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Revision Memo

12/01	Page 1	Added 5 new headings, Definitions, Source Water Quality, and First Phase Fire Fighting Systems / Equipment, Selection of First Phase Fire Fighting Equipment, Automation / Remote Operation, Sprinkler Systems. Deleted "Sprinkler" from Fixed Water Spray Sprinkler and Deluge Systems. Deleted Portable Foam Columns and Trailer Mounted Fire Pump. Amended Water Capacity Design Rates to Water Flow Rate Determination and Major Fire Risks and Fire Fighting Methods to Major Fire Risks, Fire Fighting Methods and Considerations
	Page 4	Scope; Expanded to better reflect document content. References; Added references to Onsite Design Practices XV-F/G/H/K, Marine Terminal Design Practice XXXI-I, GP 14-3-1, TMEE 0073, NFPA 11, NFPA 13, NFPA 15. References. Updated titles for GP 3-2-1, 3-2-2, 3-10-1, 17-1-1. References. Deleted GP 3-2-5, 17-2-1, EE.50ER.68, EE.7TT.77. Added Definitions and included High Flash Tankage, Low Flash Tankage, Incipient Stage, First Phase Fire Fighting.
	Page 5	Single Fire Concept: Amended wording. Major Fire Risks, Fire Fighting Methods and Considerations. Title changed to better reflect expanded content. Introduced the concept of "incipient stage" and "first phase fire fighting" Factors to note in designing and specifying fire fighting equipment are listed.
	Page 6	Water Flow Rate Determination. Title amended for increased accuracy. Wording simplified and rearranged into bullet items. Pontoon or Double Deck Floating Roof Tanks: References to resources available from mutual aid updated. Details of planning process for fighting large tank fires expanded.
	Page 7	Low-Flash Cone Roof Tanks. Subsurface foam as a primary form of protection explicitly prohibited. Introduced the possibility of provision as a secondary form of protection. Internal Floating Roof Tanks. Discussion on use of subsurface foam reduced to a simple prohibition. The possibility of waiving fixed foam protection for tanks with a constant inert atmosphere is introduced.
	Page 8	High-Flash Tanks. Reasoning for not providing fixed foam protection clarified. Possibility of providing facilities for introducing subsurface foam introduced. Fire Water use by Process Operations amended.
	Page 8	Water Source. Expanded to include caveats on use of natural sources and consistency with GP 3-2-3. Source Water Quality. Introduced to better communicate the concerns, particularly of corrosion and marine growth. Pumps and Drivers. Changes made for consistency with GP 3-2-3. Provisions for flow measuring devices and valving added to assist testing and maintenance, Provision for use of steam turbines eliminated due to availability concerns. Clarified provisions for diverse power supplies are maintained separate. Expanded requirement for auto and remote-manual start. Changed reference to fire pumps to firewater pumps.
	Page 9	Firewater Distribution System. Introduced the term "residual."



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Page 10	Firewater Distribution System. ". Amended reference to RTRP piping to better reflect GP 3-2-3, include increased C factor. Fireproofing requirements relative to drainage ditches amended for consistency with GP 14-3-1. Hydrants. Expanded to reflect enhanced criteria for locating with respect to access. Hose Reels. Reference to 1-1/2 inch units introduced for consistency with GP 3-2-3. First Phase Fire Fighting Systems. This concept introduced from EE.92E.75 as a means of better specifying when, where and how to best use monitors and deluge systems.
Page 11	Monitors. Existing text has been rearranged to better discuss each type of monitor. Consideration of trailer mounted monitors as first phase equipment is discouraged. hMobil data on wind effects introduced.
Page 12	Fixed Water Sprays. Title changed as sprinklers discussed separately. Section expanded to reflect additional heritage company data. Selection of First Phase Fire Fighting Equipment. Provides a 6 step method for identifying equipment to be protected, selecting and locating fire fighting equipment (see Table 1), etc.
Page 14	Table 1. Guidance on the preferred form of first phase fire fighting on a process equipment type basis.
Page 15/16	Table 2 & Figures. Guidance on application rates and methodology for design of fixed water sprays
Page 16	Automation / Remote Control. A set of explicit and demanding criteria introduced for when automation / remote control of fire fighting systems should be considered.
Page 17	Sprinkler Systems. Text rearranged from former section on Fixed Water Sprays and Sprinklers. Fire Main Connections to Buildings. Caveat added that hose reels should only installed when an interior structural fire brigade is available to respond.
Page 17	Foam Systems. References to use of foam at large offsite pump stations and unattended truck loading racks added, as is need for regular testing.
General	Metric measurements added throughout. "is provided" replaced with "shall be provided" throughout.



