Muncie® Power Products

Trouble-shooting and Overhauling Hydraulic Systems for Refuse Vehicles

The following two articles, were written by Stan Watkins, Muncie's Market Manager — Solid Wastes Industry. Mr. Watkins states: "When reading previous articles on hydraulics in various trade magazines, I found most to be accurate, but not easily understood or applied to actual working conditions. These articles address the real concerns that mechanics and equipment managers have expressed to our company, and our recommended corrective action."

Hydraulic Trouble-shooting for Refuse Vehicles

First Things First

The largest problem today in hydraulic failures is the inability to recognize a problem and correct it. Countless times, I have worked with customers who have had a truck with three or four failed pumps in a short period and who have continued to put pumps back on without finding the reason for the premature failure of the pumps. When a gear pump failure occurs the first time, it is solid proof of a problem in the hydraulic circuit. The problem could be in the gear pump or any other component on the hydraulic circuit.

Gear Pump Trouble-Shooting

Caution: It is important to observe standard safety precautions during any work on or around a vehicle. Always block or prop an elevated body. Be cautious of hydraulic lines with trapped pressure and extreme heat. Stay away from moving components.

Reading The Metal - Heat Failure

Like reading a good book, reading the metal parts of a pump will tell you a story of what happened to the pump. In Figure 1, we show 2 sides of a wear plate that has seen excessive heat. A Muncie pump has seals on the wear plate that exceed 400° F before melting, although any temperature exceeding 180° to 200° is considered excessive for a hydraulic system. Hydraulic fluid at this temperature breaks down and looses its lubricating qualities. Another sign of excessive heat will be discoloration of the metal parts, typically turning silver parts blue or black with heat. Also, the gear will cut into the housing of the pump, causing premature wearing away of the housing material. The number one culprit for excessive heat is too much restriction downstream of the pump pressure port. That means you have too much flow (GPM) for the system to handle, or there is a component that is too small for the flow (GPM) required. Rarely is the pump at fault for excessive heat buildup.

Trouble-Shooting Steps

1. Before removing a suspected failed pump, plug a 0 to 500 PSI pressure gauge into the pressure line somewhere between the pump and the first valve. **Caution: Do not activate any controls during this test. Check pressure first w/a 0-3000 PSI gauge to insure pressure does not exceed 500 PSI.**

2. Start the truck and run the pump at maximum operating speed. Without activating any of the controls, the pump is running oil through the valves and back to tank. Ideally, you should not register in excess of 150 PSI. If you do see more, that is the most likely cause of heat generation. The higher the back pressure, the quicker it generates heat. Let's face it, the driver is going to floor it, so if your test shows a higher reading, then engine overspeed switches and/or flow controls should be considered. These safeguards will help prevent overflowing the hydraulic circuit and should lower the back pressure on the pump by reducing excess flow. Check with your body manufacturer for recommended neutral backpressure. You must now identify the component responsible. Valves, hoses, fittings — something in the circuit is too small to accommodate the pump flow. The other choice is to move to a smaller pump, although this will possibly result in slower cycle times. If you choose to replace a valve, make sure its capacity will accommodate the amount of oil the pump will provide at maximum operating RPM. If hose size is suspect, use the following as a general guide, Figure 2. Keep in mind, we use an average line velocity of 15 feet per second (industry standard) on a discharge hose for determining hose size.

