instructions
Variable Leak Valve
Model Nos. 951-5100 and 951-5106

palo alto
vacuum
division
VARIABLE LEAK VALVE
MODEL NOS. 951-5100 & 951-5106

OPERATING INSTRUCTIONS
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Safety</td>
<td>1</td>
</tr>
<tr>
<td>II Description</td>
<td>3</td>
</tr>
<tr>
<td>III Specification</td>
<td>5</td>
</tr>
<tr>
<td>IV Installation of Operation</td>
<td>7</td>
</tr>
<tr>
<td>V Installation</td>
<td>9</td>
</tr>
<tr>
<td>VI Operation</td>
<td>13</td>
</tr>
<tr>
<td>A. To Establish a New Stop Position</td>
<td>13</td>
</tr>
<tr>
<td>B. To Set Stop Position at Any Leak Rate</td>
<td>14</td>
</tr>
<tr>
<td>C. Operating at Low Leak Rates</td>
<td>15</td>
</tr>
<tr>
<td>D. Changes in Leak Rate with Variations in Room Temperature</td>
<td>16</td>
</tr>
<tr>
<td>E. Bakeout Procedure</td>
<td>16</td>
</tr>
<tr>
<td>F. To Use as a Roughing Valve</td>
<td>17</td>
</tr>
<tr>
<td>VII Maintenance</td>
<td>21</td>
</tr>
<tr>
<td>A. Adjustment of Handle Position</td>
<td>21</td>
</tr>
<tr>
<td>B. If the Valve Will Not Close Leak Tight</td>
<td>22</td>
</tr>
<tr>
<td>C. Lubrication Instructions</td>
<td>27</td>
</tr>
<tr>
<td>D. Loss of Sensitivity at High Leak Rates</td>
<td>28</td>
</tr>
<tr>
<td>VIII Parts List</td>
<td>31</td>
</tr>
<tr>
<td>Final Assembly Drawing</td>
<td>33</td>
</tr>
<tr>
<td>IX Warranty</td>
<td>35</td>
</tr>
</tbody>
</table>
I. **SAFETY**

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**WARNING**

THE MAIN DANGER OF EXPLOSION IN VACUUM EQUIPMENT OCCURS DURING BACKFILLING FROM PRESSURIZED GAS CYLINDERS. BESIDES RUINING EQUIPMENT, EXPLOSIONS CAUSE FLYING DEBRIS WHICH MAY CAUSE SERIOUS PERSONAL INJURY OR DEATH.

THE FOLLOWING PRECAUTIONS MUST BE EXERCISED WHEN ADMITTING GAS INTO A VACUUM SYSTEM:

1. ASSURE THAT ONE LEAK VALVE IS IN THE CLOSED POSITION BEFORE ADMITTING GAS INTO THE BACKFILL LINE.

2. ALWAYS USE A PRESSURIZED RELIEF VALVE IN THE BACKFILL LINE.

3. USE A SHIELD AROUND THE SYSTEM.

4. WEAR SAFETY GLASSES.

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**CAUTION**


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**CAUTION**

OVERTIGHTENING THE ROUGHING SCREW MAY FRACTURE THE SAPPHIRE. DO NOT EXCEED 8 FT.-LBS. OF TORQUE WHEN TIGHTENING THE ROUGHING SCREW.

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**CAUTION**

DO NOT USE COMPRESSED AIR TO BLOW OUT THE VALVE. CONTAMINATING OIL, PARTICLES, AND WATER VAPOR FROM COMPRESSED AIR MAY CAUSE SEALING PROBLEMS NECESSITATING RECLEANING OF THE VALVE AND, IN SEVERE CASES, GASKET REPLACEMENT.
DO NOT OVERTIGHTEN THE SAPPHIRE ASSEMBLY WITH THE REMOVAL TOOL. HEAVY TIGHTENING CAN CAUSE THE TOOL TO RAISE A BURR IN THE SLOTS OF THE SAPPHIRE ASSEMBLY. SUCH BURRS CAN PREVENT SUBSEQUENT REMOVAL OF THE SAPPHIRE ASSEMBLY FROM THE VALVE.
II. DESCRIPTION

These instructions apply to all leak valves with serial number 464 and above. These valves differ from earlier ones in that the sapphire assembly is now replaceable.

