Preface

Hydraulic systems cannot be operated and maintained without following certain guidelines. We have attempted to compile a list of the most common precautions in use today.

This information is not intended as being all inclusive of recommended hydraulic practices, however the data provided should be considered general good practices to facilitate operation of your hydraulic equipment.

Installation

1. The most important practice to observe in assembling hydraulic systems is cleanliness. Serious damage can result quickly from foreign material in the system.
2. While in transit or during installation, both hydraulic units and hydraulic components may be subject to many usual conditions. Always inspect for damage or contamination (open ports, cracked or missing plugs, etc.) All hydraulic unit or component parts must be kept tightly plugged until final system connections are made.
3. Install components with secure mounting as required. Follow the schematic provided for piping. A pipe-sizing data sheet is enclosed for reference. Please refer to the chart located in the Flushing Procedures section. Careful attention must be paid to sizing and layout of hydraulic piping. Improper sizing or an excessive number of fittings can lead to loss of power and overheating. Additions to and deletions from the system must be designed into the system. A hydraulic system cannot be added to or capped off like a water system.
4. The importance of cleanliness in installations cannot be overemphasized. Be sure that all pipes are free of dirt, scale and rust. Field-fabricated reservoirs should be wiped down with an oiled, lint-free rag. No visible contaminants should remain in the reservoir. All pipes should be capped during installation to prevent sand and weld spatter from getting into the system.
5. Piping Recommendations: Hydraulic system piping must be clean and adequately sized for satisfactory system operation. If a schematic is provided, it will probably show suggested minimum sizing. Length of runs and practical experience should also be considered. Piping materials such as tubes, hoses and fittings must be clean. Iron pipe is usually the most troublesome. The best way to ensure you are starting with clean pipe is to use pipe that has been cleaned, pickled, lightly oiled and capped. Galvanized pipe should not be used. Be sure to use the proper tubing for your system pressure and pipe rating. Note: All hydraulic lines must be thoroughly flushed prior to connection of the components to the system.
6. Use compressed air to clean fittings as required in accordance with applicable safety precautions.
7. Examine pipe, fittings, hoses and tubing to be certain there are no scale, nicks, burrs or dirt present. Hoses, pipes, and tubing should be capped when stored.
8. Ream pipe and tubing ends to prevent swaged-over material from restricting flow or causing turbulence. Remove loose particles generated by reaming.
9. Never use high-pressure piping on pump inlet lines. The inside diameter is smaller and may restrict flow from reservoir to pump.
10. No burning or welding should be done near open hydraulic systems.
11. When using pipe sealing compound, leave the first two threads (inward) bare to keep sealing material from migrating into the system.

12. Do not use pipe compound on straight threads as this type of fitting depends on an “O” ring for sealing.
13. Select hoses adequate for the working pressures involved in the system. Refer to the schematic.

Hoses should:

Not be applied in configurations less than the published minimum bend radius for each style;

Be clamped at reasonable intervals in a manner to prevent chafing or rubbing between hoses or machine parts;

Be routed around or shielded from hot engine parts or exhaust manifolds or pipes;

Be protected by a grommet or other suitable material when penetrating a deck bulkhead;

Be limited in use to allow flexibility for vibration isolation and to facilitate awkward piping connections.

14. When field-fabricated reservoirs are used, construction should incorporate recognized hydraulic practices. Review selection and installation of hydraulic filters to be sure they meet the minimum recommended guidelines by the system component's manufacturer.
15. Always seal all reservoir openings after cleaning the reservoir. Periodic cleaning and oil changes should be part of every maintenance schedule.

General Cleaning and Flushing Requirements

To Achieve and Retain Satisfactory Initial Cleanliness Level

1. Chemically clean and treat internal system surfaces (components, tubes and hoses).

2. Perform hot oil flushing to reach target cleanliness level.

3. Inspect and verify that the cleanliness level was achieved.

4. Follow the proper steps when disassembling the flushing loops to prevent contaminants from penetrating the cleaned system. Seal off all components with plugs, blind flanges, etc.

