

NFPA No.

15

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WATER SPRAY FIXED SYSTEMS

FOR FIRE PROTECTION

1969



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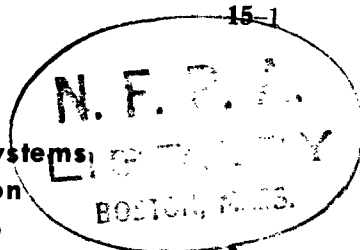
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Standard for
Water Spray Fixed Systems
for Fire Protection

NFPA No. 15 — 1969



This 1969 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 1969 Annual Meeting in New York, N.Y., May 12-16. It supersedes the edition of 1962.

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.

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SCOPE: To develop minimum standards for the design, construction, installation, maintenance, and test of fixed water spray systems for fire protection purposes.

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Standard for
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for Fire Protection

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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. The present edition has been prepared as a standard rather than as a compilation of informative material.

There are several methods of hydraulic calculation which will produce satisfactory 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 this Standard.

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.

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.

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

NOTE 2: For equipment, structures and vessels of nonferrous metals, somewhat lower temperature limits may be required.

NONABSORBING GROUND — Earth or fill which is not readily permeable or absorbent to large quantities of flammable or combustible 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.

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.)

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

NOTE: For definitions of combustible and flammable liquids, see NFPA No. 321, Standard for Basic Classifications of Flammable and Combustible Liquids.

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, in general, 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: (See Appendix A 1033)

- (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.

NOTE: Other standards also consider limitations to the application of water (slop-over, frothing, electrical clearances, etc.). See Hazardous Chemicals Data (NFPA No. 49) and Properties of Flammable Liquids (NFPA No. 325M).

1042. Materials Involved.

(a) A careful study should 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 should 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 should be tested under the conditions of use to determine the applicability of a water spray system.

(d) Water spray is generally not suitable for direct application to materials which react with water, such as metallic sodium or calcium carbide, producing violent reactions or increased hazardous products as a result of heated vapor emission. Liquefied gases at cryogenic temperatures, such as liquefied natural gas, also boil violently when heated by water. 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 may be acceptable to the authority having jurisdiction.

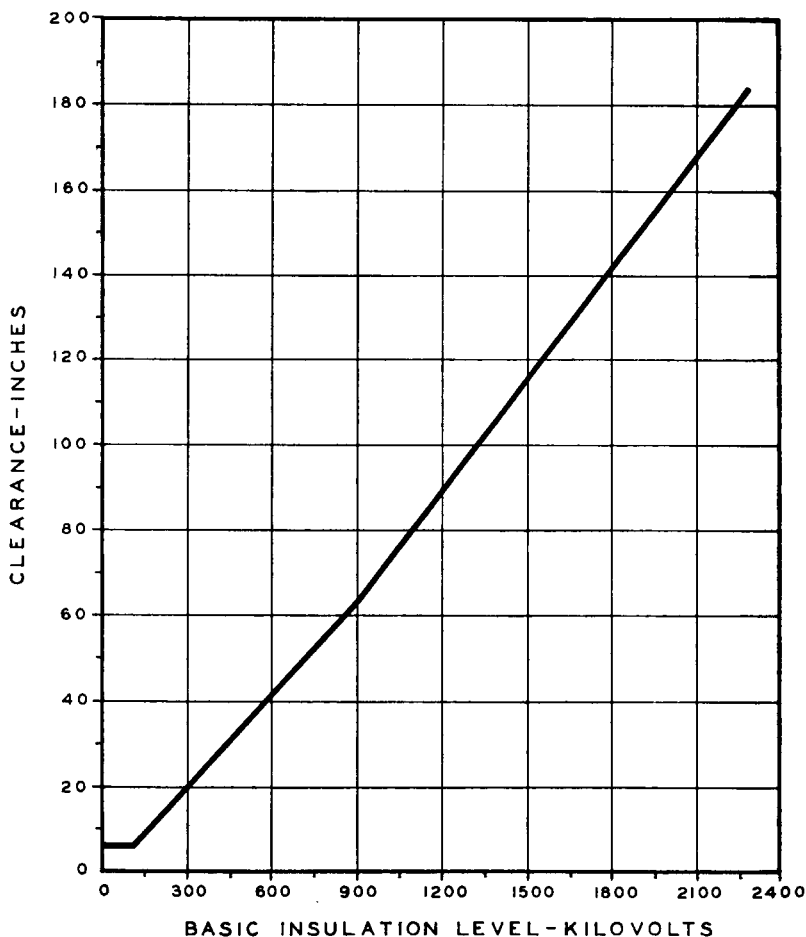


Fig. 1044(b). Clearance from Water Spray Equipment to Live Uninsulated Electrical Components.

1043. Equipment Involved.

(a) Consideration should be given to the possibility of damage, distortion, or failure of equipment operating at high surface temperatures.

1044. Clearance to Live Electrical Apparatus. (See Appendix A-1044.)

(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).

(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 should be used as a basis. 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

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
		1175	87
287-380	166-220	1300	98
		1425	109
		1550	120
500	290	1675	131
		1800	142
		1925	153
500-700	290-400	2100	168
		2300	184

NOTE: When nominal voltage to ground is used for the design criteria, the highest minimum clearance listed for this group should be used.

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).

NOTE: BIL values are expressed as KV (kilovolts), the number being the crest value of the full wave impulse test.