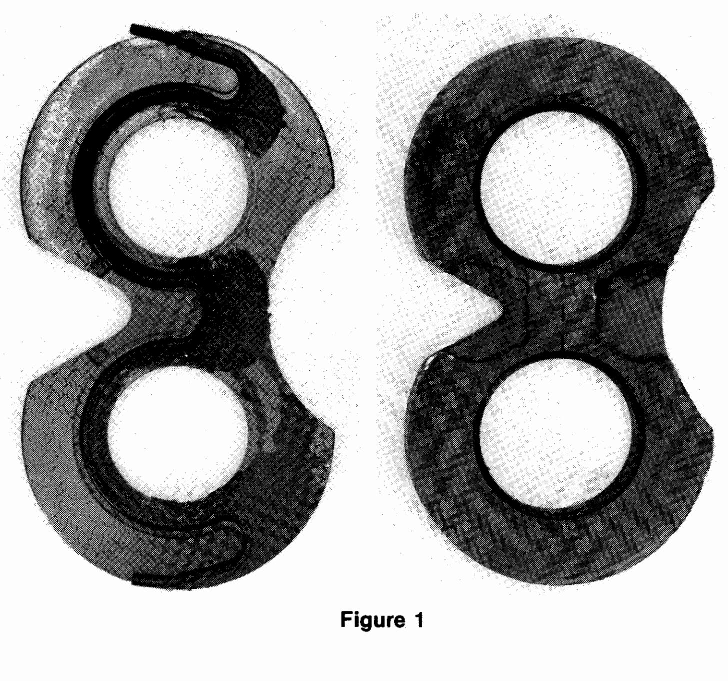


Figure 1

DISCHARGE HOSE SIZE	
Max. Gallons Per Minute (GPM)	Hose Size (Min.) (SAE 100R2 Rated)
25 to 35 GPM	3/4" I.D.
36 to 60 GPM	1" I.D.
61 to 80 GPM	1-1/4" I.D.
81 to 100 GPM	1-1/2" I.D.

Figure 2

On most front loaders, it is common to see 80 GPM maximum flow, with which a 1¼" discharge hose would be adequate. Side loaders would use smaller pumps and most likely see 55 to 60 GPM maximum flow, with which a 1" hose would be adequate. If hoses on the discharge side of the pump measure smaller and your low pressure gauge registers in excess of 150 PSI, then the hoses could be contributing to heat generation.

If you do not have a flow meter, consult with the body manufacturer to determine pump size and flow (GPM) requirements.

3. If this test proves back pressure is below 150 PSI, then the next area to look at is the relief valve. Most common relief valves used in our industry are pilot operated relief valves. These valves utilize small pilot holes in the body of the valve to allow the system pressure to move the internal spool up and down to regulate the system's maximum PSI. They are generally very accurate relief valves, but they suffer from one major problem — contamination. If foreign material plugs the orifices, it will not sense system pressure, and will open oil flow back to tank (even during low operating demand). This, in turn, generates heat. The easiest solution is to remove the relief valve and clean out the orifices with an air hose. Also check for free movement of the spool; the spring on the spool could be broken or misshapen which would cause erratic behavior. If the relief valve utilizes pipe threads for installation, check to see if the relief valve is over tightened, as the spool in the main relief may bind if it is.

This covers only the main causes of heat type failures in refuse vehicles. It does not address possible driver abuse by overspeeding or using incorrect or poor quality hydraulic fluids. Remember, if a pump has failed due to heat, replacing that pump will do no good until the source of heat generation is located and corrected.

Reading The Metal - Cavitation Failure

In Figure 3, we show a pressure wear plate with obvious signs of cavitation or aeration. Cavitation is the lack of, or restricted supply of oil on the suction side of the pump. Aeration is oil and air mixed together in the hydraulic system. Erosion of the wear plate (other than gear marks), such as heavy pitting, as shown in Figure 3, are signs of these type of failures.

It is very important that the hydraulic circuit be solid hydraulic oil with no air trapped in the circuit anywhere. What causes this erosion in the wear plates is actually tiny bubbles of air imploding against the wear plate thousands of times per minute. As the erosion becomes more severe, the less efficient the gear pump becomes. Other external signs of cavitation and aeration are excessive noise or rattling sound from the pump, spongy acting cylinders when extended, and hydraulic oil with foaming or sudsy appearance in the reservoir.

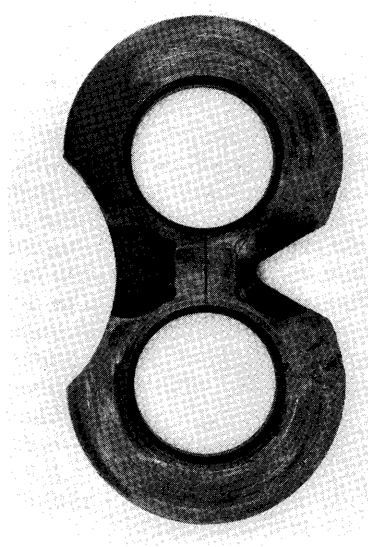


Figure 3

If you suspect this to be your problem, the following will help isolate the cause and determine the remedy.

