SAFESPILL

IGNITABLE LIQUID DRAINAGE FLOOR ASSEMBLY (ILDFA) DESIGN GUIDELINE for NEW BUILD AND RETROFIT AIRCRAFT HANGAR CONSTRUCTION

Version 2
Revised September 29, 2021

Safespill Systems, LLC

1900 Crosspoint Avenue
Houston, TX 77054
(713) 645-4370
www.safespill.com

Table of Contents

Table of Figures

1. Scope of Document

The scope of this document is to provide Ignitable Liquid Drainage Floor Assembly (ILDFA) design guidance for Architect & Engineering (A&E) firms in the early design stages of a new build hangar project or a retrofit project of an existing hangar. The goal is to provide sufficient information to specify an ILDFA for a project without the need of detailed input by the ILDFA manufacturer.

ILDFA is a new technology, therefore best practices, installation, and manufacturing improvements continuously evolve. Please check for the latest version of the document at safespill.com/hangars.

2. ILDFA Purpose

An ILDFA is designed to contain and remove ignitable liquid spills before developing into a pool fire. In its basics, it is a hollow aluminum extruded floor with a perforated top surface, connected to a trench system to remove any spilled liquid to an acceptable location (i.e., oil/water separator, containment system, or as directed by the local authority). In the event the spill is ignited, the ILDFA will rapidly control and extinguish the flammable/combustible liquid fuel fire.

One application of an ILDFA is for Class B (fuel) fire protection inside an aircraft hangar, which is accepted under NFPA 409 2022 Edition for Group 1 & 2 hangars in combination with an overhead sprinkler system. ILDFAs are approved under FM Approval Standard 6090. Additionally, the U.S. Air Force Civil Engineer Center (AFCEC) has verified fire test performance of the ILDFA. The U.S. Naval Facilities Engineering Systems Command (NAVFAC) has verified the daily operational use of the system and has various ILDFAs in use today.

3. Concrete Slab Requirements

The ILDFA has been designed and tested to support the maximum takeoff weight (MTOW) of any military aircraft under a compression load scenario. To specifically design a new build hangar construction, recessing the slab by 2 inches will provide a flush transition between the concrete floor and the ILDFA. In this scenario, no ramps will be required. When designing, please note the ILDFA will be installed directly onto the concrete slab but cannot be a part of the structural strength of the slab.

> E.g., A 12” slab thickness requirement for a hangar cannot be reduced to 10” with an ILDFA (the height of the ILDFA is 2” (50mm)); the slab needs to remain 12” thick. The slab plus the ILDFA will be 14” in this example.

The slope of the concrete slab should comply with NFPA 409, or in the case for Department of Defense aircraft hangars, UFC 4-211-01, Aircraft Maintenance Hangars. UFC 4-211-01 requires a slope with a minimum of 0.5% and maximum of 1.5% (0.3° to 0.85°). An ideal configuration will slope the concrete slab toward the hangar door entrance.

For retrofit hangar projects where there is no slope nor a consistent slope, there is a solution available to elevate the ILDFA with a girder frame. The frame will conform to the existing slab and create a slope for the ILDFA in the preferred direction. Please contact the ILDFA manufacturer for details on the above girder frame solution if necessary for a project.

4. ILDFA Ramps

For existing slabs, recessing the ILDFA is not practical. A 1:24 sloped aircraft entrance ramp will be installed inside the hangar door. A 1:12 sloped access ramp for all non-aircraft traffic sides of the hangar will be provided. Ramps are included in the ILDFA manufacturer's scope of supply.

5. ILDFA Hangar Coverage

A wall-to-wall coverage of the hangar floor will provide the greatest flexibility in an aircraft parking layout. The ILDFA may be able to be offset from the wall if there are aircraft hangar bay clearance requirements established by the owner, i.e., clearances from walls and fixed obstructions. However, in hangars where the aircraft have designated parking spots, a wall-to-wall coverage might not be necessary and significant cost can be saved by reducing the floor coverage. In a designated aircraft parking scenario, an 18 ft radius should be drawn from the outer edge of any potential area containing fuel in the aircraft, such as fuel tanks and engines. The 18 ft requirement is based on the largest lateral distance of a potential spill set by a flow rate of 400 GPM (worst case scenario). This ensures that all spilled liquid will land on the ILDFA. To view the report with spill radius data and scenarios, click here.

