Hydraulic Oil and Fluid Systems

Hydraulic oils are used in a range of equipment and tooling, typically under high pressure. If there is a breach in the equipment, a spray of the oil can escape creating a significant fire hazard.

This Loss Prevention Standard discusses these hazards and the risk management controls that can help reduce the potential for fires associated with hydraulic oil systems.

Version: 1.5
Date: 31st May 2025

Hydraulic Oil and Fluid Systems

Introduction

Hydraulic oils are typically used at high pressure within enclosed hydraulic systems to transfer power for a variety of work processes, including pressing, folding, cutting etc., and are widely used in industries that require high speed, precision machining such as metal working, engineering, construction, plastic components manufacture, woodworking etc.

Hydraulic oils are generally stable at atmospheric pressure and temperature making them suitable for a wide range of operating conditions, with a high flash point (150°C to 315°C), and auto-ignition temperature range (260 to 400°C). They also have dual functionality, meaning they can transmit energy whilst lubricating system components, providing improved performance and component longevity.

Pressurised mineral oils in hydraulic systems can however pose a significant fire hazard, especially in environments with ignition sources. A small breach or pinhole leak in pipes or equipment can release an atomised spray or mist of fine hydraulic oil droplets under high pressure. These sprays can extend in excess of 10 metres from the leak point and may ignite upon contact with heated surfaces or sparks. Depending on workplace layout and conditions, fires can spread rapidly to neighbouring equipment or combustible materials, leading to loss or damage. This document outlines the main hazards and provides practical guidance on risk management to help reduce the potential for such losses, including substitution with fire-resistant and low-flammability fluids.

Note: This document is focussed on property loss prevention in relation to hydraulic oils and fluid systems. It is not intended to address liability exposures. The presumption is that all regulatory requirements, Fire Risk Assessments, and compliance with requirements placed by the local authority having jurisdiction which would include licencing, building permissions, regulations, codes, or standards, have or will be met.

Hydraulic System Components

A hydraulic system consists of three primary components that work together to transmit power efficiently:

- **Pump unit**. The pump is responsible for converting mechanical energy into hydraulic energy by pressurising the hydraulic fluid.
- **Drives**. Drives control the movement of actuators, e.g., cylinders or motors, by regulating the flow and pressure of hydraulic oil.
- **Piping system**. The piping system transports pressurised hydraulic oil from the pump to the actuators and back to the reservoir. High-performance materials, such as corrosion-resistant alloys or composite pipes, are increasingly used to improve durability and minimise leaks.

Modern hydraulic systems may also incorporate internet enabled sensors for real-time monitoring of pressure, flow rate, and fluid condition, enabling predictive maintenance and reducing downtime, along with advanced leak detection systems which can significantly reduce downtime and enhance safety by detecting leaks before they become major incidents.

Understanding the Risks

The consequences of a hydraulic oil release will depend on several factors and can vary widely based on the system's design, operating environment, and response measures. Key considerations however include:

- **Composition of the hydraulic fluid**. Fire-resistant fluids, e.g., HFAE, HFB, HFC, significantly reduce fire hazards compared to traditional mineral oils.
- **Duration and spray distance**. High pressure leaks can create atomised sprays that can extend in excess of 10 metres, and depending on the volumes held, for prolonged periods.
- **Exposure to Combustible Materials**. Combustible equipment surfaces, storage areas, or structural elements near the leak can exacerbate fire spread if ignited.
- **System pressure and flow rate**. Higher pressures increase both the likelihood and severity of leaks.
- **Design and Construction**. Poor design and inferior construction can lead to early and regular breakdown and failure. Systems designed with advanced sealing technologies, fire barriers, and remote emergency shutdown switches can mitigate risks effectively.

In addition to fire hazards, leaks can have significant environmental impacts if they contaminate soil, water sources or other machinery and stock. Biodegradable hydraulic fluids offer an eco-friendly alternative to help reduce long-term damage in case of spills.

