5954

5954

43954

NATIONAL BUREAU OF STANDARDS REPORT

5954

A SURVEY OF SOME PROBLEMS INVOLVED IN A STUDY OF DELUGE SPRINKLER SYSTEM FOR FIRE PROTECTION OF HANGARS

By

Harry Shoub

and

E. W. Bender

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT **NBS REPORT**

1002-30-4801 June 30, 1958 5954

A SURVEY OF SOME PROBLEMS INVOLVED

IN A STUDY OF

DELUGE SPRINKLER SYSTEM FOR FIRE PROTECTION OF HANGARS

By

Harry Shoub
E. W. Bender

Report to
Office of the Chief of Engineers
Bureau of Yards and Docks
Headquarters U. S. Air Force

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

A SURVEY OF SOME PROBLEMS INVOLVED IN A STUDY OF DELUGE SPRINKLER SYSTEM FOR FIRE PROTECTION OF HANGARS

ABSTRACT

The problem of protecting aircraft hangars from the effects of possible fires by the installation of sprinkler deluge systems has been considered. An investigation has been made of tests previously conducted, and the pertinence of the available data to the current problem has been evaluated, especially in light of the magnitude of the present-day hazards.

1. INTRODUCTION

The aim in the fire protection of hangars is to provide for the safety of the planes stored therein as well as the building structure itself. In the most desirable condition, damage is confined to the plane in which the fire originates. As hangar fires are susceptible to extremely rapid spread, the possibility of using automatic, that is, closed, fixed-temperature operating sprinklers has been ruled out. Also, manually-operated hose lines, spray nozzles, and similar apparatus have been omitted from consideration as these are subject to delays in putting into operation, and also require a considerable amount of judgment in proper use which may be lacking in or forgotten by a crew acting under the stress of fire. Thus, the problem as we see it becomes one of the adequacy of a standard deluge system, and if necessary, the effect of augmenting the system with open floor sprinklers, or conversion to a foam-water sprinkler system.

2. REVIEW OF PREVIOUS TESTS

Only a very limited amount of data is available on fire tests in sprinklered hangars, and this is outdated because the planes and the hangars used in the previous tests generally cannot compare in size to those in use today.

Tests were conducted in a wooden hangar building at the National Bureau of Standards in 1930. The structure had dimensions of 66 x 81 ft with roof heights of 18 1/2 ft at walls and 28 ft at the center. Fixed temperature sprinklers (wet pipe and dry pipe) and a rate-of-rise actuated deluge sprinkler system were investigated. Involved in the fires were small, fabric-covered planes and small quantities of fuel.

The deluge system was tested with and without the addition of floor sprinklers. It was concluded then, that for the given conditions, automatic (closed head) sprinklers were not satisfactory, but that a deluge system would be entirely adequate. No necessity for augmenting the system, such as by use of floor sprinklers, was noted.

In an earlier test (1929) at the Colonial Hangar, Newark Municipal Airport, much the same conclusions had been reached except that some evidence of added effectiveness from floor sprinklers was reported. The installation in the 120-ft square building comprised 6 separate deluge sprinkler systems, one for each of the 6 bays into which the ceiling had been divided.

In 1941, tests were made of a deluge sprinkler system in Hangar No. 1 at the Washington National Airport. The structure, which is 178 by 182 ft and covered by an arched roof 28 to 55 ft in height, was equipped with 4 sprinkler systems comprising a total of 408 heads and 64 heat actuated devices. The protected area per sprinkler was approximately 80 ft^2. The tests were for the purpose of determining the operating characteristics of the system. Fires were made in comparatively small fuel pans. Actual hazards, which would include the presence of planes in a more or less crowded condition and involve spills of considerable volumes of fuel, were not simulated.

3. CONSIDERATIONS IN PLANNING A TEST PROGRAM

There have been very few tests of fire extinguishment in airplane hangars. These have been mostly small scale, and apparently none involved modern metal-clad planes or the quantities of fuel that could now possibly contribute to the fire hazard.

It is not known what effect large metal planes would have on the performance of a sprinkler installation. A deluge system derives its high effectiveness from the fact that water is applied ahead of the fire. Also, it has generally been held that fire extinction of flammable liquids by water sprays requires complete coverage of the area. The large horizontal surfaces now presented by planes together with the fact that there would not be the quick burn-through experienced with fabric-covered craft, would tend to create considerable areas concealed from the water spray. These areas, fed by flowing fuel, may very well continue to burn, and also act as a source of ignition of the planes above them.

There presumably will be large volumes of fuel to add to the hazard. The present tendency is to consider the possibility of spilling a large quantity of fuel from ruptured tanks or lines to be a lesser hazard than the explosion danger inherent in planes brought into the hangar with empty or only partially filled tanks.

In the investigation of a series of sprinkler installations in hangars, dating from about 1930, it was noted that the protected areas were classified as extra-hazard. Sprinklers were spaced to cover a maximum area of 80 ft^2 per outlet, with the usual arrangement on somewhat smaller areas, in some cases as little as 60 ft^2 to a head. Where floor sprinklers were provided, the unit areas for these were greater, an approximate average of 100 ft^2 to an outlet.