Two examples of an ILDFA hangar coverage are shown below in Figures 1 and 2.

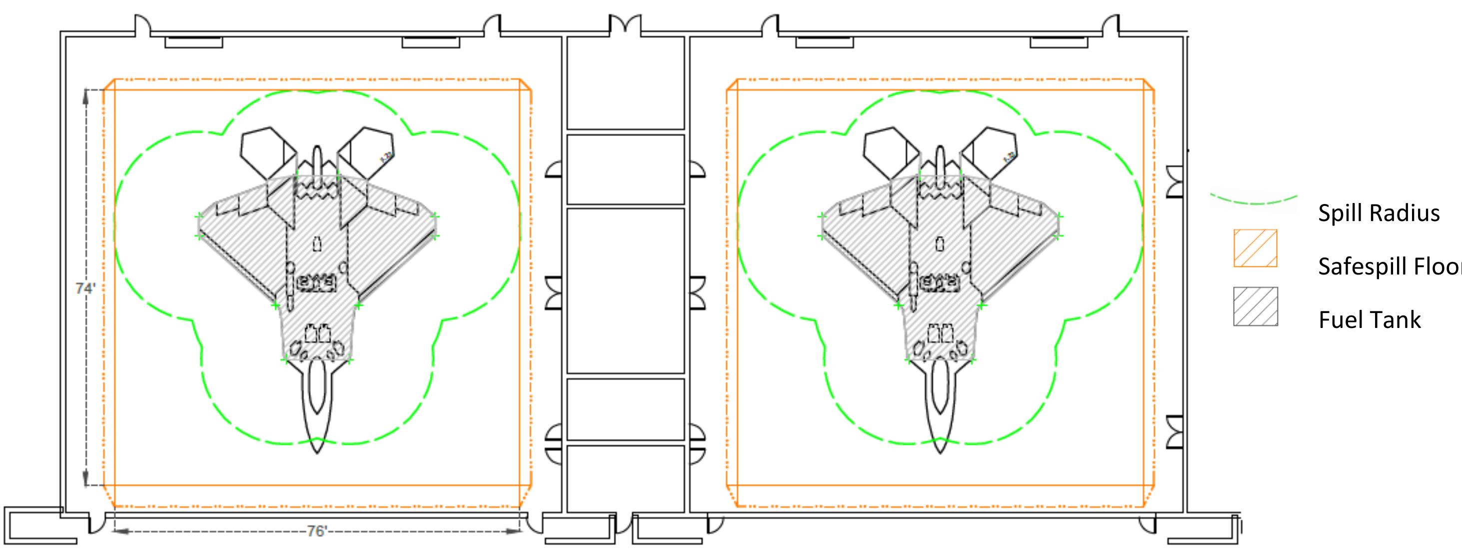

Figure 1: Example of a two-bay F-22 Raptor hangar with an ILDFA fixed to the spill radius.