Managing the Risk of Hydraulic Oil Systems

Effective risk management is essential to help mitigate the potential for fire and other hazards associated with hydraulic oil systems. Considerations include:

Selection of Appropriate Materials and Fluids

The selection of hydraulic oil is a critical element in system design. While it may not be feasible to eliminate hydraulic oils from a work process, using less flammable hydraulic fluids, such as those approved or listed, e.g., FM Approved, can significantly reduce fire risks. All hydraulic fluids will burn under certain conditions, however selecting less flammable oils, which are more challenging to ignite, can greatly reduce the potential for ignition.

Categories of reduced flammability hydraulic fluids include:

- **High water-based fluids (HFA):**
  - ✓ Comprises 90% or more water with soluble oil additives.
  - ✓ Primarily used in processes below less than 1,000 psi, however in some cases can operate in systems with up to 3,500 psi.
  - ✓ Suitable for operating temperature between 0–60°C.
  - ✓ Compatible with most seals and gaskets, except those made from cork, leather, synthetic fibres, paper etc.

- **Water-in-oil emulsions (HFB):**
  - ✓ Contains 35–40% water dispersed in mineral oil.
  - ✓ Operates within a temperature range of 10–65°C and pressures of up to 3,500 psi.
  - ✓ Stability may be compromised by excessive heating or cooling, increasing the risk of fluid ignition.
  - ✓ Compatible with most seals and gaskets, except those made from cork, leather, synthetic fibres or paper.
- **Water polymer (glycol) solutions (HFC):**
  - ✓ Contains 35–50% water in a water-glycol solution.
  - ✓ Operates within a temperature range between 18–65°C and used in processes below 2,000 psi.
  - ✓ Higher temperatures increase evaporation rates, viscosity changes, and ignition risks; frequent topping up of water levels is required.
  - ✓ Compatible with most seals and gaskets except those made from cork, leather, synthetic fibres or paper.
- **Synthetic fluids (HFD):**
  - ✓ Compromise solvents based on chlorinated hydrocarbons or phosphate esters.
  - ✓ Operate within a temperature range of up to 150°C and pressures of up to 5,000 psi.
  - ✓ May be incompatible with some natural rubbers and neoprene and may require specialised hoses and seals.
  - ✓ Can be biodegradable and more environmentally beneficial.

Note: Carefully evaluate compatibility with system components and operational requirements. Incompatible fluids can lead to leakage, high pressure release, deterioration and wear of components etc.

For further guidance on selecting and using less-flammable hydraulic fluids, refer to **ISO 7745:2024 Hydraulic Fluid Power - Fire-Resistant (FR) Fluid - Requirements and Guidelines for Use**.

Operational Controls

To reduce the likelihood of a pressurised hydraulic oil leak occurring and becoming ignited, various loss prevention measures should be implemented, including but not limited to:

- **Location**. Position large hydraulic power pack units externally, and at least 10 metres from the main property and valuable assets, or alternatively within dedicated compartments enjoying a fire resistance rating of at least 90 minutes. This can help contain fire, preventing fire spread to adjacent areas.
- **Hydraulic Fluid Containment**. Ensure appropriate liquid-tight, non-combustible containment is installed around hydraulic oil tanks/reservoirs. This containment system must be capable of safely managing the total volume of fluid in use, in the event of leaks.
- **Leak/Escape of Fluid**
  - ✓ Address all leaks immediately by cleaning and repairing the affected areas.
  - ✓ Avoid using combustible materials, such as rags or cardboard, to soak up fluid leaks as they can act as wicking agents, increasing the risk of ignition. Non-combustible spill kits should always be used.
  - ✓ Hydraulic fluids are generally difficult to ignite, however, when absorbed into combustible materials, they can ignite more easily. Ensure these materials are stored well away from hydraulic systems and operated equipment.