5. Perform routine maintenance to stabilize contaminant levels to within control targets.

Strategy for Maintaining Cleanliness After Flushing

1. Prevent new contaminants from entering.

2. Select suitable system filters. New oil should be filled through a system filter or another suitable filter.

All new components and/or modules to be connected to the system must meet the preceding requirements. Perform new cleaning and hot oil flushing after component changes, assembly, disassembly or similar procedures have occurred.

Flushing Strategy Tips

- Connect circuits in series.
- Components that can be damaged by high fluid velocity or by fluids containing moisture, particles or flushing chemicals should be isolated from the flushing circuit and cleaned individually.
- Components that restrict the flow rate, and thereby increase the pressure drop, should be isolated from the flushing circuit and cleaned individually.
- Manifolds, blocks, pump stations, motors, reservoirs, assemblies and components should be delivered clean according to a specific procedure. If not clean, they must be flushed separately. This also applies where space does not allow flushing of installed piping system.

heating. The fluid is thinned out with 4 to 5 percent water before it drains into the standard sewers. Control pH before draining.

Phase V -Drying

Dry the tubes with warm, dry air within 30 minutes after neutralization. Use high quality filtered and oil/water separated compressed air or cleaned nitrogen. The easiest way to control achieved dryness is to check moisture content during the following hot oil flushing.

Minimum Process Equipment Required

- The pickling unit requires a reservoir, pump, filter and heating facility. It is preferred to have a fluid velocity of 3 m/sec. (106 ft./sec.). The filter should be selected according to the same requirements as for the hot oil flushing rig.
- A supply of dry, clean and warm air or nitrogen is needed. It is important that the air is absolutely free of any oil content.
- Special flanges, manifolds and connectors may be needed to assemble the components to be cleaned in series.

Process Control

To verify proper chemical cleaning, the following measurements must be documented during the process:

- pH analyses
- Temperature
- Volume of chemicals in each phase
- Flow rate

Hot Oil Flushing

Generally speaking, the required cleanliness level to target during flushing is half the level during normal operation. For example, if the normal operation level is ISO 15/13/11, flush to an ISO14/12/10. Requirements for cleanliness levels of both solid particles and moisture should be achieved.

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Flushing Fluids

The flushing fluid should be compatible with the fluid used during normal system operation as specified by the client. The viscosity of the fluid at different temperature levels should be specified. As a guideline, standard flushing units normally provide sufficient turbulent flow if the viscosity is in the 10 to 15 cSt range at 104°F (40°C). Ideally, the flushing fluid should obtain that viscosity at no higher than 158°F (70°C).

Turbulent Flow, Fluid Velocity, Temperature and Pressure

With a Reynolds number equal to or greater than 4,000, the fluid is certain to have turbulent flow. This is required to remove particles from the surface inside tubes. To also prevent remaining contaminants from becoming suspended during operation, it is required that: Re-flushing number is equal or greater than 1.2 x Re-in service, but always a minimum of 4,000.

Example: a hydraulic system has a flow rate and tube diameter to achieve Re=3,400 in normal service. Flushing requires a minimum of Re=4,080. The fluid velocity (V) should not be less than 2 to 3 m/sec. (106 ft./sec.) in any part of the flushing loop. This prevents settling of particles inside tubes and hoses.

The coldest part in the flushing loop should have a minimum temperature of 122°F (50°C). This can be achieved by using a minimum flushing fluid supply of 140°F (60°C). In certain cases, this can be achieved only by insulating certain parts of the loop.

The pressure should be held to a minimum 3 to 5 bar (22 to 73 psi), measured downstream from the flushing circuit, before the return line filter and sampling port. Cleaning of ball, plug, butterfly and needle valves is an important part of the hot flush process. To ensure cleanliness has been reached in all zones, the hydraulic valves should be actuated to full-stroke movement during each step of the cleaning process.

Flushing Reservoirs, Filter Housings, Cylinders, Accumulators, Pumps and Motors

Each of these components should be cleaned in separate loops.