1050. Plans and Specifications.

1051. Water spray system design should be entrusted only to responsible persons fully experienced in this field.

1052. Prior to determining the purpose of the water spray system under consideration, the authority having jurisdiction shall be consulted. (See Chapter 4.) All plans and specifications pertinent to the installation and all devices and material shall be found acceptable by the authority having jurisdiction prior to installation. (See Section 7001.)

1060. Approval of Water Spray Systems.

1061. Before asking final approval of the water spray system by the authority having jurisdiction, the applicable parts of the Sprinkler Contractor's Certificate Covering Materials and Tests (see NFPA 13) should be completed and submitted, certifying that the work has been completed and tested in accordance with approved plans and specifications.

CHAPTER 2. SYSTEM COMPONENTS

2010. Devices and Materials.

2011. The authority having jurisdiction shall be consulted as to the acceptability of devices and materials.

2020. Component Parts.

2021. All component parts shall be coordinated to provide complete systems and should be operable by automatic means with supplementary auxiliary manual tripping means. Under certain conditions, (such as certain fire control, exposure protection, or fire prevention applications) manual operation only may be permitted, subject to approval by the authority having jurisdiction.

2022. Only listed new materials and devices shall be employed in the installation of systems except, when special conditions warrant, listed devices such as special system water control valves and their accessories, circuit closers, water motor alarm devices, non-automatic pattern spray nozzles, etc., may be reused, but if reused they shall be reconditioned by the original manufacturer. On request of the authority having jurisdiction, the original manufacturer shall furnish a certificate, stating that such specified devices have been reconditioned and tested and are considered satisfactory for reuse.

2030. Corrosion Protection.

2031. System components installed out of doors, or in the presence of a corrosive atmosphere, shall be protected from corrosion by the use of suitable materials of construction, or by protective coatings. The threaded ends of galvanized pipe, after installation, shall be suitably protected against corrosion.

2040. Spray Nozzles.

2041. Spray nozzles shall be of approved makes and types.

2042. Care shall be taken in the selection of strainers, particularly where nozzle waterways are less than $\frac{1}{4}$ -inch in least dimension. (See 2110 and 4110.)

2050. Piping.

2051. Pipe used in water spray systems shall be wrought steel or wrought iron. The chemical and physical properties of this pipe should be at least equal to those manufactured in accordance with the Specifications of the American Society for Testing and Materials for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded

and Seamless Steel Pipe for Ordinary Uses, ASTM Designation A-120-65 (USAS B36.20 — 1966) or for Welded Wrought Iron Pipe, ASTM Designation A-72-64T (USAS B36.20 — 1966). Dimensions for all pipe should be in accordance with the American Standard for Wrought Steel and Wrought Iron Pipe, USAS B36.10 — 1959. Pipe should be designed to withstand a working pressure of not less than 175 psi. It is intended that this Standard permit the use of "standard wall" pipe as described in USAS B-36.10 — 1959 for pressures up to 300 psi. Schedule 40 pipe is considered "standard wall" pipe. Schedule 30 pipe is, however, acceptable in sizes 8 inches and larger.

2052. 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.

2053. The galvanizing of galvanized pipe shall be in accordance with Specifications A120-65 of the American Society for Testing and Materials (USAS B36.20 — 1966).

2054. Other pipe or tubing which has been investigated and listed for this service by a nationally recognized testing and inspection agency may be used where acceptable to the authority having jurisdiction. The use of such tubing should involve especially 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.

2060. Fittings.

2061. 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.

2062. 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 may be acceptable to the authority having jurisdiction. In such cases special hanging or bracing may be necessary.

2070. Hangers.

2071. Hangers shall be of a type approved for use with the piping involved. (See 4100.)

2080. Valves.

2081. All valves shall be of a type approved for the purpose.

2090. Control Equipment.

2091. Automatic valves shall be special system water control valves approved for the use intended.

2092. Control of automatic valves shall be by means of approved accessories for special systems.

2093. 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.

2094. 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. Pipe line 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. In addition, the strainers 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.

2112. Pipe line 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 authority having jurisdiction shall be consulted regarding the alarm service to be provided and regarding the need for electrical fittings designed for use in hazardous locations in electric-alarm installations (see National Electrical Code, NFPA No. 70, Article 500 and other Articles in Chapter 5 thereof).

2122. A local alarm, actuated independently of water flow, to indicate operation of the heat-responsive system should be provided on each system.

2123. Outdoor water-motor or electric-alarm gongs, responsive to system water flow, may be required by the inspection authority having jurisdiction.

2124. 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.

2125. A suitable alarm shall be provided for each system to indicate failure of automatic detection equipment (including electric supervisory circuits) or other such devices or equipment upon which system actuation is dependent. If system operation will result from such failure, the trouble alarm, in some cases, may be waived by the authority having jurisdiction.

2130. Fire Department Connections.

2131. Fire department connections may be required by the authority having jurisdiction (see 3025).

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. This connection may be incorporated in the design of the strainer or provided below the automatic special system control valve.

CHAPTER 3. WATER SUPPLIES

3000. General.

3001. The authority having jurisdiction shall be consulted concerning water supplies. 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 for the required period of discharge for all systems designed to operate simultaneously.

