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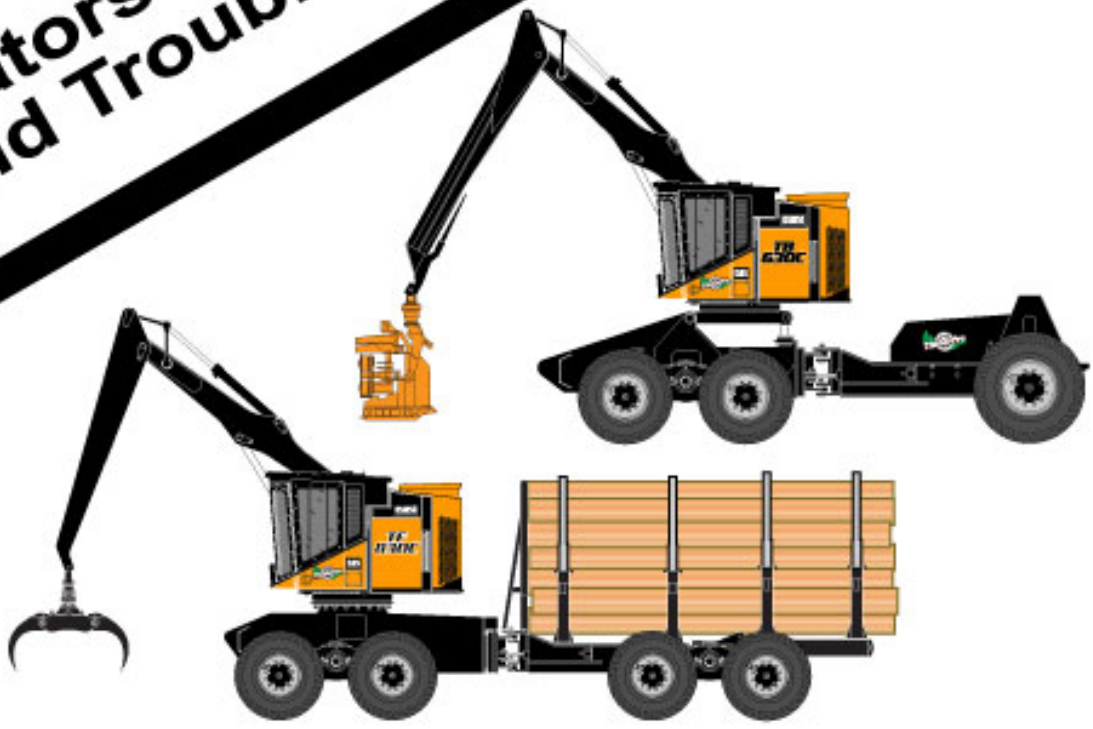
600C & 800C Series

Operators Training, Maintenance, and Troubleshooting Manual



Foreward ...

Dear Valued Customer,

With this training manual, TimberPro has decided to take a different approach and add more technical information on the machine. Because of the new technology in today's equipment, the large initial cost and the dependence on this equipment for survival in the logging business, TimberPro felt a little more "in-depth" training should be done. With the remoteness of most logging operations a dealer is not always available to take care of every problem. In most cases, what determines the availability of a machine is not only how it is used and maintained, but also the technical knowledge of the people responsible to make it work.

Most operators and forestry workers have not been trained extensively in this new hydraulic technology. With this manual, TimberPro is attempting to make this technology more understandable. Knowing that many operators do not fully understand hydraulic schematics, TimberPro has used pictorial drawings of all the hydraulic circuits to make them easy to follow. There is also a glossary that defines many of the hydraulic terms used which should help in the understanding of the hydraulic systems on the machine.

The logging business by nature is perhaps the most abusive industry on equipment, therefore, knowledge is essential to make it all work. The biggest mistake some loggers make is continuously striving for production at the expense of the equipment. A steady production pace and good maintenance practices without excessive abuse of equipment will always, over the long haul, out-profit the "production at any cost" method of logging.

TimberPro strongly advises that you take this training manual home and study it so that you have an understanding and working knowledge of your new machine.

Thank You,

Pat Crawford
TimberPro, Inc

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Hydraulic and Electrical Schematics

Glossary Of Terms

Amp

A measurement of electrical current. The IQAN digital control system actuates solenoid coils by sending proportional current to them. This current is measured in milliampere (1/1000 Amp).

Volt / Voltage

A measurement of electrical signal. The IQAN digital control system understands control actuators and sensors by supplying them with a set voltage and then monitoring the return voltage signal.

Anti-Cavitation Check Valve (Anti-cav Valve)

An anti-cavitation Check valve is a low pressure check valve (See Check Valve) that allows reverse flow of oil to a cylinder or motor when the normal supply of oil flow is limited (example: a cylinder that overruns control due to force of gravity). Anti-cavitation check valves typically have a very low cracking pressure (See Cracking Pressure), sometimes as low as 3 PSI (20 kPa).

In mobile equipment, control valves use port relief valves (See Port Relief Valve) that are equipped with anti-cavitation check valves as a standard feature.

Case Flushing Orifice

A case flushing orifice is used in hydrostatic drive systems to reduce heat build-up. The flushing orifice allows a set volume of oil from the low pressure side of the hydrostatic loop to escape, via a pump or motor case drain, where it is sent to the oil cooler. The removed oil that is replaced by fresh charge oil (See Charge Oil) at the hydrostatic pump.

Charge Oil

Charge oil is used to replace any oil volume lost in a closed loop hydrostatic system due to pump/motor leakage or case flushing orifices (See Case Flushing Orifice). Without charge oil, a closed loop hydrostatic system will run low on oil volume and cause cavitation damage to components. Charge oil is typically supplied by an auxiliary gear pump or an internal gear pump on the hydrostatic pump. Charge oil must be pressurized to enter the hydrostatic loop (See Charge Pressure) and is always filtered.

