NFPA No.

15

WATER SPRAY FIXED SYSTEMS

FOR FIRE PROTECTION

1973

NFPA

$2.00

NATIONAL FIRE PROTECTION ASSOCIATION
International
470 Atlantic Avenue, Boston, MA 02210

6M-6-73-FP-SM
Printed in U.S.A.

Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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Standard for

Water Spray Fixed Systems for Fire Protection

NFPA No. 15 — 1973

1973 Edition of No. 15

This 1973 edition of NFPA No. 15 was prepared by the Committee on Water Spray Fixed Systems and was adopted by the National Fire Protection Association at its 1973 Annual Meeting in St. Louis, Mo., on May 14–18. It supersedes the edition of 1969.

The 1969 edition of this standard was approved by the American National Standards Institute under date of August 14, 1972 and designated ANSI A54.2–1972. The 1973 edition is being submitted for similar approval. The ANSI designation and date of approval will be printed on the front cover of copies of this edition printed after approval has been received.

Origin and Development of No. 15

Standards for Water Spray Systems for Fire Protection, formerly "Water Spray Nozzles and Extinguishing Systems," first prepared by the Committee on Manufacturing Hazards, were tentatively adopted in 1939, with final adoption in 1940. Subsequently, these standards were placed under the jurisdiction of the Committee on Special Extinguishing Systems and a new edition was adopted in 1947. In 1959 the committee organization was further changed to place primary responsibility in the hands of the Committee on Water Spray, under the general supervision of the General Committee on Special Extinguishing Methods. In 1966 the General Committee on Special Extinguishing Methods was discontinued and the Committee on Water Spray was constituted as an independent committee. A revised edition was presented in 1969.

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Tentative Standard for

Water Spray Fixed Systems for Fire Protection

NFPA No. 15— 1973

Foreword

The term "water spray" refers to the use of water in a form having a predetermined pattern, particle size, velocity, and density discharged from specially designed nozzles or devices. Water spray fixed systems are usually applied to special fire protection problems, since the protection can be specifically designed to provide for effective fire control, extinguishment, prevention, or exposure protection. Water spray systems may be independent of, or supplementary to, other forms of protection.

This standard deals with water spray protection from fixed nozzle systems only. It does not cover water spray protection from portable nozzles, sprinkler systems, monitor nozzles, or other means of application covered by other standards of the National Fire Protection Association.

Water spray fixed systems are most commonly used to protect processing structures and equipment, flammable liquid and gas vessels, piping, and equipment such as transformers, oil switches, and motors. Such protection has also been shown to be effective on many combustible solids.

The design of specific systems may vary considerably, depending on the nature of the hazard and the basic purposes of protection. Because of these variations and the wide choice in the characteristics of spray nozzles, these systems must be competently designed, installed, and maintained. Although water spray has a wide application, it is essential that its limitations be understood by the designer.

Much informative material was included in earlier editions of this publication, in view of the limited knowledge about this form of protection. Over the years, however, additional test work has been done, and considerable additional field experience has become available, and later editions have been prepared as a standard rather than as a compilation of informative material.

In an effort to improve the application of this standard, this edition segregates permissive, optional and informational material

from the body of the text and places this supplemental material in the Appendix.

There are several methods of hydraulic calculation which will produce statisfactory results. There is a need, however, for a uniform method of hydraulic calculations for the sake of simplicity and consistency. For this reason a recommended method has been included in the Appendix of this standard.

NOTICE

An asterisk (*) preceding the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Chapter 1. General Provisions

1010. Scope.

1011. This standard is a minimum standard for the design, installation, maintenance, and test of water spray fixed systems, for fire protection service.

*1020. Definitions.

Automatic Detection Equipment — Equipment which will automatically detect heat, flame, smoke, combustible vapor, or other condition likely to produce fire or explosion, and cause automatic actuation of alarm and protection equipment.

Control of Burning — Application of water spray to equipment or areas where a fire may occur to control the rate of burning and thereby limit the heat release from a fire until the fuel can be eliminated or extinguishment effected.

Density — The unit rate of water application to an area or surface expressed in gallons per minute per square foot.

Exposure Protection — Application of water spray to structures or equipment to limit absorption of heat to a level which will minimize damage and prevent failure, whether source of heat is external or internal.

Flammable and Combustible Liquids — See the *Standard for Basic Classifications of Flammable and Combustible Liquids*, NFPA No. 321, 1973.

Impingement — The striking of a protected surface by water droplets issuing directly from a water spray nozzle.

Insulated Equipment, Structures, or Vessels — Equipment, structures, or vessels provided with insulation, which, for the expected duration of exposure, will protect steel from exceeding a temperature of 850°F for structural members, or 650°F for vessels; and where the insulation system is:

(a) Noncombustible and fire retardant,

(b) Mildew and weather resistant,

(c) Resistant to the force of hose streams, and

(d) Secured by fire and corrosion resistant fastenings.

Nonabsorbing Ground — Earth or fill which is not readily permeable or absorbent to large quantities of flammable or com-

bustible liquid and/or water. Most soils are not considered sufficiently permeable or absorbent to be considered absorbing ground. Pavings, such as concrete or asphalt, are considered nonabsorbing.

Run-Down — The downward travel of water along a surface, caused by the momentum of the water or by gravity.

Slippage — The horizontal component of the travel of water along a surface beyond the point of impact, caused by the momentum of the water.

Water Spray Nozzle — A water discharge device which, when supplied with water under pressure, will distribute the water in a special, directional pattern peculiar to the particular device (see 4070).

Water Spray System — A water spray system is a special fixed pipe system connected to a reliable source of fire protection water supply, and equipped with water spray nozzles for specific water discharge and distribution over the surface or area to be protected. The piping system is connected to the water supply through an automatically or manually actuated valve which initiates the flow of water. An automatic valve is actuated by operation of automatic detection equipment installed in the same areas as the water spray nozzles. (In special cases the automatic detection equipment may also be located in another area.)

Water Wastage — Wastage is that discharge from water spray nozzles which is ineffective on surface being protected. Some causes of wastage are wind velocity, and sometimes the overcarry of discharge pattern beyond the targeted surface.

Wet Water — Wet water is any water to which a compatible wetting agent has been added in quantities specified by the manufacturer.

1030. Applicability.

1031. Water spray is applicable for protection of specific hazards and equipment, and may be installed independently of or supplementary to other forms of fire protection systems or equipment..

1032. Hazards — Water spray protection is acceptable for the protection of hazards involving:

(a) Gaseous and liquid flammable materials.
(b) Electrical hazards such as transformers, oil switches, and motors.
(c) Ordinary combustibles such as paper, wood, and textiles.
(d) Certain hazardous solids.

*1033. Purposes — In general, water spray may be used effectively for any one or a combination of the following purposes:

(a) Extinguishment of fire.

(b) Control of burning.

(c) Exposure protection.

(d) Prevention of fire.

1040. Limitations.

1041. There are limitations to the use of water spray which shall be recognized. Such limitations involve the nature of the equipment to be protected, the physical and chemical properties of the materials involved and the environment of the hazard.

Other standards also consider limitations to the application of water (slopover, frothing, electrical clearances, etc.) (see *Hazardous Chemicals Data*, NFPA No. 49, 1973 and *Fire Hazard Properties of Flammable Liquids, Gases, Volatile Solids*, NFPA No. 325M, 1969.)

1042. Materials Involved.

(a) A careful study shall be made of the physical and chemical properties of the materials for which water spray protection is being considered, in order to determine the advisability of its use. The flash point, specific gravity, viscosity, miscibility and solubility of the material, temperature of the water spray and the normal temperature of the hazard to be protected are among the factors which must be given consideration.

(b) The slop-over or frothing hazard shall be considered where water spray may encounter confined materials at a high temperature or having a wide distillation range.

(c) Water soluble materials, such as alcohol, require special consideration. Fires involving spills of such materials may usually be controlled, until extinguished by dilution, and in some cases the surface fire may be extinguished by an adequate application rate and coverage. Each water soluble material shall be tested under the conditions of use to determine the applicability of a water spray system, unless sufficient supportive data is already available.

*(d) Water spray shall not be used for direct application to materials which react with water, such as metallic sodium or calcium carbide, which produce violent reactions or increased hazardous products as a result of heated vapor emission; or for liquefied gases at cryogenic temperatures, such as liquefied natural gas, which boil violently when heated by water.

1043. Equipment Involved — Consideration shall be given to the possibility of damage, distortion, or failure of equipment operating at high surface temperatures.

***1044. Clearance To Live Electrical Apparatus.**

(a) GENERAL — The clearances given are for altitudes of 3,300 feet or less. At altitudes in excess of 3,300 feet, the clearance shall be increased at the rate of one percent for each 330-foot increase in altitude above 3,300 feet.

(b) CLEARANCE

(1) Clearance between any portion of water spray equipment and unenclosed or uninsulated live electrical components, at other than ground potential, shall not be less than that given in Table 1044(b) or Figure 1044(b).

TABLE 1044(b)

CLEARANCE FROM WATER SPRAY EQUIPMENT TO LIVE UNINSULATED ELECTRICAL COMPONENTS

Nominal Line Voltage (KV)	Nominal Voltage To Ground (KV)	Design BIL (KV)	Minimum Clearance (Inches)
To 15	To 9	110	6
23	13	150	8
34.5	20	200	12
46	27	250	15
69	40	350	23
115	66	550	37
138	80	650	44
161	93	750	52
196-230	114-132	900	63
		1050	76
287-380	166-220	1175	87
		1300	98
		1425	109
		1550	120
500	290	1675	131
		1800	142
500-700	290-400	1925	153
		2100	168
		2300	184

NOTE: When the design BIL is not available, and when nominal voltage is used for the design criteria, the highest minimum clearance listed for this group shall be used.

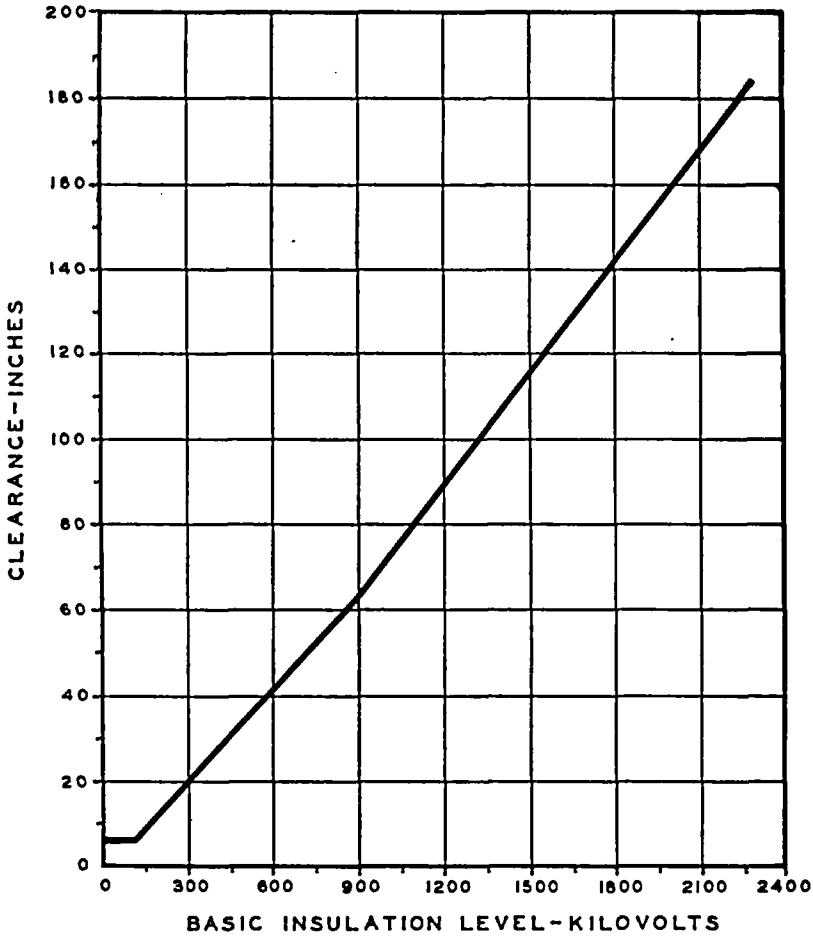


Fig. 1044(b). Clearance from Water Spray Equipment to Live Uninsulated Electrical Components.

