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Fire Extinguishing Appliances

STANDARD

for

WATER SPRAY SYSTEMS

for Fire Protection

May
1957

Fifty Cents*

NATIONAL FIRE PROTECTION ASSOCIATION
International

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National Fire Protection Association

International

Executive Office: 60 Batterymarch St., Boston 10, Mass.

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes two hundred national and regional societies and associations (list on outside back cover) and seventeen thousand individuals, corporations, and organizations. Anyone interested may become a member; membership information is available on request.

This pamphlet is one of a large number of publications on fire safety issued by the Association including periodicals, books, posters and other publications; a complete list is available without charge on request. All NFPA standards adopted by the Association are published in six volumes of the **National Fire Codes** which are re-issued annually and which are available on an annual subscription basis. The standards, prepared by the technical committees of the National Fire Protection Association and adopted in the annual meetings of the Association, are intended to prescribe reasonable measures for minimizing losses of life and property by fire. All interests concerned have opportunity through the Association to participate in the development of the standards and to secure impartial consideration of matters affecting them.

NFPA standards are purely advisory as far as the Association is concerned, but are widely used by law enforcing authorities in addition to their general use as guides to fire safety.

Definitions

The official NFPA definitions of shall, should and approved are:

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations, or that which is advised but not required.

APPROVED refers to approval by the authority having jurisdiction.

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters.

Approved Equipment

The National Fire Protection Association does not "approve" individual items of fire protection equipment, materials or services. The standards are prepared, as far as practicable, in terms of required performance, avoiding specifications of materials, devices or methods so phrased as to preclude obtaining the desired results by other means. The suitability of devices and materials for installation under these standards is indicated by the listings of nationally recognized testing laboratories, whose findings are customarily used as a guide to approval by agencies applying these standards. Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada and the Factory Mutual Laboratories test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request.

Water Spray Systems for Fire Protection.

NFPA No. 15—1957

This edition incorporates revisions adopted by the National Fire Protection Association on May 23, 1957. It supersedes the edition of 1955.

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. Subsequent to the 1947 edition, 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.

This standard has been adopted by the NBFU (No. 15) in editions dated 1940, 1947, 1950 and 1955. The NBFU editions of 1947, 1950 and 1955 do not include all of the illustrations.

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1957 REVISION

The revision adopted by the Association in 1957 is a new section in the Appendix numbered A-23-20. This new section is a recommended method of hydraulically calculating water spray systems. It contains a suggested standard calculation form, a table of abbreviations and symbols, a friction loss graph and a table of friction loss in pipe fittings. A typical water spray system is shown with the hydraulic calculations computed according to the recommended method.

This method of hydraulically calculating a water spray system will simplify checking of calculations and result in more consistent correlation between calculated system characteristics and actual system characteristics.

FOREWORD.

Fundamentally, water spray consists of a discharge from a device capable of separating the water into spray. The basic principles involved in its use for fire protection are not new; and experience has indicated the worth of both fixed water spray systems and portable water spray equipment. Because of the wide variations in the characteristics of water spray nozzles including discharge patterns, velocities, distances of projection, etc., and because of the many variables involved in hazards to be protected, fixed water spray systems must be competently designed, installed and maintained. It is equally important that portable water spray equipment be carefully selected and positioned in relation to the hazard or equipment protected. Furthermore, such equipment must be applied in a manner not only to extinguish or control a fire but also to protect the operator.

The addition of a listed wetting agent to water in proper quantities, materially reduces the surface tension of the water and increases its penetrating, spreading and/or its emulsifying ability. These added qualities may be desirable in water spray systems.

The standard sets forth four major types of systems, namely, those designed for extinguishment, for control of fire, for exposure protection or for fire prevention. The first step in considering water spray is the determination of which one or more of these four major purposes will apply The type of nozzle, the amount of water required, the unit rate of discharge, the nature and extent of the coverage and drainage are factors which will vary with the purpose of the system.

Although it has been recognized that water spray systems are particularly effective on most flammable liquid fires; experience has shown that water spray systems are effective on most of the combustible solids and on fires in electrical equipment. The type of water spray system required for any particular hazard will depend on the nature of the hazard and the form of protection desired. The most satisfactory practice would be to have tests conducted on full or sufficiently large scale to determine the most efficient system and/or equipment to use in extinguishing or controlling fires involving any specific material or equipment. Although water spray has a wide application it is essential that its limitations be recognized.

SECTION I.

ARTICLE 10.

GENERAL INFORMATION.

*11.00 Introduction.

11.10 PURPOSE—These standards are in general the minimum requirements for the installation of water spray protection and are prepared to cover the design, construction and maintenance of such systems and for the guidance of inspection departments having jurisdiction and others concerned in judging the acceptability of an installation of this type.

11.20 SCOPE—These standards are limited to rules for the design, construction, maintenance and test of fixed systems and portable equipment for the application of water spray for fire protection purposes and to advisory comment regarding its use and limitations.

*See appendix.

*11.30 DEFINITIONS—A spray nozzle is a device from which a definite pattern of water spray is discharged. This may include special directional nozzles, hollow or solid cone pattern, and all types of listed sprinklers.

NOTE: For simplification all types will be referred to simply as spray nozzles, selection of a particular type being dependent on study of the individual hazard.

*11.31 An applicator is a portable device for manually placing a water spray nozzle or nozzles in position to extinguish, control or prevent a fire.

11.32 Wet water may be defined as any water to which a proper wetting agent has been added in quantities as specified by the manufacturer.

11.33 The term Water Spray used throughout this Standard is intended to include wet water in the form of spray. (See Article 13.00.)

11.34 LISTED — Included in a list published by an approved nationally recognized testing agency such as Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, or Factory Mutual Laboratories.

12.00 Uses.

*12.10 GENERAL PURPOSES—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 equipments. Water spray systems are not ordinarily intended to replace automatic sprinklers. In general, water spray may be used effectively for any one or combination of the following purposes:

1. Extinguishment of fire.
2. Control of fire.
3. Exposure protection.
4. Prevention of fire.

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

12.12 Control of fire 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.

12.13 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.

12.14 PREVENTION OF FIRE. Start of fire is prevented by the use of water sprays to dissolve, dilute, disperse, or cool flammable materials.

12.20 HAZARDS—Water spray protection is, in general, acceptable for hazards involving:

1. Gaseous and liquid flammable materials.
2. Electrical hazards such as transformers, oil switches and motors.
3. Ordinary combustibles such as paper, wood and textiles.
4. Hazardous solids.

NOTE: See also 13.00, "Limitations."

*See appendix.

13.00 Limitations.

*13.10 LIMITATIONS—There are limitations in the use of water spray which must 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.

13.11 Because of the importance and the technical complexity of hazards usually protected by water spray, each application will require study by persons experienced in water spray protection.

13.12 CLASS "A" FIRES—Wet water has the same limitations as plain water with respect to extinguishing fires involving chemicals which react with water to create new hazards and should not be used on fires involving chemicals such as sodium, calcium carbide, etc.

13.13 CLASS "B" FIRES—The use of wet water for the extinguishment of fires involving Class "B" combustibles is limited to those materials not soluble in water such as petroleum products. In water soluble materials of the alcohol type, some control may be realized, but extinguishment is questionable.

13.14 USE OF WETTING AGENTS WITH OTHER THAN PLAIN WATER—Admixing of wetting agents with other wetting agents or with mechanical or chemical foam liquids is not recommended and shall be avoided. Mixing of these agents may have adverse results and thus render them ineffective for fire extinguishment.

13.15 The use of wetting agents in concentrations greater than specified by the manufacturer or specified by the testing laboratory should be avoided. High concentrations may cause adverse effects.

13.16 CORROSION—The corrosive effects of wetting agents should be specified by the manufacturer and included in the listing report of the testing laboratory. Generally, listed wetting agents have a definite cleaning action and will remove from metal surfaces grease, oil, mill scale, protective coatings, metallic coatings including galvanizing, etc. which normally protect metal from the corrosive attack of water, in which case accelerated water corrosion may be expected.

a. Deterioration effects upon materials and metals should be determined by the listing laboratory and results contained in their listing report and in the manufacturers directions for use.

b. As an example, the action of solutions containing wetting agents will remove galvanizing or any coating which is not chemically bonded to metal; therefore, use under those conditions should be avoided.

c. Concentrated or dilute solutions of wetting agents may cause mild pit-type corrosion of metal surfaces at the liquid level and in the vapor space. Therefore, the wetting agents in any concentration stored or handled over long periods of time in open containers and system piping should be avoided unless corrosion resistant materials are provided.

13.17 TOXICITY—In general, listed wetting agents are non-toxic. However, reasonable care should be exercised to avoid concentrated solu-

*See appendix.

tions in contact with the skin. Due to the cleansing properties similar to strong soaps, continued contact may cause mild dermatitis.

Contamination of edibles and ingestion should be avoided.

The degree of toxicity should be determined by the manufacturer and contained in the listing laboratory's report and in the manufacturers directions for use.

13.18 The use of listed wetting agents in existing water type portable extinguishers is limited to such formulations as may be specified by the manufacturer and determined by the testing laboratories. As an example, there are some wetting agents which will tolerate high concentrations of salts (sodium) and become more efficient in the presence of such concentrations. Other types may precipitate under similar conditions.

14.00 Plans and Specifications.

14.10 REQUIREMENTS—Spray system layout and installation should be entrusted to none but fully experienced and responsible persons. Before fixed water spray systems or portable equipment is installed or existing equipment remodeled, complete working plans and specifications should be submitted for approval to the inspection department having jurisdiction. Any material deviation from the approved standards will require special permission from the inspection department. Plans shall be drawn to an indicated scale, show all essential details and shall be made so they can be easily reproduced to provide the necessary copies or prints. Information which may be required includes designed purpose of system, friction loss calculations, tests of available water supply, detailed layout of piping, locations of heads and hanging. and accurate and complete layout of the entire hazard to be protected.

15.00 Approvals.

15.10 Prior to determining the purpose of water spray system under consideration, the inspection department having jurisdiction shall be consulted. All plans and specifications pertinent to the installation shall be approved by the inspection department having jurisdiction prior to installation. The inspection department shall be consulted as to devices and material. All equipment shall be approved for the particular application intended. Before asking final approval of a water spray system by the inspection department having jurisdiction, the installing company should furnish a written statement to the effect that the work has been completed and tested in accordance with approved plans and specifications.

SECTION II.

ARTICLE 20.

FIXED WATER SPRAY SYSTEMS.

21.00 Fixed Systems—General.

21.10 DESCRIPTION—Fixed water spray systems consist of fixed piping and spray nozzles connected to an approved water supply. The flow of water shall be automatically controlled, except that under special conditions the inspection department having jurisdiction may permit manual control.

*21.20 USE—Fixed piping systems are preferred for the protection of specific hazards and for all installations where the degree of hazard makes prompt application necessary. Fixed piping systems may be designed for extinguishment, control, exposure protection or fire prevention according to the need and the suitability of this type of protection.