Charge oil is also commonly used as make-up oil for the main control valve or swing motor to prevent cavitation in those work circuits.

Charge Pressure

Charge oil enters a hydrostatic loop on the low pressure leg so it must be pressurized greater than its entry point (otherwise loop oil would enter the charge oil circuit). Charge pressure is set between 400-475 PSI (2,8-3,3 Mpa) by a relief valve in the circuit. Most hydrostatic systems also use charge pressure as an internal pressure signal to actuate the hydrostatic pump's swash plate control.

On TimberPro machines, charge pressure is also used as a pressure signal to release the swing motor brake.

Check Valve

A check valve typically has two ports and is designed to allow oil flow in one direction only. Most check valves use mechanical spring force acting against a poppet assembly (usually a steel ball and machined seat). The rate of spring force used determines what hydraulic pressure is required before the valve opens and allows oil flow to pass. This spring rate/pressure is called the check valve's cracking pressure.

Check valves have many uses. Most common are to prevent back flow of oil in a circuit, to maintain a required back pressure in a circuit, or as a low pressure relief like an oil cooler bypass.

Counterbalance Valve

A counterbalance valve is used to trap oil in a component, such as a cylinder or motor, to prevent uncontrolled movement. TimberPro machines use counterbalance valve in several locations such as in the cab leveling cylinders, swing motor work ports and frame lock cylinder.

Counterbalance valve are usually used in pairs and are pilot operated from the opposing valve. For example, the cab leveling cylinders use counterbalance valves to prevent the cylinder from collapsing if a hose burst. A pilot signal from the pressurized side of the cylinder is required to open the opposing counterbalance valve to let oil out of the non-pressurized side. Without the pilot signal, oil cannot escape the cylinder. This creates a hydrostatic lock which prevents the cylinder from moving.

Load Sense Orifice

A load sense orifice is used to stabilize or smooth control of the hydraulic system by reducing the rate of change in the load sense signal to the pump. Changing the size of the load sense orifice, or even the physical size of the load sense signal line, can dramatically change the performance of the machine. A load sense orifice that is too large would result in jerky controls and an orifice too small (or restricted) would result in sluggish controls.

Load Sense Pump

A load sense pump works by having a control ability to maintain a pressure differential or margin over an orifice. This orifice is typically a proportional directional control valve. The pump, after getting a load sense signal, will maintain enough flow so that the pump output pressure remains higher than the load sense signal pressure (this is the pressure differential or margin). The load sense differential or margin pressure is usually about 300 PSI (2.0 Mpa).

Oil Cooler

An oil cooler is designed to remove heat from hydraulic oil. An oil cooler is made up of a top and bottom manifold connected by many small tubes surrounded by very fine external fins. Hot oil travels through the tubes where its heat is drawn into the mass of external fins. Air flow from the engine fan then draws the heat from the fins and away from the oil cooler. The tubes are also equipped with turbulators that increase the surface area of contact with the oil inside the tubes. Turbulators also disrupt oil flow so the moving oil cannot form an insulating layer (oil moving through center of tube stays hotter than oil next to the wall of the tube).

(POR) Pressure Override Valve

A pressure override valve is normally used to automatically stroke a pump swash plate back toward neutral to limit system pressure without forcing oil over a relief valve, which creates excess heat. POR valves are used on almost all closed loop hydrostatic pumps and also some open loop pumps.

Pressure Compensated

A) When referring to a pump, pressure compensated means the pump has the capability to maintain a constant output pressure, even without an external load sense signal. The pump will vary its stroke or flow output to maintain a constant output pressure.

B) When referring to a control valve, pressure compensated means the valve is designed to maintain a specific flow regardless of load or system pressure changes. The typical pressure compensated valve uses a component called a compensator spool that adjusts (shifts) to maintain a controlled pressure drop across a variable orifice.

Port Relief Valve

Port relief valves are usually installed in the work port galleries of control valves to protect the control valve and components in the circuit from high pressure spikes. Port relief valves are typically set at 200 PSI (1.4 Mpa) above the system POR pressure (See POR Pressure). A port relief set too low will open before the system POR pressure is reached. This will result in loss of flow, excessive heat generation, and a greater horsepower requirement when operating the function. Port reliefs are usually equipped with an anti-cavitation (See Anti-Cavitation Check Valve) feature to protect against a cavitation condition in the circuit.

Pressure Drop

Pressure drop is the loss of pressure due to the flow of oil. Pressure drop can be reduced by using properly sized lines for the amount of oil flow travelling through them.

Relief Valve

A relief valve is normally a 2 port valve used to limit pressure. If pressure exceeds a set value, the relief valve opens and vents the excess pressurized oil to tank. Relief valves can be direct-acting or a pilot operated 2-stage type.

Sequence Valve

A sequence valve is very similar to a relief valve (See Relief Valve). Unlike a relief valve, the sequence valve has a drain line in its spring chamber. This drain allows the sequence valve to have pressure in the tank line without a system pressure change.

Stand-by Pressure

Stand-by pressure is the pressure a load sense pump (See Load Sense Pump) maintains when there is no external load sense signal (such as from the main control valve). This pressure is regulated by the compensator control of the pump and is determined by the normal off-stroke pressure required by the pump.

Suction Filter

A suction filter is similar to a suction strainer except that it can filter to a much finer level. Suction filters are typically made up of a cellulose or synthetic paper medium instead of a wire mesh screen.

Suction Strainer

A suction strainer is designed to filter large contaminates from hydraulic oil in a pump's suction inlet. Suction strainers are usually made of a wire mesh screen that can filter to approximately 150-micron. The implement suction strainer used in Timberpro machines is also equipped with a magnetic stem.

