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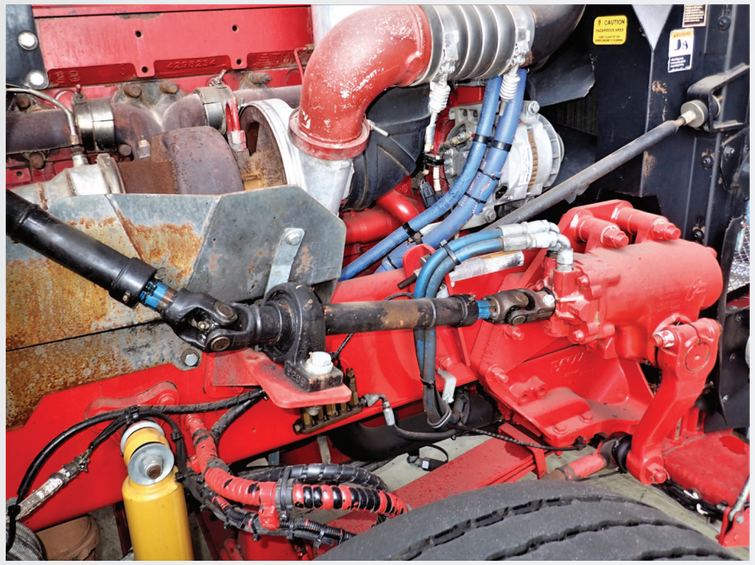
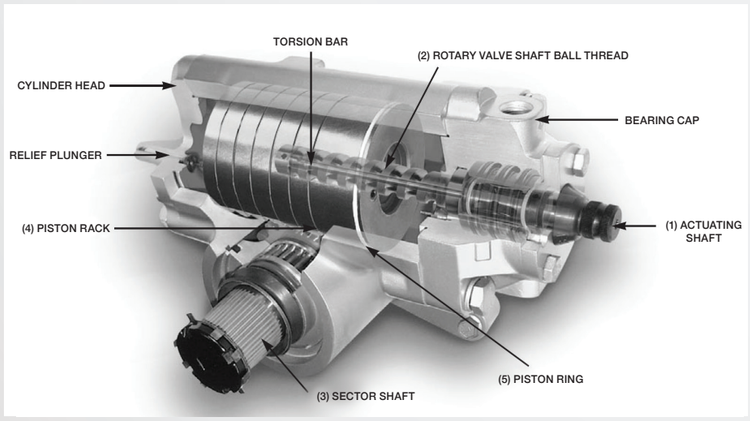
Power steering





I am currently investigating a power steering problem on a heavy-duty prime-mover. This provides me with an opportunity to learn what can go wrong and to describe to you the basics of power steering. Most heavy trucks have a single power steering box on the right-side. Dual-axle trucks will have an additional slave steering box to increase the steering force. The photo shows the steering shaft from the cabin connected to the steering box. In this installation the shaft goes via two universal joints and a bearing.

The steering box converts the rotary motion of the steering column into fore and aft movement of the Pitman arm. In turn, this arm moves the steering mechanism (for further information see my February 2019 article Steering Basics). The steering box is a gearbox with hydraulic oil pressure assistance when the steering column is turned away from the straight-ahead position. A cross-section is shown in the diagram. The actuating shaft has a ball thread that contains ball bearings. This is done to minimise the turning torque. If hydraulic assistance is lost, the driver will need to steer the wheels with manual force and so the less drag involved in the steering box the better.

The piston rack is moved by both the rotation of the actuating shaft via the threads and by hydraulic force on the piston. The hydraulic force comes from a net hydraulic pressure on the piston that occurs because turning actuating shaft opens one or other hydraulic flow valve and causes steering fluid to flow into one or other end of the piston, which provides the steering assistance.

The speed of movement of the steering system depends upon the flow rate of the steering fluid and the force that the Pitman arm can generate is determined by the fluid pressure.

Therefore, the sizing and condition of the hydraulic system is a key factor. The pressure at the outlet of the steering pump (hydraulic pump) that is installed onto an engine PTO somewhere at the front of the engine, should be 1800 – 2200 psi.

The capacity of the pump, the sizing of the hoses and the restrictions in the steering box valves will determine the flow rate that will occur.