- **System Pressure.** Maintain low system pressure to ensure hydraulic systems shut down safely during emergencies. A low-pressure switch should be fitted to the system for added safety.
- **Hydraulic Fluid Levels.** Monitor fluid levels regularly. Low hydraulic fluid levels can lead to overheating and increased fire risk. Install at least one low-level fluid switch to ensure safe operation and shutdown.
- **Ignition Source Management.** Shield all potential ignition sources (e.g. hot surfaces, electrical equipment, open flames) from hydraulic fluid-based systems. This is critical in high-risk environments such as smelting, extrusion, or other processes where ignition risks are elevated.
- **Automatic Fire detection**. Install automatic fire detection systems in areas with hydraulic fluid operated machinery.
- **Automatic Fire Suppression**. Based on the property and/or business exposures, automatic fire suppression systems should be installed in areas with hydraulic fluid operated machinery. The design of these systems should consider:
  - ✓ The nature of the hydraulic fluid.
  - ✓ The volume of the hydraulic fluid.
  - ✓ The number and type of machines/systems involved.
  - ✓ Turbine, compressor and generator hydraulic systems may require water spray protection. Design fire protection for these systems in accordance with:
    - **NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations.**
    - **NFPA 851 Recommended Practice for Fire Protection for Hydroelectric Generating Plants.**
    - **NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection.**
- **Interlocks**. Hydraulic fluid systems should be interlocked to shut down upon activation of:
  - ✓ Site-wide fire alarms.
  - ✓ Local to equipment automatic fire detection.
  - ✓ Automatic fire suppression activation alarm or impairment of localised fire suppression systems.
- **Emergency Shutdown.** Due to the flammable nature of hydraulic oil mist, a manually activated emergency shutdown switch should be provided at a safe distance from the hydraulic equipment. A clear shutdown sequence should be developed and implemented.
- **Operator Training**. All operators should receive regular comprehensive training on the use of hydraulic oil systems equipment and associated safety controls. Training should include emergency response procedures and maintenance protocols. Include training on new technologies to ensure operators are proficient in handling advanced systems.
- **Cybersecurity Measures**. Protect hydraulic systems from cyber threats by implementing robust cybersecurity protocols to prevent unauthorised access and ensure system integrity.
- **Emergency Response Planning**. Develop detailed emergency response plans including evacuation procedures and spill containment. These plans should be regularly reviewed and updated to reflect changes in system design or operational conditions.

- **Maintenance, Inspection and Testing**. Establish a comprehensive maintenance regime based on risk assessments and manufacturer recommendations. This should include regular inspections and testing of hydraulic oil systems using competent individuals to ensure continued safe operation. Conduct periodic, regular audits to ensure compliance with safety standards and identify areas for improvement. The use of thermographic camera equipment can help identify hot spots and fluid leaks.
- **Business Continuity**. Review the site's Business Continuity Plan to ensure disaster recovery and continuity arrangements adequately reflect the risks associated with the use of hydraulic oils and fluids. This includes a review of supply chain risk management arrangements to ensure all sourced components meet safety and quality standards to reduce the potential for failure.

Key Actions

- Where compatible, replace flammable hydraulic oils with fire-resistant or low-flammability hydraulic fluids. Seek guidance from Original Equipment Manufacturers (OEMs) and suppliers.
- Remove hydraulic oil systems out of main buildings and locate enclosures at least 10 metres from such buildings and other valuable assets.
- Where this is not possible, relocate hydraulic tank and pump systems within fire compartments achieving a fire resistance rating of at least 90 minutes.
- Ensure containment is installed around oil tanks and reservoirs to capture oil/fluid leaks.
- Keep the areas around hydraulic systems clear of combustible items and materials.
- Attend to leaks as a priority and dispose of any contaminated cleaning materials appropriately.
- Remove or shield ignition sources in proximity.
- Extend fire detection and fire protection systems to areas housing hydraulic oil systems, and ensure appropriate interlocks are installed to isolate hydraulic oil systems immediately, and safely, upon fire detection and/or protection system activation.
- Adopt regular formal maintenance and self-inspection programmes.
- Ensure emergency response planning is sufficient and up to date.