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SCOPE

- ▶ This section covers the conceptual design of systems intended for incipient and first-phase fire fighting and to facilitate the use of mobile equipment in a refinery or chemical plant. Also included are the basic requirements for the various equipment components of these systems

REFERENCES

DESIGN PRACTICES

Section XV-F	Emergency Isolation, Depressuring, and Shutdown Systems
Section XV-G	Equipment Spacing
Section XV-H	Blast Protection and Fireproofing
Section XV-K	Flammable Gas, Toxic Gas and Fire Detection Systems
Section XXII	Storage Facilities
Section XXXI-I	Safety Considerations for the Design of Marine Terminals

GLOBAL PRACTICES

GP 3-2-1	Sewer Systems
GP 3-2-2	Foam Systems for Storage Tanks
GP 3-2-3	Firewater Systems
GP 3-10-1	Piping Selection and Design Criteria
GP 3-10-3	Cement Lined Pipe and Fittings
GP 14-3-1	Fireproofing
GP 17-1-1	Non-Fixed Fire Fighting Equipment

OTHER REFERENCES

Fire Protection and Safety Guidelines for Marine Terminals, ER&E Report No. EE.5TT.81.
Emergency Preparedness for Large Tank Fires, ER&E Report No. EE.2DL.94.
First Phase Fire Fighting for Refineries and Chemical Plants, ER&E Report EE.92E.75
Safety Technology Manual, EMRE Manual No. TMEE 0073
Standard for Low Expansion Foam, NFPA 11
Standard for the Installation of Sprinkler Systems, NFPA 13,
Standard for Water Fixed Sprays for Fire Protection, NFPA 15

DEFINITIONS

High Flash Tankage - Tanks containing liquids with a closed-cup flash point of 100°F (38°C) or higher (such as heavy fuel oils, lubricating oils, transformer oils) when handled at a temperature not higher than their flash point minus 15°F (8°C).

Low-Flash Tankage - Tanks containing liquid having a closed-cup flash point below 100°F (38°C) (such as gasoline, kerosene, jet fuels, etc.) and any other (high flash) stocks if handled at temperatures above, or within 15°F (8°C) below, their flash point (such as some heated asphalts). For example, a stock with a closed-cup flash point of 150°F (65°C) at a temperature of 135°F (57°C) or higher is treated as a low-flash stock.

- ▶ **Incipient Stage** - That stage of a fire immediately after ignition and before it is fully established, when persons already at the scene should be able to bring it under control and extinguish it by use of hand held fire extinguishers, wheeled extinguisher (if immediately available) or a fixed hose reel.
- ▶ **First Phase Fire Fighting** - The "First Phase" of a fire in process and related facilities is that period after the incipient stage and prior to the arrival, set-up and initiation of secondary fire fighting by the fire brigade and its mobile units. Operators, maintenance personnel and other field personnel carry this out using fixed fire fighting equipment. Effective fire fighting during this stage (typically 5 to 10 minutes) is considered crucial in limiting the degree of fire spread and overall damage.

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BASIC DESIGN CONSIDERATIONS

SINGLE FIRE CONCEPT

The extent and capacity of the fire fighting equipment provided in a refinery, chemical plant or associated facilities are based on the assumption that only one major fire will occur at any one time. Thus, the requirements of the largest single fire contingency determine the design of the major fire fighting facilities. However, the sizing of the fire fighting system components may not be set by the same single fire contingency, since different fire fighting techniques are required on the various plant and offsite facilities. For example, foam production requirements are usually determined by tank extinguishing demands, whereas firewater capacity is usually a function of process unit requirements.