21.21 The data available indicate that the general clearances between any portion of the equipment and live electrical apparatus should not be less than as given in the following table, and whenever possible these clearances should be increased.

Voltages	*Distance*	*Voltages*	*Distance*
Up to 7,500	6 in.	73,000 to 88,000	52 in.
7,500 to 15,000	12 in.	88,000 to 110,000	64 in.
15,000 to 25,000	17 in.	110,000 to 132,000	77 in.
25,000 to 37,000	24 in.	132,000 to 154,000	89 in.
37,000 to 50,000	32 in.	154,000 to 187,000	106 in.
50,000 to 73,000	44 in.	187,000 to 220,000	124 in.

21.30 SIZE—Individual hazards should be protected by single systems except that the discharge capacity of any one system should not exceed that specified in Paragraph 22.10. The extent of a water spray system is dependent on many factors including the nature of hazard or combustibles involved, amount and type of equipment to be protected, adequacy of other protection, and the size areas to be protected which may be involved in a single fire. Fire areas may be properly subdivided by spacing, by fire walls or diking, by special drainage, by water curtains, or by combinations of these factors. Wherever practicable fire areas should be subdivided to facilitate protection of each subdivision by a separate, individually controlled water spray system. In cases where two or more systems are required for protection of a single fire area, the discharge capacity of each system must be limited as prescribed in paragraph 22.10. Particular care should be taken to place control valves in locations accessible during a fire.

*21.40 DRAINAGE—Adequate drainage shall be provided to promptly and effectively dispose of all water discharged from fixed water spray systems, portable hose streams and spilled liquids. Each fire area wherein flammable liquids may be involved must be drained separately, using properly trapped drains in connections to disposal systems. As a general rule, the capacity of a drainage system at gravity flow for a specific fire area should be at least equal to the discharge capacity of the water spray system at

*See appendix.

maximum possible nozzle pressure. Where the drainage system also handles cooling water, surface or other drainage, or where hose protection is considered necessary to supplement fixed water spray protection, additional drainage capacity should be provided. If the drainage system handles flammable liquids, particularly those which are insoluble or only partly soluble with water, a separator or burning pit located at a safe point should be installed.

21.50 LOCATION OF VALVES—Each system shall be provided with a shut-off valve so located as to be readily accessible during fire in the area the system protects, a severe exposure fire or, for systems installed for fire prevention, during the existence of the contingency for which the system is installed.

22.00 Water Supplies.

22.10 SIZE OF SYSTEM—The size of a single system should be kept as small as practicable, giving consideration to water supplies and other factors effecting reliability of the protection. A size of 3,000 g.p.m. designed discharge rate, calculated at the minimum pressures for which the nozzles are designed, should not be exceeded. Segregated hazards (those so separated from other hazards as not to be subject to the spread of fire from such other hazards) should be protected by separate systems.

*22.20 RATE OF DISCHARGE—The discharge rate per unit of area to be protected will depend on whether the spray system is installed for extinguishment of fire, control of fire, exposure protection or prevention of fire, and upon the characteristics of the materials involved.

*22.30 QUANTITY—Water supplies must be adequate in quantity to supply all the spray nozzles likely to be put into operation for a period of time sufficient for the particular hazard and conditions involved. The discharge shall be figured at the calculated nozzle pressures but in no case less than the minimum design pressure for the particular nozzle used.

22.40 PRESSURE—The water pressure available at the control valve shall at least be such as to produce the minimum pressure at the spray nozzles for which the system has been designed. Before installation of equipment, flow tests shall be made to determine that sufficient pressure is available at rates of discharge calculated to be ample for all the spray nozzles which would operate during any fire.

*22.50 SOURCES—Fixed equipment should be fed from a connection to sprinkler or other recognized fire protection water supplies. A single connection having adequate capacity for one system, may be acceptable for more than one system, providing such systems are segregated by adequate fire stops. The inspection department having jurisdiction shall be consulted to determine the adequacy of such supplies.

NOTE: Where automatic operation of fire pumps is required, closed circuit controls in accordance with standards of the N.F.P.A. for the Installation and Operation of Centrifugal Fire Pumps are required.

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

*22.60 STRAINERS—Strainers approved specifically for use in water spray systems shall be provided. Strainers shall be capable of removing from the water all solids of sufficient size to obstruct the spray nozzles.

*See appendix.

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. 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.

22.70 FIRE DEPARTMENT CONNECTIONS—Fire department connections for fixed water spray systems may be required by the inspection department having jurisdiction. Careful consideration should be given to such factors as the purpose of the system, reliability, capacity and pressure of the water system. The possibility of serious exposure fires and similar local conditions may also be important factors. Where a fire department may be required to draft from supplies containing foreign materials, additional strainers in the fire department connection may be required.

*22.80 FLUSHING—Before connection the system supply piping should be flushed at a rate of flow producing a velocity of not less than ten feet per second for a period of time sufficient to insure thorough cleaning.

23.00 System Piping.

23.10 MATERIALS—Piping shall be of steel, galvanized in accordance with current American Standards or equal corrosion resistant treatment. Specific conditions may require the use of more effective protection. (See paragraph 13.16.)

*23.20 SIZE—As effective protection is dependent on having adequate pressure and quantity of water available at the spray nozzles, each system requires individual consideration as to the size of the piping. The inspection department having jurisdiction may require for approval, submisson of complete computations showing pressure drop in all system piping. Friction losses in pipe and fittings shall be determined by the Hazen & Williams formula using a value of 120. Pipe sizes should be so selected as to produce proper nozzle pressure for all nozzles.

23.30 INSTALLATION—The installation standards for water spray system piping shall be the applicable sections of the N.F.P.A. "Standards for the Installation of Sprinkler Equipments" except as herein modified. Welding in accordance with A.S.A. Code for pressure pipe is permissible when it can be done without introducing fire hazards. This may require galvanizing of sections involving welded parts after fabrication. Special care should be taken to insure that the openings are fully cut out and that no obstructions remain in the waterway. All underground supply piping after the deluge valve shall be pitched ½ in. in 10 ft. to drain in the same manner as the abovementioned standards specify for aboveground piping. Provision shall be made to drain said underground and overhead piping. The supply piping to nozzles which protect a hazard in a fire area shall not pass over another hazard.

23.31 Main headers should preferably 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.

23.40 FLUSHING—All system piping shall be flushed where practicable, otherwise cleanliness shall be determined by visual examination.

*See appendix.

24.00 Valves, Fittings and Hangers.

24.10 VALVES—All valves are to be of a type approved for the purpose. Readily accessible drain valves shall be provided for low points in underground and aboveground piping. Lever operated gate valves are not acceptable.

24.20 All pipe fittings shall be American Standard for the pressure class involved but not less than 175 lbs. rating. Fittings shall be malleable steel or iron in dry sections of the piping exposed to possible fire. Automatic control valves, shut-off valves and strainers of approved types may be cast iron. All fitting subject to stress in self-supporting systems shall be steel or malleable iron.

24.30 HANGERS—All hangers must be of approved types. Tapping or drilling of load bearing structural members is not generally permitted. However, attachments may be made to existing steel or concrete structures and equipment supports. Where systems are of such a nature that the usual methods of supporting pipe 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. All supports in the fire area involved should be protected by the system. In any area where possibility of explosion may be recognized, unusual care should be taken to support the pipe from portions of the structure least liable to disruption by explosion.

24.40 TEST GAGE—A test gage connection shall be provided at the highest or at the most remote point on the system, whichever is calculated to show the least pressure under normal flow conditions.

25.00 Spray Nozzles.

25.10 SELECTION—The selection 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.

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 uniform water distribution and to allow for loss of head in water supply piping. Orifices should not be less than ¼ in. in diameter unless consideration be given to the installation of individual strainers for each nozzle if plugging is to be prevented when the water supply is not exceptionally clean and diversion of the spray by a fire updraft is to be held to a minimum.

A test of the water supply is recommended before the size of orifices is selected. A uniform solid cone pattern of water distribution with angle of discharge sufficiently flexible to provide coverage without excessive wastage of water is required for directional spray nozzles. In general, the maximum discharge angle should not exceed 120° if forceful projection is to be assured.

25.20 CORROSION—Where corrosion, coating or loading is likely, spray nozzles should be properly protected. The use of corrosion and fire-resistant materials is advised.

*25.30 SPACING—The protection provided by the nozzles shall fully include the hazard (area or volume) and where required in special cases shall have a coverage well in excess of that of the hazard.

25.31 Spray nozzles shall be spaced in accordance with their actual discharge patterns.

25.32 Spray nozzles should be placed to provide direct impingement

*See appendix.

of spray upon burning surfaces and/or surfaces to be cooled. Care should be taken to avoid any obstruction to the distribution of water.

25.40 POSITION—Spray nozzles may be placed in any position necessary to obtain proper coverage of the protected area, structures or equipment. Special 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.

26.00 Operation and Control of Systems.

*26.10 AUTOMATIC SYSTEMS—Systems of this type are automatic in operation. They may be used for extinguishment of fire, control of fire, exposure protection or fire prevention.

*26.11 Control of automatic valves for water spray systems shall be accomplished by methods recognized in the standards for other extinguishing systems. Systems which depend for operation on electric thermostats, relays, circuits or other similar equipment should be so arranged that such equipment is normally energized or completely supervised in such a manner that failure will result in system operation or positive notification of the abnormal condition.

The spacing of heat responsive devices for water spray systems installed for protection against fire exposure requires more careful engineering and may call for a different arrangement from that required for other types of systems. Where used in a corrosive atmosphere, the devices should be of a material not subject to corrosion or be protected to resist corrosion.

26.12 Automatically controlled valves shall be as close as accessibility permits to the hazard protected, so that a minimum of piping between the automatic control valve and the spray nozzles is required.

26.13 Manual tripping devices shall be provided for all automatic control valves. Such tripping devices shall be so located as to be readily accessible in the event of fire or possibility of fire. They shall be plainly marked to indicate their purpose.

26.14 Manual devices may actuate the automatic control valve by mechanical, pneumatic, electric or other approved means. If a remote manual device is mechanically operated, the length of the cable shall not exceed thirty feet and there shall be not more than three changes in direction. The manual device shall be amply strong to prevent breakage.

26.15 Where a hazard protected by an automatic spray system is in a sprinklered area, the water spray system should be designed to operate before the sprinkler system.

26.20 MANUAL SYSTEMS—Systems of this type consist of fixed piping and spray nozzles connected to an approved water supply controlled by manually operated valves. Manual systems may be installed only with specific permission of the inspection department having jurisdiction. These shall be installed in conformity with all the particulars of the standards for automatic systems, except that the control valve will be operated by manual mechanisms. When an approved automatic control valve arranged for manual operation is not used, the valve shall be of a type approved for automatic sprinkler service. If an outside post indicator valve is used with approval of the inspection department having jurisdiction, the handle or handwheel shall be permanently attached in operating position, and such control valves shall be so located as to be easily accessible in case of fire or other emergency.

*See appendix.

