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A dog of a trailer

This is the third article I have written this year about dog trailer safety (May '22 and June '22). I recently investigated a serious failure of a hydraulic lifting cylinder on a 4-axle tip-trailer. The new cylinder came apart at the second stage when the trailer was discharging about 20 tonnes of rocky fill. The metal cylinder swelled at a thin section corresponding with a pressure ring. The swelling indicated that the hydraulic pressure greatly exceeded the rated pressure of the cylinder. But why? Fortunately no one was killed, but it could have been different. The trailer owner had recently upgraded from a 3-axle tip-trailer. Four-axle tip-trailers are now acceptable under notice - that is, outside the PBS scheme - so he could pull the new trailer behind his 2013 truck without engineering review.

Tests on the tip-truck showed that the hydraulic pressure available to be sent to the tip-trailer could be 220 Bar or more when the driver was resting his foot on the throttle. The proof pressure level of the cylinder on the tip-trailer is 190 Bar, so I knew there was an incompatibility. I looked in the relevant Australian Standard, AS 1418:8-2008 Cranes, hoists and winches, Special purpose vehicles – Section 4, tip-truck hoisting systems. I wanted to understand how the hydraulic compatibility was specified. I didn't find it. The maximum hydraulic pressure that can be supplied from a tip-truck to a tip-trailer is not specified.

The failed lifting cylinder.

Hydraulic oil pressure is generated by a pump that is driven by the engine PTO. Hydraulic control systems can be open-centre or closed-centre. Open-centre systems have continuous flow and intermittent pressure. With the pump turning, oil is pumped through a central open path in the control valve and back to the reservoir. If the directional control valve is operated, flow is diverted into the cylinder load. Closed-centre system have intermittent flow and continuous pressure. If the directional control is operated, a pathway to the cylinder is revealed and simultaneously pressure signal information is delivered to the pump from the directional valve, signalling the pump to produce flow. Both types of hydraulic systems can be used on tip-trucks and tip-trailers. Most Australian hydraulic systems for tip-trucks and tip-trailers are open-centre system so oil flow is bypassed to the tank unless the cylinders are being filled.

The root cause of the cylinder failure seen in Figure 1 is that the tip-truck put out excessive hydraulic pressure to the trailer. Because of the additional load, the cylinder on the four-axle dog trailer has a larger diameter than on the old three-axle dog trailer. The proof pressure of all the cylinders is 190 Bar. The burst pressure based on material limits is higher for the smaller diameter cylinder than the larger diameter cylinder, because it has a smaller diameter, but with the same wall thickness. The smaller cylinder could take the pressure of 220 + Bar the tip-truck can put out, but the larger cylinder could not! A serious failure resulted and the trailer bin fell down. It could plausibly have killed someone, but didn't, this time.

The hydraulic hose connection to the failed five-stage hydraulic cylinder.

Hydraulic pressure compatibility is not guaranteed by technical standards because the standards (based on AS1418) do not consider the interconnection of different systems. Valves have emerged such as the OP-22 tipper open-centre valve that provide a useful flow rate and pressure limit for tip-truck and tip-trailer compatibility. But there are other valves in use that put out excessive pressures, possibly only for short periods. Standards do not specify maximum hydraulic pressure. This is obviously a problem.

There were three factors that contributed to the failure of the lifting cylinder on this new four-axle top-trailer. Firstly, the hydraulic pressure from the tip-truck was high. Second, the burst pressure on the trailer lift cylinder was relatively low. I estimate it was 260 Bar, which is a Factor of Safety based on the proof pressure of 260/190 = 1.37, which is low. Thirdly, the trailer was manufactured without any burst and over-pressure valve on the tip-trailer cylinder. Such protection is a basic safety requirement. It again indicates that tip-trailers are being built and plated with Federal approvals, that do not comply with basic safety principles that should come out of a hazard and risk assessment.

PROPOSALS

1. Introduce a new design rule for vehicles containing plant equipment that requires a Hazard & Risk Assessment to be done in prescribed format. This should explain how risks are classified and controlled.
2. Add the HRA to the modification code VSB 6.
3. Australia should work towards an 'AE' marking system similar to the European 'CE' mark requirements.

Hose burst protection is a fundamental requirement for lifting cylinders. If the flexible hose that supplies the cylinder should fail, the hydraulic oil will be released forcefully and the cylinder will come down hard and fast. To protect against such a failure, a burst valve must be used. There are two types. One type is a restrictor, which is described as a 'velocity fuse'. It slows the oil release down. The second type is a tipper safety valve, which shuts off flow when the pressure across the valve is above limit. Safety valves can also be obtained that provide cylinder pressure protection. However, they can only be used on the tip-truck because they need a reservoir to received oil bypass. I have written previously about the complete disconnect that exists between the Federal vehicle standards rules (ADRs) and the state and territory plant-equipment safety rules. Here is another example where the rules are not adequate to protect the community. So how can the safety of tip-trailer safety be improved? My proposals are in the text box.

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