HYDRAULIC FLUIDS

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1.0 SCOPE

This data sheet describes the various types of hydraulic fluids and provides recommended loss prevention practices relating to their use. Primary emphasis is placed on the fire hazard of petroleum-based hydraulic oils.

1.1 Hazards

Hydraulic fluids can create spray fires when accidentally released from the equipment or piping they are contained in. These fires tend to be intense and produce significant heat release rates. A hydraulic spray fire can easily ignite combustibles and severely damage steel building elements or metal equipment if the spray impinges on them. Depending on the flow rate and the size of the leak, sprays can extend up to 40 ft (12.2 m) from the release point.

Pressurized sprays producing very small diameter droplets are easily ignited at temperatures well below the normal flash point of the hydraulic fluid. In these cases, the small droplets promote complete combustion of the release and a corresponding short spray distance. The spray will likely damage equipment, but not building elements unless the building elements are located very close to the equipment.

In systems with high flow rates (e.g., central supply systems that feed multiple pieces of hydraulic equipment), the potential exists for a larger release to occur, which will look more like a stream of solid fluid surrounded by smaller droplets. The ignition of the small droplets on the periphery of the spray is similar to that of the finely divided mist sprays described above. The larger stream tends not to burn, but could create a large pool if the release is not stopped. This type of release can have a significant throw distance. In either release scenario, loss history clearly demonstrates that prompt shutdown of the liquid pumping system will quickly end the fire.

1.2 Changes

January 2021. This document has been completely revised. Major changes include the following:

A. Added guidance to be consistent with the revision of Data Sheet 7-32, *Ignitable Liquid Operations*. This includes the addition of a definition for very high flash point liquids, and expanded guidance on flexible hoses and the frequency of safety shutoff valve and interlock testing.

B. Clarified guidance on automatic shutoffs and when safety shutoff valves are appropriate (Section 2.4.3).

C. Added guidance on heat detector placement (Section 2.4.4).

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

2.1.1 Use FM Approved equipment, materials, and services whenever they are applicable and available. For a list of products and services that are FM Approved, see the *Approval Guide*, an online resource of FM Approvals.

2.1.2 Use a nonignitable liquid that will not sustain combustion even when in the form of a spray (e.g., water). Alternatively, use an FM Approved industrial fluid for hydraulic or control equipment, rather than an ignitable liquid such as mineral oil.

2.1.3 Where FM Approved industrial fluids are used exclusively, determine the need for protection and other safeguards, such as automatic sprinkler protection, based on the surrounding occupancy.

2.1.3.1 Use an FM Approved fluid that is suitable for use with pumps, seals, gaskets, packings, and other system components.

2.1.3.2 Follow procedures recommended by the manufacturers of the FM Approved fluid and of the hydraulic equipment in converting machines from ignitable liquids such as mineral oil. Consult the manufacturers to address issues such as draining the old fluid from the system; replacing seals, gaskets, packing, and filters; filling the system with the new fluid; and monitoring equipment and operating conditions (e.g., temperatures, inlet and outlet pressures, flow rates, fluid viscosity and stability, corrosion, etc.).

2.1.4 Where it is not possible to use a nonignitable liquid or an FM Approved industrial fluid:

A. Use a very high flash point liquid (see Appendix A for definition). Alternatively, use a fluid with as high a flash point as possible.

B. Provide additional safeguards to adequately protect the hazard, as outlined in this data sheet.

2.2 Construction and Location

2.2.1 Locate hydraulic equipment in buildings of noncombustible construction.

2.2.2 For hydraulic systems using central supplies of oil to feed multiple pieces of equipment, separate the supply from surrounding occupancies with minimum one-hour fire-rated walls. Provide a minimum 3 in. (7.6 cm) of containment in the room to control the liquid release.

2.2.3 Do not locate equipment and piping containing hydraulic fluid in below-grade locations.

2.2.4 Isolate hydraulic equipment from storage areas.

2.2.5 Locate and arrange hydraulic fluid piping and transfer systems in accordance with Data Sheet 7-32, *Ignitable Liquid Operations*.

2.2.6 Locate and arrange hydraulic equipment, piping, and storage tanks so they are protected from physical damage:

A. Locate equipment so the potential for vehicle impact damage is eliminated.

B. Provide noncombustible equipment and piping materials with high resistance to mechanical damage.

C. Locate piping overhead or in covered trenches in the floor.

2.3 Protection

2.3.1 If nonignitable or FM Approved industrial fluids are used exclusively, determine the need for automatic sprinkler protection based on the surrounding occupancy.

2.3.2 Provide non-storage automatic sprinkler protection in occupancies where hydraulic equipment is located.

2.3.3 Use a wet, deluge, or single interlock preaction system. The use of a dry system is acceptable if the equipment is designed and arranged in accordance with this data sheet.

