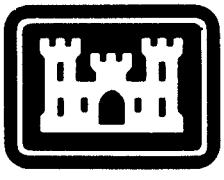
ENGINEER MANUAL

EM 1110-3-166
April 1984

ENGINEERING AND DESIGN

Water Supply, Fire Protection

Mobilization Construction



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
OFFICE OF THE CHIEF OF ENGINEERS

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314

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Engineer Manual
No. 1110-3-166

9 April 1984

Engineering and Design
WATER SUPPLY, FIRE PROTECTION
Mobilization Construction

1. Purpose. This manual establishes the minimum water supply requirements for fire protection at U.S. Army mobilization facilities.

2. Applicability. This manual is applicable to all field operating activities having mobilization construction responsibilities.

3. Discussion. Criteria and standards presented herein apply to construction considered crucial to a mobilization effort. These requirements may be altered when necessary to satisfy special conditions on the basis of good engineering practice consistent with the nature of the construction. Design and construction of mobilization facilities must be completed within 180 days from the date notice to proceed is given with the projected life expectancy of five years. Hence, rapid construction of a facility should be reflected in its design. Time-consuming methods and procedures, normally preferred over quicker methods for better quality, should be de-emphasized. Lesser grade materials should be substituted for higher grade materials when the lesser grade materials would provide satisfactory service and when use of higher grade materials would extend construction time. Work items not immediately necessary for the adequate functioning of the facility should be deferred until such time as they can be completed without delaying the mobilization effort.

FOR THE COMMANDER:

PAUL F. KAVANAUGH
Colonel, Corps of Engineers
Chief of Staff

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314

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CHAPTER 1

GENERAL

1-1. Purpose and scope. This manual establishes the minimum water supply requirements for fire protection at Army mobilization facilities. It prescribes the minimum rate of flow (gallons per minute), residual pressure (pounds per square inch), and flow duration (hours) for fire protection purposes. This manual also establishes the criteria for selection and installation of fire pumps to be used for supplying fire protection water.

1-2. Definitions.

a. Classification of occupancies. For the purpose of sprinkler protection, various occupancies are grouped according to their degree of hazard. The occupancies in a particular group present about the same hazard and impose approximately the same demand on similar sprinkler systems. The assigned standard building classification of occupancy is to be used to determine fire protection water supply requirements for that particular building design. The basic hazard classification of an occupancy does not, in all instances, categorically define the fire hazard present in all areas of that occupancy. If more hazardous processes or areas exist within a given occupancy, they should be protected in accordance with the fire protection requirements pertaining to the hazard classification of that area. The classification for special buildings or buildings where no standard building design exists will be determined from the following definitions or by comparison with one of the typical examples of occupancies listed under each classification.

(1) Light Hazard Occupancies. Occupancies or portions of other occupancies where the quantity and combustibility of contents are low and fires with relatively low rates of heat release are expected. The following are examples of Light Hazard Occupancies:

- Churches and Chapels
- Clinics (dental, outpatient)
- Clubs (Officer, Enlisted Personnel, etc.)
- Data Processing Areas
- Disciplinary Barracks
- Dispensaries
- Dwellings
- Gymnasiums
- Hospitals
- Libraries (except large stack rooms)
- Offices
- Photographic Processing Areas
- Schools

(2) Ordinary Hazard Group 1 Occupancies. Occupancies or portions of other occupancies where combustibility is low, quantity of combustibles is moderate, stock piles of combustibles do not exceed 8 feet, and fires with moderate rates of heat release are expected. The following are examples of Ordinary Hazard Group I Occupancies:

- Armories
- Bowling Alleys
- Commissaries
- Exchanges
- Forge Shops
- Printing Shops (Using inks having flash points above 110 degrees F.)
- Small Stores
- Theatres and Auditoriums

(3) Ordinary Hazard Group 2 Occupancies. Occupancies or portions of other occupancies where quantity and combustibility of contents is moderate, stock piles do not exceed 12 feet, and fires with moderate rate of heat release are expected. The following are examples of Ordinary Hazard Group 2 Occupancies:

- Air Rework Facilities
- Boiler Rooms
- Electrical Maintenance Shops
- Engine and Generator Rooms
- Laboratories
- Libraries (large stack rooms)
- Machine Shops
- Printing Plants
- Refrigeration and Air Compressor Rooms
- Ship Fitting Shops
- Switchgear Rooms
- Welding Shops

(4) Ordinary Hazard Group 3 Occupancies. Occupancies or portions of other occupancies where quantity or combustibility of contents is high, and fires of high rate of heat release are expected. The following are examples of Ordinary Hazard Group 3 Occupancies:

- Ordnance Plants (except exposed powder areas)
- Piers and Wharves
- Vehicle Repair Garages
- Woodworking Plant

(5) Extra Hazard Occupancies. Occupancies or portions of other occupancies where quantity and combustibility of contents are very high, or where flammable liquids, dust, lint, or other materials are present introducing the probability of explosion and rapidly developing

fires with high rates of heat release. The following are examples of Extra Hazard Occupancies:

- Engine Test Cells
- Flammable and Combustible Liquids (not high piles or high rack storage)
- Warehouses (not high piled or high rack storage)

Extra hazard occupancies also include other facilities or areas that fall within this general classification, but which have special protection requirements. This group includes facilities such as:

- Aircraft Hangars
- Foam Rubber or Plastic Storage
- Missile Assembly
- Ordnance Plants (exposed powder areas)
- Rubber Tire Storage
- Warehouses (high piled or high rack storage)

b. Types of construction. The types of building construction are based on fire resistivity or combustibility of structural elements. In general, standard building designs for mobilization will be of combustible materials Type V as defined in the Uniform Building Code. Life safety fire protection for standard building designs is discussed in EM 1110-3-120.

c. Subject facility. Building, storage yard, or other installation whose fire protection water supply requirements are being considered.

d. Exposed facility. A building, storage yard, or other installation within 150 feet of the subject facility.

e. Separation factor. A measure of the potential for fire transmission between an exposed facility and the subject facility.

f. Exposure factor. A factor which will modify the basic fire flow rate to recognize the need for additional water to protect exposed facilities. This factor is based on the separation factors of the subject facility.

g. Basic fire flow rate. The flow rate determined necessary for fire control in the subject facility.

h. Fire flow duration. The length of time during which the required fire flow rate needs to be supplied to the subject facility.

i. Residual pressure. The pressure in the water supply system main while the required fire flow rate is being discharged near the subject facility.

j. Required fire flow demand. The water supply determined necessary for fire control in the subject facility and for protection of exposed facilities. The required fire flow demand consists of the required fire flow rate, fire flow duration, and residual pressure.

k. Special fire suppression systems. Fire suppression systems are systems that reduce fire hazard or control fire by reducing or preventing oxygen from reaching the fuel and heat source. Fire suppression systems requiring water supply include but are not necessarily limited to the following.

System	NFPA Reference
Deluge Foam-Water Sprinkler System	16
Foam Water-Spray System	16
Foam Extinguishing System (Low Expansion)	11
High Expansion Foam System	11A
Synthetic Foam and Combined Agent System	11B
Water Spray System	15

l. Story. Usable floor level as defined in the Uniform Building Code.

m. Floor area. Usable areas within a building as defined in the Uniform Building Code.

n. Exposed wall. The wall or perimeter of an exposed facility facing the subject facility.

o. Required fire flow rate. The flow rate determined necessary for fire control in the subject facility and for protection of exposed facilities. The required fire flow rate is determined by using the basic fire flow rate and the exposure factor.

CHAPTER 2

BASIC DESIGN CONCEPTS

2-1. General.

a. Fire protection water supply. The fire protection water supply consists of that needed to simultaneously control and extinguish fire in the subject facility and to protect exposed facilities. It includes the water necessary for fire department hose streams and for automatic sprinkler or special fire suppression systems. The water for fire department hose streams should be available from fire hydrants according to spacing requirements in EM 1110-3-164. The water for automatic sprinkler or special fire suppression systems must be available at the point where those systems are connected to the water supply systems.

b. Fire protection water supply sources.