Thermal Bypass

A thermal bypass is used in a fluid cooler to limit flow into the cooler when the fluid is cold. Most thermal bypass valves use a temperature sensitive coil spring that works a poppet check against a seat. The spring contracts when cold (bypass open) and expands when warm (bypass closed). In an oil cooler, the thermal bypass remains open while the oil is cold and forces the oil to bypass the cooler and travel directly back to tank. This allows the hydraulic system to reach operating temperature quicker in cold climates. When the oil reaches a preset "warm" temperature the thermal bypass closes and the oil is routed through the oil cooler.

Accelerator - A substance which hastens the vulcanization of an elastomer, causing it to take place in a shorter time or at a lower temperature.

Accumulator - A container in which fluid is stored under pressure as a source of fluid power.

Accumulator, hydropneumatic bladder - A hydropneumatic accumulator in which the liquid and gas are separated by an elastic bag or bladder.

Actuator, pneumatic/hydraulic - A device in which power is transferred from one pressurized medium (pneumatic) to another (hydraulic) without intensification.

Additive - A chemical added to a fluid to impart new properties or to enhance those which already exist.

Adsorption - The physical mechanism by which one substance attracts another substance (either solid, liquid, gas, or vapor) to its surface and through molecular forces causes the incident substance to adhere to that surface.

Aftercooler - A device which cools a gas after it has been compressed.

Afterfilter - A filter which follows the compressed air dryer and usually for the protection of downstream equipment from desiccant dust.

Air - A gas mixture consisting of nitrogen, oxygen, argon, carbon dioxide, hydrogen, small quantities of neon, helium and other gases.

Air bleeder - A device for removal of air.

Air breather - A device permitting air movement between atmosphere and the component in which it is installed.

Air motor - A device which converts pneumatic fluid power into mechanical torque and motion. It usually provides rotary mechanical motion.

Air, compressed (pressure) - Air at any pressure greater than atmospheric pressure.

Air, dried - Air with moisture content lower than the maximum allowable for a given application.

Air, free - Air at ambient temperature, pressure, relative humidity, and density.

Air, saturated - Air at 100% relative humidity, with a dew point equal to temperature.

Air, standard - Air at a temperature of 68.8° F, a pressure of 14.70 pounds per square inch absolute, and a relative humidity of 36% (0.0750 pounds per cubic foot). In gas industries the temperature of “standard air” is usually given as 60.8° F.

Amplification, power - The ratio between the output signal variations and the corresponding input (control) power variation (for analog devices only).

Amplification, pressure - Ratio between outlet pressure and inlet (control) pressure.

Amplification - The ratio between the output signal variations and the control signal variations (for analog devices only).

Analog - Of or pertaining to the general class of fluidic devices or circuits whose output varies as a continuous function of its input.

AND Device - A control device which has its output in the logical 1 state if and only if all the control signals assume the logical 1 state.

Aniline point - The lowest temperature at which a liquid is completely miscible with an equal volume of freshly distilled aniline (ASTM Designation D611-64).

Aniline point - The lowest temperature at which equals volumes of pure, fresh aniline and an oil will completely dissolve in one another is the aniline point of the oil.

Bernoulli’s Law - If no work is done on or by a flowing frictionless liquid, its energy due to pressure and velocity remains constant at all points along the streamline.

Bleeding - Migration to the surface of plasticizers, waxes, or similar materials to form a film or beads.

Boyle’s Law - The absolute pressure of a fixed mass of gas varies inversely as the volume, provided the temperature remains constant.

Break-out - Force necessary to inaugurate sliding.

Expressed in same terms as friction. An excessive break-out value indicates the development of adhesion.

Breathing capacity - A measure of flow rate through an air breather.

Bulk modulus - The measure of resistance to compressibility of a fluid. It is the reciprocal of compressibility.

Cavitation - A localized gaseous condition within a liquid stream which occurs where the pressure is reduced to the liquid's vapor pressure, often as a result of a solid body, such as a propeller or piston, moving through the liquid; also, the pitting or wearing away of a solid surface as a result of low fluid levels that draw air into the system, producing tiny bubbles that expand explosively at the pump outlet, causing metal erosion and eventual pump destruction.

Charles' Law - The volume of a fixed mass of gas varies directly with absolute temperature, provided the pressure remains constant.

Circuit, meter-in - A speed control circuit in which the control is achieved by regulating the supply flow to the actuator.

Circuit, meter-out - A speed control circuit in which the control is achieved by regulating the exhaust flow from the actuator.

Circuit, open - A circuit in which return fluid is directed to the reservoir before reciprocation.

Circuit, regenerative - A circuit in which pressurized fluid discharged from a component is returned to the system to reduce power input requirements.

Circuit, sequence - A circuit which established the order in which two or more phases of a circuit occur.

Circuit - An arrangement of interconnected components and parts.

Cold flexibility - Flexibility following exposure to a predetermined time.

Cold flow - Continued deformation under stress.

Compatibility, seal - Ability of an elastomer to resist the action of a fluid on its dimensional and mechanical properties.

Compressibility - The change in volume of a unit volume of a fluid when subjected to a unit change in pressure.

Compression modulus - The ratio of the compressive stress to the resulting compressive strain (the latter expressed as a fraction of the original height or thickness in the direction of the force). Compression modulus may be either static or dynamic.

Compression set - The amount by which a rubber specimen fails to return to original shape after release of the compressive load.

Compressor - A device which converts mechanical force and motion into pneumatic fluid power.

Condensation - The process of changing a vapor into a liquid condensate by the extraction of heat.

Conditioner, air - An assembly comprising a filter, a pressure reducing valve with gage, and a lubricator, intended to deliver compressed air in suitable condition.

Conductor - A component whose primary function is to contain and direct fluid.

Contaminant - Any material or substance which is unwanted or adversely affects the fluid power system or components, or both.

Control - A device used to regulate the function of a component or system.

Controller - A device which senses a change of fluid state and automatically makes adjustments to maintain the state of the fluid between predetermined limits, e.g., pressures, temperatures, etc.