2.3.4 Install the sprinkler system in accordance with Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

2.3.4.1 Arrange sprinklers on a maximum 100 ft^2 (9 m^2) spacing at the ceiling and below grated or solid mezzanines.

2.3.4.2 Arrange sprinklers with a maximum on-line spacing of 10 ft (3 m). A variation of 1 ft (0.3 m) is permitted on either dimension to avoid obstructions by structural elements.

2.3.4.3 If FM Approved K25.2 EC (K360 EC) sprinklers (pendent or upright) are used, install on a minimum 13 ft (3.9 m) to a maximum 14 ft (4.2 m) spacing. At this spacing, treat as standard response sprinklers.

2.3.4.4 Do not use ordinary or light hazard, extended coverage sprinklers.

2.3.4.5 Provide standard response, ordinary temperature rated, K5.6 (K80) or larger sprinklers under any obstructions that exceed 3 ft (0.9 m) in width or diameter, or 10 ft^2 (0.9 m^2) in area (e.g., tanks or equipment). Also provide sprinklers within obstructed areas in equipment with internal hydraulic systems.

2.3.4.6 Provide a single quick response sprinkler within 2 ft (0.6 m) vertically of pumps used for central hydraulic fluid systems.

2.3.5 Design the sprinkler system as follows:

A. If the hydraulic equipment is designed in accordance with this data sheet (proper piping design and construction, the use of noncombustible equipment components, automatic interlocks to shut down the hydraulic fluid pumping system in the event of a fire, etc.), design the system to provide 0.3 gpm/ft^2 over 2500 ft^2 (12 mm/min over 230 m^2).

B. Protect cutoff rooms containing central supplies of hydraulic fluid, or equipment areas in which the potential for a large pool fire exists, as follows:

1. Design the sprinkler system to provide 0.3 gpm/ft^2 over 4000 ft^2 (12 mm/min over 370 m^2) if the ceiling height is less than or equal to 15 ft (4.6 m).

2. Design the sprinkler system to provide 0.4 gpm/ft^2 over 4000 ft^2 (16 mm/min over 370 m^2) if the ceiling height is greater than 15 ft (4.6 m).

C. Use a minimum K-factor of 8.0 gpm/psi$^{0.5}$ (115 L/min/bar$^{0.5}$).

D. Use high-temperature-rated, standard response automatic sprinklers.

E. Provide a water supply capable of meeting the design sprinkler discharge flow rate plus 500 gpm (1900 L/min) for hose streams, for a duration of 60 minutes.

F. Design sprinklers located below tanks and equipment to provide at least 30 gpm (114 L/min) and maintain a minimum sprinkler discharge pressure of at least 7 psi (0.5 bar).

G. Design sprinklers located over pumps to provide at least 20 gpm (76 L/min) and maintain a minimum sprinkler discharge pressure of at least 7 psi (0.5 bar).

H. Balance all sprinklers installed in the area with the ceiling demand at the point of connection.

2.4 Equipment and Processes

2.4.1 Design and install equipment associated with hydraulic systems to confine the fluid within the system, keep escaping material to a minimum, and prevent its spread. Design and construct hydraulic equipment, heating equipment, measurement and observation instruments, piping systems, and transfer systems in accordance with the recommendations in Data Sheet 7-32, *Ignitable Liquid Operations*.

2.4.2 Use flexible hose constructed from high-strength, noncombustible materials that are resistant to decomposition or melting when exposed to a fire, and that are compatible with the liquid in use.

A. Use all-metal construction consisting of materials such as steel, Monel, stainless steel, brass, bronze, or an equivalent material.

B. Reinforced plastic or rubber hose with a synthetic liner and a tight metal-braid covering is acceptable if interlocks are provided to automatically shut down the hydraulic system. See Figure 2.4.2 for different types of hoses.

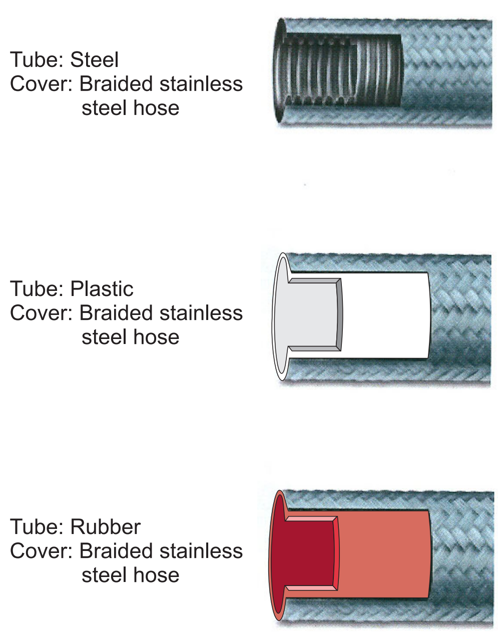

Fig. 2.4.2. Different types of hoses

C. Do not use soft rubber, plastic, or other unreinforced or unprotected combustible tubing.

2.4.3 If non-FM Approved industrial fluids are used, provide an automatically actuated means for shutting down the oil pump and shutting off flow from accumulators (reservoirs) for hydraulic systems and equipment in the event of fire.