MAJOR FIRE RISKS, FIRE FIGHTING METHODS AND CONSIDERATIONS

Fire fighting facilities are identified in [Section XV-A](#) as one of the component classifications of a plant design **directly** intended to minimize damage from fire and explosion. The other component classifications are Spacing and Layout, Fireproofing, Blast Protection, and Emergency Facilities.

Process units, marine terminals, loading racks, tankage and pressurized storage facilities are typically the areas of higher fire risk.

- During its incipient stage some fires may be small enough to be controlled by the immediate application of a fire extinguisher or hose reel, if available. First-phase fire fighting is the effort expended by plant personnel in the early stages of a fire beyond the incipient stage, prior to the arrival of the fire brigade and the deployment of mobile equipment. Optimum control of fires and limitation of damage can be achieved if other equipment in the fire area can be immediately protected against flame impingement and heat radiation. First-phase fire fighting systems comprise equipment suitable for effective operator-initiated fighting of a fire during the initial stages prior to the deployment of mobile equipment.

In a process area, firewater application is the most effective fire fighting method for reducing plant damage while the source of fuel is being isolated from the fire. Water is applied to exposed structures and equipment for cooling to prevent further failures and minimize damage until the fire is extinguished, usually by shutting off or exhausting the fuel supply. In some instances (e.g., spill fires) foam can be effectively used; but this is usually of secondary importance, as far as design capacity is concerned. The spread and impact of fire can be effectively managed by the provision of an appropriate drainage system per **GP 3-2-1** and fireproofing per **GP 14-3-1**. Judicious use of the principles of plant layout per [Section XV-G](#) will further minimize the impact of fire. In particular plant layout must incorporate adequate access ways for fire fighting.

Loading racks and marine terminals that handle flammable or combustible materials require both cooling water and foam protection, since hydrocarbon liquid spill fires can be expected for which foam is the most effective means of extinguishment. Water is the primary mean of protection for facilities that handle LPG or similar volatile materials.

Fires in tankage and pressurized storage areas are of particular concern, because of the large inventories of flammable liquids, vapors and gases involved. Foam is normally the most effective method of extinguishing a tank fire, in conjunction with water cooling of adjacent tanks. For pressurized or refrigerated LPG storage, water is the prime agent for preventing fire spread by cooling exposed facilities until the fuel supply can be isolated.

In designing and specifying fire fighting equipment, three important factors must be kept in mind.

- Any delay in cooling surrounding equipment increases damage and enhances the potential for the spread of fire.
- Traditionally, the proper and effective use of almost all the fire fighting facilities described in this section requires the direct involvement of personnel.
- There is a continuing trend of making the most efficient and effective use of personnel available to respond to the demands for first phase fire fighting.

In specifying the provision of these systems, the analysis methodology contained in EE.92E.75 shall be followed to ensure that fire fighting equipment and systems will be those most suitable to address the hazards present at the facility

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DESIGN PROCEDURES

Design requirements for fire fighting facilities in refineries and chemical plants are described below.

WATER FLOW RATE DETERMINATION

The firewater system is designed to supply the water capacity requirements of the various plant and offsite areas as follows:

- Process Areas**

The assessment of the fire water capacity requirements of a process unit is based upon a number of established considerations and well-tested principles.

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- Typically each process block will be split into a number of subdivisions for the purpose of establishing the maximum extent of any single fire and thus the fire water capacity requirement of that area. Each subdivision is separated from all others by a minimum of 50 ft (15 m) clear space. This spacing acts as a fire break and as a means of fire fighting access. A pipeband may be routed within a separation area providing at least 20 ft (6 m) is left clear for fire fighting access. (See [Section XV-G](#) for other considerations in providing fire fighting access.)
- The minimum fire water supply for any unit shall be 3000 US gpm (682 m³/h)
- Experience indicates that where refinery units are laid out in accordance with [Section XV-G](#) and with a normal degree of congestion and equipment stacking they require no more than 6000 gpm (1363 m³/h).
- In older refineries, which may have more congested units in large plots and where the layout is not in accordance with [Section XV-G](#), the requirements can rise to 8000 gpm (1817 m³/h) or more. In such instances these large firewater requirements shall be provided.
- Establishing what additional potential capacity may need to be provided by means of mobile equipment such as large diameter hose and portable or mobile pumps through the local mutual aid system.