- Reservoirs - This is one of the most difficult components of a system to flush. The system reservoir should be cleaned manually then filled with flushing fluid. Use a flushing pump with an in-line filter to circulate and flush the reservoir.

- Filter housings - These units can be connected to the flushing loop or cleaned separately as in the case of the reservoir.

- Cylinders, accumulators, motors and pumps - Clean these separately. The components that have bidirectional movement must be actuated to full movement (stroke) to achieve volume flow of at least 10 times their internal volume.

Minimum Flushing Time

Once samples from the system indicate the specified cleanliness level has been reached, continue flushing for at least 30 more minutes at turbulent flow. This increases the probability of removing adherent particles from tube walls.

Verify Flushing Results

Each flushing loop should be unique and traceable. Create individual drawings or use suitable piping and instrumentation diagrams (P&IDs). Mark position of sampling points for temperature, flow and oil samples.

Document all parameters such as startup time, temperature, flow, particle contamination level and moisture and finish time. It is recommended that a uniform and consistent method of documentation be used.

Third-party verification may be needed to confirm the cleanliness level of the final flushing loop and the complete system.

Flushing Skid

A flushing procedure should be adapted to the conditions of the flushing rig. To obtain sufficient results, the following criteria must be met:

- The filter system should have sufficient capacity and performance to remove both solid particles and moisture to the required level, within a reasonable time.

- The original filters in the system to be flushed should not be used as flushing filters. The flushing filter is important for two essential reasons: 1) it determines the final cleanliness level, and 2) it determines the rate at which this level can be reached.

- A common practice seen lately is to over-specify the filters. A filter with B3>100 with a pressure differential indicator is suitable as long as the dirt-holding capacity is sufficient. Also, it is important for the indicator to provide a warning long before actual fluid by-pass.

- There are several options for moisture removal. These include water-absorbing filter elements, coalescing filters, oil purifiers (such as vacuum distillation), and simply replacing the oil.

- In normal conditions, a water-absorbing filter should be sufficient, assuming the moisture levels are low. Certain synthetic fluids must be dehydrated with oil purifiers.

NOTE: Flushing filters to remove solid particles should not be replaced by the water-removing filters.

- The pump unit should deliver flushing fluid with flow, velocity, viscosity and pressure ratings sufficient to clean the internal surfaces in the system. It should also transport the contaminants out of the system and into the downstream flushing filter.

- The fluid temperature should be monitored and controlled to verify that the oil viscosity provides sufficient turbulent flow in all parts of the flushing loop and at values within the specification for the actual flushing pumps.

Although system flushing can be a time-consuming and expensive process, it is often required, especially at the completion of construction and after a catastrophic component failure during service. Additionally, flushing should be performed as part of a periodic proactive maintenance activity for systems in service. Both the duration and cost of the flushing can be reduced if the system is designed for flushing by the equipment builder. Seek to optimize the flushing procedure for all subsystems and components. But first, systemize and manage the flushing as a complete process for all lines and components throughout the entire system. This will provide reliable service that performs according to design specifications.

Start-Up

1. Fill the reservoir with fluid as recommended by the pump manufacturer (see pump data) which usually requires a premium grade hydraulic fluid with a viscosity index of 90 or higher. For applications with temperatures to 130° F, a fluid viscosity of 150 SSU at 100° F will provide a maximum pump service life. Automatic transmission fluid (Dextron Type D2) will usually prove satisfactory.

   The reservoir filling should always be done through a 10 or finer micron filter. This may be a fill-line filter or possibly the system return filter. In any case, do not put unfiltered oil into your clean reservoir!

2. Connect electric motors to the proper electrical source, checking the motor nameplate for proper wiring of dual-voltage motors. Jog the motor to check rotation. Polyphase motors are bi-directional and proper rotation can be established by reversing any two power leads. Size the motor wiring for proper motor amperage and voltage per information on the motor nameplate.

3. All pumps and motors with external case drains should have cases filled with hydraulic fluid before running. Just as you would not crank an engine without crankcase oil, these components should not be run without pre-filing and should be plumbed so as not to drain the case.

   Check levels and fill all gear boxes where applicable.