27.00 Alarms.

27.10 LOCAL ALARMS—Automatic alarms shall be provided on all water spray systems except that on manually operated systems they may be omitted by permission of the inspection department having jurisdiction. Alarms shall conform to the standards governing alarm apparatus for sprinkler equipment, including requirements of thermostatically operated systems for automatic alarms independent of waterflow.

28.00 Acceptance Tests.

28.10 PRESSURE TESTS—All piping shall be subjected to a two-hour hydrostatic pressure test at 200 lbs. per sq. in. or 50 lbs. in excess of the maximum pressure anticipated, whichever is greater, in general conformity with the standards of the N.F.P.A. for installation of sprinkler equipment. All horizontal piping shall be checked to determine if proper drainage pitch is provided.

28.20 OPERATING TESTS—Before acceptance, fixed water spray systems shall be subjected to such tests as may be required by the inspection department having jurisdiction. Wherever practicable these tests shall include operation of all devices and equipment installed as part of the system.

28.30 DISCHARGE TESTS—Approval and acceptance of water spray systems should be subject to flow tests where conditions permit, in order to insure that the hazard is fully protected in conformance with the design specification, that the nozzles are so adjusted as to give the most efficient coverage, and to determine the flow pressures, actual discharge capacity, and other operating characteristics.

29.00 Maintenance.

29.10 WATER SUPPLIES—Proper precautions should be taken to insure that water supplies are kept turned on and are in full operating capacity condition at all times in accordance with other standards of the N.F.P.A. governing water supplies for automatic fire protection equipment.

29.20 STRAINERS—Strainers should be thoroughly inspected and cleaned after each operation or flow test. Inspection and cleaning should be performed at intervals of not more than six months.

29.30 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 pitch is maintained for piping.

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

29.32 Where wetting agents are used, empty pipe systems should be thoroughly flushed with fresh water after each operation.

29.40 CONTROL VALVES AND DEVICES—Automatic control valves and heat-actuated devices shall be tested at least twice a year by qualified inspectors acceptable to the inspection department having jurisdiction.

NOTE: An inspection contract with the installer of the equipment for test and examination at regular periods is advisable.

29.41 Manual tripping devices and valves, including O. S. & Y. gate and post indicator valves, shall be operated at least once each six months.

29.42 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. Drain flow tests should be made after valves are reopened.

29.50 SPRAY NOZZLES—All spray nozzles shall be inspected for 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.

29.51 After each operation open spray nozzles equipped with individual screens shall be removed and the spray nozzle and screen cleaned.

SECTION III.

ARTICLE 30.

PORTABLE WATER SPRAY EQUIPMENT.

31.00 Portable Equipment—General.

*31.10 DESCRIPTION—Portable water spray equipment consists of one or more water spray nozzles attachable to hose or such devices as playpipes or applicators. This equipment may be designed to permit the discharge of either a spray or a solid stream.

31.20 USE—Portable water spray equipment may be used to supplement fixed fire protection systems, or alone for the protection of specific hazards, or in place of solid stream equipment under suitable conditions.

31.21 Portable water spray equipment may be supplied by fixed fire protection equipment water supplies, hose standpipe systems, hydrant systems or with fire department apparatus.

31.30 LIMITATIONS—Portable water spray equipment should not be used as a substitute for automatic sprinklers, fixed water spray or other fixed fire extinguishing systems.

31.31 Applicators shall not be used around energized electrical equipment.

31.32 Combination nozzles equipped for solid stream discharge shall not be used around energized electrical equipment.

32.00 Water Supplies.

32.10 FOR STANDPIPE AND HOSE SUPPLYING PORTABLE WATER SPRAY EQUIPMENT—Water supplies for standpipe and hose systems supplying portable water spray equipment shall conform to Section V of the N.F.P.A. Standards for the Installation of Standpipe and Hose Systems, except that minimum pressures required shall be the minimum pressures necessary for the satisfactory operation of the particular spray nozzle used.

*See appendix.

32.20 For Other Portable Water Spray Equipment—With the approval of the inspection department having jurisdiction, portable water spray equipment may be supplied by automatic sprinkler, or other recognized fire protection water supplies, where they are adequate to supply this additional equipment.

32.30 Strainers—Strainers approved specifically for use in water spray systems shall be provided where possibilities of foreign material in water supply or other factors, such as extremely small orifice sizes in nozzles, require the use of strainers.

32.31 Strainers shall be capable of removing all solids from the water which are of sufficient size to obstruct the spray nozzles. In addition, the strainers shall be capable of continued operation without serious increase in friction loss for a period of time estimated as ample, considering the type of protection provided, the condition of the water, and similar local conditions.

33.00 Installation of Portable Water Spray Equipment.

33.10 This equipment shall be installed to conform to the N.F.P.A. Standards for the Installation of Standpipe and Hose Systems, except that approved pressure reducing devices shall not reduce the pressure below that necessary for the satisfactory operation of the water spray nozzles used.

33.20 Hose—Approved hose suitable for the maximum working pressure shall be used.

33.21 Only rubber-lined hose shall be used.

Note: Unlined fabric hose should not be used as fabric from lining may be carried by the water and obstruct the nozzle.

33.30 Couplings

(a) For use with water pressures under 200 p.s.i., hose couplings, fittings and portable water spray equipment shall be provided with National Standard Hose Threads, except where conformity to local standard threads is desired.

(b) For use with water pressure over 200 p.s.i., couplings, fittings, and portable water spray equipment shall be provided with couplings of such design as to prevent the use of standard hose and low pressure water spray equipment on such high pressure water supplies.

34.00 Acceptance Tests.

34.10 Pressure Test—All piping in standpipe and hose systems supplying water spray equipment, shall be subjected to a two-hour hydrostatic test at 200 p.s.i. or 50 pounds in excess of the maximum pressure anticipated, whichever is greater, in general conformity with NFPA No. 13, Standards for the Installation of Sprinkler Systems.

Pressure should be taken at the base of the system.

34.20 Operating Test—Before acceptance, portable water spray equipment and systems supplying such equipment shall be subject to such tests as may be required by the inspection department having jurisdiction.

Note: Where standpipes or connections are built in the walls or partitions, the above tests should be made before they are covered or permanently concealed.

34.30 FLOW TEST—The inspection department may require actual flow tests from the highest or most remote outlet on the system to determine the adequacy of water supplies.

35.00 Maintenance.

35.10 PERIODIC INSPECTION—Systems shall be kept in operating condition at all times. Systematic periodic inspection of all portions of the standpipe and hose system is essential.

35.20 WATER SUPPLIES—Proper precautions should be taken to insure that water supplies are kept turned on and in full operating condition at all times.

35.30 VALVES—The valves in the main connections to the sources of water supply shall be opened at all times. The hose valves at the hose stations should be frequently examined to see that they are tight.

35.31 Leakage at the hose valves may be detected by inspections of the drip cocks at the valves. Drip cocks should be tested to see that they are not clogged with dirt or sediment.

35.40 STRAINERS—Strainers should be thoroughly inspected and cleaned after each operation and flow test. Inspection and cleaning should be performed at intervals of not more than six months.

35.50 DISCHARGE TEST—An annual test of standpipe and hose systems shall be made by delivering the required quantity of water at the required pressure through hose lines from the topmost outlet of the standpipe.

35.60 HOSE STATIONS—The hose stations should be frequently inspected to see that the fire hose is properly stored and that all of the equipment is in place and in good condition. The hose should be removed at intervals and new gaskets installed in the couplings both at the hose valves and at the spray nozzles.

NOTE: For further details see the National Fire Protection Association's pamphlet, "Care of Fire Hose."

35.70 SPRAY NOZZLES AND APPLICATORS—All portable water spray equipment shall be inspected and cleaned at intervals of not more than six months. Local conditions may be such as to require more frequent cleaning and inspection.

35.71 After each operation portable water spray equipment should be inspected and cleaned.

APPENDIX.

GENERAL INFORMATION.

A-11.00 Other Pamphlets.

The following pamphlets of the NFPA deal with subjects related to water spray protection systems. They also appear in Volumes III, IV and V of the National Fire Codes. The codes and pamphlets are available from the NFPA Publications Service Dept., 60 Batterymarch St., Boston 10, Mass.

Sprinkler Systems (No. 13).*

Standpipe and Hose Systems (No. 14).*

*Printed in NFC Vol. IV.

Centrifugal Fire Pumps (No. 20).*

Water Tanks for Private Fire Protection (No. 22).*

Fire Department Connections (No. 23).*

Outside Protection. (Underground piping systems supplying water for fire extinguishment (No. 24).)*

Valves Controlling Water Supplies for Fire Protection (No. 26).*

Central Station Protective Signaling Systems for Watchmen, Fire Alarm and Supervisory Service (No. 71).**

Proprietary, Auxiliary and Local Systems for Watchmen, Fire Alarm and Supervisory Service (No. 72).**

Waterproofing of Floors and Drainage and Installation of Scuppers (No. 92).†

Care and Maintenance of Sprinkler Systems (No. 13-A).*

Operation and Maintenance of Steam Fire Pumps (No. 21).*

National Standard Fire Hose Couplings (No. 194).*

Wetting Agents (No. 18).*

Pamphlets on the above listed subjects and with the same designating numbers are published by the National Board of Fire Underwriters, 85 John St., New York, N. Y.

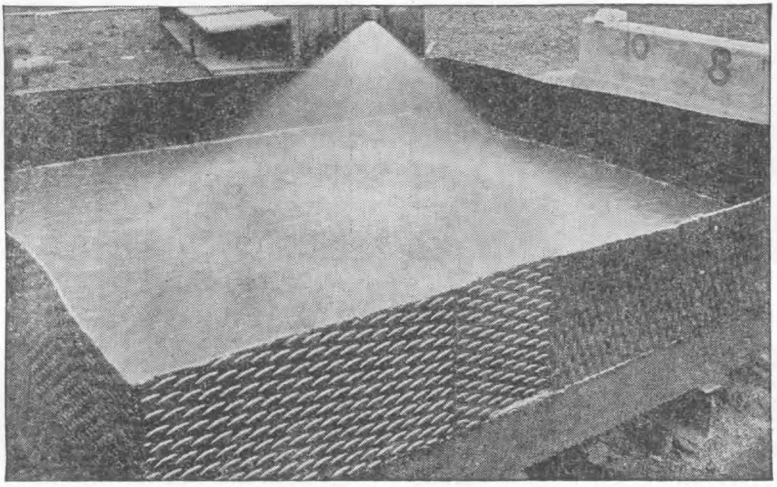
Pamphlets No. 13, 13A, 20 and 72 are published by the Dominion Board of Insurance Underwriters, 460 St. John St., Montreal, Que.

A-11.30 Spray Nozzles.