Copolymer - A polymer consisting of two different monomers chemically combined.

Creep - The progressive relaxation of a given rubber material while it is under stress. This relaxation eventually results in permanent deformation or "set."

Cushion - A device which provides controlled resistance to motion.

Cylinder cap - A cylinder end closure which completely covers the bore area.

Cylinder capacity, extending - Volume required for one full extension of a cylinder.

Cylinder capacity, retracting - Volume (annular) absorbed by one full retraction of the cylinder.

Cylinder capacity - The volume of a theoretically incompressible fluid that would be displaced by the piston during a complete stroke. (For double acting cylinders it must be given for both directions of stroke.)

Cylinder force, theoretical - The pressure multiplied by the effective piston area, ignoring friction. For double acting cylinders, the value must be given for both directions of stroke.

Cylinder, adjustable stroke - A cylinder equipped with adjustable stops at one or both ends to limit piston travel.

Cylinder, area, piston rod - Cross-sectional area of the piston rod.

Cylinder, area, piston, effective - Area upon which fluid pressure acts to provide a mechanical force.

Cylinder, bore - The internal diameter of the cylinder body.

Cylinder, cushioned - A cylinder with a piston-assembly deceleration device at one or both ends of the stroke.

Cylinder, differential - A double acting cylinder in which the ratio of the area of the bore to the annular area between the bore and the piston rod is significant in circuit function.

Cylinder, double acting - A cylinder in which fluid force can be applied to the moveable element in either direction.

Cylinder, double rod - A cylinder with a single piston and a piston rod extending from each end.

Cylinder, dual stroke - A cylinder combination which provides two working strokes.

Cylinder, duplex - A unit comprised of two cylinders with independent control, mechanically connected on a common axis to provide three or four positions depending on the method of application.

Cylinder, piston type - A cylinder in which the piston has a greater cross-sectional area than the piston rod.

Cylinder, plunger (ram) - A cylinder in which the piston has the same cross-sectional area as the piston rod.

Cylinder, rotary actuator - A cylinder which translates piston reciprocation into oscillation of an output shaft.

Cylinder, rotating - A cylinder in which the piston and piston rod, plunger or ram, is permitted to rotate with reference to the cylinder housing.

Cylinder, single acting - A cylinder in which the fluid force can be applied to the movable element in only one direction.

Cylinder, tandem - Arrangement of at least two pistons on the same rod moving in separate

chambers on the same cylinder body allowing the compounding of force on the piston rod.
Cylinder, telescoping - Cylinder with two or more stages or extensions, achieved by hollow piston rods sliding one within the other (may be single or double acting).

Cylinder, tie rod - A cylinder with head and cap end closures that are secured by tie rods.

Cylinder - A device which converts fluid power into linear mechanical force and motion. It usually consists of a movable elements such as a piston and piston rod, plunger or ram, operating within a cylindrical bore.

Darcy's Formula - A formula used to determine the pressure drop due to flow friction through a conduit.

Deliquescent - Moisture is separated by using the absorptive properties of special hygroscopic compounds.

Desiccant - Material that tends to remove moisture from compressed air.

Dew point - The temperature at which vapors in a

gas condense. For practical purposes, it must be referred to a stated pressure.

Digital - Of or pertaining to the general class of fluidic devices or circuits whose output varies in discrete steps (i.e., pulses or “on-off” characteristics).

Displacement, volumetric - Volume absorbed or displaced per stroke of a cylinder or per cycle of a pump or motor.

Dissolved air - Air which is dispersed at a molecular level in hydraulic fluid to form a single phase.

Dissolved water - Water which is dispersed at a molecular level in hydraulic fluid to form a single phase.

Dither - A low amplitude, relatively high frequency periodic electrical signal, sometimes superimposed on the servovalve input to improve system resolution. Dither is expressed by the dither frequency (Hz) and the peak-to-peak dither current amplitude.

Droop - The deviation between no flow secondary pressure and secondary pressure at a given flow.

Dryer, compressed air - A device for reducing the moisture content of the working compressed air.

Durometer - 1. An instrument for measuring the hardness of rubber. Measures the resistance to the penetration of an indentor point into the surface of rubber. 2. Numerical scale of rubber hardness.

Efficiency - Ratio of output to the corresponding input.

Elasticity - The property of a material which tends to return to its original shape after deformation.

Elastomer - Any synthetic or natural material with resilience or memory sufficient to return to its original shape after distortion.

Elongation - Generally means “ultimate elongation” or percent increase in original length of a specimen when it breaks.

Emulsion, oil in water - A dispersion of oil in a continuous phase of water.

Emulsion, water in oil - A dispersion of water in a continuous phase of oil.

Emulsifier - additive that promotes formation of a stable mixture, or emulsion, of oil and water.

Emulsion - A homogeneous dispersion of two immiscible liquids, generally of a milky or cloudy appearance.

Entrained air - A mechanical mixture of air bubbles having a tendency to separate from the liquid phase.

Expectancy, life - The predicted working period during which a component or system will maintain a specified level of performance under specified conditions. Sometimes expressed in statistical terms as a probability.

Filter - 1. A device whose primary function is the removal by porous media of insoluble contaminants from a liquid or a gas. 2. Chemically inert, finely divided material added to the elastomer to aid in processing and improve physical properties.

Filter, strainer - A coarse hydraulic filter usually of woven wire construction. This may be in the form of a complete filter or just an element.

Filter, by-pass (reserve) A filter which provides an alternate unfiltered flow path around the filter element when a preset differential pressure is reached.

Filter, spin-on - A filter with spin-on element sealed in its own pressure housing for independent mounting to the filter.

Filtration ratio (βm) - The ratio of the number of particles greater than a given size (β) in the influent fluid to the number of particles greater than the same size (m) in the effluent fluid.

Fitting - A connector or closure for fluid power lines and passages.

