VENT SIZING FOR FIRE

CONSIDERATIONS FOR

EXTERNAL FIRE DURATION

Developed by the

DIERS USERS GROUP

ERS DESIGN FOR FIRE COMMITTEE

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Background

The methods for calculating heat flux to a vessel exposed to fire are well documented. API RP 520, 521, Standard 2000 and NFPA 30 are basic industry guidelines providing correlations to calculate this heat flux. Other guidelines are available for less general cases. Given the heat flux, a relieving rate can be calculated to prevent vessel damage due to over pressure. Considering height and geometry variables, the heat flux is calculated based on exposed vessel wall area which is wetted by internal liquids. Some add a contribution due to heat flux through unwetted surfaces.

Issue

NFPA and API provide guidance on calculating the steady state heat flux due to an external fire. However, they are silent on estimating how long a fire may burn. There are many factors to consider; heat up times, fuel inventories, drainage, curbing, dikes, firefighting capabilities and overall risk to the public, operating personnel, the environment and to equipment and supplies. Each of these factors and others must be considered when making design decisions on predicted fire duration. This document will try to expand on information already published to provide designers or HAZOP teams with guidance on this difficult issue. Even in an obvious fire-risk area, it may be possible, as explained in guideline #3 below, to support designing the relief system for a non-fire contingency.

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Guidelines

1.   All of these guidelines apply to vent sizing for the external fire case. As always, there may be additional over pressure scenarios that may apply. If one of the alternate scenarios requires a larger vent than the fire case, then the larger vent should be installed. If this is done, the fire case and its relieving rate should still be documented.

2.   Refer to the documents, "Vent Sizing for Fire Considerations for Special Equipment and Piping", "Vent Sizing for Fire Considerations for Jacketed Vessels" and "Vent Sizing for Fire Considerations for Heat Flux Variations Due to Fuel Composition" for additional guidelines that may apply to the case of small or unusually shaped equipment, exchangers and vessel jackets exposed to fire or fuels with unusual burning characteristics.

3.   Fire Hazard. The classic fire hazard is an accumulation of flammable liquid that could be ignited resulting in an extended duration pool fire that exposes process equipment. While areas containing flammable vapors or gases can have releases resulting in fires, the fire will normally be either a flash fire of very short duration or a directed flame at the leak point that can impinge on other process equipment. The flash fire does not last long enough to heat the contents of a vessel. The impingement fire can overheat a small portion of adjacent equipment and cause failure at the hot spot -pressure relief devices will not protect the equipment from this event. Consequently, industry practice is to not size relief devices for fire exposure for facilities that handle flammable vapors or gases only (no flammable or combustible liquids).

Note however, that pool fires are possible and have been documented for gases liquified by pressure. LPG for example, has been known to cause huge pool fires causing vessels to rupture due to excessive pressure and temperature.

While fires can occur wherever combustible materials are handled, the likelihood of a fire occurring from high flash point, Class IIIB, combustible liquids (flash point at or above 200 °F), when the liquid is not heated to within 30 °F of the flash point, is very small. (The flash point is the temperature of the liquid at which a flame will flash through the vapor in air when ignited. It corresponds roughly to the temperature at which the vapor pressure of the liquid equals the lower flammable limit in air. Flash points of chemicals can typically be obtained from MSDSs. For definitions of the Flammability Classes of liquids, see NFPA 30, paragraph 1.2, Definitions. Consequently, this document does not recommend sizing relief devices for fire exposure where the only fire hazard is Class IIIB combustible liquids that are not heated to within 30 °F of their flash points except for lube oil systems for large compressors or other equipment where an oil leak could be ignited by a hot bearing or other hot surface. This recommendation is supported by OSHA 29 CFR 1910.106, "Flammable and

Combustible Liquids" (OSHA 1910.106 is based on NFPA 30, 1969) which excludes Class IIIB combustible liquids. However, if a storage tank containing a Class IIIB combustible liquid or a non-combustible liquid is exposed by another fire hazard source, fire exposure relief is to be provided in accordance with the OSHA requirements.