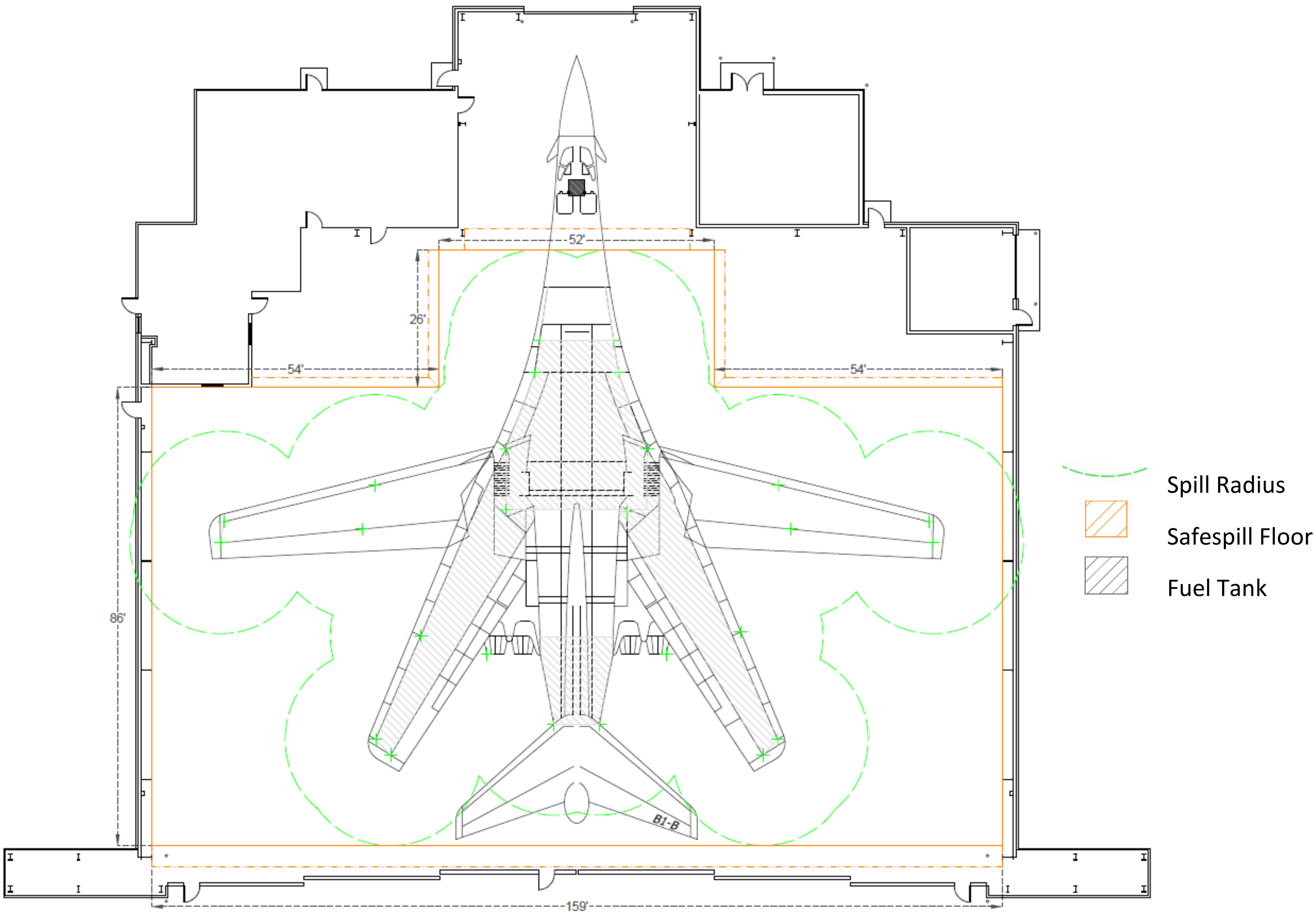

Figure 2: Example of a B1-B Lancer Hangar designed wall-to-wall due to large spill radius.

6. ILDFA Trench Design

The ILDFA will require a trench system to drain spilled liquid and flushing water. In a new build hangar construction, these trenches should be designed into the hangar slab.

For retrofit projects, the existing hangar slab will likely need to be cut and prefabricated trenches will be installed. In the case of thinner slabs (< 8 in thick), a cast-in place solution might be required.

Aircraft supported trench covers are included in ILDFA manufacturer scope.

