Section 35
Chapter 1

How to Read Symbols in a Hydraulic Schematic
SECTION 35 - HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC - CHAPTER 1

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SECTION 35 - HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC - CHAPTER 1

**HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC**

**Introduction**
Accurate diagrams of hydraulic circuits are essential to the man who must repair them. The diagram shows how the components will interact. It shows the field technician how it works, what each component should be doing and where the oil should be going so that he can diagnose and repair the system.

The purpose of this section is to show you how to find your way around schematic circuit diagrams.

**Circuit Diagrams**
There are two types of circuit diagrams.

1. **Cutaway Circuit Diagrams** show the internal construction of the components as well as the flow paths. By using colors, shades or various patterns in the lines and passages, they are able to show many different conditions of flow and pressure. Cutaway diagrams take considerably longer to produce because of their complexity.

2. **Schematic Circuit Diagrams** use the “shorthand” system of the industry, are usually preferred for troubleshooting. A schematic diagram is made up of simple geometric symbols for the components and their controls and connections.

**Symbol Systems**
There are several systems of symbols used when making schematic diagrams. They are as follows:

- I. S. O. = International Standards Organization
- A. N. S. I. = American National Standards Institute
- A. S. A. = American Standards Association
- J. I. C. = Joint Industry Conference

A combination of these symbols are shown in this section. There are differences between the symbols but there is enough similarity so that if you understand the symbols in this section you will be able to interpret other symbols as well.

**Using Schematic Symbols**

**Reservoirs**

- **Vented Reservoir**
  - ![Vented Reservoir Symbol](710L8B)
- **Pressurized Reservoir**
  - ![Pressurized Reservoir Symbol](710L8D)

A rectangle with the top removed represents a vented reservoir. A rectangle with the top in place represents a pressurized reservoir.

- **Pressurized Reservoir**
  - ![Pressurized Reservoir Symbol](710L8C)
- **Pressurized Reservoir**
  - ![Pressurized Reservoir Symbol](710L8A)

There are other schematic diagrams that show a slightly different version of a pressurized reservoir, but the symbols are similar and easily recognized. An oval with a short line on top or a rectangle with curved sides represents a reservoir that is pressurized.

- **Return Line Above the Oil Level**
  - ![Return Line Above Symbol](710L8E)

Lines connected to the reservoir usually are drawn from the top, regardless of where the actual connection is.

- **Suction Line or Return Line Below the Oil Level**
  - ![Suction Line Below Symbol](710L8F)

If the hydraulic line terminates below the fluid level, it is drawn all the way to the bottom of the symbol.
A hydraulic line connected to the bottom of the reservoir may be drawn from the bottom of the symbol if the bottom connection is essential to the system operation.

If the pump inlet must be charged or flooded with a positive head of oil above the inlet port, we would position the reservoir symbol above the pump symbol, and draw the suction line out of the bottom of the reservoir symbol.

Every vehicle or system reservoir has at least two hydraulic lines connected to it, and some may have many more. Often the components that are connected to the reservoir are spread all over the schematic. Rather than having a lot of confusing lines all over the schematic, it is customary to draw individual reservoir symbols close to the components. The reservoir is usually the only component symbol pictured more than once.

Lines, Tubes and Hoses

A hydraulic line, tube, hose or any conductor that carries the fluid between components is shown as a line.

A working line, such as an inlet pressure or return, is shown as a solid line.

Working lines with arrows show direction of flow.

Pilot or control lines are broken into long dashes.

Drain lines for leakage oil are broken into short dashes.

A flexible line is shown as an arc between two dots and is always represented by a solid line.

Quite often you will see an enclosure outline that indicates that there are several symbols that make up a component assembly such as a valve or a valve stack. The enclosure outline appears like a box and is broken with dashes on all sides.
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Crossing or Joining Lines

LINES THAT ARE NOT CONNECTED

DOT CONNECTION TEE CONNECTION

LINES THAT ARE CONNECTED

VARIABLE DISPLACEMENT

VARIABLE DISPLACEMENT PRESSURE COMPENSATED

A variable displacement pump is designated by drawing an arrow through the pump symbol at 45 degrees. To indicate a variable displacement pressure compensated pump, a small box with an arrow in it will be added to the side of the pump symbol.