Combustible solids are not normally considered to be a fire exposure hazard.

NOTES FOR TABLE 1:

Note 1: FP means flash point. Use closed cup flash point where available.
Note 2: Quantity in a single vessel or in vessels manifolded together / the potential flow into the area via pipeline.
Note 3: Table 1 shows the guidelines for determining if a fire area is a high, moderate, or low fire hazard. Fire durations shown later in these guidelines will be shown to depend on this degree of fire hazard in a given area.

TABLE 1
FIRE HAZARD RATINGS FOR LIQUIDS

Flammability Class Note 1	Handling Temperature			
	< (Flash Point minus 30°F)		≥ (Flash Point minus 30°)	
	Quantity (Note 2) (pounds/gpm)	Fire Hazard	Quantity (Note 2) (pounds or gpm)	Fire Hazard
I (FP < 100 °F)	≥ 10,000/50	High	≥ 10,000/50	High
	1,000 - 10,000/ 5 - 50	Moderate	1,000 - 10,000/ 5 - 50	Moderate
	<1,000/5	Low	<1,000/5	Low
II (100°F ≤ FP < 140°F)	≥ 10,000/50	Moderate	≥ 10,000/50	High
	<10,000/50	Low	1,000 - 10,000/ 5 - 50	Moderate
			<1,000/5	Low
IIIA (140°F ≤ FP < 200°F)	≥ 10,000/50	Low	≥ 10,000/50	Moderate
	<10,000/50	Low	<10,000/50	Low
IIIB (FP ≥ 200°F)		No Fire Hazard	≥ 10,000/50	Moderate
			<10,000/50	Low

4.   Heat Up Time. Heat Up Time (HUT) is defined as the time between the fire start with the vessel at operating conditions and the time where the vessel contents reach bubble point temperature at relieving pressure or the "no return" (or onset) temperature for reactive systems. HUT is a function of vessel geometry, vessel inventory, vessel fluid composition, the effective heat flux to vessel contents and the occurrence of any reactions which might accelerate or impede fluid temperature rise. HUT can range from just a few minutes to hours or even days. In general, HUT is compared to probable fire duration. If HUT is substantially longer, it may be a reasonable decision to design the

relieving system for a non-fire contingency.

In general, HUT can be calculated by modelling the system to be protected. In the simplest case, HUT may be (conservatively ignoring the heat needed to raise the vessel metal by ?T):

$$HUT = \frac{M\ CP\ \Delta T}{Q}$$

where:

HUT = Heat Up Time, hrs
M = liquid inventory in vessel, lbs
CP = liquid heat capacity at the midpoint of the temperature rise, BTU/lb-°R
?T = temperature rise from operating temperature to bubble point or "no-return" temperature at relieving pressure, °R
Q = steady state heat flux to the vessel, BTU/hr

5. Vessel Inventory. Assumed vessel inventory can significantly impact calculated heatup time. It may be necessary to consider a range of vessel inventories. Of course, when using API RP 520/521 methods, fire heat flux is a function of vessel fill level. If using NFPA methods, heat flux values are determined independent of fill level. However, it is probably unreasonable to use NFPA heat fluxes with low vessel fill levels when calculating heat up time.

    So, check HUTs at several inventory levels. If using NFPA or API-2000 heat fluxes, calculate HUT at the maximum likely inventory. If this results in a HUT low enough to justify vent sizing calculations, then proceed. If it results in an excessively long HUT, then calculate HUTs at lower inventories, say at 50% and 25% of the maximum inventory. At these lower inventories, lower HUTs may result. Of course, at lower inventories complete vapor-liquid disengagement is more likely and the vent may be sized for all-vapor flow. As has been stated many other places, this is probably a reasonable minimum vent size for most vessels exposed to external fire.