Checklist

A generic **Hydraulic Oil Systems Checklist** is presented in Appendix 1 which can be tailored to your own organisation.

Specialist Partner Solutions

Aviva Risk Management Solutions can offer access to a wide range of risk management products and services at preferential rates via our network of Specialist Partners.

For more information please visit: Aviva Risk Management Solutions – Specialist Partners

Sources and Useful Links

- ISO 7745:2024 - Hydraulic fluid power — Fire-resistant fluids — Requirements and guidelines for use
- NFPA 30 Flammable and Combustible Liquids Code
- ISO 6743-4:2015 - Lubricants, industrial oils and related products (class L) — Classification — Part 4: Family H (Hydraulic systems)
- NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
- NFPA 851 Recommended Practice for Fire Protection for Hydroelectric Generating Plants
- NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection
- RiscAuthority Documents:
  - ✓ RC55 Recommendations for fire safety in the storage, handling and use of flammable and highly flammable liquids
  - ✓ RC56 Recommendations for fire safety in the storage, handling and use of highly flammable and flammable liquids: storage in containers other than external fixed tanks
  - ✓ RC57 Recommendations for fire safety in the storage, handling and use of highly flammable and flammable liquids: storage in external fixed tanks

Note: Whilst UK standards and legislation are referenced in this document, other international standards and legislation should be referenced where applicable.

Additional Information

Relevant Aviva Loss Prevention Standards include:

- **Flammable Liquids**
- **Emergency Response Teams**
- **Housekeeping**
- **Maintenance Regimes**
- **Managing Change - Property**
- **Material Damage Risk Assessment**
- **Self-Inspections**
- **Thermographic Surveys**
- **Permit to Work Systems**
- **Business Continuity Management**
- **Business Continuity Planning - Testing and Maintenance**
- **Business Impact Analysis**
- **Supply Chain Risk Management**

To find out more, please visit Aviva Risk Management Solutions or speak to one of our advisors.

Email us at riskadvice@aviva.com or call 0345 366 6666.*

*The cost of calls to 03 prefixed numbers are charged at national call rates (charges may vary dependent on your network provider) and are usually included in inclusive minute plans from landlines and mobiles. For our joint protection telephone calls may be recorded and/or monitored.

Appendix 1 - Hydraulic Oil Systems Checklist

Location	
Date	
Completed by (name and signature)	

	Hydraulic Oil Systems	Y/N	Comments
1.	Has a formal risk assessment been carried out, incorporating a cause-and-effect analysis of hydraulic system process and work equipment processes powered by the hydraulic system?		
2.	Does the environmental impact assessment cover the process and the environment that it is taking place within, including: ✓ The number of machines? ✓ Proximity of machines, and oil reservoirs, to one another? ✓ Volume of oil bunds and reservoirs? ✓ Does the risk assessment include an environmental impact analysis for potential spills or leaks?		
3.	• Have you evaluated the hydraulic fluids that you're using, making sure they are the least flammable hydraulic oils available? • Have you considered using biodegradable hydraulic fluids to reduce environmental impact in case of leaks?		
4.	Are your hydraulic oil systems located in buildings, or an enclosure, of non-combustible construction?		
5.	If your hydraulic system is supplying more than one item of work equipment, is the hydraulic reservoir located within an enclosure with a minimum fire resistance of 90-minutes?		
6.	Are all components used in the hydraulic system made from non-combustible materials?		
7.	Have fixed steel pipework with welded connections, and inflexible hose, been used to connect the hydraulic system where possible?		