Trouble-Shooting Steps

1. Cavitation, again, is caused by restricted oil supply to the pump. Before removing suspected gear pump, install a 0 to -30 Hg vacuum gauge on the inlet (or suction) side of pump, preferably keeping the gauge as close to the pump inlet as possible. This can be accomplished by simply removing 3/4" plug from Power-Miser valve. Drilling and tapping the last fitting going into the pump to accommodate the thread size of the gauge will also work. Do not drill and tap fittings unless removed from pump to prevent metal shavings from entering the pump. With the gauge installed (and tank shut-off valve open) run the engine to maximum operating speed and read the amount of vacuum registered on the gauge. The maximum for a Muncie gear pump is 5" Hg. If you show a higher reading (10 or higher is critical and pump failure will occur), then the pump is probably cavitating. The higher the Hg number, the more severe the cavitation. This will cause premature gear pump failure. As an example, piston type pumps require a positive head pressure in order to function properly. They will not work properly with a negative vacuum reading.

2. Two of the main suspected causes of cavitation are the improper size and the incorrect route of the inlet (suction) hose. With the popularity of crank driven (front) gear pumps comes a major problem, hoses have to be very long to reach from the reservoir to the pump and are often routed up and around crossmembers. Anytime the hose rises above the reservoir level (horizontal) and the pump, it will slow or stop the gravity flow of oil to the pump. Try to insure that the hose has a downward or at least a level run from the reservoir to the pump. The size of the hose greatly determines whether the pump cavitates. The following chart, Figure 4, shows correct hose size for the GPM required. Keep in mind this is inlet (suction) hose only. Since we are at the mercy of gravity, inlet hoses are much larger than discharge hoses. We are using a 4' per second (industry standard) oil velocity as an average to determine inlet hose size.

INLET HOSE SIZE (SUCTION) - FRONT PUMPS

Max. Gallons Per Minute (GPM)	Hose Size (Min.) (SAE 100R2 Rated)
25 to 35 GPM	1-1/2" I.D.
36 to 60 GPM	2" I.D.
61 to 80 GPM	2-1/2" I.D.
81 to 100 GPM	3" I.D.

Figure 4

If slip-on type fittings are used for connecting the hose to the pump, make sure all clamps and fittings are tight. Loose clamps and connections will let air into the hydraulic circuit. If a gate valve or ball valve is used for a shutoff at the tank, make sure it is sized accordingly. For example, a 2" ball valve may have only a 1½" opening on the ball. This will produce a restriction when we require a 2" I.D. all the way to the pump. This means you may have to use a 2½" ball valve to insure a 2" hole in the ball.

The reservoir outlet being lower than the pump will create poor flow to the pump and, as a result, will improve chances for cavitation. Try to locate the reservoir so that it is at least even with the pump horizontally. Also try to avoid an excessive number of bends in the hose.

The final culprit to look for in cavitation problems is the suction strainer or filter. Oftentimes, regular service is missed on a strainer because it is usually hidden in the reservoir. Sludge builds up on the bottom of the reservoir and will eventually plug the strainer or suction filter. If this occurs, you will register a very high vacuum test, probably in excess of -10 Hg and, of course, the gear pump will cavitate.

3. Suspected Causes of Aeration.

Generally speaking, aeration and the cause are easier to identify. Since aeration is the mixing of oil and air, the most common cause is a low reservoir level. One way to determine if you have enough oil is to extend all cylinders to the maximum positions, and measure the amount of oil left in the reservoir. If the level is not at least 3" above the inlet (suction) line in the reservoir, then there is not enough oil in the reservoir to supply the entire hydraulic circuit. Other causes of aeration are loose fittings and connectors. Cylinders may draw in air if the packings are loose or just worn out.

A defective or mis-adjusted relief valve could also introduce air into the hydraulic circuit. If the relief is set too low, pressure will bypass the hydraulic circuit and go through the relief valve. The same could happen even if the relief is set properly. When the hydraulics are exposed to excessive operation, the relief valve will be open more often due to overloading. This can create a foaming action in the oil.