Fitting, compression - A fitting which seals and grips by manual adjustable deformation.

Fitting, flange - A fitting which utilizes a radially extending collar for sealing and connection.

Fitting, flared - A fitting which seals and grips by a pre-formed flare at the end of the tube.

Fitting, flareless - A fitting which seals and grips by means other than a flare.

Flash point - The temperature to which a liquid must be heated under specified conditions of the test method to give off sufficient vapor to form a mixture with air that can be ignited momentarily by a flame.

Flip flop - A digital component or circuit with two stable states and sufficient hysteresis so that it has “memory.” Its state is changed with a control pulse; a continuous control signal is not necessary for it to remain in a given state.

Flow characteristic curve - The change in regulated (secondary) pressure occurring as a result of a change in the rate of air flow over the operating range of the regulator.

Flow rate - The volume, mass or weight of a fluid passing through any conductor per unit of time.

Flow, laminar (streamline) - A flow situation in which fluid moves in parallel lamina or layers.

Flow, output - Flow rate discharged at the outlet port.

Flow, turbulent - A flow situation in which the fluid particles move in a random fluctuating manner.

Flow - Movement of fluid generated by pressure differences.

Fluid capacity - The liquid volume coincident with the “high” mark of the level indicator.

Fluid friction - Friction due to the viscosity of fluids.

Fluid logic - A branch of fluid power associated with digital signal sensing and information processing, using components with or without moving parts.

Fluid miscibility - Capacity of fluids to be mixed in any ratio without separation into phases.

Fluid power system - A system that transmits and controls power through use of a pressurized fluid within an enclosed circuit.

Fluid power - Energy transmitted and controlled through use of a pressurized fluid.

Fluid stability - Resistance of a fluid to permanent changes in properties.

Fluid stability, oxidation - Resistance of a fluid to permanent changes caused by chemical reaction with oxygen.

Fluid, anti-corrosive - A fluid containing metal corrosion inhibitors.

Fluid, aqueous - A fluid which contains water as a major constituent besides the organic material. The fire resistance properties are derived from the water content.

Fluid, fire resistant - A fluid difficult to ignite which shows little tendency to propagate flame.

Fluid, hydraulic - A fluid suitable for use in a hydraulic system.

Fluid, Newtonian - Fluid having a viscosity that is always independent of the rate of shear.

Fluid, pneumatic - A fluid suitable for use in a pneumatic system, usually air.

Fluid, rust protection - Capacity of a fluid to prevent the formation of rust under specified conditions.

Fluid - A liquid, gas or combination thereof.

Force motor - A type of electromechanical transducer having linear motion used in the input stages of servovalves.

Free air - Any compressible gas, air or vapor trapped within a hydraulic system that does not condense or dissolve to form a part of the system fluid.

Free water - Water droplets or globules in the system fluid that tend to accumulate at the bottom or top of the system fluid depending on the fluid’s specific gravity.

Frequency response - The changes, under steady-state conditions, in the output variable which are caused by a sinusoidal input variable.

Gage damper (snubber) - A device employing a fixed or variable restrictor inserted in the pipeline to a pressure gage, to prevent damage to the gage

mechanism caused by rapid fluctuations of fluid pressure.

Gage protector - A device inserted in the pipeline to a pressure gage and arranged to isolate the pressure gage from the fluid pressure if this exceeds a predetermined limit. The device can usually be adjusted to suit the range of the pressure gage.

Gage, bourdon tube - A pressure gage in which the sensing element is a curved tube that tends to straighten out when subjected to internal fluid pressure.

Gage, diaphragm - A gage in which the sensing element is relatively thin and its inner portion is free to deflect with respect to its periphery.

Gage, instrument - An instrument or device for measuring, indicating, or comparing a physical characteristic.

Gage, pressure - A gage which indicates the pressure in the system to which it is connected.

Head - The height of a column or body of fluid above a given point expressed in linear units. Head is often used to indicate gage pressure. Pressure is equal to the height times the density of the fluid.

Head, cylinder - The cylinder end closure which covers the differential area between the bore area and the piston rod area.

Head, friction - The pressure required to overcome the friction at the interior surface of a conductor and between fluid particles in motion. It varies with flow, size, type and condition of conductors and fittings, and the fluid characteristics.

Head, pressure - The pressure due to the height of a column or body of fluid.

Head, static - The height of a column or body of fluid above a given point.

Heat exchanger - A device which transfers heat through a conducting wall from one fluid to another. (Typically to cool a system.)

Heater - A device which transfers heat through a conducting wall from one fluid to another. (Typically to warm up a system.)

Hose, wire braided - Hose consisting of a flexible material reinforced with woven wire braid.

Hose - A flexible line or conductor whose nominal size is its inside diameter.

Hydraulic amplifier - A fluid device which enables one or more inputs to control a source of fluid power and thus is capable of delivering at its output an enlarged reproduction of the essential characteristics of the input. Hydraulic amplifiers may utilize sliding spools, nozzle-flappers, jet pipes, etc.

Hydraulic motor - A device which converts hydraulic fluid power into mechanical force and motion. It usually provides rotary mechanical motion.

Hydraulic motor efficiency, hydromechanical - Ratio of the effective torque to the derived torque.

Hydraulic motor efficiency, overall - Ratio of the output power to the effective hydraulic power.

Hydraulic motor efficiency, volumetric - Ratio of the derived output flow to the effective input flow.

Hydraulic motor, fixed displacement - A hydraulic motor in which the displacement per unit of output motion cannot be varied.

Hydraulic motor, flow, input - Flow rate crossing the transverse plane of the inlet port.

Hydraulic motor, gear, external - A motor having two or more external gears.

Hydraulic motor, gear, internal - A motor with an internal gear in engagement with one or more external gears.

Hydraulic motor, gear - A motor in which two or more gears act in arrangement as working members.

