CSDA Best Practice

Title: **Hydraulic Concrete Cutting Equipment**
Issue No: **CSDA-BP-006**
Effective Date: **Nov 1, 2008**
Revised Date:

Introduction
Hydraulic powered tools are quite common in the concrete cutting industry powering a full range of cutting tools including wall saws, core drills, hand held saws, chain saws and even flat saws. While hydraulics are a low-cost and dependable way to transmit power, there are a multitude of ways to design a system for optimum performance in specific applications. This Best Practice will focus on a few design considerations or options, general maintenance issues and some troubleshooting guidelines.

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1. Horsepower Rating

1.1. Calculation of hydraulic power In English units.
The formula for determining the horsepower rating of any hydraulic operating system in English units is as follows:

Flow (in gallons per minute) x operating psi divided by 1,714 equals the theoretical horsepower.

Most systems are only 80 to 90% efficient, depending on the distance from the pump to the motor, the condition of the main system components, the design of the hose couplings and general system design.

Example:

A 25 gpm system operating under load at 1,800 psi at the motor (even though max psi of the system pump is 2,500) is:

25 x 1,800 = 45,000
Divided by 1,714 = 26
Times 0.85 efficiency = 22 horsepower

If the flow is being diverted for the operation of another system component then the actual horsepower to the main drive will be less.

1.2 Calculation of Hydraulic Power in Metric Units

Hydraulic Power (kW) = $\frac{\text{Flow volume (liter/min) x Pressure (bar)}}{600}$

Example:

Delivery of the pump	Q = 40 liter/min
Operating pressure	P = 180 bar
Power output of the hydraulic pump	$P = \frac{Q \times P}{600} = \frac{40 \times 80}{600} = 12$ kW

Pressure Drop

Friction between the fluid flowing through a conductor (hoses, valves, fitting's or QD's) and its inside walls will cause losses, which are quantified as pressure drop. Pressure drop in conductors is an important consideration for the designer, especially in systems where long pipe or hose runs are necessary. The pressure drop over a length of pipe or hose is shown in the chart below.

Before proceeding to the pressure drop chart, the following variables need to be determined.

a. The inside diameter of the hose.
b. The length of the hose.
c. The flow rate.
d. Condition of the hoses in use. (Not crushed or kinked).

Hose Diameter (Inch)	Oil Flow		Pressure Drop	
	(liters/min)	Per Meter	(Bar) 10M x 2	20M x 2
0.5	40	0.60	12.0	24.0
0.5	60	1.30	26.0	52.0
0.75	40	0.17	3.4	6.8
0.75	60	0.35	7.0	14.0

The pressure drop in one pair of quick disconnect couplings results in 3-5 bar 44-72 psi.

It is vital to inspect the hoses on a daily basis for damage due to kinking or being crushed. Unrolling the hoses completely from the hose reel will decrease the chance that when the hoses are pressurized, they will not crush the inner windings of the hose left on the reel. This will also allow more heat to escape from the surface of the hoses.

The loss of efficiency up to the saw blade on a 18.8 kW power pack.

- Hydraulic power pack 18.8 kW (25 hp)
- Losses in the hoses - 2.2 kW (-3 hp)
- Losses in the hydraulic motor - 2.2 kW (-3 hp)
- Losses in the transmission - 0.7 kW (-1 hp)

(18 hp)

Power on the saw blade 13.7 kW

2. Cleanliness and Filtration

Dirt or other contaminants in a hydraulic system will cause serious damage to the components very quickly. Because of the close tolerances and high forces under which the components operate, contaminants will cause a high degree of wear resulting in a less efficient system rapidly. This lowers productivity and increases heat generated due to the less efficient system. It is wise to follow the system designer's specific instructions for filter and oil specifications as well as the specific maintenance advice provided. Listed below are some of the possible actions:

