Turbine Powered Starters
Series ST900

Installation and Maintenance Information

Save These Instructions
Product Safety Information

Intended Use:
The ST900 Series air starters are intended for use in starting reciprocating internal combustion engines. These starters are designed to be operated from a remote location after proper installation on the engine requiring starting.

For additional information refer to Air Starters for Internal Combustion Engines Product Safety Information Manual Form 45558624. Manuals can be downloaded from ingersollrandproducts.com

Operating Guidelines

![WARNING]

- Never exceed the Nameplate operating pressure rating.
- Always release the start button immediately after the engine starts.
- If the engine has not started after 30 seconds of cranking, refer to the engine maintenance guides for information on starting, ignition, and fuel systems.
- When using the starter for dynamic timing measurements, rest the starter for 2.1/2 minutes between 30 second measurements.
- ST900-267 Strainer or equivalent is required for all starters used in stationary applications.

![NOTICE]

- Supply must be free of contaminants. New piping must be free of scale.
- For natural gas operation, starter main exhaust must be piped away. To pipe the drive housing vent, remove the drive housing plug and replace it with a suitable tubing line. The tubing must vent at a safe location and must not be interconnected with any other exhaust lines which might introduce a back pressure on the drive housing vent.
- The ST900 series starter is designed for long crank heavy duty applications. When cranking attempts fail to start the engine in 30 seconds, stop and allow the starter to cool for 2.1/2 minutes before attempting to start the engine.

Placing Starter in Service

**Installation**

For maximum performance, read this manual prior to the installation or operation of Series ST900 Turbine-Powered Starters.

**General Information**

1. We recommend that on all vehicular installations and on stationary engines subject to vibration that hoses of the specified diameter be used instead of rigid pipe connections to the starter. Engine vibration will loosen rigid pipe connections, whereas hoses will absorb the vibration and connections will remain tight.
2. This starter is designed for flange mounting at the inlet. The furnished Flange Mounting Kit is required for installation. All piping, hoses and valving must be clean prior to installation. Make sure that the starter inlet is free of dirt and foreign material during installation.
3. In mounting a starter, have the hose connections already made at the receiver and to have the starter end of the hose handy for attaching to the starter.
4. Engine design often requires mounting the starter underneath in extremely close quarters, and even though two of the mounting bolt holes are easy to reach, the third one is often less accessible. To install a starter, the following tools are required; regular ratchet wrench, sockets, universal joint, socket extension and single or double-end box wrench.
5. Improper hook-up impairs the efficiency of an Air Starter. Hoses smaller than those recommended will reduce the volume of air to the motor and the use of reducers for piped-away applications in the exhaust port will restrict the exhaust causing back pressure to the motor resulting in reduced performance. Keep the number of tees and elbows, and the length of the supply line to a minimum. Use 1.1/2" hose or pipe for supply lines up to 15 feet long; use 2" hose or pipe if the supply line is over 15 feet long.
6. We recommend that you install a strainer in the inlet line for each starter. These 300 mesh strainers provide 40 micron filtration and offer significant protection against supply line contaminants which could damage the turbine components. Ingersoll Rand offers 3 sizes; ST900-267-24 for 1.1/2 inch lines, ST900-267-32 for 2 inch lines, and ST900-267-64 for 4 inch lines. Replacement elements are: ST900-266-24 for 1.1/2 inch, ST900-266-32 for 2 inch, and ST900-266-64 for 4 inch lines.

7. A leak in any live air line connections means that the system will drain overnight and will have to be repressurized the next morning by use of another vehicle or compressor. Make your connections bubble tight to avoid unnecessary costs and delays. On all threaded connections throughout the system, use Ingersoll Rand No. SMB-441 Sealant, non-hardening No.2 Permatex or Always run the air supply line from the side or top of the receiver, never at or near the bottom. Moisture in the air collects at the bottom of the receiver resulting in damage which could cause the valves to become inoperative. Periodically, open the petcock at the bottom of the tank to drain the water.
8. Whenever using a hazardous gas to operate the starter, there must be no leaks in inlet or exhaust piping or from any other starter joints. Pipe away all discharges to a safe area.
9. We recommend installation of a “glad hand” for emergency re-pressurizing of the system. To keep the “glad hand” clean and free of dirt, and to protect it from damage, a second “glad hand” closed by a pipe plug can be mated to it, or a “glad hand” protector bracket can be used.

**Orientation of the Air Starter**

We recommend that starters be ordered to proper orientation for your specific mounting or installation requirements. However, if the starter must be reoriented for installation, proceed as follows:

1. Refer to the dimension illustration on pages 4 and 5 and note that the Drive Housing can be located in any one of sixteen radial positions relative to the Gear Case. The air inlet can be located in any one of four radial positions relative to the Drive Housing.
2. Study the engine mounting requirements, and determine the required orientation of the Drive Housing relative to the Gear Case. If the Drive Housing has to be reoriented, remove the eight Drive Housing Cap Screws and rotate the Drive Housing to its required position. Separation of the Drive Housing from the Gear Case is not required. Reinstall the Drive Housing Cap Screws and tighten to 28 ft-lb (38 Nm) torque.

**NOTICE**

During field orientation do not change the relationship between the offset housing (28) and the intermediate housing (13). It is important that the cut out section of the bearing boss on the intermediate housing (13) aligns with the drive gear (24).
3. After the Drive Housing is properly oriented relative to the Gear Case, determine if the inlet port will be favorably located for hose installation. If either or both of these members must be reoriented, use an 8 mm hex-head wrench to remove the four motor housing cover capscrews, and rotate the motor housing and/or motor housing cover to its desired position.

**NOTICE**

Do not separate the Motor Housing from the Intermediate Gear case as gear lubrication oil will be lost.

Reinstall the motor housing cover cap screws and alternately tighten them to 60 ft-lb (81.4 Nm).

**Mounting the Air Starter**

1. Study the appropriate piping diagrams and install as indicated.
2. The air receiver tank for a starter installation must have a working pressure rating equal to or greater than the maximum pressure at which the starter will be operated.
3. When connecting the starter to a receiver tank that is already in service, bleed off the air pressure in the tank prior to installing the starter.

**WARNING**

Bleed off the air pressure through a valve or petcock. Do not remove a plug from the tank while the tank is still pressurized.

Drain off any water that may have accumulated in the bottom of the tank.
4. Using a 1.1/2" short nipple, install the SRV 150 Starter Relay Valve on the end of the receiver tank as shown in the piping diagram.

**NOTICE**

Make certain the connection is made to the inlet side of the Relay Valve indicated by the word “IN”, cast on the valve body.

5. For air installations, install the Starter Control Valve (SMB-618) on the dash panel (for vehicular installations) or some other appropriate panel (for stationary installations). An optional control circuit utilizing an electric solenoid control valve and a panel mounted switch are available. Mount the 12V Solenoid Valve (150-BMP-1051B) securely and preferably in a vertical position away from any concentration of heat, vibration or contamination. Connect the leads to the operator’s starting switch which should be located on the dashboard or control panel.

6. Attach Starter Instruction Label (TA-STR-100) to the control panel adjacent to the Starter Control Valve.
7. Mount the Air Pressure Gauge (150BMP-1064) on or adjacent to the control panel. It should be located where it is readily visible to the operator.
8. Connect the Starter Control Valve to the Relay Valve with 1/4" hose. Install a tee in this line with a short feeder hose to the Pressure Gauge.