Pump Symbols

FIXED DISPLACEMENT

FIXED DISPLACEMENT REVERSIBLE

A simple fixed displacement pump is shown as a circle with a black triangle that is pointing outwards. The black triangle is like an arrow head and points in the direction that the oil will flow. If the pump is reversible or designed to pump in either direction, it will have two black triangles in it and they will be opposite each other.

If the pump is controlled by a lever or a pedal, it will be shown on the side of the pump.

A drive shaft is shown as two short parallel lines extending from the side of the pump. If a curved arrow is shown on the drive shaft, it will indicate the direction of rotation.
Hydraulic Motor Symbols

Hydraulic motor symbols are circles with black triangles, but opposite a pump the triangles point inward to show the motor is a receiver of oil. One triangle is used in a nonreversible motor and two triangles are used for a reversible motor.

A simple schematic diagram is shown with a hydraulic motor connected to a hydraulic pump.

Cylinder Symbols

A cylinder symbol is a simple rectangle representing the barrel. The piston and rod are represented by a tee that is inserted into the rectangle. The symbol can be drawn in any position.

If the cylinder is single acting there is only one port shown on the symbol. The port is shown on the end of the cylinder that receives pressurized fluid and the opposite end of the cylinder is left open. A double acting cylinder symbol has both ends closed and has two ports on the symbol.

A double rod end cylinder has a rod extending from each end of the rectangle.

Some cylinders have cushions built into them. The cushion slows down the movement of the piston as it nears the end of its stroke. Cylinder cushions are shown as a smaller rectangle on the piston. If the cushion has an adjustable orifice, a slanted arrow is drawn at 45 degrees across the symbol.
Pressure Control Symbols

The basic symbol is a square (which is called an envelope) with external port connections and an arrow inside to show the oil passage and direction of flow. Usually this type of valve operates by balancing the oil pressure against a spring, so a spring is shown on one side of the symbol and a pilot pressure line on the other side.

Normally Closed

A normally closed valve, such as a relief or sequence valve, is shown with the arrow offset from the ports and toward the pilot pressure line side of the square. The spring holds the valve closed until the pilot line oil pressure is greater than the spring pressure. Mentally visualize a build up of pressure in the pilot line and the square moving over, compressing the spring. The oil can now flow through the valve.

Normally Open

A normally open valve is shown with the arrow connecting the two ports. It closes when pressure overcomes spring force. Mentally visualize a build up of pressure in the pilot line and the square moving over, compressing the spring. The oil flow through the valve is now blocked.

Relief Valve

A relief valve is shown as a normally closed symbol connected between the pressure line and the reservoir. The flow direction arrow points away from the pressure line port and toward the reservoir. This shows very graphically how a relief valve operates. When pressure in the system overcomes the valve spring, flow is from the pressure line through the relief valve to the reservoir.

Pressure Reducing Valve

A pressure reducing valve is shown as a normally open symbol in a pressure line. This valve works opposite of a relief valve, since it senses outlet pressure versus inlet pressure. As the outlet pressure builds, it works against a predetermined spring force. As the spring force is overcome, flow through the valve is modulated or shut off.
Sequence Valve

The normally closed symbol is also used for a sequence valve. The inlet port is connected to a primary cylinder and the outlet port to the secondary cylinder line. When the piston in the primary cylinder reaches the end of its stroke, the pressure in the supply line increases. The sequence valve is also connected to the supply line and also feels the increase in pressure. As pressure increases, the square and directional flow arrow moves over, connecting the inlet and outlet ports allowing fluid to flow to the secondary cylinder.

Directional Control Symbols

Simplified Symbols
One Way Valve

A simple ball check valve is shown. When oil pressure is exerted on the left side of the ball, the ball is forced into the V and no oil can flow past it. When oil pressure is applied to the right side of the ball, the ball moves away from the V and oil can flow past it.

By Pass Valve

A by pass valve is shown as a one way valve with a spring on the ball end of the symbol. This shows that a pressurized flow will be necessary to overcome the spring force and allow flow around the ball.