(1) The water supply necessary to meet the required fire flow demands as developed in chapters 3 and 4 may usually be provided by the following sources:

(a) A municipal water supply system with elevated storage or pumping capacity which is capable of simultaneously meeting the domestic/industrial peak daily demands and the required fire flow demand.

(b) An individual facility process water supply system which is capable of simultaneously meeting the peak daily industrial demand and the required fire flow demand.

(2) If these sources cannot supply the required fire flow demand simultaneously with domestic/industrial demands, alternate fire protection water supply sources need to be developed.

c. Alternate fire protection water supply sources. There are several ways of developing alternate fire protection water supplies. Examples of such alternate sources are:

(1) An individual facility fire protection water supply system capable of independently meeting the required fire flow demand (such as an elevated storage tank or a fire pump and ground level reservoir).

(2) An individual facility fire protection water supply system which will supplement the water supply available from a municipal or process water supply system so that the combined systems can provide the required fire flow demand simultaneously with the domestic/industrial demands. Examples of such systems would be an

elevated storage tank, a pressure tank, or a fire pump and ground level reservoir.

(3) Fire pumps taking suction from the municipal water supply system or from a process water supply system when that system has adequate volume capacity but insufficient pressure capacity to simultaneously supply the domestic/industrial demands and the required fire flow demands.

d. Required residual pressure. The minimum residual pressure will be 20 psi.

2-2. Guide for the use of this manual.

a. Required fire flow. Chapter 3 discusses developing the required fire flow demand for individual buildings and chapter 4 for developing the required fire flow demand for petroleum, oils, and lubricants (POL) storage and handling facilities, general outdoor storage areas, and vehicle parking facilities.

b. Fire flow demand application. The water supply system needs to be capable of supplying the largest single required fire flow demand when multiple facilities are being considered. The individual facility fire flow demands are not cumulative.

c. Limiting consideration for fire flow demand. When the required fire flow rate exceeds 2,500 gpm, a benefit/cost analysis should be conducted to determine if additional fire protection systems or if a change in the construction type or use of a facility is more cost effective than providing the required fire flow rate. Such changes may reduce the required fire flow rate to a point where it can be more economically provided.

d. Alternate fire protection systems. Chapter 5 discusses alternate sources for fire protection water supply and requirements for any needed pumping stations in cases where inadequate water supplies exist.

CHAPTER 3

PROCEDURE FOR DETERMINING BUILDING FIRE FLOW DEMAND

3-1. General. The following steps are to be used in determining the required fire flow demand. Deviation from these steps may be required depending upon the particular circumstances at the subject facility.

3-2. Step one. Establish building parameters.

a. Item one. Determine the type of construction of the subject facility. Construction can be determined from architectural plans or by inspecting building structural components.

b. Item two. Determine the number of stories in the subject facility. This manual differentiates between single story buildings and multiple story buildings only.

c. Item three. Determine the hazard classification of the subject facility occupancies as defined in the standard design of subject facility.

d. Item four. Determine the floor area of each story of the subject facility.

e. Item five. Determine the distance from the subject facility to each exposed facility. This distance is the shortest distance measured from the subject facility wall to the exposed facility, and rounded to the nearest whole foot. This distance is to be measured for each exposed facility.

f. Item six. Determine if automatic sprinkler or special fire suppression systems are to be installed in the subject facility. If the subject facility will have a complete automatic sprinkler system, skip steps two through seven and go directly to step eight. If a partial sprinkler system or special fire suppression systems are installed, or if no systems are installed, continue to step two.

3-3. Step two. Using the parameters obtained in step one, develop the basic fire flow rate using figures 3-1 and 3-2. Figures 3-1 and 3-2 contain curves to be used with Type V (ordinary, heavy timber, wood frame) construction. Determine the appropriate curve on the figure which is related to subject facility height (single story or multiple story) and hazard classification of the subject facility occupancies (light, ordinary, or extra).

3-4. Step three. Determine the basic fire flow rate from the appropriate curve using the area of the largest floor developed in step one, item four.

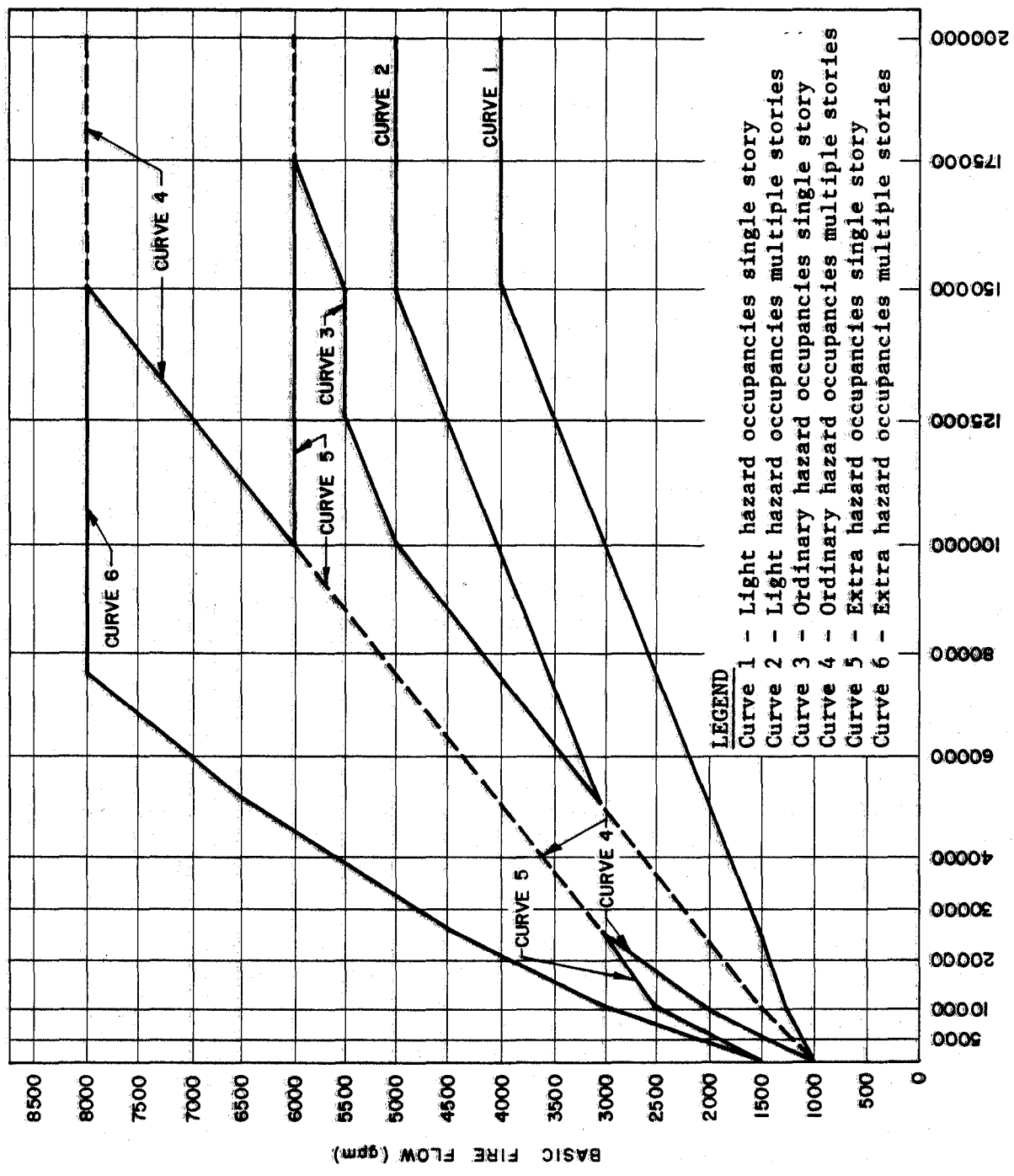

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FIGURE 3-1. TYPE V (COMBUSTIBLE) CONSTRUCTION CURVES
(0 TO 200,000 SQUARE FEET)