a. Keep hose couplings out of contact with slurry. The fittings nearest the motor that are frequently disconnected and reconnected should be washed down thoroughly before disconnecting and reconnecting and then wiped dry with a clean cloth.
b. Change filters regularly and clean strainers regularly. Use filters with element condition indicators if possible.
c. Perform any system maintenance or work including filter changes in a clean location using "clean practices."
d. Keep all connections throughout the entire system tight so that air (and contaminants it may contain) is excluded from the system.
e. Make sure the air breathers and reservoir covers are properly installed and tightly secured at all times.
f. Stop any leakage of water into the system from coolers or to other sources. It is best to keep the reservoir filled to the recommended fill line to minimize condensation in the tank.
g. Use a portable filtration unit with at least a 25-micron filter for filling and emptying the hydraulic reservoir.
h. Flush all new systems and any that have undergone major repair before starting the unit.
i. Take fluid samples and have them analyzed occasionally so that you know what the most common contaminants that are in the system. This will help you locate and minimize them.

j. Change fluid regularly. Degraded fluid can result in contamination due to oxidation or the formation of gummy deposits that can break loose and clog control valve orifices.
k. Before draining the system the system should be started and the fluid allowed to heat up before draining. This will lower the draining time and help many impurities to become suspended in the fluid before draining.

3. Hydraulic Fluid

Hydraulic fluid is the "life" of the hydraulic circuit. It is usually petroleum oil with various additives. In addition to transferring energy, hydraulic fluid needs to lubricate components, suspend contaminants and metal filing for transport to the filter, and to function well to several hundred degrees Fahrenheit.

Most hydraulic systems will operate satisfactorily using a variety of fluids. These include multigrade engine oil, automatic transmission fluid and more conventional antiwear hydraulic oil. But which type of fluid is best for a particular application? While it is not possible to make one definitive recommendation that covers all types of hydraulic equipment in all applications, the following are some of the factors to consider when selecting a hydraulic fluid.

3.1 Multigrade or Monograde.

Viscosity is the single most important factor when selecting a hydraulic fluid. It doesn't matter how good the other properties of the oil are if the viscosity grade is not correctly matched to the operating temperature range of the hydraulic system. In this situation, maximum component life will not be achieved. Defining the correct fluid viscosity grade for a particular hydraulic system involves consideration of several interdependent variables. These include:

a. Starting viscosity at minimum ambient temperature.
b. Maximum expected operating temperature which is influenced by maximum ambient temperature.
c. Permissible and optimum viscosity range for the systems components.

If the hydraulic system is required to operate in freezing temperatures in winter and tropical conditions in summer, then it is likely that mulitgrade oil will be required to maintain viscosity within permissible limits across a wide operating temperature range. If fluid viscosity can be maintained in the optimum range, typically 25 to 36 centistokes, the overall efficiency of the hydraulic system is maximized (less input power is given up to heat). This means that under certain conditions, the use of a multigrade oil can reduce the power consumption of the hydraulic system. For mobile hydraulic equipment users this translates to reduced fuel consumption.

3.2 Detergent or No Detergent.

DIN 51524; HLP-D fluids are a class of anitwear hydraulic fluids that contain detergents and dispersants. The use of these fluids is approved by most major hydraulic component manufacturers. Detergent oils have the ability to emulsify water, and disperse and suspend other contaminants such as varnish and sludge. This keeps components free from deposits, however, it also means that contaminants do not settle out – they must be filtered out. These can be desirable properties in mobile hydraulic systems, which unlike industrial systems, have little opportunity for settling and precipitation of contaminants at the reservoir.

As far as hydraulic oil recommendations go, for commercial reasons relating to warranty, it is wise to follow the equipment manufactures recommendations. However in some applications, the use of a different type of fluid to that originally specified by the equipment manufacture may increase hydraulic system performance and reliability. Always discuss the application with a technical specialist from your oil supplier and the equipment manufacture before switching to different type of fluid.