Hydraulic motor, vane - A motor in which the fluid under pressure acting on a set of radial vanes causes rotation of an internal member.

Hydraulic stepping motor - A hydraulic motor which follows the commands of a stepped input signal to achieve positional accuracy.

Hydraulics - Engineering science pertaining to liquid pressure and flow.

Hydrodynamics - The engineering science which governs the movement of liquids and the forces opposing that movement.

Hydrokinetics - Engineering science pertaining to the energy of liquid flow and pressure.

Hydropneumatics - Pertaining to the combination of hydraulic and pneumatic fluid power.

Hydrostatic transmission - Combination of one or more hydraulic pumps and motors forming a unit.

Hydrostatics - Engineering science pertaining to the energy of liquids at rest.

Indicator, differential pressure - An indicator which signals a difference in pressure between two points in a fluid power system.

Inhibitor - Any substance which, when present in very small proportions, slows, prevents or modifies chemical reactions such as corrosion or oxidation.

Intensification, ratio of - The ratio of the secondary pressure to the primary pressure or of the primary flow rate to the secondary flow rate.

Intensifier, double acting - A unit which magnifies the secondary fluid pressure regardless of the direction of flow of the primary fluid.

Intensifier, single acting - A unit which only magnifies the fluid pressure in one direction of flow of the primary fluid.

Intensifier, single shot - An intensifier in which the continuous application of primary fluid at the inlet port can only give a limited volume of secondary fluid.

Intensifier - A device which converts low pressure fluid power into higher pressure fluid power.

Joint - A line positioning connector.

Joint, rotary - A joint connecting lines which have relative operational rotation.

Leakage rate - The rate at which a gas or liquid passes through a barrier. Total leakage rate includes the amounts that diffuse or permeate through the material of the barrier as well as the amount that escapes around it.

Line, return - A pipe (conductor) to return the working fluid to the reservoir.

Line, working - A line which conducts fluid power.

Line - A tube, pipe, or hose for conducting fluid.

Lubricator - A device which adds controlled or metered amounts of lubricants into a fluid power system.

Magnetic plug - A plug which attracts and holds ferromagnetic particles.

Manifold - A conductor which provides multiple connection ports.

Maximum inlet pressure - The maximum rated gage pressure applied to the inlet port of the regulator.

Memory - Tendency of a material to return to original shape after deformation.

Modulus of elasticity - One of the several measurements of stiffness or resistance to deformation, but often incorrectly used to indicate specifically static tension modulus.

Modulus - Tensile stress at a specified elongation. (Usually 100% elongation for elastomers.)

Moving parts logic - The technology of achieving logic control by means of fluid devices having moving parts.

Muffler - A device for reducing gas flow noise. Noise is decreased by back pressure control of gas expansion.

Newt - A unit of kinematic viscosity in the English system. It is expressed in square inches per second (see Stokes).

NOR device - A control devices which has its output in the logical 1 state if and only if all the control signals assume the logical 0 state.

NOT device - A control device which has its output in the logical 1 state if and only if the control signal assumes the logical 0 state. The NOT device is a

single input NOR device.

Oil swell - The change in volume of a rubber article due to absorption of oil or other fluid.

OR device - A control device which has its output in the logical 0 state if and only if all the control signals assume the logical 0 state.

Outgassing - A vacuum phenomenon wherein a substance spontaneously releases volatile constituents in the form of vapors or gases. In rubber compounds, these constituents may include water vapor, plasticizers, air, inhibitors, etc.

Output stage - The final stage of hydraulic amplifications used in a servovalve.

Ozone resistance - Ability to withstand the deteriorating effect of ozone (which generally causes cracking).

Packing - A sealing device consisting of bulk deformable material of one or more mating deformable elements, reshaped by manually adjustable compression to obtain and maintain effectiveness. It usually uses axial compression to obtain radial sealing.

Pascal's Law - A pressure applied to a confined fluid at rest is transmitted with equal intensity throughout the fluid.

Permanent set - The deformation remaining after a specimen has been stressed in tension for a definite period and released for a definite period.
Permeability - The rate at which a liquid or gas under pressure passes through a solid material by diffusion and solution. In rubber terminology, it is the rate of gas flow expressed in atmospheric cubic centimeters per second through an elastomeric material one centimeter square and one centimeter thick.

Petroleum fluid - A fluid composed of petroleum oil which may contain additives and/or inhibitors.

Pipe - A conductor whose outside diameter is standardized for threading. Pipe is available in standard, extra strong, or double extra strong wall thickness.

Piston rod - The element transmitting mechanical force and motion from the piston.

Plasticizer - A substance, usually a heavy liquid, added to an elastomer to decrease stiffness, improve low temperature properties, and improve processing.

Pneumatics - Engineering science pertaining to gaseous pressure and flow.

Poise - The standard unit of dynamic viscosity in the cgs (centimeter gram second) system. It is the ratio of the shearing stress to the shear rate of fluid and is expressed in milli-pascal sec. (equals 1 centipoise).

Polymer - A material formed by the joining together of many (poly) individual units (mer) of one or more monomers; synonymous with elastomers.

Port - A terminus of a passage in a component to which conductors can be connected.

Port, differential pressure - A port which provides a passage to the upstream and downstream sides of a component.

Post cure - The second step in the vulcanization process for the more exotic elastomers. Provides stabilization of parts and drives off decomposition products resulting from the vulcanization process.

Pour point - The lowest temperature at which a liquid will flow under specified conditions (ASTM Designation D97).

Power unit - A combination of pump, pump drive, reservoir, controls and conditioning components to supply hydraulic power to a system.

Pressure - Force per unit area, usually expressed in pounds per square inch (bar).

Pressure, absolute - The pressure above zero absolute, i.e., the sum of atmospheric and gage pressure. In vacuum related work it is usually expressed in millimeters of mercury (mm-Hg).