The fire water demand for each subdivision will be based upon a application rate varying between 0.1 and 0.3 gpm per ft² [0.25 and 0.75 m³/(h*m²)] of area depending on equipment density. Compact and multi-story units with a high density of stacked equipment (exchangers, drums etc.) or units containing an unusual amount of high-risk equipment (e.g. pumps handling flammable liquid above 600°F / 316°C or above auto-ignition temperature) will require the higher rates. Similarly, consideration of the likely provision of first phase fire fighting equipment (monitors, deluge systems and hose reels) may be a useful cross check on capacity requirements.

Offsite Facilities - Minimum Requirements

Utility plants:	1500 gpm (341 m ³)
Loading racks:	1500 gpm (341 m ³)
Piers:	2000 gpm (454 m ³ /h) plus water requirement for foam (Note 1)
Large central pumping areas and similar facilities:	2000 gpm (454 m ³ /h)
Separators and waste disposal systems:	1000 gpm (227 m ³ /h)
Office buildings, workshops, storehouses, etc.:	1000 gpm, (227 m ³ /h) plus sprinkler requirements if specified

Note 1: For the firewater requirements of Marine Terminals, see, [Section XXXI-I](#), Safety Considerations for the design of Marine Terminals.

Tankage Areas. Water requirements for foam generation and cooling are based on the assumption of a fire on any single tank. As a minimum, 2000 gpm should be available in tankage areas.

- Pontoon or Double Deck Floating Roof Tanks** - A seal fire is the design fire scenario for the purposes of determining firewater capacity and installation of fixed equipment. A floating roof tank requires a minimum of 1500 to 2000 gpm (341 to 454 m³/h) for foam generation and external cooling of its shell. For large floating roof tanks with fixed foam systems, the foam generation requirement is determined from **GP 3-2-2**, and an additional 1000 gpm (227 m³/h) of water should be provided for cooling and/or foam production for spill fire extinguishment.

Although experience indicates that installation of fixed facilities to fight sunken floating roof full surface tank fires is not justified, these fires can occur and viable emergency plans should be available to cover these contingencies. The main thrust of these plans should be to establish the resources required and strategy for containment and extinguishment and how they might be realistically employed through mutual aid arrangements with outside industrial and municipal fire departments. One of the major difficulties is to supply adequate water to produce sufficient foam to obtain extinguishment. Supplemental water supplies (e.g. by use of large diameter hose and portable pumps) will need to be established with mutual aid partners, together with other support equipment and personnel. In order for these plans to achieve a "workable" status, simulated training exercises should be held regularly. Where mutual aid cannot provide the required capacity the facility shall give consideration to the eventuality of a full surface fire in its largest floating roof tank and develop a risk-based strategy for addressing it, including in it the possibility of increasing the amount and capacity of fixed equipment. For more details see *Emergency Preparedness for Large Tank Fires*, ER&E Report EE.2DL.94.

Open-top tanks with pan-type floating roofs are not recommended for new construction, due to the ease of sinking the roof. However, existing pan-type floating roofs should be considered the same as cone roof tanks, with regard to fire protection.

- Low-Flash Cone-Roof Tanks** - Experience indicates that the only effective means of fighting fires within these tanks is by means of fixed equipment. Generally the events leading to a surface fire result in only partial removal of the roof. In such circumstances it is impractical to direct portable foam streams inside the tank on the fire area from any reasonably safe location. Fixed foam systems, per **GP 3-2-2** designed to handle a full surface fire is provided for such tanks.

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Subsurface foam systems should not be used as a prime form of protection. These systems are deemed unreliable as they are inaccessible for inspection and maintenance and they require careful control and monitoring if they are to be effective. Facilities to introduce subsurface foam protection may be provided as a secondary form of protection when approved by the owner's engineer and adequate mobile foam production capacity is available.

