FLIGHT AND OTHER SIMULATORS

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1.0 SCOPE

This data sheet covers fire and associated hazards of simulators with hydraulically operated and electrically operated motion-control systems, referred to in this data sheet as hydraulic simulators and electric simulators, respectively. This data sheet includes specific information on flight simulators used for the purposes of training aircraft pilots and crews. This data sheet also applies to simulators located in other occupancies, such as in universities and amusement parks, and static simulators.

1.1 Hazards

General information relative to the primary hazards, including the use of hydraulic fluid and electrical equipment, is located in Data Sheet 7-98, *Hydraulic Fluids*, and Data Sheet 5-32, *Data Centers and Related Facilities*, respectively.

For flight simulators, the hydraulic fluid hazard tends to be associated with older units. New modern simulators generally have electrically operated motion-control systems.

1.2 Changes

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

A. Changed the title to *Flight and Other Simulators* (was *Flight Simulator Systems*).

B. Added guidance for electrically operated motion-control systems.

C. Added an option to omit protection from underneath a hydraulic simulator if certain conditions are met (Section 2.4.2.1).

D. Added further protection options for the interior of the simulator (Section 2.4.3).

E. Added guidance to be consistent with the recent revision of Data Sheet 7-32, *Ignitable Liquid Operations*, including the definition of “very high flash point liquids.”

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.

2.2 Construction and Location

2.2.1 Provide noncombustible construction for the building and/or room(s) used to house the simulator system. Ensure any raised floors and supports are also noncombustible.

2.2.2 Construct the simulator module of a noncombustible material. Where plastic materials are used, install them in accordance with Data Sheet 1-57, *Plastics in Construction*.

2.2.3 For a hydraulic simulator, unless a non-ignitable liquid or FM Approved industrial fluid is used in the hydraulic system, do the following:

A. Separate the hydraulic pump and reservoir from the simulator module(s) by a minimum of one-hour fire-rated walls.

B. Provide at least 3 in. (7.6 cm) of containment in the hydraulic pump and reservoir room to control the liquid release and prevent the flow of liquid into adjacent areas of the facility that are not protected for an ignitable liquid hazard.

2.2.4 Locate individual simulator modules in separate rooms of noncombustible construction.

2.2.4.1 Multiple simulator modules located in the same room are acceptable if (a) simulators are electric or, if hydraulic, they have automatic shutoffs, and (b) simulator exteriors are constructed of noncombustible materials.

2.2.5 Do not locate other combustible materials within the simulator area.

2.2.6 In large simulator facilities where there are numerous simulator systems, arrange the electric data processing equipment so no more than two simulator systems are controlled from any one area.

2.3 Occupancy

2.3.1 Arrange ventilation and air conditioning to service individual simulator modules, or otherwise prevent smoke and heat from being communicated from one simulator module to another.

2.4 Protection

2.4.1 Simulator System Room/Building

2.4.1.1 For hydraulic simulators, provide automatic sprinklers in the room/building at ceiling level in accordance with Data Sheet 7-98, *Hydraulic Fluids*.

2.4.1.2 For electric simulators, provide automatic sprinklers in the room/building at ceiling level in accordance with Hazard Category 2 (HC2) protection recommendations in Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*.

2.4.2 Simulator Module for Hydraulic Simulators Using non-FM Approved Hydraulic Fluids

2.4.2.1 Automatic protection is not needed under the simulator module when **all** of the following are true:

A. The hydraulic fluid used qualifies as a very high flash point liquid (see definition in Appendix A).

B. Fire detection (heat or flame) underneath the simulator module is arranged to automatically shut off and deenergize the hydraulic system.

C. There is no in-process or combustible storage within the vicinity of the simulator.

If **all** of the conditions in items A through C cannot be met, provide automatic protection beneath the simulator module in accordance with 2.4.2.2 or 2.4.2.3.

2.4.2.2 If the simulator module is located in a large, unenclosed space, provide one of the following forms of protection beneath the module:

A. Quick response, ordinary temperature rated, K8.0 (K115) or larger automatic sprinklers. Use a wet pipe sprinkler system. Provide a minimum discharge density of 0.3 gpm/ft^2 (12 mm/min) beneath the simulator module area.