9. To determine the exact length of 1.1/2" air hose required, run a piece of heavy duty hose or some other flexible tubing of the same diameter from the Relay Valve on the receiver to the starter location on the engine.
10. Attach the 1.1/2" air hose to the outlet side of the Relay Valve, and run the hose through the frame, etc. to its final position at the starter location.
11. At this point determine whether or not it is feasible or practical to attach the hose to the starter before or after the starter is actually mounted. In many cases it may be necessary to attach the hose to the starter before mounting.
12. If possible, liberally grease the teeth on the ring gear with a good quality sticky gear grease. This will help promote the life of the ring gear and the starter Pinion.
13. Move the starter into position, and mount it on the flywheel housing. Tighten the mounting bolts to 100 ft-lb (136 Nm) of torque.

14. **For Pre-Engaged Models only**, Install a 1/4" hose line from the delivery side (marked "DEL") of the starter Control Valve or Solenoid Valve to the “IN” port on the Starter Drive Housing.
15. Install a 1/4" hose line from the “OUT” port on the Starter Drive Housing to the small pipe tapped portion top of the Starter Relay Valve or Solenoid Valve.
16. If the exhaust is to be piped away, remove the standard Splash Deflector which is located at the rear of the Housing Exhaust Cover and replace the Assembly with the 1/4" N.P.T. pipe plug supplied with the starter.
17. Pressurize the complete starting system and check every connection with a soap bubble test. There must be no leaks in the live air lines or other connections.

**Barring Over the Engine**

Occasionally, for setting injectors and/or for timing purposes, it may be desirable to bar over the engine in such a manner that any given piston can be stopped at any given location. This is very easily done with a Series ST900 Turbine Starter.

1. Remove the 1/4" pipe plug located on the exhaust.
2. Manually rotate the Motor Assembly until the engine is cranked to the desired position.

**For Pre-Engaged Models**

1. Disconnect the 1/4" hose at the “OUT” port on the Drive Housing, and plug the hole in the Drive Housing with a 1/4" pipe plug.
2. Engage the Drive Pinion with the flywheel by applying a minimum of 70 psig (4.8 bar/483 kPa) to the “IN” port on the Drive Housing.
3. Using a 6" long hex wrench, manually rotate the Motor Assembly until the engine is cranked to the desired position.
Mounting Dimensions (Pre-Engaged) for Series ST900 Starters

1/4" Pipe Plug in Housing Inlet Boss can be removed and Gages installed to check supply pressure to Starter. Before re-installing Plug, clean threads and apply Pipe Thread Sealant (RJ no. SMB-441 or equiv.) to prevent leakage.

Standard Inlet Flange Kit ST700-K166 (includes Mounting Hardware) Inlet positions "0" thru "9" (0 shown) over ST700-166 Flange

The Hex. Plug must be removed to access the 1/4" Hex. Drive Boring Hole in the Rotor Shaft. Before removing the Hex. Plug, make certain the Starter is level to prevent draining of oil from the Gear Case. When the Hex. Plug is removed, a slight amount of oil may leak from the Hole (this is normal).

1/4" Pipe Plug in Housing Inlet Boss can be removed and Gage installed to check supply pressure to Starter. Before re-installing Plug, clean threads and apply Pipe Thread Sealant (RJ no. SMB-441 or equiv.) to prevent leakage.

Notes:
1. Drive Housing orientation code is based on position of Control Ports.
2. Starter Orientation illustrated is "000" with Exhaust Elbow. If not Specified when ordering orientation "000" will be shipped.
3. Starter Weight = 69 LBS (31.3 Kg) without Inlet Flange.
4. When ordering Starter, Include Model number and orientation code number.
5. Information concerning Models not listed should be requested from Ingersoll Rand "Engine Starting Systems" Marketing Department.
6. Orientation code based on Starter Gear Case positioned as shown.

** For Natural Gas Operation, piped Exhaust must be used and Exhaust Housing Vent Plug replaced with suitable Hose that is connected to piped Exhaust System. Threaded connectors to be sealed with Thread Sealant (RJ no. SMB-441) or equivalent.

(Dwg. TPA1428-5)

Mounting Dimensions (Pre-Engaged) “D” Ratio Drive Housing

Inlet positions "0" thru "3" "O" shown.

1/4" Pipe Plug in Housing Inlet Boss can be removed and Gage installed to check supply pressure to Starter. Before re-installing Plug, clean threads and apply Pipe Thread Sealant (RJ no. SMB-441 or equiv.) to prevent leakage.

Standard Inlet Flange Kit ST700-K166 (includes mounting hardware)

The Hex. Plug must be removed to access the 1/4" Hex. Drive Boring Hole in the Rotor Shaft. Before removing the Hex. Plug, make certain the Starter is level to prevent draining of oil from the Gear Case. When the Hex. Plug is removed, a slight amount of oil may leak from the Hole (this is normal).

** For Natural Gas Operation, piped Exhaust must be used and Drive Housing Vent Plug replaced with suitable Hose that is connected to piped Exhaust System. Threaded connectors to be sealed with Thread Sealant (RJ no. SMB-441) or equivalent.

Notes:
1. Starters should be installed on the Engine with the Exhaust pointed down.
2. These Models are not approved for applications where the Starter is exposed to the Transmission Fluid.
3. Drive Housing Orientation Code is based on position of Mounting Hole opposite the Pinion opening.
4. Standard orientation shown of will be shipped unless otherwise specified.
5. Please read the instructions before attempting to reorient.
6. Starter weight = 96 LBS (44.5 Kg).

(Dwg. TPA1446-3)
Mounting Dimensions ST900 Turbine Starter (Inertia)

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1. The Splash Deflector Assembly must be removed for accessing the 1/4" Hole Drive Barring Hole or when installing a Piped away Exhaust.
2. Before removing the Hex. Plug the Starter must be reasonably level to prevent draining the Oil from the Gear Case.
3. When the Hex. Plug is removed a slight amount of Oil may leak from the Hole. (This is normal)
4. Before reassembly clean all Oil from the Threads and apply Pipe Thread Sealant (R no. SMB-441 or equiv.) to prevent Oil leakage.
5. Torque to 10-15 lb. ft.

(Dwg. TPA1503)

Piping Diagram with Engine prelube system for a standard high pressure system when supply pressure is over pressure rating of Starter.

(Dwg. TPA1448)
Piping Diagram for a Typical Multiple Starter Installation Pre-engaged.

Supply must be adequate to maintain desired operating pressure at the Starters with Starters running. (Not to exceed max. pressure shown on Starter Nameplate.)

ST900 Series multiple Starter Piping schematic showing the Control Circuit.

Note:
- Use Sealant on all the pipe connections.
- SMB-441
- Ingersoll Rand Part Number

For Natural Gas operation, Starter Main Exhaust must be piped away.
To pipe the Drive Housing Vent, Remove the Drive Housing Vent Plug and replace it with a suitable Tubing Line. The tubing must vent at a safe location and must not be interconnected with any other Exhaust Lines which might introduce a back pressure on the Drive Housing Vent.

(Dwg. TPA1449-2)
How to Order a Starter

Series ST900 Turbine-Powered Starters are designed for air or gas operation in off-highway, marine and stationary applications.

Model Coding

- **Size Starter**: 50
- **Percent Arc**: BR
- **Gear Set Ratio**: B=2.18-1, C=2.53-1, D=3.44-1
- **Type of Drive Housing**: P=Pre-engaged, i=Inertia
- **Inlet**: Exh
- **Exhaust**: Int
- **Exhaust Type**: S= Straight, No Letter = Elbow Exhaust
- **Rotation**: Drive
- **Type Mounting Flange**: Pinion (See Table of Pinion Data)

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(Dwg. TPD1808)

For different models or special applications, contact your nearest Ingersoll Rand Distributor or Ingersoll Rand Office.