(2) The clearances are based upon minimum general practices related to design BIL (Basic Insulation Level) values. To coordinate the required clearance with the electrical design, the design BIL of the equipment being water spray protected shall be used as a basis, if available. Where the design BIL is not available, the

voltage may be used as a basis. However, in either event, the clearance between uninsulated energized parts of the electrical system equipment and any portion of the water spray system shall not be less than the minimum clearances provided elsewhere for electrical system insulation on any individual component (the minimum unshielded straight line distance from the exposed electrical parts to nearby grounded objects). BIL values are expressed as KV (kilovolts), the number being the crest value of the full wave impulse test.

1050. System Design.

1051. Water spray system design shall be entrusted only to responsible persons fully experienced in this field (see 4010).

1060. Certification of Water Spray Systems.

1061. The contractor shall prepare and submit a description and diagram of the system and its purpose, maintenance and instruction bulletins, and the applicable parts of the Sprinkler Contractors Certificate covering material and tests (see *Standard for the Installation of Sprinkler Systems*, NFPA 13, 1973) certifying that the work has been completed and tested in accordance with plans and specifications; before requesting final approval of the water spray system.

Chapter 2. System Components

2010. Component Parts.

2011. All component parts shall be coordinated to provide complete systems. Systems shall be operable by automatic means with supplementary manual tripping means.

Manual operation, only, is acceptable where:

(1) Automatic operation of the system presents a hazard to personnel, or

(2) A system is isolated and is attended by trained personnel at all times.

2012. Only listed new materials and devices shall be employed in the installation of systems except that, where age and condition permit, listed devices such as special system water control valves and their accessories, circuit closers, water motor alarm devices, nonautomatic pattern spray nozzles, etc., may be reused, but if reused they shall be reconditioned by the original manufacturer. The original manufacturer shall furnish a certificate, stating that such specified devices have been reconditioned and tested and are considered satisfactory for reuse.

2020. Corrosion Protection.

2021. System components installed out of doors, or in the presence of a corrosive atmosphere, shall be constructed of materials which will resist corrosion or be covered with protective coatings. The threaded ends of galvanized pipe, after installation, shall be protected against corrosion.

2030. Spray Nozzles.

2031. Care shall be taken in the application of nozzle types. Distance of "throw" or location of nozzle from surface shall be limited by the nozzle's discharge characteristics (see 4070).

Care shall also be taken in the selection of nozzles to obtain waterways which are not easily obstructed by debris, sediment, sand, etc., in the water. Requirements for strainers and their placement are described in 2110 and 4110.

2040. Piping.

2041. Pipe and tube used in water spray systems shall be of the materials listed in Table No. 2041. The chemical properties,

physical properties and dimensions of the materials listed in Table No. 2041 shall conform at least to the standards cited in the table. Pipe and tube used in water spray systems shall be designed to withstand a working pressure of not less than 175 psi. Whenever the word "pipe" is used, it shall be understood to also mean "tube".

Table No. 2041

Material & Dimensions	Standard
Ferrous Piping (Welded & Seamless)	
Hot Dipped, Zinc Coated (Galvanized) Steel Pipe	ASTM A-120-69 ASTM A-53-69a ANSI Standard B36.10-70*

*Standard Wall schedule 40 pipe permitted for pressures up to 300 psi. Schedule 30 pipe acceptable in sizes 8 in. and larger.

2042. Galvanized pipe shall be used except that; where corrosion of galvanized pipe may be caused by corrosive atmospheres or the water, or by additives to the water, other suitable coatings shall be provided.

2043. The galvanizing of galvanized pipe shall be in accordance with specifications of the above standards.

2044. Other pipe or tubing which has been investigated and listed for this service by a nationally recognized testing and inspection agency may be used. The use of such tubing shall involve careful consideration of the following factors:

1. Pressure rating.
2. Beam strength (hangers and spacing).
3. Corrosion (chemical and electrolytic).
4. Methods of joining (strength, permanence, fire endurance).
5. Availability of fittings (for water spray nozzle outlets and proper routing).
6. Resistance to limited exposure time without water and resistance to rapid temperature change and steam pressure generated upon the admittance of water.

2050. Fittings.

2051. All fittings shall be of a type specifically approved for fire protection systems and of a design suitable for the working pressures involved, but not less than 175 psi cold water pressures. Ferrous fittings shall be of steel, malleable iron or ductile iron in dry sections

of the piping exposed to possible fire or in self-supporting systems. Galvanized fittings shall be used where galvanized pipe is required.

2052. Rubber gasketed fittings subject to direct fire exposure are generally not suitable. Where necessary for piping flexibility, or for locations subject to earthquake, explosion, or similar hazards, such installations are acceptable. In such cases special hanging or bracing may be necessary.

2060. Hangers.

2061. Hangers shall be of a type approved for use with the piping involved (see 4100).

2070. Valves.

2071. All valves shall be of a type approved for the purpose. Manual shutoff or control valves shall be of the indicating type.

2080. Control Equipment.

2081. Automatic valves shall be special system water control valves approved for the use intended.

2082. Control of automatic valves shall be by means of approved accessories for special systems.

2083. Manual devices may actuate the automatic control valves by mechanical, hydraulic, pneumatic, electrical, or other approved means. The manual device shall be amply strong to prevent breakage. Manual controls shall not require a pull of more than 40 pounds (force) nor a movement of more than 14 inches to secure operation.

2084. Automatic detection equipment shall be of a type listed by a nationally recognized testing laboratory for use with special system water control valves.

2100. Pressure Gages.

2101. Required pressure gages shall be of approved type and shall have a maximum limit not less than twice the normal working pressure when installed. They shall be so installed as to permit easy removal, and shall be located where they will not be subject to freezing.

2110. Strainers.

2111. Pipeline strainers shall be specifically approved for use in water supply connections. Strainers shall be capable of removing from the water all solids of sufficient size to obstruct the spray

nozzles (normally ⅛ in. perforations are suitable). In addition, the strainer shall be capable of continued operation without serious increase in head loss, for a period estimated to be ample when considering the type of protection provided, the condition of the water, and similar local circumstances (see 4113).

2112. Pipeline strainer designs shall incorporate a flushout connection.

2113. Individual strainers for spray nozzles, where required, shall be of approved type capable of removing from the water all solids of sufficient size to obstruct the spray nozzle they serve.

***2120. Alarms.**

2121. The location, purpose, and type of system shall determine the alarm service to be provided.

2122. Electrical fittings and devices designed for use in hazardous locations shall be used where required by the *National Electrical Code*, NFPA No. 70.

2130. Fire Department Connections.

2131. Fire Department connections, where used, shall be of a type approved for the purpose (see 3022).

2140. Flushing Connections.

2141. A suitable flushing connection shall be incorporated in the design of the system to facilitate routine flushing as required by 6019.

Chapter 3. Water Supplies

3000. General.

3001. It is of vital importance that water supplies be selected which provide water as free as possible from foreign materials.

3010. Volume and Pressure.

***3011.** The water supply flow rate and pressure shall be capable of maintaining water discharge at the design rate and duration for all systems designed to operate simultaneously.

3012. For water supply distribution systems, an allowance for the flow rate of hose streams or other fire protection water requirements shall be made in determining the maximum demand.

Sectional control shutoff valves shall be located with particular care so that they will be accessible during an emergency.

3013. When only a limited water source is available, sufficient water for a second operation shall be provided so that the protection can be re-established without waiting for the supply to be replenished.

3020. Sources.

***3021.** The water supply for water spray systems shall be from reliable fire protection water supplies, such as:

(a) Connections to waterworks systems,

(b) Gravity tanks (in special cases pressure tanks), and/or

(c) Fire pumps and suction supply.

***3022. Fire Department Connections.**

One or more Fire Department connections shall be provided in all cases where water supply is marginal and/or where auxiliary or primary water supplies may be augmented by the response of suitable pumper apparatus responding to the emergency. Fire department connections are valuable only when fire department pumping capacities can equal maximum demand flow rate. Careful consideration shall be given to such factors as the purpose of the system, reliability, and capacity and pressure of the water system. The possibility of serious exposure fires and similar local conditions shall be considered. A pipe line strainer in the Fire Department connection shall be provided if indicated by 4110. Where a Fire Department connection is required, suitable suction provisions for the responding pumper apparatus shall be provided.

NOTE: See also the applicable sections of *Standard for the Installation of Sprinkler Systems*, NFPA No. 13 1973 — *Standard for the Installation of Standpipe & Hose Systems*, NFPA No. 14 1973 — *Standard for Outside Protection*, NFPA No. 24 1973.

Chapter 4. System Design and Installation

4000. Workmanship.

4001. Water spray system design, layout, and installation shall be entrusted to none but fully experienced and responsible parties. Water spray system installation is a specialized field of sprinkler system installation which is a trade in itself.

4010. Plans, Specifications, and Hydraulic Calculations.

4011. Before a water spray system is installed or existing equipment remodeled, complete working plans, specifications and hydraulic calculations shall be prepared and made available to interested parties. For details concerning plans, specifications and hydraulic calculations, see Chapter 7.

4020. Design Guides.

4021. Water spray system designs shall conform to the applicable requirements of the following Standards of the National Fire Protection Association, except where otherwise specified herein :

Title	Number and Date
Installation of Sprinkler Systems	NFPA No. 13 -1973
Installation of Standpipe and Hose Systems	NFPA No. 14 -1973
Wetting Agents	NFPA No. 18 -1972
Installation of Centrifugal Fire Pumps	NFPA No. 20 -1972
Water Tanks For Private Fire Protection	NFPA No. 22 -1971
Outside Protection	NFPA No. 24 -1973
Supervision of Valves	NFPA No. 26 -1958
National Electrical Code	NFPA No. 70 -1971
Central Station Protective Signaling Systems	NFPA No. 71 -1972
Local Protective Signaling Systems	NFPA No. 72A-1972
Auxiliary Protective Signaling Systems	NFPA No. 72B-1972
Remote Station Protective Signaling Systems	NFPA No. 72C-1972
Proprietary Protective Signaling Systems	NFPA No. 72D-1973
Protection From Exposure Fires	NFPA No. 80A-1970
Indoor General Storage	NFPA No. 231 -1972
Rack Storage of Materials	NFPA No. 231C-1973

NOTE: Components of the electrical portions of these protective systems, where installed in locations subject to hazardous vapors or dusts, shall be of types approved for use therein.