6. Viscous Systems. Be very careful when taking credit for long heat up times for highly viscous systems. Long heat up times are based on uniformly heating the entire vessel inventory to boiling or reaction onset temperature. Achieving uniform vessel fluid temperatures requires the establishment of convective currents to distribute the external fire heat from the vessel wall to its interior. As viscosity increases, the strength of these convective currents decreases. When this happens, vessel inventory temperatures become less and less uniform. At high viscosities, there can be significant differences between the fluid temperature at the vessel wall and fluid temperature at the vessel interior.

For non-reactive, boiling systems, this means boiling and pressure rise will occur in significantly less than the calculated HUT. For reactive systems, it can mean that if fluid temperatures at the vessel wall reach runaway reaction onset temperatures, then the runaway can start even if vessel average temperatures are less than onset temperature. Then, the reaction could continue even if the fire stops. In this case, it may be necessary to size the vent for an external-fire-driven runaway reaction.

7. Fire Duration. A calculated fire duration is only used to determine the size of a relief device for a decomposition or runaway reaction in a vessel or for determining the possibility of two-phase flow venting of liquid-filled vessels. For reactivity cases, if the fire is of sufficient duration, a decomposition or runaway reaction may be initiated. If the fire is not of sufficient duration, the relief device is sized on the basis of an indefinite duration fire without considering decomposition and runaway reaction as the sizing basis. The same type of reasoning is followed for determining the possibility of two-phase flow venting. If the fire does not last long enough to cause the relief device to open, the vent is not sized for two-phase flow, but is sized for all-vapor flow.

The degree of fire hazard is determined from Table 1. Once the fire hazard level has been established, the next step is to calculate the fire duration for each vessel of concern based on fire exposure from leakage of their own contents, leakage from vessels in adjacent areas, or pipeline leaks where the liquid flash point is less than 200 °F or where liquids are being handled at or above their flash points minus 30 °F. The burn area for consideration from adjacent vessels is the sum of the pad areas of the vessel of concern and the adjacent vessel. The highest calculated fire duration for each vessel is used unless it falls outside the limits for the degree of fire hazard as shown in Table 2, in which case, the minimum or maximum fire duration value is used instead.

Minimum and maximum durations are considered for storage areas and for process area fires. The following minimum and maximum fire duration limits apply:

TABLE 2
FIRE DURATION LIMITS

Duration	Storage Areas	Process Area Fire Hazard		
		Low	Moderate	High
Minimum	30 min.	30 min.	1 hour	2 hours
Maximum	4 hours	2 hours	3 hours	4 hours

Areas that only handle non-combustibles or high flash point combustibles (Class IIIB liquids) at temperatures below 30 °F below their flash points are not considered to be a fire hazard area. Liquids located close enough for a leak to spray onto hot surfaces (above 500°F) should be considered as having fire hazard potential. Experience has shown that high pressure combustible hydraulic fluids and lube oil for machine lube oil consoles can be ignited by hot bearings or other hot surfaces. The area where this type of equipment is located is considered to be a low fire hazard area.

8.   Fire Duration Calculations. A great deal of experimental data are available on the burning rate of flammable liquids in a pool. The experimental burning rate is not affected by pool diameter for fires larger than two meters. The size of the pool is often constrained by the dike containing the flammable material. In the case of continuous spills in undiked areas, the liquid will spread and increase the burning area until the total burning rate equals the spill rate (valid for liquid hydrocarbons released at temperatures below their ambient boiling point).

A fire duration can be calculated by determining the depth of liquid in a dike or drainage (collection) area and assuming that the liquid burning rate due to a pool fire is one inch per seven minutes. (Reference 1) Liquid runoff due to drains and/or trenches is usually ignored to obtain a conservative value. However, if the drainage or grading is designed to quickly remove liquid spills to minimize exposure to a vessel of concern, the fire duration can be significantly reduced. Five situations have been identified which can result in a fire of sufficient duration to raise the temperature of the contents of storage tanks or process vessels enough to initiate a runaway reaction.