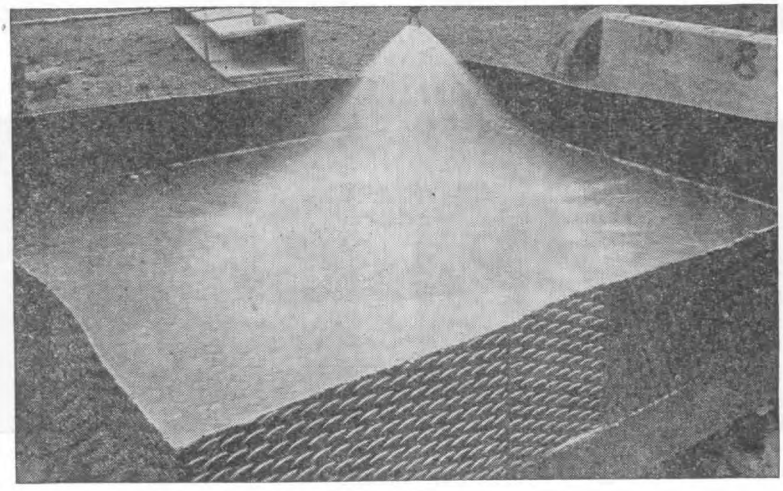
Following are pictures of representative types of spray nozzles showing typical patterns of discharge:

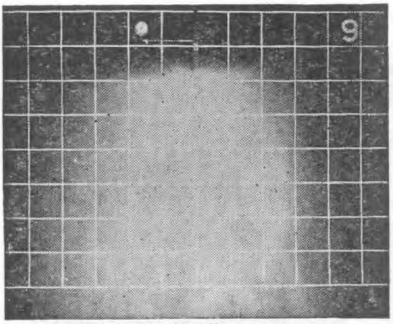
*Printed in NFC Vol. IV—Extinguishing Equipment.
**Printed in NFC Vol. V—Electrical.
†Printed in NFC Vol. III—Building Construction and Equipment.

A11.30. A spray nozzle discharge showing the pattern of the spray. Numbers on wall indicate distance from nozzle in feet.

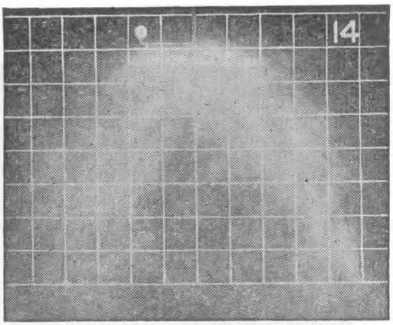


Representative types of spray nozzles installed above tanks to protect open surfaces of flammable liquids.

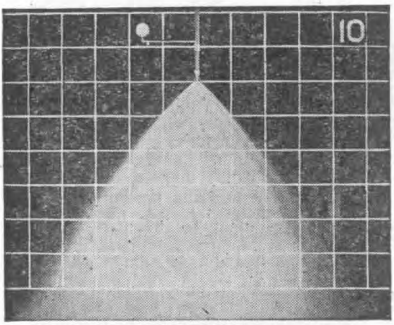




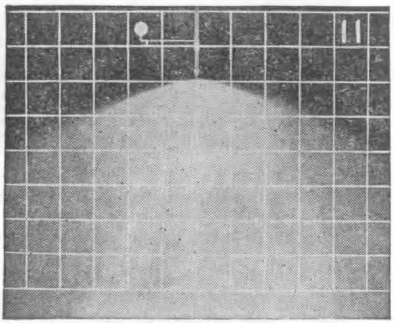
Spray head, "fog" type, narrow angle.



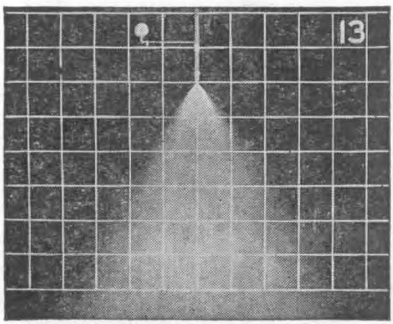
Spray head, "fog" type, wide angle.



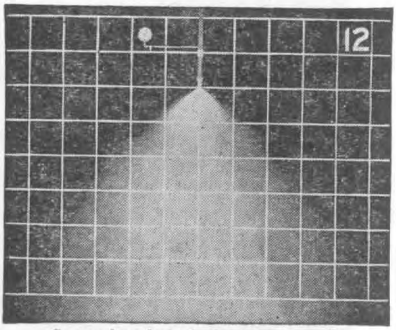
Spray head, deflector type, narrow angle.



Spray head, deflector type, wide angle.

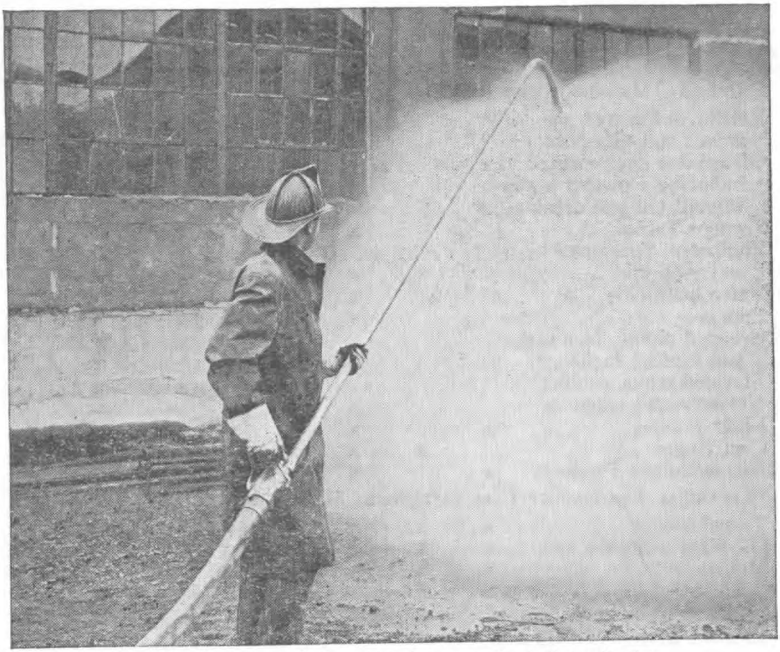


Spray head, turbulent type, narrow angle.



Spray head, turbulent type, wide angle.

A.11.30. Representative types of spray nozzles showing typical patterns of discharge. Lines are one foot apart.



A-11.31. Spray nozzle in operation on a typical applicator.

A-11.31 Applicators.

An applicator consists of a tube or pipe with spray nozzle or nozzles attached to one end and with means of connecting to hose at the other. The applicator may have any special form or attachments required by local conditions. Applicators are usually available in lengths of three to twelve feet.

A-12.10 Purposes.

The following is a list of typical hazards which have been protected by fixed water spray systems. This list is intended as a guide to illustrate the type of hazard protected by water spray, but is not intended to include all hazards which may be successfully so protected.

Type of Hazard	Extinguishment of Fire		Control of Fire		Fire Exposure Protection		Fire Prevention	
	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray
AIRPLANE MANUFACTURE								
Engine test cells	x			x				
Jet propulsion test cells	x			x				
CHEMICAL MANUFACTURE								
Still columns (including supports)			x	x	x		x	
Condensers, heat exchangers, etc.			x	x	x		x	

Type of Hazard	Extinguishment of Fire		Control of Fire		Fire Exposure Protection		Fire Prevention	
	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray
CHEMICAL MANUFACTURE (cont.)								
Kettles, autoclaves, reactors and digestors			x	x	x		x	
Oil heating equipment, including Dowtherm and Merrill Oil and areas	x		x	x	x		x	
Storage Tanks			x	x	x		x	
Equipment structures and supports			x	x	x		x	
Valve manifolds			x	x	x		x	
Pumps			x	x	x		x	
Grouped piping, pipe racks and loading racks			x	x	x		x	
Elevated tanks, cooling towers and supports			x	x	x		x	
Filter presses	x		x	x	x		x	
Centrifuges		x	x	x	x		x	
Nitrocellulose Products	x		x		x		x	
ELECTRICAL EQUIPMENT (See paragraphs 31.31 and 31.32)								
Transformers	x	x	x	x	x	x	x	x
Oil-filled switches, etc.	x	x			x	x	x	x
Motors	x	x			x	x		
Generators	x	x			x	x		
Lubricating oil lines	x	x	x	x	x	x	x	x
POWDER MANUFACTURE								
Rolls	x	x			x	x	x	x
Machining Equipment	x	x			x	x	x	x
Shell Loading	x	x			x	x	x	x
Presses	x	x			x	x	x	x
Drying	x	x			x	x	x	x
Extrusion	x	x			x	x	x	x
General Handling	x	x			x	x	x	x
REFINERIES								
Fractionating towers			x	x	x		x	
Loading platforms and racks			x	x	x		x	
Pipe Lines			x	x	x		x	
Pump Houses			x	x	x		x	
Manifold Pits			x	x	x		x	
Separator Tanks			x	x	x		x	
Storage Tanks			x	x	x		x	
SHIPBOARD								
Engine Room, fire room and bilges	x	x	x	x	x	x	x	x
Ammunition magazines	x	x					x	x
Powder hoists and gun turrets	x	x					x	x
MISCELLANEOUS								
Dry Sulfur Storage	x	x	x	x	x		x	
Driers and Ovens	x	x						

Type of Hazard	Extinguishment of Fire		Control of Fire		Fire Exposure Protection		Fire Prevention	
	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray	Coarse Spray	Fine Spray
MISCELLANEOUS (cont.)								
Paper laminating process	x	x						
Soap Powder, drying equipment	x							
Aluminum rolling mills	x	x						
Air conditioning filters	x	x						
Soya bean extraction plants	x	x						
Small container storage areas			x	x	x		x	
Spreaders, callandars, and coating machines, including pre-dip and post-dip	x	x						
Churn and mixing rooms	x	x						
Cloth dust collectors	x	x						
Tanks-quench, dip and degreasing	x	x						
Oil Cellars	x	x						
Cooking kettles and tanks as linseed, soya and varnish	x	x						

A-12.11 Extinguishment.

EXTINGUISHMENT BY SURFACE COOLING—If the surface of the material is cooled below the temperature at which it will give off sufficient vapor to support combustion, the fire will be extinguished. Liquids with flash point below the temperature of the water spray particles are not affected by these particles and vapors continue in sufficient quantities to support combustion. Thus, such materials cannot be extinguished by surface cooling alone. The efficiency of the cooling effect depends on complete coverage, by water spray, of the entire surface.

EXTINGUISHMENT BY SMOTHERING FROM STEAM PRODUCED—When water expands into steam its volume is increased approximately 1,700 times. If sufficient steam is generated by the heat of the fire, oxygen is displaced or excluded and the fire is extinguished by this smothering action. The amount of steam created depends on the intensity of the fire and the extent of the smothering effect is determined by this factor. In cases where oxygen is liberated in the material itself when heated, smothering is not an extinguishing factor.