2.4.3.1. Provide safety shutoff valves if there is the potential for gravity release from the system.

2.4.4 Accomplish automatic shutdown of hydraulic systems using one or more of the following methods.

2.4.4.1 Actuation by use of a fire detection system (i.e., heat detector, flame detector, or video detector) arranged to ensure prompt detection of a fire and installed in accordance with Data Sheet 5-48, *Automatic Fire Detection*, and in accordance with the applicable FM Approval listing.

A. For ceiling heights up to 60 ft (18 m), install ordinary temperature spot or linear detectors in accordance with the following:

1. Space heat detectors located below solid barriers or ceilings up to 30 ft (9 m) above the fire hazard in accordance with the manufacturer's FM Approved spacing.

2. Space heat detectors located below solid barriers or ceilings between 30 ft (9 m) and 60 ft (18 m) above the fire hazard at not more than 10 ft x 10 ft (3 m x 3 m) spacing.

B. For ceiling heights greater than 60 ft (18 m), or if the ceiling is obstructed by piping or equipment, provide local area heat detection or flame/video detectors in accordance with the following:

1. Provide intermediate heat detector(s) within 10 ft (3 m) vertically above the identified fire hazard. Place the detectors near potential leak points. Provide at least two detectors near each potential leak point with a horizontal spacing between detectors of no more than 4 ft (1.2 m).

2. Locate flame or video detectors in positions that provide a clear line of sight to the fire hazard. Flame or video detectors must be Approved for use with the hydraulic fluid expected to be involved in the fire.

C. Locate additional heat detectors within any shielded equipment areas.

2.4.4.2 Operation of the automatic sprinkler system. Arrange the system to permit protection system alarm testing without unwanted production shutdown by providing a push button switch that requires constant attendance to bypass the interlock.

2.4.5 Provide one or more stop buttons or switches within the operation area (arranged for easy access by the operators and at points of egress from the building or structure) and at accessible remote locations (e.g., control room, security station, etc.) to allow for manual shutoff of the hydraulic systems.

2.5 Operation and Maintenance

2.5.1 Operate, maintain, test, and inspect hydraulic equipment and piping systems in accordance with Data Sheet 7-32, *Ignitable Liquid Operations*, and the manufacturer's instructions. Establish a complete preventive maintenance program designed to ensure equipment is operating as it has been engineered to operate.

2.5.2 Refer to Data Sheet 9-0, *Asset Integrity*, for the development and implementation of loss prevention asset integrity programs for systems and equipment.

2.5.3 Perform annual tests of safety shutoff valves in clean service. For safety shutoff valves in fouling service (resins) or for those exposed to fouling conditions, conduct more frequent tests (e.g., a monthly frequency may be appropriate).

2.5.3.1 Confirm the valve can be closed by simulated actuation (e.g., signal the fire detection system).

2.5.4 Maintain and test all system safety interlocks at least annually or in accordance with manufacturer's recommendations, if more frequent. Maintain records of these tests

2.5.5 Develop and implement a formal operator audit procedure to ensure compliance with established standard operating and emergency response procedures. Conduct these audits at least semi-annually.

2.5.6 Implement a management of change program. Conduct a full review of all planned changes by qualified loss prevention consultants as well as other authorities having jurisdiction before the project begins.

2.5.7 Create a series of routine checkpoints with normal condition limits to be inspected by the operator for prompt detection of abnormal conditions. Conduct frequent inspections to detect and repair leakage. Determine the frequency of the checks based on the process conditions and severity of the consequences of a process upset.

2.5.8 Monitor and maintain FM Approved industrial fluid conditions (viscosity, water content, acidity, particulates, etc.) in accordance with the manufacturer's recommendations.

2.5.8.1 Conduct fluid inspections at intervals recommended by the manufacturer, but not less than annually.

2.5.8.2 When necessary, filter or reclaim the fluid in accordance with the manufacturer's instructions.

2.6 Training

2.6.1 In addition to other recommended emergency organization responsibilities (refer to Data Sheet 7-32, *Ignitable Liquid Operations*), train equipment operators in the following areas:

A. The location, function, and proper operation of emergency oil shutoff switches

B. Precautions for avoiding accidental rupture of hydraulic piping, tubing, and hoses

C. Procedures for prompt cleanup of spills and leaks

2.7 Human Factor

2.7.1 Establish an emergency response plan at locations with hydraulic fluid systems, with a focus on the following items:

- Prompt fire service notification
- Shutdown of the hydraulic fluid systems
- Availability of provided fire protection features
- Spill response procedures aimed at limiting the fluid release size (e.g., prompt shutdown of liquid flow), containing released fluid, and eliminating all ignition sources that may be exposed by the release.