Total water to be supplied to an area should be the sum of the appropriate numbers from the following three columns:

TANK DIAMETER ft (m)	WATER FOR FOAM PRODUCTION gpm (m ³ /h) per GP 3-2-2	WATER FOR COOLING OF BURNING TANK ⁽³⁾ gpm (m ³ /h)	WATER FOR COOLING ADJACENT TANKS ⁽¹⁾ gpm (m ³ /h) per EXPOSED TANK
Up to 20 (6)	0	750 (170)	250 (57)
20 to 56 (6 to 19)	500 (114)	750 (170)	250 (57)
56 to 80 (19 - 24)	500 (114)	1000 (227)	500 (114)
80 to 110 (24 - 33)	1000 (227)	1250 (284)	750 (170)
110 to 130 (33 to 40)	1500 (341)	1500 (341)	750 (170)
130 to 140 (40 - 43)	2000 (454)	1750 (397)	1000 (227)
140 to 150 (43 - 46) (max) ⁽²⁾	2000 (454)	2000 (454)	1000 (227)

Notes:

- (1) Consider a downwind quadrant concentric with the burning tank and of radius 2D, where D is the diameter of the burning tank. If any part of an adjacent tank is located within this quadrant, it is considered to require cooling. Water for this purpose should be available at a rate according to its diameter, as indicated in the last column.
- (2) Cone roof tanks (or fixed-roof tanks with internal floating covers) larger than 150 ft diameter should not be used in low-flash service because of the uncertainty of being able to extinguish fires in these larger size tanks.
- (3) Water for cooling the shell of a burning tank is beneficial to help in extinguishment while applying foam. There is questionable value in applying water to the walls of a burning tank unless a sustained foam attack is planned.

3. **Internal Floating Roof Tanks** - The problems of fighting fires within Internal Floating Roof (IFR) tanks in Low Flash service are similar to those noted for Cone Roof tanks in Low Flash service. Thus these tanks must be supplied with fixed equipment. Although the total fire record of fires in IFR tanks is good, approximately 50% of fires that did occur involved sunken floating roofs. Accordingly these foam and fire water capacity requirements shall be as per Low Flash Cone Roof Tanks, above. The cooling water requirements for the involved tank and adjacent tanks shall be as per Low Flash Cone Roof Tanks, above. Note that tanks in this service are restricted to a diameter of less than or equal to 150 ft (45 m).

An acceptable deviation from the above is where the tank in question is an open roof tank with a pontoon-type or double deck design floating roof and the cover is a geodesic dome of lightweight construction. In this case, since the "roof" will fail early in any fire situation, the tank can be treated as an open top floating roof tank and the fire fighting facilities can be based on the requirements in GP 3-2-2 for seal fires.

Consideration can be given to relaxing the need for providing foam protection when an IFR tank is in a service where it is **constantly** maintained under an inert atmosphere (by means of a secure supply of inert gas e.g. by nitrogen, not fuel gas), for process purposes.

Subsurface foam systems shall not be used for internal floating roof tanks. Fire experience indicates that a sunken roof further impedes its effectiveness.

4. **High-Flash Tanks** - In high-flash tankage areas, experience demonstrates that the fire risk is low enough that investment in fixed extinguishment systems is not justified. Water resources are provided to restrict the spread of fire to adjacent tanks and protect them from other exposures. The rates required are based on cooling adjacent tanks only, calculated according to the final column of the above table for low-flash cone-roof tanks. When local regulatory provisions require the provision of a fixed system for a tank in High-Flash service, a semi-fixed subsurface system, designed per NFPA 11 may be supplied for this service, provided the tank has a fixed roof, no internal floating cover and stores non-polar liquids.
5. **Pressurized and Refrigerated Storage** - Firewater requirements are based on supplying the deluge system of any one vessel which is assumed to be on fire, plus the deluge systems of adjacent exposed vessels, plus 1000 gpm (227 m³/h) from monitors and hose streams for cooling surfaces not covered by the deluges, as specified in GP 1-2-3.