4030. Density and Application.

***4031. Extinguishment.**

(a) Extinguishment of fires by water spray may be accomplished by surface cooling, by smothering from steam produced, by emulsification, by dilution, or by various combinations thereof. Systems shall be designed so that, within a reasonable period of time, extinguishment shall be accomplished and all surfaces shall be cooled sufficiently to prevent "flashback" occurring after the system is shut off.

(b) The design density for extinguishment shall be based upon test data or knowledge concerning conditions similar to those that will apply in the actual installation. A general range of water spray application rates that will apply to most ordinary combustible solids or flammable liquids is from 0.2 gpm per sq. ft. to 0.5 gpm per sq. ft. of protected surface.

NOTE: There are some data available on water application rates needed for extinguishment of certain combustibles or flammables; however, much additional test work is needed before minimum rates can be established.

*(c) Each of the following methods or a combination of them shall be considered when designing a water spray system for extinguishment purposes:

1. Surface Cooling.
2. Smothering by Steam Produced.
3. Emulsification.
4. Dilution.
5. Other Factors.

4032. Control of Burning.

(a) A system for the control of burning shall function at full effectiveness until there has been time for the flammable materials to be consumed, for steps to be taken to shut off the flow of leaking material, for the assembly of repair forces, etc. System operation for hours may be required.

(b) Nozzles shall be installed to impinge on the areas of the source of fire, and where spills may travel or accumulate. The water application rate on the probable surface of the spill shall be at the rate of not less than 0.50 gpm per sq. ft.

(c) Pumps or other devices which handle flammable liquids or gases shall have the shafts, packing glands, connections, and other critical parts enveloped in directed water spray at a density of not less than 0.50 gpm per sq. ft. of projected surface area.

4033. Exposure Protection.

*(a) GENERAL:

(1) The system shall be able to function effectively for the duration of the exposure fire which is estimated from a knowledge of the nature and quantities of the combustibles and the probable effect of fire-fighting equipment and materials. System operation for hours may be required.

(2) Automatic water spray systems for exposure protection shall be designed to operate before the formation of carbon deposits on the surfaces to be protected and before the possible failure of any containers of flammable liquids or gases because of the temperature rise. The system and water supplies shall, therefore, be designed to discharge effective water spray from all nozzles within 30 seconds following operation of the detection system.

(3) The densities specified for exposure protection contemplate minimal wastage of 0.05 gpm per sq. ft. (see 4070).

*(b) VESSELS:

(1) These rules for exposure protection contemplate emergency relieving capacity for vessels, based upon a maximum allowable heat input of 6,000 Btu per hour per sq. ft. of exposed surface area. The density shall be increased to limit the heat absorption to a safe level in the event required emergency relieving capacity is not provided.

(2) Water shall be applied to vertical or inclined vessel surfaces at a net rate of not less than 0.25 gallons per minute per sq. ft. of exposed uninsulated surface. Individual nozzle water application rates shall be increased to provide for any run-down or slippage allowances. Where run-down is contemplated, the vertical distance between nozzles shall not exceed twelve feet. The horizontal extremities of spray patterns shall at least meet.

(3) Spherical or horizontal cylindrical surfaces below the vessel equator cannot be considered wettable from run-down, unless engineering data to the contrary is available.

(4) Where projections (manhole flanges, pipe flanges, support brackets, etc.) will obstruct water spray coverage, including run-down or slippage on verticle surfaces, additional nozzles shall be installed around the projections to maintain the wetting pattern which otherwise would be seriously interrupted.

(5) Bottom and top surfaces of verticle vessels shall be completely covered by directed water spray at an average rate of not less than 0.25 gallons per minute per sq. ft. of exposed uninsulated surface. Consideration may be given to slippage but on the bottom

surfaces the horizontal extremities of spray patterns shall at least meet.

(6) Special attention shall be given to distribution of water spray around relief valves and around supply piping and valve connection projections.

(7) Uninsulated skirts shall have water spray applied on one exposed (uninsulated) side, either inside or outside, at a net rate of not less than 0.10 gpm per sq. ft.

(c) STRUCTURES & MISCELLANEOUS EQUIPMENT:

(1) Horizontal, stressed (primary) structural steel members shall be protected by nozzles spaced not greater than ten feet on centers (preferably on alternate sides) and of such size and arrangement as to discharge not less than 0.10 gpm per sq. ft. over the wetted area (see Figure 4033(c)).

(2) Vertical structural steel members shall be protected by nozzles spaced not greater than ten feet on centers (preferably on alternate sides) and of such size and arrangement as to discharge not less than 0.25 gpm per sq. ft. over the wetted area (see Figure 4033(c)).

(3) Metal pipe, tubing and conduit runs shall be protected by water spray at a basic rate of 0.10 gpm per sq. ft. of aggregate pipe wall area. Structural supports shall be protected as indicated in 4033(c)(1) and (2). This rate may be reduced if the cumulative discharge over all areas exceeds 0.50 gallons per minute per sq. ft. of projected grade area. Nozzles shall be located to cause water spray to directly impinge on surfaces of pipe and supporting structure. Factors to be considered when designing water spray protection for pipe racks include the number of levels of pipe, the spacing between pipes, and the general configurations of the pipe rack (see Figures 4033(c-3-1) and 4033(c-3-2) for typical water spray application rate calculations).

*(4) If spill-fire exposure protection is desired for nonmetallic sheathed insulated electrical cable and/or nonmetallic tubing runs in open trays, see Appendix.

(d) TRANSFORMERS:

(1) Transformer protection shall contemplate essentially complete impingement on all exterior surfaces, except underneath surfaces which in lieu thereof may be protected by horizontal projection. The water shall be applied at a rate not less than 0.25 gpm per sq. ft. of projected area of rectangular prism envelope for the transformer and its appurtenances and not less than 0.15 gpm per sq. ft. on the expected nonabsorbing ground surface area of

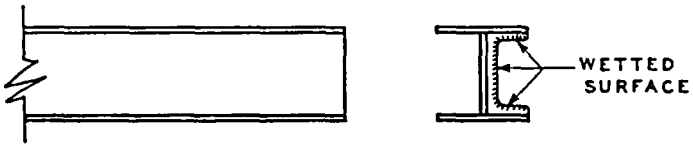


Fig. 4033(c). The wetted surface of structural member — beam or column is defined as one side of the web and the inside surface of one side of the flanges as shown above.

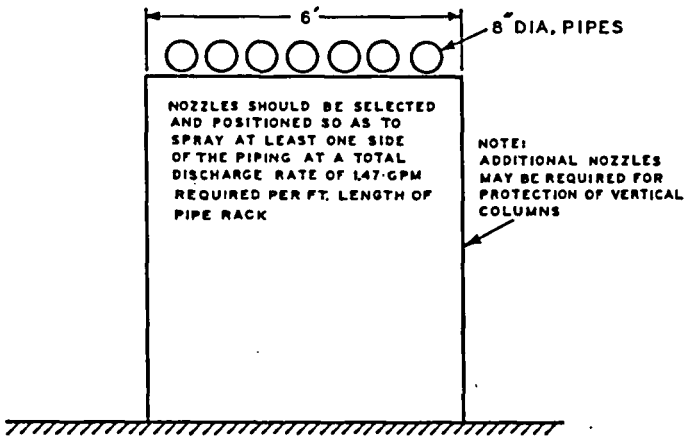


Fig. 4033 (c-3-1). Calculation of water spray density requirement for typical pipe rack.

The sum (Σ) of the total number (N) of pipes multiplied by π times the diameter (d) of the pipe in feet multiplied by a unit length (L) of pipe of 1 foot, times the density rate (q) equals total gpm required per ft. length of pipe rack.

$\Sigma N\pi dLq = 7\pi(8/12)\,(1)\,(0.1) = 1.47$ gpm required per ft. length of pipe rack.

To determine density in gpm per square foot, divide the total discharge per foot of length of pipe rack by the width of the pipe rack in feet: $1.47 \div 6 = 0.245$ gpm/ft^2 of projected grade area.

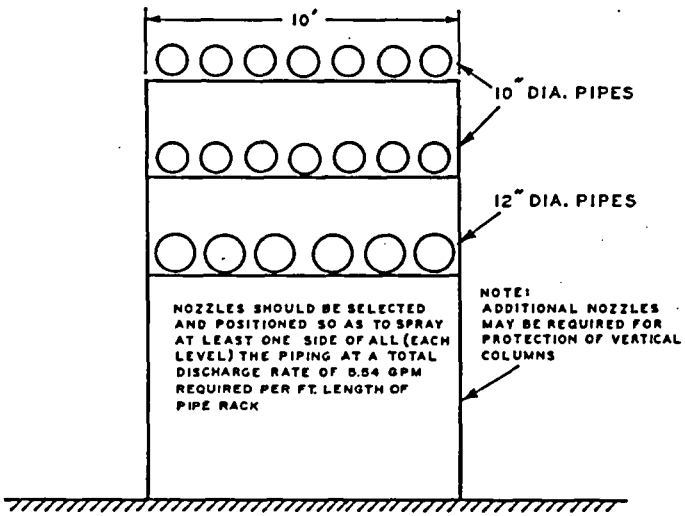


Fig. 4033 (c-3-2). Calculation of water spray density requirement for typical pipe rack.

The (Σ) of the total number (N) of pipes multiplied by π times the diameter (d) of the pipe in feet multiplied by a unit length (L) of pipe of 1 foot, times the density rate (q) equals total gpm required per ft. length of pipe rack.

$\Sigma N\pi dLq = 14\pi\ (10/12)\ (1)\ (0.1) + 6\pi(12/12)\ (1)\ (0.1) = 3.66 + 1.88 = 5.54$ gpm required per ft. length of pipe rack.

To determine density in gpm per square foot, divide the total discharge per foot of length of pipe rack by the width of the pipe rack in feet: $5.54 \div 10 = 0.55$ gpm/ft^2 of projected grade area. Reduce to not more than 0.50 gpm/ft^2 of projected grade area. (See 4033 (c) (4)]

exposure. Additional application is needed for special configurations, conservator tanks, pumps, etc. Spaces greater than twelve inches in width between radiators, etc., shall be individually protected.

(2) Water spray piping shall not be carried across the top of the transformer tank, unless impingement cannot be accomplished with any other configuration and provided the required distance from the live electrical components is maintained (see 1044).

(3) In order to prevent damage to energized bushings or lightning arrestors, water spray shall not envelop this equipment by direct impingement, unless so authorized by the manufacturer or his literature, and the owner.

(e) BELT CONVEYORS.

(1) THE DRIVE UNIT: (See Figure 4033.e.1.) Water spray system shall be installed to protect the drive rolls, the take-up rolls, the power units and the hydraulic-oil unit. The rate of water application shall be 0.25 gallons per minute per sq. ft. of roll and belt.