Must be specified when ordering.
ST900 Turbine Starter (Pre-Engaged) Exploded Diagram

ST900-90 Spacer to be used with old style carrier #ST900-500

(Dwg. TPA1451-6)
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<td>58</td>
<td>for all ST900 D Ratio Models</td>
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<td>Gear Frame Bearing</td>
<td>T06-24</td>
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<td>Cap Screw (3)</td>
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<td>Gear Case</td>
<td>SS850-37</td>
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<td>Piston Return Spring</td>
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<td>60</td>
<td>Drive Pinion Retaining Screw</td>
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<td>SS825C-9</td>
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<td>for all ST900 D Ratio Models</td>
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<td>for all other Models</td>
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<td>Front Drive Gear Bearing</td>
<td>SS800-278</td>
<td>61</td>
<td>Drive Pinion Retaining Screw</td>
<td></td>
</tr>
<tr>
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<td>Rear Drive Gear Bearing</td>
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<td>ST900 B and C Ratio Right Hand Models</td>
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<td>Drive Gear Bearing Retainer</td>
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<td>ST900 B and C Ratio Left Hand Models</td>
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<td>Drive Gear Screw</td>
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<td>Drive Pinion Washer</td>
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<td>Drive Gear Lock Washer</td>
<td>SS800-180</td>
<td></td>
<td>for all ST900 D Ratio Models</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Drive Gear Cup</td>
<td>SS800-177</td>
<td></td>
<td>for all Models (Right)</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Drive Gear O-Ring</td>
<td>SS800-176</td>
<td></td>
<td>for all Models (Left)</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Drive Housing Cap Screw (8)</td>
<td>SS800-744</td>
<td>63</td>
<td>Drive Pinion</td>
<td></td>
</tr>
<tr>
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<td>Drive Housing Cap Screw Lock Washer (8)</td>
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<td>for Model ST950BP03R31 and ST999BP03R31</td>
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<td>for ST950 D Ratio Models</td>
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<td>for ST950BP03R31 and ST999BP03R31</td>
<td>SS815R-13-31</td>
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<td>for 950CP03R25 and ST999CP03R25</td>
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<td>for ST905CP03L26 and ST999CP03L26</td>
<td>SS825L-13-26</td>
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<td>for all ST999 Left Hand Models</td>
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<td>41</td>
<td>Drive Housing O-Ring</td>
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<td>64</td>
<td>Pinion Spring Sleeve</td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>SS850-335</td>
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* Not Illustrated
† Indicates Tune-up Kit part
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<td>Inlet flange Kit (includes Inlet Flange,</td>
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<td>O-Ring, Mounting Bolts and Lock Washers)</td>
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<td>73 Splash Deflector</td>
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<td>Exhaust Flange Kit (includes illustrated parts</td>
<td>ST700-K351</td>
<td>74 Deflector Return Spring</td>
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<td>67, 68, 69, 70 and 71)</td>
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<td>Lockwashers (6)</td>
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<td>* Flange Mounting Hardware Kit (includes</td>
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<td>O-Ring, Mounting Bolts and Lockwashers)</td>
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* Not Illustrated.
† Indicates Tune-up Kit part.
Series ST900 Turbine Starters (Inertia) Exploded Diagram

ST900-90 Spacer to be used with old style carrier #ST900-500

(Dwg.TPA1486-1)
## Series ST900 Turbine Starters (Inertia) Parts List

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Description</th>
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<td>Starter Assembly Cap Screw (4)</td>
<td>ST700-2574</td>
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<td>SS800-359</td>
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<td>7</td>
<td>Cap Screw Washer (4)</td>
<td>SS800-26</td>
<td>32</td>
<td>Gear Case Cover</td>
<td>SS810-678</td>
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<td>8</td>
<td>Mortor Housing Assembly</td>
<td>ST900-A40</td>
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<td>Gear Case Cover O-Ring</td>
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<td>Housing Plug (2)</td>
<td>R2-227</td>
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<td>Drive Gear Shaft Seal</td>
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<td>Housing Plug Inlet Boss</td>
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<td>Nameplate</td>
<td>ST900-301</td>
<td>37</td>
<td>Drive Gear Key (2)</td>
<td>20BM-610</td>
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<td>Nameplate Screw (4)</td>
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<td>Drive Housing</td>
<td>SS810-300</td>
</tr>
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<td>Drive Housing Bearing</td>
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<td>12A</td>
<td>for All ST950 Right Hand Models</td>
<td>ST750L-A53A</td>
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<td>ST750R-A53A</td>
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<td>Drive Housing Cap Screw Lock Washer (8)</td>
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<td>for All ST999 Right Hand Models</td>
<td>ST799L-A53A</td>
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<td>Inlet Flange Kit (includes Inlet Flange, O-Ring)</td>
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<td>Cylinder O-Ring Seal (2)</td>
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<td>Mounting Bolts and Lock Washers</td>
<td>ST700-KS1</td>
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<td>12E</td>
<td>Intermediate Pinion</td>
<td>SS800B-17</td>
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<td>Exhaust Flange (43, 44, 45, 46 and 47)</td>
<td>ST700-351</td>
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<td>Front Gear Case O-Ring</td>
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<td>Weld Sleeve Part</td>
<td>ST700-352</td>
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<td>Seal</td>
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<td>17A</td>
<td>Carrier / Ring Gear</td>
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<td>17C</td>
<td>Bearing</td>
<td>SS800-22</td>
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<td>Flange mounting Hardware Kit (includes O-Ring, Mounting Bolts and Lock Washers)</td>
<td>ST750-K167</td>
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<td>17D</td>
<td>Screw</td>
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<td>50</td>
<td>Tune-up Kit (for Inertia Drive Models)</td>
<td>ST700I-TK6</td>
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<td>18</td>
<td>Idler Gear Frame</td>
<td>ST900-108</td>
<td>51</td>
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<td>ST700I-TK6</td>
</tr>
<tr>
<td>19</td>
<td>Idler Gear (3)</td>
<td>ST900-10</td>
<td>52</td>
<td>Housing Exhaust Cover</td>
<td>ST700-562</td>
</tr>
<tr>
<td>20</td>
<td>Idler Gear Bearing (6)</td>
<td>ST900-24</td>
<td>53</td>
<td>Splash Deflector</td>
<td>ST700-735</td>
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<tr>
<td>21</td>
<td>Idler Gear Bearing Spacer (3)</td>
<td>ST900-91</td>
<td>54</td>
<td>Deflector Return Spring</td>
<td>D10-275</td>
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<td>22</td>
<td>Idler Gear Shaft (3)</td>
<td>ST900-191</td>
<td>55</td>
<td>Deflector Return Screw</td>
<td>ST700-737</td>
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<td>23</td>
<td>Gear Frame Bearing</td>
<td>T06-24</td>
<td>56</td>
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</table>

* Not Illustrated
# Not listed and not illustrated.
- To keep downtime to a minimum, it is desirable to have on hand certain repair parts. We recommend that you stock one (pair or set) of each part indicated by a bullet (*) for every four tools in service.
Maintenance, Disassembly / Assembly Instructions

ST900 Lube and Torque Specifications

To torque to 50-55 ft. lbs.

To torque to 10 ft. lbs.