4. Aeration

Aeration is a condition caused when air bubbles are somehow introduced into the hydraulic oil. You can generally tell if the system you are operating is suffering from aeration by the noise coming from the pump caused by "cavitation" which can produce a light to strong "pounding" effect. Aeration caused by small bubbles causes extreme and rapid ring wear and vane tip wear. Large bubbles cause the vanes to collapse and pound. With extreme aeration cases, the wear is so rapid that the ring and vanes can be destroyed within an hour, so this is a condition that should definitely be avoided.

4.1 Possible Causes:
a. Leaking inlet lines.
b. Control valve o-rings leaking.
c. Shaft seal leakage.
d. Turbulence or sloshing in the fluid reservoir.
e. Vortexing fluid in the reservoir.
f. Release of air naturally suspended in the fluid.
g. Shaft misalignment in pump.

4.2 Cures:
a. Use an approved type of pipe thread sealer on all pipe threads.
b. Check to see if the pump inlet flanges are rough, porous or mutilated. Air leakage past the o-ring seal can result.
c. Check alignment of shaft and correct if necessary.
d. Make sure that the fluid return line discharges the flow below the fluid level in the tank.
e. Make sure the fluid return is not directly up against a wall of the tank causing vortexting.

5. Hydraulic Pumps

Hydraulic pumps deliver high-pressure fluid flow to the pump outlet. Hydraulic pumps are powered by a mechanical energy source to pressurize fluid. A hydraulic pump, when powered by pressurized fluid, can rotate in a reverse direction and act as a motor. Operating specifications, housing materials and features are all important specifications to consider when searching for hydraulic pumps.

Pump type and pump stages are the most important operating specification to consider when searching for hydraulic pumps. Choices for hydraulic pump types include axial piston, radial piston, internal gear, external gear and vane. An axial piston pump uses an axially-mounted piston to pressurize the fluid. Mechanical motion from the pumps power source moves the piston through a chamber, pressurizing the fluid it comes in contact with. A radial piston pump uses pistons mounted radially about a central axis to pressurizing fluid. An alternate form of radial piston pump uses multiple interconnected pistons, usually in a star pattern. The hydraulic pump's power source causes the pistons to move, forcing the pistons through the chambers and pressurizing fluid. An internal gear pump uses internal gears to pressurize fluid. The pumps power source causes the internal gears to turn, which forces fluid through the pump outlet. An external gear pump uses external gears to pressurize fluid. The pumps power source causes external gears to turn, which forces fluid through the pump outlet. A vane pump uses a vane to pressurize fluid. The pump's power source causes the vane to rotate. As the vane rotates, blades on the vane push fluid out the pump's outlet. Pump stages include single stage, double stage, triple stage and four or more pump stages.

Additional operating specifications to consider for hydraulic pumps include continuous operating pressure, maximum operating pressure, operating speed, operating horsepower, operating temperature, maximum fluid flow, maximum fluid viscosity, displacement per revolution, and pump weight. The continuous operating pressure is the maximum pressure available at the pump outlet. The maximum operating pressure refers to the maximum peak pressure available at the pump outlet on a noncontiguous (intermittent) basis. The operating speed is the speed at which the pump's moving parts rotate is expressed in revolutions per minute, or similar terms. The operating horsepower is the amount of power the pump is capable of delivering. Horsepower is dependent on the pressure and flow of the fluid through the pump. The operating temperature is the fluid temperature range the pump can accommodate. Maximum and minimum fluid temperature is dependent upon internal component materials, and varies greatly between manufacturers. The maximum volumetric flow through the pump is expressed in terms of gallons per minute, or similar units. The maximum fluid viscosity the hydraulic pump can accommodate is a measure of the fluid's resistance to shear, and is measured in centipoise. Centipoise is a common metric unit of dynamic viscosity equal to 0.01 poise or 1 millipascal second. The dynamic viscosity of water at 20 degrees C is about 1 centipoise. The correct unit is cP, but cPs and cPo are sometimes used. The fluid volume displaced per revolution of the pump is measured in cubic centimeters (cc) per revolution, or similar units. The weight of the hydraulic pump is measured in pounds or similar units.