Nozzles shall be located to direct water spray onto the surfaces to extinguish fire in hydraulic oil, belt, or contents on the belt. Water spray impingement on structural elements shall be such as to provide protection against radiant heat or impinging flame.

(2) THE CONVEYOR BELT: (See Figure 4033.e.2.) Water spray system shall be installed to automatically wet the top belt, its contents, and the bottom return belt. Discharge patterns of water spray nozzles shall envelop, at a rate of 0.25 gallons per minute per sq. ft. of top and bottom belt area, the structural parts and the idler-rolls supporting the belt. Water spray system protection shall be extended onto transfer belts, transfer equipment and transfer buildings beyond each transfer point. Or, systems for the protection of adjacent belts or equipment shall be interlocked in such a manner that the feeding belt water spray system will automatically actuate the water spray system protecting the first segment of the down-stream equipment.

Special consideration shall be given to the interior protection of the building, gallery, or tunnel housing the belt conveyor equipment.

Also, the exterior structural supports for galleries shall be protected from exposure such as fires in flammables located adjacent to the galleries.

The effectiveness of belt conveyor protection is dependent upon rapid detection and appropriate interlocks between the detection system and the machinery (see Chapter 8).

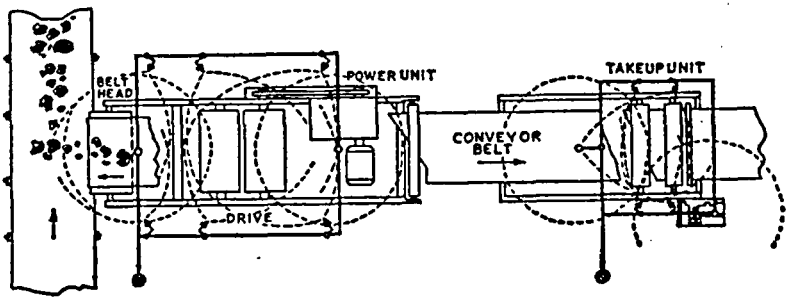


Fig. 4033 (e-1). Plan view — Typical Belt to Belt Transfer Station with Conveyor Belt, Drive, Power Unit & Takeup Unit.

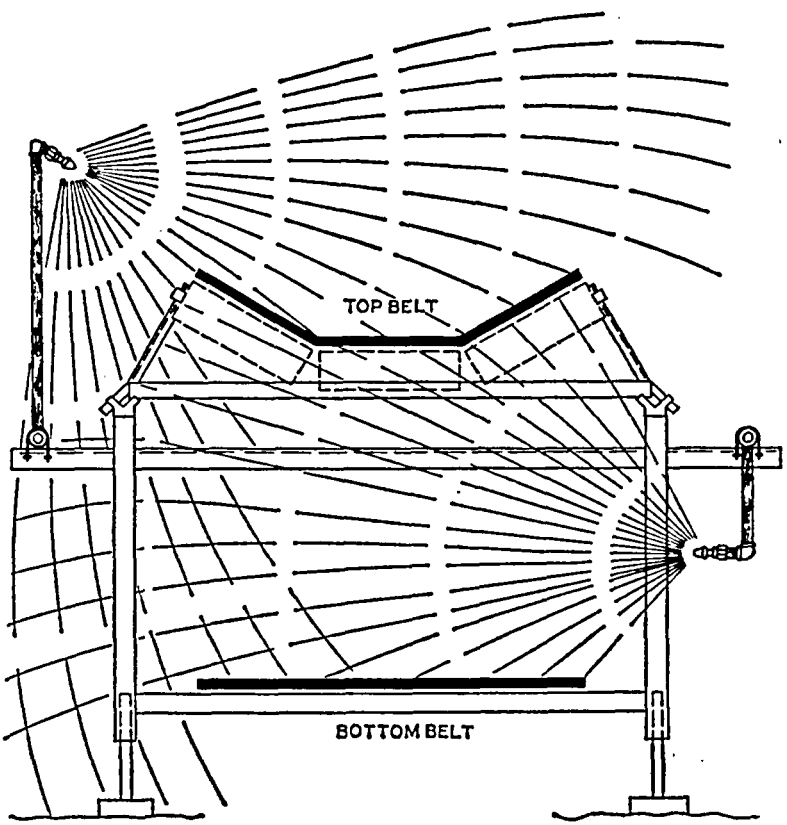


Fig. 4033 (e-2). Belt Conveyor Cross Section.

4034. Fire Prevention.

(a) The system shall be able to function effectively for a sufficient time to dissolve, dilute, disperse, or cool flammable or hazardous materials. The possible duration of release of the materials shall be considered in the selection of duration times.

(b) The rate of application for fire prevention shall be based upon experience with the product or upon test.

4040. Size of System.

4041. Separate fire areas shall be protected by separate systems. Single systems shall be kept as small as practicable, giving consideration to the water supplies and other factors affecting reliability of the protection. A design discharge rate of 3,000 gpm shall not be exceeded for a single system (see Chapter 3).

***4050. Separation of Fire Areas.**

4051. Separation of fire areas shall be by space, fire barriers, diking, special drainage, or by combination of these. In the separation of fire areas consideration shall be given to the possible flow of burning liquids before or during operation of the water spray systems.

4052. Area Drainage.

(a) Adequate provisions shall be made to promptly and effectively dispose of all liquids from the fire area during operation of all systems in the fire area. Such provisions shall be adequate for:

(1) Water discharged from fixed fire protection systems at maximum flow conditions.

(2) Water likely to be discharged by hose streams.

(3) Surface water.

(4) Cooling water normally discharged to the system.

(b) There are four methods of disposal or containment:

(1) Grading.

(2) Diking.

(3) Trenching.

(4) Underground or enclosed drains.

The method used shall be determined by:

(1) The extent of the hazard.

(2) The clear space available.

(3) The protection required.

Where the hazard is low, the clear space is adequate, and the degree of protection required is not great, grading is acceptable. Where these conditions are not present, consideration shall be given to dikes, trenching, or underground or enclosed drains.

(c) For the methods of drainage or diking, see *Standard for Flammable and Combustible Liquids*, NFPA No. 30, 1973.

4060. Valves.

4061. Shutoff Valves. Each system shall be provided with a shutoff valve so located as to be readily accessible during a fire in the area the system protects or adjacent areas, or, for systems installed for fire prevention, during the existence of the contingency for which the system is installed.

4062. Automatically Controlled Valves.

(a) Automatically controlled valves shall be as close to the hazard protected as accessibility during the emergency will permit, so that a minimum of piping is required between the automatic valve and the spray nozzles.

(b) Remote manual tripping devices, where required, shall be conspicuously located where readily accessible during the emergency and adequately identified as to the system controlled.

4063. Drain Valves. Readily accessible drains shall be provided for low points in underground and aboveground piping.

4070. Spray Nozzles.

4071. Selection. The selection of the type and size of spray nozzles shall be made with proper consideration given to such factors as physical character of the hazard involved, draft or wind conditions, material likely to be burning, and the general purpose of the system (see 2031).

4072. Position. Spray nozzles may be placed in any position necessary to obtain proper coverage of the protected area. Positioning of nozzles with respect to surfaces to be protected, or to fires to be controlled or extinguished, shall be guided by the particular nozzle design and the character of water spray produced. The effect of wind and fire draft on very small drop sizes or on larger drop sizes with little initial nozzle velocity shall be considered,

since these factors will limit the distance between nozzle and surface, and will limit the effectiveness of exposure protection, fire control or extinguishment. Care shall be taken in positioning nozzles that water spray does not miss the targeted surface and reduce the efficiency or calculated discharge rate (gpm/ft^2). Care shall also be exercised in placement of spray nozzles protecting pipe lines handling flammable liquids under pressure, where such protection is intended to extinguish or control fires resulting from leaks or ruptures.

4080. Piping.

4081. Size. As effective protection is dependent on having adequate pressure and quantity of water available at all spray nozzles, each system requires individual consideration as to the size of the piping. This requires that the size of the piping be based upon hydraulic computations (see Chapter 7). However, piping shall not be less than one-inch nominal diameter.

*4082. Installation.

(a) The installation standards for water spray system piping shall be applicable sections of the *Standard for the Installation of Sprinkler Systems*, NFPA 13, 1973, except as herein modified.

(b) Welding is permissible. Welding shall be conducted in accordance with the Code for Pressure Piping, ANSI B31.1 – 1973 and Supplements, where applicable. This may require galvanizing of sections involving welded parts after fabrication. Special care shall be taken to insure that the openings are fully cut out and that no obstructions remain in the waterway. Safe welding or cutting practices shall be followed.

(c) All underground supply piping after the automatic control valve shall be pitched ½ inch in ten feet to drain in the same manner as the above mentioned Standards specify for aboveground piping. Provision shall be made to drain underground and overhead piping.

(d) Provision shall be made for test gages at or near the highest or most remote nozzle on each major separate section of the system. At least one gage connection shall be provided at or near the nozzle calculated as having the least pressure under normal flow conditions.

4100. Hangers.

4101. System piping shall be adequately supported. All supports in the fire area should be protected by the system. In any area where possibility of explosion may be recognized, special care shall

be taken to support the piping from portions of the structure least liable to disruption.

4102. Tapping or drilling of load-bearing structural members is not permitted unless the design of the structural members contemplates this feature or their design is such that the additional load can be safely tolerated, and no other arrangement is feasible. Attachments may be made to existing steel or concrete structures and in some cases to equipment and its supports. Where welding of supports directly to vessels or equipment is necessary, it shall be done in a safe manner in conformance with the provisions of all safety, structural, and fire codes and standards.

4103. Where the usual methods of supporting piping for fire protection purposes cannot be used, the piping shall be supported in such a manner as to produce the strength equivalent to that afforded by such usual means of support. In such cases, piping arrangements which are essentially self-supporting may be employed together with such hangers as are necessary.

4110. Strainers.

4111. Main pipeline strainers shall be provided for all systems utilizing nozzles with waterways less than $\frac{3}{8}$ inch and for any system where the water is likely to contain obstructive material.

4112. Pipeline strainers shall be installed so as to be accessible for cleaning during the emergency.

4113. Care shall be taken in the selection of strainers, particularly where nozzle waterways are less than $\frac{1}{4}$ inch in least dimension. Individual strainers shall be provided at each nozzle where water passageways are smaller than $\frac{1}{8}$ inch. Consideration must be given to size of screen perforation, to volume available for accumulation without excessive friction loss and the facility for inspection and cleaning.

4120. Gages.

4121. Gages shall be installed as follows:

(a) Below the seat of the automatic valve and arranged so as to indicate the residual pressure in the riser with the test pipe valve wide open.

(b) At each independent pipe from an air supply to an automatic valve.

(c) On the water supply connection to hydraulically controlled automatic valves.

(d) At the air pump supplying an air receiver.

(e) At an air receiver.