Coat with Dexron

Coat with IR #130 Grease

Coat Clutches and Splines with IR #130 Grease

Coat Bore with IR #130 Grease

Coat Pinion with IR #130 Grease

Torque to 72-88 ft. lbs.

Torque to 55-58 ft. lbs.

Pack with IR #130 Grease (225-250 ml)

1/2 drops of Hermanite 11

Apply 175 ml of Dexron

Coat Bore with IR #130 Grease

Coat Shaft with IR #130 Grease

Coat Clutched and Splines with IR #130 Grease

Notes:
1. Torque all Pipe Plugs and Vents to 6 ft. lbs. Lubricate the same with the Pipe Sealant with Tellon.

2. Apply Parker O-lube to all O-rings.

(Dwg. TPB1020)
Maintenance, Disassembly / Assembly Instructions

**WARNING**
Always wear eye protection when operating or performing maintenance on this tool.
Always turn off the air supply and disconnect the air supply hose before installing, removing or adjusting any accessory on this tool or before performing any maintenance on this tool.

**Lubrication**
Each time a Series ST900 Starter is disassembled for maintenance or repair, lubricate the starter as follows:

**For Models with Inertia Drive**

**NOTICE**
On models with inertia drive, do not lubricate the threaded area of the Drive Shaft as it could collect dirt and foreign material which will prevent efficient operation.

**For Models with Pre-Engaged Drive**
1. Lubricate the inside diameter of the Drive Shaft (57) with Ingersoll Rand No. 130 Grease.
2. Lubricate the Pinion end of the Drive Shaft with Ingersoll Rand No. 11 Grease.
3. Wipe a thin film of Ingersoll Rand No. 130 Grease in the bore of the Drive Housing (40).
4. Roll the Piston Return Spring (59) in Ingersoll Rand No. 130 Grease.
5. Coat the outside of the Piston (54) with Ingersoll Rand No. 130 Grease.
6. Lubricate the Drive Gear (29) with 8 oz. (240 ml) of Ingersoll Rand No. 130 Grease.

**For All Models (refer to Lubrication and Torque drawing)**
1. Lubricate the O-Rings with O-Ring lubricant.
2. Add 175 ml (approximately 1/3 pint) of Dexron® II Automatic Transmission Fluid through the side plug hole in the Motor Housing (8).
3. Add 15 ml of Dexron® II Automatic Transmission Fluid to exhaust pipe plug hole (see page 6 left end view).

**Disassembly**

**General Instructions**
1. Do not disassemble the starter any further than necessary to replace worn or damaged parts.
2. When grasping a part in a vise, always use leather-covered or copper-covered vise jaws to protect the surface of the part and help prevent distortion. This is particularly true of threaded members.
3. Do not remove any part which is a press fit in or on a subassembly unless the removal of that part is necessary for replacement or repairs.
4. Always have a complete set of seals and O-Rings on hand before starting any overhaul of a Series ST900 Turbine Starter. Never reuse old seals or gaskets.
5. Always mark adjacent parts on the Housing Exhaust Cover (1), Motor Housing (8), Intermediate Gear Case (13), Gear Case (28) and Drive Housing (40) so these members can be located in the same relative position when the Starter is reassembled.
7. Do not press any needle bearing from a part unless you have a new needle bearing on hand for installation. Needle bearings are always damaged during the removal process.

**Disassembly of the Exhaust Elbow, Motor Assembly, and Motor Housing and Intermediate Gear Case.**
1. If replacing the Motor Assembly (12), remove both Housing Plugs (10) and drain the oil from the gearing before beginning disassembly of the Starter.

**NOTICE**
Removing Exhaust Cover Pipe prior to dislodging Housing Exhaust allows easier disassembly.

2. Using an 8 mm hex-head wrench, unscrew and remove the Starter Assembly Cap Screws (6) and washers (7).
3. Pull the Housing Exhaust Elbow (1) from the Motor Housing (8) to dislodge the Housing Exhaust Elbow, rotate it until the ears clear the Motor Housing. Using a plastic hammer, tap the ears alternately until the Housing Exhaust Elbow can be removed from the Motor Housing. Refer to Dwg. TPD1736.
4. To disassemble the Housing Exhaust Elbow and components, refer to Dwg. TPA1451-3.
5. Tap the Motor Housing with a plastic hammer to dislodge it from the Intermediate Gear Case (13). Refer to Dwg. TPD1737.
6. Grasp the rear of the Motor Assembly (12) and pull it from the rear of the Motor Housing. Refer to Dwg. TPD1161.
7. Support the Intermediate Gear Case on a bench and position it in a copper-faced vise so that the Intermediate Pinion (17B) is secured in the jaws of the vise. Tighten the vise only enough to hold the Intermediate Pinion securely.

8. Loosen the Intermediate Pinion Retaining Screw (17D) 1.5 turns only. Do not remove.

**WARNING**

If the Intermediate Gear Case is not supported on a bench and if the Intermediate Pinion Retaining Screw is completely removed, the Intermediate Gear Case and components could fall causing injury. Refer to Dwg. TPD1739.

(Dwg. TPD1161)

9. Remove the Intermediate Gear Case Assembly from the vise and remove the Intermediate Pinion. Remove the Rear Gear Case O-Ring and Front Gear Case O-Ring from the Intermediate Gear Case.

10. Remove the Carrier / Ring Gear (17A).

11. Remove Seal (16).

12. Remove Bearing (17C) by pressing from front of Intermediate Gear Case. Refer to Dwg. TPD1743.

13. Remove the Cap Screws (24) from the Idler Gear Frame (18) and remove the Idler Gear Frame from the front of the Motor Housing. If the Idler Gear Frame will not come out of the Motor Housing easily, use a wooden dowel to tap the Idler Gear Frame from inside the rear of the Motor Housing.

14. If the Gear Frame Bearing (23) needs to be replaced, press it off of the shaft of the Idler Gear Frame.

15. Press the Idler Gear Shafts (22) out of the Gear Frame and remove the Idler Gears (19).

16. Press one of the Idler Gear Bearings (20) out of the Idler Gear, remove the Spacer (21), and press out the other Idler Gear Bearing. Repeat this process for the other two Idler Gears. Refer to Dwg. TPD1741.

(Dwg. TPD1741)

Disassembly of the Drive Housing

Pre-Engaged Models:

1. Grasp the Drive Pinion (63) in a copper-faced vise with the Starter supported on the workbench.

2. Remove the Drive Pinion Retaining Screw (61).

3. Remove the Starter from the vise.

4. Remove the Drive Pinion Washer (62) and the Drive Pinion.

5. Slide the Pinion Spring Sleeve (64) and the Pinion Spring (65) off the Drive Shaft.

6. Using an impact wrench with a 5/16" (8 mm) x 8" (203 mm) long hex inserted into the end of the Drive Shaft, unscrew the Drive Gear Screw (34).

7. Unscrew and remove the Drive Housing Cap.

8. Tap the Drive Housing (40) with a plastic hammer to help dislodge it from the Gear Case (28).

**WARNING**

Failure to follow this procedure could result in injury to personnel.

9. Place the Drive Housing in an arbor press, piston end up. Apply a load to the Piston (54) using the arbor press to compress the Piston Return Spring (59) before removing the Bulkhead Retainer (45).

10. Using a screwdriver, remove the Bulkhead Retainer. Use the arbor press. Do not use compressed air to load the piston.

**CAUTION**

Make sure the tension of the spring pushes the Bulkhead out of the Drive Housing before removing the Drive Housing from the arbor press.