5.1. Radial Piston Pumps.
Radial piston pumps (fixed displacement) are used especially for high pressure and relatively small flows. Pressures of up to 650 bar are normal. In fact variable displacement is not possible, but sometimes the pump is designed is such a way that the plungers can be switched off one by one, so that a sort of variable displacement pump is obtained.

5.2. Pumps for Open and Closed Systems.
Most pumps are working in open systems. The pump draws oil from a reservoir at atmospheric pressure. It is very important that there is no cavitation at the suction side of the pump. For this reason the connection of the suction side of the pump is larger in diameter than the connection of the pressure side. In case of the use of multi-pump assemblies, the suction connection of the pump is often combined.

It is preferred to have free flow to the pump (pressure at inlet of pump at least 0.8 bars). The body of the pump is often in open connection with the suction of the pump. In a closed loop systems, both sides of the pump can be at high pressure. The reservoir is pressurized with 2-20 bars of boost pressure. For closed loop systems normally axial pumps are used.

6. Hydraulic Motors

Hydraulic motors are powered by pressurized hydraulic fluid and transfer rotational kinetic energy to mechanical devices. Hydraulic motors, when powered by a mechanical source, can rotate in reverse direction and act as a pump. Operating specifications and features are the most important parameters to consider when searching for hydraulic motors.

The most important operating specification to consider when searching for hydraulic motors is the motor type. Choices for motor type include axial piston, radial piston, internal gear, external gear and vane. An axial piston motor uses an axially-mounted piston to generate mechanical energy. High pressure flow into the motor forces the piston to move in the chamber, generating output torque. A radial piston hydraulic motor uses pistons mounted radially about a central axis to generate energy. An alternate-form radial piston motor uses multiple interconnected pistons, usually in a star pattern, to generate energy. Oil supply enters piston chambers, moving each individual piston and generating torque. Multiple pistons increase the displacement per revolution through the motor, increasing the output torque. An internal gear motor uses internal gears to produce mechanical energy. Pressurized fluid turns the internal gears, producing output torque. An external gear motor uses externally-mounted gears to produce mechanical energy. Pressurized fluid forces the external gears to turn, producing output torque. A vane motor uses a vane to generate mechanical energy. Pressurized fluid strikes the blades in the vane, causing it to rotate and produce output torque.

Additional operating specifications to consider for hydraulic motors include operating torque, operating pressure, operating speed, operating temperature, power, maximum fluid flow, maximum fluid viscosity, displacement per revolution and motor weight. The operating torque is the torque the motor is capable of delivering. Operating torque depends directly on the pressure of the working fluid delivered to the motor. The operating pressure is the pressure of the working fluid delivered to the hydraulic motor. Working fluid is pressurized by an outside source before it is delivered to the motor. Working pressure affects operating torque, speed, flow and horsepower of the motor. The operating speed is the speed at which the hydraulic motor's moving parts rotate. Operating speed is expressed in revolutions per minute, or similar terms. The operating temperature is the fluid temperature range the motor can accommodate. Minimum and maximum operating temperatures are dependent on internal component materials of the motor and can very greatly between products. The power the motor is capable of delivering is dependent on the pressure and flow of the fluid through the motor. The maximum volumetric flow through the motor is expressed in terms of gallons per minute, or similar units. The maximum fluid volumetric the motor can accommodate is a measure of the fluids resistance to shear, and is measured in centipoise. Centipoise is a common metric unit of dynamic viscosity equal to 0.01 poise or 1 millipascal second. The dynamic viscosity of water at 20 degrees C is about 1 centipoise. The correct unit is cP, but cPs and cPo are sometimes used. The fluid volume displaced per revolution of the motor in cubic centimeters (cc) per revolution, or similar units. The weight of the motor is measured in pounds or similar units.