Chapter 5. Acceptance Tests

5000. Flushing of Piping.

5001. Supply Piping. Underground mains and lead-in connections to system risers shall be flushed thoroughly before connection is made to system piping, in order to remove foreign materials which may have entered the underground during the course of the installation or which may have been present in existing piping. The minimum rate of flow shall be not less than the water demand rate of the system which is determined by the system design, or not less than that necessary to provide a velocity of ten feet per second, whichever is greater. For all systems the flushing operations shall be continued for a sufficient time to insure thorough cleaning. When planning the flushing operations consideration shall be given to disposal of the water issuing from the test outlets.

Flow Required to Produce a Velocity of Ten Feet Per Second in Pipes

Pipe Size (Inches)	Flow (Gallons Per Minute)
4	390
6	880
8	1560
10	2440
12	3520

5002. System Piping. All system piping shall be flushed where practicable; otherwise, cleanliness shall be determined by visual examination.

5010. Hydrostatic Pressure Tests.

5011. Hydrostatic Tests. All new system piping shall be hydrostatically tested in accordance with the provisions of the *Standard for Installation of Sprinkler Systems*, NFPA No. 13, 1973.

5020. Water Discharge Test.

5021. When practicable, full flow tests with water shall be made of system piping as a means of checking the nozzle layout, discharge pattern, any obstructions and determination of relation between design criteria and actual performance, and to insure against clogging of the smaller piping and the discharge devices by foreign matter carried by the water.

5022. When practicable, the maximum number of systems that may be expected to operate in case of fire shall be in full operation simultaneously in order to check the adequacy and condition of the water supply.

5023. The discharge pressure at the highest, most remote nozzle, shall be at least that for which the system was designed.

5030. Operating Tests.

5031. All operating parts of the system shall be fully tested to assure they are in operating condition.

5032. The operating tests shall include a test of automatic detection equipment.

***5040. Acceptance Test Suggestions.** (See Appendix A-5040.)

Chapter 6. Periodic Testing and Maintenance

6000. General.

6001. Water spray systems require competent and effective care and maintenance to assure that they will perform their purpose effectively at the time of fire. Systems shall be serviced and tested periodically by men trained in this work. An inspection contract with a qualified agency for service, test, and operation at regular intervals is recommended and may be required.

6002. Operating and maintenance instructions and layouts shall be available or can be posted at control equipment and at the plant fire headquarters. Selected plant personnel shall be trained and assigned to the task of operating and maintaining the equipment.

6003. At weekly, or other frequent regularly scheduled plant inspections, equipment shall be checked visually for obvious defects, such as broken or missing parts, nozzle loading, or other evidence of impaired protection.

6010. Maintenance.

6011. Water Supplies. Proper precautions shall be taken to insure that water supplies are kept turned on and are in full operating condition at all times when hazard or exposure exists.

6012. Strainers. Strainers, except individual nozzle strainers (see 6018), shall be thoroughly inspected after each operation or flow test and cleaned if necessary. Routine inspection and cleaning shall be performed annually, and more frequently if necessary, based on experience.

6013. Piping. All piping shall be examined at regular intervals to determine condition and proper drainage. Frequency of inspections will be dependent upon local conditions and shall be at intervals of not more than one year.

6014. Flow tests of open head spray systems shall be made at least every five years or more frequently, as determined from experience.

6015. Control Valves & Devices. Control valves and automatic detection equipment shall be tested at least annually, by qualified personnel.

6016. Manual tripping devices and valves, including O. S. & Y. gate and post indicator valves, shall be operated at least annually.

6017. Where normally opened valves are closed following system operation or test, suitable procedures shall be instituted to insure that they are reopened and that the system is promptly and properly restored to full normal operating condition. Main drain flow tests shall be made after valves are reopened (see *Recommended Practice for the Care and Maintenance of Sprinkler Systems*, NFPA No. 13A, 1971 — Flow Tests).

6018. Spray Nozzles. All spray nozzles shall be inspected for proper positioning, external loading, and corrosion, and cleaned if necessary at intervals of not more than twelve months or more frequently if necessary, based on experience. Local conditions may require such inspection and cleaning more frequently and may require internal inspection. After each operation open spray nozzles equipped with individual screens shall be removed and the spray nozzle and screen cleaned, unless observation under flow conditions indicates this is not necessary.

6019. Flushing. Underground lead-in connections to system risers shall be flushed at least annually, in accordance with 5001. This may be accomplished by:

(a) A flow test of the system, or

(b) Flowing water from a suitable flushing connection of adequate size.

Chapter 7. Plans, Specifications & Hydraulic Calculations

7000. Plans and Specifications.

Working plans, including elevations, shall be drawn to an indicated scale, show all essential details, and the following data:

Date.

Name of owner and occupant.

Location, including street address.

Point of compass.

Structural features.

Relative elevations of nozzles, junction points and supply or reference points.

Full information concerning water supplies, including pumps, underground mains, etc., and flow test results.

Make, type, size, location, position, and direction of spray nozzles.

Make, type, model, and size of special system valve.

Types of alarms to be provided.

Number of each size and type of spray nozzles on each system.

Lengths of pipe and whether center to center or cutting lengths are shown.

Size of all pipe and fittings.

Heat responsive equipment, including type, arrangement and location.

Hydraulic reference points.

Design purpose of system.

Make and type of hangers and inserts.

All control and check valves, strainers, drain pipes, and test pipes.

Small hand hose and hose equipment.

The weight or class, lining and size of underground pipe and the depth that the top of the pipe is to be laid below grade.

Provisions for flushing underground pipe.

Accurate and complete layout of the hazard being protected.

When the equipment to be installed is an addition or change, enough of the old system should be indicated on the plans to make all conditions clear.

Name and address of contractor.

***7010. Hydraulic Calculations.**

General. Hydraulic calculations shall be prepared on forms that include a summary sheet, detailed work sheets, and a graph sheet.

Chapter 8. Automatic Detection Equipment

8000. General.

8001. The arrangement of automatic detection equipment for water spray systems requires careful engineering, and a different arrangement from that required for other types of systems. The provisions of this Chapter are based upon the type of equipment presently available for use with special systems. Other types shall give at least equivalent performance.

8010. Selection.

8011. Care shall be exercised in the selection and adjustment of detection equipment to assure proper operation and to guard against premature operation of the system from normally fluctuating conditions. For example, particular care shall be taken to compensate for normal temperature fluctuations in installations such as transformer protection involving heat exchangers having automatic fans, and installations involving industrial ovens and furnaces. Additionally, protection of machinery involving movement of a hazardous material such as a belt conveyor would require a detection system having a faster response time than normal, and appropriate interlocks to stop drive units, etc.

8020. Protection.

8021. Corrosion Protection. Detection equipment installed out of doors or in the presence of possible corrosive vapors or atmospheres shall be protected from corrosion by suitable materials of construction or by suitable protective coatings applied by the equipment manufacturer.

8022. Protective Canopy. Detection equipment requiring protection from the weather shall be provided with a canopy, hood, or other suitable portection.

8023. Mechanical Damage. Detection equipment shall be located so as to be protected from mechanical damage.

8024. Mounting. Detectors shall, in all cases, be supported independently of their attachment to wires or tubing.

***8030. Location & Spacing of Detectors.**

8031. Automatic detection equipment shall be so located and adjusted as to operate reliably. The location of detectors shall be based upon data obtained from field experience, tests, engineering surveys, the manufacturer's recommendations, and recognized laboratory listing, insofar as these are applicable. In addition, location shall take into consideration such factors as the nature of the hazard being protected, air velocity, temperature variations, number and height of structural levels, shielding, indoors or outdoors, open or closed structures, and other variable conditions where the exercise of judgment based upon experience with such detection equipment in actual tests and service, is needed. For example, the spacing and location of detectors for belt conveyors must include consideration of the nature of the material being conveyed, the combustibility of the belt, the speed at which the

material is conveyed, the rapidity of detection necessary, the necessity of detection devices between upper and lower belts as well as above the conveyor belt, etc.

8032. Two or More Systems. Where there are two or more systems in one area controlled by separate systems of fire detectors, those on each system shall be spaced at least up to the dividing line between systems, as to a wall or partition or draft stop.

8040. Arrangement & Supervision of Systems.

8041. Supervision. Central station, remote station, or proprietary supervision of detection equipment is recommended.

NOTE: For the applicable standards, see *Central Station Protective Signaling Systems*, NFPA No. 71, 1972, *Remote Station Protective Signaling Systems*, NFPA No. 72C, 1972, and *Proprietary Protective Signaling Systems*, NFPA No. 72D, 1973.

8042. Electric Systems. Water spray systems which depend for operation on electric thermostats, relay circuits, or other similar equipment shall be so arranged that such equipment is normally energized, or completely supervised in a manner that will result in positive notifications of an abnormal condition unless failure of the detection system results in the operation of the water spray system.

8043. Pneumatic and Hydraulic Systems. Pneumatically and hydraulically operated systems shall be supervised in a manner so that failure will result in positive notification of the abnormal condition, unless the failure shall result in operation of the water spray system.

8050. Response Time.

***8051.** The heat detection system shall be designed to cause actuation of the special system water control valve within 20 seconds under expected fire conditions. Under test conditions when exposed to a standard heat source, the system shall operate within 40 seconds. These are to be considered as maximum response times subject to the considerations described in 8011 and 8031.

Appendix

A-1020. Definitions.

Insulated Equipment, Structures, or Vessels —

1. Noncombustible materials affording two-hour ratings under the *Standard Method of Fire Tests of Building Construction and Materials*, NFPA No. 251, 1972, will usually satisfy the requirements of 1020 when properly fastened and weather protected.

2. For equipment, structures, and vessels of nonferrous metals, somewhat lower temperature limits than indicated in 1020 may be required, based upon reliable metallurgical data.

A-1033. Design Purposes.

(a) Extinguishment of fire by water spray is accomplished by cooling, smothering from steam produced, emulsification of some liquids, dilution in some cases, or a combination of these factors.

(b) Control of fires is accomplished by an application of water spray to the burning materials producing controlled burning. The principle of control may be applied where combustible materials are not susceptible to complete extinguishment by water spray, or where complete extinguishment is not considered desirable.

(c) Effective exposure protection is accomplished by application of water spray directly to the exposed structures or equipment to remove or reduce the heat transferred to them from the exposing fire. Water spray curtains are less effective than direct application but may, under favorable conditions, provide some protection against fire exposure through subdivision of fire areas. Unfavorable conditions may include such factors as windage, thermal updrafts, and inadequate drainage.

(d) Start of fire is prevented by the use of water sprays to dissolve, dilute, disperse, or cool flammable materials.

A-1042(d). Water Reactive Materials.

In special cases, where adequate safeguards have been provided, water spray systems for the protection of structures, equipment, or personnel in the presence of such materials as described in 1042(d) may be acceptable.

A-1044. Clearance to Live Electrical Apparatus.

Possible design variations in the clearance required at higher voltages are evident on Table 1044(b) where a range of voltages is indicated opposite the various BIL test values in the high voltage portion of the Table.

Up to system voltages of 161 kv the design BIL kv and corresponding minimum clearances, phase to ground, have been established through long usage. At the higher voltages, the relationship between design BIL kv and the various system voltages has not been established in practice and is dependent upon several variables, so that the required clearance to ground should be based upon the design BIL used, rather than on the nominal line voltage or voltage to ground.