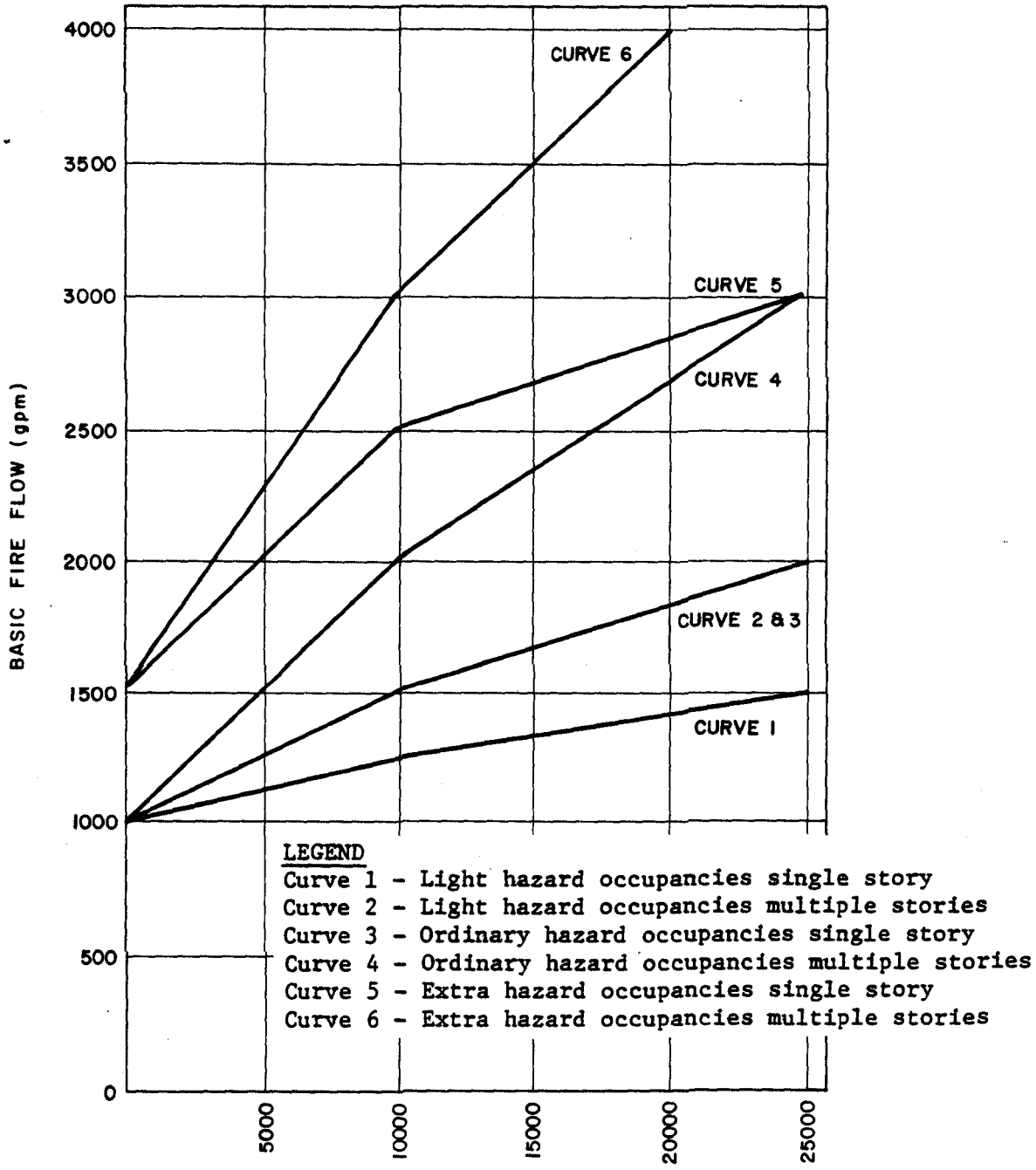

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FIGURE 3-2. TYPE V (COMBUSTIBLE) CONSTRUCTION CURVES (0 TO 25,000 SQUARE FEET)

3-5. Step four. Determine the increase needed for exposure protection.

a. Item one. Determine the separation factor from table 3-1 for each exposed facility, using the distances developed in step one, item five.

Table 3-1. Distance Versus Separation Factor

Separation Distance (in feet)	Separation Factor
0 - 10	5
11 - 25	4
26 - 50	3
51 - 100	2
101 - 150	1
over 150	0

b. Item two. Add the separation factors for all exposed facilities.

c. Item three. Determine the exposure factor from figure 3-3, using the sum of the separation factors calculated in step four, item two. The maximum value of the exposure factor is 1.75, even though the separation factor total may be greater than 15.

d. Item four. Determine the required fire flow rate by multiplying the basic fire flow rate by the exposure factor, rounding to the closest 250 gpm.

3-6. Step five. Determine the required fire flow duration from table 3-2 using the required fire flow rate developed in step four, item four.

Table 3-2. Required Fire Flow Duration

Required Fire Flow gpm	Minimum Duration hours
1,500 or less	2
1,750 - 3,500	3
3,750 or over	4

3-7. Step six. Determine the minimum required residual pressure.

3-8. Step seven. Determine the need for additional water flow rate, duration, or pressure requirements created by use of a partial automatic sprinkler system, or special fire suppression systems in the subject facility.

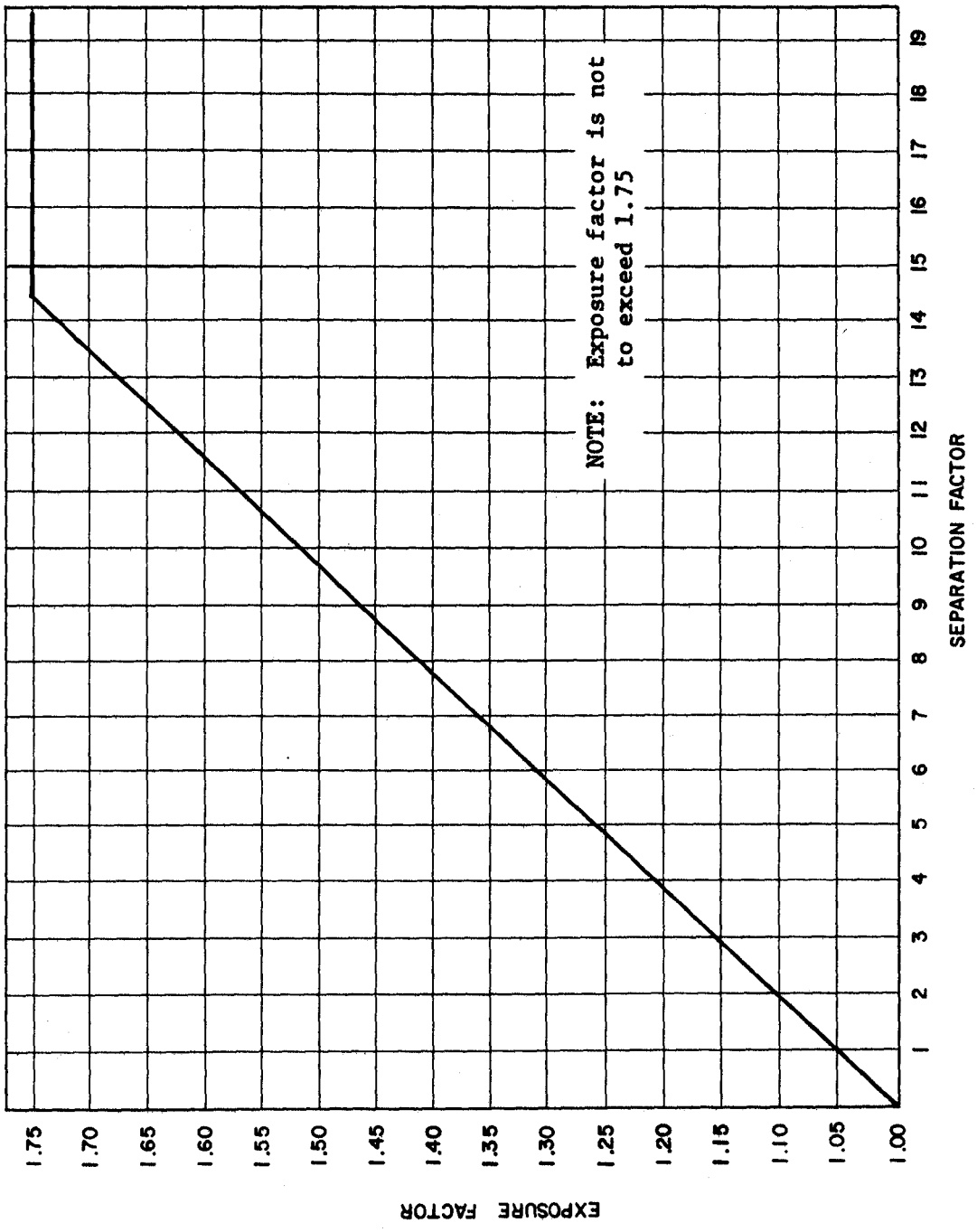

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FIGURE 3-3. EXPOSURE FACTOR CURVE

a. Item one. Determine partial automatic sprinkler system or special fire suppression system water requirements from tables 3-3 and 3-4 and paragraph 1-2.k.