Additional features to consider when searching for hydraulic motors include mounting in any position, rated for continuous duty and quiet operation.

7. Fittings, Piping and Cost of Hydraulic Leaks

7.1. Reliable Connections.
Leak-free reliability begins at the design stage, when the type of hydraulic fitting is selected for port, tube-end and hose-end connections.

Ports – Connectors that incorporate an elastomeric seal such as UNO, BSPP and SAE 4-bolt flange offer the highest seal reliability. NPT is the least reliable type of connector for high pressure hydraulic systems because the thread itself provides a leak path. The threads are deformed when tightened and as a result, and subsequent loosening or tightening increases the potential for leaks. In existing systems, pipe thread connections should be replaced with UNO or BSPP for leak free reliability.

Tube and Hose Ends – ORFS (Face Seal) tube and hose end connections feature the high seal reliability afforded by an elastomeric seal but, due to the cost, ORFS is not as widely used as compression fittings and JIC 37-degree flare.

Flared connections have gained widespread acceptance due to their simplicity and low cost. However, the metal-to-metal seal of the flare means that a permanent, leak-free joint is not always achieved, particularly in the case of tube-end connections.

Leaking flare joints can be eliminated using a purpose-built seal developed by Flaretite. The Flaretite seal is a stainless stamping shaped like the JIC nose, with concentric ribs that contain pre-added sealant. When tightened, the ribs crush between the two faces of the joint, eliminating and misalignment any surface imperfections. The combination of the crush on the ribs and the sealant insure that a leak-free joint is achieved.

Incorrect Torque – A common cause of leaks from flare joints is incorrect torque. Insufficient torque results in inadequate seat contact, while excessive torque can result in damage to the tube and fitting through cold working.

The following is a simple method to ensure flare joints are correctly torqued:

a. Finger tighten the flare nut until it bottoms on the seat.
b. Using a permanent marker, draw a line lengthwise across the nut and fitting.
c. Wrench tighten the nut until it has been rotated the number of flats listed in the following table.

Tube Dash Size	Hex Flats
4	2.5
5	2.5
6	2.0
2	2.0
10	1.5-2.0
12	1.0
16	0.75-1.0
20	0.75-1.0
24	0.5-0.75

7.2. Vibration.
Vibration can stress plumbing, affecting hydraulic fitting torque and causing fatigue. Tube is more susceptible than hose. If vibration is excessive, the root cause and if necessary, replace problematic tubes with hoses.

7.3. Seal Damage.
Having outlined the benefits of hydraulic fittings that incorporate an elastomeric seal, it is important to note that their reliability is contingent on fluid temperature being maintained with acceptable limits. A single over-temperature event of sufficient magnitude can damage all the seals in a hydraulic system, resulting in numerous leaks.

7.4. Conclusion.
A leak-free hydraulic system should be considered the norm for modern hydraulic machines, not the exception. But the proper selection, installation and maintenance of hydraulic plumbing are essential to ensure leak-free reliability.

8. Operating Instructions for a Hydraulic Power Pack

8.1. Operating Instructions for a Typical Low Pressure – High Volume Hydraulic System. Most hydraulic systems operating in North America are low pressure, high volume systems. Many European hydraulic systems are high pressure low volume systems. Either system has its own set of advantages and disadvantages as the system is applied to our concrete cutting industry. The example used for our Best Practice is a low pressure, high volume system. For Best Practice do's and don'ts for high pressure, low volume systems please consult your manufacturer's operating manual.

The pressure compensated, flow control valve on this example unit allows full flow control while the gas engine remains at its optimum wide-open throttle. This allows a higher pressure at all flows. For low flow or low pressure situations, the engine may be throttled back to reduce noise, heat generation and fuel consumption, but it is not necessary.

Valve settings for both gas and electric units are: 0-2, all flow routed to tank; 8-10, all flow routed to tool; 2-8, adjustable range. If the gas engine is run at a lower speed, the "all flow to tool" range will increase, and the "adjustable range" will decrease i.e.: the "8" will drift toward 7,6 and so on.