Reading The Metal - Contamination Failure

Figure 5 shows a pump housing and a pressure wear plate with advanced signs of extreme contamination. The score marks and grooves indicate foreign material caught between the gear and housing, and the gear and wear plate. In order to create such damage, the foreign material is large in size (100 micron and larger) and abrasive in nature (weld slag and sand are most common). Other indications of contamination are spool control valves sticking in position without returning to neutral, relief valves stuck open, and score marks on outside sleeves of hydraulic cylinders. Dirt and other contaminants enter the hydraulic circuit in various ways and some are even present when the truck is new.

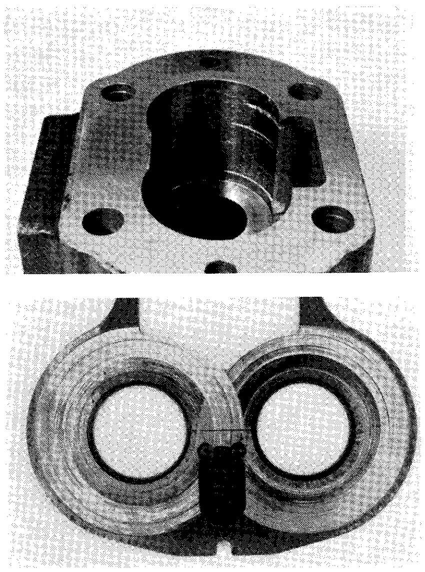


Figure 5

The most simple and modern way to determine if you have contaminated oil is to draw a sample and have it independently tested. A sample is most accurate when drawn from the middle to lower section of the reservoir just after the truck has been running with the hydraulics engaged. Your hydraulic oil supplier should be able to provide this test for you. The sample oil will not only tell you the amount of contaminants, but will also reveal the amount of lubrication qualities that are left in the oil, as well as any additives that are in the oil which may be damaging to the hydraulic components.

Trouble-Shooting Steps

1. If you determine you have a contamination failure of a hydraulic pump, there are several steps to take to correct this problem. Lack of regular maintenance is most often the cause of contamination, so the most obvious solution is to change filters and screens regularly. Using a portable filter cart to strain out contaminants is an excellent way of removing the majority of foreign material. Remember, when using a filter cart, it is important to cycle all functions on the hydraulic circuit so as to help remove foreign material from cylinders and valves. Although this does not remove all contaminants, it will serve the purpose well.

2. Weld slag, metal shavings from the hydraulic reservoir, dirty or poor breather caps, cylinders shedding metal internally, and not filtering replacement oil are all sources of contamination.

Okay, okay. We understand that the working environment for garbage trucks is less than clean and it is virtually impossible to keep contaminants out, so here are some simple recommendations:

A. Most important is a large clean-out port in the hydraulic tank. A larger port will allow you to fully clean the inside of the tank. The tank should be clean enough "to eat out of", to prevent the biggest reason for contamination failure — debris in the tank.

B. Incorporate a high quality, 10 micron (absolute) return line filter with bypass indicator gauge. Remember to purchase this filter with a flow (GPM) rating twice that of what the pump is capable of producing. For example, if the pump produces 50 GPM at maximum engine RPM, then you need a 100 GPM return line filter. Also select a return line filter with as large a square inch surface area as possible. The more area on the filter element, the more contaminants it can hold.

C. Find and install a large magnet to place on the bottom of the reservoir (inside). This will attract and hold metal particles (other than aluminum) and can be cleaned on regular service intervals. You may also choose a return line filter with a magnet in its housing.

D. Do not use teflon tape. In addition to increasing the chance of cracked fittings and ports, it also gets into the hydraulic system. Pieces of teflon tape plug up even the best filters and can wreck the control valves. Other thread sealant, such as pipe dope, can be used as long as care is taken not to get any over the ends of the thread.

E. Use a minimum 250 mesh suction strainer on the inlet to the pump. Locate the strainer so it is easily serviced. Caution — suction filters are not recommended because they will impede the flow of oil to the pump.

In this article, Part I, we have covered the three main causes of pump failures and how to correct the problem. In the next article, Part II, we will cover other hydraulic components and their causes for failure as well as suggestions for correcting those problems.

As usual, Muncie Power Products stands ready to answer any questions you have concerning hydraulics and power take-offs. Simply call 1-800-FOR-PTOS (367-7867).