The Variable Leak Valve can be added to any vacuum system to establish an adjustable leak. It offers unprecedented control sensitivity and stability with leak rates as small as $1 \times 10^{-10}$ torr-liters per second. Leak rate adjustment is controlled with finger knobs. The entire valve, including the drive mechanism, is bakeable to $450^\circ C$ in either the open or closed position. Both components of the seal mechanism (sapphire assembly and gasket assembly) are easily replaceable.
### III. SPECIFICATIONS

<table>
<thead>
<tr>
<th><strong>Minimum Leak Rate</strong></th>
<th>$1 \times 10^{-9}$ torr-liters/sec in normal operation. $1 \times 10^{-10}$ torr-liters/sec with condensable vapors eliminated from leak gas.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rate of Change of Leak</strong></td>
<td>The valve provides an increasing rate of change as the size of the leak increases giving precise control in proportion to the size of the leak.</td>
</tr>
<tr>
<td><strong>Vacuum Range</strong></td>
<td>From atmospheric pressure to below $10^{-11}$ torr.</td>
</tr>
<tr>
<td><strong>Temperature Range</strong></td>
<td>Up to $450^\circ$C in either the open or closed position.</td>
</tr>
<tr>
<td><strong>Inlet Gas Pressure</strong></td>
<td>500 psi maximum</td>
</tr>
<tr>
<td><strong>Gasket Life</strong></td>
<td>For unbaked systems, approximately 300 closures. For baked systems, 20 to 30 closures. Gasket assemblies are replaceable.</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td>Clean, bakeable materials: 300 series stainless steel; sapphire; OFHC copper, and copper alloy.</td>
</tr>
</tbody>
</table>
IV. PRINCIPLE OF OPERATION

A precisely designed sapphire-copper alloy valve seal provides extremely sensitive leak-rate control. The seal consists of a movable piston with an optically flat sapphire face that meets a "captured" metal gasket. The sapphire surface presses against the gasket to form a seal completely free from friction or seizing.

The valve is shipped in a closed, leak-tight condition. To open a leak, the finger knobs must be turned a minimum of two full turns counterclockwise. The valve is closed by turning the knobs (together) clockwise to the stop position against the handle.

CAUTION

V. INSTALLATION

The valve is received in a closed, leak-tight position, lubricated and ready for installation.

A. Flange Connection

The ConFlat® flange on which the Variable Leak Valve is mounted mates with any 2-3/4 inch OD ConFlat flange.

1. Place a new copper gasket (Model No. 953-5014) between the two ConFlat flanges.

2. Lubricate and install bolts and nuts. Use Fel-Pro C-100 (Model No. 953-0031) high temperature lubricant on screw threads and under the nuts.

3. Tighten each nut to 5 to 8 ft.-lbs. torque. This will partially close the gap between the flange faces. Repeat the sequential tightening two more cycles.

4. The copper gaskets are partially sheared in making the seal and the bolts should be tightened until the flange faces meet.

5. Leak check.

B. Inlet Gas Connection

Model 951-5100

The inlet gas line fitting accepts 1/4 inch OD tubing. Any high vacuum tubing material that flares is satisfactory. Connections made with copper tubing remain leak tight when baked to 450°C.
1. Slide the nut (packaged with spare parts) and sleeve onto the tubing.

2. Flare the end of the tubing to a 90° included angle.

3. Lubricate threads of the fitting on the valve with Fel-Pro C-100 high temperature lubricant.

**NOTE**

DO NOT GET LUBRICANT ON SEALING SURFACE OF THE FITTING. A LEAK MAY RESULT.

4. Assemble the flared end to the valve fitting. Slide the sleeve in place and screw on the nut. Tighten the nut to 6 to 8 ft.-lbs. of torque when using half-hard OFHC copper tubing. Use a second wrench on the fitting body to offset the torque.

Model 951-5106

The inlet gas line fitting accepts any 1-5/16 inch OD ConFlat flange.

1. Place a new copper gasket (Model No. 953-5070) between the two ConFlat flanges.

2. Lubricate and install bolts and nuts. Use Fel-Pro C-100 (Model No. 953-0031) high temperature lubricant on screw threads and under the nuts.

3. Tighten each nut to 5 to 8 ft.-lbs. torque. This will partially close the gap between the flange faces. Repeat the sequential tightening two more cycles.
4. The copper gaskets are partially sheared in making the seal and the bolts should be tightened until the flange faces meet.

5. Leak check.
VI. OPERATION

The valve is received in a closed, leak-tight position. The adjusting finger knobs are tightened against the handle.