IMPORTANT: The power units are equipped with positive displacement gear pumps. All tools must be equipped with a control valve that allows flow directly to return ports when not in use. Blocking flow or abruptly disconnecting the tool can send all flow over relief and potentially overheat the system.

The following procedure must be adhered to when starting and operating the power unit.

a. Set the flow control valve to zero (all flow to tank).
b. Connect hydraulic hoses to the power unit. Push couplings together until you hear it click. Turn locking ring of coupling to the secured position.
c. Connect tool at the properly selected quick disconnects. Excess flow will return to the tank.
d. Start engine. For gas, choke if necessary. (Refer to engine manual for details of control functions.)
e. Idle gas engine at 1,000 rpm, gradually increasing speed to max 3,450 rpm over two to three minutes to warm engine.
f. Rotate lever on valve toward 10 to direct required flow to tool.
g. To stop tool operation and unload the system prior to shutdown, rotate lever to zero position.
h. Running the power unit for extended periods with the tool off, or the power unit in the zero position, still heats the hydraulic oil. It is best to shut the system down to avoid heating and conserve energy.

Heating cold oil: Forcing the oil over relief will quickly increase the oil temperature. With the supply ports closed, move the valve setting toward 10. This will force an increased percentage of oil over relief. The supply ports are normally closed until a tool is connected to them. Cold oil greatly increases pressure loss in hoses and fittings.

IMPORTANT: Setting the control valve to 10 in a deadheaded system will force all flow over relief and lock the internal spool in the relief position even if the valve is returned to zero. The unit must then be shut down to allow this pressure lock to bleed off.

DANGER: Do not operate the engine within enclosed or confined spaces. Exhaust from the engine contains carbon monoxide, a poisonous, odorless, invisible gas, which if breathed by the operator or other occupants of the enclosed space can cause serious illness or possible death. Enclosed spaces include all areas where natural ventilation is restricted, such as buildings, truck enclosures and access paths between buildings. Open skyways, windows, and doorways are not sufficient for preventing this hazard.

8.2. Hydraulic Oil Cooler.
The power unit is equipped with a 4-pass-type oil cooler. Water is frequently passed through the cooler before it is used for dust control or blade and bit cooling. Some tools will automatically shut off water flow when not actively cutting or drilling. This may result in high oil temperatures if the power unit continues to run for long periods.

IMPORTANT: If there is a risk of frost, the water must be drained after use to prevent damage by freezing.

8.3. Preparing the Unit.
Unpack the power unit carefully to prevent damage. The power unit should be inspected and operated before shipment, and should not require any additional adjustments prior to its initial use.

8.4. Hydraulic System.
IMPORTANT: Introduction of contaminants into the system will reduce component service life and void any warranty.

HYDRAULIC FLUID: The reservoir of the hydraulic power unit must be filled with fluid prior to start-up. The use of high quality petroleum-based hydraulic oil with the following properties is recommended,

a. Anti-wear
b. Low foaming
c. Rust and oxidation inhibitors
d. Wide temperature range

It should have fluid viscosity approximately 300 SSU at 100 degrees Fahrenheit (ISO 68). For use in higher ambient temperature climates regularly above 80 degrees Fahrenheit, the oil should have fluid viscosity of approximately 225 SSU at 100 degrees Fahrenheit (ISO 46). Check with local oil suppliers for availability. The oil must be kept free of contamination to avoid damage to system components. The strainer in the filler tube must always be in place when adding oil. Quick disconnects must be cleaned before connections are made. The hydraulic system is compatible with most hydraulically driven sawing and drilling components. The system may not be compatible with components, however some manufactures may be able to supply information as to operational capabilities if sufficient specifications are available.

IMPORTANT: Maximum recommended oil temperature is 180 degrees Fahrenheit (82 degrees Celsius).