2.7.2 Familiarize the facility's emergency response team members and the local fire service with the location of processes using hydraulic fluids, as well as the emergency response plan. Use emergency response drills to reinforce the employee training programs (including prompt shutdown of the equipment) and assist the fire service in pre-fire planning.

2.7.3 Establish and maintain excellent housekeeping standards for areas containing hydraulic equipment (including pits).

2.8 Ignition Source Control

2.8.1 Eliminate or control ignition sources in accordance with the recommendations in Data Sheet 7-32, *Ignitable Liquid Operations*.

2.8.2 Use light fixtures with a low surface temperature (e.g., LED, fluorescent) in the vicinity of hydraulic systems.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

Pressurized oil in hydraulic systems presents a considerable fire hazard, particularly in processes where ignition sources are constantly present, as in plastic forming, die casting, automatic welding and melting, and heat-treating of metal. Escaping hydraulic oil has caused many severe fires, particularly where building contents or construction were combustible, interlocks to automatically shut down pumping systems were not provided, or sprinkler protection was lacking.

The consequences of an accidental release of hydraulic fluid are dependent on a number of factors, including the following:

- Duration of spray
- What is exposed to the fire (high value equipment, storage, or important building structural elements)
- Pressure and flow rate
- Equipment/piping arrangement and location
- Equipment/piping construction

Properly designed hydraulic equipment will shut down quickly and prevent the release of additional fluid into the fire. In occupancies where well-arranged hydraulic equipment with automatic shutoffs are in use, the provision of basic sprinkler protection will provide adequate protection for most expected fire scenarios. Conversely, in cases where hydraulic systems are not shut down in the event of a fire, even a small volume system can produce a spray fire resulting in the loss of a high-value piece of equipment, regardless of fire protection available at the ceiling. Similarly, where combustible equipment is in use (e.g., rubber hoses, combustible day tanks), the release of additional fluid into the fire is possible regardless of the presence of automatic interlocks to shut down the equipment.

3.1.1 Causes of Oil Release

High-pressure pipe with welded and threaded joints, steel and copper tubing, and metal-reinforced rubber hose are used to conduct oil to the various units, at pressures ranging up to 10,000 psi (690 bar). Failure of piping, failure of valves and gaskets or fittings, pulling out of copper and steel tubing from fittings, and rupture of flexible hoses have been the principal causes of oil release from the system. Lack of adequate support or anchorage to prevent vibration or movement of piping has been a factor in these failures. Repeated flexing and abrasion of rubber hoses against other hoses or parts of machines have created weak spots that eventually resulted in rupture. Tubing under pressure has released oil when accidentally cut by welding torches or stepped on during maintenance procedures.

3.1.2 Fire Characteristics

When hydraulic oil is released under pressure, the usual result is an atomized spray or mist of oil droplets. The oil spray is ignited readily by hot surfaces, such as heated or molten metal, electric heaters, open flames, or welding arcs. The resulting fire usually is torch-like, with a very high rate of heat release. Spray fires cannot be extinguished by automatic sprinklers, so this high heat release fire will continue until the flow of liquid is shut down.

3.1.3 FM Approved Industrial Fluids

FM Approved industrial fluids have been developed to replace petroleum-based oils in all types of hydraulic systems. FM Approved industrial fluids present a minimal fire hazard and do not by themselves create a need for fire protection features for the equipment or building. These fluids, if sprayed onto very hot surfaces, can result in a flaring fire. However, these fluids should stop burning when they flow away from the hot surface. Loss experience indicates that properly maintained systems with FM Approved hydraulic fluids significantly reduce the extent of damage in a fire as compared to systems with petroleum-based oils.

Hydraulic fluids are available that are designated as “less flammable.” These fluids are not considered to be equivalent to FM Approved industrial fluids in terms of the fire hazard they present. The methodologies used in validating these other fluids as “less flammable” are inconsistent and not fully understood. The actual fire hazard that these liquids present is unknown, and they may still sustain a high heat release rate spray fire despite their designation.

3.2 Automatic Interlocks

Automatically operated shutoffs are the most reliable means of ensuring the flow of oil is stopped in the event of a release or fire. The primary objective of the automatic interlocks is to eliminate the high-pressure fluid spray, minimize the release quantity by shutting off the flow of fluid, and reduce the impact on adjacent equipment. As such, the interlocks should be designed to minimize the total hydraulic fluid release.