To open a leak, turn the knobs a minimum of two full turns counterclockwise. During normal operation, the knobs are fixed with respect to the fine-drive screw. When the collar butts against the handle, the stop position is reached.

A. To Establish a New Stop Position

Each time a seal is made, the valve’s captured metal gasket is compressed. High temperature bakeout accelerates the compression of the gasket. If no change is made to the position of the knobs on the fine-drive screw, the point of closure will gradually come closer to the point at which the knobs and collar butt against the
handle. **Eventually the stop will be engaged before a leak tight closure is made.** When this happens a new stop position must be established.

1. The valve must be attached to a leak detector or the system must be equipped with gauging adequate to determine when no leak exists.

2. With the knobs tightened against the handle, unlock the knobs from each other by holding the inner knob and turning the outer knob counterclockwise about four turns.

3. Turn the inner knob counterclockwise until it is locked tight against the outer knob.

4. Turn the two locked knobs clockwise until the valve closes as indicated on the leak detector or system gauging.

5. Turn the knobs clockwise two additional turns past the point of closure.

6. Loosen the knobs from each other without allowing the screw to turn. Turn the inner knob clockwise until the collar is against the handle, then turn the outer knob clockwise until it locks against the inner knob. The knobs are now in position to return to and stop at a point two turns past closure.

7. After the stop has been adjusted several times, the handle must be re-set as described in Section VII, Maintenance.

B. To Set Stop Position at Any Leak Rate

The stop position can be adjusted to provide any desired leak rate.
1. Open the valve to the desired leak rate as determined by a leak detector, vacuum gauge or other experimental means.

2. Loosen the knobs from each other without allowing the fine drive screw to turn.

3. Turn the inner knob clockwise until the collar stops against the handle. Turn the outer knob clockwise until it locks against the inner knob.

4. The valve can now be opened to larger leak rates and when returned to the stop position will provide a leak of this pre-set rate.

---

**NOTE**

THE VALVE CANNOT BE CLOSED LEAK TIGHT WITH THE STOP SET IN THIS MANNER. TO CLOSE THE VALVE, FOLLOW THE PROCEDURE OUTLINED IN THE SECTION "TO ESTABLISH A NEW STOP POSITION".

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C. **Operating at Low Leak Rates**

When the valve operates with leak rates of $1 \times 10^{-9}$ torr-liters/sec and smaller, condensable vapors and contaminants reduce the leak opening. The valve must be baked to $250^\circ$C in the open position and under vacuum for 30 minutes to drive off these internally adsorbed vapors. See "Bakeout Procedure" below.

For operation at leak rates of $3 \times 10^{-10}$ and lower, in addition to the bakeout described above, the inlet gas must be free of condensable vapors. Use a dry gas or pass the inlet gas through a drying agent such as a liquid nitrogen cold trap. A molecular sieve trap can be used for drying the gas but a filter must be employed to assure that no particles of sieve enter the valve.
D. Changes in Leak Rate with Variations in Room Temperature

Changes in room temperature will cause changes in leak rate; as the temperature rises, leak rate increases. A leak setting should be made in the range of interest and then mild heat applied to raise the temperature of the valve to the maximum expected value. If the resulting change in leak rate is not acceptable to the intended experiment, some means of temperature control must be used.

E. Bakeout Procedure

1. Bakeout in open position

   a. No special steps are required to bake the leak valve in the open position.

   b. A leak that has been set with the valve at room temperature will increase due to thermal expansion as the valve is heated during bakeout. Monitoring of system pressure and readjustment of the leak is necessary if a constant leak is desired during temperature cycling.

2. Bakeout in closed position

   a. The valve must be overdriven three turns past closure (normal setting is two turns) to compensate for differential expansion of materials during bakeout.

   b. To prepare the valve for bakeout, follow the procedure shown in the prior section, "To Establish a New Stop Position", with the following exception: in steps 4, 5, and 6, substitute "three turns" for the "two turns" specified.
3. Operation after bakeout

a. Bakeout in the closed position to 250°C and above will increase the size of leak for a given setting of the knobs. A full three turns may not be required to open a leak after bakeout. Length of bakeout and elapsed time at temperature will both affect the amount of change.

b. If the stops are to be readjusted, follow the procedure described in Sections "A" and "B" above.