HOSES: Large diameters and short lengths are preferred, and offer the highest system efficiency. If one is operating 100 feet from the power source, there is also a 100 feet return for 200 feet total hose length. With oil at 100 degrees Fahrenheit, this could result in a 600 psi pressure loss with a ½-inch hose and a 200 psi loss with 5/8-inch hose. Pressure loss will change dramatically with oil temperature.

8.5. Engine.

Make sure that the engine crankcase is filled with oil to the proper level. Refer to your engine for oil checking and changing procedures, along with oil specifications, etc.

IMPORTANT: Operating the engine without oil will ruin the engine.

FUEL: Use regular grade unleaded gasoline to fuel the engine. Premium grade may be used if necessary. Only add fuel to the tank when the engine is not running and has been allowed to cool. Care should be taken to prevent spilling fuel over any part of the equipment. The operator is advised to drain the tank during storage within an enclosed area, as this will reduce the chance of a fire.

IMPORTANT: Do not overfill the fuel tank. Always leave enough space for expansion due to environmental heating.

WARNING: In the event of fuel spillage, do not attempt to start the engine or operate any electrical component until the spillage has been removed.

8.6. General Safety Precautions.

Tool operators and maintenance personnel must always comply with the safety precautions stated in this document, and on any stickers and tags attached to the equipment. These safety precautions are provided for your safety. Review them carefully before operating the tool and before performing general maintenance or repairs. Supervisors should develop additional precautions relating to the specific work area and local safety regulations.

The hydraulic power unit will provide safe and dependable service if it is operated in accordance with the instructions in this document. Failure to do so could result in personal injury or equipment damage.

a. Operators must start work in the work area without bystanders. The operator must be familiar with all prohibited work areas such as excessive slopes and dangerous terrains.
b. Establish a training program for all operators to ensure safe operation.
c. Do not operate the power unit unless thoroughly trained, or under the supervision of an instructor.
d. Always wear safety equipment such as goggles, ear and head protection and safety shoes at all times when operating the power unit and/or a hydraulic tool.
e. Do not inspect or clean the power unit while it is running.
f. Always use hoses and fittings rated at a minimum 2,500 psi. (172 bar) with a four to one safety factor for pressure lines.
g. Be sure all hose connections are tightly fastened.
h. Make sure all hoses are connected for correct flow direction to and from the tool being used.
i. Do not inspect hoses and fittings for leaks by using bare hands. “Pin-hole” leaks can penetrate the skin.

j. Never operate the gas power unit in a closed space. Inhalation of engine exhaust can be fatal.
k. Do not operate a damaged or improperly-powered unit.
l. Never wear loose clothing that can become entangled in the working parts of the power unit.
m. Keep all bodily parts away from the working parts of the power unit.
n. Always wear appropriate Personal Protective Equipment (PPE) such as goggles, ear protection, and toe guards. Certain tools used in conjunction with the power unit may require other safety equipment such as breathing filters.
o. Keep clear of hot engine exhaust.
p. Do not add fuel to the power unit while the power unit is running or is hot.
q. Do not operate the power unit if gasoline odor is present.
r. Do not use flammable solvents around the power unit engine.
s. Do not operate the power unit within 3.3 feet. (1 meter) of buildings, obstructions or flammable objects.
t. Allow the engine to cool before storing the power unit.

To avoid personal injury or equipment damage, all tool repair, maintenance and service must only be performed by authorized and properly trained person.

