DRAINAGE AND CONTAINMENT SYSTEMS FOR IGNITABLE LIQUIDS

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1.0 SCOPE

This property loss prevention data sheet provides guidelines for the design of drainage and containment systems to minimize fire damage in areas using or storing ignitable liquids. The design of system components not directly related to fire protection, such as ignitable liquid/water separators and environmental protection requirements, are not covered, except by reference. Due to the many tiers of regulations (federal, state or provincial, and local), the variance in regulations from country to country, and the extensive nature of regulations within any given jurisdiction, this data sheet does not address environmental protection regulations, and is not intended to ensure that drainage systems are in compliance with those regulations. However, all recommendations are made with an awareness that applicable regulations may limit the design of drainage and containment systems. A properly designed drainage system provides the best level of environmental protection against any ignitable liquid fire by ensuring that all liquid goes to a predefined, controlled location.

The recommendations in this data sheet are a guide to key aspects that should be considered when designing ignitable liquid drainage and containment. This data sheet does not replace the need to have the system designed and constructed by a qualified person.

1.1 Changes

January 2015. Interim revision. Clarification on the containment needs for ignitable liquid storage of drums and IBCs was added (2.2.1.12).

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

Where containment and emergency drainage are recommended by other data sheets for ignitable liquid storage or use, follow the guidelines below to design adequate drainage and containment.

2.2 Construction and Location

2.2.1 Containment Design

2.2.1.1 Use any of the following where containment of ignitable liquids is needed:

- Curbs
- Liquid-tight walls sealed to the floor
- Depressed floors in the ignitable liquid area
- FM Approved spill barriers
- Grated trenches around the entire perimeter of any area that cannot be walled off

2.2.1.2 Use watertight floors in ignitable liquid areas to prevent leakage to unsafe areas (see Data Sheet 1-24, *Protection Against Liquid Damage*, for design information).

2.2.1.3 Use blank, liquid-tight walls sealed to the floor and make all openings into the ignitable liquid room from the outdoors, where possible, to provide the optimum containment. If interior openings must be made in these walls, arrange the openings to be above the level of the minimum curb height needed.

2.2.1.4 Construct a ramp or curb, as specified in this data sheet, across all interior doorways from the ignitable liquid room to prevent flow into adjacent areas. If ramps or curbs cannot be used, construct a grated trench at each doorway. Provide drains in the trenches as described in Section 2.2.3.

2.2.1.5 Arrange trenches at doorways to prevent liquid flow beyond the trench and through the doorway.

2.2.1.6 Extend doorway trenches a minimum of 3 in. (76 mm) beyond both sides of the door jamb (see Figure 1).

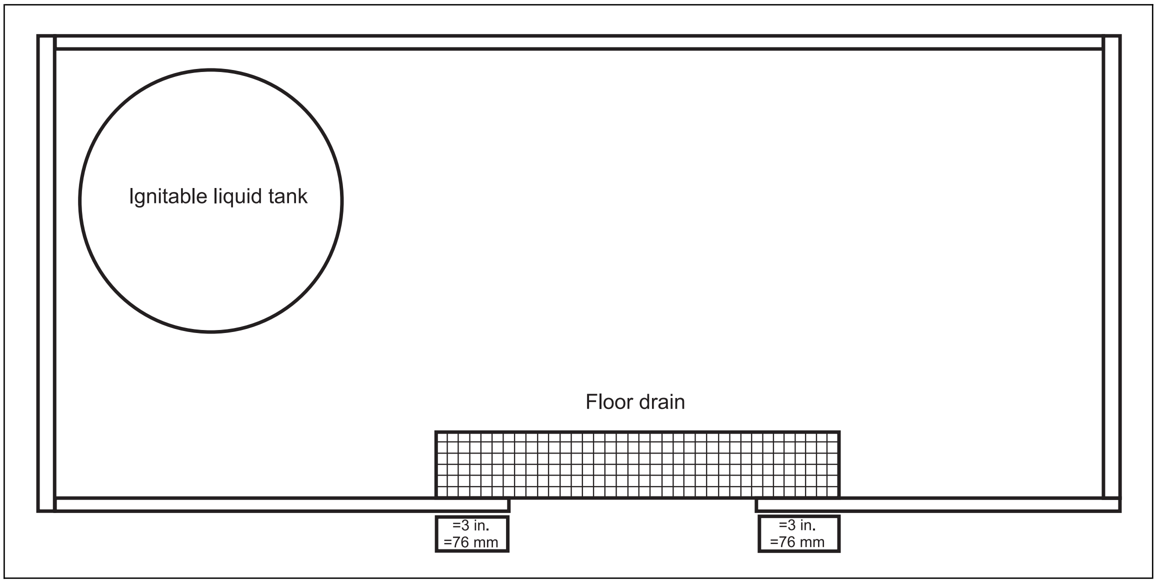


Fig. 1. Floor drain across a door opening

2.2.1.7 Provide a sufficient number of drains to provide an outflow capacity equal to or greater than the sum of the ignitable liquid spill and the automatic sprinkler discharge, where both drainage and containment are needed.

2.2.1.8 Where only containment is needed and perimeter and/or doorway trenches are used, install drains in the trenches. Size trench drains in accordance with Section 2.2.3, and to collectively handle the full sprinkler system demand of the contained area.

2.2.1.9 Provide curbs with a minimum height of 3 in. (76 mm) where curbing is provided in conjunction with adequate drainage.

2.2.1.10 Design curbs or ramps to confine the ignitable liquid spill and sprinkler discharge for the duration of the fire where adequate drainage is not provided.

2.2.1.11 Determine the minimum curb height needed to confine the total fluid content for the duration of thefire as prescribed in 2.2.1.10 above, using the following formula:

English:

$$H = \frac{1.6Q}{A} + 2$$

Where:
Q = maximum quantity of fluid that needs to be contained (spill and sprinkler discharge) (gal)
A = containment area (ft^2)
H = calculated curb height (in.)
2 = 2 in. allowance for freeboard

Metric:

$$H = \frac{Q}{1000A} + 0.05$$

Where:
Q = maximum quantity of fluid that needs to be contained (spill and sprinklers discharge) (L)
A = containment area (m^2)
H = calculated curb height (m) 0.05 = 0.05 m allowance for freeboard

Subtract the floor areas occupied by equipment and large tanks other than the chosen spill vessel from the containment area (A). This is especially important in rooms with many large tanks.

If H is greater than 3 in. (76 mm), use the calculated curb height as the minimum curb height. If H is equal to or less than 3 in. (76 mm), construct 3 in. (76 mm) high curbs.

2.2.1.12 Size the containment area for ignitable liquid storage of drums and IBCs such that the containment curb is located at least 2 ft (0.6 m) from the edge of the nearest container.

2.2.2 Spill Barriers

FM Approved doorway spill barriers can be used in place of, or to supplement, permanent containment features such as curbs. Their purpose is to prevent liquids, including ignitable liquids and water from sprinklers and hose streams, from spreading beyond the room of origin.

Their advantage over permanent containment features is their minimal impact on traffic flow across the room's threshold. However, this advantage needs to be balanced with the possibility of liquids escaping the room of origin while the barrier is moving into its final position.

2.2.2.1 Buoyancy-Driven Automatic Spill Barriers

2.2.2.1.1 Install the barrier on the interior side of the doorway. Installing the barrier on the external side may allow liquid to flow past the barrier prior to deployment.

2.2.2.1.2 Place the barrier flush with the walls and floor.

2.2.2.1.3 Install the barrier as recommended by the manufacturer. Use a grout or mortar recommended by the manufacturer in order to maintain the fire rating of the barrier.