Composite Symbols

One Way Valves

A more complex one way valve is now shown. This directional control symbol uses a multiple envelope (square) system that has a separate square for each position. Remember all of the port connections are made to the envelope that shows the neutral condition of the valve. Within each envelope are arrows showing the flow paths when the valve is shifted to that position.

Two Position Valves

A simple control valve has two envelopes (representing the spool) if it is a two position valve. The envelopes show the flow conditions when they are in one position. The above schematic is showing that oil is being supplied to the rod end of the cylinder. If we mentally visualize the directional control valve moved to the other position, it would be as shown below.

Here, pressurized oil is being supplied to the piston end of the cylinder and oil from the rod end of the cylinder is allowed to flow to the reservoir.
Three Position Valves

Three position valves will have a centered (neutral) position. The centered position can be either open or closed to flow. The open center is usually used with a fixed displacement pump and the closed center is usually used with a variable displacement pump.

Actuating Controls

Valve spools are controlled by levers, pedals, pilot oil, electric solenoids, etc., which are called actuating controls. These actuating controls are shown by symbols placed on the ends of the envelopes.

Flow Control Symbols

Restrictors

The basic flow control symbol is a representation of a restrictor. If the restrictor is adjustable, a slanted arrow is drawn across the symbol. The restrictor could be a special fitting with a small hole in it or a small drilled passageway within a valve. If it is an adjustable restriction, it could be thought of as a water faucet that can be controlled by turning the handle to regulate the flow. Restrictors can be applied to meter out, meter in and bleed off circuits.

There are adjustable restrictors that are pressure compensated. That means that the size of the opening in the restrictor will change with increases and decreases in pressure. A perpendicular arrow indicates pressure compensation. If the restrictor has both pressure and temperature compensation, the symbol for a thermometer will also be shown.
Accessories

Filters, strainers and heat exchangers are represented as squares that are turned 45 degrees and have the port connection at the corners.

A dotted line perpendicular to the flow line indicates a filter or strainer.

An oval with details inside indicate an accumulator. The details inside will tell you what type of accumulator it is: spring loaded, gas charged, or other features.

The divider line indicates there is a separator between the charge and the oil. A hollow triangle indicates gas.

A spring shows that the accumulator is spring loaded.

The symbol for a heater is like the symbol for a cooler, except the black triangles point in.

Two sets of triangles pointing in and out indicates a temperature control unit.

As you can see, the black triangles point in the direction that the heat is dissipated. Or in the case of the control unit, they show that the heat can be regulated.
Now that you have completed hydraulic symbols, we have put some of the symbols together to form a simple hydraulic schematic. See if you can find your way around the schematic without reading the text for each valve. The text explains the function of each valve in the hydraulic system.
Valve A
This valve is a three position valve. The spool is lever operated and spring centered. It is an open center valve. Visually place the envelopes into the center position and you will see that the valve will direct oil into one end or the other of cylinder A. When the spool in valve A is moved out of the centered position, the valves downstream will receive no oil.

Valve B
Valve B is similar to valve A but it is a four position valve. The fourth position is a float position and is held into that position with a detent. With this valve the cylinder B can be extend, retracted, or placed in the float position. Visualizes the envelope for the float position in the inlet passageway.

You will see that oil can continue to flow to the next valve downstream and that the rod in cylinder B could be pushed back and forth. The oil could move from one end of the cylinder to the other via the valve. Both ends of the cylinder are also connected to the return line to the reservoir.

Valve C
This valve is also similar to valve A but is designed to control a single acting cylinder. When you visualize placing the upper envelope in the center position you will see that oil can drain back to the reservoir from cylinder C.

At the same time, oil from the pump can flow through valve C to the next valve.

Valve D
Valve D is a lever operated, spring centered valve and is designed to control a hydraulic motor. If a hydraulic motor was turning a flywheel and the oil supply and return were shut off abruptly, this would cause damage to the hydraulic lines, the motor, or whatever it was powering. Therefore when the valve supplying the motor is shut off, the motor should be able to slow down gradually. The center (neutral) position of valve D will allow that to happen by letting oil from the outlet of the motor return to the inlet side.