Table 3-3. Water Demands for Sprinklered Facilities

Occupancy classification	Sprinklers: Design density gpm/ft^2	Sprinklers: Design area ft^2	Hose gpm	Duration of supply (minutes)
Light hazard	0.10	3,000	250	45
Ordinary Hazard Group 1	0.15	3,000	500	60
Ordinary Hazard Group 2	0.20	3,000	500	75
Ordinary Hazard Group 3	0.25	3,000	500	90
Extra hazard	0.35	3,000	750	105
Ordnance plants (exposed powder area)	0.50	Entire area	750	45
Missile assembly	0.25	Entire area	500	45

Note: For dry pipe systems, increase design area by 30 percent.

Table 3-4. Water Demands for Rubber Tire Storage

Arrangement	Density gpm/sq. ft.	Area of Demand, sq. ft.: Wet system	Area of Demand, sq. ft.: Dry system
A. On-Side Storage			
1. 5-10 ft high	0.45	3,000	3,900
2. 10-15 ft high	0.60	3,000	3,900
3. Up to 25 ft high	0.60	5,000	6,500
B. On-Tread Storage			
1. 5-8 ft high	0.40	3,000	3,900
2. 8-12 ft high	0.60	3,000	3,900
3. Up to 20 ft high	0.60	5,000	6,500

Note: Hose stream demand is 750 gpm for 180 minutes.

b. Item two. Determine if increases are needed to the required fire flow rate, fire flow duration, or minimum residual pressure.

(1) If the partial automatic sprinkler or special fire suppression system flow rate, residual pressure, and duration are less than those of the required fire flow demand, no adjustment is necessary.

(2) If the partial automatic sprinkler or special fire suppression system fire flow duration requirement is greater than the fire flow duration requirement of the required fire flow demand, the

CHAPTER 4

PROCEDURE FOR DETERMINING POL, VEHICLE PARKING, AND YARD STORAGE FACILITY FIRE FLOW DEMAND

4-1. General. The required fire flow demand for POL, vehicle parking, and yard storage facilities is determined using the following steps. Deviation from these steps may be required depending upon the particular circumstances at each facility.

4-2. Above-ground atmospheric POL tanks. The fire protection water supply necessary to protect this type of facility includes the water necessary to cool a burning tank, to cool exposed tanks, and to supply special fire suppression systems.

a. Step one. Determine the fire flow rate needed to cool the largest tank in a tank farm facility, from table 4-1.

Table 4-1. Atmospheric POL Tank Cooling Water

Tank Diameter (feet)	Fire Flow Rate (gpm)
0 - 65	500
65 - 120	750
120 - 155	1,000
155 - 200	1,250
200 or greater	1,500

b. Step two. Determine the fire flow rate necessary to cool exposed tanks, pressure vessels, or handling facilities that are within 50 feet or one tank diameter of the largest tank under consideration, whichever is greater. Allow 500 gpm for each such exposed tank, pressure vessel, or handling facility.

c. Step three. Determine the water flow requirements for special fire suppression systems from paragraph 1-2.k.

d. Step four. Determine the required fire flow rate by adding the fire flow rate requirements determined in step one through three, rounded to the nearest 250 gpm.

e. Step five. The required fire flow rate is to be available for a minimum duration of 4 hours.

f. Step six. Determine the required residual pressure. When the special fire suppression system pressure requirements are greater than that of the required fire flow demand, increase the pressure of that portion of the fire flow demand needed to operate the special systems.

The remainder of the fire flow demand may be supplied at the established residual pressure or at a higher pressure.

4-3. Above-ground pressurized POL tanks. The fire protection water supply needed to protect this type of facility is similar to that needed for atmospheric tanks. It includes water for cooling the subject tank, for cooling exposed tanks, and for special fire suppression systems.

a. Step one. Determine the fire flow rate needed to cool the subject tank or group of tanks from table 4-2.

Table 4-2. Pressurized POL Tank Cooling Water

Tank Group Size	Fire Flow Rate (gpm)
Single tank (less than 30,000 gallon capacity)	250
Single tank (more than 30,000 gallon capacity)	500
2 to 6 tanks (each tank less than 30,000 gallon capacity)	500
2 to 6 tanks (one or more tank greater than 30,000 gallon capacity)	1,000
7 or more tanks (each tank less than 30,000 gallon capacity)	1,000
7 or more tanks (one or more tanks greater than 30,000 gallon capacity)	1,500

b. Step two. Determine the fire flow rate necessary for protection of exposed facilities. Provide 500 gpm for each atmospheric tank within 50 feet of a pressurized tank grouping and 250 gpm for each handling facility within 50 feet of a pressurized tank grouping.

c. Step three. Determine the water requirements for special fire suppression systems from paragraph 1-2.k.

d. Step four. Determine the required fire flow rate by adding the fire flow rate requirements determined in steps one through three, rounding to the nearest 250 gpm.

e. Step five. The required fire flow rate should be available for a minimum duration of 4 hours.

f. Step six. Determine the minimum required residual pressure. If the special fire suppression pressure requirements are greater than that of the required fire flow demand, increase the pressure of that portion of the fire flow demand needed to operate the special systems. The remainder of the fire flow demand may be supplied at the established residual pressure or at a higher pressure.

4-4. POL handling facilities. The required fire flow demand for POL handling facilities is to be determined according to the procedures presented in chapter 3, for determining building fire flow requirements (excluding step five). The flow duration should be available for a minimum of 4 hours. Each exposed tank is to be treated as an exposed facility for use in determining increases to the basic fire flow rate.

4-5. Aircraft parking and refueling facilities. A minimum fire flow rate of 1,000 gpm for a 2-hour duration is to be provided for all such facilities.

4-6. Vehicle parking. A minimum fire flow rate of 500 gpm for a 2-hour duration is to be provided for all such facilities.

4-7. General yard storage.

a. Step one. Determine yard storage parameters.

(1) Item one. Storage pile height. This manual considers two classifications of storage pile height: low piled storage which does not exceed 15 feet, and high piled storage which exceeds 15 feet.

(2) Item two. Stored material class. This manual considers two classes of yard storage, "noncombustible" storage as defined in NFPA 231 and "combustible" storage which constitutes all other storage.

(3) Item three. Storage area. The area available for storage.

(4) Item four. Exposed facilities. Determine the distance from the storage area to each exposed facility. This distance is the shortest distance from the storage area perimeter to the exposed facility and rounded to the nearest whole foot. This distance is to be measured for each exposed facility.

b. Step two. Using the parameters obtained in step one, choose the appropriate curve on figure 4-1 or 4-2 to be used in developing the basic fire flow rate. The curves on figure 4-1 or 4-2 consider the storage height and class of the stored materials.

c. Step three. Determine the basic fire flow rate from the appropriate curve on figure 4-1 or 4-2 using the storage pile area determined in step one, item three.