11. Remove the Bulkhead (46) from the Piston.

12. Remove the Outer Bulkhead Ring (47) and the Inner Bulkhead Ring (48).

13. Slide the Drive Shaft (57) from the Drive Housing.

14. Pull the Piston Return Spring (59) off the Drive Shaft.

**NOTICE**

Do not remove the Front Drive Shaft Bearing (42) or the Drive Housing Seal (43) unless replacement is necessary and new parts are available. The Bearing and/or the Seal will always be damaged when removed from the Drive Housing.
15. Remove the Piston Ring (55) from the Piston.
16. Press the Clutch Spring Cup (50) down and remove the Clutch Spring Cup Retainer (49).
17. Remove the Clutch spring Cup and Clutch Spring (51).
18. Remove the two Clutch Jaws (52).
19. Remove the Front Drive Gear Bearing (30), Drive Gear Cup (46), Drive Gear Lock Washer (35), Drive Gear Screw Ring (37) and Drive Gear Screw (34).
20. Using a screwdriver, remove the large Drive shaft Bearing Retainer (53).
21. Press the Rear Drive Shaft Bearing and Drive Shaft (57) out of the Piston. If the Rear Drive Shaft Bearing needs to be replaced, proceed as follows:
   a. Using a small chisel, cut and remove the small drive shaft bearing retainer (53) in the Drive shaft.
   b. Press the Rear Drive Shaft Bearing (58) off the Drive shaft.
22. Place the Gear Case (28) on a workbench.
23. Using retaining ring and working through the access holes in the gear web, remove the Drive Gear Bearing Retainer (32). Refer to Dwg. TPD1170.
24. Pull the Drive Gear (29) out of the Gear Case.

**NOTICE**

*Do not disassemble the Drive Gear and Clutch parts of Series ST900 Turbine-Powered Starters. If the Drive Gear Shaft is defective, install a new or factory-rebuilt unit.*

25. Using retaining ring pliers, remove the Drive Gear Shaft Bearing Retainer (33).
26. Remove the Rear Drive Gear Bearing (31) from the Drive Gear.

**Inertia Models:**

1. Remove the eight Drive Housing Cap Screws (40) and Lock Washers (41).
2. Tap the Drive Housing (38) with a plastic hammer to help dislodge it from the Gear Case Cover (32). Remove the Drive Housing (38) from the Starter Drive (36). Refer to Dwg. TPD1168.
3. Place the Drive Housing in an arbor press, bearing end up. Using a pressing bar, remove the Drive Housing Bearing (39) from the Drive Housing.
4. Using a screwdriver, displace the locking spring and remove the screw holding the Starter Drive (36) to the Drive Gear Shaft.
5. Slide the Starter Drive off the Drive Gear Shaft.
6. Remove the two Drive Gear Keys (37) from the Drive Gear Shaft. Refer to Dwg. TPD1171.
7. Remove the Gear Case (32) from the Gear Case (38).
8. Remove the Drive Housing O-Ring (35) and the Gear Case Cover O-Ring (33) from the Gear Case Cover.
10. Remove the Rear Drive Gear Bearing (31) and the Front Drive Gear Bearing (30) from the Drive Gear.

**Assembly**

**General Instructions (refer to lubrication and torque drawing).**

1. Always press on the inner ring of a ball-type bearing when installing the bearing on a shaft.
2. Always press on the outer ring of a ball-type bearing when pressing the bearing into a bearing recess.
3. Whenever grasping a starter or part in a vise, always use leather-covered or copper-covered vise jaws. Take extra care with threaded parts or housings.
4. Except for bearings, always clean every part and wipe every part with a thin film of oil before installation.
5. Check every bearing for roughness. If an open bearing must be cleaned, wash it thoroughly in a clean, suitable, cleaning solution and dry with a clean cloth. Sealed or shielded bearings should never be cleaned. Work grease thoroughly into every open bearing before installation.
6. Apply a film of O-Ring lubricant to all O-Rings before final assembly.

**Assembly of the Gear Case and Drive Housing**

**Pre-Engaged Models:**

1. Place the Drive Gear Bearing Retainer (32) over the rear end of the Drive Gear.
2. Using an arbor press, press the Rear Drive Gear Bearing (31) onto the rear end of the Drive Gear.
3. Using a plastic Hammer, seat the Rear Drive Gear Bearing into the Gear Case by tapping the opposite end of the Drive Gear.
4. Using retaining ring install the Drive Gear Shaft Bearing Retainer (33).
5. Using retaining ring pliers and working through the access holes in the gear web, install the Drive Gear Bearing Retainer. Refer to Dwg. TPD1170.
6. Lubricate the Drive Gear with approximately 8 oz. (240ml) of Ingersoll Rand No. 130 lubricant.
7. Press the Rear Drive Shaft Bearing (58) onto the Drive Shaft.
8. Slide the rear bearing retainer convex side first, onto the Drive shaft. Press it into position in accordance with the instructions packaged with the new Retainer.

9. Assemble the Drive Gear Screw (34), Drive Gear Lock Washer (35), Drive Gear Cup (36) and Drive Gear Screw O-Ring (37).

10. Grasp the Drive shaft (57) in a vise, external splined end down. Place assembled Drive Shaft Screw Unit into the Drive Shaft, screwhead down. Lubricate the inside diameter of the Drive Shaft with Ingersoll Rand No. 28 Lubricant.

11. Slide the Drive Gear Bearing (30) into the Drive Shaft.

12. Lubricate with Ingersoll Rand No. 130 Lubricant and install the Driving Clutch jaw teeth facing up and Driven Clutch Jaw teeth facing down into the Drive Shaft.

13. Insert the Clutch Spring (51) into the Drive shaft.

14. Insert the Clutch Spring Cup (50) into the Drive Shaft.

15. Press the inserted parts into the Drive Shaft, and install the Clutch Spring Cup Retainer (49).

**NOTICE**

If it is necessary to replace the Drive Housing (40) and drive components, make sure that the Piston Seal (part number SS800-272) has been removed from the rear of the new Piston (54). The piston Seal must be removed to prevent pressure build-up which will cause movement of the Planet Gear Frame Shaft Seal (16). If this condition occurs, the Piston cannot retract and the Drive Pinion (63) will remain in engagement with the flywheel, causing damage to the Starter drive train and/or Starter motor. To remove the Piston Seal, insert a screwdriver inside the lip of the Seal and pry it loose from the Piston.

16. Install the Piston (54) onto the Drive Shaft until the Rear Drive Shaft Bearing seats into the Piston.

17. Using a thin, flat blade screwdriver to assist in this operation, coil the Large Drive Shaft Bearing Retainer (53) into the groove of the Piston to retain the outer race of the Drive Shaft Bearing.

18. Using O-Ring lubricant, lubricate the Piston O-Ring (55) and install it in the groove of the Piston.

19. Position the Drive Housing in an arbor press, pinion-end down and install the Drive Housing Seal (43) into the Drive Housing. Using a pressing sleeve of the proper size, press the Seal into the Drive Housing so that the lip of the seal faces towards the Drive Pinion.

20. Using a sleeve that contacts the outer race of the Front Drive Shaft Bearing (42), press the Bearing into the Drive Housing until it seats. For “B” and “C” ratio models only, drop the Piston Return Spring Seat (60) on top of the Front Drive Shaft Bearing.

21. Slide the Piston Return Spring (59) onto the Drive Shaft and snap it into the front of the Piston so that it is against the Large Drive Shaft Bearing Retainer (53).