   Caution!
   Many engine-driven hydraulic pumps are ruined during engine start up. Be sure that the pump is disengaged or is ready to pump with an adequate supply of oil prior to engine start up.

4. Make sure all suction valves are open and all compensator and relief valves are backed up to the minimum setting. Caution: Relief valves on hydraulic units are preset at pressure shown on the schematics prior to shipment.

5. During start up of the pump, verify that it is priming properly. If the pump fails to prime, shut down immediately, vent discharge pipe to atmosphere and restart to establish fluid flow. Check suction valves to assure that they are open. Loosen hose or pipe connection on pressure side of pump. Jog pump drive and note oil flow to assure prime. Retighten loosened connections after priming. Unusual pump noise is often caused by air entering the pump suction line. The tightening of suction fittings will usually eliminate such problems.

6. Adjust pressure controls to settings recommended on the circuit drawings.

7. The electrical characteristics for electrically-operated valves are shown on the solenoid valve covers.

8. Important: After hydraulic unit has been started and all lines filled, replenish the oil in the reservoir to the proper level. This will insure that the oil cools properly and prevent cavitation of the pump.

9. After the first two (2) hours of system operation, inspect and clean or replace all filter elements to remove any contamination flushed out of the system components. Replacement elements are readily available from SunSource. Repeat this task every two (2) hours for the next eight (8) hours of operation then as needed. (See the Oil Maintenance section.)

   Caution!
   Simultaneously energizing both solenoids on double solenoid valves will cause coil burnout!

Important!

For most applications an operating temperature of 150° is considered maximum. At higher temperatures difficulty is often experienced in maintaining reliable and consistent hydraulic control. Component service life is also reduced, hydraulic fluid deteriorates and potential danger to operating personnel is created.

Fluid Maintenance / Filtration

Contamination in hydraulic fluid has been given a lot of attention by the industry. Research and testing of the effects of dirt, water, wear products, oil deterioration products and other contaminates in the oil are important factors in today's high performance hydraulic equipment.

Why Cleanliness?

The demand for even greater performance from smaller packages has greatly increased the need for keeping the oil clean. Wear occurs in all hydraulic systems. If dirt particles remain suspended in the oil, they act like a grinding compound and increase wear. Other foreign particles, particularly metal, have the same effect.

Hydraulic components are affected by contamination. Sticking and sluggishness can occur. Small controlling passages may become plugged. Dirt can prevent valves from seating, resulting in leakage and loss of control.

Hydraulic oil, itself, is affected by contamination. Water has a tendency to separate certain inhibitors from high-performance hydraulic oil, reducing its usable life. Other contaminants seem to be a catalyst or "helping hand" effect on oil oxidation. It has been demonstrated that fine particulate contamination actually reduces the safe operating temperature of a system. Extremely clean fluids can operate as much as 25° to 50° hotter than contaminated fluids without oxidation.

Hydraulic oil is kept clean by the filters. The periodic replacement of filter elements is mandatory for satisfactory operation. Replace elements immediately upon indication of an installed bypass indicator or every 500 hours of operation once the system is in production.

Hydraulic systems are precision units and their continued smooth operation depends on proper care. Keep them clean, change the oil filter at established intervals and follow prescribed maintenance.

Maintenance Instructions

Periodic Procedures

1. Check the reservoir oil level and add oil as required. The level must be maintained between the high and low marks on the sight gauge.

2. Check the operating temperature. 150° is considered maximum for most industrial applications.

3. If an external suction filter is used, check the filter indicator for dirty elements every two (2) hours for the first eight (8) hours of operation then clean or replace when necessary. Check the filter indicator once every day for the next five (5) days of operation and clean or replace when necessary. Check periodically thereafter at intervals that will prevent the filter from bypassing or cavitating the pumps.

4. Check the return filters as in Step 3. These are usually finer mesh filters and will require more frequent element changes or cleansing than the suction filter. Always change filters when the oil is changed.

5 At least once a year or every 4,000 operating hours the reservoir, pump, suction filter (if one is used) and air vent filter should be cleaned. Check the entire system at this time for possible future difficulties. Some applications or environmental conditions may dictate such maintenance is performed at more frequent intervals.

