008	min. 0.014	4.504 4.502
	TSR6-02A-007		266	4.470 4.469	min. 0.023	min. 0.023			
	TSR6-02A-011		392	4.463 4.461	min. 0.028	min. 0.031			
TSR6 WLD	TSR6-02A-004	217	158	4.460 4.459	min. 0.031	min. 0.026	0.018 0.016	min. 0.016	4.504 4.502
	TSR6-02A-008		266	4.457 4.456	min. 0.035	min. 0.028			
	TSR6-02A-012		392	4.455 4.454	min. 0.040	min. 0.030			

ORDERING REPLACEMENT PARTS

When ordering replacement parts for your T-Series pumps, be sure to list the following:

1. Complete ***Model Number*** from nameplate (see example below).
2. Pump ***Serial Number*** from nameplate.
3. Replacement Part ***Key Number*** and ***Description*** from parts lists shown on following pages.

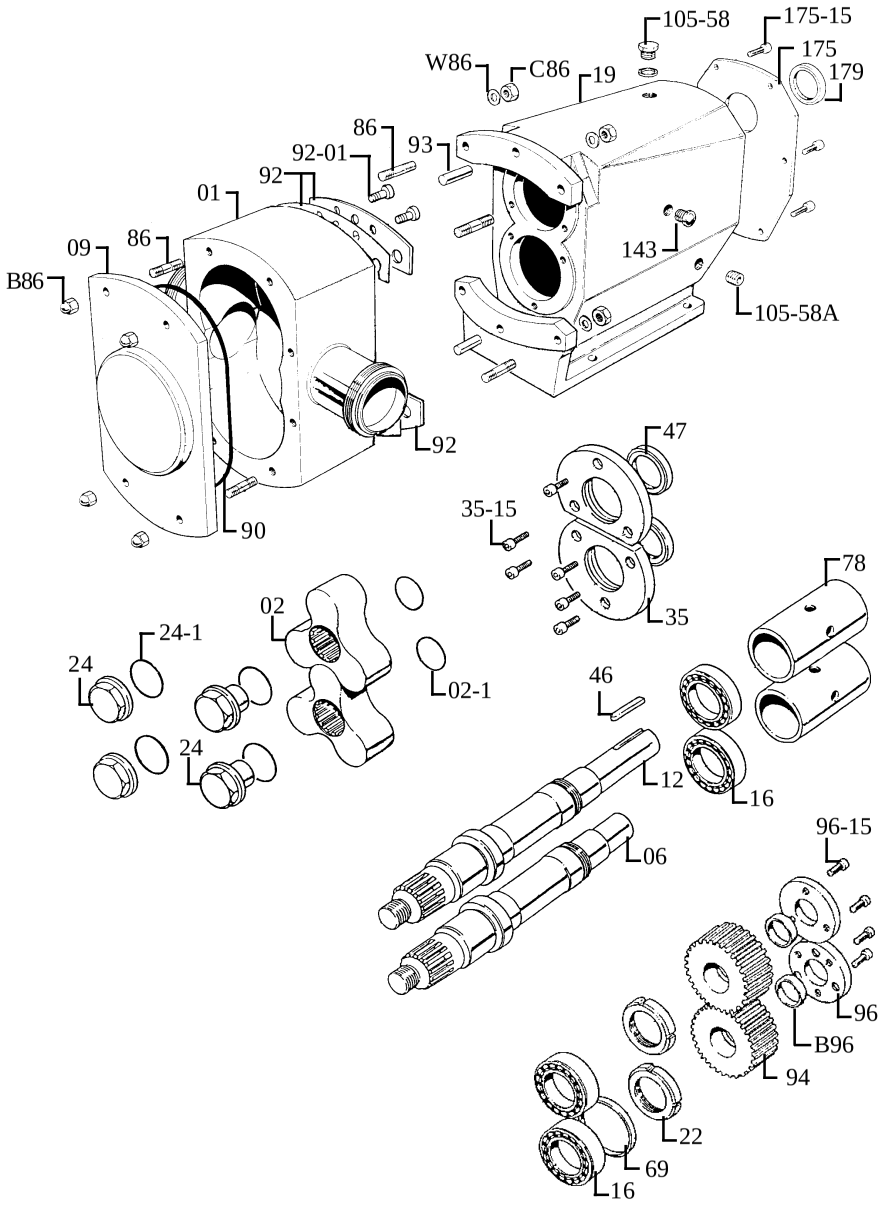


Note:

- TSR pump with a relief cover is indicated by a second "R" in the model number prefix. Example TSR**R**4-WLD-30MDU0WT-AO.
- TSR pump with a water jacket is indicated by adding a "J" to the model number prefix. Example TSR**J**4-WLD-30MDU0WT-AO.

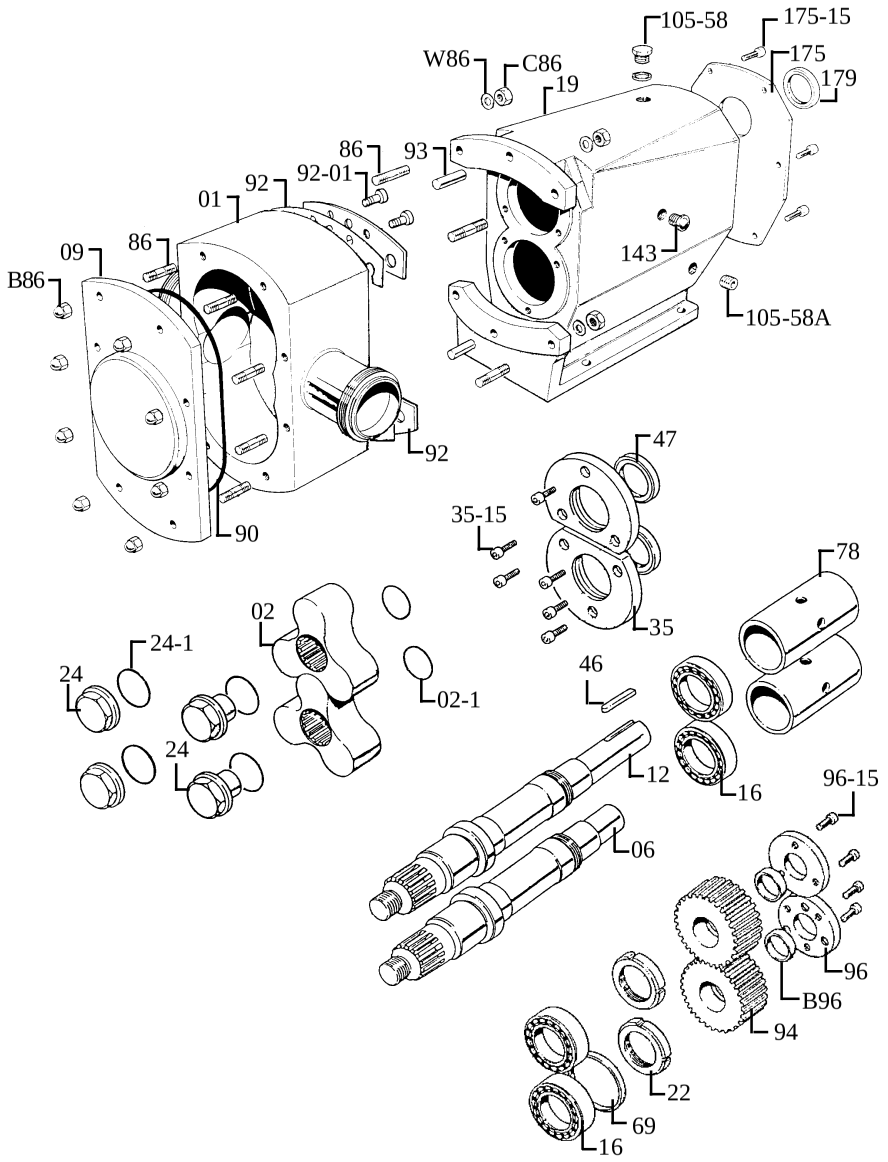
PARTS LIST - TSR1 & TSR2

Key Number	Description
01	Casing
02	Rotor
02-1	O-ring Rotor
06	Pump Shaft
09	Front Cover
12	Drive Shaft
16	Bearing
19	Gearcase
22	Locknut
24	Rotor Nut
24-1	O-Ring Rotor Nut
35	Brg. Front Cover
35-15	Screw Brg. Front Cover
46	Key Coupling
47	Seal Inb'd Brg
69	Spacer Shaft Alignment
78	Spacer Brg.
86	Stud - Casing
B86	Nut - Front Cover
C86	Nut - Casing
W86	Washer
90	O-Ring - Front Cover
92	Shimset
92-01	Shim Retainer Screw
93	Pin - FR. Alignment
94	Timing Gear
96	Clamp Plate
96-15	Screw - Clamp Plate
B96	Locking Element