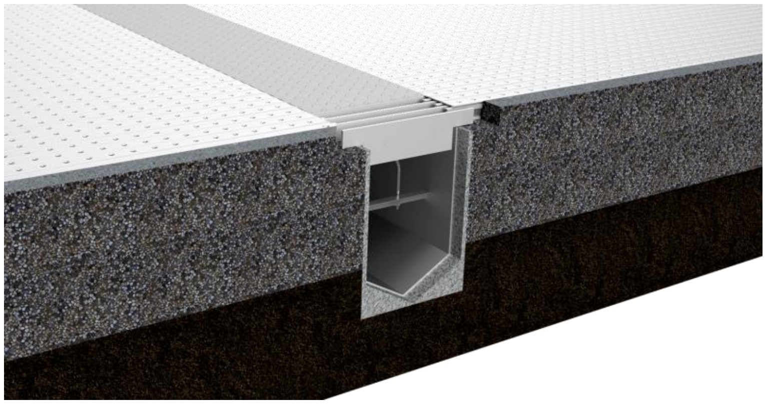

Figure 3: Render of recessed ILDFA and sub-grade prefabricated trench design.

The spacing of trenches is based on the following:

ILDFA sections are manufactured at standard 32.8 ft lengths. They are directly installed and connected to a corresponding trench that is 12 inches wide. This means the spacing of the trenches needs to be 33.8 ft (10,300 mm) from the center of each trench. ILDFA sections can be shortened; however, this should only be done if necessary as it will increase production cost.

E.g., A 90 ft deep hangar will have 2 trenches spaced at 33.8 ft and a third trench for the remaining length of (90’- 33.8’- 33.8') = 22.4’.

In this case, only one row of ILDFA sections will need to be modified to a custom length instead of three rows to 30 ft, therefore reducing additional production cost.

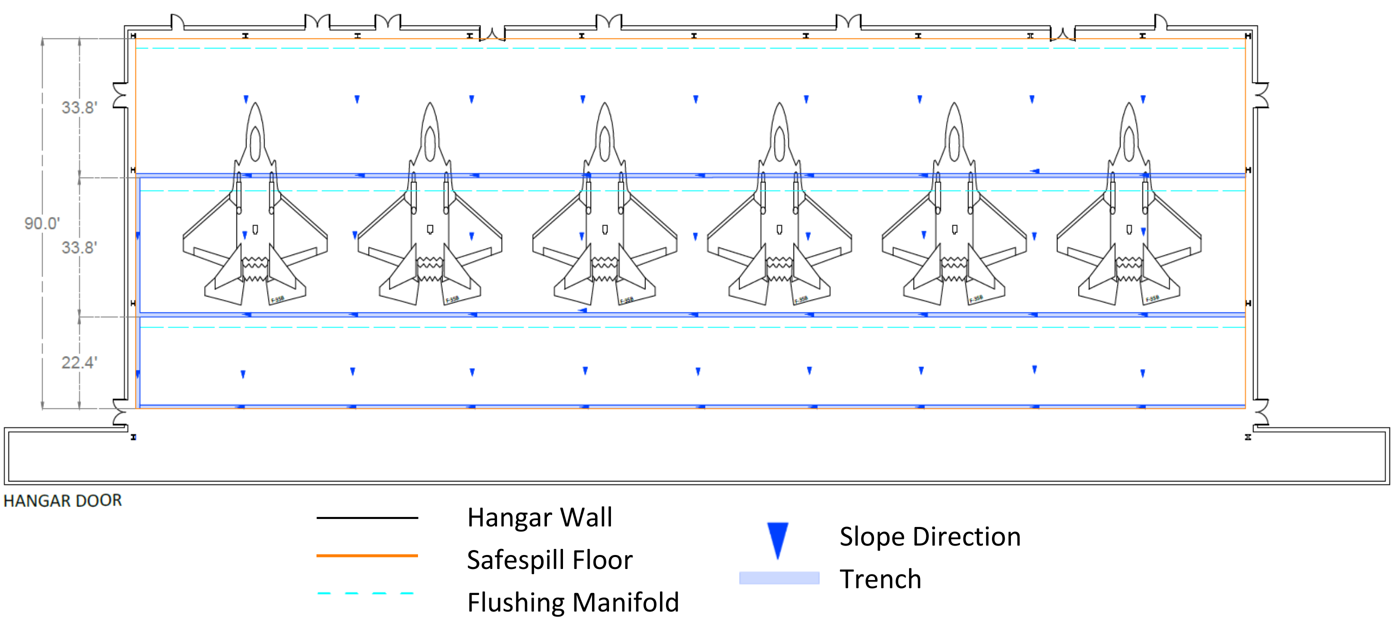

Figure 4: Trench spacing example for ILDFA design.