As an example, many hydraulic systems include an accumulator to account for pressure variations in the system, and serve as an auxiliary power source in the event of a pump failure. Depending on the size of the hydraulic system, the accumulator may contain up to hundreds of gallons (liters) of additional hydraulic fluid that will continue to supply the hydraulically controlled components even if the pump is shut off. Interlocks should be arranged to minimize the potential release from all system components, including accumulators.

If automatic interlocks are not provided to shut down a system in the event of a release, hydraulic fluid will continue to spray from the system. This will result in a larger release, prolonging the fire event by providing a continuous supply of fuel. The impact of the lack of interlocks will depend on the quantity of hydraulic fluid that can be released from the system and the corresponding duration of the fire event, which will vary with the anticipated failure mode, hydraulic fluid capacity, system pressure, etc.

3.3 Loss History

FM clients reported 66 fires involving hydraulic fluids from 2005 through 2019. The gross cost of these losses was US$185.6 million (indexed to 2020 dollars).

As shown in Figure 3.3-1, nearly half of the reported losses cost less than US$1 million. However, 50% of the total gross loss cost was produced by only 10% of the losses. That several large losses produced the majority of the cost indicates that a lack of adequate control features, such as automatic sprinkler protection and prompt shutdown of the pressurized oil source, will result in an increased quantity of liquid involved and loss size (see Figure 3.3-2).