EXTINGUISHMENT BY EMULSIFICATION—When two immiscible liquids, such as oil and water, are agitated together, one liquid may be dispersed within the other in the form of minute droplets, thus forming an emulsion. This occurs in many instances when water spray strikes the surface of burning oils or similar flammable materials with which water will not mix. Such emulsions, in general, will not burn. Therefore, the effect is to make the surface of the material temporarily incombustible. In some light oils and liquids it is believed the emulsification is extremely temporary, being present only during actual application of water spray. With more viscous materials it may persist for some time and thus safeguard against the danger of flashback.

EXTINGUISHMENT BY DILUTION—Flammable materials which are soluble in water may, in some instances, be extinguished by dilution. The percentage of dilution necessary to effect extinguishment varies greatly and the volume of water spray and the time necessary for extinguishment will vary accordingly.

EXTINGUISHMENT BY OTHER FACTORS—Fire in certain flammable materials which are heavier than water, such as asphalt, tar, carbon disulfide and some nitrocellulose solutions, can be extinguished by the formation of a continuous film created by the application of water spray to the surface of the mixture.

Certain materials are said to burn when they chemically decompose. Such decomposition may be accompanied by the evolution of smoke and the presence of flame. Some of these cases require no oxygen for the decomposition to continue and, in certain cases, it may continue under water. It is possible that water spray can be used on some of these materials and produce extinguishment as a result of rapid cooling below the temperature at which the chemical decomposition can be self-sustaining.

A-12.30—A careful study should be made of the physical and chemical properties of the materials for which water spray protection is being considered to determine the advisability of its use.

The flashpoint, 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 all factors which must be given consideration.

In general, gaseous and liquid flammable materials with flashpoints below the general range of 100° to 125° F. are difficult to extinguish with water spray and, under many conditions, extinguishment may be undesirable as the existence or continued evolution of unburned gases or vapors may result in the development of extremely dangerous fire and explosion hazards.

The following are a few typical limitations which may be used as a guide in considering water spray installations:

Where water supply is inadequate and/or unreliable.

Materials reacting violently with water or producing hazardous materials when reacted with water.

Liquids in open containers without adequate overflow and drainage facilities.

Open containers of flammable liquids at elevated operating temperatures above 250° F.

Where a boil-over hazard is serious, such as in materials at high temperature and those with wide distillation range.

Where direct application of water spray may cause serious damage or failure of equipment operating at high surface temperatures (usually over 500° F.).

A-21.20—Fixed water spray systems are generally required to control fires adequately in process and storage equipment areas containing flammable liquids, solids or gases under the following conditions: (1) the fire hazard and/or value of the materials justifies such an installation; (2) the area is congested; (3) hose streams cannot be brought into play promptly or the area may not be approached safely at the distance required for hose stream protection.

Liquid contents of large tanks cannot be vaporized within minutes as can the contents of smaller tanks. Thus, tanks above 15 feet in diameter containing ordinary (stable) flammable liquids, if adequately vented, accessible to hose streams and otherwise suitably protected may not require fixed water spray installations although vessels below 15 feet in diameter, containing the same flammable material may require such protection.

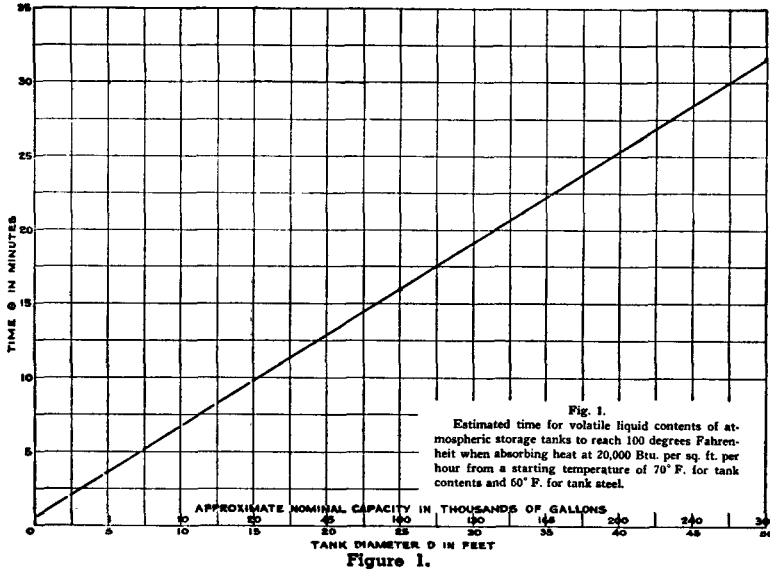


Fig. 1.
Estimated time for volatile liquid contents of atmospheric storage tanks to reach 100 degrees Fahrenheit when absorbing heat at 20,000 Btu. per sq. ft. per hour from a starting temperature of 70° F. for tank contents and 60° F. for tank steel.

Figure 1.

The contents of uninsulated vessels under average plant conditions, when enveloped by flame will absorb heat at a rate of at least 20,000 B.t.u. per hour per square foot of surface, wetted by the contents. Unwetted, uninsulated steel equipment absorbs heat rapidly and failure occurs from over-pressure and/or overheating, when such equipment is exposed to fire. Figure 1 shows a time-temperature curve showing the length 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 Fig. 7, A-22.20 C (a)) for heat absorption rates when water spray is used.

Figures 2 and 3, indicating several aspects of the types and extent of hazards protected by fixed water spray systems, are shown on pages 15-24 and 15-25.

A-21.40—Drainage—In general, there are four methods of drainage (1) grading, (2) diking, (3) trench, 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—All areas which contain flammable liquids or into which is likely to be discharged large quantities of water, should be properly graded for drainage. For this purpose, concrete surfacing is most desirable. However, other hard surfacing or crushed rock is acceptable.

DIKING—Areas containing large volumes of flammables such as storage areas should be properly diked in accordance with the Standards of the N.F.P.A. Figure 4 is based on N.F.P.A. requirements and will serve to illustrate the necessary features of adequate diking.

TRENCH—General specifications for drainage trench and recovery systems installation, which is a desirable drainage arrangement for storage and equipment areas, are listed on page 15-25.

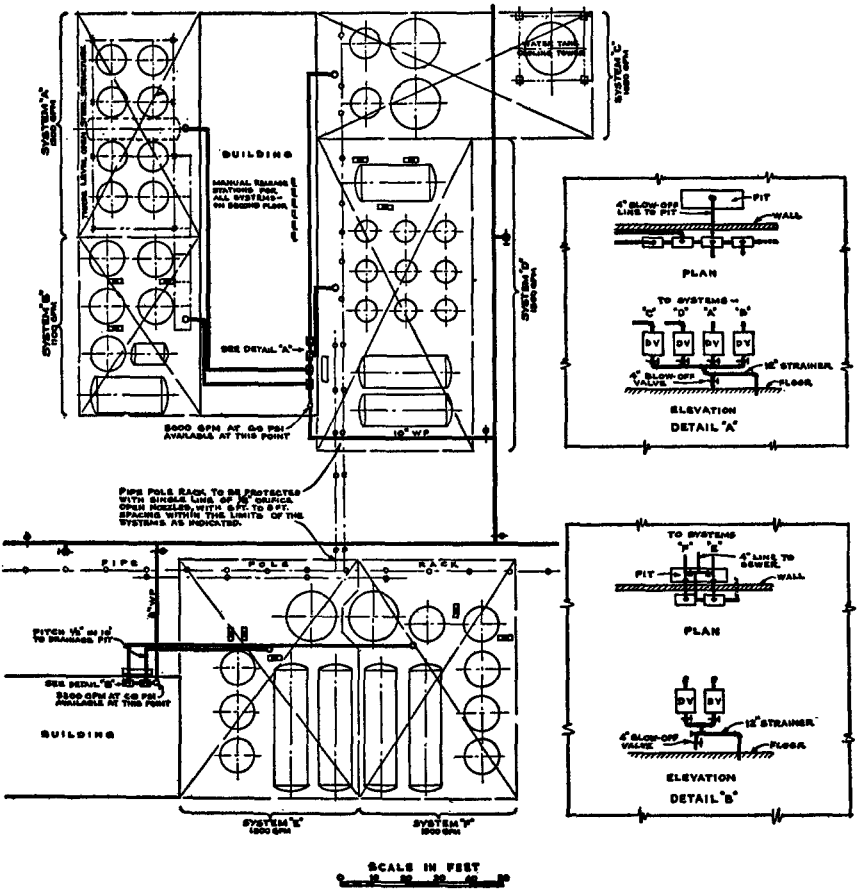


FIG. 2

TYPICAL ARRANGEMENT OF OPEN HEAD SPRAY SYSTEMS FOR OUTSIDE EQUIPMENT

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.

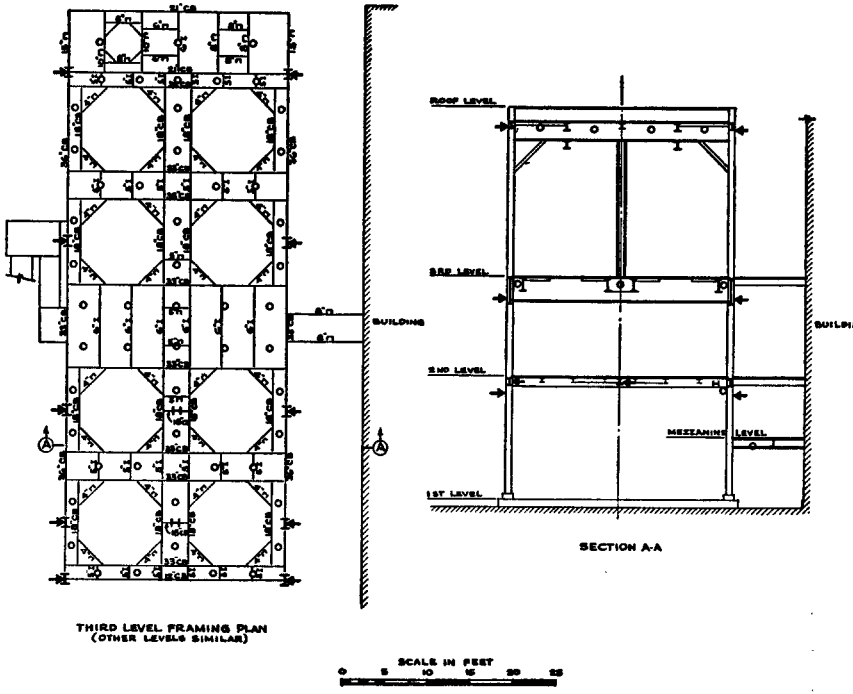


FIG. 3

TYPICAL SPRAY SYSTEM FOR STRUCTURE SHOWING LOCATION OF NOZZLES

B. Construction of Drainage Trench

(a) Drainage trench should be constructed of reinforced concrete, except that "Haydite," "Waylite" or equal, aggregate should be used in pre-cast trench cover.