22. Lubricate and insert the assembled Drive Shaft into the Drive Housing.

23. Using O-Ring lubricant, lubricate and install the Outer Bulkhead O-Ring (47) and the Inner Bulkhead O-Ring (48) on the Bulkhead (46).

24. Slide the Bulkhead onto the Piston.

25. With the Drive Housing in the arbor press, press down on the rear face of the Piston.

**NOTICE**

Feel the underside of the Drive Housing to make sure the Drive Shaft passes through the Bearing.

26. Using a screwdriver, install the Bulkhead Retainer (45).

**WARNING**

Make sure the Bulkhead Retainer is properly seated in the Motor Housing groove before easing off the arbor press. Failure to do so will allow improperly retained parts to separate when removed from the arbor press resulting in injury to personnel.

27. Remove the Drive Housing from the arbor press.

**NOTICE**

Models ending in R25, R31 and R51 have a lefthand thread; models ending in L26, L32 and L52 have a right-hand thread.

Install the Drive Pinion Retaining Screw into the end of the Drive Shaft and tighten it to 80 ft-lb (108.5 Nm) torque for models with “B” and “C” gear ratios and to 125 ft-lb (169.5 Nm) torque for models with “D” gear ratio.

Inertia Drive Models:

On models with Inertia Drive, do not lubricate the threaded area of the Drive Shaft as it could collect dirt and foreign material which will hinder efficient operation.

**Gear Case**

1. Install the Rear Drive Gear Bearing (31) and Front Drive Gear Bearing (30) onto the Drive Gear (29).

2. Install the two Drive Gear keys (37) into the drive gear shaft. Refer to Dwg. TPD1171.

3. Slide the Rear Drive Gear Bearing into the Gear Case.

4. Lubricate the Drive Gear with approximately 8 oz. (240 ml) of Ingersoll Rand No. 130 Grease.

5. Press the Drive Gear Shaft Seal (34) down into the Gear Case Cover (32). Lip facing upward.

6. Install the Gear Case Cover O-Ring (33) onto the Gear Case Cover.

7. Install the Gear Case Cover into the Gear Case.

8. Slide the Starter Drive (36) onto the drive gear shaft and tighten the Starter drive locating the ring and screw securely.

9. Press the Drive Housing Bearing (39) into the Drive Housing (38) and lubricate it with Ingersoll Rand No. 130 Grease. See Dwg. TPD786.
Needle Bearing Inserting Tool

Pilot to fit I.D. of Bearing. Length of Pilot to be approximately \( \frac{1}{8} \)" less than length of Bearing.

(Dwg. TPD786)

10. Install the Drive Housing O-ring (35) onto the Drive Housing.
11. Install the Drive Housing onto the Gear case, aligning the punches.
12. Install the eight Drive Housing Cap Screws (40) and Drive Housing Cap Screw Lock Washers (41). Tighten to 28 ft-lb (38 Nm) torque. Refer to Dwg. TPD1168.

Installation of the Motor Housing, Motor Assembly and Intermediate Gear Case

1. Press one Idler Gear Bearing (20) into a Idler Gear (19).
2. Press Idler Gear Spacer (21) into the Idler Gear until it seats against the Bearing.
3. Press the other Idler Gear Bearing into the Idler Gear until it seats against the Spacer. Repeat this procedure for the other two Idler Gears.
4. Install the assembled Idler Gears in the Idler Gear Frame (18) by aligning the holes in the Gears and the Bearings with the holes in the Idler Gear Frame and pressing in the Idler Gear Shafts.
5. Press the Gear Frame Bearing (23) on the Shaft of the Idler Gear Frame. Refer to Dwg. TPD1741.

(Dwg. TPD1741)

6. Install the Idler Gear Frame Assembly in the front of the Motor Housing and secure it with Loctite and torque to 10 ft-lb with Cap Screws (24). Refer to Dwg. TPD1745.

(Dwg. TPD1745)

7. Install the Spacer (17) on the shaft of the Carrier/Ring Gear (17A).
8. Using a bearing pressing tool of the proper size, press the Bearing (17C) into the rear of the Intermediate Gear Case (13).
9. Using a sleeve which contacts the outer ring of the Seal (16), press the Seal over the Spacer, flat side first.

Make sure that the flat side of the seal will be installed against the Bearing.

10. Install the shaft of the Carrier through the Spacer until the shoulder of the Carrier seats against the Spacer. Refer to Dwg. TPD1743.

(Dwg. TPD1743)

11. Install the Intermediate Pinion (17B) making sure that the notches at the rear of the Pinion align with the notches and tangs in the shaft of the Idler Gear Frame.
12. Clean the threads of the Intermediate Pinion Retaining Screw (17D) and apply 2-3 drops of Permabond HMI® *** to the threads approximately 3 mm from the end of the Screw. Install Screw and tighten enough to hold assembly together.
13. For final tightening, position the Intermediate Gear Case so the Intermediate Pinion is secured in the jaws of a leather-covered or copper-covered vise. Tighten the Intermediate Pinion Retaining Screw to 90 ft-lb (122 Nm) torque. Refer to Dwg. TPD1739.

(Dwg. TPD1739)

14. Remove the Intermediate Gear Case from the vise and set it on a bench. Align the punch marks on the Intermediate Gear Case and Gear Case and using a plastic hammer, tap the Intermediate Gear Case until it seats in the rear of the Gear Case. Mike sure the Intermediate Pinion meshes with Drive Gear. Refer to Dwg. TPD1746.

*** Registered trademark of Permabond
NOTICE
During field orientation do not change the relationship between the offset housing (28) and the intermediate housings (13). It is important that the cut out section of the bearing boss on the intermediate housing (13) aligns with the drive gear (29).

15. Install the Rear Gear Case O-ring (14) in the groove at the rear of the Intermediate Gear Case and the Front Gear Case B-Ring (15) in the groove at the front of the Intermediate Gear Case. Coat both O-Rings with O-Ring lubricant.

16. Before installing the Motor Assembly, coat the O-Rings on the Motor Assembly and the inside of the Cylinder with O-Ring lubricant. Install the Motor Assembly through the rear of the Motor Housing with the geared end of the rotor toward the front. Refer to Dwg. TPD1161.

17. Align the punch marks on the Motor Housing with the punch marks on the Intermediate Gear Case and using a plastic hammer, tap the Motor Housing until it seats on the rear of the Intermediate Gear Case. Refer to Dwg. TPD1747.

Assembly of the Directional Housing Exhaust Cover
1. Coat the Exhaust Cover Seal (2) with O-ring lubricant and install in the groove in the Directional Housing Exhaust Cover (1).
2. Install Directional Housing Exhaust Cover on the rear of the Motor Housing in the desired orientation and using a plastic hammer, tap the Directional Housing Exhaust Cover until it seats.
3. Secure the Directional Housing Exhaust Cover on the rear of the Motor Housing using the Starter Assembly Cap Screws and Cap Screw Washers. Using an 8 mm hex-head wrench, tighten each Cap Screw a little at a time to a final torque of 51 ft-lb (69 Nm) in 20 ft-lb (27 Nm) increments. Refer to Dwg. TPD1748.

4. Lubricate Exhaust Adapter Seal (71) with O-Ring lubricant and install in groove in Exhaust Flange (67).
5. Install Exhaust Flange with Exhaust Adapter Seal down on Directional Housing Exhaust Cover. Align holes and secure Adapter with Cap Screws (69) and Lock Washers (70). Tighten each Cap Screw a little at a time to a final torque of 48 ft-lb (65 Nm) torque in 20 ft-lb (27 Nm) increments.