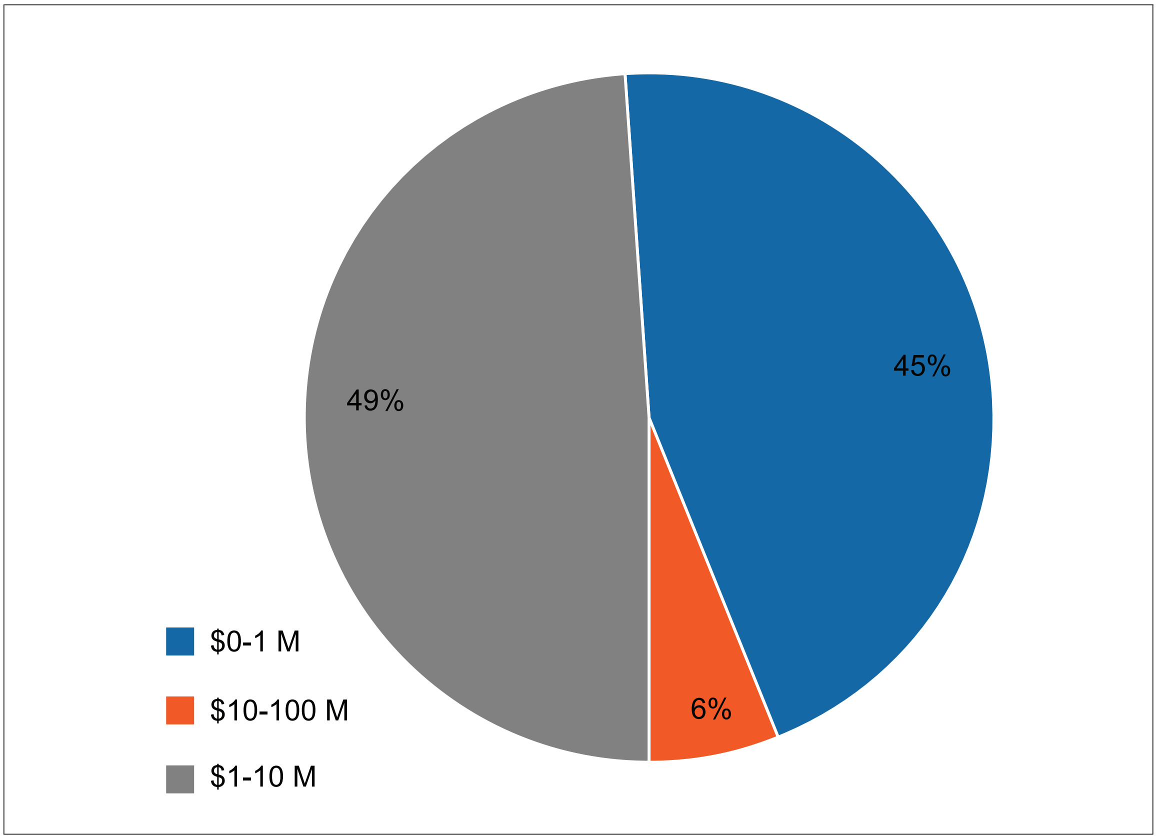

Fig. 3.3-1. Percentage of Losses by Total Loss Value

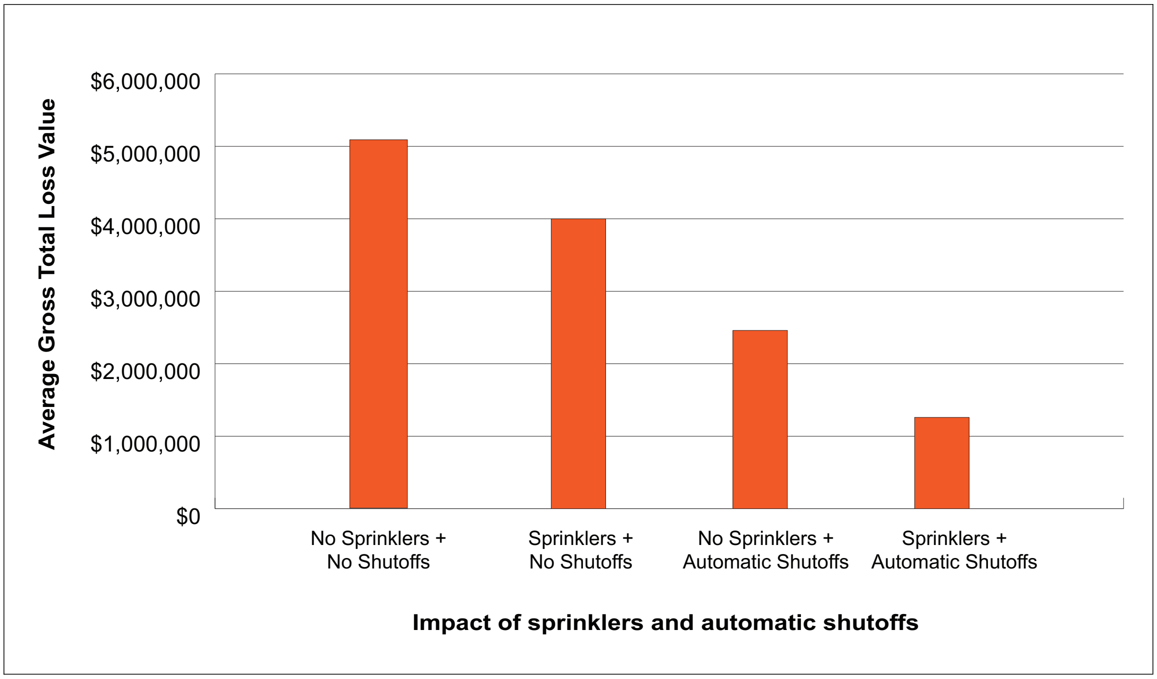

Fig. 3.3-2. Impact of shutoffs and sprinklers

The causes of hydraulic fire losses are shown in Figure 3.3-3. The leading cause, which accounts for half of the losses, is leaks from the pipe/hose/fitting. The ignition source in approximately 60% of the losses was a hot surface.