The ILDFA manufacturer requires prefabricated trenches to be installed for both new build and existing hangar scenarios. This solution reduces production costs and installation time. The internal slope of the trench is required to be a minimum of 0.5% (0.3°) to ensure liquid drains to the lowest point. The trench sections are made of prefabricated aluminum and include liquid sensor mounting positions, piping for the flushing manifolds, and house solenoid valves. The minimum depth of a trench should be 6 inches to allow for proper flow of spilled liquid. The maximum depth of the prefabricated sections is 17 inches. Based on a 0.5% (0.3°) slope, this results in a maximum trench length of 175 ft. For hangars wider than 175 ft., two trench sections can be mirrored in such way that the shallowest point of the trench is at the center and the deepest end of the trenches are at the outer hangar walls. Pump skids will be located at each end along the hangar wall to transport liquid from the trenches to external containment. Alternatively, the liquid can be transported by individual drain connection points to external containment.

7. Hangar Slab Access Points

Openings in the ILDFA to access tie down points or preconditioned air connection points are possible. Standard solutions are available for openings varying from 4 inches up to 12 inches. However, if a wall or overhead connection is possible, those should be considered due to openings in the ILDFA increase production cost and add complexity. A visual representation of an ILDFA access point solution is shown below in Figure 5.

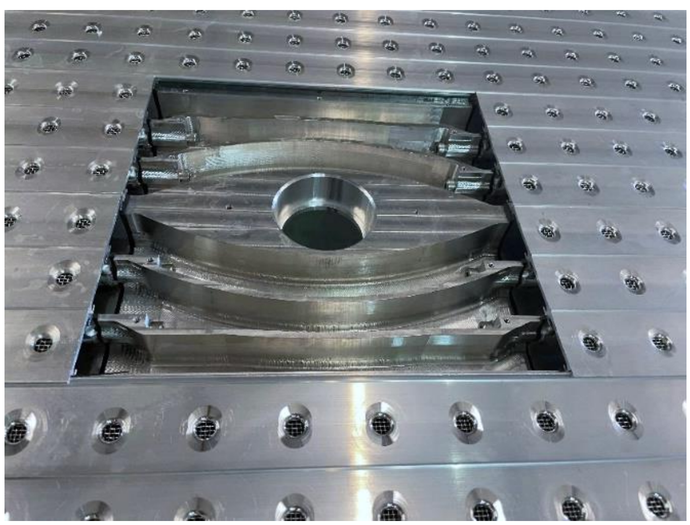

Figure 5: Trench spacing example for ILDFA design.

8. Grounding Points

Grounding points for aircraft grounding are integrated in the ILDFA and will be connected to the ILDFAs grounding grid. The ILDFA grounding grid will be connected to ground rods or building ground. An example of an ILDFA grounding point is shown below in Figure 6.

Figure 6: ILDFA grounding point example.

9. Liquid Containment Sizing

If containment of spilled hydrocarbons is required, there are two liquid containment solutions. The first is using gravity-fed drainage to an underground containment tank. In this case, a civil engineer will be responsible for designing the system, which is beyond the scope of this document.

In the event an underground containment tank is not preferred due to cost or environmental concerns, an above ground containment system can be used. This option can be included in the scope of the ILDFA manufacturer. The ILDFA will need to be equipped with pumps to remove liquid (hydrocarbon-based) from the lowest points in the trench system. The pumps will direct the liquid to a UL-142 Double-Wall steel aboveground tank.