6. Make visual checks of all hose and tube connections. Regular checking and tightening of all hydraulic connections will help to assure trouble-free operation.

7. Periodically check pressure settings. The system was designed to operate at a specific pressure and increasing the pressure above that level will result in motor overload. The system should be operated at the minimum pressure required to do the intended function. The lower the system pressure, the longer system components can be expected to last.

8. Check pump/motor coupling periodically for misalignment. A flexible coupling should always be used with the shafts accurately aligned – parallel and angularly. Check set screws in couplings for loosening and tighten as required.

9. The reservoir cover should remain tightly sealed at all times except in the case of in-tank maintenance and periodic checks for in-tank leaks. This will prevent atmospheric contamination from entering the system.

Safety Precautions

Required for Hydraulic Machinery Operation & Maintenance

Although the scope of this manual covers only the hydraulic operation of the equipment, these safety precautions also apply to pneumatically-powered equipment and should be observed when appropriate.

The hydraulic equipment has been constructed using the highest standards of workmanship with industry accepted, state-of-the-art techniques, components and designs and has been inspected and tested for defects, workmanship and proper operation prior to shipment.

This equipment, however, may develop problems due to normal use, unforeseeable circumstances or abuse. It requires, therefore, proper operation and maintenance. In the course of performing these functions, personnel may be required to work on or near the equipment. The following precautions are given to avoid injury.

All safety requirements listed below are those generally applicable to hydraulically-powered machinery but are **not** intended to be an all-inclusive list. They are intended as **guidelines only** and will assist in avoiding risk of injury when followed by qualified, experienced personnel who understand the hazards of machinery operation and maintenance. These precautions should be included in the comprehensive safety program for the particular machinery, equipment, plant or process and overseen by personnel capable of analyzing any hazards associated with operating and maintaining the equipment.

1. Return all movable machine members to their normal startup condition, if possible, before starting unit.

   Note: Many types of equipment may have parts of the machinery which may start rotating, rising, falling, reciprocating, etc. out of their proper sequence as soon as the hydraulic or pneumatic circuit is filled and pressurized which could result in injury to personnel or damage to machinery.

2. Be sure all personnel, product, etc. are clear of machinery before starting hydraulic unit.

3. Check to make sure any hydraulic connections which may have been removed, replaced or disconnected during shut down have been reconnected securely before starting hydraulic unit.

4. Return all valves (manual and control system operated) which may have been changed from their normal start-up condition during shut down back to start up condition before starting hydraulic unit.

5. Before shutting down hydraulic unit, block or lock in position any machine members which may move and cause injury to personnel or damage to product or equipment upon loss of hydraulic flow and pressure.

6. Clear all personnel and product from machinery before shutting down the hydraulic unit.

7. If hydraulic system has oil accumulators in circuit, drain pressurized oil from all accumulators as soon as hydraulic unit is shut down (if automatic drainage is not built into the circuit). If the accumulator has a shut off valve, close that valve also.

8. Shut down the hydraulic unit and relieve pressure from all pressurized accumulators, actuators and lines before removing, tearing down or performing maintenance on any remotely-located actuators, hoses, filters, valves, piping, etc.

9. Keep in place and maintain any equipment guards including coupling and chain guards and protective cowling. Do not wear loose clothing or jewelry that could get caught in moving parts.

10. In addition to any other company-mandated safety equipment worn by your personnel, make sure anyone in the vicinity of the hydraulic system during operation wears eye protection to reduce the risk of injury in the event of a hydraulic line rupture and high-velocity oil leak.

11. Check noise levels in the vicinity of the equipment and have personnel wear ear protection, if required, as set forth in OSHA regulations.

12. Any personnel observing or working on or adjacent to hydraulically-powered equipment must never place themselves in a location or position that could produce an injury in the event of:

    a. A hydraulic line failure either with the unit running or shut down,

    b. Power blackout, or electrical outage,

    c. Pump or motor failure or,

    d. Movement of machine members during a normal operating cycle or as a result of a component malfunction or failure.