NOTE


F. To Use as a Roughing Valve

The Variable Leak Valve can be used as a roughing valve when pumping small vacuum systems (several liters volume). The valve must be opened to its maximum conductance for this operation.

1. Connect Roughing Pump

Connect a roughing pump to the inlet gas fitting. Where available, install a molecular sieve or liquid nitrogen trap in the line between the pump and valve to reduce contamination of the valve from mechanical pump oil vapors.
2. Open Valve
   
a. Open the valve four counterclockwise turns of the knobs.
   
b. Remove the hole cover on top of the valve.
   
c. Loosen the roughing screw two full turns using a 5/16" allen wrench.

3. Rough Pump

4. Close and Readjust Valve
   
a. Turn the knobs clockwise until the handle is parallel to the valve body.
   
b. Tighten the roughing screw to 6 ft.-lbs. of torque.

   --- CAUTION ---

   DO NOT EXCEED 8 FT.-LBS. OF TORQUE WHEN TIGHTENING THE ROUGHING SCREW. THE SAPPHIRE MAY BE FRACTURED.

   c. Replace the hole cover.
   
d. Unlock the knobs without allowing the fine drive screw to turn.
   
e. Turn the inner knob clockwise until the collar is against the handle. Lock the outer knob against the inner knob.
   
f. Due to the coarse adjustment of the roughing screw, the valve may require from 2 to 6 turns of the finger knobs to open a leak.
g. After completion of the work cycle, when the valve can be adjusted without affecting process procedures, the knobs should be reset as described in Section VII, A. "Adjustment of Handle Position".
VII. MAINTENANCE

A. Adjustment of Handle Position

As described in "OPERATION", continual reduction in gasket height necessitates resetting of the stop position and eventual readjustment of handle position. When the angle between the handle and body at point of closure has changed from its original parallel (approximate) position to an angle of $\pm 5^\circ$, the valve should be readjusted. This adjustment will maintain proper relationship between handle travel and size of leak.

1. Set Handle

Turn the locked knobs counterclockwise until the valve handle is approximately parallel to the side of the valve body.

2. Close Valve Using Roughing Screw

a. Remove the hold cover from the top of the valve.

b. With a 5/16" allen wrench, tighten the roughing screw to 6 ft.-lbg. of torque.

CAUTION

DO NOT EXCEED 8 FT.-LBS. OF TORQUE WHEN TIGHTENING THE ROUGHING SCREW. THE SAPPHIRE MAY BE FRACTURED.

c. Replace the hole cover.

d. The valve should now be leak tight, but this can be determined reliably only with a leak detector. If the valve leaks across the seal, refer to section VII, B. "If The Valve Will Not Close Leak Tight".
3. Adjust Knobs
   
a. Turn the knobs counterclockwise until a leak is generated.
   
b. Turn the knobs clockwise until the valve is closed leak tight.
   
c. Turn the knobs two additional turns clockwise to provide the proper amount of overdrive.
   
d. Loosen the knobs without allowing the fine drive screw to turn, and turn the inner knob clockwise until the collar is against the handle. Look the outer knob against the inner one.
   
e. Two counterclockwise turns should open a leak.

B. If Valve Will Not Close Leak Tight

If the valve is not leak tight across the sapphire-gasket seal after the knobs have been turned to the stop position, one of several problems may be the cause.

1. The gasket has been compressed and the stops must be reset.

2. The valve, sapphire and/or gasket are contaminated and need cleaning.

3. The gasket is scratched, nicked, or compressed beyond further use and must be replaced.

4. The sapphire is fractured and must be replaced.

The following procedures should be followed in the order listed.
a. Reset the Stops

Follow the steps outlined in Section VI, A. "To Establish a New Stop Position". If the valve is still not leak tight, proceed to step "b" below.

b. Disassemble, clean and inspect the sealing components

Particles, oxide on the gasket or other contaminants may prevent the valve from closing leak tight. Disconnect the valve from other components and disassemble, inspect and clean the valve, sapphire and gasket in the following steps.

1) Disassemble

a) Turn the knobs counterclockwise four turns.

b) Remove the pressed-in cover and with a 5/16" allen wrench loosen the roughing screw two turns.

c) Use a clean 1/4" allen wrench to remove the gasket assembly. The thread is normal right hand and 20-25 ft.-lbs. of torque will be required to loosen it.

d) Clean the sapphire removal tool with acetone, insert it into the hole that held the gasket assembly, and engage the fingers of the tool with the slots on the periphery of the sapphire assembly.
e) Hold the valve and tool in the upright position and turn the tool counterclockwise to remove the sapphire assembly. Four full turns will disengage the threads.

f) Maintain the upright position of valve and tool, and lower the tool and sapphire assembly from the valve.