Yes, it's a headache to take it apart, replace components, and reassemble. But overhauls save money and extend equipment life.

Overhauling That Hydraulic System

A previous article (published in the December, 1987, *Waste Age*) discussed system failures and how to identify them, with most of the focus placed on pump failures and their causes. But there is an entire array of components required for a successful and reliable hydraulic system.

These components are hydraulic reservoirs, directional control valves, flow controls, air valves, cylinders, relief valves, cable controls, hydraulic hose and fittings, shut-off valves, sequence valves, and power take-offs (PTOs).

Is it time for an overhaul?

Most of us can accept the sad fact that there are "no miracles" in curing a sick hydraulic system. Given that, it is important to identify if it's time for an "overhaul."

Good candidates for complete overhauls are packers with some age on them. This does not mean that a newer-style packer will not need an overhaul; it is remote, but possible. In the same turn, not all older packers need a hydraulic overhaul. Listed below are several key items to look for to identify a potential overhaul candidate packer ... in order of importance:

1. Packer has gone through (destroyed) several pumps in a short period. Example: five pumps gone in 14 months.

2. Packings in cylinders are leaking, even though they were replaced only a short time ago.

3. Hoses have burst repeatedly.

4. Although you are filtering the hydraulic oil through a portable cart, the oil turns contaminated within a short time.

5. Control valve is sticking or hanging up when activated.

6. Plumbing (hoses and hard lines) has been rerouted and replaced several times.

7. Hydraulic problems continue, even after trouble-shooting and repairing individual components.

The benefits: longer vehicle life

We all know that hydraulic system overhaul can be expensive. For one thing, it requires removal of the packer from active service for a short time. But the long-term benefits are well worth the cost.

There aren't too many things that cause a maintenance shop foreman more headaches than a disruptive hydraulic system on a refuse packer. If one accounts for the cost of downtime and trouble-shooting the components of a vehicle that is a constant source of problems, the price of a hydraulic system overhaul is quite reasonable.

In addition to that, there is another bottom-line benefit: Once the overhaul is completed, the life of the refuse packer has been extended. That fact alone has become increasingly more important as haulers attempt to get longer life out of the average refuse vehicle.

Component decisions: the pump

As described in the first article, most problems in a hydraulic system on a garbage packer result in a "premature pump failure." When identifying what type of failure the pump had, it is also a good time to see if the pump can be rebuilt or if it has to be replaced. Cavitation, aeration, contamination, and heat are common types of pump failures. If the pump is rebuildable, replace all O-rings and seal components.

What generally determines if the pump is "rebuildable"? The decision should be based the condition of the

Figure One
Seal Plates Showing Wear

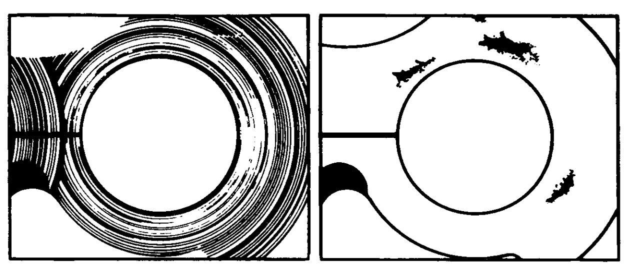
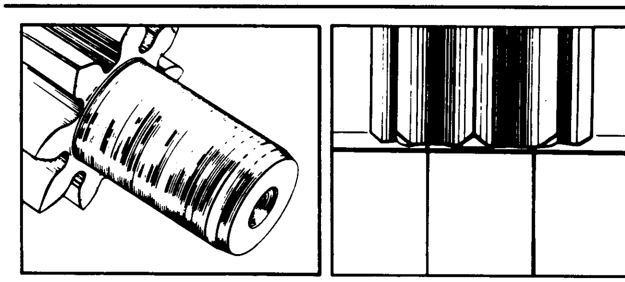


Figure Two
Worn Gear Assemblies



pump body. If the inside gear cavity of the pump body has heavy gouges and scoring where the gears have been riding, then it is not recommended for rebuilding. Putting new seals and wear plates in a pump that has this kind of damage will result in short-term success, at best. One other item to check on the pump body is "cutout"; in simple terms ask "how much has the gear worn into the gear cavity?"