3012. The authority having jurisdiction shall be consulted as to the water flow rate required for hydrant systems for hose stream protection. Unless water supplies and distribution systems for water spray systems are separate from hydrant systems, thus insuring adequate hose protection in the event of the disruption of water spray equipment by explosion or otherwise, supplies should contemplate additional water for hose streams. Where the distribution system is not separate, 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, it is considered good practice to provide sufficient water for a second operation of the system so that the protection can be re-established without waiting for the supply to be replenished. In estimating the period of time sufficient for duration of operation of water spray systems for a particular hazard, an ample factor of safety should be included. (See Chapter 4.)

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, see 3023), and/or
- (c) Fire pumps and suction supply.

3022. **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.

3023. 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.

3024. 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.

3025. Fire Department Connections. To provide an auxiliary supply, one or more fire department connections shall be provided when required by the authority having jurisdiction. Careful consideration should 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 may also be important factors. A pipe line strainer in the fire department connection may be required.

CHAPTER 4. SYSTEM DESIGN AND INSTALLATION

4000. Workmanship.

4001. Water spray system design, layout, and installation should 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 submitted to the authority having jurisdiction. 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:

NFPA Standard Number	Title
13	Sprinkler Systems
14	Standpipe and Hose Systems
18	Wetting Agents
20	Centrifugal Fire Pumps
22	Water Tanks for Private Fire Protection
24	Outside Protection
26	Supervision and Care of Valves Controlling Water Supplies for Fire Protection
70	National Electrical Code
71	Central Station Protective Signaling Systems
72A	Local Protective Signaling Systems
72B	Auxiliary Protective Signaling Systems
72C	Remote Station Protective Signaling Systems
72D	Proprietary Protective Signaling Systems

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. Design Purpose.

4031. The authority having jurisdiction shall be consulted as to the purpose of the water spray system under consideration. (See Section 1033.)

4040. Density and Application.

4041. 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) 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.

(c) 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.

(d) 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.

(e) 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.

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

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 N.B.F.U. Research Report No. 10, "The Mechanism of Extinguishment of Fire by Finely Divided Water", published by the American Insurance Association.

4042. 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 should 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 square foot of projected surface area.

4043. 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 should 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 should, 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 square foot. In some cases additional wastage should be contemplated to insure proper application on the surfaces. (See 4080.)

(4) 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 steel columns, above the 30- or 40- foot level, and above the third or fourth level of multi-level open structures.

(5) 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.

(b) VESSELS:

(1) These rules for exposure protection contemplate adequate emergency relieving capacity for vessels, based upon a maximum allowable heat input of 6,000 Btu per hour per square foot of exposed surface area. The density shall be increased to limit the heat absorption to a safe level in the event adequate emergency relieving capacity is not provided. (See Appendix A-4043(b).)

(2) Where the temperature of a vessel or its contents must be limited, higher densities than called for under (4) or (7) will be required.

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

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

(5) In most cases spherical or horizontal cylindrical surfaces below the vessel equator cannot be considered wettable from rundown.

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

(7) Bottom and top surfaces of vertical vessels shall be completely covered by directed water spray at an average rate of not less than 0.25 gallons per minute per square foot 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.

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

(9) 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 square foot.

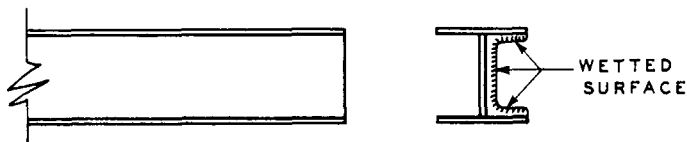


Fig. 4043(c). The wetted surface of structural member — beam or column is defined as one side of the web and the inside surface of one side of the flanges as shown above.

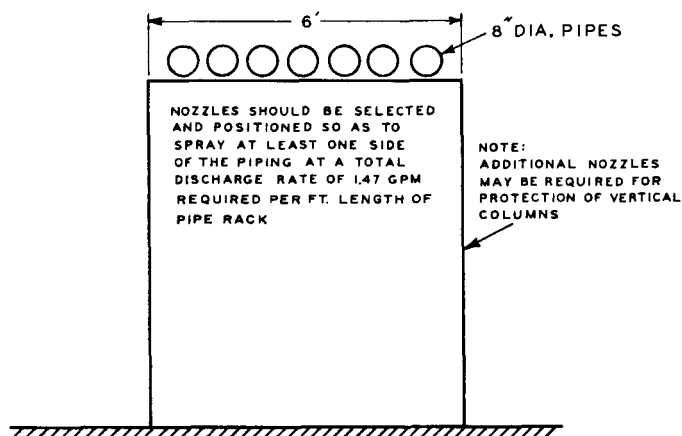


Fig. 4043 (c-4-1). Calculation of water spray density requirement for typical pipe rack.

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.

$$\Sigma N \pi d L q = 7 \pi (8/12) (1) (0.1) = 1.47 \text{ gpm required per ft. length of pipe rack.}$$

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/ft² of projected grade area.