A-2120. Alarms.

(a) A local alarm, actuated independently of water flow, to indicate operation of the heat-responsive system should be provided on each system.

(b) Outdoor water-motor or electric-alarm gongs, responsive to system water flow, may be required.

(c) Central station or proprietary station water-flow alarm service is desirable, but where not available, it may be advisable to connect electrical alarm units to the public Fire Department alarm headquarters, or other suitable place where aid may be readily secured.

A-3011. Volume and Pressure.

For large areas protected by many adjacent systems, it may not be necessary to base the design flow rate on all systems operating simultaneously. With drainage designed to reduce the flow of flammables to adjacent areas, the maximum design flow rate could be determined by adding the flow rate for any system to the flow rates for all immediately adjacent systems (see Example in Figure A-3011). The largest sum determined from considering all logical combinations should be used. This maximum anticipated flow rate basis is valid when the systems selected are judged to represent the worst case situation. Most fires would be adequately controlled with fewer systems operating.

SYSTEM 1	SYSTEM 2	SYSTEM 3	SYSTEM 4	SYSTEM 5	SYSTEM 6
1800 GPM	2100 GPM	1950 GPM	2300 GPM	2400 GPM	1700 GPM

System Flow		System Flow		System Flow		System Flow	
1	1800	2	2100	3	1950	4	2300
2	2100	3	1950	4	2300	5	2400
3	1950	4	2300	5	2400	6	1700
	5850		6350		6650		6400

The combination of Systems 3, 4, and 5 creates the largest flow, therefore the design flow rate for this installation is selected as 6650 GPM. Total water demand would be 6650 GPM plus an allowance for hose stream application.

Figure A-3011. Determining Design Flow Rate Multiple Water Spray Fixed Systems.

A-3021. Water Supply.

1. CYCLE SYSTEMS — Where the quantity of water supply is extremely limited, a cycle water system may be acceptable in some instances. For such an arrangement water could be collected by means of a fire drainage trench and interceptor system. Suction would then be taken from the last pass in the interceptor (or separator). However, caution should be observed when designing such a system and full consideration should be given to such items as type of flammables involved, foreign materials which may be present in the drainage system, and valving arrangements.

2. PRESSURE TANKS — Pressure tanks generally are of inadequate volume to serve as a water supply for water spray systems. In special cases, however, such as remotely located transformers, where pressure tanks can furnish an adequate volume and pressure, they may be acceptable.

3. AUXILIARY SUPPLIES — Readily available sources of water supply should be made accessible as auxiliary supplies for water spray systems. Cross connections from service water systems in industrial plants should, where permissible, be made to fire main systems. Where connections are made from public waterworks systems it is necessary to guard against possible contamination

of the public supply. The requirements of the public health authority should be determined and followed. The effect of reducing water pressures when large quantities of water are drawn for fire fighting must be carefully studied to prevent potentially dangerous operating situations. Manual operation of auxiliary sources may be acceptable.

A-3022. Fire Department Connections.

Suitable suction provisions may entail the following:

1. Suitable suction hydrants accessible to apparatus on primary and/or auxiliary supplies.

2. Suitable all-weather landings or locations where pumper apparatus may take suction at surface water supplies.

A-4031. Extinguishment — General.

1. Where systems are designed for extinguishment of fires involving solids, consideration should be given to such factors as penetrating ability of the water, and the configuration and state of the material.

2. Where extinguishment of flammable or combustible liquids is contemplated, the rate of water application necessary will depend on such characteristics of the fuel as vapor pressure, flash point, viscosity, water solubility, and specific gravity. Care must be observed with very viscous heated materials, such as asphalt, because of the potential slop-over or froth-over hazard. When water spray extinguishment systems are designed for material of this type, the use of nonfoaming agents, special containment capacity, drains, or extensions of the spray system beyond the immediate area of the initial containment, should be contemplated. Care must also be observed with materials having a hazardous chemical reaction with water.

3. In all cases, the positioning of nozzles with respect to burning surfaces to be extinguished shall be guided by the particular nozzle design, the water pressure available, and the character of water spray produced. The effect of wind and fire draft on very small drop sizes or on larger drop sizes with little initial nozzle velocity will limit the distance between nozzle and surface.

A-4031(c). Extinguishment — Methods.

1. SURFACE COOLING — Where extinguishment by surface cooling is contemplated, the design shall provide complete water spray coverage over the entire surface. Surface cooling is not effective on gaseous products or flammable liquids having a flash point below the temperature of the applied water and is not generally satisfactory for flammable liquids having flash points below 140°F.

2. SMOTHERING BY STEAM PRODUCED — Where this effect is contemplated the intensity of the expected fire shall be sufficient to generate adequate steam from the applied water spray and conditions shall be otherwise favorable for the smothering effect. The water spray shall be applied to essentially all the areas of expected fire. This effect shall not be contemplated where the material protected may generate oxygen when heated.

3. EMULSIFICATION — This effect shall be contemplated only for liquids not miscible with water. The water spray shall be applied over the entire area of flammable liquids. For those having low viscosities the coverage shall be uniform and the minimum rate required shall be applied and the nozzle pressure shall not be less than the minimum on which approval is based. For more viscous materials the coverage should be complete but need not be so uniform and the unit rate of application may be lower. Wet water may be considered where the effect of emulsification is contemplated.

4. DILUTION — The material shall be miscible with water where this effect is contemplated. The application rate shall be adequate to effect extinguishment within the required period of time based upon the expected volume of material and the percentage of dilution necessary to make it nonflammable, but not less than that required for control and cooling.

5. OTHER FACTORS — The system design may contemplate other extinguishing factors, in some cases, such as a continuous film of water over the surface where the material is not miscible with water and has a density much greater than 1.0 (such as asphalt, tar, carbon disulfide, and some nitrocellulose solutions). Water spray may also be used on some materials to produce extinguishment as a result of rapid cooling below the temperature at which the material will decompose chemically at a self-sustaining rate.

NOTE: For the effect of droplet size, see NBFU Research Report No. 10, *The Mechanism of Extinguishment of Fire by Finely Divided Water*, published by the American Insurance Association, 165 Water St., New York, N.Y.

A-4033(a). Exposure Protection — General.

1. Generally, the upper portions of equipment and the upper levels of supporting structures are less severely exposed by fire than are the lower portions or levels due to the accumulation at grade level of fuel from spillage or equipment rupture. Consideration may thus be given to reducing the degree of (or eliminating) water spray protection for the upper portions of high equipment or levels of structures, provided a serious accumulation of fuel, or torch action from broken process piping or equipment, cannot occur at these elevations, and serious exposure does not exist. Examples are some distillation columns, above the 30- or 40-foot level, and above the third or fourth level of multi-level open structures.

2. Where equipment, structures, or vessels are provided with insulation systems which are considered of some value, but which do not fully meet the requirements for the definition of "Insulated" (see 1020), consideration may be given to the reduction of water application rates specified for exposure protection.

A-4033(b). Exposure Protection — Vessels.

1. It has been established that uninsulated vessels, under average plant conditions, when enveloped with flame, may be expected to absorb heat at a rate of at least 20,000 Btu per square foot per hour, of exposed surface wetted by the contents. Unwetted, uninsulated steel equipment absorbs heat rapidly, and failure occurs from overpressure and/or overheating when such equipment is exposed to fire. Figure A-4033(b-1) is a time-temperature curve showing the lengths of time required for vessels of different sizes containing volatile materials to have their contents heated to 100°F from a starting temperature of 70°F for tank contents and 60°F for the tank steel. (See *Requirements for Relief of Overpressure in Vessels Exposed to Fire*, J. J. Duggan, C. H. Gilmour, P. F. Fisher; Transactions of the A.S.M.E., January, 1944, Pages 1-53; *Venting of Tanks Exposed to Fire*, NFPA Quarterly, October, 1943; and Rubber Reserve Company Memorandum 89, *Heat Input to Vessels*.)

The application of water spray to a vessel enveloped by fire will reduce the heat input rate to a value on the order of 6,000 Btu per square foot per hour of exposed surface wetted by the contents when the unit rate of water application is 0.2 gallons per minute per square foot of exposed surface. The 6,000 Btu rate was also established in Rubber Reserve Co. Memorandum 123, *Protection of Vessels Exposed to Fire*. Figure A-4033(b-2) shows the estimated time for volatile liquid contents of atmospheric storage tanks to reach the boiling point when absorbing heat at 6,000 Btu per hour per square foot. This may be compared with the figure shown in Figure A-4033(b-1) to show the benefits derived from water spray systems.

2. Where the temperature of a vessel or its contents must be limited, higher densities than called for under 4033(2) or (5) will be required.

3. Internally insulated or lined vessels require special consideration to determine necessary water spray requirements.

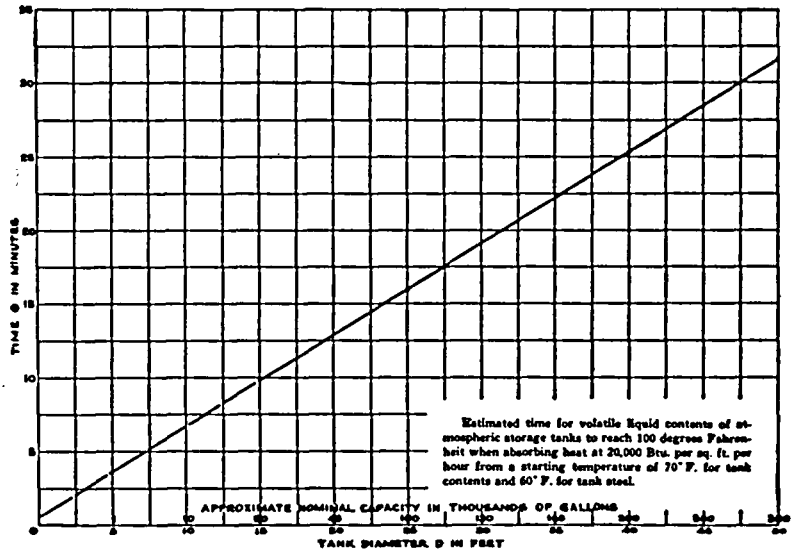


Fig. A-4033(b-1)

A-4033(c)(4). Exposure Protection — Nonmetallic Cable and Tubing Runs. Nonmetallic sheathed insulated electrical cable and nonmetallic tubing runs in open trays should be protected from spill fire exposure by water spray at a basic rate of 0.30 gallons per minute per square foot of projected plane area. Water spray should be applied at this rate over and under each tray and to the supports. Rapid automatic detection systems should be utilized.

Requirements for water spray may be reduced where flame shields with the resistance of 1/16th inch thick sheet metal are supported three inches below the lower edge and extended at least six inches beyond the tray side rails are used. Water density requirements should be 0.15 gallons per minute per square foot projected surface area. Water should be applied at that rate to the upper surface of each tray and to the supporting structure.

Requirements may be reduced where fixed automatic rapid-response fire protection systems are provided to control or extinguish spill fires or other sources of exposure. Water density requirements should be 0.15 gallons per minute per square foot of projected surface area. Water should be applied to the upper surface of each tray and to the supporting structure.