2.2.2.1.4 Perform commission testing of the barrier after installation is complete, including, at a minimum, an operational test of the barrier using water. Conduct any additional testing as required by the manufacturer. Keep a written record of the commission testing.

2.2.2.1.5 Remove all liquid collecting in the sump promptly to avoid damaging parts that may be susceptible to damage caused by prolonged exposure to liquids. Follow the manufacturer's instructions for cleaning the barrier.

2.2.2.1.6 Conduct weekly visual inspections of the barrier. Items to check include, but are not limited, to the following:

- Check that no objects are located on top of the barrier (i.e. stock, equipment, fork lifts, etc.).
- Check for any signs of wear or corrosion. Replace any excessively worn or corroded parts.
- Inspect the whole assembly for damage or deformation.
- Inspect the seal for damage. If damage is found, replace the seal.
- Inspect the barrier flap for warping or other damage. Ensure the barrier flap sits level with the floor. Check to see if the vacuum seal of the barrier flap is intact, with no tears or punctures. Replace the flaps if the vacuum seal is broken.
- Inspect the springs for signs of corrosion or damage. Replace the springs if damage is discovered.
- Ensure the barrier and surrounding area are clean (free of debris and combustibles).
- Check that the sump collection area is clean. Remove any debris from this area.
- Ensure the lifting mechanisms and protection flaps are in the correct position and that nothing is present that would prevent the barrier from operating normally.

2.2.2.1.7 Clean the liquid-collection sump at least monthly to prevent a buildup of debris that may interfere with the operation of the barrier.

2.2.2.1.8 Conduct physical testing of the barrier flap at least quarterly. Maintain written records of the testing. Test the barrier in one of the following ways:

A. By lifting the barrier until the mechanism triggers and the barrier moves into its fully deployed position. Follow the manufacturer's guidelines when undertaking the manual lift test.

B. By pouring water into the sump collection area until the barrier activates. If using the water method to trigger the barrier, ensure all the liquid is promptly removed from the sump area after testing is completed.

2.2.2.1.9 Follow the manufacturer's instructions for maintenance and repair of the barrier. Use only replacement parts provided by the manufacturer or the manufacturer's authorized distributor if repairs are necessary. Prohibit anyone but the manufacturer from adjusting the tension of the springs.

2.2.2.1.11 Prohibit hot work from being conducted on or near the barrier. If hot work is unavoidable, adhere to the recommendations in Data Sheet 10-3, *Hot Work*.

2.2.2.1.12 Keep a written record of all inspections, testing, and maintenance performed on the barrier.

2.2.3 Drainage Design

2.2.3.1 Determine the type of ignitable liquid drainage system to be used based on the performance goals listed below:

- **Trench drain design**. Trench drains are used to curb an area and prevent liquid from flowing beyond the limits of the drains. The trench drains are located around the ignitable liquid containers or systems, at a doorway with the remainder of the space curbed, or arranged in a regular pattern to limit the size of the potential ignitable liquid pool. This design is intended to keep the level of liquid buildup to a minimum (less than an inch).

  With this type of design, the drainage system capacity (maximum flow rate) is limited by the smaller of (a) the capacity of the vertical outlet pipes within the trench drain, (b) the horizontal discharge pipe that the vertical outlet pipes are connected to, or (c) the inflow into the trench drains (determined by the total length of the perimeter of the drains and the grate free area).

- **Floor drain design**. Floor drains are used to remove the liquid from an area physically enclosed by curbs (bunds) or high crowns at the apex of sloped floors. In this case, the floor drains are typically located close to the center of the enclosed area containing the ignitable liquid containers or systems. This design is intended to contain a liquid and allow it to accumulate within the area and then drain it from the room so the buildup of liquid within the room is typically a few inches (e.g., 2-4 in.), but can be deeper. The flow rate through the drains will increase as the liquid depth above the drain increases, allowing greater drainage capacity. The disadvantage to this system is that burning ignitable liquids will spread to the limits of the curbed area, exposing equipment and stock to the fire.

  With this type of design, the drainage system capacity (maximum flow rate) is limited by the smaller of (a) the capacity of the vertical outlet pipes connected to the floor drains, or (b) the horizontal discharge pipe that the vertical outlet pipes are connected to.

- **Catch Basin design**. Catch basins are designed to remove the liquid from a room quickly by collecting it within a large basin. A catch basin design will limit the buildup of fluid within the contained area to a minimum (less than an inch). The collected liquid within the basin is used to develop sufficient hydraulic head to allow adequate flow capacity through the outlet and into the horizontal discharge pipes, rather than allowing the fluid to build up within the contained area.

  The floor is sloped so that liquid flows into one or a number of large catch basins, depending on the size of the curbed area. The catch basin is designed so that rate of liquid flowing into the collection basin equals the maximum outflow capacity (this occurs when the hydraulic head reaches its maximum height within the basin) rather than being held up in the room containing the stock or equipment. Due to the large hydraulic heads that can be developed in catch basins, the outlet pipe is typically horizontal.

  With this type of design, the drainage system capacity (maximum flow rate) is limited by the smaller of (a) the inflow through the drain grate, which is a function of the free area of the drain grate, (b) the outlet capacity of the basin drain, or (c) the capacity of the horizontal discharge pipes that the catch basin outlet pipes are connected to.

2.2.3.2 Arrange emergency drainage to limit the travel distance of spilled ignitable liquid to the drainage points, while also preventing it from flowing under storage or process equipment that is not involved in the initial incident. Refer to Section 2.2.7 for further details.

2.2.3.3 Design emergency drainage systems to handle the total combined liquid flow of the following:

A. The ignitable liquid flow rate in a piping system without an automatic interlock arranged to shut down the flow in the event of a fire

B. The water discharged from ceiling and in-rack sprinklers, water-spray nozzles, and other fixed fire protection systems (where open sprinkler deluge systems are used, include the operation of all systems within a 100 ft (31 m) radius)

C. Any production or domestic water normally discharged into the drainage system

D. Surface water at outdoor locations (see Data Sheet 1-40, *Flood*, for rainfall intensity)

2.2.3.4 Arrange piping from floor drains, trench drains, or catch basins as follows:

A. Size the piping from floor drains, trench drains, or collection sumps to adequately handle the flow collected as detailed in Section 2.2.3.3.

B. Provide traps where possible so discharged ignitable liquids will not continue to burn at the collection point.

C. Provide fittings and ports to facilitate inspection and cleaning.

D. Design and locate liquid separator tanks so liquid does not back up in piping between the hazard and separator.

2.2.3.5 Discharge emergency drainage systems to a storage location for recovery of ignitable liquids and waste water treatment. Where permitted by local authorities, provide a separator tank to remove ignitable liquids from the overall drain flow, or impounding basins to collect ignitable liquids if practical.

2.2.3.6 Size emergency drainage system impounding basins or collection facilities to hold the total drainage system discharge for the duration of the sprinkler operation, plus other liquids normally stored in the collection facility.

2.2.3.7 Provide space separation or diking and drainage between open ignitable liquid separator or collection basins and important structures or exposed property in accordance with Data Sheet 7-88, *Ignitable Liquid Storage Tanks*, using storage tanks of equivalent size and flashpoint as the exposing hazard.

2.2.3.8 Do not install control valves on drainage system piping. If a control valve is necessary, locate the control valve in an easily accessible location that is not exposed to burning liquid and is locked in the fully open position. Include these control valves as part of facility's routine fire protection valve inspection program.

2.2.3.9 Ensure drainage system piping is constructed of iron, steel, concrete, or tile.

2.2.3.10 Provide drains in the floor (e.g., trench drains, catch basins, floor drains) as described in Sections 2.2.4, 2.2.5, and 2.2.6.