13. Before removing or performing maintenance on any hydraulic system components containing electrical components (i.e. solenoid valves, switches, electric motors, etc.), shut off and padlock electrical power to the unit and/or control system. See Paragraphs 5 and 12 above before shutting off power. This applies to pneumatically controlled equipment as well.

14. Avoid locating equipment in any environment for which it was not designed and which may create a dangerous operating condition such as an explosive atmosphere (e.g.,. gas, dust), high heat (e.g., molten metal, furnace), chemicals, extreme moisture, etc.

15. Certain hydraulic fluids may be irritating or injurious to the eyes and skin. Check with your fluid suppliers to obtain this information. Avoid bodily contact with such fluids. Fire resistant or synthetic fluids should be especially guarded against.

16. Avoid the use of unauthorized or substitute parts and materials when servicing the equipment. Substitute parts or materials could produce a hazardous operating condition.

17. When piping your equipment, use only materials of adequate size and strength to suit the flows and pressures of the system. If a schematic has been provided, it will normally note the minimum suggested line sizes and lengths of runs. Practical experience may indicate use of line sizes larger than shown on the schematic. Consider all safety factors when selecting the strength of materials to allow for shock and over-pressure conditions which could occur.

Trouble Shooting Your Hydraulic System (Pg 1)

PROBLEM	POSSIBLE CAUSES	REMEDY
Failure of pump to deliver fluid	Low fluid level in reservoir	Add recommended oil and check level to be certain pump suction line inlet is submerged deeply enough to prevent air entering directly or by the formation of a vortex.
	Oil intake pipe or strainer plugged	Clean or replace
	Air leak in suction line, prevent priming or causing noise and irregular action of control circuit	Repair leaks
	Oil viscosity too heavy to pick up prime (especially in cold weather)	Use lighter viscosity oil or install a low density immersion heater (with steel element only)
	Wrong direction of rotation	Must be reversed to prevent damage to pump
	Broken pump shaft or parts broken inside pump	Replace
Pump making noise	Intake line, suction filter of pipe restricted	Clean intake, filter or eliminate restriction. Be sure suction line is completely open
	Air leaks 1) At pump intake piping joints 2) At pump shaft packing (if present) or seals 3) Air drawn in through inlet pipe opening	1)Tighten as required 2) Repair or replace 3) Be sure suction and return lines are below oil level in reservoir
	Reservoir air vent plugged	Air must be allowed to breathe in the reservoir. Clean or replace reservoir breather.
	Too high oil viscosity	Use lower viscosity oil. Check recommendations in start-up information
	Coupling misalignment	Re-align
	Worn or broken parts	Replace

Trouble Shooting Your Hydraulic System (Pg 2)

PROBLEM	POSSIBLE CAUSES	REMEDY
No pressure in the system	Pump does not deliver	Follow the remedies given for "Failure of Pump to Deliver Fluid"
	Bad pump-to-motor shaft connection	Check pump/motor coupling for breakage, stripped key or keyway and replace or repair
	Relief Valve Malfunction	
	1) Incorrect valve setting	1) Reset to specifications
	2) Valve leading or by-passing	2) Check main valve seat and pilot valve for scoring and dirt. Replace and clean
	3) Valve spring broken	3) Replace spring and reset
	Free re-circulation of oil to tank being allowed through system.	Check or relief valve may be stuck in open position or return line open unintentionally Vent Valve* is dumping flow through relief valve at low pressure. Bypass valve to tank is open. Open center 4-way Valve* is not shifted, dumping oil to tank. See "Solenoid Valve not Shifting" if valve is solenoid operated.
No pressure in circuit with Variable Volume Piston Pumps	Pressure compensated pump not compensating properly.	Check compensator for broken spring or contamination and repair as required.
	Relief valve setting is lower than pump compensator setting	Set relief to max system pressure and pump compensator to operating pressure at least 250 psi below relief.
	Hydrostatic drive not building torque (no system pressure)	See remedies in "Hydrostatic Troubleshooting" provided by the pump manufacturer.