Fire detection devices should be located above and below each tray level. Piping system should be designed to deliver water in not less than fifteen seconds time after fire is detected.

Nozzles should be placed within the cable tray structure or adjacent to the cable tray structure in such a manner as to obtain direct impingement of water spray on top and bottom of trays and on supporting structures.

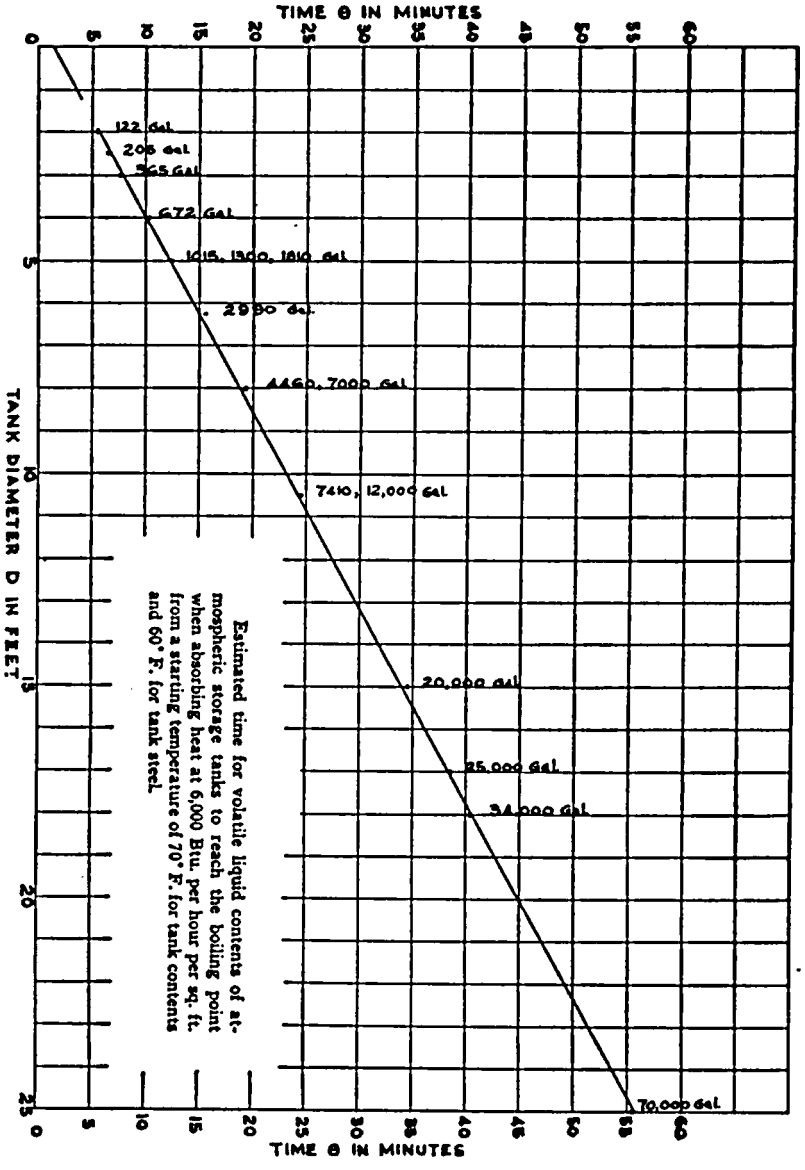

TIME θ IN MINUTES
0
5
10
15
20
25
30
35
40
45
50
55
60
122 Gal
205 Gal
365 Gal
672 Gal
1015, 1360, 1810 Gal
2930 Gal
4460, 7000 Gal
7410, 12,000 Gal
20,000 Gal
25,000 Gal
34,000 Gal
70,000 Gal
TANK DIAMETER D IN FEET
0
5
10
15
20
25
Estimated time for volatile liquid contents of atmospheric storage tanks to reach the boiling point when absorbing heat at 6,000 Btu. per hour per sq. ft. from a starting temperature of 70° F. for tank contents and 60° F. for tank steel.

Fig. A-4033(b-2)

A-4050. Drainage.

As stated, there are four methods of drainage (1) grading, (2) diking, (3) trenching, and (4) underground or enclosed drains, the application of which must be determined by the extent of the hazard and the degree of protection desired.

GRADING — Where grading is employed a slope of not less than 1 percent should be provided. Concrete surfacing is most desirable. However, other hard surfacing or crushed rock is acceptable.

DIKING — Where diking is employed dikes should be in accordance with the requirements of *Flammable and Combustible Liquids Code*, NFPA No. 30, 1973. Figure A-4050(1) is based on NFPA requirements and will serve to illustrate the necessary features of adequate diking.

TRENCHING — General specifications for drainage trench and recovery systems installation, which is a desirable drainage arrangement for storage and equipment areas, are as follows:

A. PURPOSE OF DRAINAGE TRENCH.

(a) To remove from the area and promptly and effectively dispose of all accidentally spilled liquids and water discharged from fixed spray systems and/or hose streams.

(b) To provide, by means of partial closure of trench top, a basin within which ignited flammable liquids may be safely consumed by controlled burning without seriously exposing adjacent equipment.

(c) To act as a container for retention of accidentally spilled, unignited high value liquids for salvage purposes.

B. CONSTRUCTION OF DRAINAGE TRENCH.

(a) Drainage trench should be constructed of reinforced concrete, except that expanded blast furnace slag aggregate should be used in precast trench cover.

(b) The minimum size of any drainage trench should be 3 ft. wide and 1 ft. 6 in. deep. In no case should the depth exceed the width.

(c) Whether the closed portion of the trench top is precast or constructed of grating and steel plate, the open section should be equal to one-third the width of the trench, located centrally. Distance from either edge of the open area of the top to either inside wall should not be less than 12 inches. Open section should be covered with 1¼ in. steel walkway grating.

(d) Sumps should be poured monolithically with trench. Watertight bonds should be provided for joining concrete tank pad to trench.

(e) Where piling is required in the construction of concrete pad it should also be used for support of trench and sump.

(f) Slope of trench floor to sump should be a minimum of one percent.

C. DRAINAGE TRENCH CAPACITY REQUIREMENTS.

(a) Flowing: (Surface area served by the trench)

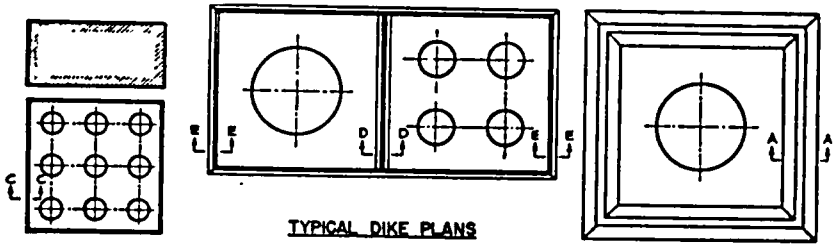
1. 750 GPM per 2,400 sq. ft. — drainage from fire hose discharge, plus

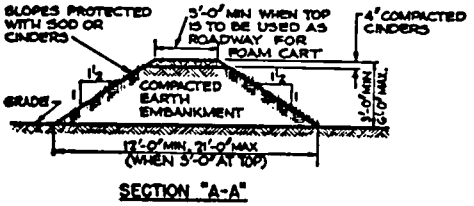
2. 1,500 GPM per 2,400 sq. ft. (maximum) — drainage where fixed water spray systems are installed, plus

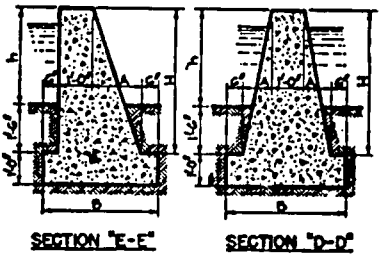
3. Normal surface drainage.

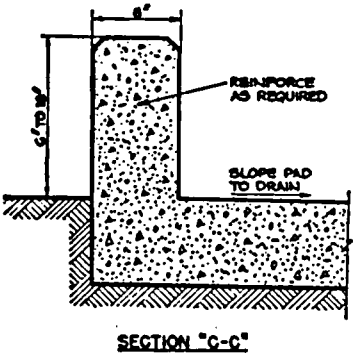
(b) Holding: (Total trench volume)

1. Should be equal to the total capacity of largest vessel in the area, served by the trench.









SECTION "E-E"	h	3'-0"	4'-0"	5'-0"	6'-0"
	H	4'-6"	5'-6"	6'-6"	7'-6"
	A	1'-6"	2'-1"	2'-8"	3'-4"
	B	3'-6"	4'-1"	4'-8"	5'-4"
	P,PSF	978	1180	1380	1518
	CY/LF	.42	.56	.74	.94
SECTION "D-D"	h	3'-0"	4'-0"	5'-0"	6'-0"
	H	4'-6"	5'-6"	6'-6"	7'-6"
	A	10"	1'-2"	1'-7"	1'-11"
	B	3'-8	4'-4"	5'-2"	5'-10"
	P,PSF	1110	1300	1480	1660
	CY/LF	.44	.60	.81	1.05

TABLE OF DIMENSIONS, SOIL PRESSURES AND CONCRETE QUANTITIES

Fig. A-4050(1). Standard dikes for field storage tanks.

2. Holding capacity may be disregarded for water insoluble liquids where individual drains are provided to an interceptor where such insolubles may be separated and retained.

3. Where individual drains, separators, or interceptors are not used, shut-off valves should be provided for each trench system to prevent accidentally spilled materials from polluting public waterways.

D. TANK PADS & CURBS.

(a) Tank pads, if used, should be constructed of concrete and sloped toward trench with at least a two percent grade.

(b) Concrete curbs should be provided around the perimeter of the tank pad or process area and between groups served by a common trench, to confine accidental liquid spillages to their respective areas.

(c) Curbs should be formed in a concave manner to throw back sudden wash of flammable liquid from a large spill.

E. SEPARATORS & INTERCEPTORS.

Separators and interceptors should be designed to remove from drainage systems water insoluble liquids which may be either reclaimed or destroyed. In any event, these materials which are usually flammable and/or toxic are thus prevented from entering public waterways. Separators should be installed in locations sufficiently remote from processing and storage areas to be beyond the range of fire exposure.