2.2.3.11 Pitch floors toward drains with a slope of at least 1/8 in. per ft (10 mm/m) to minimize the fire size by limiting the area exposed to the spill, and to allow sufficient buildup of head over the drains for adequate flow to be achieved.

2.2.4 Trench Drain Design

Trench drains are preferable to standard floor drains for the following reasons:

A. Trench drains maximize the flow through the drain system by providing larger drain areas.

B. Trench drains can also be used to confine ignitable liquid spill fires where the liquid should not flow beyond the drain grating or to subdivide process areas, tanks, etc. (See Section 2.2.6 for examples.)

C. Trench drains can be used to limit the potential surface area of a pool fire. Reducing the surface area will limit the overall heat release rate and flame height, potentially reducing damage.

2.2.4.1 When trench drains are used as containment and drainage as described in Section 2.2.3.1, determine the capacity of the system as follows (refer to the example in Figure 2).

A. Determine the total amount of fluid that needs to be removed from the contained area (refer to Section 2.2.3.3).

B. Determine the total length of trench drain needed by dividing the total flow required by the trench drain inflow capacity per unit length (e.g., gpm/linear ft). If the inflow rate of the trench drain is unknown, use an inflow rate of 30 gal/min/linear ft (372 L/min/linear m) when liquid inflow is from one side of the drain and 60 gal/min/linear ft (745 L/min/linear m) when liquid inflow is from both sides of the drain.

C. Determine the flow capacity within the trench drain using Table 1.

D. Determine the size and number of vertical outlet pipes needed to accommodate the flow through the trench using Table 2.

E. Use Table 5 to determine the size of the horizontal pipe needed to adequately discharge the sum of the flows from all the vertical outlet pipes connected to the trench.

F. Check the adequacy of the trench drain design by ensuring the free area of the trench is at least 3 times greater than the total vertical outlet pipe area (if there is more than one vertical outlet drain, add the areas of each outlet pipe together).

2.2.4.2 Design trench drains to facilitate cleaning and to contain small routine spills (i.e. install the outlet pipe slightly above the floor of the trench drain).

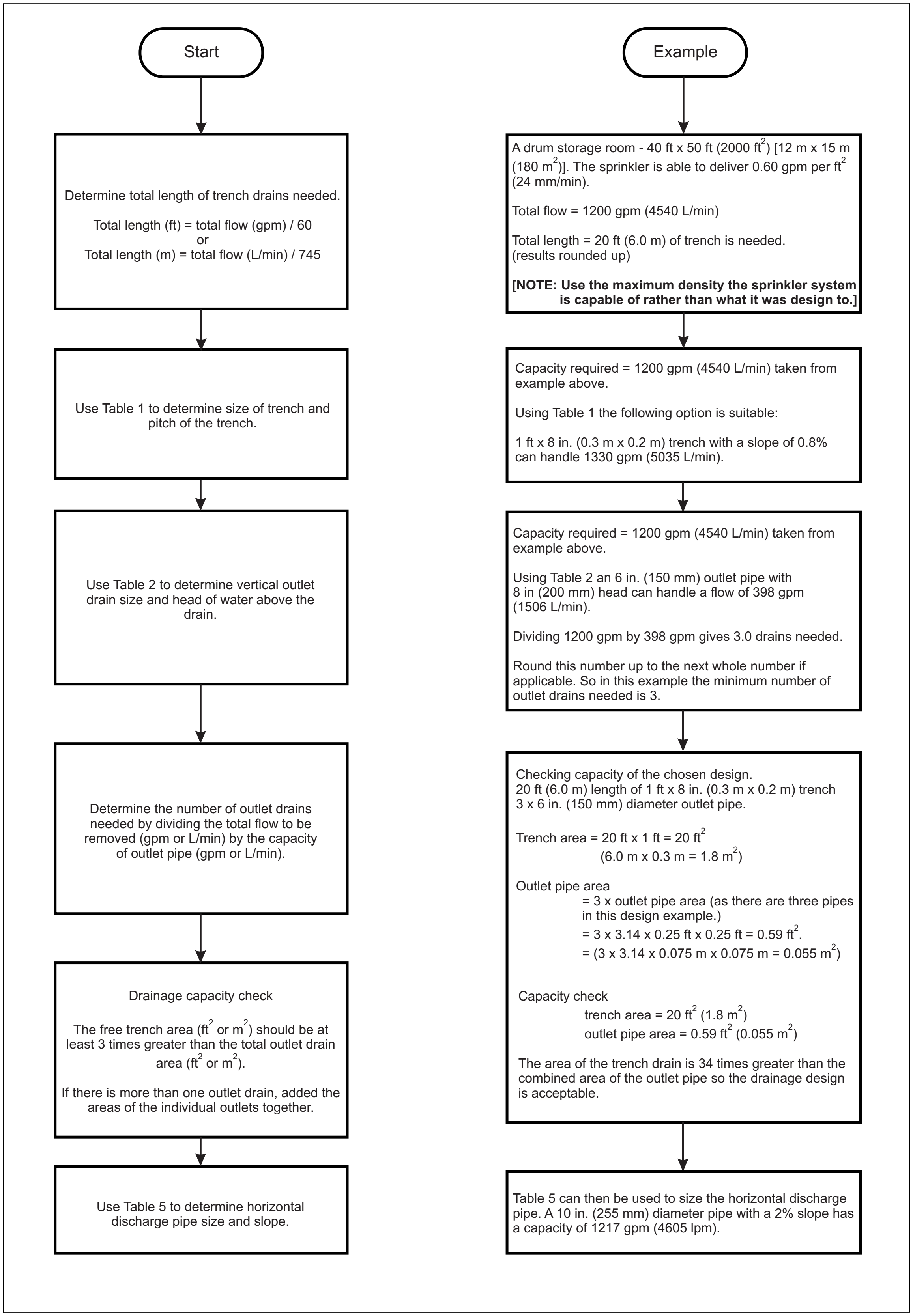


Fig. 2. Trench drain design flowchart

Table 1. Horizontal Trench Drain Flow Capacity

Trench Capacity (gal/min)				
Trench Dimensions per linear ft (W x D/linear ft)	Slope (in./ft)			
	1/10 (0.8%)	1/8 (1%)	¼ (2%)	½ (4%)
1 ft x 8 in.	1330	1490	2100	2980
1 ft x 1 ft	2210	2470	3500	4950
2 ft x 8 in.	3330	3720	5270	7450
2 ft x 1 ft	5800	6480	9170	13,000
2 ft x 2 ft	14,000	15,700	22,200	31,400

Note: Interpolation is appropriate

Trench Capacity (L/min)				
Trench Dimensions per linear meter (W x D/linear m)	Slope (m/m)			
	0.008/1 (0.8%)	0.01/1 (1%)	0.02/1 (2%)	0.04/1 (4%)
0.3 x 0.2 m	4830	5400	7630	10,800
0.3 x 0.3 m	8030	8970	12,700	17,900
0.6 x 0.2 m	12,100	13,500	19,100	27,000
0.6 x 0.3 m	21,000	23,500	33,300	47,000
0.6 x 0.6 m	51,000	57,000	80,600	114,000