Trouble Shooting Your Hydraulic System (Pg 3)

PROBLEM	POSSIBLE CAUSES	REMEDY
Excessive wear of pump parts	Sustained high-pressure above maximum pump rating	Check relief valve maximum setting.
	Drive misalignment	Check and correct.
	Air recirculation causing chatter in system	Check air problems in pump making noise.
	Abrasive material in the oil	Clean or replace filter and change oil.
	Viscosity of oil too low at working conditions	Check recommendations.
Breakage of inside pump Housing	Excessive pressure above pump rating	Check relief valve maximum setting.
	Seizure due to lack of oil	Check reservoir level, oil filter and possibility of restriction in suction line.
External oil leakage around pump shaft or housing	Shaft packing or seals worn	Replace.
	Damaged head packing seals	Replace.
	excessive case pressure due to restricted case drain flow (back to tank)	Check case drain line for a restriction and remove. Drain line may be too small; if small, line is creating back pressure, replace with larger line.
	Excessive case pressure due to excessive drain flow	Repair pump for excessive leakage from pumping element to case.
	Cracked housing	Replace all damaged parts and seals.

Trouble Shooting Your Hydraulic System (Pg 4)

PROBLEM	POSSIBLE CAUSES	REMEDY
Solenoid valve problem	Solenoid burned out	Replace solenoid coil. Check control voltage (high or low voltage will burn out coil).
		For double solenoid valves, check to see if both solenoids are being energized at the same time. Correct control circuit if this occurs.
	No pilot pressure for shifting main spool	If valve is externally piloted, check pilot pressure source for adequate pressure.
	No pilot pressure for shifting main spool (continued)	Check valve for proper internal plugs for ext. pilot. If valve is internally piloted, check for proper internal plugs for internal pilot. Clean all internal pilot passages and orifices of foreign particles and clogging.
	No pilot drain	Check to see if valve has proper internal plugs and orifices for inter. or ext. drain.
		If externally drained, check drain line and clear of any clogging.
	Spool jammed by foreign particles of silt	Disassemble pilot valve and main valve and remove all foreign particles and silt. If a contamination or silting problem continues to reoccur, install filtration in the system to remove particles.
	Internal breakage or damage	Disassemble, examine and replace any damaged parts in pilot valve or main valve.

Trouble Shooting Your Hydraulic System (Pg 5)

PROBLEM	POSSIBLE CAUSES	REMEDY
Cylinder won't develop full force or hold position when valve closes lines	Leaking piston packing	Apply pump flow to one end and stroke cylinder until it bottoms out at end of stroke. Loosen return line at opposite end (from pressurized end) and measure leakage flow coming out. Any flow more than slow dripping requires new piston packing. Repeat for opposite end and stroke.
	Worn 4-way control valve	Disconnect cylinder lines at 4-way valve and plug. Shift valve to either position and check to see if full pressure builds up. If relief is not built into 4-way valve, check to see how much flow is leaking across to the tank port.
	Loss of system pressure	See previous trouble shooting guide.
Cylinder loses force at some intermediate point in stroke	Scored barrel	Repeat above except mechanically stop piston rod so piston is at point where force drops off. If leakage is determined, barrel must be repaired or replaced.
	Dented barrel	Examine barrel tube for dents at point where it loses force. Replace if tube is dented.

Trouble Shooting Your Hydraulic System (Pg 6)

PROBLEM	POSSIBLE CAUSES	REMEDY
Excessive heating because of component conditions	Relief valve set incorrectly	Readjust valve to system specifications pressure; usually 100-150 psi above compensator setting.
	Internal oil leakage (pump)	Repair or replace pump.
	Viscosity of oil too high	Check recommendations to start-up information.
	Leaking valves	Repair or replace.
	Improper functioning of oil cooler (if installed)	Inspect cooler and see that it is working properly.
	Restricted lines	If lines are crimped, replace; if partially plugged for any reason, remove obstruction.
	Scored or damaged rotor, valve plate, pistons and piston bores, or other internal moving parts	Check case drain line for excessive drain flow; if possible filter drain flow and check for metal (brass or steel) filings or particles; replace damaged parts.

