Hastings Deering CAT

Equipment Safety Bulletin

Technical Support Department

Reference Number	Bulletin 02 – 2019 Revision 01
Affected Product	All diesel engines
Risks Identified	Injury or death may be caused by the ejection of pressurised fluid from a cylinder.
Release Date	4 March 2019 - This revision released 10 August 2021 *This revision includes specific mention of cylinder leakage tests. It will create increased awareness of the correct procedures and potential hazards associated with pressurising engine cylinders. The form numbers of several Caterpillar publications that provide further guidance are also included.*

Risk Overview

Fluid injection from hydraulic systems, high-pressure fuel systems, and during some engine diagnosis activities, has the potential to cause serious injuries and deaths. These incidents can occur due to equipment and part failures or during maintenance and repair work.

Warning: High pressure fluid penetration of any part of the body can cause serious injury or death

The dangers of high-pressure fluid injection are well known, but some maintenance practices and other factors can unwittingly create pressure in a component that has previously been verified as safe and free of residual pressure. Some examples are:

- The mechanical movement of a hydraulic cylinder by the application of external force e.g., crane, jacking, gravity.
- When a closed or locked hydraulic circuit or component is subject to an increase in ambient temperature.
- During engine repairs or fault finding on a diesel engine, with fuel injectors removed. Under certain circumstances fluid can be ejected under pressure from an engine cylinder via the fuel injector orifice in the cylinder head. **NB**. In certain situations, similar risks could exist on a petrol or gas engine, or a reciprocating piston compressor.

This bulletin details some potential risks associated with working on a diesel engine with injectors removed and provides general guidance to minimize the risk of injury or death due to fluid ejection from a cylinder.

Discussion

Fluid can enter an engine cylinder from a number of sources:

- Water entry via inlet or exhaust systems during severe weather events, component failures, inadequate protection during transport, or poor storage procedures.

- Fuel entry due to the design characteristics of certain engines when injector/s are removed.
- On occasions, maintainers have added a fluid to an engine cylinder to prevent corrosion or for other purposes.

When the injectors are removed from an engine for service work, any fluid in cylinders has the potential to be ejected at very high velocities and pressures from the injector orifice in cylinder head:

- Pressurising a cylinder with compressed air to check for leakage into cooling system, via valves, or past piston rings (Cylinder leakage test), can cause the crankshaft to rotate, ejecting fluid from adjacent cylinders.
- When cranking or 'bumping' the engine with the starter motor with fluid present in an engine cylinder, with an injector removed. This activity can cause a high pressure ejection of fluid from the cylinder via the fuel injector orifice in the cylinder head.
- Turning an engine by hand with fluid present in a cylinder can, under certain circumstances, result in ejection of fluid with considerable force.

Best Practices

- Training on the task, and the process of identification of the potential hazard of high-pressure fluid ejection from an engine cylinder should be provided to all personnel who are likely to be involved in engine repairs.
- Always wear suitable PPE including face and eye protection where a risk of high-pressure fluid injection exists.
- Service personnel should be trained on the hazards and correct procedures for performing the tasks they are allocated. Emphasise the requirement to read, understand, and follow the OEM's relevant maintenance procedures and warnings before undertaking a task.
- Treat every engine with injectors removed as a potential source of high-pressure fluid ejection. Always keep clear of 'line of fire'.
- When working on an engine with injectors removed, always confirm that no fluid is present in engine cylinders before turning the engine or pressurizing a cylinder. Do not attempt to remove fluid from a cylinder by cranking the engine with the starter motor. In addition to the risk of an incident with fluid present in a cylinder, engine damage can occur – even with injectors removed.
- Fluid can be removed with a suitable suction gun, vacuum pump and tubing. Refer form RENR2336 via Caterpillar SIS: "Remove injector" for suitable tooling.

  NB. Fuel and water can continue to leak into cylinders in some instances – check and repeat the fluid removal procedure; remain vigilant and keep clear of line of fire.

- Refer to the relevant OEM procedure before conducting a cylinder leakage test.

  NB. If using nitrogen to conduct a cylinder leakage test, ensure users are trained and competent in the use of high-pressure gas cylinders, hoses, and fittings. Nitrogen should be regulated to 'shop air' pressure via a regulator connected to Nitrogen bottle (a regulator will still be required at engine end).

- Before connecting an air or nitrogen supply to a cylinder, the nitrogen/air supply must be turned off at source. Install a suitable regulator set to zero pressure/flow (regulator control wound all the way out in anticlockwise direction) at the delivery end of line (engine end). Partially open supply valve to check there is no air/nitrogen flow from delivery end regulator before connecting to engine. Shut off supply valve again before connecting line to engine cylinder.

- When testing for cylinder leakage, gradually increase pressure with regulator, ensure the air/nitrogen delivery pressure is regulated to 550 to 690 kPa (80 to 100 psi) depending on OEM guidelines. Use the regulator at the engine end of supply hose to ensure pressure is supplied to the cylinder gradually.

  WARNING: Never use Oxygen to pressurise a cylinder or any other compartment – an explosion may result!

- At all times stand well clear of the line of fire of all cylinders with injectors removed and wear suitable PPE – eye and face protection.

- Air pressure supplied to an engine cylinder can result in engine rotation. When testing for leaks at engine valves or leaks into cooling system, Hastings Deering's recommendation is to ensure the piston in the cylinder being tested is at Bottom Dead Centre (BDC). Valve actuation mechanism must be removed to allow valves to be closed during test. This procedure will prevent engine rotation.

- On engines with rectangular section rings, a cylinder leakage test is used to identify excess leakage past piston rings, as well as valves. This testing is done with pistons at TDC (Top Dead Centre). This can result in partial rotation of engine - especially if piston in cylinder being tested is not at exact TDC. It is critical that all cylinders are clear of fluids before applying pressure to any cylinder. The relevant Caterpillar special instructions and procedures must be followed with consideration given to effects of partial movement of crankshaft. A safe means to prevent crankshaft movement should be employed. Installation and locking of engine turning tool is suggested. A risk assessment process is strongly recommended for testing at TDC.

- Pressure remaining in an engine cylinder after a cylinder leakage test will normally bleed off rapidly after regulator is wound off at completion of test. A three-way valve in the cylinder supply connection can also be used to safely control the release of pressure from the cylinder after completion of test.

- If the engine needs to be rotated during maintenance activities, in addition to these recommendations, follow the OEM procedure. For Caterpillar engines, use the specified engine turning tool.

- If it is necessary to crank an engine via the starter motor with injectors removed, ensures cylinders are free of fluids first, conduct risk assessment and clear personnel/tooling from 'line of fire'.
- Stay alert and keep all personnel out of 'the line of fire', even if all fluids and contaminants have been removed from a cylinder.

Useful references - refer SIS 2.0.

GMG00694 – Analysing Cylinder condition by measuring air flow*

M0065756 – Cylinder leakage test* – Gas engines

REHS9230 – Head gasket leak test for C175 engines

REHS7138 – Head gasket leak test for 3500 series engines

SEBD1302 – "Use caution during replacement of damaged nozzle adapters" (Service Magazine article)

* *Engines with rectangular section rings only.*

If you have any questions regarding this bulletin, please contact your Product Support Representative.