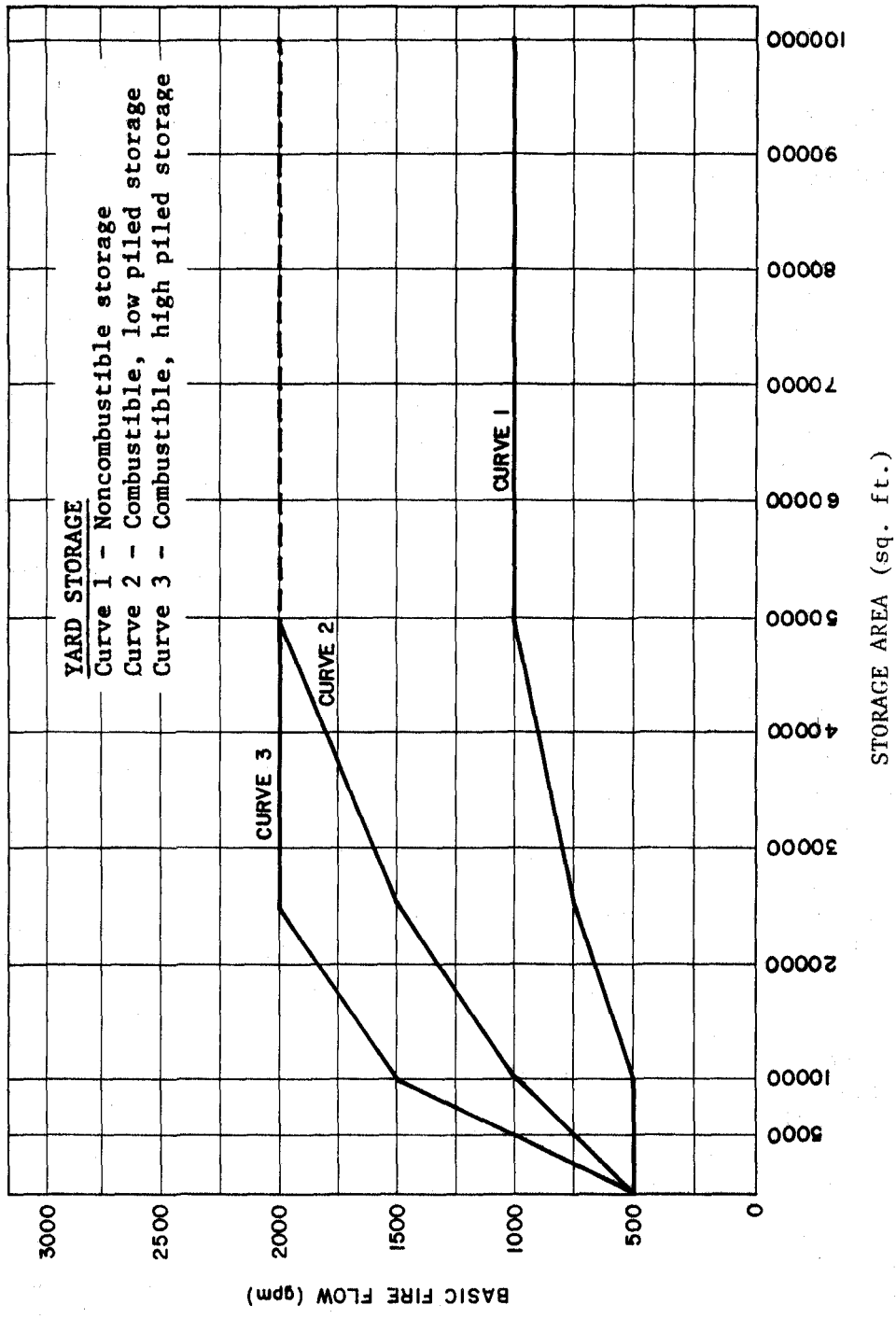

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FIGURE 4-1. YARD STORAGE CURVES (0 TO 100,000 SQUARE FEET)

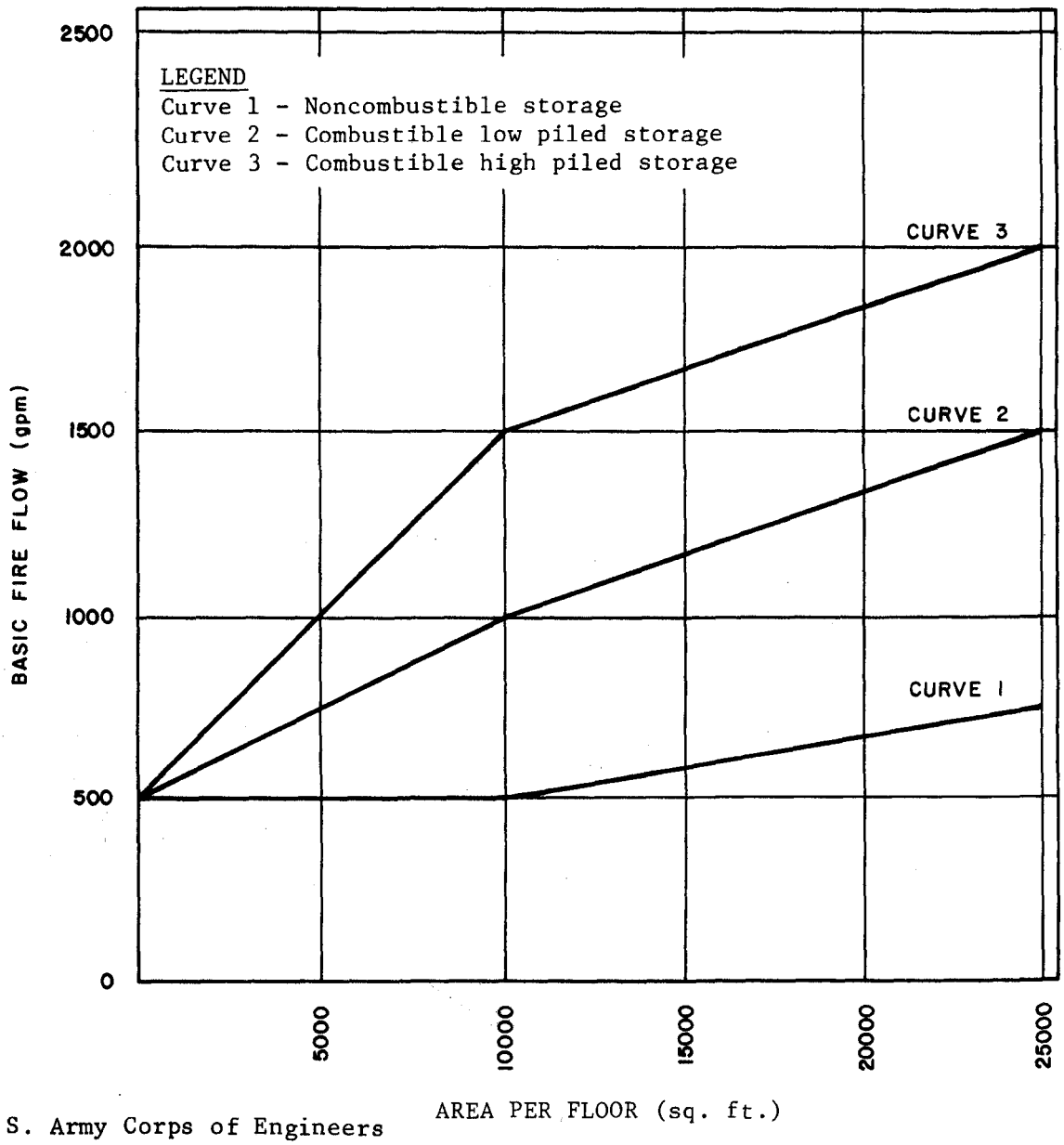

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FIGURE 4-2. YARD STORAGE CURVES (0 TO 25,000 SQUARE FEET)

d. Step four. Determine the increase needed for exposure protection.

(1) Item one. Determine the separation factor from table 3-1 for each exposed facility using the distances developed in step one, item four.

(2) Item two. Add the separation factors for all exposed facilities.

(3) Item three. Determine the exposure factor from figure 3-3 using the sum of the separation factors calculated in item two above. The maximum value of the exposure factor is 1.75, even though the separation factor total may be greater than 15.