The steering fluid temperature will rise due to flow through restrictions. The fluid also cushions road vibrations that might reach the steering shaft via the steering box, which will heat the fluid. The more steering activity, the more temperature will be produced. The steering fluid cools off inside the steering reservoir which has a metal surface positioned to be cooled by airflow.

Steering box systems (and hydraulic systems generally) are often repaired by specialists, rather than a general workshop.

The installation of Teflon seals inside the steering box can be a specialist task. The generalist might draw the line adjusting the wheel-cut stops. But the generalist also needs to know what can go wrong and where, so that the correct help can be obtained. The following Table gives my assessment of the causes of problems that can occur with steering systems and what to look at.

Lane assist and autonomous steering will require electric assistance and intelligent controls. In the first step an electric motor will be integrated with the hydraulic steering box. In the second step the hydraulic steering system will be replaced by an electric system, which will save 3.5 – 8 kW (5 -10 Hp) engine power. Trucks will soon have a steering wheel position sensor and a steering controller. The electric assist will provide fine control at all speeds and reduce driver effort. At high speeds electric steering will keep the truck in the lane. The photo shows ZRF's electric steering box. It requires 48 volts dc – and that's another story!

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SYMPTOM	CAUSES
Hard steering with slow steering wheel turns.	Universal joints are stiff Universal joint angle is excessive (>20°). Tight bearings inside the steering box. Mechanical damage in the steering box. Low pump pressure. Wide tyres fitted or low tyre air pressures. If only in one direction, contamination in one piston relief valve; or metal in relief ball seat in piston
Hard steering with fast steering wheel turns.	Internal fluid leaking / failed internal seals.
Slow steering response.	Low flow rate due to a restriction in the hydraulic system. Pinched return fluid line.
Darting / wandering steering	Air trapped in steering fluid path. Oil flow too high. Insufficient front axle load. Rear axles not parallel.
Cyclical binding felt at the steering wheel.	Eccentricity or interference on the input side. Worn or misassembled universal joints. If it happens more than once per turn of the steering wheel, the joints may have too high an angle.
Unbalanced wheelcut.	Wheel stops are incorrectly adjusted. The Pitman arm or the draglink are misadjusted. The poppets are operating for one direction prematurely.
Steering kickback when turning the steering wheel.	Air in the steering fluid. Low pump flow. Mechanical looseness.
Steering kickback on the move.	Poor steering design that produces bump steer. Worn or failed shock absorbers.
Excessive backlash / freeplay	Work universal joint. Pitman arm ball is worn "egg shaped". Mechanical looseness.
Directional pull with steering wheel centered.	If it occurs during braking, brake imbalance on the steer axle. Steer wheel toe in or toe out. Tyre imbalance on the steer axle. Wheel alignment problems generally. Wheel bearing pending failure on one side. Unbalanced tyre pressure.
Non-recovery of steering wheel to neutral position.	No positive caster. Verify caster angles. Fifth wheel ungreased and binding. Binding in steering mechanism or wheel kingpins.
Directional pull with steering wheel off centre.	Leaking internal seal in the box. Steering mechanism is out of adjustment.
Steering shimmy.	Air in the hydraulic system. Abnormal tyre wear on edges or runout. Mechanical looseness.
Abnormal Noise from the steering system.	Low steering fluid level. Loose steering column components. Mechanical looseness in the steering mechanism. Particulate contamination in steering fluid. Incorrectly installed filter in reservoir.
Hydraulic fluid leaks.	Check hoses and fittings.
Steering oil is discoloured.	Excessive operating temperature.
Engine oil contamination in steering reservoir.	Failed oil seal in the steering pump.
Frothing in the reservoir, overflowing reservoir.	Indicates air in the hydraulic system. Blocked filter.
Water in the reservoir indicated by milky steering fluid.	Indicates water in the hydraulic system. Corrosion and blocking of valves will likely occur resulting in slow response.
Low fluid in the reservoir.	Indicative of leaks from hoses and fittings. Risk of pump failure and overheating of steering fluid. Hot fluid risks damage to seals and valves.
Lack of steering assistance.	Worn out pump cannot produce necessary pressure. Insufficient oil volume. Sticking pressure relief valve.