Electric Motor Trouble Shooting (Pg 1)

PROBLEM	POSSIBLE CAUSES	REMEDY
Motor runs excessively hot	Overloaded	Reduce load or load peaks and number of starts in cycle.
	Blocked ventilation	Clean external ventilation system-check fan.
	a. TEFC's	Blow out internal ventilation passages.
	b. O.D.P.'s	Eliminate external interference to motor ventilation.
	High ambient temperature over 40 C (104 F)	Reduce ambient temperature or provide outside source of cooler air.
	Unbalanced input current	Balance supply voltage. Check motor leads for tightness.
	Single Phased	Eliminate single ph. condition.
Won't start (just hums and heats up)	Single Phased	Shut power off. Eliminate single phasing. Check motor leads for tightness.
	Rotor or bearings locked.	Shut power off. Check shaft for freeness of rotation.
		Be sure proper sized overload relays are in each of the 3 phases of starter. Refer to National Electrical Code.
Runs noisy under load (excessive electrical noise or chatter under load)	Single Phases	Shut power off. If motor cannot be restarted, it is single phased. Eliminate single phasing.
		Be sure proper sized overload relays are in each of the 3 phases of the starter. Refer to National Electrical Code.
Excessive voltage drop (more than 2 or 3% of nominal supply voltage)	Excessive starting or running load	Reduce load.
	Inadequate power supply. Undersized supply lines. High resistance connections.	Consult power company. Increase line sizes. Check motor leads and eliminate poor connections.

Electric Motor Trouble Shooting (Pg 2)

PROBLEM	POSSIBLE CAUSES	REMEDY
Overload relays tripping upon starting	Slow starting (10-15) seconds or more) due to high inertia load.	Reduce starting load. Increase motor size if necessary.
	Low voltage at motor Terminals	Improve power supply and/or increase line size.
Running loaded	Overload	Reduce load or increase motor size.
	Unbalanced input current	Balance supply voltage.
	Single phasing	Eliminate.
	Excessive voltage drop	Eliminate (see below).
	Too frequent starting or intermittent overloading	Reduce frequency of starts and overloading or increase motor size
	High ambient starter temperature	Reduce ambient temperature or provide outside source of cooler air.
	Wrong size relays	Correct size per nameplate current of motor. Relays have built in allowances for service factor current. Refer to National Electrical Code.
Excessive vibration (mechanical)	Out of balance:	
	a. Motor mounting	Be sure motor mounting is tight and solid.
	b. Load	Disconnect belt or coupling-restart motor-if vibration stops, the unbalance was in load.
	c. Sheaves or coupling	Remove sheave or coupling-securely tape 1/2 key in shaft keyway and restart motor-if vibration stops, the unbalance was in the sheave or coupling.
	d. Motor	If the vibration does not stop after checking a, b, and c above, the unbalance is in the motor-replace the motor.
	e. Misalignment on close coupled application	Check and realign motor to the driven machine.

Electric Motor Trouble Shooting (Pg 3)

PROBLEM	POSSIBLE CAUSES	REMEDY
Noisy Bearings: (listen to bearings for the following)		
Smooth mid range hum	Normal fit	Bearing OK.
High whine	Internal fit of bearing too tight	Replace bearing-check fit.
Low rumble	Internal fit of bearing too loose	Replace bearing-check fit.
Rough clatter	Bearing destroyed	Replace bearing-avoid: a. mechanical damage b. excessive greasing c. wrong grease d. solid contaminants e. water running into motor f. misalignment on close coupled application g. excessive belt tension
High input current (all three Phases)	Accuracy of ammeter readings	First check accuracy of ammeter readings on all three phases.
Running idle (disconnected from load)	High line voltage 5 to 10% over nameplate	Consult power company-possibly decrease by using lower transformer tap.
Running loaded	Motor overload	Reduce load or use larger motor.
	Motor voltage rating does not match power system voltage	Replace motor with one of correct voltage rating. Consult power company-Possibly correct by using a different transformer tap.