A.   Catastrophic failure of one tank in a dike/area which contains other tanks that are exposed to a subsequent fire. The contents of the largest tank in the dike/area and the ground surface area are used to determine the liquid depth. See example 1.

B.   Self-leakage from a tank in a dike/area with the rate of leakage equal to the burning rate. The liquid burning rate and ground surface area are used to determine the leakage rate. The leakage rate and the volume of the contents of the tank are used to determine the fire duration.

C.   Leakage from a pipe (transfer line) with the resultant spill providing the fuel for fire exposure of the tanks in a dike/area. The leakage rate, duration of the leak, and the ground surface area are used to determine the liquid depth. An estimate is made of the time it takes to detect the fire and stop the flow (minimum of 15 minutes). The calculated fire duration is the time it takes to stop the leak plus the time it takes to burn the accumulated liquid. See example 2.

D.   Overfilling a tank with the resultant spill providing the fuel for fire exposure of the tanks in a dike/area. The liquid pumping transfer rate, duration of the spill (15 minutes minimum), and the ground surface area are used to determine the liquid depth.

E.   Leakage from a process vessel in a processing area that exposes another process vessel in an adjacent drainage area. See example 3.

Based on the availability of adequate fire fighting equipment, water and foam supplies, and trained personnel, minimum and maximum fire durations other than those calculated by the method described above can often be justified.

The calculation for determining fire duration is:

Fire Duration in Minutes   = $\dfrac{\text{(Spill Volume in Gallons)(12 in/ft)(7 min/in)}}{(7.48 \text{ gal/ft}^3)(\text{Burn Area in ft}^2)}$

Note: A first pass can be run using the total containment area and the largest vessel contents. If the fire duration calculated exceeds the maximum, then use the maximum.

Use the following considerations to calculate the burn area of the spill:

A.   The calculation considers the largest vessel in the containment area that contains a material with a flash point under 200°F, unless there is a material with a higher flash point handled at or above its flash point minus 30°F.

B.   The vessel is considered to leak at a rate equal to the burn rate. This provides the longest fire duration.

C.   The burn area is that area contained by curbing, diking, sloping pad, or artificial barrier, or an estimated circular area that would be expected to contain the vessel contents in the event of a failure. The area available is reduced by any area taken up by equipment, i.e., tanks supported on pads or skirts, located within the flooded volume.

D.   All drains, trenches, sewers, etc. are normally assumed to be plugged.

E.   Vessel of concern is assumed to be fully engulfed by the fire.

F.   Duration of pipe line leaks are estimated for each case considering the time to detect the fire and stop the leak with a minimum duration of 15 minutes.

G.   For a process area, the burn area for the calculation is the total area of the sloped pad that directs spills to the nearest sewer drain.

H.   For self-leakage cases where no natural or installed containment exists and a spill could engulf the piece of equipment in question, the spill should be modeled as a circle with the radius extending from the spill point and reaching five feet beyond the vessel.

I.   To calculate the burn area size, the following information and documentation should be available:

1.   Drawings that define the containment area for any spill.
2.   Sketches with the number, type and size of all tanks or equipment located in the burn area. Note the size of the largest vessel containing a flammable or combustible liquid.
3.   Materials being handled for process areas, or materials stored in tank farm areas.

Where the spill would subject other vessels to potential fire involvement, use a radius of 30 feet for the burn area with the center of the burn area located so the vessel is engulfed by the fire. If the radius still does not engulf the vessel, then the radius should be extended to reach five feet beyond the vessel being reviewed with the center of the burn area located between the spill and the vessel.

9.   Reduction in Fire Duration. Fire duration can often be reduced by isolating equipment, by providing intermediate dikes or curbs, by sloping process areas to prevent spills from flowing towards critical vessels, and by enlarging the burn area.

10.   Tank Cars and Tank Trucks. Tank cars and tank trucks present a unique problem in determining the fire exposure potential. Because of their mobile nature, it is hard to determine what area should be considered in calculating fire exposure and what fuel source should be considered. Drainage and diking cannot be considered as always being available to control fuel. For purposes of fire duration, tank cars should be considered as being subjected to full fire involvement for a duration of four hours and tank trucks for two hours.