Note: Interpolation is appropriate

Table 2. Capacity of vertical outlet pipes with no grate

Drain Dia [in.]	*2*	*3*	*4*	*6*	*8*
Head [in.]	Flow [gpm]				
0.5	4	8	11	17	22
1	7	14	23	47	63
1.5	12	19	31	64	105
2	18	29	39	79	131
2.5	24	39	54	93	154
3	29	49	69	107	177
3.5	32	60	85	134	199
4	34	70	101	162	220
5	38	86	133	219	303
6	42	94	167	277	390
7	45	101	180	337	479
8	48	108	192	398	569
10	54	121	215	484	754
12	59	133	236	530	943
16	68	153	272	612	1090
20	76	171	304	684	1220
24	83	187	333	750	1330

Note: Interpolation is appropriate

Drain Dia. [mm]	*50*	*75*	*100*	*150*	*200*
Head [mm]	Flow [L/min]				
13	15	31	42	64	85
25	26	53	87	178	240
38	45	70	115	234	387
51	66	107	145	292	482
64	88	145	202	346	572
76	108	181	255	397	650
89	117	222	315	499	732
102	125	262	376	604	823
127	139	314	495	813	1130
152	153	343	610	1030	1440
178	165	371	660	1250	1780
203	176	397	705	1470	2110
254	197	444	789	1770	2800
305	216	486	864	1940	3460
406	249	561	997	2240	3990
508	279	628	1120	2510	4460
610	306	688	1220	2750	4890

Note: Interpolation is appropriate

2.2.5 Floor Drain Design

Floor drains are commonly circular, but do come in a variety of shapes and sizes and are normally installed in areas with sloped floors. This section covers circular floor drains.

2.2.5.1 When a floor drain design is used as described in Section 2.2.3.1, determine the capacity of the system as follows:

A. Determine the total amount of fluid that needs to be removed from the contained area (refer to Section 2.2.3.2).

B. Determine the maximum hydraulic head that can be achieved within the contained area (maximum hydraulic head = height of the curb - freeboard).

C. Use Table 3 to determine the size and number of floor drains required. Note that the drain diameter in Table 3 refers to the pipe diameter, not the size of the grate or the diameter of the collection bowl within the floor drain.

D. Use Table 5 to determine the size of the horizontal pipe needed to adequately discharge the sum of the flows from all the floor drains connected.

E. If the floor drains have a diameter less than 6 in. (150 mm), adjust the number of floor drains in the design to account for the possibility of drain blockage. Increase the total number of floor drains needed by 50% where the total number of drains is four or fewer, and increase the number of drains by 25% where the total number of drains is five or more.

Table 3. Capacity of Circular Floor Drains

Drain Dia. [in.]	*2*	*3*	*4*	*6*
Head [in.]	Flow [gpm]			
0.5	9	16	21	31
1	15	30	49	89
1.5	23	40	66	135
2	30	55	82	167
2.5	35	67	104	198
3	39	78	123	227
3.5	41	87	140	264
4	43	94	155	299
5	46	104	180	361
6	50	112	198	414

Note: Interpolation is appropriate

Drain Dia. [mm]	*50*	*75*	*100*	*150*
Head [mm]	Flow [L/min]			
13	33	60	79	119
25	55	112	185	337
38	85	148	244	496
51	110	203	306	618
64	130	249	387	733
76	143	286	453	837
89	151	320	517	978
102	158	348	573	1110
127	170	382	662	1330
152	182	409	726	1520

Note: Interpolation is appropriate.

2.2.6 Catch Basin Design

2.2.6.1 When a catch basin design is used as described in Section 2.2.3.1, determine the capacity of the system as follows:

A. Determine the total amount of fluid that needs to be removed from the contained area (refer to Section 2.2.3.2)

B. Determine the inflow capacity through the grate of the catch basin using Table 4. Table 4 assumes the catch basin is square; if the catch basin is rectangular, calculate the equivalent side length of the basin using the following equation:

$$L_{eq} = \tfrac{1}{2}(L + W)$$

Where L_{eq} = equivalent side length (in. or mm), L = side length of the grate (in. or mm), and W = side width (in. or mm).

C. Apply the following location correction factors to the inflow capacity from Table 4 if the catch basin is located along a wall or in a corner. Multiply the inflow capacity by 0.75 if the basin is located against a wall, and by 0.5 if the catch basin is located in a corner.

D. Determine the number of catch basins needed to adequately remove the liquid from the room basedon the inflow capacity.

E. Determine the out-flow capacity of the catch basin using the following equation:

English:

$$Q = 5.7d^2 \sqrt{\frac{h-2}{1+k_e}}$$

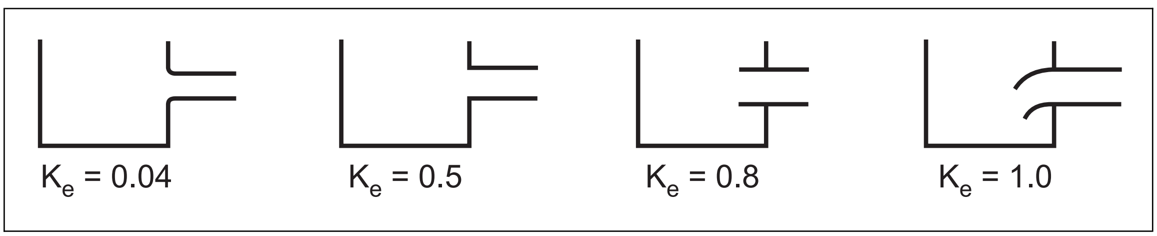
Where:
Q = Flow in gpm.
d = Diameter of the outlet in in.
k_e = Discharge coefficient.
h = Distance from floor to center line of outlet (in.)

Metric:

$$Q = 0.0066d^2 \sqrt{\frac{h-51}{1+k_e}}$$

Where:
Q = Flow in L/min.
d = diameter of the outlet in mm.
k_e = Discharge coefficient.
h = Distance from floor to the center line of outlet (mm)

Discharge Coefficient:



F. Use Table 5 to determine size of the horizontal discharge pipe needed to adequately discharge the flow from the catch basin.

Table 4. Inflow into catch basin with a grate having 50% or more free area.

Side Length (in.)	*4*	*6*	*8*	*10*	*12*	*14*	*18*	*22*	*26*	*30*	*36*	*48*	*60*	*72*	*96*
Flow (gpm)	28	54	72	89	107	125	161	197	233	269	322	430	537	645	860

Note: Interpolation is appropriate

Side Length (mm)	*100*	*150*	*200*	*250*	*300*	*360*	*460*	*560*	*660*	*760*	*910*	*1220*	*1530*	*1830*	*2440*
Flow (L/min)	105	203	267	334	400	480	614	747	881	1010	1210	1630	2040	2440	3255

Note: Interpolation is appropriate

2.2.6.2 Design catch basins to facilitate cleaning and to contain small routine spills.

Figure 3 shows one possible design for an inlet catch basin. The elbow on the intake outlet is removable to facilitate cleaning pipe feeding from drains. The elevation difference between the inlet and outlet pipes helps to retard flammable vapor spread. Small quantities of unignited, spilled liquids not involving high fire protection system water flows may be contained in the catch basins, to be removed with air-operated pumps or other fire-safe means without allowing ignitable liquids to flow into the site drainage system during a routine spill.