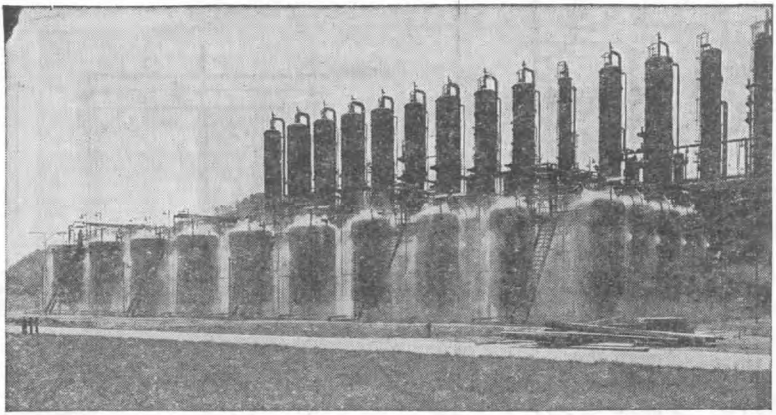
(b) The minimum size of any drainage trench should be 3 ft. wide and 1 ft. 6 in. deep. In no case should the depth exceed the width.

(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.

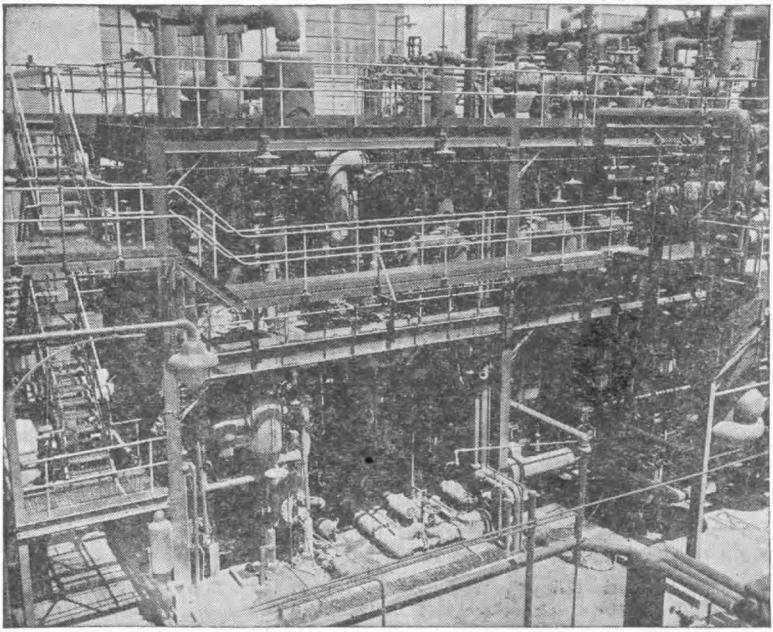
(d) Sumps should be poured monolithically with trench. Watertight bonds should be provided for joining concrete tank pad to trench.

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

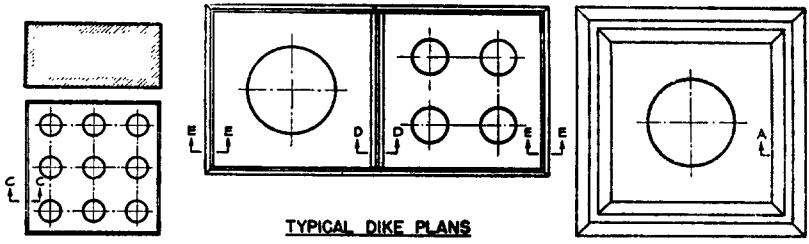
(f) Slope of trench floor to sump should be a minimum of one per cent.



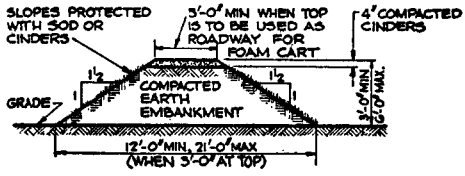
A21.20. Typical installation to protect storage tanks.



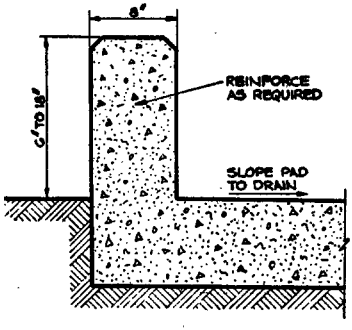
A21.20. Typical water spray installation to protect chemical process equipment.



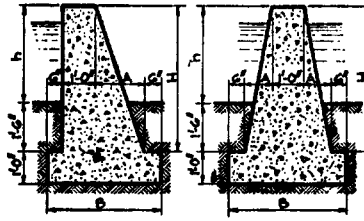
TYPICAL DIKE PLANS



SECTION "A-A"



SECTION "C-C"



SECTION "E-E" SECTION "D-D"

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	975	1180	1380	1515
	C/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	1500	1480	1660
	C/LF	.44	.60	.81	1.05

TABLE OF DIMENSIONS, SOIL PRESSURES AND CONCRETE QUANTITIES

FIG. 4

STANDARD DIKES FOR FIELD STORAGE TANKS

C. Drainage Trench Capacity Requirements

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

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

2. 1,500 g.p.m. 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, plus 10 per cent.

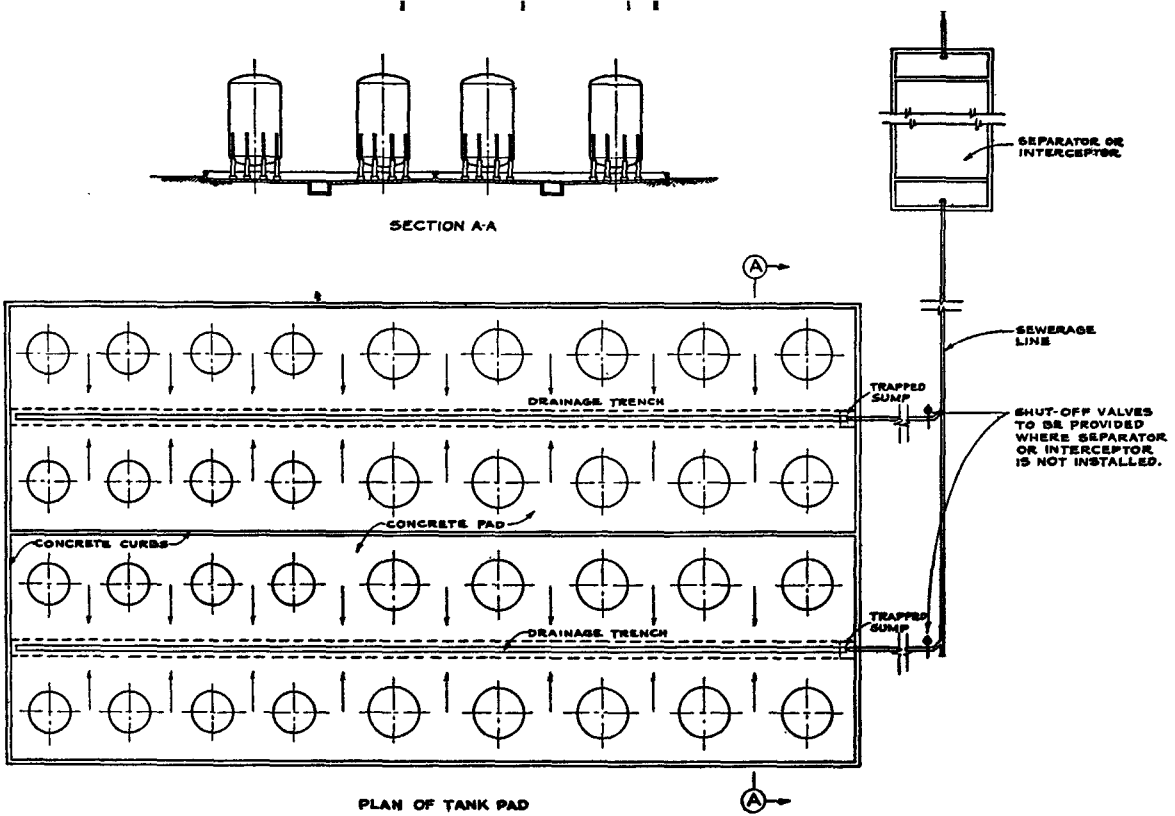


FIG. 5

SUGGESTED DESIGN FOR DRAINAGE SYSTEM FOR TANK AREAS CONTAINING FLAMMABLE LIQUIDS

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, shutoff valves should be provided for each trench system to prevent accidentally spilled materials from polluting public waterways.

D. TANK PADS AND CURBS

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

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 6), 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. 5 and 6).

(a) Drainage trenches should be installed to serve to divide two rows of tanks or equipment, one row on each side, so that run-off 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 vapor-tight.

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

A-22.20—The rate of discharge required to extinguish or control a fire will vary with the degree of hazard involved. The rate of discharge per unit of area to be protected will depend on whether the spray system is to be used for (a) extinguishment, (b) control, (c) exposure protection or (d) prevention, and shall be consistent with the requirements of the inspection department having jurisdiction.

A. EXTINGUISHMENT—For extinguishment of flammable liquid fires, as represented by kerosene or diesel oil, the minimum unit rate of water application should not be less than that forming the basis for the approval of the particular nozzle involved. Unit rates may vary from 0.20 to 0.75 g.p.m. per sq. ft. Deviations above or below these limits may be expected

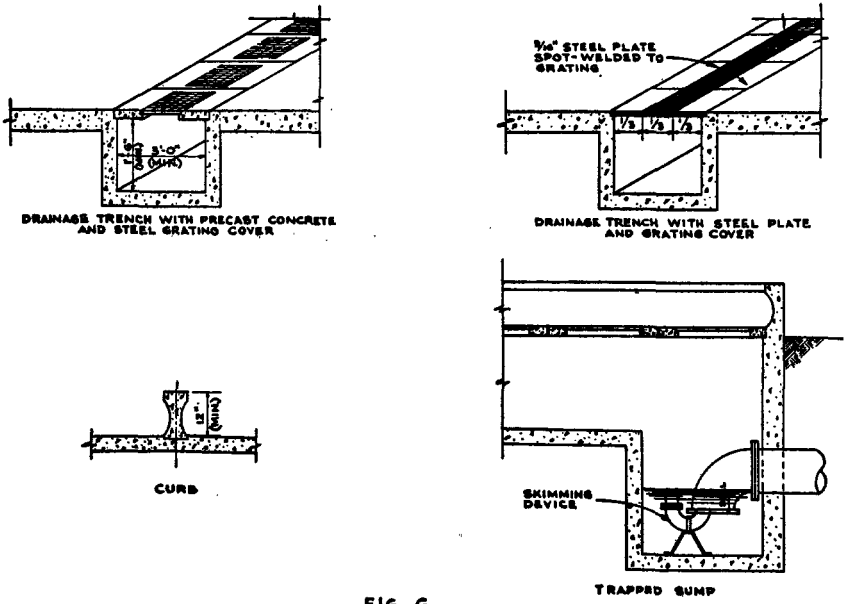


FIG. G
DRAINAGE SYSTEM DETAILS FOR TANK AREAS CONTAINING FLAMMABLE LIQUIDS

with other materials and conditions. The minimum rate necessary to accomplish the desired results should be used. The discharge pressure available should be not less than the minimum on which approval is based.