Containment tank size calculations are based on the following:

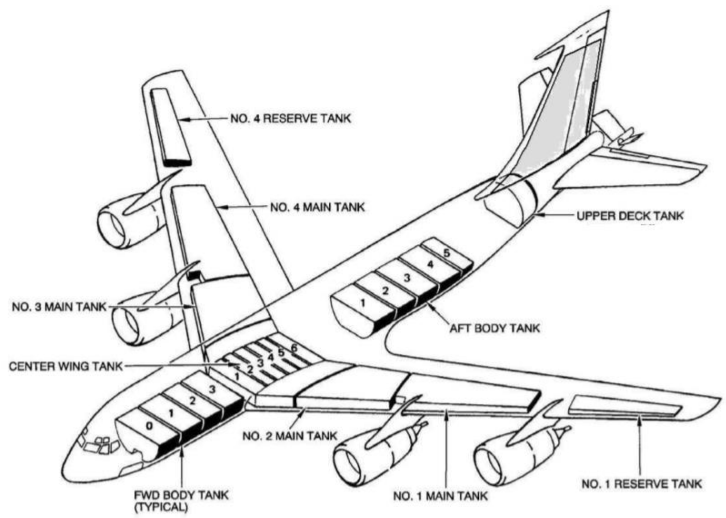

Figure 7: KC-135 Stratotanker fuel cell locations.

*(*Discharge spill rate referenced from Reballasting the KC-135 Fleet for Fuel Efficiency- Military Operations Research Vol.16 No.3 2011)*

When calculating the necessary spill containment tank for a larger aircraft, the largest internal fuel cell size for the largest potential spill (LPS) is used. However, for a smaller aircraft it is recommended to use the entire fuel capacity of the aircraft.

Example of KC-135 Spill Containment Calculation (Worst Case Scenario – WCS)

Largest Potential Spill	**7,270 gallons**	Largest Internal Fuel Cell
WCS Spill Flow Rate	400 GPM	Fuel Cell Puncture
Drain Time	7,270 / 400	= 18 min. (round up to 30 min.)
WCS Flushing Water	180 GPM x 30 min.	= **5,400 gallons** *(ref. pg. 11 for 180 GPM calculation)*
Spill Containment Tank	**12,670 gallons**	**(minimum capacity = LPS + WCS flush)**

For one KC-135 spill calculation, one 20,000-gallon UL-142 Double-Wall Horizontal steel tank is recommended, based on a conservative assessment in the above calculation. Multiple hangar bays can use one containment tank dependent upon location. The ILDFA manufacturer recommends to account for at least 30% additional capacity.

Based on heat flux data from fire tests, it is extremely unlikely that an ignited spill on an ILDFA produces enough heat to activate an overhead sprinkler. However, based on the relatively low amount of water produced by a sprinkler activation and the incremental increase in tank size needed to account for sprinkler water, it could be considered that 1,000 sqft (one ILDFA zone) would have sprinkler activation.

Total sprinkler water amount is found by using the sprinkler water density in NFPA 409, or in the case for the Department of Defense, UFC 4-211-01.

E.g., 0.17 GPM/sqft * max spill area 1,000 sqft * 30 mins = 5,100 gallons

Figure 8: Example of 20,000-gallon UL-142 steel aboveground tank; shown for reference only.

Due to the use of water as a flushing medium, water will be mixed in the spilled volume within the containment tank. To reduce the frequency of emptying the containment tank and to reduce remediation cost, an Oil Water Separator (OWS) can be included in the tank package of the ILDFA manufacturer's scope. The OWS will be controlled by the ILDFA hangar control panel and will automatically process the tank's liquid content after a spill has occurred.

The ILDFA pump skid system typically uses two 4" 15HP centrifugal pumps. The hangar layout, width, and number of trenches will determine if one or two pump skids are required. A 460/480VAC power supply of 50 amps is required per pump skid. Therefore, the hangar power supply should account for 100 amps.

10. ILDFA Piping and Instrumentation

A 110VAC control panel will be placed in a location inside the hangar that is accessible to emergency responders and maintenance personnel. Wiring from all electrical components, such as solenoid valves and liquid detectors, shall be routed to the control panel. A simplified example of an ILDFA Piping and Instrumentation Diagram (P&ID) is shown below in Figure 9.