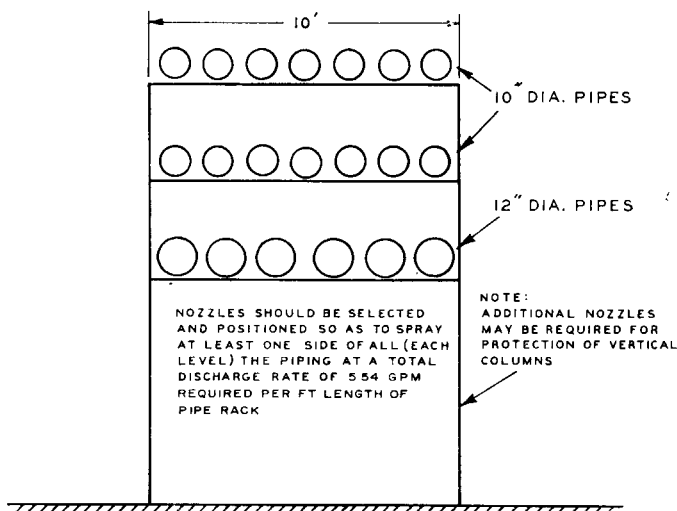


Fig. 4043(c-4-2). Calculation of water spray density requirement for typical pipe rack.

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.

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

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/ft² of projected grade area. Reduce to not more than 0.50 gpm/ft² of projected grade area. [See 4043(c) (4)]

(c) STRUCTURES AND 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 square foot over the wetted area. See Figure 4043(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 square foot over the wetted area. See Figure 4043(c).

(3) Pipe, tubing, conduit, and cable runs shall be protected by water spray at a basic rate of 0.10 gpm per square foot of the aggregate pipe wall area. In the interest of conserving water, this rate should be limited to maintain a cumulative projected grade area rate of not more than 0.50 gpm per square foot. 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 4043(c-4-1) and 4043(c-4-2) for typical water spray application rate calculations. Nozzle arrangement will depend upon characteristics of nozzles chosen and the design selected to meet the requirements.

(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 square foot of projected area of rectangular prism envelope for the transformer and its appurtenances and not less than 0.15 gpm per square foot on the expected nonabsorbing ground surface area of exposure. Additional application may be needed for special configurations, conservator tanks, pumps, etc. Spaces greater than twelve inches in width between radiators, etc., should be individually protected.

(2) Water spray piping should not be carried across the top of the transformer tank.

(3) In order to prevent damage to energized bushings or lightning arrestors, water spray should not envelop this equipment by direct impingement. If it is desired to envelop this equipment, the manufacturer, or his literature, and the owner should be consulted.

4044. 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. The authority having jurisdiction shall be consulted concerning rates of application.

4050. Size of System.

4051. Separate fire areas should be protected by separate systems. Single systems should 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 should not be exceeded for a single system. (See Chapter 3.)

4060. Separation of Fire Areas.

4061. Fire areas may be properly subdivided by space, fire barriers, diking, special drainage, or by combination of these. In the separation of fire areas consideration must be given to the possible flow of burning liquids before or during operation of the water spray systems.

4062. 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 should be 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) and Appendix A-4060.

4070. Valves.

4071. 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.

4072. 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.

4073. Drain Valves.

(a) Readily accessible drains shall be provided for low points in underground and aboveground piping.

(b) Where feasible automatic drain may be acceptable.

4080. Spray Nozzles.

4081. Selection — The selection of the type 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.

4082. Size — A test of the water supply is recommended before the size of spray nozzle orifices is selected, unless full information concerning the water supply is readily available. It is required that piping be hydraulically calculated and sized, and, if necessary, that spray nozzle orifices be varied in size in order to obtain desired water distribution and to allow for loss of head in water supply piping. Where nozzle waterways are less than $\frac{1}{4}$ -inch in least dimension, particular care shall be taken in the selection of strainers. (See 2110 and 4110.)

4083. 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. Care should 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.

4090. Piping.

4091. 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 in general should not be less than one-inch nominal diameter.

4092. 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), except as herein modified.

(b) Welding is permissible. The authority having jurisdiction should be consulted to assure safe welding or cutting practices. Welding should preferably be done in the shop. When done in the field, the fire hazard of the process shall be suitably safeguarded. Welding shall be conducted in accordance with the USA Standard Code for Pressure Piping, USAS B31.1 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.

(c) All underground supply piping after the automatic control valve shall be pitched $\frac{1}{2}$ 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) 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.

(e) Gage connections shall be provided for test gages near the highest or most remote nozzle on each major separate section of the system or where indicated by the authority having jurisdiction. In any event, one gage connection shall be provided near the nozzle calculated as having the least pressure under normal flow conditions.

(f) Unions, flanges, or other approved couplings may be used to assemble closed loops of piping or to assemble prefabricated piping. (See 2062.)

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 generally is not permitted. 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 should be installed so as to be accessible for cleaning during the emergency. Dual type strainers or equivalent may be necessary if water supplies are badly contaminated.

4113. Individual strainers shall be provided for nozzles having water passageways smaller than $\frac{1}{8}$ inch.

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 should be not less than the water demand rate of the system which is determined by the system design; in any case, it should not be less than that necessary to provide a velocity of ten feet per second. For all systems the flushing operations should 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).

5020. Water Discharge Test.

5021. When practicable, full flow tests with water should 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. The maximum number of systems that may be expected to operate in case of fire should be in full operation simultaneously in order to check as to 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.

5041. All tests should be made by the contractor in the presence of the inspector for the authority having jurisdiction. When an inspector is not available, and permission is granted by the authority having jurisdiction, tests may be witnessed by, and the test certificate signed by the owner or his representative.