Types of nozzles and their proper placement must be such as to afford complete and uniform coverage with as little surface agitation as possible, and with as little induced draught effect as possible. Unnecessarily high pressures should be avoided.

For extinguishment of less flammable liquid fires as represented by the heavier oils, the unit rate of water application can be lowered. Coverage should be complete but need not be so uniform and less care is necessary to avoid undue surface disturbance.

Minimum pressures should be in accordance with individual nozzle approvals, but excessive pressures are not so harmful.

B. CONTROL—For control of fires in very volatile liquids, the gases from most of which are heavier than air where extinguishment is impossible with water (benzol, for example), or where it is preferable to let the gases burn rather than escape (butadiene, for example), present indications are that satisfactory performance should be obtained with a rate of 0.25 to 0.50 g.p.m. per sq. ft. with emphasis on prevention of undue agitation of the burning liquid surface and on prevention of undue air entrainment but with less emphasis on uniformity of coverage.

C. EXPOSURE PROTECTION—For exposure protection a minimum average rate of discharge of 0.20 to 0.25 g.p.m. per sq. ft. should be satisfactory. the lower the rate of discharge the greater the necessity for complete coverage and competent engineering. It is desirable that nozzles be as close

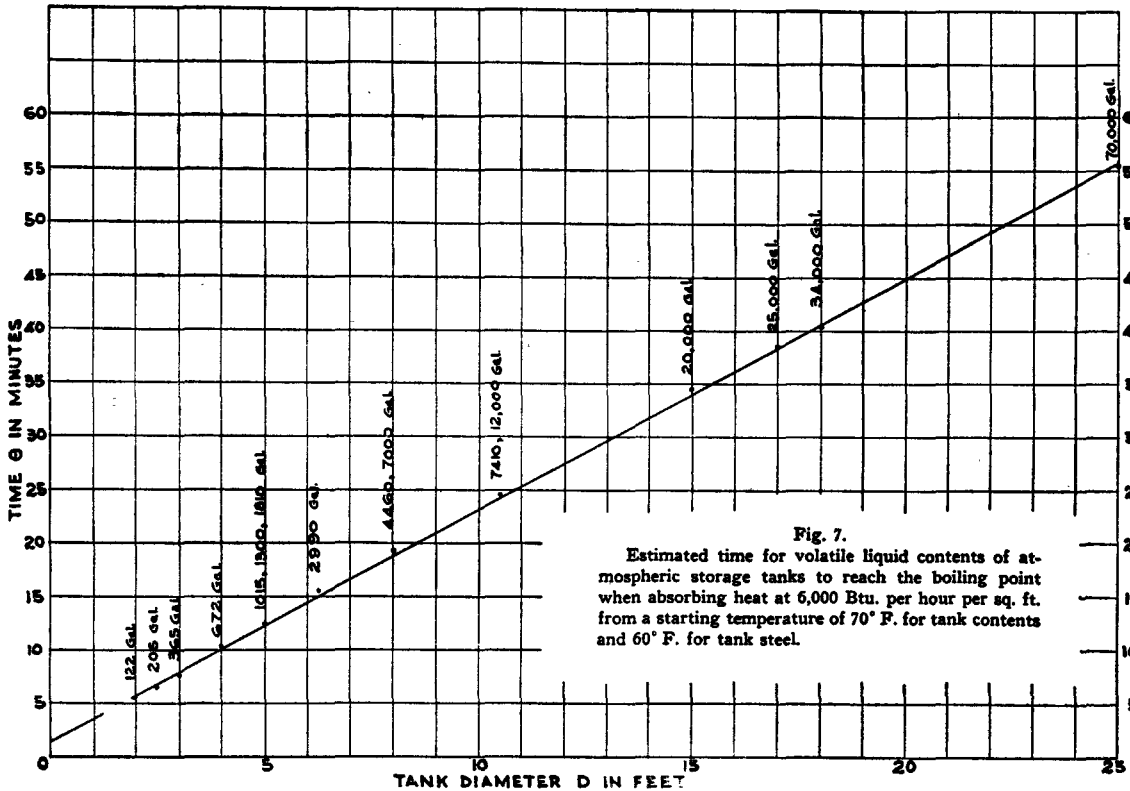


Fig. 7.

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.

as possible to the surface to be protected, possibly a maximum of two feet, to minimize the loss of water from draughts and the pre-heating of the water. On high vertical walls a considerable allowance for "run-down" may be made in laying out protection for the lower portions of these walls. For vertical tanks raised off the ground on supports complete direct coverage should be figured for the lower end of the tank. All supporting structures for tanks should be completely protected.

a. *Tanks*—It has been established that vessels enveloped with flame may be expected to absorb heat at a rate of at least 20,000 B.t.u. per hr. per sq. ft. of exposed surface wetted by tank contents. 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," N.F.P.A. *Quarterly*, October, 1943; and Rubber Reserve Company Memorandum 89, "Heat Input to Vessels." Obviously, the application of water spray to a vessel enveloped by fire will reduce the heat input rate. This reduction is to a value on the order of 6,000 B.t.u. per hr. per sq. ft. of exposed surface wetted by the contents when the unit rate of water application is 0.2 gal. per min. per sq. ft. of exposed surface. The 6,000 B.t.u. rate was also established in Rubber Reserve Company Memorandum 123, "Protection of Vessels Exposed to Fire." Figure 7 shows the estimated time for volatile liquid contents of atmospheric storage tanks to reach the boiling point when absorbing heat at 6,000 B.t.u. per hr. per sq. foot. This may be compared with the figure shown in Figure 1, A-21.20 to show the benefits derived from water spray systems.

b. *Structural Steel*—Generally, structural steel should be protected by nozzle arrangements similar to those used for standard sprinkler protection, giving special consideration to vertical members (which can be protected by a ¼ in. or ⅜ in. orifice, window type sprinkler, discharging into the web of the structural column) and other irregular structural members. Allowance should be made for "run-down" from one level to another in the case of multiple level, open (grating floor) structures. Total water discharge rates should be comparable to those from deluge type sprinkler systems for a given area covered.

c. *Grouped Piping, Valve Manifolds, Pumps, Etc.*—All grouped piping, valve manifolds, pumps, etc., in hazardous areas should be fully covered by water spray protection to prevent failure or damage to same from a fire. Usually ¼ in. orifice nozzles adequately spaced and discharging at ordinary pressures will suffice for this type of protection.

d. *Prevention*—For fire prevention use no generalization can be made for the necessary unit rate of water application. For air washing the rate will be low with emphasis on fineness of water drops and a wide distribution pattern; for wall opening protection the rate will also be low but with emphasis on a high velocity, narrow pattern, large drop discharge, which will completely box in the opening and set up a draught through the opening counter to the natural draught expected.

A-22.30—The quantity of water reserved solely for the operation of fixed spray systems may be calculated with reasonable accuracy by determining the sum of the discharge rates in g.p.m. for all nozzles on the system as determined in Paragraph 22.10 and multiplying this figure by the number of minutes considered to be sufficient for the duration of discharge. Ample factor of safety shall be added to the total thus obtained. 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.

Particularly when limited water supplies are provided it is advisable to make additional water available. Such additional water supplies may be in the form of water works connection, fire pumps, industrial water supplies or fire department connections. For most of the purposes for which water spray systems are installed, with the possible exception of automatic systems for extinguishment, manual operation of the additional secondary or auxiliary supplies may be acceptable. Re-cycling of water used in a system may be possible under specific controlled conditions.

In estimating the period of time sufficient for duration of operation for a particular hazard, the following factors are among those which should receive consideration:

FOR EXTINGUISHMENT—A properly designed system should effect complete extinguishment within five minutes.

FOR CONTROL OF FIRE—A system for the control of fire should 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 a matter of hours may be required.

FOR EXPOSURE PROTECTION—The system should be able to function effectively for the duration of the exposure fire which can only be 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 a matter of hours may be required.

FOR FIRE PREVENTION—The system should be able to function effectively for sufficient time to remove hazardous material from the air or to dilute sufficiently materials such as acids.

A-22.50—One of the important considerations in designing fixed water spray installations is the possibility of mis-application and improper operation during a fire. This is particularly true when considering the heavy demand on available water supplies. With this in mind the following recommendations are made:

A. It is desirable to design systems and provide water supplies for same, so that in no case more than 50 per cent of the available water for fire fighting is discharged through fixed water spray systems in any given fire area.

B. Persons who are responsible for coping with fires that do occur in areas protected by water spray systems must be carefully trained to control water application in a manner to effect maximum protection. As an example, a serious explosion or conflagration which results in more than one fire area being involved, may necessitate an all important decision as to use of available water supplies for protection of facilities or equipment not yet involved in the fire rather than attempt over-all extinguishment or control at reduced or ineffective water spray nozzle pressure.

C. The disastrous results of sprinkler control valves, located within the fire area, being shut off after a fire has presumably been extinguished and then such valves not being accessible when the fire breaks out again, has been apparent time and time again. The same problems prevail in operating water spray systems. It is equally important to be able to close valves which control any system that may be badly ruptured due to explosion.

D. Consideration should be given to providing water supplies for spray systems separate from hydrant systems, thus insuring adequate hose

A-22.60 Above is shown a basket from a strainer installed in the supply to a fixed water spray system. Note the caulking material caught by strainer. It is important to flush all spray system piping adequately (both underground and aboveground) prior to completion.

protection in the event of the disruption of water spray equipment by explosion or other reason. If mill service systems are used for fire protection (in industrial plants), such as process cooling water systems, the effect of reducing water pressures when large quantities of water are drawn for fire fighting, must be carefully studied. In all such instances, cross connection should be made to fire main systems.

E. Where the quantity of water supply is extremely limited it may be feasible to install a cycle water system in some instances. For such an arrangement water could be collected by means of a fire drainage trench and interceptor system (see A-21.40). 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, other foreign materials valving arrangements, etc.

A-22.60 Strainers. It is recommended, where feasible, that any main line strainers should have baskets with openings of one-half the diameter of the smallest spray nozzle orifice. Of course, this is not practicable where very fine spray nozzles are used. However, it is felt to be a prudent specification, particularly where the possibility of foreign materials in water supplies is considerable.

A-22.80—As underground supply piping is increased in size, the volume of water necessary to produce a minimum velocity of ten feet per second increases geometrically. Fire protection supplies are normally designed for water velocities of less than ten feet per second. However, flushing at this higher velocity is essential in order to more nearly approach the much higher velocities occurring for a brief period following operation of a quick opening valve. The following table of flows required for supply pipe sizes 4" to 12" indicates that serious consideration must be given to the problem of water disposal:

Pipe Size	*Velocity-ft. per sec.*	*Quantity-G.P.M.*
4	10	390
6	10	883
8	10	1562
10	10	2440
12	10	3520

A-23.20 Hydraulic Calculations. It is recommended that hydraulic calculations for determining the water flow characteristics of water spray systems be made in accordance with the recommendations outlined below. It is recognized that satisfactory results may be obtained by using other calculation forms, other pipe friction and fitting loss data, etc. However, in order to simplify the checking of calculations and to obtain more consistent correlations between calculated system characteristics and actual system characteristics it is obviously desirable to use a standard method.