105-58A	Drain Plug - Oil
105-58	Filler Plug - Oil
143	Sight Level - Oil
175	Gearcover
175-15	Screw - Gearcover
179	Seal, Gearcover



PARTS LIST - TSR3

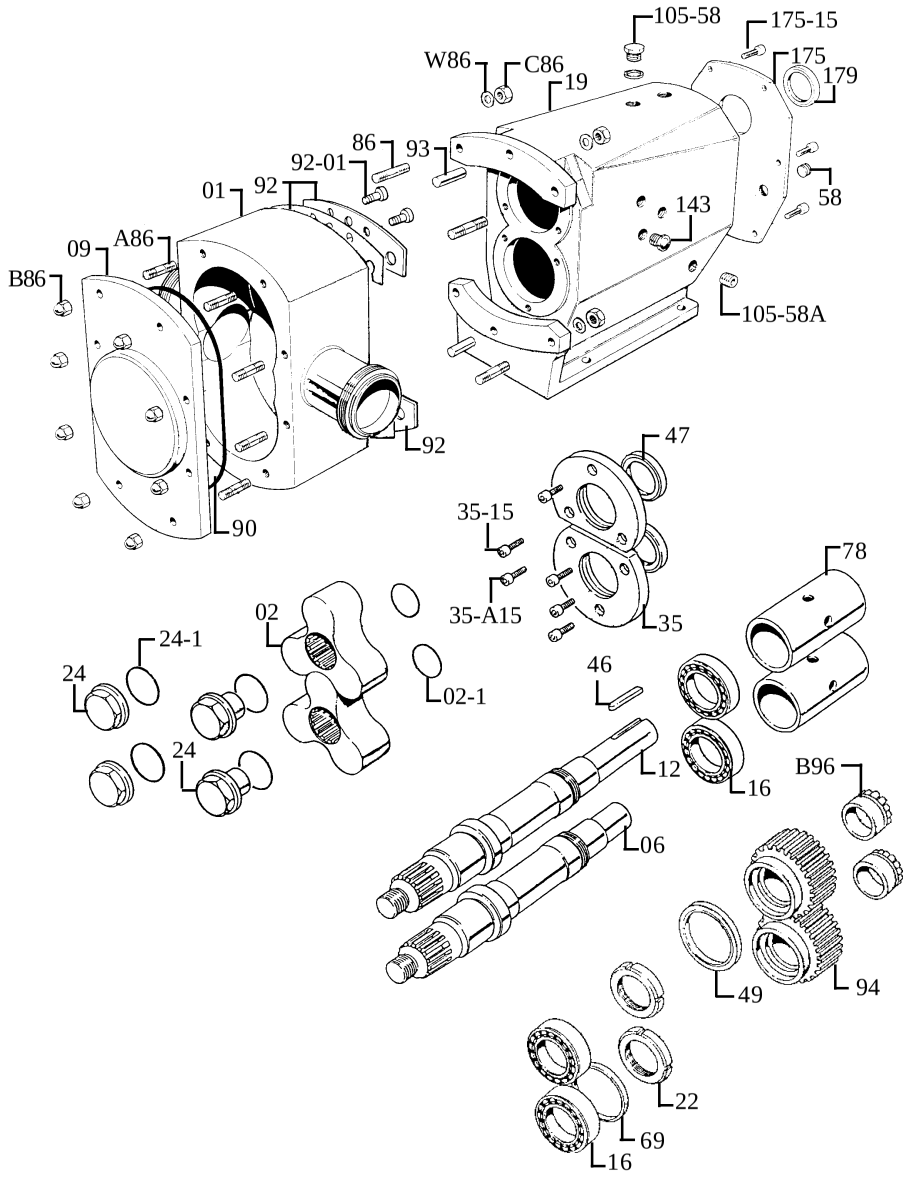
Key Number	Description
01	Casing
02	Rotor
02-1	O-Ring Rotor
06	Pump Shaft
09	Front Cover
12	Drive Shaft
16	Bearing
19	Gearcase
22	Locknut
24	Rotor Nut
24-1	O-Ring Rotor Nut
35	Brg. Front Cover
35-15	Screw Brg. Front Cover
46	Key Coupling
47	Seal Inb'd Brg
69	Spacer Shaft Alignment
78	Spacer Brg.
86	Stud - Casing
B86	Nut - Front Cover
C86	Nut - Casing
W86	Washer
90	O-Ring - Front Cover
92	Shimset
92-01	Shim Retainer Screw
93	Pin - FR. Alignment
94	Timing Gear
96	Clamp Plate
96-15	Screw - Clamp Plate
B96	Locking Element
105-58A	Drain Plug - Oil
105-58	Filler Plug - Oil
143	Sight Level - Oil
175	Gearcover
175-15	Screw - Gearcover
179	Seal, Gearcover