5042. Before asking for final approval of the protective equipment by the authority having jurisdiction, 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.

5043. The applicable parts of the Sprinkler Contractor's Certificate Covering Materials and Tests (see NFPA 13) should be completed and submitted, certifying that the work has been completed and tested in accordance with approved plans and specifications.

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 should be serviced and tested periodically by men experienced in this work. An inspection contract with a qualified agency acceptable to the authority having jurisdiction for service, test, and operation at regular intervals is recommended and may be required.

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

6003. At weekly, or other frequent routine plant inspections, equipment should 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 should be taken to insure that water supplies are kept turned on and are in full operating condition at all times.

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 should be performed at intervals of not more than six months and shall be performed annually.

6013. Piping — All piping shall be examined at regular intervals to determine condition. Frequency of inspections will be dependent upon local conditions and should be at intervals of not more than one year. This should include tests to determine that proper drainage is maintained for piping.

6014. Flow tests of open head spray systems shall be made at such intervals as are deemed necessary by the authority having jurisdiction, wherever such tests are practicable.

6015. Control Valves and Devices — Control valves and automatic detection equipment shall be tested at least annually and more often if conditions warrant, by qualified inspectors acceptable to the authority having jurisdiction.

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 should 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 should be made after valves are reopened (see NFPA No. 13A — 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 six months. 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, AND HYDRAULIC CALCULATIONS

7000. Plans and Specifications.

7001. 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.

7011. **General** — Hydraulic calculations should be prepared on forms that include a summary sheet, detailed work sheets, and a graph sheet. (See Figures 7020, A-7090b. and A-7090d. for typical forms.)

— 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.....
 PUMP DATA:
 RATED CAPACITY... G.P.M. AT.....P.S.I.
 ELEVATION.....LOCATION.....
 TANK DATA:
 CAPACITY.....GALS.-ELEVATION.....
 LOCATION.....
 REMARKS:

Fig. 7020. Sample Summary Sheet

7020. Summary Sheet.

The summary sheet (for sample summary sheet see Figure 7020) 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.
- (h) Design purpose.
- (i) Minimum rate of water application (density) . . . gpm per square foot.
- (j) Total water requirements as calculated including allowance for inside hose and outside hydrants.
- (k) Water supply information.

7030. Detailed Work Sheets.

Detailed work sheets or computer print-out sheets (for sample work sheet, see Fig. A-7090b.) should contain the following information:

- (a) Sheet number, date, job number, and identification of calculations covered.
- (b) Description and discharge constant (K) (or provide the discharge curve or tabulation) for each nozzle type.
- (c) Hydraulic reference points.
- (d) Flow in gpm.
- (e) Pipe size.
- (f) Pipe lengths, center to center of fittings.
- (g) Equivalent pipe lengths for fittings and devices.
- (h) Friction loss in psi per foot of pipe.
- (i) Total friction loss in psi between reference points.
- (j) Elevation head in psi between reference points.
- (k) Required pressure in psi at each reference point.
- (l) Velocity pressure and normal pressure if included in calculations.
- (m) Notes to indicate starting points, reference to other sheets or to clarify data shown.
- (n) When extending existing equipment hydraulic calculations are to be furnished indicating the previous design, volume, and

pressure at points of connection, and adequate additional calculations to indicate effect on existing systems.

7040. Graph Sheets.

7041. The graph sheet should be made to $n^{1.85}$. Water supply curves and system requirements plus hose demand should be plotted so as to present a graphic summary of the complete hydraulic calculation. (For sample graph sheet, see Fig. A-7090d.)

7050. Abbreviations and Symbols.

7051. The following standard abbreviations and symbols should be used.

<i>Symbol or Abbreviation</i>	<i>Item</i>
P	Pressure in psig.
gpm	Flow rate in U. S. Gallons per minute.
q	Flow increment in gpm to be added at a specific location.
Q	Summation of flow in gpm at a specific location.
P_t	Total pressure at a point in a pipe.
P_f	Pressure loss due to friction between points indicated in location column.
P_e	Pressure due to elevation difference between indicated points. This can be a plus value or a minus value. Where minus, the symbol (—) shall be used; where plus, no sign need be indicated.
P_v	Velocity pressure at a point in a pipe.
P_n	Normal pressure at a point in a pipe.
E	90° Elbow
EE	45° Elbow
$Lt E$	Long Turn Elbow.
Cr	Cross.
T	Tee, flow turned 90°.
GV	Gate Valve.
$Del V$	Deluge Valve.
DPV	Dry-Pipe Valve.
$AL V$	Alarm Valve.
CV	Swing Check Valve.
St	Strainer.
$psig$	Pounds per square inch gage.
v	Velocity of water in pipe in feet per second.
g	Acceleration due to gravity in feet per second per second (generally 32. or 32.16 is used).
K	A constant.
C	Hazen and Williams friction loss coefficient.
p	Frictional resistance per foot of pipe in psi per ft.
d	Actual internal diameter of pipe used, in inches.