A major problem, in addition to the actual sprinkler installation and its financing, is the provision of an adequate water supply. An average requirement is 15 gpm for each head. If it is assumed that application up to 45 min duration may be necessary, the requirement for the protection of a hangar of 60,000 ft^2 area will be in the order of 500,000 gal if the entire area is involved. This is for overhead sprinklers alone; floor sprinklers would impose an additional burden on the water supply. If high-capacity replenishing sources are available, the necessary storage volume could be reduced.

In the event that the deluge system should prove inadequate, or if water supplies of the required magnitude are unobtainable, consideration may possibly be given to the installation of a foam-water sprinkler system. The piping and spacing for such a system may be similar in arrangement to that for water sprinklers in extra-hazard locations. Provision would have to be made for tying in foam introducing equipment into the system. Using the required liquid discharge rate for tank protection, 1.6 gpm per 10 ft^2 of protected area, as a standard, the flow rate per nozzle covering 80 ft^2 will be approximately 13 gpm. As the foam expansion factor is 8 to 10, it can be seen that the 6-in. blanket of foam usually considered more than sufficient for extinguishment will be obtained in only several minutes. Such a system, even allowing for adaquate reserves, can be operated with only a moderate water supply. A further advantage of a foam system is that because of the flow property of the material, it need not be applied over an entire surface, but will readily spread to cover such areas as may be concealed by airplane structuresor other equipment.

For the possibility of running a full scale test of a sprinkler deluge system in a hangar, it is considered that the only feasible arrangement would be to use a system installed in accordance with all applicable standards, and preferably, if at all possible, augmented by the use of open floor sprinklers. The magnitude of the installation is such that it would be almost impossible to vary the spacing of the sprinklers, and it cannot be seen that there would be much advantage in doing this in a system already properly designed to give adequate coverage. It is possible that limited control of flow rates may be achieved by varying the pressure at which the water is supplied, provided of course, that the variation does not impair the effectiveness of the distribution pattern. The flow at any sprinkler should not be reduced below 10 gpm.

to
th
to
to
of
cu
me
mo

an
Sp
th

m

In designing a sprinkler system, consideration must also be given to the problems posed by the structure of the building. Division of the system into zones of sprinklers and their orientation with respect to doors and openings will depend to some extent on the possible effect of drafts on the HAD's, and the presence or lack of suitable draft curtains. Attention also must be given to the provision of suitable means of draining and disposing of the water which on occasion may carry more or less fuel.

In our opinion, the design of a hangar deluge sprinkler system, and possibly its installation, should be left to the National Automatic Sprinkler and Fire Control Association, perhaps in consultation with the appropriate committees of the NFPA.

4. TESTS, FACILITIES AND EQUIPMENT

A tentative test program can be organized if the following equipment is made avaiable:

1. A hangar, preferably of incombustible construction, the size to be of the order of 200 by 300 ft with an approximately 75-ft ceiling (50 ft clear).

2. A deluge sprinkler system to be installed in the hangar, preferably augmented by floor sprinklers. The sprinkler installation to meet the NFPA standard for extra-hazard occupancies. For the hangar specified in (1), a minimum of 750 open overhead sprinklers, 56 HAD's, and approximately 600 floor sprinklers would be required. The sprinkler system to be in 4 to 6 zones. It would be highly desirable also that provision for conversion to a foam-water system be included.

3. An adequate water supply for the sprinkler system. (Example: For the overhead sprinklers alone, there must be capacity to supply 10,000 to 12,000 gpm for 45 min)

4. For the hangar described, occupancy by a minimum of 6 B-25 planes, or equivalents, the planes to be fully fueled for each test conducted.

5. Emergency back-up equipment (tractors, crash trucks, crews) in the event the sprinkler system proves inadequate during a test.

6. Temperature measuring equipment; for the test setup described, to read 96 thermocouple locations; to include 8 12-point recorders, 2 sec per point, with necessary couples, leads, etc

The test program could be initiated by igniting the fuel from a broken line after a predetermined flow such that an adjoining plane may be involved. Change in draft conditions can be accomplished by varying the open area of the doors. Tests can be conducted without floor sprinklers to determine if adequate protection can be so obtained. In the absence of data, it is difficult to lay out a specific program, and it is suggested that planning the program may best be deferred until after one or more trial runs have given some indication of what may be required.

5. PARTICIPATION BY NATIONAL BUREAU OF STANDARDS

The design and installation of sprinkler systems is beyond the scope of the work of the Bureau. We can, however, participate in discussions and consultations leading to such design, inspect the installations that may be made, and assist in the actual tests to the extent of aiding the planning of the program, observing test phenomena, and recording data.

A greater participation by the Bureau may be possible if a suitable staff and facilities could be temporarily assigned for the duration of the project.

As we see it, the major cost of the project would be incurred in providing the facilities and equipment for the test. The fee for the Bureau's participation in the project can be better estimated when the extent and location of the work is more clearly defined.

USCOMM-NBS-DC

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major laboratories in Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside front cover.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.
Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.
Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.
Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment.
Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.
Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.
Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.
Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.
Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.
Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer.
Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.
Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

- Office of Basic Instrumentation.
- Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.
Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research.
Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology.
Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

NBS