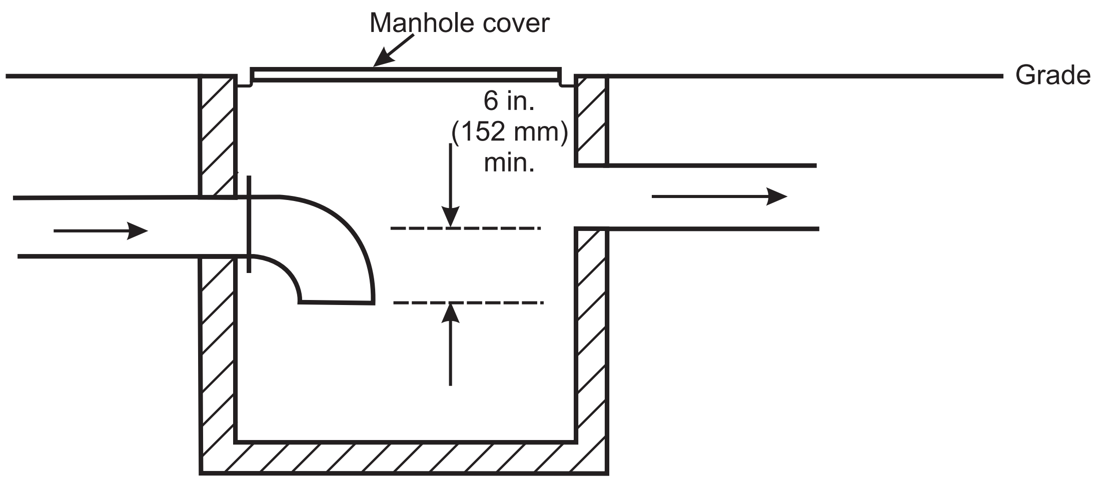


Fig. 3. Sealed inlet catch basin

2.2.6.3 Use catch basins with a dry box design similar to that shown in Figure 4 near fired heaters, such as hot oil furnaces, to collect spilled fuel oil, heat transfer oil, etc. arranged with separate drains through a sealed outlet into the drainage system to prevent accumulation of liquid beneath a potential ignition source.

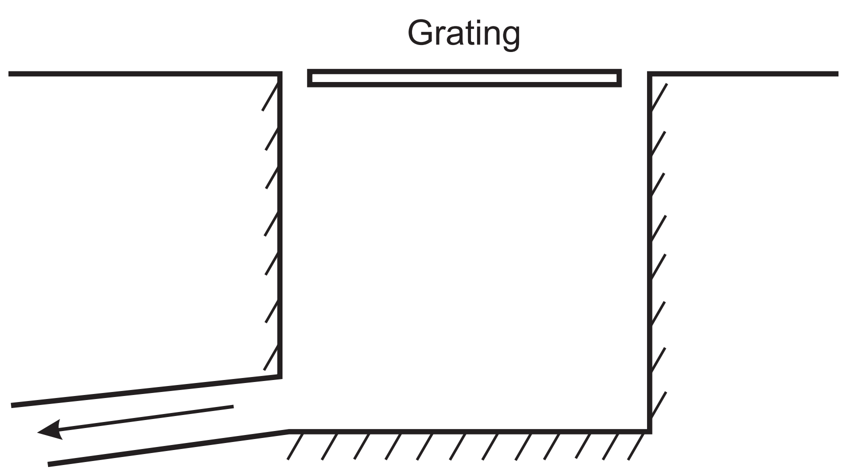


Fig. 4. Dry box catch basin

2.2.7 Horizontal Discharge Piping

2.2.7.1 Provide an adequate method of carrying the liquid that has entered the drain(s) to the point of disposal. In the case of standard floor drains, trench drains, and catch basins, this is accomplished by piping.

2.2.7.2 Use Table 5 to determine the size of the horizontal discharge pipe required. Ensure the capacity of the horizontal discharge pipe is sufficient to accommodate all individual vertical and horizontal discharge pipes that feed into it. (Refer to Figure 2 for a worked example.)

Table 5 shows the approximate capacities of common concrete or tile discharge pipes for low flows. Once the required flow is known, an appropriate pipe size and slope can be selected from the table.

Table 5. Horizontal Discharge Piping Capacity

English Units			
Diameter of Drain or Pipe (in.)	Horizontal Drainage Piping, gpm slope (in. per ft)		
	1/8 (1%)	1/4 (2%)	1/2 (4%)
3	35	51	75
4	75	110	159
5	135	197	286
6	219	318	463
8	466	678	986
10	839	1220	1770
12	1350	1970	2860
15	2440	3540	5150
Metric Units			
Diameter of Drain or Pipe (mm)	Horizontal Drainage Piping, L/min slope (mm/m)		
	0.01:1 (1%)	0.02:1 (2%)	0.04:1 (4%)
75	128	187	271
100	274	398	578
125	492	715	1040
150	795	1160	1680
200	1690	2460	3580
255	3210	4660	6780
305	5140	7470	10,900
380	9160	13,300	19,400

Note: Table 5 assumes concrete or tile drain pipes are used and is intended for approximate evaluations of drainage adequacy and for preliminary drainage layouts. Use of other pipe materials, unusually long pipes, changes in flow direction through fittings, etc. will affect the drainage system capacity.

2.2.7.3 Use a qualified drainage specialist to design emergency drainage systems and to create final working plans for drainage installations.

2.2.8 Drainage Layout

The location of floor drains in ignitable liquid areas can play a critical role in achieving control of a fire involving a liquid spill. Floor slope is an inherent design parameter that can have a dramatic effect on the performance of the drainage system.

2.2.8.1 Position drains and slope floors to achieve the following:

A. Prevent ignitable liquid from spreading from one process area or storage rack or pile to another.

B. Limit the potential surface area of an ignitable liquid pool.

C. Prevent the buildup of fluid across the entire floor area of the room.

D. Maximize the flow rate of ignitable liquid into the floor drains.

E. Prevent ignitable liquid flowing under racking or equipment.

Figures 5, 6, and 7 show examples of good drain placement.

2.2.8.2 Arrange drainage systems protecting multiple hazardous areas as follows:

A. Pipe the drains from each separate area to a catch basin in that area. This facilitates cleanup of minor spills within that area and minimizes the impact on the overall system.

B. Pipe the area catch basin aggregate drainage pipes into the main drainage system through manholes to facilitate inspection and cleaning.

C. Arrange the main drain or sewer pipe to discharge to a separator tank, retention basin, or other appropriate waste treatment process located a safe distance from important facilities to minimize fire exposure.

D. Locate the catch basins in each area in open sections of the protected area and away from important equipment and structures to minimize fire exposure.

E. Provide traps or seals on all inlets to the catch basins and manholes to impede flammable vapor spread.

F. Avoid connecting hazardous liquid drainage systems to drains from non-hazardous locations. Vapors have been known to travel in drainage systems into areas with unrestricted ignition sources, causing fire and explosion.

2.2.8.3 Provide smaller, separate, sloped floor drainage areas with individual drains at specialized equipment or operations that may have a higher frequency of spills, such as pumps that may develop packing leaks.