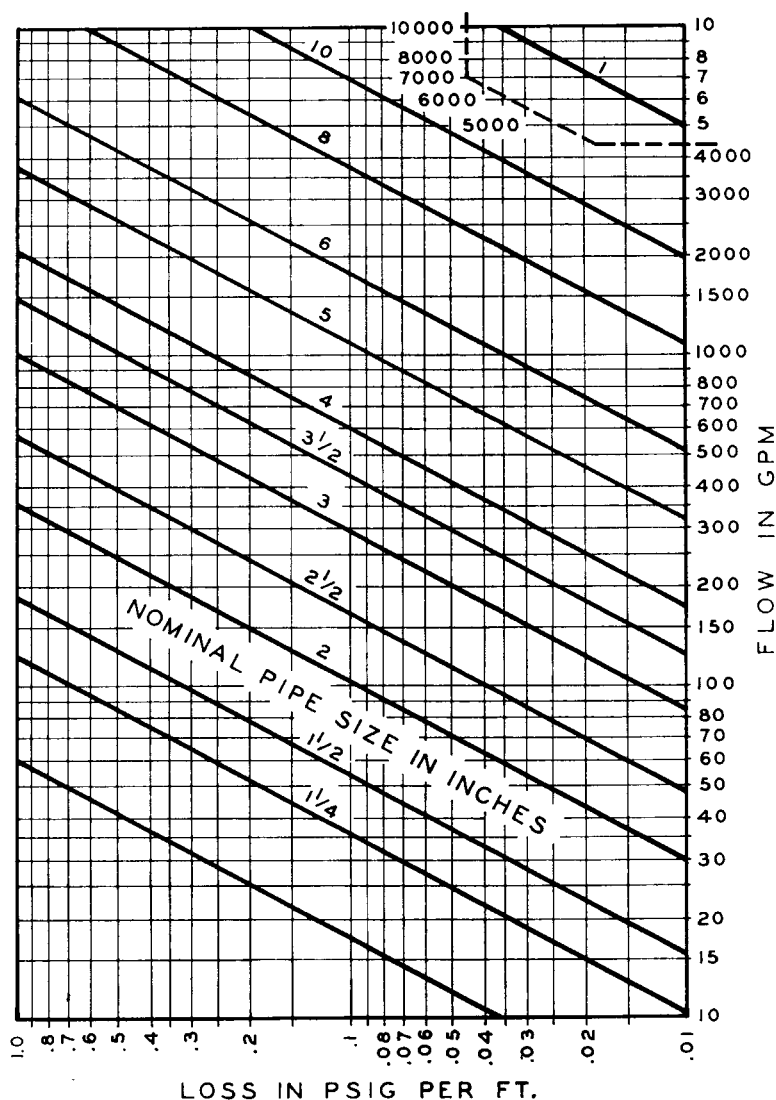


Fig. 7060.a. Friction loss in schedule 40 steel pipe, Hazen & Williams C-120.

7060. Formulae.

- a. Pipe friction losses should be determined on the basis of Hazen and Williams formula. (See Fig. 7060a.)

$$P = \frac{4.52}{C^{1.85}} \frac{Q^{1.85}}{d^{4.87}}$$

- b. The velocity pressure should be determined on the basis of

$$P_v = 0.433 \frac{v^2}{2g}$$

Where v is the upstream velocity.

- c. Normal pressure should be determined on the basis of

$$P_n = P_t - P_v$$

- d. Hydraulic junction point calculations except for loops should be balanced to the higher pressure by the formula*

$$Q = K\sqrt{P} \quad \text{or} \quad K = \sqrt{\frac{Q}{P}} \quad \text{or} \quad \frac{Q_1}{Q_2} = \sqrt{\frac{P_1}{P_2}} \quad (\text{corrected for elevations})$$

- e. The discharge of a nozzle may be calculated by the formula*

$$Q = K\sqrt{P}$$

*NOTE: (1) P may be the total or normal pressure according to whether or not the velocity pressure is being included.

(2) Piping may be looped to divide the total water flowing to the design area.

7070. Velocity Pressure.

- a. The velocity pressure P_v may or may not be included in the calculations at the discretion of the designer.

NOTE: The omission of the velocity pressure from the calculations introduces an error that is generally on the safe side. However, under some conditions with high velocity, the velocity pressures should be considered.

- b. The velocity pressure P_v is a measure of the energy required to keep the water in a pipe in motion. At the end of the nozzle or end section of system (when considering junction of sections of systems) the total pressure available in the pipe at that point should

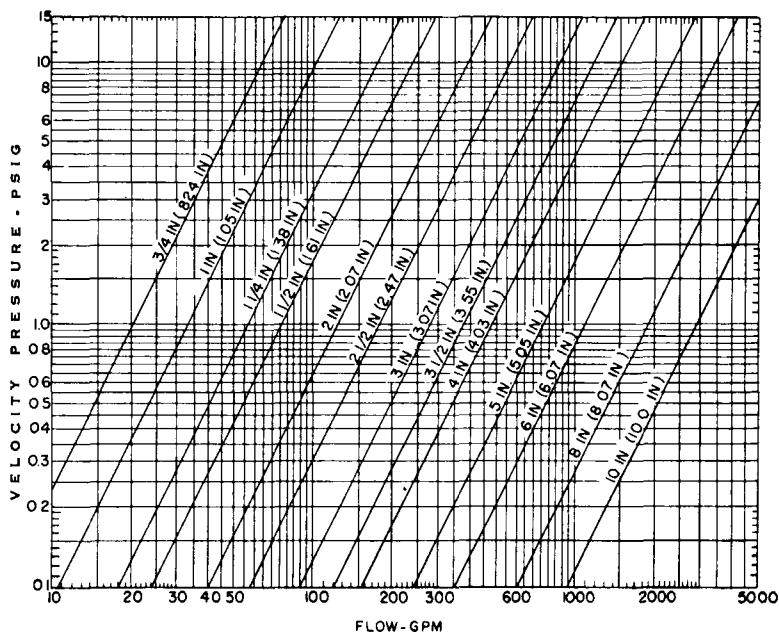


Fig. 7070.b. Graph for the determination of velocity pressure.