1. Hard pipe the sprinklers under the simulator module using hangars to attach the pipe work to the simulator module body. Use a steel braided, 250 psi (17.2 bar) minimum working pressure flexible hose to feed the hard pipe. During installation, check that the bend radius for the hose is able to match the maximum expected bend radius of the simulator.

2. Provide a means of isolating this sprinkler system (e.g., indicating control valve) to allow the sprinklers to be replaced without impairing other fire protection systems.

B. An FM Approved water spray system.

C. A water mist system FM Approved for local application protection and designed as follows:

1. Design and install the water mist system in accordance with Data Sheet 4-2, *Water Mist Systems*, the manufacturer's recommendations, and the system's listing in the *Approval Guide*. Ensure all system limitations, such as nozzle spacing, are met.

2. Provide an FM Approved fire detection system that is compatible with the water mist system and has a response time equivalent to that of a quick-response sprinkler.

3. Design the water mist supply to provide water discharge for the time specified in the system's *Approval Guide* listing, but not less than 10 minutes, assuming the hydraulic system is arranged to deenergize and shut down. If the system is not arranged to do this, provide a duration equivalent to the time that it takes the system to deenergize and shut down.

2.4.2.3 If the simulator module is enclosed by walls or noncombustible barriers, a total flooding water mist system or a hybrid (water and inert gas) system that is FM Approved for machinery in enclosures may be used as an alternative to the protection methods listed in Section 2.4.2.2. Design the system as follows:

A. Design and install the system in accordance with Data Sheet 4-0, *Special Protection Systems*, or 4-2, *Water Mist Systems*, as applicable, as well as the manufacturer's instructions and the system's listing in the *Approval Guide*. Only use systems FM Approved for "Machinery in Enclosures."

B. Ensure all system limitations, such as protected volume size, ventilation rate, and opening size, are met.

C. Provide an FM Approved fire detection system that is compatible with the water mist system and has a response time equivalent to that of a quick-response sprinkler.

D. Hydraulically design the water mist or hybrid system in accordance with the manufacturer's instructions and the system's listing in the *Approval Guide*.

E. Design the water mist supply or the hybrid system supply to provide discharge for the time specified in the system's *Approval Guide* listing, but not less than 10 minutes.

F. Provide automatic sprinklers for the room/building in accordance with Section 2.4.1.1.

2.4.2.4 Provide capability for remote manual actuation of extinguishing systems at both the instructor's station and a control station located external to the module.

2.4.3 Simulator Interior

2.4.3.1 Provide a high-sensitivity smoke detection system installed in accordance with Data Sheet 5-48, *Automatic Fire Detection*.

2.4.3.2 Protect the simulator interior if combustible materials (e.g., foam seats, cables, plastic materials, wooden materials, combustible concealed spaces) are present. Provide protection in accordance with 2.4.3.2.1, 2.4.3.2.2, or 2.4.3.2.3.

2.4.3.2.1 Protect the simulator interior with a water mist system designed for the occupancy present.

A. Design and install the water mist system in accordance with Data Sheet 4-2, *Water Mist Systems*, the manufacturer's recommendations, and the system's listing in the *Approval Guide*. Ensure all system limitations, such as nozzle spacing and openings, are met.

B. Design the water mist supply to provide water discharge for an equivalent duration to automatic sprinklers.

2.4.3.2.2 Provide sprinkler protection within the simulator interior and under raised floors.

A. Use quick-response, ordinary temperature rated, K5.6 (80) or larger automatic sprinklers. Use a wet pipe sprinkler system. Provide a minimum discharge density of 0.2 gpm/ft^2 (8 mm/min) over the interior floor area of the simulator.

B. Where flexible hose is present, use a steel braided, 250 psi (17.2 bar) minimum working pressure flexible hose. During installation, check that the bend radius for the hose is able to match the maximum expected bend radius of the simulator.

C. Provide a means of isolating this sprinkler system (e.g., indicating control valve) to allow the sprinklers to be replaced without impairing other fire protection systems.