2) Inspect and Clean Sapphire

a) Check the sapphire to assure that it has no cracks or chips. Any fractures will require replacement of the sapphire assembly.

b) Check the cleanliness of the polished face by viewing light reflected from its surface. Flush the face with acetone (CP grade recommended) and wipe off any film or grease. Assure that no particles remain on the sapphire when ready for reassembly.
3) Inspect and Clean Valve Body

a) Check the valve body for any loose particles or other contaminants.

b) Remove any contaminants by flushing acetone through the inlet gas fitting while holding the valve upright.

c) Blow out the valve with a clean, dry gas through the inlet gas fitting.

--- CAUTION ---

DO NOT USE COMPRESSED AIR TO BLOW OUT THE VALVE. CONTAMINATING OIL, PARTICLES, AND WATER VAPOR FROM COMPRESSED AIR MAY CAUSE SEALING PROBLEMS NECESSITATING RECLEANING OF THE VALVE AND, IN SEVERE CASES, GASKET REPLACEMENT.

4) Inspect and Clean Gasket Assembly

a) Inspect the copper alloy gasket to assure that it is clean, smooth, free of oxide and protrudes above the surface of the gasket collar by at least 0.002 inch. A hand lens or microscope will facilitate inspection of the surface.

b) If the top surface of the gasket is scored, scratched or nicked, the gasket assembly must be replaced.

c) If the copper portion of the assembly does not protrude at least 0.002 inch above the collar, the gasket assembly must be replaced.

d) Oily films or other residue should be removed using acetone.
e) Oxide or other slight surface imperfections can generally be removed by polishing with a very fine rouge paper. When polishing, rotate the gasket assembly about its center axis to avoid leaving scratches that cross the sealing surface. Clean the gasket with acetone after any polishing.

f) Keep the gasket free of contamination while awaiting reassembly.

5) Reinstall Sapphire Assembly

a) Hold the sapphire removal tool upright and attach the sapphire assembly to the tool engaging the four slots. Be certain that the tool is clean.

b) With the valve in the upright position, insert the tool and sapphire into the valve. Turn the tool clockwise to engage the threads. Only light finger pressure is required to tighten the assembly into the valve properly.

CAUTION

DO NOT OVERTIGHTEN THE SAPPHIRE ASSEMBLY WITH THE REMOVAL TOOL. HEAVY TIGHTENING CAN CAUSE THE TOOL TO RAISE A BURR IN THE SLOTS OF THE SAPPHIRE ASSEMBLY. SUCH BURRS CAN PREVENT SUBSEQUENT REMOVAL OF THE SAPPHIRE ASSEMBLY FROM THE VALVE.

6) Reinstall Gasket Assembly

a) To avoid contamination, hold the valve in the upright position. Install the gasket assembly and tighten finger tight.
b) Tighten the gasket assembly to 22 to 24 ft.-lbs. of torque. Assure that the allen wrench is clean before using.

--- NOTE ---

INSTALL THE VALVE ON THE VACUUM SYSTEM AS SOON AS POSSIBLE AFTER REASSEMBLY TO AVOID PARTICLE CONTAMINATION. IF STORAGE IS NECESSARY, PLACE VALVE IN A CLEAN POLY-ETHYLENE BAG AND CLOSE THE BAG SECURELY. AVOID SETTING THE VALVE ON DUSTY SURFACES.

7) Leak Check and Adjust Closure

Reset the handle position, roughing screw and knobs, and leak check the valve as described in the section "Adjustment of Handle Position".

C. Lubrication Instructions

Fel-Pro C-1000 (Model 953-0031) is recommended for lubrication. After each bakeout cycle, lubricate the threads of the fine-drive screw. After every three bakeouts at temperatures over 300°C, disassemble the drive mechanism and lubricate it. Use the SST brush to remove flaky or caked-on lubricant before re-lubrication.