Whenever assembling the Exhaust Cover to the starter, be sure to add 15ml of Dexron™ II Automatic Transmission Fluid to the pipe plug hole marked “OIL HERE”.

Use Ingersoll Rand SMB-441 Pipe Sealant on all plugs.

6. Install the bottom Housing Plug (10) and the Housing Plug Inlet Boss (11). Put the Starter on its side with the side plug hole upward. Add 175 ml (approximately 1/3 pint) of Dexron™ II Automatic Transmission Fluid through the side plug hole in the Motor Housing (8).

Turbine Module Change-Out

These instructions will ensure a successful change-out of a turbine module (Motor Assembly) on an Ingersoll Rand starter. These instructions will cover starters with and without Directional Housing Exhaust and cover mechanical components, plumbing, lubrication and disposition of leftover components.

Definitions
1. **Turbine Module.** The turbine module consists of the Motor Rotor Assembly (12), Exhaust Kit (1 or 72), the Motor Housing (8), the Intermediate Gear Case (13) and included parts.
2. **Gear Case (28).** The Gear Case is of an offset shape and has four long socket head Cap Screws (6). The heads of the Cap Screws are seen from the rear of the starter.
3. **Drive Housing Kit,** The Drive Housing Kit contains the 3-bolt Flange (44C) that attaches the starter to the engine or the drive housing (40) and included parts.
4. **Housing Exhaust Cover Assembly (72).** The Housing Exhaust Cover Assembly consists of the Cover and its associated parts found on the rear end of starters.
5. **Directional Housing Exhaust Cover (1).** The Directional Housing Exhaust Cover consists of a 90, 3-1/2 inch flanged elbow located on the rear end of starters equipped with the Housing Exhaust Cover Assembly.
6. **Starter Assembly Cap Screw (6).** The Starter Assembly Cap Screws are 1.5 x 10 mm socket head cap screws. Four Cap Screws are required on each starter.

Procedure

For Starters Without Directional Housing Exhaust:
1. Tag off the starter control to prevent inadvertent use of the starter.
2. Remove the four Cap Screws (66) that attach the Inlet Flange (66) to the side of the Motor Housing (8). Save the O-Ring (66) found under the Inlet Flange.
3. Remove the four Starter Assembly Cap Screws (6) found on the rear end of the starter.
4. Remove the turbine module and the Housing Exhaust Cover Assembly (72) as a unit from the Gear Case (28) and set aside.
5. Insert the replacement turbine module into the Gear Case making sure that the cutout portion of the front of the turbine module is facing the large Drive Gear (29) inside the Gear Case.
6. Install the four Starter Assembly Cap Screws and torque them each to 45-50 ft-lb torque in 20 ft-lb increments.
7. Apply some grease to the O-Ring saved from the Inlet Flange. Push the O-Ring into the groove on the Inlet Flange and reinstall the Flange. Remove the tag from the starter control and test the starter.
8. Place the leftover turbine module into the box and ship it to Ingersoll Rand using the return goods authorization and shipping label provided with the replacement turbine module.

For Starters with Directional Housing Exhaust:
1. Tag off the starter control to prevent inadvertent use of the starter.
2. Remove the four Cap Screws (66) that attach the Inlet Flange (66) to the side of the Motor Housing (8). Save the O-Ring (66) found under the Inlet Flange.
3. Remove the four Starter Assembly Cap Screws (6) found on the rear end of the starter.
4. Disconnect the Directional Housing Exhaust Cover (1) from the exhaust piping.
5. Remove the turbine module and Directional Housing Exhaust Cover as a unit from the Gear Case (28). Remove the Directional Housing Exhaust Cover from the turbine module. Set the turbine module aside.
6. Remove the Directional Housing Exhaust Cover Assembly from the replacement turbine module.

Before returning starter to service, make sure that the rear bearing of the turbine (Motor Assembly) has an adequate amount (15 mm) of Dexron II lubricant.

For Starters without the Directional Housing Exhaust Cover:
1. Remove the Deflector Return Screw (75) at the center of the Splash Deflector (75) at the rear of the starter.
2. Using a lube injector, squirt some Dextron II into the Cap Screw hole. Reinstall the Deflector Return Screw.

For Starters with the Directional Housing Exhaust Cover:
1. Remove the I/4 inch Plug on the outside and back of the Directional Housing Exhaust Cover.
2. Using a lube injector, squirt some Dextron II into the hole until it begins to flow back out. Reinstall the Plug. Before the job is completed, verify that the starter is receiving the proper gas supply pressure while running. The desired pressure is printed on the nameplate of the starter. Measurement of this pressure should be taken at the motor inlet of the starter. Before turning on the starter, a 0-160 psig gage may be connected to the inlet of the starter by first removing a 1/4 inch NPT plug at the starter motor inlet. Return the starter to operation and adjust gas supply to proper pressure.

Do not overfill. Install the side Housing Plug (10) and tighten all plugs to 5 to 10 ft-lb (6.8 to 13.6 Nm) torque.

Test and Inspection Procedure
1. Clutch Ratcheting: Turn the Drive Shaft Pinion (63) by hand in the direction of Starter rotation. The clutch should ratchet smoothly with a slight clicking action.
2. Motor and Gearing Freeness: Turn the Drive Shaft Pinion (63) opposite the direction of Starter rotation. The Drive Shaft Pinion should turn by hand.
3. Motor Action: Secure Starter in a vise and apply 90 psi (6.2 bar/620 kPa) pressure using a 3/8” (9 mm) supply line to the inlet of the motor. Starter should run smoothly.
4. Motor Seals: Plug the exhaust and slowly apply 20 psi (1.38 bar/138 kPa) pressure to the inlet of the motor. Immerse the Starter for 30 seconds in a nonflammable, bubble-producing liquid. If the Starter is properly sealed, no bubbles will appear.
5. Gear Case Seals: Plug the exhaust and slowly apply 20 psi (1.38 bar/138 kPa) pressure to the inlet of the motor. Immerse the Starter for 30 seconds in a nonflammable, bubble-producing liquid. There should be no leakage in the housing joints in the Gear Case area or in the shaft seal in the Intermediate Gear System. If the Starter is properly sealed, no bubbles will appear.
6. Confirm Motor Adjustment: Remove Housing Plug (10). Use a 1/4” hex drive to rotate the motor to verify proper motor adjustment Motor should rotate freely.
7. Orientation: Drive Housing must be assembled to customer orientation or per engineering drawing. If orientation is not specified by customer, standard orientation will be supplied.
8. Confirm Drive Rotation: Apply low pressure to motor and observe rotation. Drive Pinion (63) must rotate in the direction stamped on the nameplate. Chamfer on pinion teeth should be on trailing edge of gear tooth.
10. Drive Housing Function - Pre-Engaged Models Only: Apply 120 psig (8.2 bar/827 kPa) to “IN” port of Drive Housing (40). Cycle five times. Air should exhaust through “OUT” port during each cycle.
11. Exhaust Deflector Operation: Install the Starter on testing fixture. Apply low air pressure to motor and observe. The Deflector must return to its normal position after operation of the Starter.
12. Concentricity and Squareness of Shaft to Housing "D" Ratio
   Only: Assemble indicator on shaft. Indicate pilot diameter. Check
   squareness of face at mounting surface. Pilot diameter must be
   concentric with .008 max. T.I.R. Mounting face must be square
   with shaft within .004 T.I.R. max.