2.4.3.2.3 Protect the simulator interior with a clean agent fire extinguishing system designed as follows:

A. Design and install the system in accordance with Data Sheet 4-9, *Clean Agent Fire Extinguishing Systems*, the manufacturer's instructions, and the system's listing in the *Approval Guide*.

B. Provide an FM Approved fire detection system that is compatible with the clean agent system.

C. Design the gas concentration to extinguish a Class C (electrical) fire, based on the *Approval Guide* and the manufacturer's design manual.

2.4.4 Other Protection

2.4.4.1 Protect ancillary areas (e.g., electronic switchgear, electronic data processing cabinets, the electronic data processing center) in accordance with Data Sheet 5-32, *Data Centers and Related Facilities*.

2.4.4.2 Where hydraulic simulators are present, protect the hydraulic fluid pump room and storage facility in accordance with Data Sheet 7-98, *Hydraulic Fluids*.

2.4.4.3 Provide one of the methods of protection outlined in Data Sheet 5-31, *Cables and Bus Bars*, for areas containing grouped cables.

2.4.4.4 Where visual aid equipment is installed as part of the simulator system, provide automatic sprinklers if the visual display is of combustible construction. Such displays may include rubber belts, plastic materials, etc.

2.5 Equipment and Processes

2.5.1 Arrange the simulator, air conditioning and ventilation supply, and electric power to the area to automatically shut down in the event of a fire.

2.5.1.1 For hydraulic simulators, in addition to the shutdown of the items in 2.5.1, arrange and design the hydraulic system to shut down in accordance with Data Sheet 7-98, *Hydraulic Fluids*.

2.5.2 For hydraulic simulators, design and install hydraulic equipment, piping, and transfer systems in accordance with Data Sheet 7-98, *Hydraulic Fluids*. Where possible, use an FM Approved industrial fluid in place of a non-FM Approved fluid such as mineral oil.

2.5.3 Provide a manual remote shutoff for the simulator and hydraulic system (if present) in a location that will be readily accessible under fire conditions, such as the control room or other location outside of the simulator room.

2.6 Human Factor

2.6.1 Establish a documented emergency plan that includes actions to shut down the simulator and associated equipment as detailed in this data sheet if shutdown does not actuate automatically.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 General

Simulators are found in various occupancies and used for a variety of reasons, such as training personnel in the travel industry (e.g., aviation, railroad). Sophisticated simulators are also found in amusement parks as rides. The motion control systems for simulators are either hydraulically or electrically operated.

3.2 Flight Simulators

The complexity and cost of training flight crews in large, turbine-powered aircraft have required the development and use of sophisticated flight simulator systems. The newer types of simulators can realistically represent every facet of flight control, including acceleration and deceleration, and they may employ a visual aid system for further realism. Simulator systems have been installed (or are under construction) for all sizes and types of aircraft, from large business jets up to the new generation of commercial jets. In addition, newer, more sophisticated systems are being installed to replace or supplement existing simulators for older aircraft. The values of these flight simulator systems can range up to US$10 million.

A flight simulator system has four major areas in which a serious fire may occur:

A. The simulator module, which is an exact replica of the flight deck of an actual aircraft (Figure 3.2-1). The module contains all of the flight control instrumentation of the aircraft (Figure 3.2-2), plus additional instrumentation for the instructor.

Fig. 3.2-1. Simulator module

Fig. 3.2-2. Inside a simulator module showing the flight control instrumentation of an aircraft

B. The electronic data processing center to which all of the module instrumentation and flight controls are connected. In some simulator systems, the electronic data processing equipment is an integral part of the simulator module. In most instances, however, the electronic data processing equipment is located in a separate room. Occasionally, it may be found in the same room as the simulator module.

