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The basics of truck hydraulics

I want to explain the basics about truck and trailer hydraulic systems for lifting, rotating and pushing and pulling applications. This article concerns working systems that are not part of the original equipment design. Therefore, they are the responsibility of a modifier. Generally, they are not covered by the Australian Design Rules or in-service vehicle standards regulations. However, there are occupational work safety regulations that must be complied with and there are some safe-practice principles that should be followed. Installation of a hydraulic system is not a recognised modification in National Heavy Vehicle Modification Code (VSB 6).

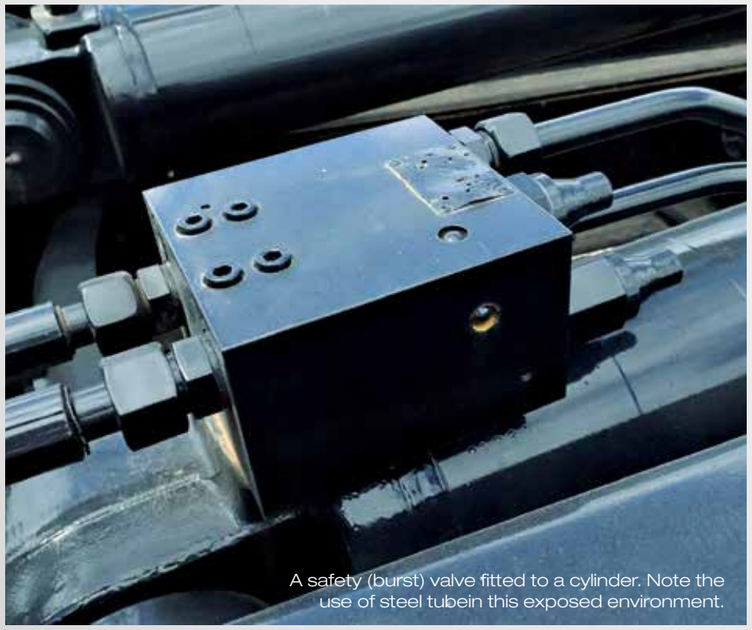
Hydraulic systems use oil flow and pressure to transfer energy and do work. The oil is essentially incompressible. That's different to pneumatic systems where compression of air is a factor. There are four pressure numbers that are important for any hydraulic system:

- Atmospheric pressure – 1 Bar
- Neutral pressure – This is the pump outlet pressure when the system is not working but is circulating oil. This pressure should be less than 20 Bar.
- Working pressure or pump operating pressure – this is the pressure required to accomplish work. It can be 140 Bar, which is twenty times the maximum pneumatic (brake air tank) pressure.
- Relief Pressure – the pressure at which the relief valve opens and bleeds pressure back to the reservoir. It is usually set at 15 per cent above working pressure.
- Burst Pressure – the pressure at which a vulnerable component (such as a hose) will burst. This should be at least four times the Working pressure.

The braided hydraulic hose that transfers hydraulic oil to moving parts must withstand pressure changes during operation between Neutral and Working pressure. The hoses experience pressure pulses so they expand and contract. Hoses vibrate and jiggle around. The stresses of this are felt at the end fittings which are fixed. Hoses need to be secured so that they do not rub and do not crack at the end fitting. Hoses must be correctly sized for the working flow rate. Too small and the pressure drops are great. Too large and the hose is hard to install and bend. The larger the hose diameter, the greater the expansion force to be resisted. Hoses have two ratings, which are Working Pressure and Burst Pressure. As a guide Burst = 4 x Working pressure.

The hydraulic pump is often driven by a Power Take Off (PTO) that is installed into the gearbox. The pump probably produces an output flow rate that is proportional to PTO speed. Consequently, the flow must return to the reservoir when in Neutral (idling). However, there are pump types called load sensing pumps that change flow rate according to conditions.