9. Hydraulic Troubleshooting

Prevention is the best medicine. Proper maintenance of your hydraulic system will prolong the life of your system. Here are a few tips to keep your system in optimum operating condition.

a. It is recommended to drain, flush and clean your hydraulic system every 200 to 300 hours. This will prevent varnish buildup, viscosity breakdown that will damage your pump and other components of your hydraulic system.
b. Utilizing an offline, oil-filtering system that pulls the hydraulic oil from your tank, filters it and returns it to the tank will remove water, varnish and particulate buildup which prolongs the life of your hydraulic oil.
c. Always monitor the temperature of the hydraulic oil while operating the system. It is recommended to utilize either an air-to-oil or water-to-oil type of cooler to keep the hydraulic oil within the operating limits designated by the manufacturer of the particular hydraulic system.
d. Monitoring the water content of the oil is very important in any hydraulic system. Water can enter a system in various ways.
    - Water can enter the system through self-contamination by power washing the tank and not protecting the fill cap.
    - The water cooler can possibly have a small leak allowing water to enter the system.
    - A hot hydraulic system expands the hydraulic oil and when the system cools down it will draw in moisture and humidity through the fill cap and add water to the oil.
    - Always warm up the hydraulic system prior to operating any hydraulic tools. This especially important in cooler temperatures. When the hydraulic oil is cold, this will increase the return pressure on the hydraulic system and damage internal components of the tool as well as the operating efficiency.

Using the proper viscosity hydraulic oil in the various temperature regions will keep your system operating efficiently.

Please refer to Appendix A on the following pages for an associated troubleshooting guide.

Appendix A – Hydraulic Troubleshooting Guide

Problem	Symptom	Pressure Reading Power Unit	Flow and Pressure on Test Kit	Cause	Solution
No blade rotation		0 or maximum Maximum psi		Hydraulic quick coupler not connected; Wall saw internal damage "locked up"	Inspect, connect as necessary, test Disconnect from hydraulic system-test by hand to locate problem
	Pump noise	0 psi		Pump shaft failed-pump not rotating	Remove pump to inspect – repair as necessary
Blade rotates but with major power loss	Excessive system temp., pump or meter may be noisy	Maximum psi, but slow gauge response under blade stall	Partial to full flow, but psi slow response Maximum flow, maximum psi	Excessive aeration in hydraulic oil or pump cavitation	Refer to pump service manual
	Excessive hose vibration	Maximum psi, but slow gauge response under blade stall	Partial to full flow, but psi slow response	Hydraulic meter failure-excess internal slippage – may be noisy Pump failure - excess internal slippage shaft failure -	Repair or replace as necessary Repair or re place as necessary
Blade rotates but with major power loss	Minor heat build - up, no blade	Difficult to maintain 1250 psi & over stalling blade	Maximum flow Maximum psi	Blade polished can not utilize horsepower output from hydraulic saw	Replace blade or attempt to "open up"

Problem	Symptom	Pressure Reading Power Unit	Flow and Pressure on Test Kit	Cause	Solution
Blade rotates but with major power loss	No heat build-up, no noise Oil to compensator when hose fitting checked*	300 psi or less	12 gpm or less 300 psi or less	Stuck flow compensator spool	Remove and clean as necessary. Inspect on removal to prove cause
		Maximum psi	Flow less than maximum psi	Worn flow compensator spool **or** Weak spring on flow compensator spool	Adjust to correct reading or replace
		Maximum psi or less than max.	Less than max flow or pressure. or less than max on both	Misadjusted compensator spools	Adjust to correct specs
	No oil to compensator when hose fitting checked.*	300 psi or less	12 gpm or less 300 psi or less	Sensing hose obstructed or sensing hose not connected	Repair or replace Inspect and correct
	Aerated oil to compensator when hose fitting checked.*	300 psi or less, but erratic	12 gpm or less 300 psi or less but erratic	Aeration in hyd oil **or** Air inclusion in sensing line	Refer to pump aeration cause and solution **or** Bleed sense line
	No heat build up, no noise oil to compensator when hose fitting checked.*	300 psi or less	12 gpm or less 300 psi or less	Stuck pressure compensator spool	Remove and clean as necessary. Inspect on removal to prove cause
		Less than max., slow response on stall	Full flow, but less than max. psi. Slow response	Weak spring on press. comp spool Worn press. Comp. Spool	Adjust to correct reading or replace comp assy

*** Check oil to comp. at fitting where ¼-inch sensing hose in attached to pump comp.**