	Hydraulic Oil Systems Continued	Y/N	Comments
8.	Have you considered the effect of a high-pressure spray deflecting off machinery surfaces, and the potential outcome?		
9.	Is pipework secured to reduce the risk of wear from movement and/or vibration?		
10.	Does the hydraulic oil system incorporate a relief valve that will release system pressure back into the oil-reservoir for use if there is external pressure-shock? **For example:** if the piston is subject to sudden shock, the pressure inside the system will rise abruptly and increase the risk of pipework and hoses breaking.		
11.	Are all hydraulic pipes and hoses sited away from sources of heat, such as heated machine components, and screened off to reduce the risk of ignition if there's a pipe/hose breach?		
12.	Has a maintenance and testing programme that's undertaken by competent individuals been established for your hydraulic systems, covering: ✓ Inspections prescribed by the equipment manufacturer? ✓ A formal daily inspection of the system, including leaks, worn and/or damaged components/loose connections? Are periodic audits conducted to ensure compliance with safety standards and identify areas for improvement?		
13.	Are low-level cut-offs in place on oil reservoirs and has the cut-off level been set?		
14.	Are fluid reservoirs contained within non-combustible bunding, capable of containing 110% of the capacity of the reservoir?		
15.	• Has a procedure been established for clearing up spills, and are spill kits available? • Are spill kits non-combustible, and are operators trained on proper spill containment procedures? **Note:** Ensure that spill kits do not include combustible materials such as rags, which could act as wicking agents.		
16.	Are worn or damaged components replaced with new components made from non-combustible materials that are compatible with the hydraulic oil and rated to applicable temperature and pressure levels?		
17.	Are hydraulic fluids tested and replaced in line with manufacturers' guidance?		

	Hydraulic Oil Systems Continued	Y/N	Comments
18.	Is the work area where hydraulic systems are located monitored by heat/smoke detection?		
19.	Are fire suppression systems designed based on the specific type and volume of hydraulic fluid used in the system?		
20.	• Is there a readily available, manually operated emergency shut-off/isolation button for the system located in a safe location? • Is the emergency shutdown switch clearly marked and located at least 15m away from the hydraulic system?		
21.	Is the work area protected by an automatic fire control system such as automatic sprinklers, designed and installed to a recognised standard, e.g. NFPA, LPC and FM?		
22.	Does the hydraulic system isolate and de-energise upon activation of the: ✓ Site fire alarm system? ✓ Local automatic fire detection system? ✓ Sprinkler flow alarm (if provided)?		
23.	Are oil pressure levels within the hydraulic system monitored?		
24.	Does the hydraulic system shut down if there's a drop in system pressure?		
25.	Is a permit to work system in place, covering works upon pressure systems?		
26.	Is the local area around the hydraulic system kept clear of combustible materials? **Note:** the area of segregation will be dependent upon the potential spray distance.		
27.	Is segregation of combustible materials maintained based on the maximum potential spray distance from hydraulic systems?		
28.	Are standards of housekeeping for areas that are used to house hydraulic equipment checked on a daily basis?		
29.	Have advanced leak detection systems been installed to identify potential issues early?		

	Hydraulic Oil Systems Continued	Y/N	Comments
30.	Are all areas exposed to hydraulic oil leaks or accumulation, including within the retention bund itself, maintained totally clear of all combustible? materials such as cardboard, rags, etc., that could act as wicking agents?		
31.	Have operators been trained on new technologies, emergency response procedures, and maintenance protocols for hydraulic systems?		
32.	Are cybersecurity protocols in place to protect IoT-enabled hydraulic systems from unauthorised access or cyber threats?		
33.	Additional comments:		

Please Note

This document contains general information and guidance only and may be superseded and/or subject to amendment without further notice. Aviva has no liability to any third parties arising out of ARMS' communications whatsoever (including Loss Prevention Standards), and nor shall any third party rely on them. Other than liability which cannot be excluded by law, Aviva shall not be liable to any person for any indirect, special, consequential or other losses or damages of whatsoever kind arising out of access to, or use of, or reliance on anything contained in ARMS' communications. The document may not cover every risk, exposure or hazard that may arise, and Aviva recommend that you obtain specific advice relevant to the circumstances.

31st May 2025

Version 1.5

ARMSGI832021