Pressure, atmospheric - Pressure exerted by the atmosphere at any specific location. (Sea level pressure is approximately 14.7 pounds per square inch absolute. 1 bar = 14.5 psi).

Pressure, back - The pressure encountered on the

return side of a system.

Pressure, breakloose (breakout) - The minimum pressure which initiates movement.

Pressure, burst - The pressure which causes failure of and consequential loss of fluid through the product envelope.

Pressure, charge - The pressure at which replenishing fluid is formed into a fluid power system.

Pressure, control range - The permissible limits between which system pressure may be set.

Pressure, cracking - The pressure at which a pressure-operated valve begins to pass fluid.

Pressure, differential (pressure drop) - The difference in pressure between any two points of a system or a component.

Pressure, gage - Pressure differential above or below ambient atmospheric pressure.

Pressure, induced - Pressure generated by an externally applied force.

Pressure, inlet - The pressure at the apparatus inlet port.

Pressure, intensified - In a fluid power cylinder, the outlet pressure required to slow the piston rod extending under regulated pressure introduced at the cap end.

Pressure, maximum inlet - The maximum rated gage pressure applied to the inlet.

Pressure, nominal - A pressure valve assigned to a component or system for the purpose of convenient designation.

Pressure, outlet - Pressure at the apparatus outlet port.

Pressure, override - The difference between the cracking pressure of a valve and the pressure reached when the valve is passing its rated flow.

Pressure, peak - The maximum pressure encountered in the operation of a component.

Pressure, pilot - The pressure in the pilot circuit.

Pressure, precharge - The pressure of compressed gas in an accumulator prior to the admission of a liquid.

Pressure, proof - The non-destructive test pressure, in excess of the maximum rated operating pressure, which causes no permanent deformation, excessive external leakage, or other resulting malfunction.

Pressure, rated - The qualified operating pressure which is recommended for a component or system by the manufacturer.

Pressure, shock - The pressure existing in a wave moving at sonic velocity.

Pressure, static - The pressure in a fluid at rest.

Pressure, surge - The pressure resulting from surge conditions.

Pressure, system - The pressure which overcomes the total resistances in a system. It includes all losses as well as useful work.

Pump - A device which converts mechanical torque and motion into hydraulic fluid power.

Pump, fixed displacement - A hydraulic pump in which the volume displaced per cycle cannot be varied.

Pump, gear, external - Pump with two or more external gears.

Pump, gear, internal - Pump with an internal gear in engagement with one or more external gears.

Pump, gear - Pump in which two or more gears act in engagement as pumping members.

Pump, hydraulic - A device which converts mechanical force and motion into hydraulic fluid power.

Pump, multiple stage - Two or more hydraulic pumps in series.

Pump, piston, axial - Pump having several pistons with mutually parallel axes which are arranged around and parallel to a common axis.

Pump, piston, inline - Pump having several pistons with mutually parallel axes arranged on a common plane.

Pump, piston, radial - Pump having several pistons arranged to operate radially.

Pump, piston - Pump in which the fluid volume is displaced by one or more reciprocating pistons.

Pump, screw - A hydraulic pump having one or more screws rotating in a housing.

Pump, vane, balanced - Pump in which the transverse forces on the rotor are balanced.

Pump, vane, unbalanced - Pump in which the transverse forces on the rotor are not balanced.

Pump, vane - A hydraulic pump having multiple radial vanes within a supporting rotor.

Pump, variable displacement - A hydraulic pump in which the volume displaced per cycle can be varied.

Pump-motor - Unit which functions either as a pump or as a rotary motor.

Quick disconnect coupling - A component which can quickly join or separate a fluid line without the use of tools or special devices.

Refrigerated dryer - Moisture is separated by lowering the air temperature by means of refrigeration compressor and heat exchanger.

Regenerative dryer - The capacity of the dryer to separate moisture can be restored without replacing the drying compound.

Regulator, air line pressure - A regulator which transforms a fluctuating air pressure supply to provide a constant lower pressure output.

Regenerative circuit - see Circuit, regenerative.

Reinforcing agent - Material dispersed in an elastomer to improve compression, shear, or other stress properties.

Reservoir (tank) - A container for storage of liquid in a fluid power system.

Reservoir, hydraulic - A reservoir for storing and conditioning a liquid in a hydraulic system.

Reservoir, pressure sealed - A sealed reservoir for storage of fluids under pressure.

Resilient - Capable of returning to original size and shape after deformation.

Reyn - The standard unit of absolute viscosity in the English system. It is expressed in pound-seconds per square inch.

Reynolds Number - A numerical ratio of the dynamic forces of mass flow to the shear stress due to viscosity. Flow usually changes from laminar to turbulent between Reynolds Numbers 2,000 and 4,000.

Ring, O - A ring which has a round cross-section.

Ring, piston - A piston sealing ring. It is usually one of a series and is often split to facilitate expansion or contraction.

Ring, scraper - A ring which removes material by a scraping action.

Rotation - The direction of rotation is always quoted as viewed looking at the shaft end. In dubious cases, provide a sketch.

Seal, cup - A sealing device with a radial base integral with an axial cylindrical projection at its outer diameter.

Seal, dynamic - A sealing device used between parts that have relative motion.

Seal, elastomer - A material having rubber-like properties; i.e., having the capacity for large deformation and rapid and substantially complete recovery on release from the deforming force.

Seal, rod (shaft) - A sealing device which seals the periphery of a piston rod.

Seal, static (gasket) - A sealing device used between parts that have no relative motion.

Sensor - A device which detects and transmits changes in external conditions.

Separator - A device whose primary function is to

isolate contaminants by physical properties other than size. (Separators remove gas from liquid medium or remove liquid from gaseous medium).

Servovalve - A valve which modulates output as a function of an input command.

Servovalve, electrohydraulic - A servovalve which is capable of continuously controlling hydraulic output as a function of an electrical input.