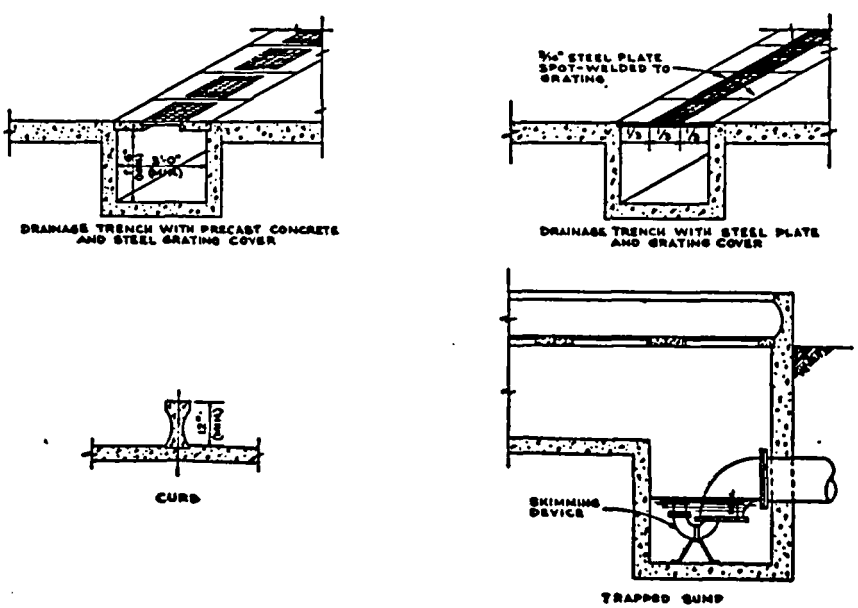
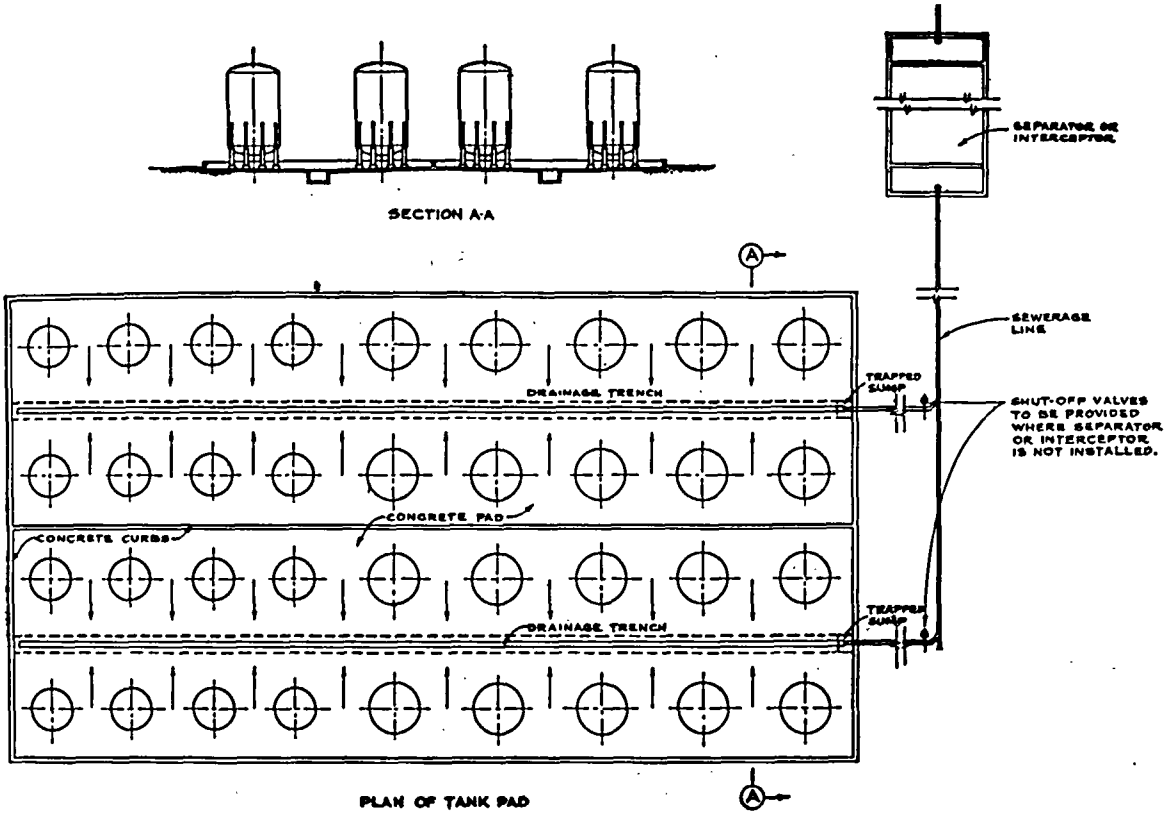


Fig. A-4050(2). Drainage system details for tank areas containing flammable liquids.



SUGGESTED DESIGN FOR DRAINAGE SYSTEM FOR TANK AREAS CONTAINING FLAMMABLE LIQUIDS

Fig. A-4050(3)

F. UNDERGROUND OR ENCLOSED DRAINS.

The capacity of the system should be equivalent to required flowing capacities of the drainage trenches connected to it, plus any additional drains on the system, plus drainage for any anticipated future developments which may be required. All points of connection should be sealed (see detail of sump Figure A-4050(2), to prevent propagation of flame through the drainage system. A skimming device is useful for removing objectionable materials from the water surface in the sump.

G. GENERAL. (See Figs. A-4050(2) and A-4050(3).)

(a) Drainage trenches should be installed to serve to divide two rows of tanks or equipment, one row on each side, so that runoff from any vessel will enter directly into trench without exposing adjacent vessels.

(b) Where holding capacity is not a factor, small quantities of water may be directed into trench continuously to keep it clean and to assure a positive seal in the sump at all times.

(c) The installation of piping in drainage trenches should be avoided. Where it is necessary for pipe to enter or leave a drainage trench, passage should be through the grating; if through walls, the openings should be vaportight.

(d) The drainage system and grating shall be kept clean and free of debris.

A-4082. Installation.

Main headers should be installed underground or at least as near as possible to ground level as protection against the effects of possible fire, explosion, or mechanical injury. Where overhead piping is necessary, it should not pass over another hazard. Piping may be looped if desired.

A-5040. Acceptance Test Suggestions.

1. All tests should be made by the contractor in the presence of an authorized inspector. When an inspector is not available, tests may be witnessed by, and the test certificate signed by the owner or his representative.

2. Before asking for final approval of the protective equipment, installing companies should furnish a written statement to the effect that the work covered by its contract has been completed and all specified flushing of underground, lead-in, and system piping has been successfully completed, together with specified hydrostatic pressure tests.

3. The applicable parts of the Sprinkler Contractor's Certificate Covering Materials and Tests (see *Standard for the Installation of Sprinkler Systems*, NFPA No. 13, 1973) should be completed and submitted, certifying that the work has been completed and tested in accordance with approved plans and specifications.

A-7010. Hydraulic Calculation — General.

1. SUMMARY SHEET. The summary sheet (for sample summary sheet see Figure A-7010.a.) should contain the following information:

(a) Date.
(b) Location.
(c) Name of owner and occupant.
(d) Building or plant unit number.
(e) Description of hazard.
(f) Name and address of contractor.
(g) Authority having jurisdiction.

— SUMMARY SHEET — HYDRAULIC CALCULATION —

NAME AND ADDRESS OF CONTRACTOR.....
CONTRACT NO.....CALCULATOR.....DATE.....
NAME OF OWNER AND OCCUPANT.....
ADDRESS.....
BUILDING OR PLANT UNIT NUMBER.....
DESCRIPTION OF HAZARD.....
AUTHORITY HAVING JURISDICTION.....

— SYSTEM REQUIREMENTS —

DESIGN PURPOSE: EXTINGUISHMENT.....
EXPOSURE PROTECTION.....
CONTROL..... FIRE PROTECTION.....
TYPE SYSTEM: AUTOMATIC.....MANUAL.....
DENSITY (G.P.M. PER SQ. FT.).....
TOTAL NOZZLE FLOW REQUIRED.....G.P.M.
ALLOWANCE FOR INSIDE HOSE STATIONS.....G.P.M.
ALLOWANCE FOR OUTSIDE HYDRANTS.....G.P.M.
TOTAL WATER REQUIRED.....G.P.M. AT.....P.S.I.
REMARKS: .....

— WATER SUPPLY INFORMATION —

TYPE OF WATER SUPPLY: PUBLIC.....PRIVATE.....
STATIC PRESSURE IN P.S.I.....
RESIDUAL PRESSURE:
G.P.M. FLOWING.....AT .....P.S.I.
ELEVATION.....LOCATION .....
ELEVATION.....LOCATION .....
PUMP DATA:
RATED CAPACITY.....G.P.M. AT.....P.S.I.
ELEVATION.....LOCATION .....
ELEVATION.....LOCATION .....
TANK DATA:
CAPACITY.....GALS.-ELEVATION .....
LOCATION .....
REMARKS: .....
.....

Fig. A-7010.a. Sample Summary Sheet

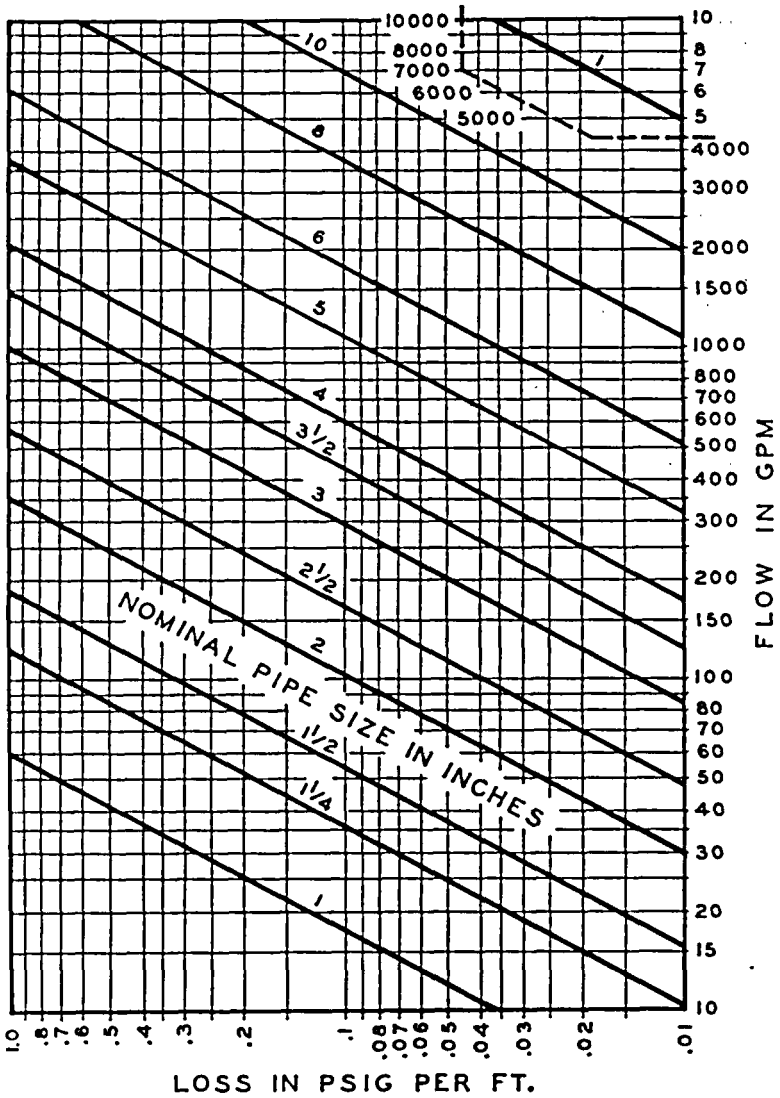


Fig. A-7010.b. Friction loss in schedule 40 steel pipe. Hazen & Williams C-120.