C. The motion-control systems for flight simulators that replicate the conditions and forces (such as storms and high winds) pilots routinely encounter and must master as part of their training. Each simulator sits on six linear actuators that move the cockpit of the simulator to replicate the flying parameters of various aircraft. This is called a hexapod and enables the cockpit to travel in multiple directions or degrees of freedom. The linear actuators consist of a cylinder and piston that are telescopic, along with a ball joint/swivel to facilitate the upward, downward, and rotational movement. The linear actuators are controlled by either hydraulic or electric systems. These systems generate speed and power to help create a realistic flight simulation. Typically, the linear actuators are in sets of two, which forms an overall tripod. Below is a description of both types of motion-control systems:

1. Hydraulically operated motion-control systems (Figure 3.2-3). The hydraulic system has a main reservoir that feeds individual reservoirs for the linear actuators. The hydraulic system transfers energy and power to the linear actuators to move the simulator in the desired direction with the desired force. There is a complex system of solenoid valves on the hydraulic line that controls the flow of fluid to the module tripod to create the desired motion. In a large flight simulator system, the hydraulic system can have pumping rates up to 300 gpm (1150 L/min) at a pressure of 1800 psi (125 bar). Storage of hydraulic fluid may be in excess of 1400 gal (5300 L). Generally, the hydraulic oils used in flight simulator systems are not FM Approved industrial fluids. Flash points vary with the manufacturer but usually will be above 300°F (149°C).

2. Electrically operated motion-control systems (Figure 3.2-1). For these types of systems, electric motors and actuators are used instead of the hydraulic reservoirs at the base of the linear actuators. The actuators are commonly referred to as servodrives. A key component of the motion-control system is the ball screw. This translates rotation into linear movement. The ball screws and servodrives generate the energy and power to move the simulator in place of the hydraulic systems. They are connected to high performance microprocessors in the motion-control cabinet which communicate back and forth with the simulator host computer. Electrically operated motion-control systems have a lubrication oil system for each linear actuator. The lubrication oil is for the cylinder, piston, and ball screw to prevent internal friction involving the components and is under minimal pressure. Due to the small volume of oil used in the lubrication system, it does not typically create an unusual ignitable liquid fire hazard. Currently in industry, all of the new simulators being manufactured are electric. They don't require large volumes of oil and the recommended maintenance requirements are much less. This allows for more simulator time for flight training.

D. The simulator room or building, which may contain one or more simulator modules within an enclosure. In addition to the simulator module, these areas may contain electronic data processing equipment and various furnishings such as desks, chairs, and cabinets. The room may have a raised floor. With older simulator systems, small air-conditioning units may be located alongside the module to provide cooling and ventilation for the module.

Fig. 3.2-3. View of hydraulic system under simulator module (courtesy of SimTech Aviation)

4.0 REFERENCES

Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*
Data Sheet 4-0, *Special Protection Systems*
Data Sheet 4-2, *Water Mist Systems*
Data Sheet 4-9, *Clean Agent Fire Extinguishing Systems*
Data Sheet 5-31, *Cables and Bus Bars*
Data Sheet 5-32, *Data Centers and Related Facilities*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 7-98, *Hydraulic Fluids*

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 liquid, combustible liquid, inflammable liquid, and any other term for a liquid that will burn.

Very high flash point liquid: Liquids that meet one of the following criteria:

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 higher 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. Changed the title to *Flight and Other Simulators* (was *Flight Simulator Systems*).

B. Added guidance for electrically operated motion-control systems.

C. Added an option to omit protection from underneath a hydraulic simulator if certain conditions are met (Section 2.4.2.1).

D. Added further protection options for the interior of the simulator (Section 2.4.3).

E. Added guidance to be consistent with the recent revision of Data Sheet 7-32, *Ignitable Liquid Operations*, including the definition of “very high flash point liquids.”

July 2013. The following major changes were made:

A. Revised terminology and guidance related to ignitable liquid to provide increased clarity and consistency. This includes the replacement of references to “flammable” and “combustible” liquid with “ignitable” liquid throughout the document. The title of the document was changed to ″Flight Simulator Systems″ from ″Flight Simulator Protection″.

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

C. Added information to assist in evaluating the fire hazard scenario associated with flight simulators, which primarily includes those associated with hydraulic fluid and control rooms. Further guidance on these hazards has been added throughout the document. In addition, references to Data Sheets 7-98, *Hydraulic Fluids,* and 5-32, *Data Centers and Related Facilities,* have been included where applicable.

D. Expanded the guidance on the construction and location of flight simulators.

E. Revised the fire protection recommendations for flight simulators.

January 2000. The revision of the document was reorganized to provide a consistent format.