be considered as causing flow. However, at other nozzles or junction points the pressure causing flow will be the normal pressure which is the total pressure minus the velocity pressure. Figure 7070.b. may be used for determining velocity pressures, or velocity pressure may be determined by dividing the flow in gpm squared by the proper constant from Table 7070.b.

TABLE 7070.b.

Pipe Schedule	Pipe Size	Constant Based on Actual I. D.
40	1	1,080
40	1 1/4	3,230
40	1 1/2	5,980
40	2	16,200
40	2 1/2	33,100
40	3	78,800
40	3 1/2	141,000
40	4	234,000
40	5	577,000
40	6	1,204,000
30	8	3,780,000
40	8	3,620,000

c. The following assumptions are to be used in applying velocity pressure to the calculations.

1. At any nozzle along a pipe, except the end nozzle, only the normal pressure can act on the nozzle. At the end nozzle, the total pressure can act.

2. At any nozzle along a pipe, except the end nozzle, the pressure acting to cause flow from the nozzle is equal to the total pressure minus the velocity pressure on the upstream side.

3. To find the normal pressure at any nozzle except the end nozzle, assume a flow from the nozzle in question, and determine the velocity pressure for the total flow on the upstream side. Because normal pressure = total pressure — velocity pressure, the value of the normal pressure so found should result in a nozzle flow approximately equal to the assumed flow. If not, a new value should be assumed and the calculation repeated.

7080. Equivalent Pipe Lengths of Valves and Fittings.

a. Table 7080 should be used to determine equivalent lengths of pipe for fittings.

b. Specific friction loss values or equivalent pipe lengths for deluge valves, strainers, and other devices shall be made available to the authority having jurisdiction.

7090. Calculating Procedure.

7090. In order to maintain consistency in hydraulic calculations, whether done by hand or by computer, the following rules should be followed. Experience has shown that good results are obtained if the calculations are made in accordance with these rules. It is recognized that satisfactory results may be obtained by using other methods. However, in order to simplify the checking of calculations and to obtain more consistent correlation between calculated system characteristics and actual system characteristics it is desirable to use a standard method.

a. The first work sheet should start at a remote nozzle and proceed directly to a point of known or proposed water supply. Branch calculations should be made on subsequent sheets.

b. Include the friction loss on all pipe and devices such as valves, meters, and strainers.

c. Include all fittings where a change in direction of the flow occurs, as follows:

1. Calculate the loss for a tee or a cross where flow direction change occurs, based on the equivalent pipe length for the smaller size of the tee or cross in the path of the turn. Do not include any loss for that portion of the flow which passes straight through the run of a tee or a cross.

TABLE 7080

EQUIVALENT PIPE LENGTH CHART

Fittings and Valves

Fittings and Valves Expressed in Equivalent Feet of Pipe.

	3/4 in.	1 in.	1 1/4 in.	1 1/2 in.	2 in.	2 1/2 in.	3 in.	3 1/2 in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.
45° Elbow	1	1	1	2	2	3	3	3	4	5	7	9	11	13
90° Standard Elbow	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90° Long Turn Elbow	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee or Cross (Flow Turned 90°)	4	5	6	8	10	12	15	17	20	25	30	35	50	60
Gate Valve	—	—	—	—	1	1	1	1	2	2	3	4	5	6
Swing Check*	4	5	7	9	11	14	16	19	22	27	32	45	55	65

Use with Hazen and Williams C = 120 only. For other values of C, the figures in Table 7080 should be multiplied by the factors indicated below:

Value of C	100	120	130	140
Multiplying factor	0.713	1.00	1.16	1.32

(This is based upon the friction loss through the fitting being independent of the C factor applicable to the piping.)

Specific friction loss values or equivalent pipe lengths for alarm valves, dry-pipe valves, deluge valves, strainers and other devices shall be made available to the authority having jurisdiction.

*Due to the variations in design of swing check valves, the pipe equivalents indicated in the above chart to be considered average.

2. Calculate the loss of reducing elbows based on the equivalent feet value of the smallest outlet. Use the equivalent feet value for the "standard elbow" on any abrupt ninety degree turn, such as the screw type pattern. Use the equivalent feet value for the "long turn elbow" on any sweeping ninety degree turn, such as a flanged, welded, or mechanical joint type elbow.

3. Friction loss should be excluded for tapered reducers and for the fitting directly supplying the spray nozzle.

d. Include all elevation changes affecting the discharge and/or the total required pressure where it occurs.

e. Piping may be looped to divide the total water flowing to the design area.

f. The water allowance for outside hydrants when served from the same underground mains may be added to the system requirement at the system connection to the underground main. The total water requirement should then be calculated through the underground main to the point of supply.

g. Orifice plates should not be used for balancing the system.

h. Calculate pipe friction loss in accordance with the Hazen and Williams formula using "C" value of 120 for black or galvanized steel pipe, C-140 for cement lined cast iron pipe or copper tubing, and C-100 for unlined cast iron pipe. The authority having jurisdiction may recommend other C values. These coefficients contemplate the use of the actual pipe internal diameter in the formula.