Directional or Spool Valves direct hydraulic oil into actuators (cylinders, pumps) to do useful work. Once the Cylinder is extended or retracted, the hydraulic pressure is either locked in by a control valve or it is released by a bypass valve and flows back to the reservoir. Directional valves can be either Open Centre or Closed Centre. In an Open Centre valve the oil flow is continuous and it is routed through a central passageway (Neutral conditions) and back to the reservoir unless a spool in the valve is 'stoked' (moved) and the flow is directed towards a load. The oil flow is maintained. The pump pressure must rise to overcome the load and move. Open centre systems have continuous flow and intermittent pressure.



A safety (burst) valve fitted to a cylinder. Note the use of steel tubein this exposed environment.

In a Closed Centre system, the oil flow is intermittent, and the pressure is constant. Under Neutral conditions only flow is produced to maintain a standby pressure at the direction control valve. When a spool is 'stoked, a pathway for flow is revealed and the pump is signalled to increase the flow.

Three-way direction valves are used to control power-up, gravity-down cylinders. In the Neutral position the pressure in the cylinder is locked until the valve is moved to the release position where oil can flow back out of the cylinder. Four-way direction valves are used to power-up and power-down cylinders. Valves used for controlling motors must have a 'free-flow' or motor feature that allows the oil from the motor that is being driven by a load to circulate to avoid damaging the motor.

The lifting force of the cylinders is Working Pressure x Cylinder Inner Area. Note that the flow rate can be adjusted via the variable orifice.

Reservoirs are closed tanks that are usually made of steel or aluminium. Aluminium has about three times the heat dissipation capacity of steel and is lighter but is harder to fabricate. Heat dissipation is necessary because the hydraulic oil heats up as it does work. The oil return port must be low down to avoid frothing the oil in the tank. The oil return port should also be away from the intake port to avoid circulation of hot oil. The tank will need a breather to cope with oil level changes. Keeping the oil topped up will minimise the air space and therefore minimise the condensation moisture that can get into the oil. Contamination is the greatest enemy of hydraulic systems. An unclogged filter must be in the low-pressure pump intake. A suction strainer should also be installed in the reservoir to catch larger debris. The filter should be placed before the cooler to prevent clogging. Safety Valves must be fitted

Direction valve unit on a tilt tray tow truck. Note the identifiers and the Emergency Stop.

on lifting cylinders that are used on tip trucks, tilt trays and bin hooks. The valve prevents oil loss under gravity if the outlet is open, that is if the outlet hose has burst. The valve is fitted directly to the cylinder, as shown in the photo. A 'burst valve' installed directly onto a lifting cylinder.

Here are some safe practice requirements for hydraulic systems:

1. The safety of a person should not depend only on the hydraulic system working. There must be a second independent protection. On tip trucks there must be a safety leg and a safety valve on the lifting cylinder.
2. The controls must be identified with words, arrows or symbols so the operator knows what response will occur to a control movement.
3. There must be an emergency stop that can be activated away from the control location.
4. The failure of a hydraulic hose should not create a hazard.
5. Never face the outside of a hose bend towards the operator because if it comes off it could hit him/her.
6. Do not twist hydraulic hoses. A 10° twist will shorten life by 90 per cent!
7. Manufacturer's minimum hose bend radius must be met. Otherwise the ends will fail prematurely.
8. Route hoses so they flex in one plane only. The printed "lay line" should stay in one plane only.
9. Hoses should not be tight. Parts of vehicles move relative to each other and this will stress the hose.
10. For long runs metal tubing is preferred over hoses. Steel must be plated but not galvanised because the later can flake off.
11. Avoid locating hydraulic hoses or fittings near to unshielded exhaust pipes. If the hose or an end fitting fails, a fire will probably occur.
12. Do not use Teflon tape on NPT (tapered) fittings. The Teflon tape may get inside the system.
13. Restriction of oil flow into the pump can cause cavitation, which releases wear particles into the hydraulic system. These will clog the direction valves.
14. Safety valves must be used on a cylinder when hose failure can cause a lifted load to fall.
15. Hot oil degrades system components. A satisfactory operating temperature is 60°C.

Note that work safety regulations require the designers and installers of plant to conduct a hazard risk assessment. This applies to vehicles!

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