PARTS LIST - TSR4* & TSR5*

Key Number	Description
01	Casing
02	Rotor
02-1	O-Ring Rotor
06	Pump Shaft
09	Front Cover
12	Drive Shaft
16	Bearing
19	Gearcase
22	Locknut
24	Rotor Nut
24-1	O-Ring Rotor Nut
35	Brg. Front Cover
35-15	Screw Brg. Front Cover
35-A15	Screw Brg. Front Cover
46	Key Coupling
47	Seal Inb'd Brg
49	Seal Outb'd Brg.
58	Plug Pressure Taper
69	Spacer Shaft Alignment
78	Spacer Brg.
86	Stud - Casing R.C., G.C.
A86	Stud - Casing F.C., R.C
B86	Nut - Front Cover
C86	Nut - Casing
W86	Washer
90	O- Ring - Front Cover
92	Shimset
92-01	Shim Retainer Screw
93	Pin - FR. Alignment
94	Timing Gear
B96	Locking Element
105-58A	Drain Plug - Oil
105-58	Filler Plug - Oil
143	Sight Level - Oil
175	Gearcover
175-15	Screw - Gearcover
179	Seal, Gearcover

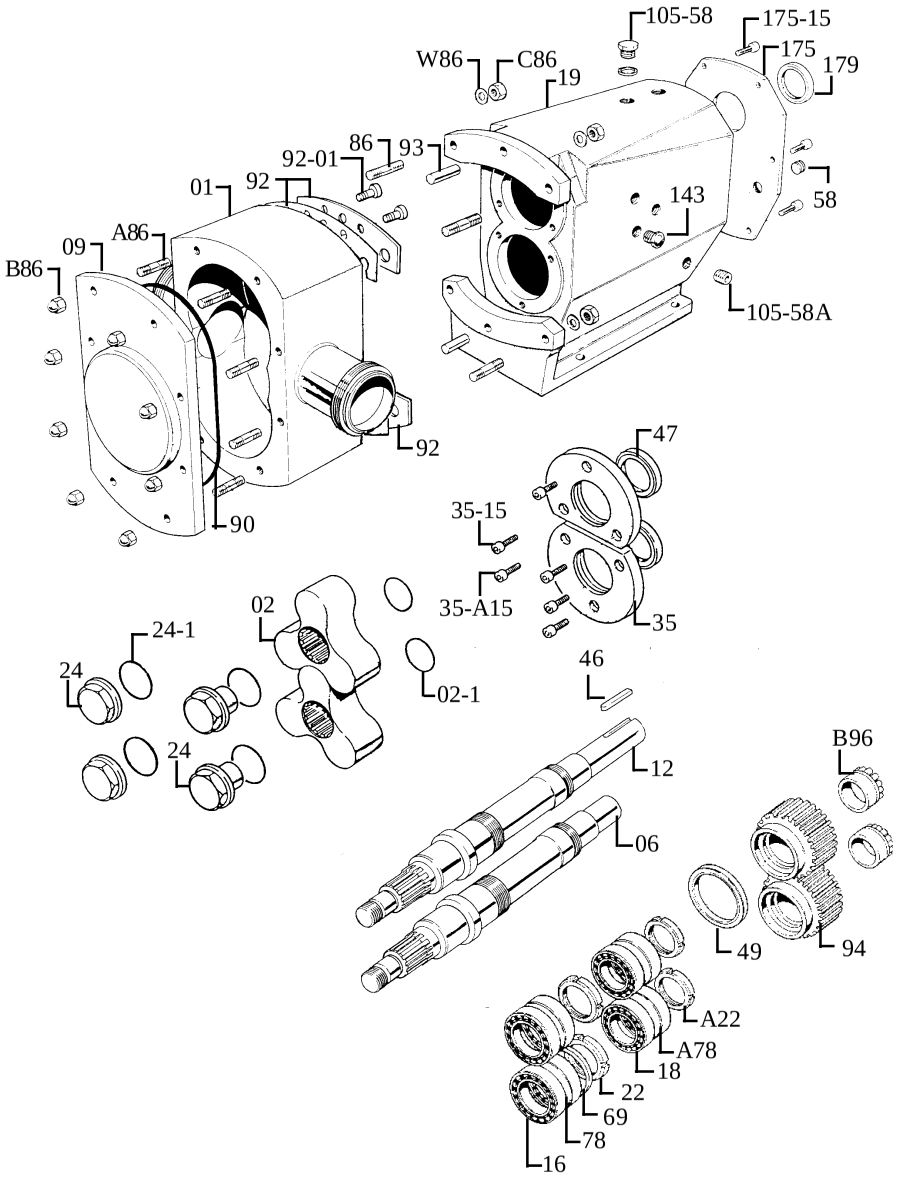
For TSR4 / N or W / SS and TSR5 / N or W / SS



PARTS LIST - TSR4* & TSR5*

Key Number	Description
01	Casing
02	Rotor
02-1	O-Ring Rotor
06	Pump Shaft
09	Front Cover
12	Drive Shaft
16	Bearing Inb'd
18	Bearing Outboard
19	Gearcase
22	Locknut Inb'd Brg.
A22	Locknut Outb'd Brg.
24	Rotor Nut
24-1	O-Ring Rotor Nut
35	Brg. Front Cover
35-15	Screw Brg. Front Cover
35-A15	Screw Brg. Front Cover
46	Key Coupling
47	Seal Inb'd Brg
49	Seal Outb'd Brg.
58	Plug Pressure Taper
69	Spacer Shaft Alignment
78	Spacer Brg. - Inb'd
A78	Spacer Brg. - Outb'd
86	Stud - Casing R.C., G.C.
A86	Stud - Casing F.C., R.C.
B86	Nut - Front Cover
C86	Nut - Casing
W86	Washer
90	O-Ring - Front Cover
92	Shimset
92-01	Shim Retainer Screw
93	Pin - FR. Alignment
94	Timing Gear
B96	Locking Element
105-58A	Drain Plug - Oil
105-58	Filler Plug - Oil
143	Sight Level - Oil
175	Gearcover
175-15	Screw - Gearcover
179	Seal, Gearcover