(4) Item four. Determine the required fire flow rate by multiplying the basic fire flow rate by the exposure factor, rounding to the nearest 250 gpm.

e. Step five. Determine the required fire flow duration from table 3-2 using the required fire flow rate calculated in step four, item four.

f. Step six. Determine the minimum required residual pressure.

4-8. Sample calculations. Appendix A, sample 2 provides an example of establishing the fire flow demands for a POL facility containing four tanks and a pumping station using the procedures outlined in paragraphs 4-2, 4-3, and 4-4.

CHAPTER 5

PUMPING STATIONS FOR FIRE PROTECTION WATER SUPPLY

5-1. General provisions. All pump installations (pumps, pump house or pump room, controls, piping) to be used in fire protection service will meet the requirements of NFPA 20.

5-2. Pump type. A fire pump may be either a horizontal or vertical shaft centrifugal pump or a vertical shaft turbine pump, whichever is most economical and appropriate for the intended use. A vertical shaft turbine pump type only will be used for suction lift.

5-3. Pump size. Fire pumps are to be sized to provide the required fire flow demand at not more than 150 percent of the rated pump capacity. The benefit/cost relationship of using multiple pumps, arranged to start sequentially on system pressure drop, (in lieu of a single pump) to provide the total required fire flow demand should be investigated.

5-4. Pump starting arrangement. Fire pumps must be arranged to start automatically except that they may be arranged for manual starting when other available water supply sources are capable of providing the demands for all automatic sprinkler and special fire suppression systems simultaneously with the domestic/industrial demands. All fire pumps require manual shutdown after starting. Automatic shutdown is not permitted except on complete consumption of reservoir water.

5-5. Pump drive. When electric power is economically available from a reliable single power source or from two independent sources in accordance with NFPA 20, fire pumps will be electric motor-driven only. When such electric power supplies are not available, fire pumps will be diesel engine-driven. Spark ignited internal combustion engines will not be used to drive fire pumps.

APPENDIX A - SAMPLE CALCULATIONS

SAMPLE 1
INDUSTRIAL SITE

BUILDING 1

Description: 17,000 square feet, 4-story open loft parachute building, Type V (combustible) construction, automatic sprinkler system installed (see fig A-1).

Procedure:

Step 1 item 1 Type V (combustible) construction

item 2 Multiple story building

item 3 Ordinary hazard (Group 3) occupancies

item 4 17,000 square feet per floor (from plans)

item 5 Building 1 to 3 - 30 feet

Building 1 to 2 - 70 feet (from area plan)

item 6 Automatic sprinkler system (wet system) installed

Move to step 8 as automatic sprinkler system is installed.

Step 8 For this example, the building sprinkler system is designed to deliver 0.25 gpm per square feet over 3,000 square feet (see table 3-3) and the calculated sprinkler system demand is 825 gpm at 70 psi residual pressure (actual demand is obtained from sprinkler system design calculations). To this, the required hose stream demand of 500 gpm (table 3-3) must be added to obtain the required fire flow demand of 1,500 gpm (825 + 500, rounded to 1,500). The required fire flow duration is 90 minutes (table 3-3). The sprinkler system design is obtained from NFPA recommendations (except water demand criteria).

BUILDING 2

Description: 55,000 square feet, one-story warehouse, Type V (combustible) construction.

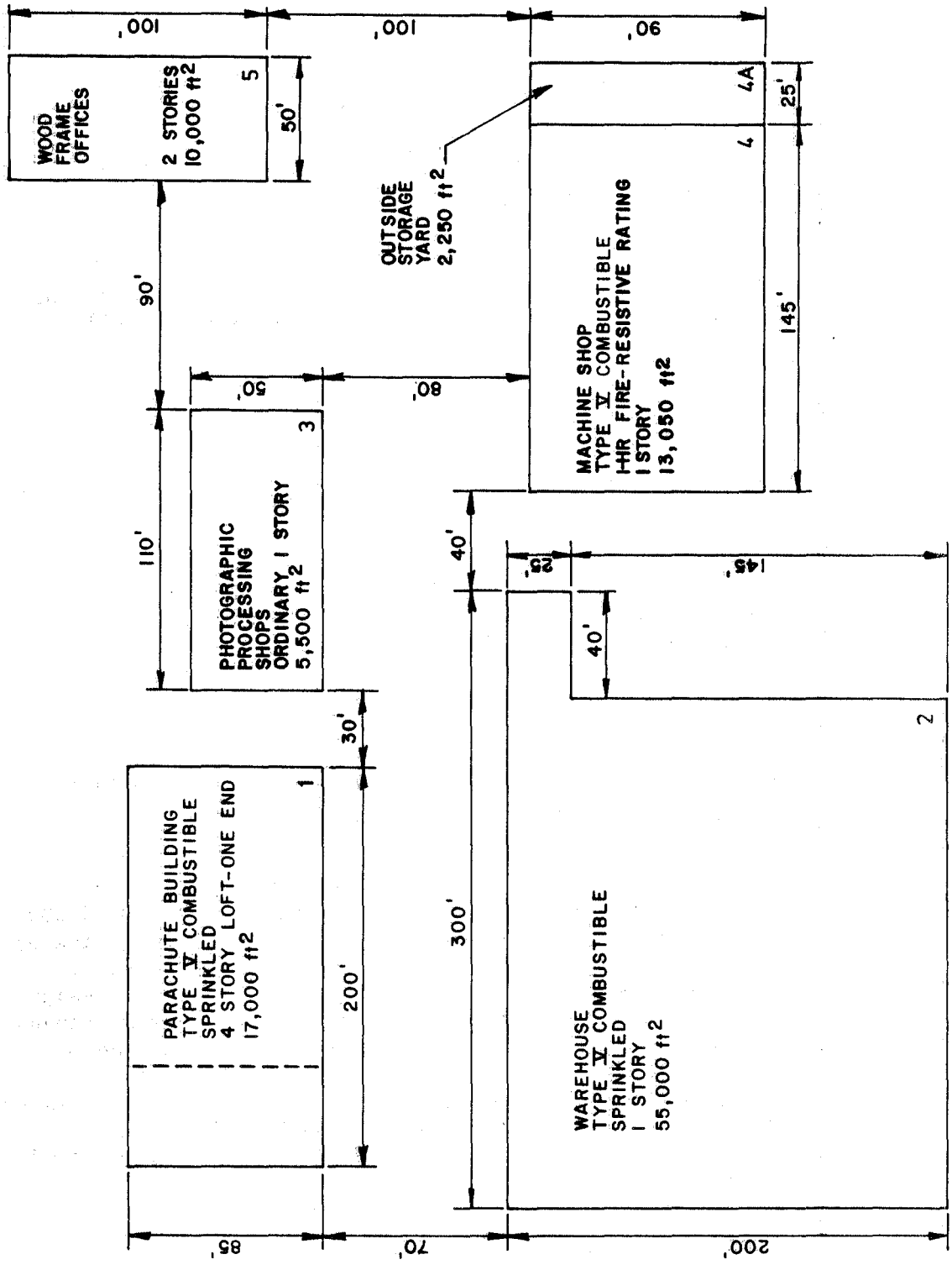

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FIGURE A-1. SAMPLE 1 AREA PLAN

Procedure:

Step 1 item 1 Type V (combustible) construction

item 2 1 story - single story building

item 3 Extra hazard occupancies

item 4 55,000 square feet per floor

item 5 Building 2 to 1 - 70 feet

Building 2 to 3 - 70 feet

Building 2 to 4 - 40 feet
(Use only the closest distance between the buildings for the distance.)

item 6 Automatic sprinkler system (Dry System).

Move to step 8 as automatic sprinkler system is installed.

Step 8 For this example, the building sprinkler system is designed to deliver 0.35 gpm per square foot over 3,900 square feet (3,000 square feet plus 30 percent increase in design area for dry pipe system) resulting in a calculated sprinkler system demand of 1,500 gpm at 70 psi residual pressure (calculated demand includes a 10 percent increase in flow to account for differential flows at far ends of system). To this, the required hose stream demand of 750 gpm must be added to obtain the required fire flow demand of 2,250 gpm. The required fire flow duration is 105 minutes.