11.   Fire Duration in Small Pilot Plants. In small pilot plant operations where the total fuel potential in an area is less than fifty gallons (based on one-half hour feed rate plus all interconnected vessel contents), the 30 minute minimum fire duration can be replaced by the actual calculated value or 10 minutes, whichever is greater.

12.   Maximum Contents Temperature with Water Spray Protection (Reactive Case).   Under ideal

conditions, water films covering the metal surfaces of a vessel can absorb substantially all incident radiation from fire exposure to the vessel. Water spray protection requires creation of a film of water on the top, sides and bottom of protected equipment. Individual nozzles mounted on a piping grid are used to provide complete coverage of the equipment. Single water spray protection requires sufficient nozzles to provide 0.24 gpm/ft^2 of coverage over the entire exposed surface of the vessel. A total of 0.04 gpm/ft^2 of water is assumed to be lost due to splashing. The remaining water is adequate to prevent excessive heating of the equipment. Double water spray protection (0.48 gpm/ft^2) requires twice the number of nozzles as those provided for single water spray. In both cases, nozzles must be provided every 12 feet of vertical height and underneath horizontal vessels to ensure that the falling water film does not boil to dryness.

When designing emergency relief for an uncontrolled reaction, as opposed to a boiling liquid case, the maximum wall temperature for a water-sprayed vessel can be used to eliminate runaway reaction as a credible scenario by maintaining the temperature of the process material below the exothermic onset temperature. Typical maximum temperature estimates are given below:

<u>Maximum Temperature</u>

Single Water Spray	194 °F
Double Water Spray	158 °F

Note: These values have intentionally been made conservative; it has been calculated that the maximum temperature of the vessel contents due to fire exposure with single water spray coverage is 140 °F.

Caution: For reactivity cases, water spray protection is assumed to be effective 5 minutes after initiation of the fire. Small vessels can be heated substantially above the temperatures shown above during the 5 minute delay in water spray application.

13.   Literature References. The above methods may be supplemented by the information provided by Lees (2), section 12.10.8 and section 16.7.2, and by Fisher and Forrest (1).

14.   Firefighting Capabilities. Consider also the capabilities of the responding fire brigade. Is it a dedicated, on-site unit familiar with the layout, equipment and processes used? Or, does this site depend on response from the local public fire company? In either case, do they regularly practice fighting the kinds of fires likely in this unit? If so, review practice response time data and refer to it in the design considerations documentation.

Review the fire water system: Are there adequate hydrants, monitors, sprinklers or water sprays?

15.   In any case, keep the fire brigade personnel informed. This is especially important if a maximum fire duration is used as the basis for designing emergency relief systems.

16.   The quality of fire protection of the plant structure will determine how long the structure can survive an extended fire. If the fire duration is long enough that the structure would weaken, it may not be necessary to provide fire relief for times after the structure is damaged beyond repair. At this point, the plant has been lost anyway. However, pressure relief may be appropriate to try to prevent injury to people (if they have not been evacuated) from exploding vessels. Further, depressuring the vessel by automated controls may be more appropriate than pressure relief by pressure relief valves.

17.   Note that providing a properly sized relief device does not necessarily assure that the vessel will not ultimately fail in a fire. Reclosing relief devices (pressure relief valves, etc.) maintain pressure in the vessel. If the fire continues long enough for vessels in liquid service, the metal of the vessel will become dry and develop hot spots if there is no reliable provision for water spray. Ultimately the vessel will fail near the set pressure of the device (see API 520-I, parts 3.3.2, 3.3.3, D.3.2 and D.5.2.4; API 521, App. A). For vessels in gas service, the rate of heating of the metal must be considered (API 521, App. A). See part 3.19 of API 521 for systems to lower the venting pressure level and thus reduce the severity of the consequences of vessel failure. Nonreclosing devices (rupture disks, etc.) do not hold pressure on the vessels if there is no superimposed back pressure.