1. Open the valve four counterclockwise turns on the knobs.

2. Withdraw the two screws on the upper part of the valve body and remove the cover.

3. Remove the roughing screw. Lubricate its threads and the spherical socket.

4. Insert the screws that held the cover into the two pivot rods and, using the screws as handles, pull out the rods.
5. Lift out the handle. Its sides have been sprayed with a semipermanent coat of molybdenum-disulphide. The lubricant in most cases will not require replenishing. If the user judges that relubrication is necessary, a small amount of Fel-Pro C-100 should be applied to each side of the handle where it guides in the body.

6. Remove the rod assembly and lubricate both ends. Replace it.

7. Lubricate the pivot rod holes in the handle. Do not lubricate the pivot rod holes in the body.

8. Reassemble the handle and pivot rods.

9. Replace the roughing screw, valve cover and two small screws.

10. Follow the procedure specified in the section "Adjustment of Handle Position" to close the valve and adjust the drive mechanism for proper operation.

D. Loss of Sensitivity at High Leak Rates

Repeated bakeouts at 450°C will result in partial annealing and a loss of tension in the spring washers that provide the force to open the valve. This will be evidenced by decreasing sensitivity of control at high leak rates. This is not a common situation, but may occur after months of use under high temperature conditions. Replacement of the spring washers and adjustment are required.

1. Disassemble drive mechanism.

   a. Open the valve four counterclockwise turns of the knobs.
b. Withdraw the two screws on the upper part of the valve body and remove the cover.

c. Remove the roughing screw.

d. Remove the two pivot rods by grasping each with a screw. Lift out the handle.

2. Replace spring washers.

a. With a 3/4-inch hex-socket wrench remove the nut above the spring washers.

b. Remove and replace the spring washers.

c. Replace the 3/4-inch hex nut.

3. Adjust tension. With a 3/4-inch hex-socket wrench tighten the nut above the spring washers just enough so that there is no clearance between the washers and the nut.

4. Reassemble.

a. Replace the handle, pivot rods, roughing screw and cover.

b. Repeat the closure adjustment to reposition the handle and knobs.
### VIII. PARTS LIST

#### REPLACEMENT PARTS

<table>
<thead>
<tr>
<th>Order No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>953-5050</td>
<td>Gasket Assembly</td>
</tr>
<tr>
<td>953-0072</td>
<td>Sapphire Assembly</td>
</tr>
<tr>
<td>00-611022-02</td>
<td>Body Assembly - for 951-5100</td>
</tr>
<tr>
<td>00-611022-09</td>
<td>- for 951-5106</td>
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<tr>
<td>28-629886-00</td>
<td>Fitting Nut (951-5100 only)</td>
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<td>28-629887-00</td>
<td>Fitting Sleeve (951-5100 only)</td>
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<tr>
<td>00-609523-01</td>
<td>Spring Washer (3 req’d)</td>
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<td>00-609324-01</td>
<td>Nut</td>
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<td>00-611689-00</td>
<td>Rod Assembly</td>
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<td>00-608935-01</td>
<td>Cover</td>
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<td>00-609908-01</td>
<td>Roughing Screw</td>
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<td>23-619912-00</td>
<td>Hole Cover</td>
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<td>00-609531-01</td>
<td>Pivot Rod (2 req’d)</td>
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<td>00-609526-01</td>
<td>Handle</td>
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<td>00-609528-00</td>
<td>Knob (2 req’d)</td>
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<tr>
<td>00-611690-00</td>
<td>Fine Drive Screw Assembly</td>
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<tr>
<td>00-611954-00</td>
<td>Fine Drive Spring Washer</td>
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<tr>
<td>00-610618-00</td>
<td>Collar</td>
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#### ACCESSORIES

- High Temp Lubricant, Fel-Pro C-100 953-0031
- Sapphire Removal Tool 00-614174-00
- Wrench, 1/4 hex key 29-899874-00
- Wrench, 5/16 hex key 29-899877-00
- Wire Brush 29-899650-00
ITEM  DESCRIPTION
1 Gasket Assembly  
2 Sapphire Assembly  
3 Body Assembly  
4 Fitting Nut - Model 951-5100 only  
5 Fitting Sleeve - Model 951-5100 only  
6 Spring Washer  
7 Nut  
8 Rod Assembly  
9 Cover  
10 Roughing Screw  
11 Hole Cover  
12 Pivot Rod  
13 Pan Head Screw, 8-32 x 1/4"  
14 Handle  
15 Knob  
16 Fine Drive Screw Assembly  
17 Fine Drive Spring Washer  
18 Collar  

VARIABLE LEAK VALVE