As you have seen, this brief information is all you need to read hydraulic schematics. The more you use it, the more you will be comfortable using hydraulic schematics as a troubleshooting guide.
COMMON SYMBOLS

Lines and Line Functions

- SOLID LINE MAIN LINE
- DASHED LINE PILOT LINE
- DOTTED LINE EXHAUST OR DRAIN
- ENCLOSURE OUTLINE

Mechanical Devices

- MECHANICAL CONNECTIONS (SHAFTS, LEVERS, ETC)
- VARIABLE COMPONENT (RUN ARROW THROUGH SYMBOL AT 45 DEGREES)
- SPRING

Pumps and Motors

- LINES CROSSING
- LINES JOINING
- LIQUID DIRECTION OF FLOW
- GASEOUS DIRECTION OF FLOW
- FLEXIBLE LINE

- HYDRAULIC PUMP FIXED DISPLACEMENT
- HYDRAULIC PUMP VARIABLE DISPLACEMENT
- PRESSURE COMPENSATED VARIABLE DISPLACEMENT PUMP
- FIXED DISPLACEMENT HYDRAULIC PUMP (TWO DIRECTIONAL FLOW)
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### Cylinders

- **Hydraulic Motor, Fixed Displacement**: 711L8P
- **Single Acting**: 711L8P
- **Hydraulic Motor, Variable Displacement**: 730L8E
- **Double Acting Single Rod End**: 711L8P
- **Double Acting Double Rod End**: 712L8A
- **Hydraulic Oscillator**: 730L8C
- **Single Rod End Fixed Cushion Both Ends**: 740L8F

### Reservoirs

- **Reservoir Open to Atmosphere**: 710L8B
- **Pressurized Reservoir**: 730L8F
- **Differential Cylinder**: 730L8F

### Valves

- **Line to Reservoir Below Fluid Level**: 710L8F
- **Check Valve**: 712L8J
- **Line to Reservoir Above Fluid Level**: 710L8E
- **Pilot Operated Check**: 731L8A
- **On-Off Manual Shut Off**: 731L8B

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SECTION 35 - HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC - CHAPTER 1

- REGULATING OR SELECTOR VALVES
- PRESSURE REDUCING VALVE
- 2 POSITION - 2 WAY VALVE
- NON - ADJUSTABLE RESTRICTOR
- 2 POSITION - 3 WAY VALVE
- ADJUSTABLE RESTRICTOR
- 2 POSITION - 4 WAY VALVE
- ADJUSTABLE RESTRICTOR PRESSURE COMPENSATED
- 3 POSITION - 4 WAY VALVE
- ADJUSTABLE RESTRICTOR (TEMPERATURE AND PRESSURE COMPENSATED)
- 2 POSITION - 4 WAY OPEN CENTER CROSS OVER
- PRESSURE RELIEF VALVE

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**Valve Actuators**

- **Solenoid**
- **Detent**
- **Spring**
- **Manual**
- **Push Button**
- **Push Pull Lever**
- **Pedal**
- **Mechanical**

**Accessories**

- **Pressure Compensated**
- **Pilot Pressure Remote Supply**
- **Liquid Supply**
- **Filter**
- **Cooler**
- **Heater**
- **Temperature Controller**
- **Accumulator Hydro - Pneumatic**
SECTION 35 - HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC - CHAPTER 1

1. **Reversing Motor**
   - Symbol: [Diagram of Reversing Motor]
   - Code: 730L8K

2. **Pressure Switch**
   - Symbol: [Diagram of Pressure Switch]
   - Code: 730L8P

3. **Station or Test Point**
   - Symbol: [Diagram of Station or Test Point (Disconnected)]
   - Code: 730L8M

4. **Pressure Indicator**
   - Symbol: [Diagram of Pressure Indicator (Connected)]
   - Code: 730L8N

5. **Temperature Indicator**
   - Symbol: [Diagram of Temperature Indicator]
   - Code: 730L8L

6. **Quick Disconnects**
   - Symbol: [Diagram of Quick Disconnects (Disconnected)]
   - Code: 731L8J

   Symbol: [Diagram of Quick Disconnects (Connected)]
   - Code: 731L8K

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