If a fire has the potential to last long enough to cause vessel failure, other means of protection should be considered. Some possible other protection measures include water sprays, use of rupture disks instead of pressure relief valves and remotely-actuated depressuring facilities.

18.   When considering design options as a result of this document, it may appear desirable to avoid designing for the fire case by specifying higher vessel design pressures. In general, this option is not recommended as higher relieving pressures also involve higher relieving temperatures. Further, at elevated pressures and temperatures, fluid latent heats decline. Fire-sized relief devices protect vessels because of the cooling effect of boiling a liquid inside the vessel. In the extreme, once the vessel fluid becomes supercritical, the boiling effect is lost entirely and vessel wall cooling only occurs through natural convection. Consequently, designing a vessel for supercritical fire relief should be avoided where possible.

19.   Consider any other risk issues that may be present such as:

A.   Quantity and toxicity of fluids present
B.   Number and locations of workers and on-site personnel.

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C.   Proximity to public receptors such as houses, schools, hospitals, roads, etc.
D.   Consider the environmental risk if the process fluid escapes.

20.   The relief system design documentation package should evaluate HUT vs. fuel inventories, an estimated fire duration and the above other considerations. Try to be consistent within a plant site or corporation. Where appropriate, it may be reasonable to judge that an external fire may not cause a two-phase flow or runaway reaction over pressure event. Make sure that such a judgement has consensus in the affected operating organization and that it is well documented. Then, design the relieving system for fire-sized, all-vapor flow as well as all other applicable contingencies.

References.

1.   Fisher, H.G. and Forrest, H.S., "Protection of Storage Tanks form Two-Phase Flow Due to Fire Exposure", AIChE Summer National Meeting, August, 1994.

2.   Lees, F.P., "Loss Prevention in the Process Industries", First Edition, Volume 1, Butterworths, 1980.

3.   American Petroleum Institute "Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries", API Recommended Practice 520, Part 1, Sixth Edition, 1993.

4.   American Petroleum Institute "Guide for Pressure-Relieving and Depressuring Systems", API Recommended Practice 521 Fourth Edition, 1997.

5.   American Petroleum Institute "Venting Atmospheric and Low-Pressure Storage Tanks", API Standard 2000 Fourth Edition, January 1992.

6.   National Fire Protection Association, "ANSI/NFPA 30, Flammable and Combustible Liquids Code", 1996 Edition.

7.   H.G. Fisher, H.S. Forrest, S.S. Grossel, J.E. Huff, A.R. Muller, J.A. Noronha, D.A. Shaw, B.J. Tilley, "Emergency Relief System Design Using DIERS Technology (The Design Institute for Emergency Relief Systems (DIERS) Project Manual), The Design Institute for Emergency Relief Systems of the American Institute of Chemical Engineers, 1992.

8.   Center for Chemical Process Safety of the American Institute of Chemical Engineers, "Guidelines for

Pressure Relief and Effluent Handling Systems", 1998.

Examples

FIRE DURATION CALCULATION EXAMPLE 1

Determine the fire duration for the following case:

Tank A contains 20,000 gallons of a reactive flammable liquid (flash point of 70 °F). Tank OD = 12 ft.

Tank B contains 15,000 gallons of a non-reactive flammable liquid (flash point of 90 °F). Tank OD = 10 ft.

Tank C contains 30,000 gallons of ethylene glycol (flash point of 240 °F). Tank OD = 15 ft.

All three tanks are in a diked area (30 ft by 80 ft with 2 ft high dike).

All three tanks are flat bottom and have a pump-in rate of 200 gpm.

SOLUTION

The largest spill for a fire is 20,000 gallons. (Ethylene glycol has a flash point of 240 °F which is above 200 °F and is not a hazard unless heated above 210 °F.)