BUILDING 3

Description: One-story, 5,500 square feet, photographic processing area, ordinary construction.

Procedure:

Step 1 item 1 Type V (combustible) construction

item 2 1 story - single story

item 3 Light hazard occupancies

item 4 5,500 square feet per floor

item 5 Building 3 to 1 - 30 feet

Building 3 to 2 - 70 feet

Building 3 to 4 - 80 feet

Building 3 to 5 - 90 feet

item 6 No automatic sprinklers, no special systems.

Step 2 Refer to figure 3-1 or 3-2 for Type V construction, curve 1 for light hazard occupancies, 1 story.

Step 3 Read the basic fire flow from the curve based on an area of 5,500 square feet, 1,140 gpm.

Step 4 item 1 Building 3 to 1 - Separation factor of 3

Building 3 to 2 - Separation factor of 2

Building 3 to 4 - Separation factor of 2

Building 3 to 5 - Separation factor of 2

item 2 Total separation factor = 3 + 2 + 2 + 2 = 9

item 3 Exposure factor from figure 3-3 is 1.48.

item 4 Required fire flow = 1,140 x 1.48 = 1,687 rounded to 1,750.

Step 5 The duration is 3 hours from table 3-2.

Step 6 A fire department pumper will be used. The fire flow test shows the required flow is available at a residual pressure of 20 psi, so the required residual pressure is 20 psi.

Step 7 No special systems are installed.

Step 8 No sprinkler systems provided.

BUILDING 4

Description: Machine shop, 13,050 square feet, Type V (combustible) construction, 1 story, with an outside storage yard to the east. (Note: the storage yard is considered separately.)

Procedure:

Step 1 item 1 Type V (combustible) construction

item 2 1 story - single story building

item 3 Ordinary hazard occupancies

item 4 13,050 square feet per floor

item 5 Building 4 to 2 - 40 feet

Building 4 to 3 - 80 feet

Building 4 to 5 - 100 feet

Building 4 to Yard 4A - 0 feet

The storage yard is handled as a building for development of exposure increases.

item 6 No automatic sprinklers or special systems installed.

Step 2 Refer to figure 3-1 or 3-2 for Type V (combustible) construction, curve 3 for ordinary hazard occupancies, single story.

Step 3 Read the basic fire flow from the curve based on the area of 13,050, 1,620 gpm.

Step 4 item 1 Building 4 to 2 - Separation factor of 3

Building 4 to 3 - Separation factor of 2

Building 4 to 5 - Separation factor of 2

Building 4 to 4A - Separation factor of 5

item 2 Total separation factor = 3 + 2 + 2 + 5 = 12

item 3 Exposure factor from figure 3-3 is 1.63

item 4 Required fire flow = 1,620 x 1.63 = 2,640 rounded to 2,750

Step 5 The duration is 3 hours from table 3-2.

Step 6 The water is supplied from existing mains at the site. A fire flow test has shown there are 2,750 gpm at 22 psi residual available at the site. Since this is greater than 20 psi, a pumper will be used and no upgrade of the existing system is required.

Step 7 No special systems are installed.

Step 8 No sprinkler systems provided.

YARD STORAGE

Description: 8 feet high yard storage, metal parts in wood crates, with 2,250 square feet available for storage.

Procedure:

Step 1 item 1 The storage is not over 15 feet high and is classified as low piled storage.

item 2 The storage is classified as combustible because of the wood crates.

item 3 2,250 square feet is available.

item 4 Yard 4A to Building 4 - 0 feet

Yard 4A to Building 5 - 100 feet

Step 2 Refer to figure 4-1 or 4-2 curve 2 for low piled combustible storage.

Step 3 The basic fire flow from curve 2 based on the area of 2,250 square feet is 650 gpm.

Step 4 item 1 Yard 4A to Building 4 - Separation factor of 5

Yard 4A to Building 5 - Separation factor of 2

item 2 Total separation factor - 7

item 3 Exposure factor from figure 3-3 is 1.375.

item 4 Required fire flow = 650 x 1.375 = 894 rounded to 1,000 gpm.

Step 5 The duration is 2 hours from table 3-2.

Step 6 Since this facility is adjacent to Building 4, it is obvious by inspection that the existing system is adequate with use of a pumper.

BUILDING 5

Description: 2-story, Type V (combustible) construction, wood frame office building, 10,000 square feet total area (5,000 each floor)

Procedure:

Step 1 item 1 Type V (combustible) construction

item 2 2 story - multistory building

item 3 Light hazard occupancies

item 4 5,000 square feet per floor

item 5 Building 5 to 3 - 90 feet

Building 5 to 4 - 100 feet

Building 5 to Yard 4A - 100 feet

item 6 No automatic sprinklers or special system installed.

Step 2 Refer to figure 3-1 or 3-2 Type V (combustible) construction, curve 2 for multistory light hazard occupancies.

Step 3 The basic fire flow from the curve based on an area of 5,000 square feet per floor is 1,280 gpm.

Step 4 item 1 Building 5 to 3 - Separation factor of 2

Building 5 to 4 - Separation factor of 2

Building 5 to Yard 4A - Separation factor of 2

item 2 Total separation factor = 2 + 2 + 2 = 6

item 3 Exposure factor from figure 3-3 is 1.325

item 4 Required fire flow = 1,280 x 1.325 = 1,696, rounded to 1,750 gpm

Step 5 The duration of the required fire flow is 3 hours from table 3-2.

Step 6 A fire flow test from existing hydrants nearest the site shows a flow available of 1,750 gpm at a residual pressure of 25 psi. With use of a pumper, the existing system is adequate.

Step 7 No special systems are installed.

Step 8 No automatic sprinkler systems provided.

SUMMARY

Based on the required fire flow demands for the six subject facilities on this area, the water supply system needs to provide 2,750 gpm at 20 psi for 3 hours (based on Building 4, the building with the highest demand). The system also needs to provide 2,250 gpm at 70 psi to supply the sprinkler system in Building 2 or a fire pump is needed for Building 2. If 1,500 gpm at 70 psi is not available at Building 1 for its sprinkler system, a fire pump will be required. These requirements are in addition to domestic or process water demands.

SAMPLE 2
POL FACILITY

Description: Flammable liquids storage in above-ground atmospheric tanks, pressurized LP gas storage in above-ground pressurized tanks, and pumping facilities (see fig A-2).

1. Above-ground atmospheric POL tanks

Step 1 Cooling water, 500 gpm for Tank 1 from table 4-1.

Step 2 Provide additional cooling water, as required by paragraph 4-2.b., for:

Tank 2 - 500 gpm

Pressure Vessel 5 - 500 gpm

Pump House 3 - 500 gpm

Step 3 No special systems are installed.

Step 4 Total required fire flow rate
= 500 + 500 + 500 + 500 = 2,000 gpm.

Step 5 Duration 4 hours, as required by paragraph 4-2.e.

Step 6 The minimum residual pressure is to be 20 psi with use of a pumper or other pressure boosting measures.

2. Above-ground pressurized tanks

Step 1 Cooling water, 500 gpm from table 4-2.

Step 2 Provide additional cooling water, as required by paragraph 4-3.b., for:

Tank 1 - 500 gpm

Pump House 3 - 250 gpm

Step 3 A water spray system meeting the following requirements, as required by NFPA 30:

Surface area = 1,662 square feet x .25 gpm/square feet = 415 gpm, 80 psi minimum pressure, from actual hydraulic calculation of water spray system.

Step 4 Required fire flow rate = 500 + 500 + 250 + 415 = 1,665, rounded to 1,750 gpm.