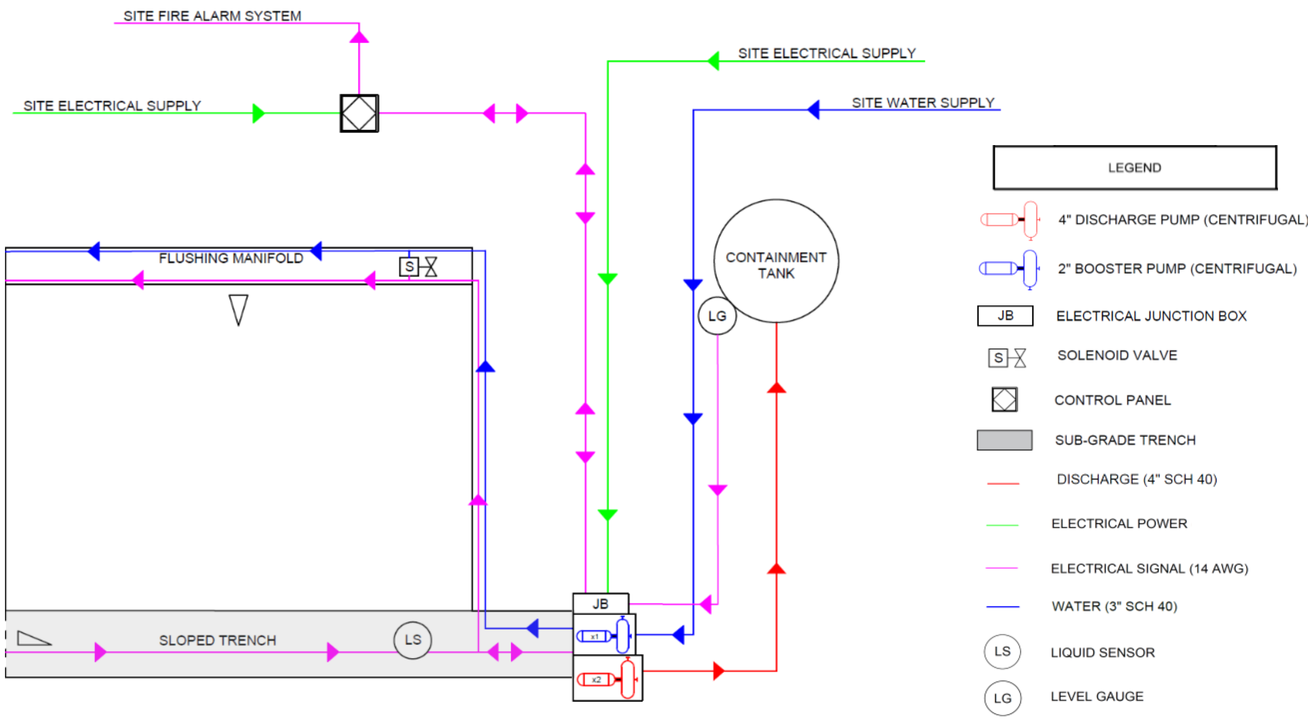

Figure 9: Simplified ILDFA Piping and Instrumentation Diagram (P&ID) of one zone.

An ILDFA is divided in zones of roughly 1,000 sqft. Each zone has its own fiber optic liquid detectors and flushing manifold. When a spill occurs, only the flushing manifold dedicated in that zone will activate. Each flushing manifold requires about 45 gallons per minute (GPM) of flushing water. In case a spill occurs on the corner of a zone adjacent to a zone in both x and y direction, 4 zones could detect a spill and activate all 4 flushing manifolds. In this case, 4 x 45 GPM will require 180 GPM as the worst-case scenario.

Please note, fire detection is not required for ILDFA operation. Consult with the local authority to determine if fire detection is required to activate the flushing manifold.

Figure 10 below is an example of an ILDFA that is 6 zones. The tie-in points represent what a third-party contractor will be responsible for. The ILDFA manufacturer does not include this in the scope of supply, however it can be added if necessary.