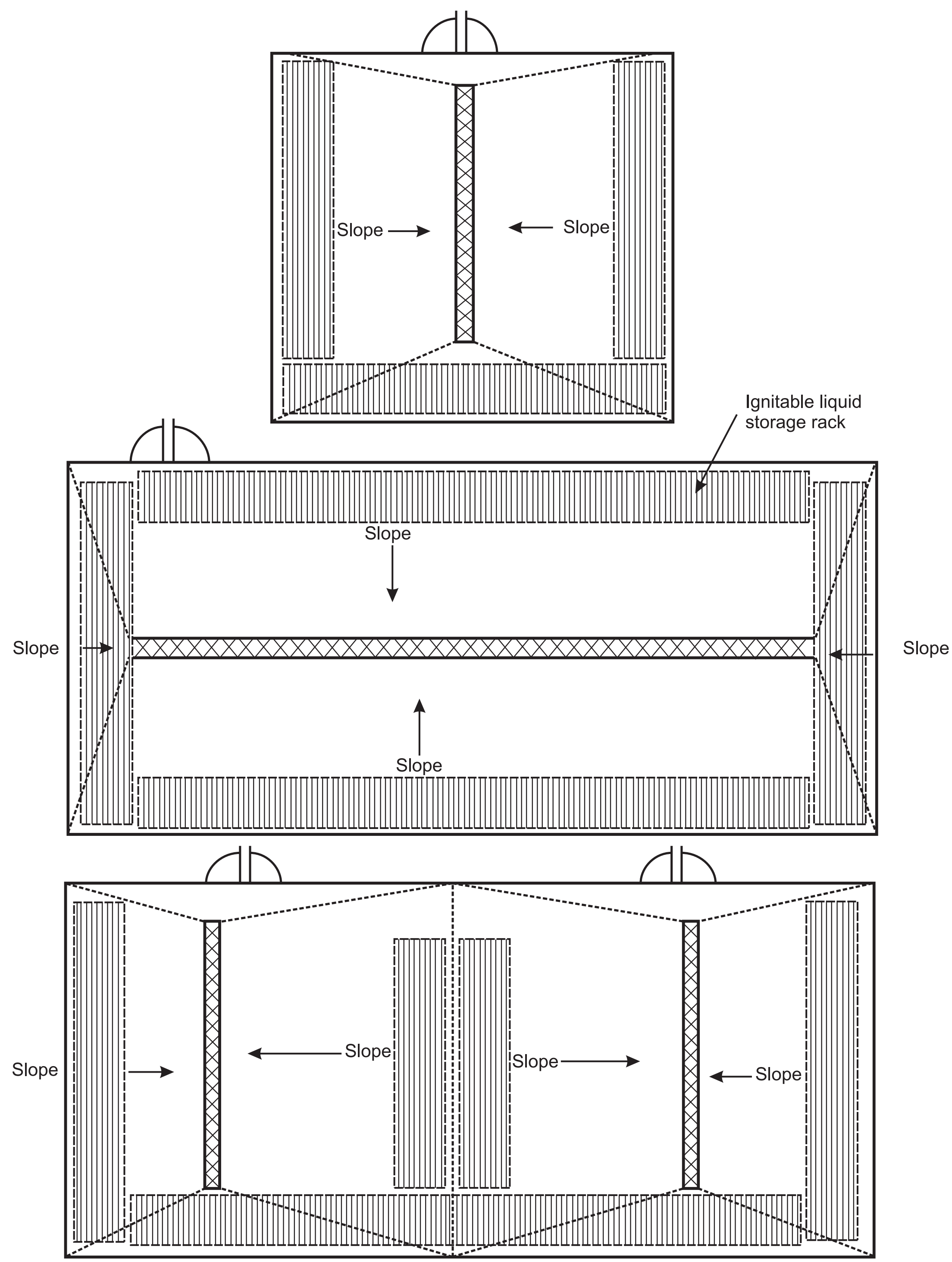


Fig. 5. Effective trench drain placement and floor slope

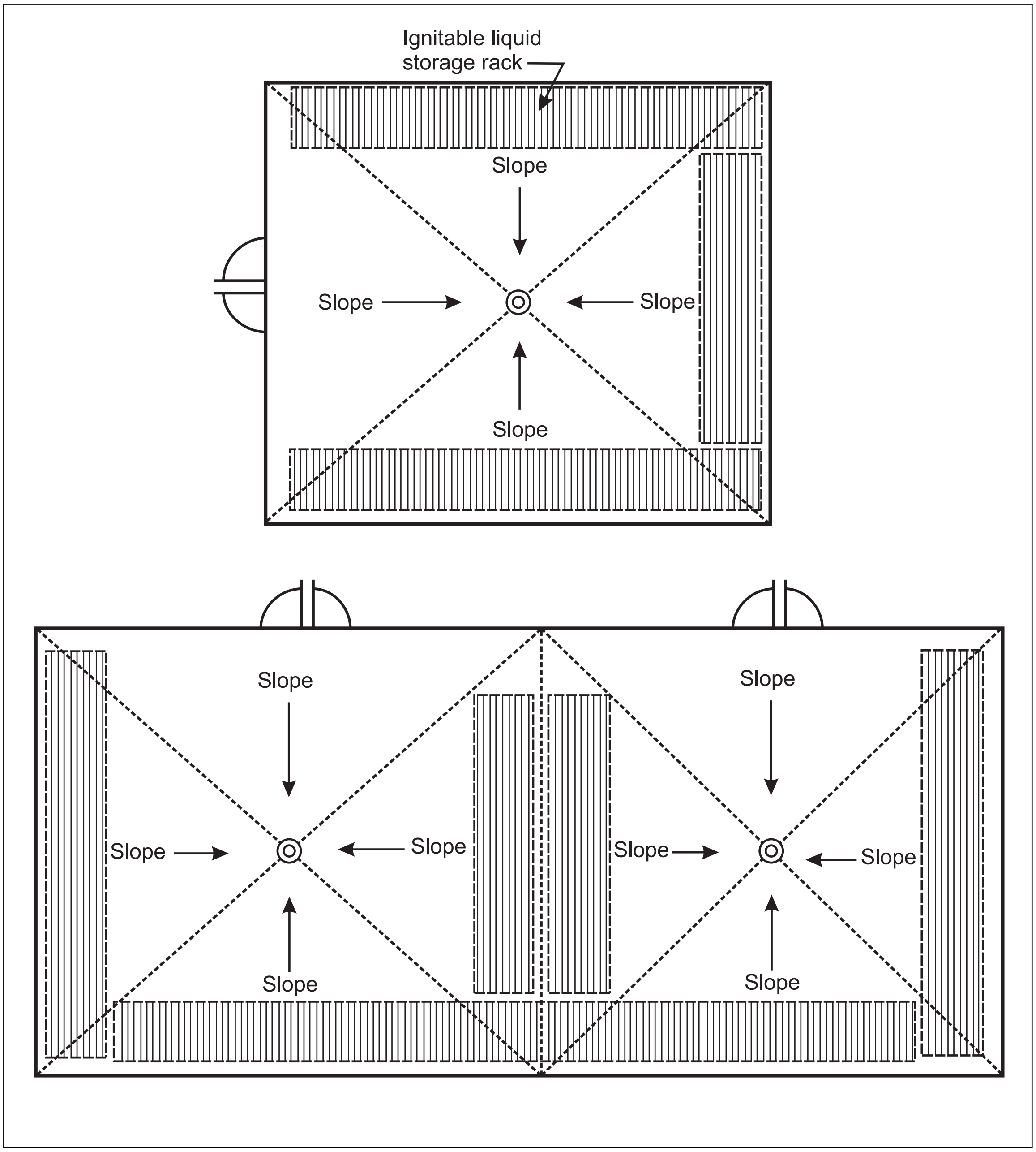


Fig. 6. Effective circular drain placement and floor slope

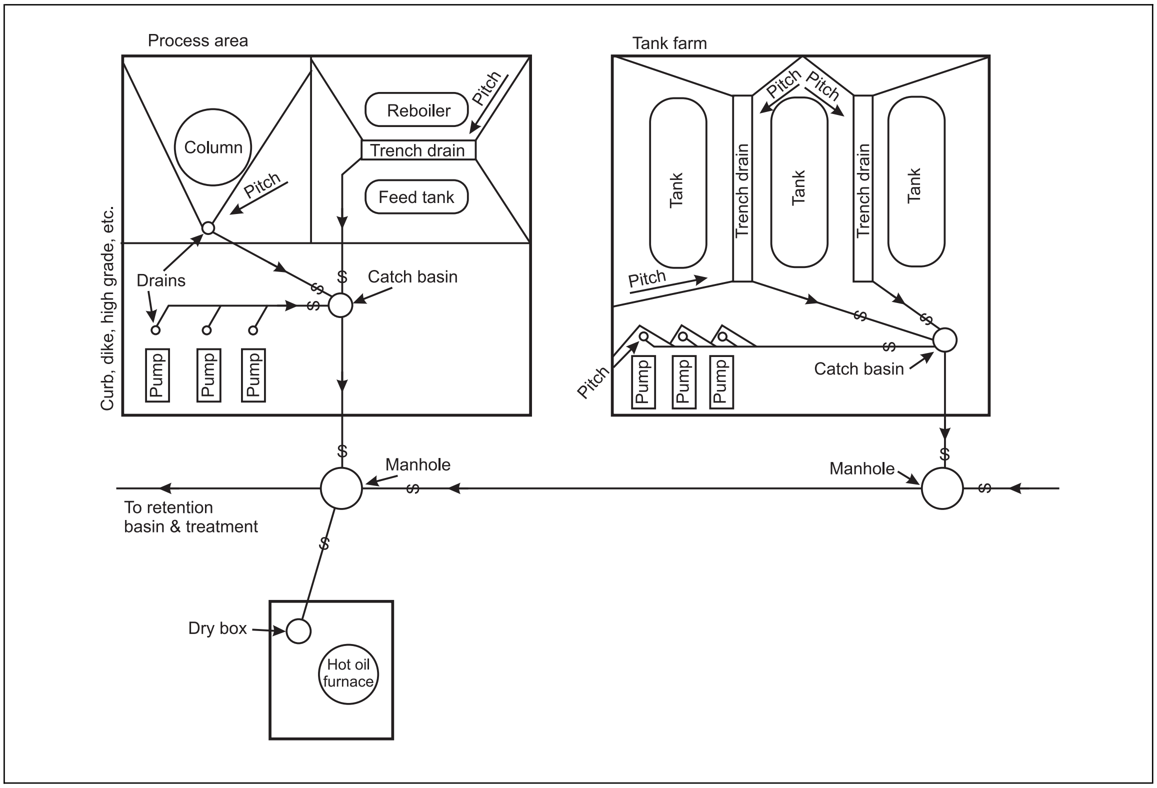


Fig. 7. Typical drainage system for a multi-unit outdoor facility

2.2.9 Wall Scuppers

Wall scuppers may provide adequate drainage where local conditions (including federal, state, and local regulations) allow their installation in accordance with the recommendations listed below. However, the use of wall scuppers will be impractical at some locations. If the criteria listed in the recommendations cannot be met, use another more suitable form of drainage.

2.2.9.1 Direct discharge from wall scuppers away from important facilities and neighboring properties to minimize the fire exposure. Burning ignitable liquids will likely be carried through the scuppers.

2.2.9.2 Direct the discharge from wall scuppers onto liquid-tight surfaces.

2.2.9.3 Limit the use of wall scuppers to rooms where the largest dimension is less than 150 ft (46 m).

2.2.9.4 Determine the approximate number of wall scuppers needed using Table 6. Increase the total number of wall scuppers by 25% and round up to the nearest whole number to account for blockage. This is the minimum number of scuppers needed.

Table 6. Wall Scupper Capacity

English Units						*Metric Units*				
Scupper Height (in.)	Maximum Flow (gpm)					Scupper Height (mm)	Maximum Flow (L/min)			
	Width (in.)						Width (mm)			
	4	6	8	12			100	150	200	300
1	11	17	23	34		25	40	62	83	125
2	30	46	62	95		50	108	168	228	349
3	51	81	112	172		75	188	298	409	629
4	74	121	167	260		100	272	442	612	952

Note: Interpolation is appropriate.

2.2.10 Alternatives to Drainage

Some properties, such as those located in urban areas or modern industrial parks, lack the space needed for large drainage systems. Also, local ordinances may prohibit outdoor drainage in some areas.

Where drainage installations are impractical, consider other alternatives that could reduce the ignitable liquid hazard, minimizing the fire exposure to important facilities. Refer to Data Sheets 7-32, *Ignitable Liquid Operations*, and 7-29, *Ignitable Liquid Storage in Portable Containers*, as well as other applicable occupancy-specific data sheets, for specific guidance.

2.2.10.1 Install an FM Approved special protection system, FM Approved for the ignitable liquid occupancy or storage arrangement. Refer to Data Sheets 7-32, 7-29, or the relevant occupancy-specific data sheet for information on which special protection systems are suitable. Note that total flooding special protection systems are a supplement to automatic sprinkler protection and do not replace the need for automatic sprinklers.

2.3 Operation and Maintenance

2.3.1 Conduct acceptance tests of new or renovated drainage installations to ensure effective performance as follows:

A. Where possible, test new systems with water flow equal to the maximum expected water flow during a fire.

B. Where large water flows are not possible, use the maximum practical flow from hoses to ensure adequate floor pitch, drain capacity, and containment.

2.3.2 Keep floor drains, trenches, catch basins, and wall scuppers clear of obstructing material.

2.3.3 Remove liquids from drainage system retention basins, tanks, etc., as needed to ensure adequate retention capacity.