NOTE: See Appendix for sample calculations.

CHAPTER 8. AUTOMATIC DETECTION EQUIPMENT

8000. General.

8001. The arrangements 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 should 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 should 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.

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 protection.

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 and Spacing of Detectors.

8031. Automatic detection equipment shall be so located and adjusted as to operate reliably. The location of detectors should be based upon data obtained from field experience, tests, engineering surveys, the manufacturer's recommendations, and recognized laboratory listings, insofar as these are applicable. In addition, location should 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.

8032. Location and spacing of detectors may be in accordance with the manufacturer's recommendations where such recommendations are based upon tests satisfactory to the authority having jurisdiction. In the absence of such recommendations the following rules apply.

8033. Outdoor Installations.

(a) Detectors used outdoors should be installed with a markedly reduced spacing from that shown by tests to be satisfactory for indoor installation.

NOTE: Presently, fire detectors for special systems have been investigated and identified by Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, and the Factory Mutual Engineering Corporation; however, the spacing limitations specified are for indoor installations, principally under smooth ceilings.

(b) Detectors should be located around the perimeter of the hazard and within the area enclosed by the perimeter detectors. The uppermost complement, vertically, of detectors, should be a minimum of one foot above the general level of the top of the equipment.

8034. Unenclosed Structures.

(a) Detectors should be located in a manner similar to those for outdoor installations.

(b) Beneath solid floors or ceilings the detectors, except for the perimeter, may be installed under the rules for indoor installations.

(c) Installations beneath floors or ceilings which are not solid should be considered as outdoor installations.

8035. Indoor Installations.

(a) **CEILING HEIGHTS.** The ceiling height and nature of the expected fire shall be given consideration in the selection and spacing of detectors. Where ceiling heights exceed 35 feet detectors should be so spaced that the area covered by each detector will not exceed 75 percent of the area normally covered.

(b) **SPACING.** Detector spacings shall not exceed the linear maximums indicated by tests of Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, or Factory Mutual Engi-

neering Corporation for the particular device used. Closer spacing may be required due to structural characteristics of the protected area, possible drafts, or other conditions affecting detector operation.

(c) **DISTANCE BETWEEN DETECTORS AND WALLS.**

(1) Where ceilings are level, the distance between the wall and the nearest detector shall not exceed one-half the distance allowed between detectors.

(2) With sloping ceilings, (slope more than $1\frac{1}{2}$ inches per foot) the distance to the lowest detector shall not exceed two-thirds the distance allowed between detectors. Distance may be measured horizontally for both level and sloping ceilings.

(3) In areas requiring only a single row of detectors the distance between the end detector and the end wall shall not exceed one-third the distance allowed between detectors.

8036. 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 and Supervision of Systems.

8041. Supervision. Central station, remote station, or proprietary supervision of detection equipment may be required by the authority having jurisdiction.

NOTE: For the applicable standards, see NFPA 71, 72C and 72D.

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 such 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 should 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 should operate within 40 seconds.

NOTE: (1) Some detection circuits may be deliberately desensitized in order to override unusual ambient conditions. In such cases the above response may be exceeded subject to the authority having jurisdiction.

(2) Testing of integrating tubing systems may be related to this test by means of a standard pressure impulse test specified by the listing laboratory.

(3) *One method of testing heat detection uses a radiant heat surface at a temperature of 300° F. and a capacity of 350 watts at a distance of one but not more than two inches from the nearest part of the detector. This method of testing with electric test set should not be used in hazardous locations. Other test methods may be employed but the results shall be related to the results obtained under these conditions. [See 4043 (a) (2).]*

APPENDIX

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-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.

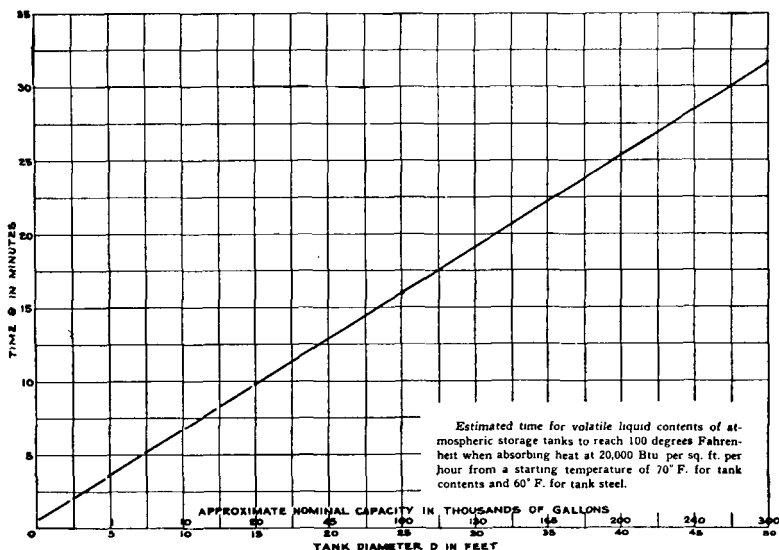


Fig. A-4043 (b-1)