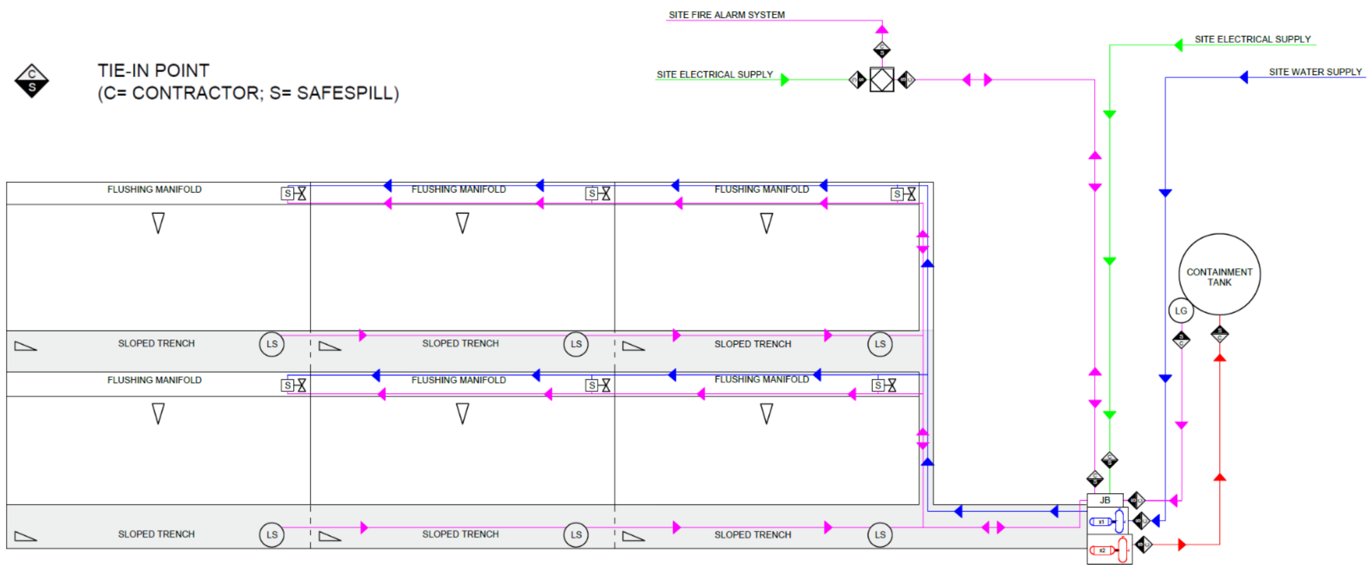

Figure 10: Six zone ILDFA P&ID with tie-in points.

11. ILDFA Water Requirements

An ILDFA requires water to flush the internal geometry of the zones. The ILDFA water requirement is 180 GPM (assuming 4 zones are activated). The flushing manifold will require a minimum of 2" water main connection. For larger hangars, the water main connection may need to be increased due to friction losses created by longer pipe runs. If providing a dedicated line to the hangar requires significant plumbing, a dedicated flushing water tank placed next to the outside hangar wall could be an alternative.

The flushing manifold operates at a minimum pressure of 60 PSI and a maximum pressure of 100 PSI. Depending on the water pressure of the hangar, a booster pump or pressure reducer can ensure the correct pressure will be supplied to the ILDFA.

The flushing water should not be connected to the hangar fire water main for the sprinkler water. If a spill occurs or the flushing system is used for cleaning of the system periodically, it should not activate the fire alarm system, which will likely be activated by flow switches in the fire main. It is recommended to use domestic water for an ILDFA.

12. Overhead Sprinkler System

Provide a sprinkler system as required by NFPA 409; in the case for Department of Defense, UFC 4-211-01; or local authority.

Note: When an ILDFA is installed, if an ignitable liquid fire occurs, it is unlikely that closed head sprinklers will activate if installed on a typical hangar ceiling based on reductions in spill size and heat release rate.