The burn area is the area of the dike minus the area taken up by the 3 tanks (2,032 ft^2)

The calculated fire duration is:

$$\frac{20,000}{7.48} * \frac{12}{2,032} * 7 = 111 \text{ minutes}$$

From Table 2, the allowable fire duration range for storage areas is 30 minutes to 240 minutes. So, use 111 minutes as the fire duration time.

Notes:

1.   The same fire duration applies for all 3 tanks.

2.   The tanks for which we need to know the fire durations for reactivity considerations are Tank A and possibly Tank C.

3. The pump-in rate did not enter into the calculation because it was assumed the tanks were full and not being filled.

4. The 2 foot dike is high enough to contain the entire spill (1.3 feet needed). If the dike was only 1 foot high, it would be assumed that the spill would occur slowly enough that it would not overflow the dike and the fire duration would be the same.

FIRE DURATION CALCULATION EXAMPLE 2

Determine the fire duration for the following case:

A 20,000 gallon, 12 ft OD, flat bottom storage tank containing a reactive Class IIIB combustible liquid stored at ambient temperature is in a curbed area by itself. The curbed area is 20 ft by 20 ft with a 6-inch high curb and a normally open drain. A flammable liquid line passes over the curbed area; the normal flow rate in the line is 200 gpm. Several operators work in this area so it is unlikely a fire will go undetected for more than 20 minutes. It will take about 5 more minutes to shut off the flow.

SOLUTION

The Class IIIB combustible liquid is not a fire hazard since it is handled at temperatures below the flash point. However, the flammable liquid line passing through the diked area does constitute a fire hazard.

The burn area is the area of the curb minus the area taken up by the tank (287 ft^2)

The liquid will burn at a rate of 1/7 inches per minute or about 25 gpm. (287 ft^2 * 1/7 inch/minute $\approx$ 25 gpm) As it is assumed that the drain is plugged for fire duration calculations, the liquid will overflow the curb until the flow is shut off. The fire duration will be the time from when the fire starts until the flow is shut off plus the 42 minutes it takes to burn off 6 inches of liquid depth. Fire duration = 42 + 25 = 67 minutes.

From Table 2, the allowable fire duration range for storage areas is 30 minutes to 240 minutes. So, use 67 minutes as the fire duration time.

FIRE DURATION CALCULATION EXAMPLE 3

Determine the fire duration for the following case:

> A process vessel containing 1,000 gallon of flammable reactive liquid (flash point of 80 °F) is located in a 20 ft by 20 ft bay sloped to a central drain. A vessel in an adjacent area contains 2,500 gallons of combustible liquid (flash point of 120 °F). It is located in a 20 ft by 25 ft bay sloped to a central drain. This vessel has a feed rate of 25 gpm that could continue during fire exposure; flow out of the vessel is level controlled so it will stop on leakage from the vessel.

SOLUTION

There are two cases to examine, self-leakage and exposure from the vessel containing the reactive chemical and exposure due to leakage from the adjacent vessel.

For the self-leakage case, it is assumed that the drain is plugged and the leak fills the 20 ft by 20 ft sloped area and leaks out at the burn rate. This produces the largest fire duration.

The calculated fire duration is:

$$\frac{1,000}{7.48} * \frac{12}{400} * 7 = 28.1 \text{ minutes}$$

For exposure from the adjacent vessel it is assumed the spill flows into both drainage areas (total floor area = 900 ft^2), the drains are plugged and the leakage rate equals the burn rate. Assume it takes 30 minutes for someone to stop flow to the vessel.

The total quantity that can leak out is 2,500 gallons plus 25 gpm x 30 minutes = 3,250 gallons.

The calculated fire duration is:

$$\frac{3,250}{7.48} * \frac{12}{900} * 7 = 40.6 \text{ minutes}$$

From Table 1, it is determined that (for the fluid from the 2500 gallon tank) this is a moderate fire hazard area so from Table 2, the fire duration limits are from 1 hour to 3 hours. So, use the minimum 1 hour as the fire duration time.

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