Servovalve, electrohydraulic, flow control - An electrohydraulic servovalve whose primary function is control of output flow.

Servovalve hysteresis - The difference in the servovalve input currents required to produce the same output during a single cycle of valve input current when cycled at a rate below that at which dynamic effects are important.

Servovalve null leakage - Total internal leakage from the valve in the null position.

Servovalve, pressure control - A hydraulic servovalve whose primary function is the control of output pressure.

Shrinkage - Decreased volume of seal, usually caused by extraction of soluble constituents by fluids followed by air drying.

Silencer - A device for reducing gas flow noise. Noise is decreased by tuned resonant control of gas expansion.

Snubber - see gage damper.

Solenoid, digital - Electrically energized device which generates on-off signals.

Solenoid, proportional - An electrical device that reacts proportionally to strength of electrical signal.

Sorption - The term used to denote the combination of absorption and adsorption processes in the same substance.

Specific gravity, liquid - The ratio of the weight of a given volume of liquid to the weight of an equal volume of water.

Squeeze - Cross section diametral compression of O-ring between surface of the groove bottom and surface of other mating metal part in the gland assembly.

Stage - A hydraulic amplifier used in a servovalve. Servovalves may be single stage, two stage, three stage, etc.

Standard - A document, or an object for physical comparison, for defining product characteristics, products, or processes; prepared by a consensus of a properly constituted group of those substantially affected and having the qualifications to prepare the standard for voluntary use.

Stokes - The standard unit kinematic viscosity in the cgs (centimeter gram second) system. It is expressed in square centimeters per second; 1 centistokes equals 0.01 stokes.

Strainer - see filter, strainer.

Surface tension - The surface force of a liquid in contact with a fluid by which it tends to assume a spherical form and to present the least possible surface. It is expressed in pounds per foot or dynes per centimeter.

Surge - A transient rise of pressure or flow.

Swell - Increased volume of specimen caused by immersion in a fluid (usually a liquid).

Switch, float - An electric switch which is responsive to liquid level.

Switch, flow - An electric switch operated by fluid flow.

Switch, pressure differential - An electric switch operated by a difference in pressure.

Switch, pressure - An electric switch operated by fluid pressure.

Synthetic fluid, silicate ester - A fluid compound of organic silicates. It may contain additives.

Synthetic fluid - Fluid other than mineral on which has been artificially compounded for use in a fluid power system.

Temperature, ambient - The temperature of the environment in which an apparatus is working.

Tensile strength - Force in pounds per square inch required to cause the rupture of a specimen of a rubber material.

Terpolymer - A polymer consisting of three different monomers chemically combined.

Tie rod - An axial external cylinder element which traverses the length of the cylinder. It is prestressed at assembly to hold the ends of the cylinder against the tubing. Tie rod extensions can be a mounting device.

Torque motor - A type of electromechanical transducer having rotary motion used in the input stages of servovalves.

Torque - Rotary force transmitted by the driving shaft of the pump.

Torr - A unit of pressure equal to 1/760 of an atmosphere.

Torricelli's Theorem - The liquid velocity at an outlet discharging into the free atmosphere is proportional to the square root of the head.

Transducer, flow - A device which converts fluid flow to an electrical signal.

Transducer, pressure - A device which converts fluid pressure to an electrical signal.

Trunnion - A mounting device consisting of a pair of opposite projecting cylindrical pivots. The cylindrical pivot pins are at right angle or normal to the piston rod centerline to permit the cylinder to swing in a plane.

Tube - A conductor whose size is its outside diameter. Tube is available in varied wall thickness and material.

Vacuum - Pressure less than ambient atmospheric pressure.

Vacuum pump - A device which uses mechanical force and motion to evacuate gas from a connected chamber to create subatmospheric pressure.

Valve - A device which controls fluid flow direction, pressure or flow rate.

Valve actuator - The valve part(s) through which force is applied to move or position flow-directing elements.

Valve, air - A valve for controlling air.

Valve, cartridge - A valve with working parts contained in a cylindrical body. The cylindrical body must be inserted into a housing for use. Ports through the body cooperate with ports in the containing housing.

Valve, directional control - A valve whose primary function is to direct or prevent flow through selected passages.

Valve, directional control, 3-way - A directional control valve whose primary function is to pressurize and exhaust a port.

Valve, directional control, 4-way - A directional control valve whose primary function is to pressurize and exhaust two ports.

Valve, directional control, check - A directional control valve which permits flow of fluid in only one direction.

Valve, directly operated - A valve in which the controlling forces acting on the element directly influence the movement of the control elements.

Valve, electrohydraulic, proportional - A valve which responds proportionally to input signals.

Valve, flow control (flow metering) - A valve whose primary function is to control flow rate.

Valve, flow control, bypass - A pressure compensated flow control valve which regulates the working flow diverting surplus fluid to reservoir or to a second service.

Valve, flow control, deceleration - A flow control valve which gradually reduces flow rate to provide deceleration.

Valve, flow control, pressure compensated - A flow control valve which controls the rate of flow independent of system pressure.

Valve, flow dividing, pressure compensated - A flow dividing valve which divides the flow at a constant ratio regardless of the difference in the resistances

of the branches.

Valve, flow dividing - A valve which divides the flow from a single source into two or more branches.

Valve, hydraulic - A valve for controlling liquid.

Valve, needle - A flow control valve in which the adjustable control element is a tapered needle. Its usual purpose is the accurate control of the rate of volume of flow.

Valve, pilot operated (indirect) - A valve in which a relatively small flow through an integral vent line relief (pilot) controls the movement of the main element.

Valve, pilot - A valve applied to operate another valve or control.

Volume change - A change in the volume of a seal as a result of immersion in a fluid expressed as a percentage of the original volume.

Vulcanization - A thermo-setting reaction involving the use of heat and pressure, resulting in greatly increased strength and elasticity of rubber-like materials.