13. Drive Housing Leakage - Pm-Engage Models Only: Plug Drive Housing (40) "OUT" port and apply 150 psig (3.45 bar/344 kPa) to "IN" port to extend Drive Shaft (57). There should be no leakage.

14. Test Pinion Engagement - Pm-Engaged Models Only: Plug "OUT" port in Drive Housing (40). Apply 50 psig (3.45 bar/344 kPa) as needed. In its normal position, the distance from the mounting flange to the end of the Drive Shaft (57) should be 1-3/4". In its extended position, the distance from the mounting flange to the end of the Drive Shaft should be 2-7/8". While the Drive Shaft is extended, push the Drive Pinion (63) back on helical splined shaft. Rear face of Drive Pinion must move back 47° ± 0.035°.

Troubleshooting Guide

<table>
<thead>
<tr>
<th>Trouble</th>
<th>Probable Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor will not run</td>
<td>No air supply.</td>
<td>Check for blockage or damage to air supply lines or tank.</td>
</tr>
<tr>
<td>Damaged Motor Assembly</td>
<td>Inspect Motor Assembly and power train and repair or replace if necessary.</td>
<td></td>
</tr>
<tr>
<td>Foreign material in Motor and/or piping</td>
<td>Remove Motor Assembly and/or piping and remove blockage.</td>
<td></td>
</tr>
<tr>
<td>Blocked exhaust system.</td>
<td>Remove Housing Exhaust Cover and check for blockage.</td>
<td></td>
</tr>
<tr>
<td>Defective Control Valve or Relay Valve.</td>
<td>Replace Control Valve or Relay Valve.</td>
<td></td>
</tr>
<tr>
<td>Loss of Power</td>
<td>Low air pressure to Starter.</td>
<td>Check air supply.</td>
</tr>
<tr>
<td>Restricted air supply line.</td>
<td>Check for blockage or damage to air lines.</td>
<td></td>
</tr>
<tr>
<td>Relay Valve malfunctioning.</td>
<td>Clean or replace lines or Relay Valve. Lube Relay Valve.</td>
<td></td>
</tr>
<tr>
<td>Exhaust flow restricted.</td>
<td>Check for blocked or damaged piping. Clean or replace piping.</td>
<td></td>
</tr>
<tr>
<td>Damaged Motor Assembly.</td>
<td>Replace Motor Assembly.</td>
<td></td>
</tr>
</tbody>
</table>

For Models with Inertia Drive:

<table>
<thead>
<tr>
<th>Trouble</th>
<th>Probable Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive will not engage</td>
<td>Foreign material in Starter Drive.</td>
<td>Remove obstruction.</td>
</tr>
<tr>
<td>Damaged or worn Drive parts.</td>
<td>Check Drive components and replace if necessary.</td>
<td></td>
</tr>
</tbody>
</table>

For Models with Pre-Engaged Drive:

<table>
<thead>
<tr>
<th>Trouble</th>
<th>Probable Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive will not engage</td>
<td>No pressure to Drive Housing port.</td>
<td>Check air supply.</td>
</tr>
<tr>
<td>Internal Drive Housing ports blocked</td>
<td>Remove blockage.</td>
<td></td>
</tr>
<tr>
<td>Fluid in drive unit components.</td>
<td>Remove fluid.</td>
<td></td>
</tr>
<tr>
<td>Damaged or worn Piston Assembly, O-Rings or seals.</td>
<td>Replace damaged or worn parts.</td>
<td></td>
</tr>
<tr>
<td>O-Rings and seals dry.</td>
<td>Re-lube O-Rings and seals.</td>
<td></td>
</tr>
<tr>
<td>Damaged Drive Pinion or flywheel.</td>
<td>Disassemble drive train and replace worn or damaged parts.</td>
<td></td>
</tr>
<tr>
<td>Damaged Starter Drive or components.</td>
<td>Inspect Drive components and replace worn or damaged parts.</td>
<td></td>
</tr>
<tr>
<td>Low air pressure.</td>
<td>Check air supply.</td>
<td></td>
</tr>
<tr>
<td>Wrong Drive Pinion</td>
<td>Replace with proper Drive Pinion.</td>
<td></td>
</tr>
<tr>
<td>Oil blowing out of exhaust</td>
<td>Oil in air supply line.</td>
<td>Inspect air line and remove source of oil.</td>
</tr>
<tr>
<td>Splash Deflector Retaining Screw or pipe plug missing.</td>
<td>Install Splash Deflector Retaining Screw or pipe plug.</td>
<td></td>
</tr>
<tr>
<td>Worn or damaged rotor seals or static O-Rings.</td>
<td>Replace static seals on outside of Motor or send Motor to Ingersoll Rand to be rebuilt.</td>
<td></td>
</tr>
<tr>
<td>Oil leaking from Gear Case</td>
<td>Worn or damaged O-Rings.</td>
<td>Replace O-Rings.</td>
</tr>
<tr>
<td>Loose joints.</td>
<td>Make sure that joints fit properly and that Starter Assembly Cap Screws are tightened to 91 ft-lb (126 Nm.) torque. Make sure that all seals and O-Rings fit and seal properly at their perimeters. If they do not, replace with new seals and O-Rings.</td>
<td></td>
</tr>
<tr>
<td>Excessive high-speed operation.</td>
<td>Operate according to recommendations.</td>
<td></td>
</tr>
<tr>
<td>High number of start cycles.</td>
<td>Replace worn components.</td>
<td></td>
</tr>
<tr>
<td>Loose or leaking Pipe Plugs.</td>
<td>Tighten or replace Pipe plugs using Ingersoll Rand 5MB-441 Pipe Sealant.</td>
<td></td>
</tr>
<tr>
<td>Splash Deflector Retaining Screw or pipe plug missing.</td>
<td>Tighten Splash Deflector Retaining Screw or replace pipe plug.</td>
<td></td>
</tr>
<tr>
<td>Air or gas leakage</td>
<td>Loose Joints.</td>
<td>Make sure that joints fit properly and that Starter Assembly Cap Screws are tightened to 60 ft-lb (81 Nm.) torque. Make sure that all seals and O-Rings fit and seal properly at their perimeters. If they do not, replace with new seals and O-Rings.</td>
</tr>
<tr>
<td>Excessive high-speed operation</td>
<td>Operate according to recommendations.</td>
<td></td>
</tr>
<tr>
<td>High number of start cycles</td>
<td>Replace worn components.</td>
<td></td>
</tr>
<tr>
<td>Loose or leaking Pipe Plugs.</td>
<td>Tighten or replace pipe plugs.</td>
<td></td>
</tr>
<tr>
<td>Splash Deflector Retaining Screw loose or Pipe Plug missing</td>
<td>Tighten Splash Deflector Retaining Screw or replace pipe plug.</td>
<td></td>
</tr>
</tbody>
</table>
Parts and Maintenance

**CAUTION**

The use of other than genuine Ingersoll Rand replacement parts may result in safety hazards, decreased motor performance, and increased maintenance, and may invalidate all warranties. Ingersoll Rand is not responsible for customer modification of motors for applications on which Ingersoll Rand was not consulted. Repairs should be made only by authorized trained personnel. Consult your nearest Ingersoll Rand Authorized Service center.

When the life of the Starter has expired, it is recommended that the Starter be disassembled, degreased and parts be separated by material so that they can be recycled.

Manuals can be downloaded from ingersollrandproducts.com

Refer all communications to the nearest Ingersoll Rand Office or Distributor.