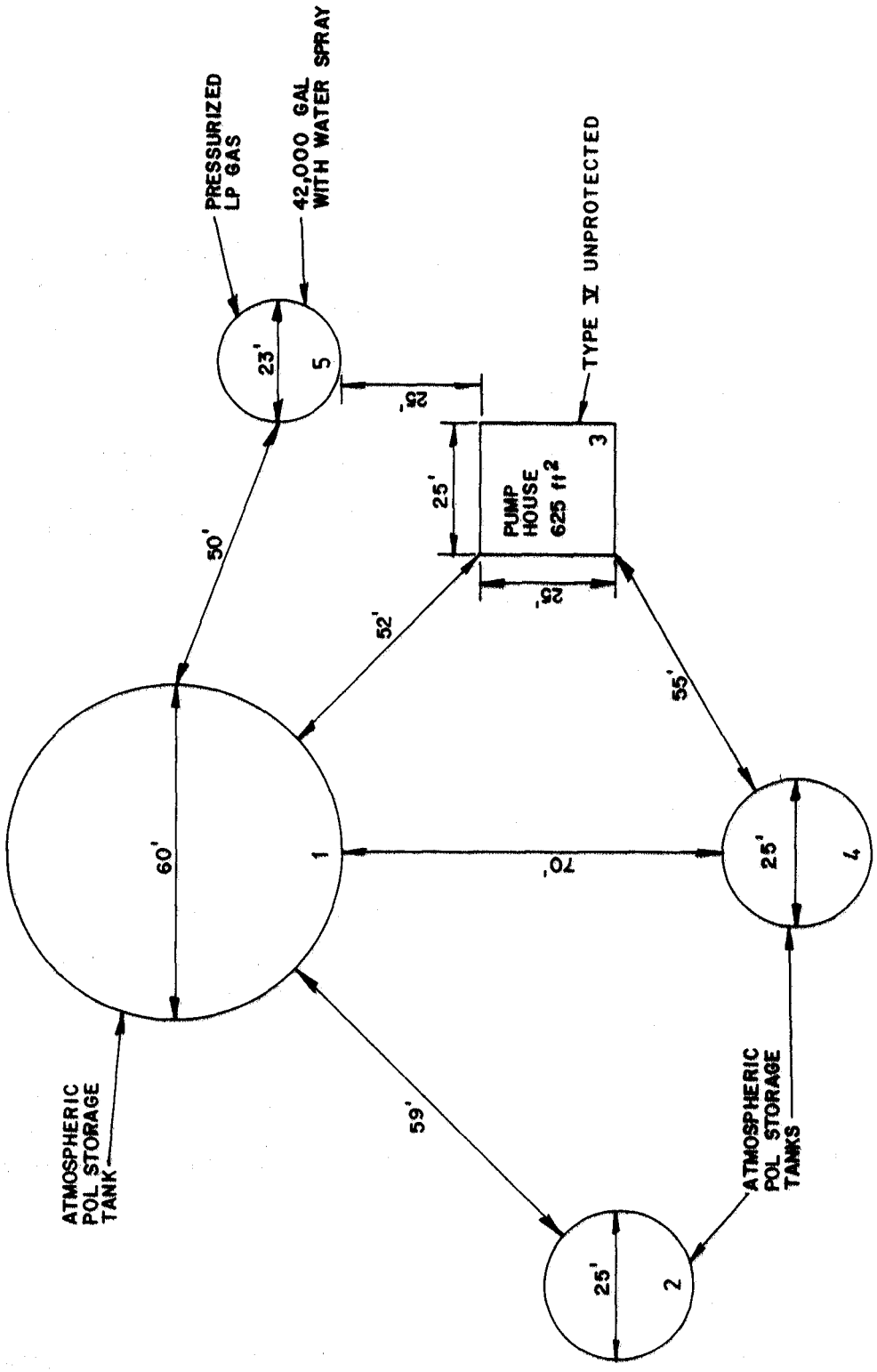

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FIGURE A-2. SAMPLE 2 AREA PLAN

Step 5 Duration of 4 hours as required by paragraph 4-3.e.

Step 6 The minimum residual pressure is to be 20 psi with use of a pumper or other pressure boosting measures.

3. Pump House

Step 1 item 1 Type V (1-HR fire-resistive rating) construction

item 2 1 story - single story

item 3 Extra hazard occupancies

item 4 625 square feet

item 5 Pump house to LP gas tank - 25 feet

Pump house to 60 foot tank - 52 feet

Pump house to 25 foot tank - 55 feet

item 6 No special protection provided

Step 2 Refer to figure 3-1 or 3-2 for Type V (combustible) construction, curve 5 for 1 story, extra hazard occupancies.

Step 3 The basic fire flow, using the area of 625 square feet, is 1,600 gpm.

Step 4 item 1 Pump house - LP tank - separation factor of 4

Pump house - 60 foot tank - Separation factor of 2

Pump house - 25 foot tank - Separation factor of 2

item 2 Total separation factor = 4 + 2 + 2 = 8

item 3 Exposure factor from figure 3-3 = 1.425

item 4 Required fire flow rate = 1,600 gpm x 1.425 = 2,280 gpm, rounded to 2,300 gpm

Step 5 Duration of flow is 4 hours.

Step 6 The minimum residual pressure is to be 20 psi with use of a pumper or other pressure boosting measures.

Step 7 No special systems are installed.

Step 8 No sprinkler systems provided.

SUMMARY

This POL facility has a required fire flow demand of 2,300 gpm. A minimum residual pressure of 20 psi will be obtained with or use of a pumper or other pressure boosting measures.

SAMPLE 3
EXPLOSIVES OPERATING BUILDING

Description: 15,000 square feet, 2-story ordnance plants, Type V construction, automatic deluge sprinkler system installed in exposed powder area (3,000 square feet) and wet pipe automatic sprinkler system installed in balance of building. Exposed powder area is separated from balance of building by fire walls.

Procedure:

Step 1 item 1 Type V (combustible) construction

item 2 2 stories - multiple-story building

item 3 Ordinary hazard occupancies (Group 3) - without exposed powder area

item 4 7,500 square feet per floor

item 5 No exposed facilities within 150 feet

item 6 Automatic sprinkler systems installed

Move to step 8 as automatic sprinkler systems are installed

Step 8 For this example, the building sprinkler system is designed to deliver 0.25 gpm per square foot over 3,000 square feet except in exposed powder areas where 0.50 gpm per square foot is provided over the entire exposed powder area. The calculated wet pipe sprinkler system demand is 1,100 gpm at 75 psi residual pressure and the deluge sprinkler system demand is 1,800 gpm at 115 psi (actual demand is obtained from sprinkler system design calculations). Because the exposed powder area is separated from the balance of the building by fire walls, only the highest demand (1,800 gpm at 115 psi) needs to be provided. If the fire walls were not provided, both demands would need to be supplied simultaneously. To this demand, the hose stream demand of 750 gpm must be added to obtain the required fire flow demand of 2,500 gpm at 115 psi (1,800 + 750, rounded to 2,500). The required fire flow duration is 45 minutes. The sprinkler system design is obtained from NFPA recommendations (except water demand criteria).

APPENDIX B

REFERENCES

Government Publications.

Department of the Army.

EM 1110-3-120	Design of Buildings for Mobilization.
EM 1110-3-164	Water Supply, Water Distribution.

Nongovernment Publications.

International Conference of Building Officials (ICBO), 5360 S. Workman Mill Rd., Whittier, CA 90601

1982 Uniform Building Code.

National Fire Protection Association (NFPA), Batterymarch Park, Quincy, MA 02269

No. 11-1978	Foam Extinguishing Systems.
No. 11A-1981	High Expansion Foam Systems.
No. 11B-1977	Synthetic Foam and Combined Agent Systems.
No. 13-1980	Installation of Sprinkler Systems.
No. 14-1980	Standpipe and Hose Systems.
No. 15-1979	Water Spray Fixed Systems for Fire Protection.
No. 16-1980	Sprinkler and Spray Systems, Deluge Foam-Water.
No. 20-1980	Centrifugal Fire Pumps.
No. 30-1981	Flammable and Combustible Liquid Code.
No. 80A-1980	Protection of Buildings from Exterior Fire Exposures.
No. 206M-1976	Building Areas and Heights.
No. 220-1979	Types of Building Construction.

No. 231-1979	Indoor General Storage.
No. 231C-1980	Rack Storage of Materials.
No. 231A-1975	Outdoor General Storage.
No. 409-1979	Aircraft Hangars.
No. 495-1982	Explosive Materials.