2.3.4 Include drainage systems in monthly inspections of fire protection systems. Pay particular attention to the following:

A. Storage on top of drains or trenches that will reduce the flow capacity

B. Floor drain, trench drain, and catch basin grating plugged by spilled viscous liquids

C. Wall scuppers stuffed with rags to prevent drafts, or blocked by snow banks

D. Damaged gratings that may result in lift truck accidents and subsequent property damage

E. Valves in drainage system piping that are not in their proper normally open or shut position

F. Accumulations of surface and rainwater in drainage system containment ponds, basins, or tanks

2.3.5 Flow water through drainage system piping at least biannually to ensure it is open and to flush out debris.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Comments on Recommendations

Provision of emergency drainage is an integral part of adequate ignitable liquid protection. Other FM data sheets providing specific guidance for the protection of ignitable liquid storage and/or processing occupancies assume that adequate drainage is provided when needed.

Drainage is needed in areas where ignitable liquids are present for the following reasons:

A. To prevent ignitable liquid fires. Flow of unignited liquids from well-arranged ignitable liquid areas into unsafe areas can cause a fire.

B. To minimize the fire duration by removing the fuel. Automatic sprinklers or water spray can extinguish fires in liquids having flash points above 200°F (93°C), in liquids soluble in water, in liquids heavier than water, and in viscous, low flash-point materials. Fires in other ignitable liquids must be extinguished with special fire suppression agents or by removing fuel through drainage.

C. To minimize fire spread by preventing flow of burning liquid to areas exposing other equipment or facilities.

D. To reduce fire severity. The heat release rate from an ignitable liquids fire is proportional to the pool size. Properly arranged floor slopes, curbing, and drainage can reduce the area of the fire. (FM fire tests for protection of multilevel ignitable liquid process structures found that three-dimensional spill fires create a more severe fire exposure than floor spill fires. Curbs and drains prevent vertical flow to lower levels.)

To protect the environment from potentially hazardous materials. Public fire services may decide to withhold firefighting efforts where environmentally sound drainage is not provided.

From a fire protection perspective, drainage is needed wherever substantial quantities of ignitable liquid can be released.

For high flash-point or water-soluble liquids, containment alone may be sufficient to prevent fire spread until sprinklers extinguish the fire. For low flash-point liquids, drainage is aimed at removing the fuel while automatic sprinklers cool and protect the structure and equipment.

3.1.1 Floor Drain Design

Standard plumbing floor drains, normally used for wash down in mechanical rooms or similar spaces, typically have a free area of approximately 20% to 30%, which results in inadequate flow rates for ignitable liquid drainage purposes (see Figure 8). Industrial-style drain grates that are sometimes installed on trench drains and catch basins can have free areas up to 55% (see Figure 9).