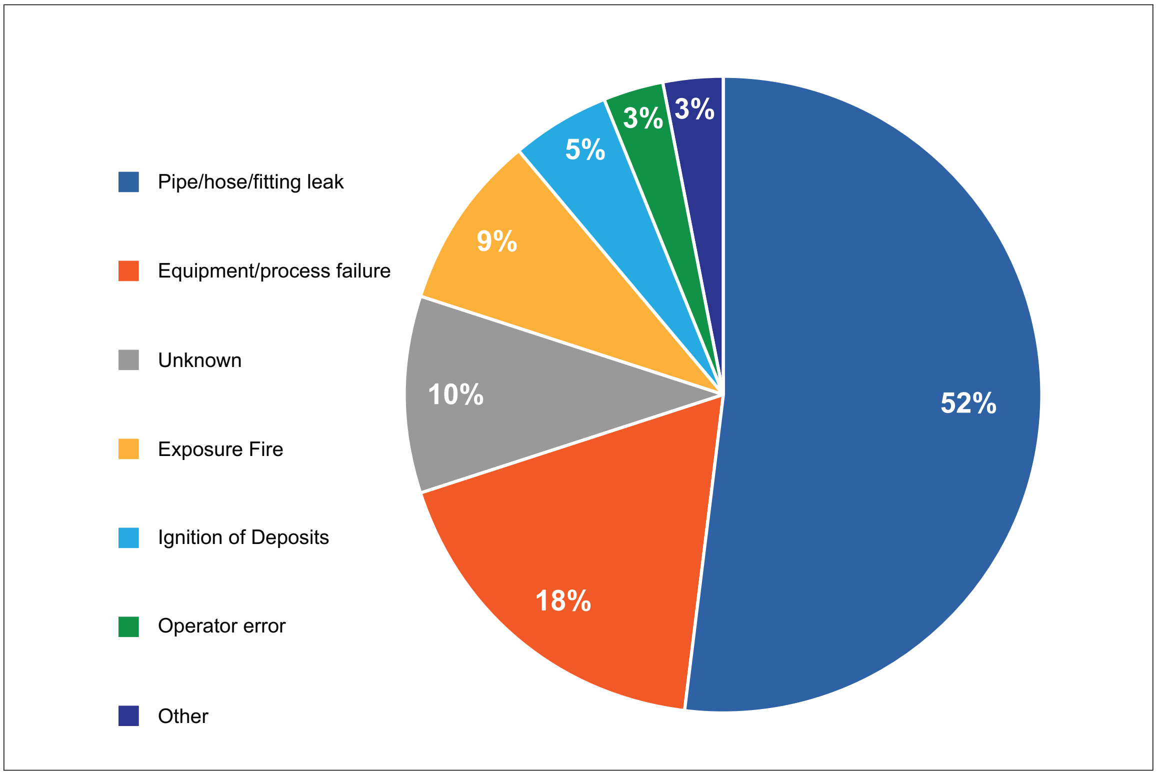

Fig. 3.3-3. Causes of hydraulic fire losses (by frequency)

4.0 REFERENCES

4.1 FM

Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 9-0, *Asset Integrity*
Data Sheet 13-8, *Power Presses*

Understanding the Hazard: *Hydraulic Fluids* (P0031)

APPENDIX A GLOSSARY OF TERMS

FM Approved: Products and services that have satisfied the criteria for FM Approval. Refer to the *Approval Guide*, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Ignitable liquid: Any liquid or liquid mixture that has a measurable flash point. The hazard of a liquid depends on its ability to sustain combustion or create a flammable vapor-air mixture above its surface. Flash point is one way of understanding if a liquid can create that flammable vapor-air mixture. For a liquid to burn in a pool, it must have a fire point as well as a flash point. Ignitable liquids include flammable liquids, combustible liquids, inflammable liquids, and any other term for a liquid that will burn.

Very high flash point liquid: Treat liquids that meet one of the following as very high flash point liquids:

A. Unheated liquids with a flash point at or above 414°F (212°C).

B. Heated liquids with a flash point at or above 414°F (212°C) that have an operating temperature that meets the following equation:

Closed cup flash point - operating temperature > 324°F (180°C)

C. Vegetable oils and fish oils with a closed cup flash point of 450°F (232°C) and greater, that are heated to less than or equal to 150°F (65°C).

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

January 2021. This document has been completely revised. Major changes include the following:

A. Added guidance to be consistent with the revision of Data Sheet 7-32, *Ignitable Liquid Operations*. This includes the addition of a definition for very high flash point liquids, and expanded guidance on flexible hoses and the frequency of safety shutoff valve and interlock testing.

B. Clarified guidance on automatic shutoffs and when safety shutoff valves are appropriate (Section 2.4.3).

C. Added guidance on heat detector placement (Section 2.4.4).

April 2018. Interim revision. Minor editorial changes were made.

July 2013. The following major changes were made:

A. Revised terminology and guidance related to ignitable liquids to provide increased clarity and consistency. This includes the replacement of references to “flammable” and “combustible” liquids with “ignitable” liquids throughout the document.

B. Reorganized the document to provide a format that is consistent with other data sheets.

C. Provided information to assist in evaluating the fire hazard scenario associated with hydraulic equipment, including an evaluation of the specific hydraulic fluid used in the system.

D. Included additional information on hydraulic fluids and FM Approved industrial fluids.

E. Provided recommendations on the proper construction and location of central supplies of hydraulic fluid.

F. Added reference to Data Sheet 7-32, *Ignitable Liquid Operations,* for the appropriate design of piping systems.

G. Provided information on protection of hydraulic piping and equipment from mechanical damage.

H. Revised the sprinkler protection recommendations for areas containing hydraulic fluid, including the exception to eliminate sprinkler protection for oil capacities less than 100 gal (380 L).

I. Deleted the exception to eliminate automatic shutoffs for adequately sprinklered areas; automatic interlocks to shut down hydraulic fluid pumping systems are now recommended for all hydraulic systems.

J. Updated the methods for automatically shutting down hydraulic systems to reflect current technologies and practices.

K. Added information related to human factor, ignition source control, and housekeeping.

May 2003. Minor editorial changes were made for this revision.

May 2000. This revision of the document has been reorganized to provide a consistent format.

APPENDIX C SUPPLEMENTARY INFORMATION

C.1 General

Hydraulic fluids are used for transmitting power or motion to the various parts of equipment and machines. The function of the fluid may be power multiplication as in hydraulic presses, actuation of automatic equipment as in die casting, or remote actuation or precision control of various machines and instruments.