If rebuilding, discard all old seals and wear plates that are damaged. Remember, always replace old seals with new ones when repairing a pump. Review the service inspection procedure listed below (reprinted from the Muncie Power-Miser Parts List and Service Manual, SP84-04):

• Discard seal plates that have score marks, heavy wear pattern, or show erosion marks indicating cavitation or aerated oil condition. See Figure One.

• Discard gear assemblies if:

1. shaft journals show excessive wear or pitting;
2. gear teeth show excessive wear;
3. gear face is scored or cracked; or
4. drive shaft splines or keyways are distorted or worn.

See Figure Two. *Note:* Gear assemblies should be replaced in pairs.

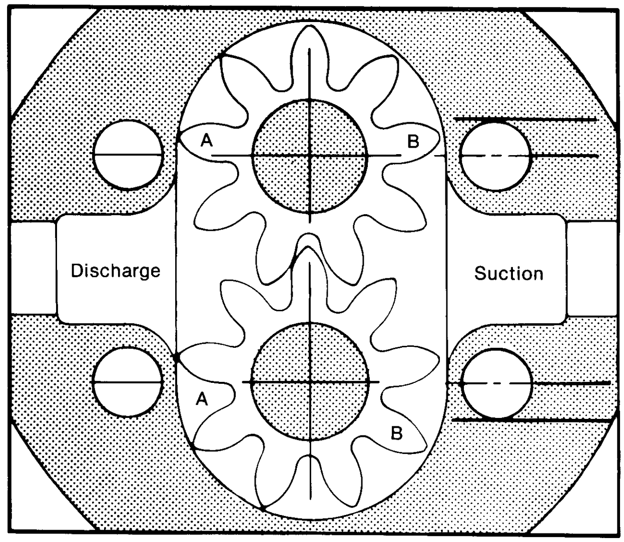
• Check clearance between the gear housing and gear teeth. To measure this clearance, place an .005-inch-thick shim at point 'A,' measure clearance at point 'B' while holding the gear against the shim at point 'A.' The cover/housing and/or gears should be replaced if the clearance exceeds .010 inch at point 'B.' See Figure Three.

• Bearings should be examined visually for evidence of spalling of rollers and fracture of stamped cages. Check roughness of outer race by sliding rollers around periphery of cage. Any of these defects would be reason for replacement. *Note:* Bearings should be replaced in sets of four.

• Check roller bearing for internal clearance by use of a feeler gauge. Bearings and gear assemblies should be replaced if clearance exceeds .003 inch. See Figure Four. *Note:* Always replace the bearings if a gear assembly is replaced or vice versa.

A final note: It makes good sense to keep a rebuilt pump on the shelf for emergencies; odds are in your favor that most Muncie pumps are rebuildable, barring major damage.

Figure Three
Clearance Between Gear Housing And Teeth



Reservoirs, hoses, plumbing, oil

These components can be the largest contributors to hydraulic system contamination if they are not in good working order. Any time the reservoir or hose leading to the pump has a leak, no matter how slight, there is an increased chance of "aeration."

Reservoirs should have large clean-out access covers, a good-quality filter breather, and ports designed for good flow of oil to and from the reservoir. Part of any hydraulic system rebuilding should include dismounting the reservoir from the truck — and completely flushing and wiping down the reservoir inside and out. Replace any magnets and strainers, making sure not to use any screen finer than 100 mesh; any smaller mesh (150 or more) can cause pump cavitation by slowing the flow of oil to the pump. Muncie does not recommend inlet strainers.

Hose: A properly sized and vacuum-rated (SAE 100 R4) hose should be used on the inlet from reservoir to pump. Any hose in the system with kinks, abrasion, leaks, and sharp bends should be replaced. Look at the routing of the old hose before replacing; this may help you find a better location for the new hose. SAE 100 R2 is the minimum quality accepted for up to 2,500 pounds per square inch continuous-duty hose. Avoid making sharp bends with hose. Use "sweep 90" tube fittings where possible. A good rule of thumb: Keep the line as straight as possible from point 'A' to point 'B.'

Minimize the number of bends and turns required. Thread options on fittings should be considered. It is no longer standard accepted practice to use "only" pipe. New technology has made JIC 37 flare and split flange connectors more readily available and less expensive. "Straight thread O-ring"-type fittings are leak-proof when installed correctly.