For TSR4 / N or W / LS or LD and TSR5 / N or W / LS or LD



PARTS LIST - TSR6

Key Number	Description
01	Casing
02	Rotor
02-1	O-Ring Rotor
06	Pump Shaft
09	Front Cover
12	Drive Shaft
16	Bearing Inb'd
18	Bearing Outboard
19	Gearcase
22	Locknut Inb'd Brg.
A22	Locknut Outb'd Brg.
24	Rotor Nut
24-1	O-Ring Rotor Nut
34	Rotor Locking As'bly
35	Brg. Front Cover
35-15	Screw Brg. Front Cover
35-A15	Screw Brg. Front Cover
46	Key Coupling
47	Seal Inb'd Brg
49	Seal Outb'd Brg.
58	Plug Pressure Taper
69	Spacer Shaft Alignment
78	Spacer Brg. - Inb'd
A78	Spacer Brg. - Outb'd
86	Stud - Casing R.C., G.C.
A86	Stud - Casing F.C., R.C.
B86	Nut - Front Cover
C86	Nut - Casing
W86	Washer
90	O-Ring - Front Cover
92	Shimset
92-01	Shim Retainer Screw
93	Pin - FR. Alignment
94	Timing Gear
B96	Locking Element
105-58A	Drain Plug - Oil
105-58	Filler Plug - Oil
143	Sight Level - Oil
175	Gearcover
175-15	Screw - Gearcover
179	Seal, Gearcover