A. Calculation Form

Calculations should be presented on a form similar to the one shown in Figure No. 9.

B. Information to be Given on Drawing

The preliminary or working drawing should be marked with numbers or letters indicating the starting point of the calculation, section or system junction points, etc. These numbers or letters shall be used in the first column of the Calculation Form headed "Location".

Each type of water spray nozzle should be identified on the drawing and the discharge constant for each type of nozzle should be indicated either on the plan or on the hydraulic calculation form. If the discharge constant is not given, a discharge curve for each nozzle should be made available to the authority having jurisdiction. The discharge constant shall be the constant "K" in the following formula:

$$Q = K\sqrt{P} \qquad \text{or } K = \frac{Q}{\sqrt{P}}$$

where Q is the flow in gpm at pressure P* in p.s.i.

*The pressure P is the actual pressure causing flow.

HYDRAULIC CALCULATIONS

FOR____

SHEET____OF____
BY ________
DATE ________
JOB NO.________

NOZZLE IDENT. AND LOCATION	FLOW IN G.P.M.	PIPE SIZE	PIPE FITTINGS AND DEVICE	EQUIV. PIPE LENGTH	FRICTION LOSS PSI/FOOT	PRESSURE SUMMARY	NORMAL PRESSURE	NOTES
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	
	q			Lgth		Pt	Pt	
				Fit		Pe	Pv	
	Q			Tot		Pf	Pn	

Fig. 9. Calculation Form.

The drawing should be made in such a manner that the relative elevations of all discharge nozzles, junction points and supply or reference points can be readily determined.

C. Abbreviations and Symbols

The following standard abbreviations and symbols should be used on the calculation form.

Symbol or Abbreviation	*Item*
P	Pressure in p.s.i.
gpm	Flow in 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 in p.s.i. at a point in a pipe
P_v	Velocity pressure in p.s.i. at a point in a pipe ($P_v = .43\frac{v^2}{2g}$)
P_n	Normal pressure at a point in pipe in p.s.i. Normal pressure is equal to the total pressure minus the velocity pressure ($P_n = P_t - P_v$)
P_f	Pressure lost 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 (—) sign shall be used; where plus, no sign need be indicated.
E	90° Ell
EE	45° Ell
C	Cross
T	Tee — flow turned 90°
GV	Gate Valve
Del V	Deluge Valve
St.	Strainer
p.s.i.	Pounds per square inch
v	Velocity of water in pipe in feet per second
g	Acceleration due to gravity 32 ft. per second per second

D. Velocity Pressure

The velocity pressure P_v may or may not be included in the calculations at the discretion of the calculator. The omission of the velocity pressure from the calculations introduces an error that is always on the safe side and results in somewhat higher indicated flows. The error introduced by ignoring velocity pressures of 5% or less is small enough to be considered insignificant.

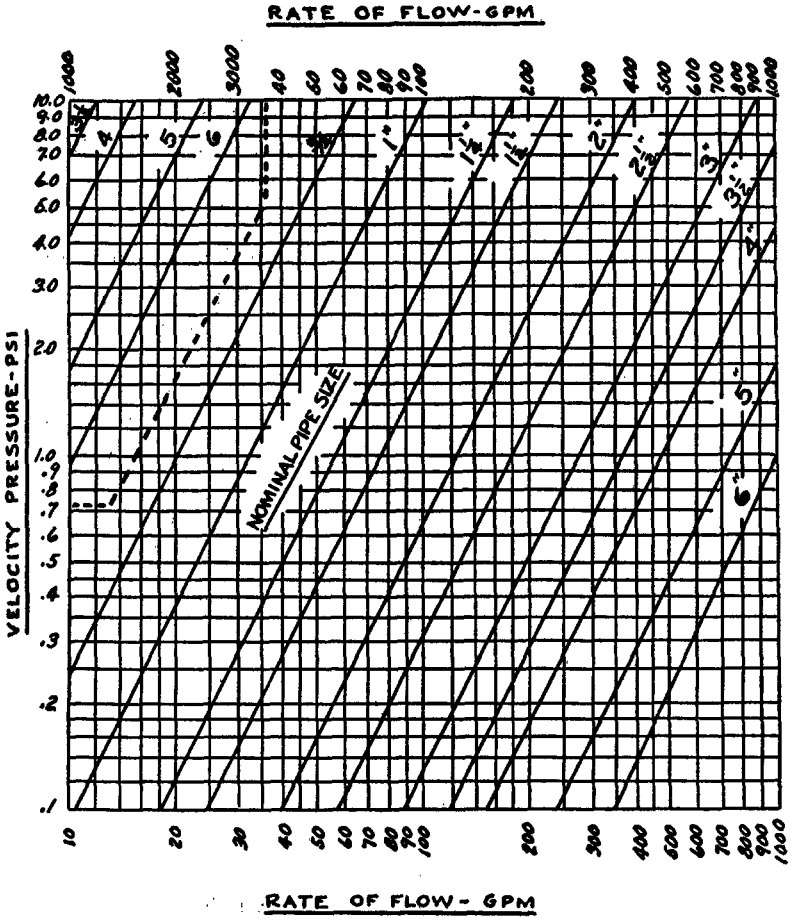


Fig. 10. Graph for Determination of Velocity Pressure.

The velocity pressure P_v is a measure of the energy required to keep the water in a pipe in motion. At the end nozzle or end section of system (when considering junction of sections of systems) the total pressure available in the pipe at that point should 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 No. 10 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 the accompanying table.

Pipe Size Inches	*Constant*	*Pipe Size Inches*	*Constant*
1	1,080	3	78,800
1¼	3,230	3½	141,000
1½	5,980	4	234,000
2	16,200	5	577,000
2½	33,100	6	1,204,000
		8	3,620,000

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 branch line 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, assume a new value and try again.

E. Fittings

Figure No. 12 shall be used to determine equivalent lengths of pipe for fittings. Experimental data has shown that good results can be obtained if fittings are arbitrarily included in accordance with the following rules.

1. Include all fittings where a change in flow direction occurs with the following exceptions:
   a) Do not include fittings directly feeding flowing nozzles. Where nozzles are located on swing joint assemblies of nipples and elbows do not include fitting directly feeding nozzle or line fitting feeding swing joint assembly, but do include elbows between these two fittings.

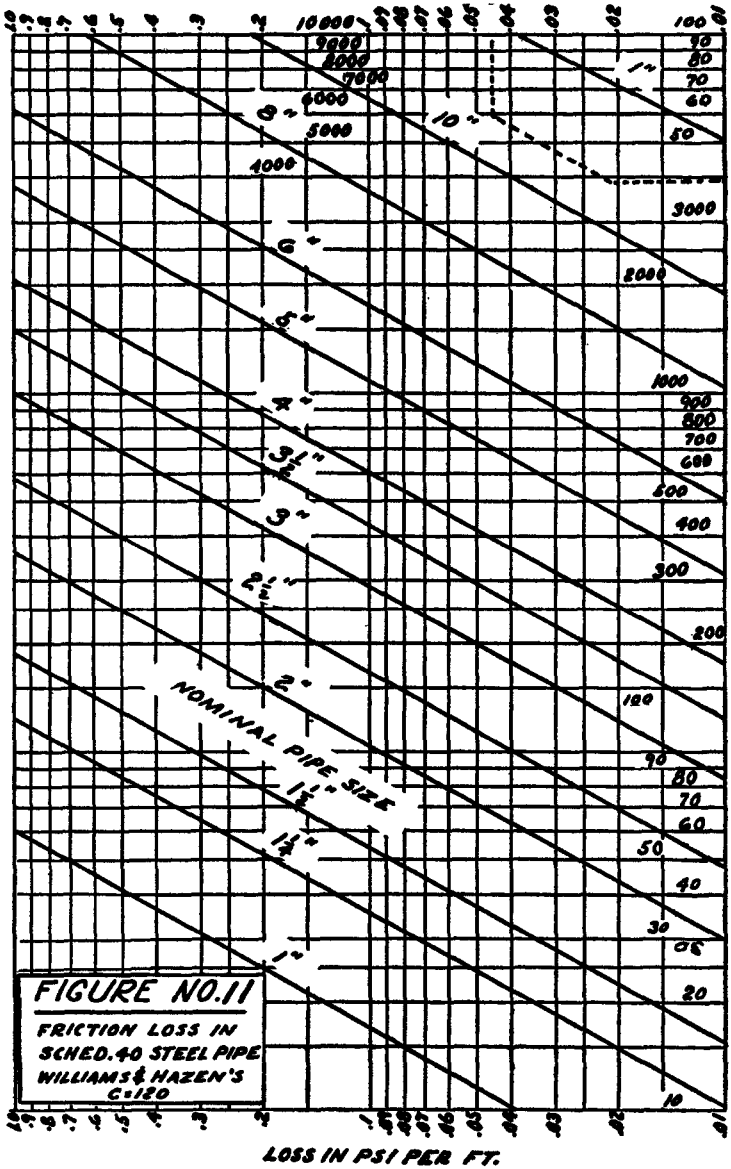


FIGURE NO.11

FRICTION LOSS IN SCHED.40 STEEL PIPE WILLIAMS & HAZEN'S C=120

b) Do not include cross main tees feeding flowing lines or loops. When riser nipples are used, the tee on top of the riser nipple shall be included with the riser nipple (See sample calculations).

2. Include all control or deluge valves, gate valves, check valves, strainer, meters, or similar devices.

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

PIPE SIZE	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6	8	10	12
STD. ELL	2	2	3	4	5	6	7	8	10	12	14	18	22	27
MED. TURN ELL	2	2	3	3	4	5	6	6	8	10	12	16	19	22
LONG TURN ELL	1	2	2	2	3	4	5	5	6	8	9	13	16.	18
45° ELL	1	1	1	2	2	3	3	3	4	5	7	9	11	13
TEE- 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
CHECK VALVE	4	5	7	9	11	14	16	19	22	27	32	45	55	65
CROSS	4	5	6	8	10	12	15	17	20	25	30	35	50	60

USE WITH WILLIAMS & HAZENS C=120 ONLY

Fig. 12. Friction Loss in Pipe Fittings and Valves in Equivalent Feet of Straight Pipe.

F. Pipe Friction Chart

Pipe friction loss should be determined from a table or chart based on Williams & Hazens formula, C = 120 similar to Figure No. 11; tables or charts based on other values of C may be used by applying a correction factor to give losses equal to those determined from a table based on C = 120.

G. Sample Calculation

Figure No. 14 shows a sample calculation for the system shown in Figure No. 13 using pipe sizing and nozzles with constants such that the velocity pressures generally exceed 5% of the total pressures, and the calculator elected to include velocity pressures.