To sum up: The options are yours — to drip, or not to drip.

Oil: The correct hydraulic oil is an absolute must. By removing an "oil sample" before tearing down the hydraulics, you may identify how your current supply or oil type is performing.

The following items should be used in your consideration of "what is the right oil."

1. Viscosity: For your average climate conditions, select the proper weight oil. Operating temperatures for the hydraulic system should not exceed 200°F, and should be targeted at 130°F to avoid lubricant thermal degradation and reduce the frequency of oil changes.

The viscosity index should be not less than 173 to 185 SSU @ 100°F.

2. Select hydraulic oil with EP, anti-foaming, anti-corrosion, and anti-oxidation properties.

3. Do not ever add diesel fuel to thin hydraulic oil. Do not use brake fluid or low-viscosity naphtha-based engine oils.

4. If you use recycled oil, make sure you receive an independent oil sample evaluation on each new delivery, as some recycled oils do not meet required specs. Even some new oils could have the same problem.

5. Consult with Muncie or other product supplier engineers when considering using aircraft or water-based fluids. Seal changes will be required.

Control valves, flow controls & cylinders

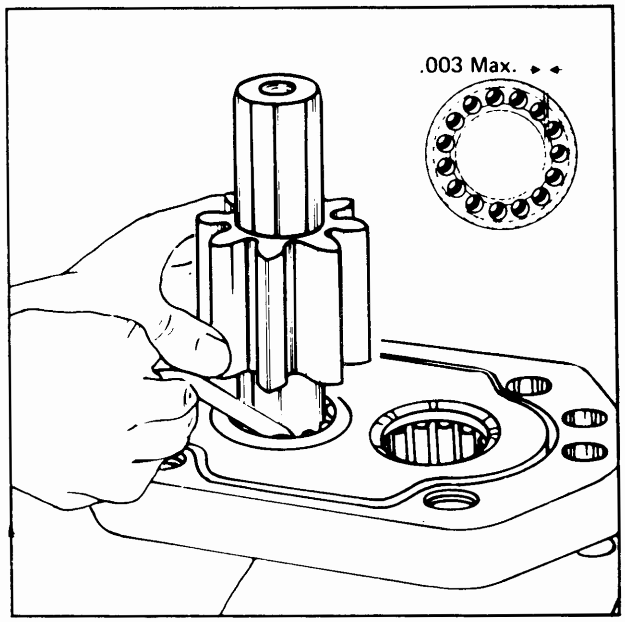
Directing, dividing, and producing work are the main functions of these components. Typically, contamination is the main cause of failure — but do not rule out excess heat.

Spools on the control valve will stick (making them hard to move) or hang up (leaving them stuck in position) when exposed to contamination. In addition, main relief valves will plug with erratic pressure regulation. Pressure-compensated flow controls also will plug, since the spool is similar, result in erratic behavior.

Typically, removing and dismantling the valves and cleaning and replacing seals will renew the life of the valve. In extreme contamination, the spools may be scored enough to require replacement. Please consult with the manufacturer of the valves for detailed repair procedures.

Cylinders (or actuators) are vulnerable to all three main causes in hydraulic system failure: heat, contamination, and excess pressure. Again, like valves, cylinders may be torn down and rebuilt. It only makes sense that the outside sleeves and gland nuts be in good condition before even considering to rebuild a cylinder. It is of little use to rebuild if the cylinder starts leaking shortly after replacement.

Figure Four
Checking Roller Bearings For Internal Clearance



PTOs & cable controls

Once installed, PTOs require very little attention. PTOs can fail if maximum torque, horsepower, or rotations per minute exceed manufacturer's maximum operating conditions. Safeguards, such as overspeed switches, should be used.

Rebuilding of PTOs may become necessary if operated with improper engagement or severe working conditions. Contact supplier engineers for rebuilding instructions.

Control cables: Dirt, water, and sharp bends all shorten the life of control cables. Eliminating these three will prove beneficial. Although most control cables cannot be rebuilt, they can be shortened to eliminate a "bad spot." Specify heavy-duty aircraft quality cables with dust-water caps on each end. Also, a cable with enclosed friction reducing material (graphite) is recommended.

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