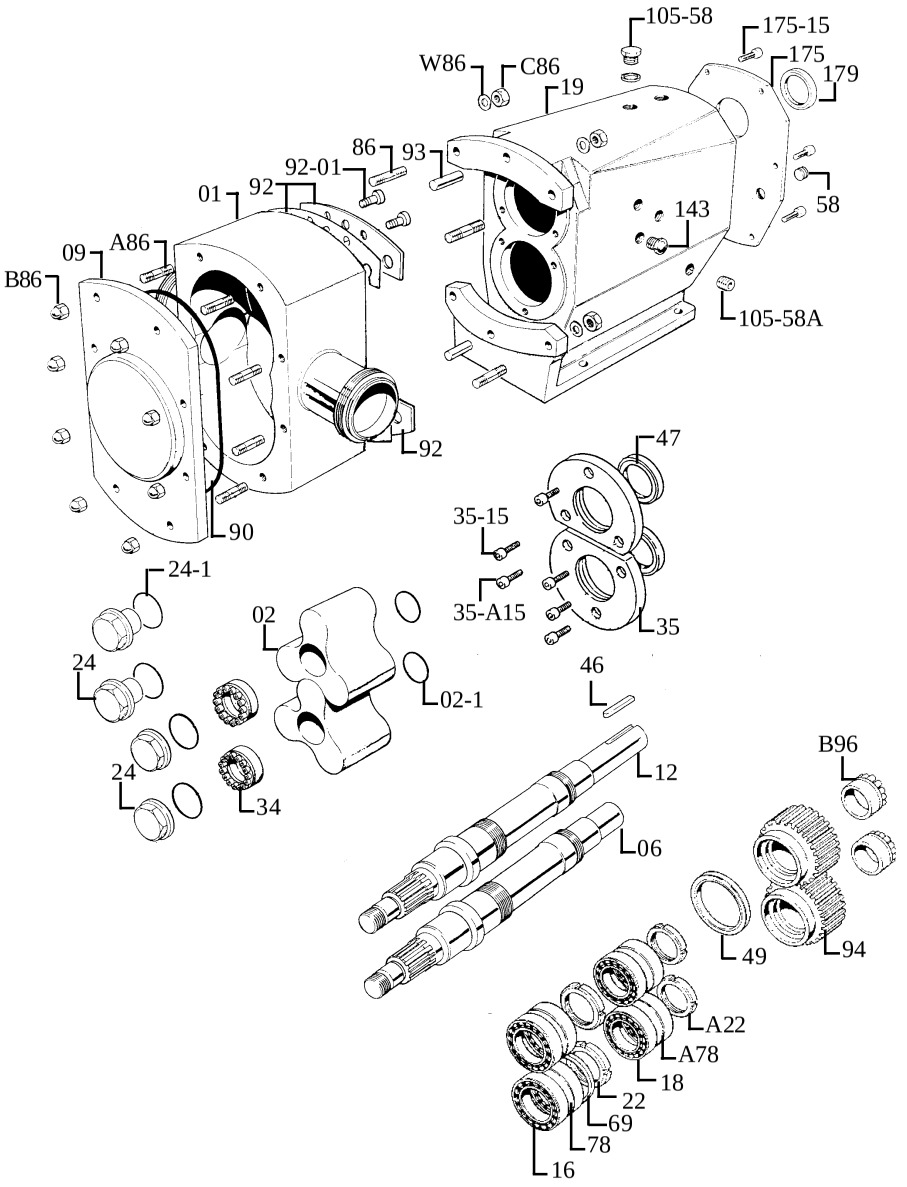


FIGURE AND TABLE INDEX

Tri-Clover

manufactures

a complete line of

TRI-WELD® fittings

TRI-CLAMP® fittings

BEVEL SEAT fittings

POSITIVE PUMPS

CENTRIFUGAL PUMPS

AUTOMATIC Air Actuated VALVES

STAINLESS STEEL TUBING

AUTOMATED FLOW CONTROL SYSTEMS

Terms, Warranty Provisions, Notice of Claims and Limitation of Liability

Prices and all terms and conditions of sale are established in current price sheets and are subject to change without notice. All orders are subject to acceptance by Tri-Clover Inc. at its Kenosha, Wisconsin or Distribution Center* offices only. No assignment of the purchaser's rights may be made without consent of Tri-Clover Inc.

Each Tri-Clover item is warranted to be free from manufacturing defects for a period of one (1) year from the date of shipment, providing it has been used as recommended and in accordance with recognized piping practice, and providing it has not been worn out due to severe service, such as encountered under extremely corrosive or abrasive conditions.

This warranty is expressly in lieu of any other warranties, express or implied, including but not limited to, any implied warranty of merchantability or fitness for a particular purpose.

All claims must be in writing and must be mailed or delivered by purchaser within thirty (30) days after purchaser learns of the facts upon which such claim is based. Any claim not made in writing and within the time period specified above shall be deemed waived.