Fig. 8. An industrial-style drain grate with a free area of approximately 20-30%

Floor drains consist of a sunken box with a flush grating. The floor gratings for commercially available round drains usually have a free open area approximately twice that of the outlet pipe to provide sufficient free grate area for drain flow rates adequate only for area and equipment wash down, but are not usually adequate for ignitable liquids drainage purposes. The nominal size of a standard round floor drain is designated by both the size of the drain body and the outlet pipe - not the diameter of the inlet grate.

Fig. 9. An industrial-style drain grate with a free area of approximately 50%

The capacity of a floor drain is limited by the lesser of three parameters: the flow rate through the drain itself including the grate, the flow rate through vertical piping attached to the drain sump, and the flow rate through horizontal piping either attached to the drain sump or attached to vertical piping which is in turn attached to the drain sump.

3.1.2 Drainage Layout

Properly designed drainage can reduce the damage to nearby equipment and the building structure in the following ways:

- Reducing or limiting the heat release rate by restricting the surface area of the pool of burning liquid. This is achieved by containing the spill area with adequate floor slope, or bounding the spill area with trench drains or curbing.
- Limiting the duration of the fire by reducing the depth of the pool of burning liquid by draining the ignited liquid away quickly.

Key factors in drainage design are placement of the drains and slope of the floor. In order to develop the flow rates necessary for good drainage, some depth of liquid has to build up over the drain. This liquid depth is known as the hydraulic head (usually measured in inches). Without an adequate floor slope, the pool of liquid that needs to develop to achieve an adequate hydraulic head increases in size. At the extreme, if the floor is flat (i.e., no slope at all), the liquid will fill the entire room (assuming there is a sufficient quantity of liquid) before reaching the depth needed to achieve the necessary hydraulic head for adequate drain flow. As the fire's heat release rate is proportional to the surface area of the burning pool, the heat release rate possible from the spilled ignitable liquid is maximized when there is no floor slope.

A bounding trench drain design can be used, in conjunction with floor slope, to limit the potential liquid spread and keep the fire hazard confined to the area of origin, similar to curbing. This applies equally to indoor and outdoor arrangements.

3.1.3 Types of Spill Barriers

There are several types of spill barriers available, including the following:

- Manual Spill Barriers - These need to be manually placed across the opening. They can either be normally in position and removed periodically when traffic needs to pass through the opening, or they can be stored close by and placed into position when needed.
- Sensor-Activated Automatic Spill Barriers - These barriers are normally positioned out of the path of traffic and, when activated, will move into place to form a barrier. The barrier is normally connected to a remote sensor, such as a liquid detection sensor, smoke detector, or a fire protection flow switch, that activates the barrier.
- Buoyancy-Driven Automatic Spill Barriers - These barriers are normally flush with the floor to allow the flow of traffic into and out of the room. They have a sump area for the collection of spilled liquids. The flow of liquid into the sump will trigger the buoyancy mechanism and activate the barrier. Once fully deployed, the weight of the spilled liquids, collecting behind the barrier, help keep the barrier in place.

  Currently, this is the only barrier type that has been exposed to a severe flowing pool fire and is FM Approved. Refer to the *Approval Guide* for further details.

3.2 Loss History

During the ten-year period from 1998 to 2009, FM clients reported 16 ignitable liquid fires where drainage was a factor. The average loss was US$8.4 million, with the largest single reported loss having a value of US$43 million (all amounts indexed to 2010 values).

Principal causes of these fires were hot surfaces, overheating, electrical spark or arc, and friction. Although drainage will reduce the damage from a fire, ignition sources must be controlled to reduce the frequency of fires in ignitable liquid occupancies as recommended in other data sheets.

Other factors that contributed to these losses include lack of automatic sprinklers, shut sprinkler system valves, inadequate electrical protection, inadequate ignitable liquid drainage and containment, insufficient operator training, and product storage arrangement.

4.0 REFERENCES

4.1 FM

Data Sheet 1-24, *Protection Against Liquid Damage*
Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 7-88, *Ignitable Liquid Storage Tanks*
Data Sheet 7-29, Ignitable Liquid Storage in Portable Containers
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 7-88, *Ignitable Liquid Storage Tanks*

4.2 NFPA Standards

NFPA 16, *Deluge Foam-Water Sprinkler Systems and Foam-Water Spray Systems*
NFPA 30, *Flammable and Combustible Liquids Code*

APPENDIX A GLOSSARY OF TERMS

FM Approved: References to ″FM Approved″ in this data sheet mean the products and services described 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.

APPENDIX B DOCUMENT REVISION HISTORY

January 2015. Interim revision. Clarification on the containment needs for ignitable liquid storage of drums and IBCs was added (2.2.1.12).

July 2013. Minor editoria changes were made. Information on types of spill barriers was moved to Section 3.1.3 from Section 2.2.2.

April 2012. The equations for determination of the out-flow capacity of the catch basin were simplified by using different units (Section 2.2.6).

January 2012. This document has been restructured as an installation guide that provides recommendations on how to achieve adequate drainage and containment. This data sheet no longer contains information on when drainage and containment are needed. Refer to Data Sheets 7-32, *Ignitable Liquid Operations*; 7-29, *Ignitable Liquid Storage in Portable Containers*; or the relevant occupancy-specific data sheet for guidance on when and where drainage and/or containment should be provided.

The methods for achieving adequate drainage and containment have been updated and simplified where possible. Changes in this revision include the following:

- Removed the recommendation for hose streams to be included in the capacity of drains and containment.
- Reduced the minimum curb height to 3 in. (76 mm) to align with other FM Global data sheets.
- Updated the table showing capacity of floor drains (Table 2) based on recent research and included new table showing capcity of vertical outlet pipes within trench drains (Table 3), and inflow into catch basins (Table 4).
- Replaced the nomograph for computing the capacity of circular discharge pipes with a equation to allow calculation of circular drains of various materials.
- Reorganized drainage options to promote good drainage design using trench drains and catch basins.
- Included guidance on limiting factors in the capacity of various drainage designs and how to calculate the flow through the drain grate for different drain designs.
- Added a section on automatic spill barriers.
- Added drainage capacity of inlet catch basins.

January 2000. The document has been reorganized to provide a consistent format.

September 1998. Document reformatted.

December 1990. This revision of the data sheet recognizes that increased concern for environmental protection is creating a two-sided fire protection problem.

APPENDIX C BIBLIOGRAPHY

1. Isner, Michael. ″$49 Million Loss in Sherwin-Williams Warehouse Fire.″ Fire Journal Vol. 82 (March/April 1988), NFPA.

2. National Fire Protection Association. *Water Spray Fixed Systems for Fire Protection*. NFPA 15. Quincy, Mass: NFPA, 1982.

3. New York State Department of Environmental Conservation. *Technology for the Storage of Hazardous Liquids*. New York: Bureau of Water Resources, New York State Department of Environmental Conservation, 1983.

4. Petroleum Association for Conservation of the Canadian Environment. *Bulk Plant Design Guidelines for Oil Spill Prevention and Control*. PACE Report No. 80-3. Ottawa, Canada: PACE Product Storage and Handling Committee, 1980.

5. Slye, O. M. ″Loss Prevention Fundamentals for the Process Industry.″ American Institute of Chemical Engineers, Annual Loss Prevention Symposium, March 6, 1988.

6. U.S. Government. Code of Federal Regulations, Title 40, Parts 100-149. Washington D.C.: U.S. Government Printing Office.