Hydraulic fluids are used in die casting and plastic molding machines, mining equipment, automatic welding equipment, machine tools (such as drill presses, milling machines, grinders, boring mills, shapers, saws, broaching machines, punch presses, shears, and riveters), and in hydraulic couplings, torque converters, oil cookers, elevators, lift trucks, heat-treating furnace-door operations and melting-furnace tilting units. Large hydraulic presses are an important application of hydraulic power transmission. (See Data Sheet 13-8, *Power Presses*, for further information.) Most hydraulically operated equipment has individual oil systems located nearby, although some equipment, particularly hydraulic presses, may have very large or centralized hydraulic oil systems located in a cut-off area, with the oil then fed to multiple pieces of equipment.

Earlier hydraulically operated equipment used water as the hydraulic medium, but because of its corrosive effect on the metallic parts of the machines and its lack of lubricity, it was replaced by petroleum-based oils. Except for its fire hazard, oil is an ideal hydraulic fluid. It is not corrosive, does not affect seals, has good lubricating properties, can be obtained in various viscosity ranges, and is readily available. Flash points range from 300° to 600°F (150° to 315°C). Autoignition temperatures range from 500° to 750°F (260° to 400°C).

C.2 FM Approved Industrial Fluids

Approval tests for hydraulic fluids evaluate the fire hazard of a fluid intended for use in industrial equipment by determining its chemical heat release rate from spray fires and the fluid's critical heat flux for ignition. Based on these two parameters, a Spray Flammability Parameter (SFP) is calculated. The SFP is then used as the basis for classifying the fluid as an FM Approved fluid. The SFP is essentially a measure of how hard it is to ignite a liquid and how severely it will burn once it is ignited. Hydraulic fluids that have an SFP less than 5×10^4 when tested to FM Approval Standard 6930, *Flammability Classification of Industrial Fluids*, are considered FM Approved.

High water content fluids may not exhibit a fire point. The SFP cannot be calculated without a fire point, but high water content fluids can still burn in the form of an atomized spray. FM Approval Standard 6930 also includes criteria to evaluate fluids without a fire point for Approval.

FM Approved fluids are either of the high water base (oil-in-water emulsion), water-in-oil emulsion, water-glycol, or synthetic types. These are referred to internationally as HF-A, HF-B, HF-C and HF-D fluids, respectively.

High Water Base Fluids (Oil-in-Water Emulsions)

High water base fluids (HF-A) contain 90% or more water. Additives to the water are generally synthetics or soluble oils. These fluids have viscosities approaching that of water and are used mainly in light-duty applications, with pressures below 1000 psi (69 bar), using special pumps.

Recommended temperature limits are 40° to 120°F (4° to 49°C). High water base fluids are compatible with most types of seals and gaskets, except those made from cork, paper, leather and synthetic fibers.

Water-in-Oil Emulsions

Water-in-oil emulsions (HF-B) consist of 35% to 40% water in mineral oil, with a small amount of emulsifying agents, rust inhibitors, and anti-wear additives. The water is dispersed in fine droplets in the continuous oil phase.

Recommended temperature limits are 15° to 150°F (-10° to 65°C). At temperatures above 150°F (65°C), a periodic addition of water normally is required. Either excessive heating or cooling can upset emulsion stability. Loss of water from emulsions tends to reduce viscosity and increase the potential for ignition of the fluid.

Water-in-oil emulsions are compatible with most types of seals and gaskets, except those made from cork, paper, leather and synthetic fibers.

Water-Glycol Fluids

Water-glycol fluids (HF-C) normally consist of 35% to 50% water, ethylene or propylene glycol to improve low temperature properties, and additives for proper viscosity and resistance to corrosion, wear and bacteria.

Recommended temperature limits are 0° to 150°F (-18° to 65°C), with normal operation at 120° to 150°F (49 to 65°C). At temperatures above this range, the rate of water evaporation is such that additional makeup water frequently is required. As water evaporates, the viscosity and fire hazard of the fluid increases. Operation at a hazardously low water concentration is difficult.

Water-glycol fluids are compatible with most types of seals and gaskets used with mineral oils, but are incompatible with certain types of cork, paper, leather and synthetic fiber materials. They also are incompatible with zinc, cadmium and magnesium, but these materials are seldom used in hydraulic systems.

Synthetic Fluids

Most synthetic hydraulic fluids (HF-D) are one of four types: phosphate esters, chlorinated hydrocarbons, blends of phosphate esters, and chlorinated hydrocarbons and fluids containing other compositions. Most of these fluids have relatively high specific gravities. Larger diameter or shorter pump suction lines may be needed to prevent cavitation. Because of the high density, particles do not settle out as easily, making good filtration necessary.

Recommended temperature limits are 20° to 200°F (-7° to 93°C).

Synthetic fluids are not compatible with natural rubber, BunaT, or neoprene seals or hoses. These should be replaced with fluorocarbon, silicone, butyl rubber, Teflon, or nylon materials. Synthetic fluids also may attack metal protective paints, lacquers and electrical wiring insulation.