Purchaser's sole and exclusive remedy and Tri-Clover Inc.'s maximum liability for claims arising hereunder or for negligence for any and all losses and damages resulting from any cause shall be either the repair or replacement of defective items or, at Tri-Clover Inc.'s option, the refund of the purchase price for such items. In no event, including in the case of a claim for negligence, shall Tri-Clover be liable for incidental or consequential damages including loss of profits.

No person, including any representative, employee or agent of Tri-Clover, is authorized to assume on behalf of Tri-Clover Inc., any liability or responsibility in addition to or different from that described in this provision. Any and all representations, promises, warranties or statements that are in addition to or different from the terms of this provision are of no force or effect.

**Distribution Centers in Union City, California and Memphis, Tennessee*

Tri-Clover Inc.

9201 Wilmot Road
Kenosha, Wisconsin 53141-1413
414-694-5511
FAX: 414-694-7104
International Sales: 414-697-3170
FAX: 414-694-8188

Tri-Clover Canada
101 Milner Avenue
Scarborough, Ontario M1S 4S6
416-299-5490
FAX: 416-299-5095

Tri-Clover Mexico
Recursos Petroleros No. 7
Fracc. Ind. La Loma
54060 Tlalnepantla, Edo. de Mexico
PHONE: 52-5-397-0601 FAX: 52-5-362-3246

Alfa Laval
TSM-95
Printed in August 1995