Prevention and Control of Fire Losses

A HANDBOOK

U. S. DEPARTMENT OF THE INTERIOR

National Park Service

Prevention and Control of Fire Losses

∴

A HANDBOOK

By FRANK L. AHERN, Chief, Safety Division, National Park Service, and Chairman, Committee on Health and Safety, United States Department of the Interior

---

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1943

UNITED STATES

DEPARTMENT OF THE INTERIOR

Harold L. Ickes, *Secretary*

1943

NATIONAL PARK SERVICE

Newton B. Drury, Director

For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., Price 10 *cents*

CONTENTS

FOREWORD

During the past year fire has taken a heavy toll of human life as well as of critical materials and equipment such as rubber, foodstuffs, and ships. Conservation of existing facilities has become of prime importance. It is hoped that this Handbook will be of value in promoting such conservation and that it will also serve as a guide in post-war planning.

The Handbook presents in brief form a procedure for the prevention and control of fire losses. It contains some fundamentals of construction, operation, and protection which have a bearing on fire prevention and control. Defects that have been found from many years of experience in the review of plans and from field surveys to be somewhat common are emphasized in the text. Safe practice standards for specific types of hazards are summarized in the Appendix.

Fire losses can be controlled, and the extent of such control will depend upon the degree of protection that is justifiable in the design of a building and its equipment, the standard of maintenance that is established, and the availability of trained personnel and suitable equipment to cope with emergencies.

Incendiary bombs, high-explosive bombs, and sabotage are not discussed in this Handbook. Information on these important current problems is now available in publications of the Office of Civilian Defense, War Department, Federal Bureau of Investigation, and the National Fire Protection Association.

The material presented in this Handbook is a summary of lectures on the "Management Aspects of Fire Loss Prevention" prepared by the author and delivered by him in the Engineering Defense Training Courses on Fire Protection Engineering at George Washington University. It was used also in the In-Service Training Courses in Fire Protection Engineering conducted by the author for selected members of the professional staff in three of the Regional Offices of the National Park Service and in special training courses for mining engineers of the Bureau of Mines in connection with its Mineral Production Security Program.

NEWTON B. DRURY,
Director, National Park Service.

December 12, 1942.

ACKNOWLEDGMENTS

The encouragement of Newton B. Drury, Arthur E. Demaray, and Hillory A. Tolson, Director, Associate Director, and Chief of Operations, respectively, of the National Park Service, in the preparation of this Handbook is appreciated.

Safe practice recommendations included in the Appendix were prepared with the assistance of the National Park Service Safety Committee, of which the author is Chairman. When the recommendations were prepared, the committee consisted of C. W. Andrae, Branch of Plans and Design; N. G. Baker, Branch of Land Planning; N. J. Burns, Museum Division; J. S. Cross, Branch of Engineering; W. F. Haiber, National Capital Parks; A. J. Knox, Office of the Chief Counsel; and J. F. Shanklin, Branch of Forestry.

All members of the Interior Department Committee on Health and Safety reviewed the manuscript, and the committee's assistance is acknowledged. The committee includes Floyd E. Dotson, Chief Clerk, Office of the Secretary; Paul L. Fickinger, Associate Director, Education Division, Office of Indian Affairs; Alfred R. Golzé, Assistant Supervisor of Operation and Maintenance, Bureau of Reclamation; Daniel Harrington, Chief, Health and Safety Branch, Bureau of Mines; and Mrs. J. Atwood Maulding, Director of Personnel, Office of the Secretary.

Thanks are due E. V. French, President, Arkwright Mutual Fire Insurance Company; Robert S. Moulton, Technical Secretary, National Fire Protection Association; O. W. Stewart, Manager, Inspection Department, Associated Factory Mutual Fire Insurance Companies; and R.

C. Stange, Fire Protection Consultant, United States Coast Guard, Navy Department, for their reviews of the manuscript.

The author is particularly indebted to Lt. Comdr. Harold K. Hughes, Chief, Fire Protection Section, Bureau of Yards and Docks, Navy Department, and to Nolan D. Mitchell, Fire Resistance Section, National Bureau of Standards, for their complete analysis of the text and for their helpful criticisms and suggestions.

Prevention and Control of Fire Losses

I. MANAGEMENT INCENTIVES IN FIRE-LOSS PREVENTION

Numerous incentives to management to safeguard their properties against fire might be mentioned. In a museum the protection of irreplaceable works of art may be the prime objective; for hotels, apartment houses, schools, and hospitals, safety to life should be the foremost consideration; and for industrial plants, safety to life, continuity of operation, savings in insurance costs, protection of valuable records, patterns, and the like are of the utmost importance.

In general, the incentives may be grouped in three representative classifications, namely, safety to life, continuity of operation, and savings in insurance costs.

A. SAFETY TO LIFE

The statistics of fatal accidents published by the Bureau of the Census show for the years 1934 to 1940, inclusive, loss of life by fire of 54,048 persons, or an average of 7,721 per year. The figures for each of the 7 years are:

Year	*Number of persons*
1934	8, 261
1935	7, 874
1936	8, 706
1937	7, 928
1938	7, 145
1939	6, 625
1940	7, 509
Total	54, 048

Maintenance of safety to life, always a first consideration for management, is helpful to organization morale.

B. CONTINUITY OF OPERATION

The prevention of interruption of normal operations, with possible loss of business, loss of goodwill, or loss of customers, is an incentive to guard against fire losses. Many industries regard continuity of operation as a factor of the utmost importance. In time of war "safeguarding production" is a daily reminder of the importance of continuity of operation.

In many cases the loss of a plant by fire has resulted in the loss to the community of an important supporting industry due to the fact that the plant was not rebuilt. Fires may result also in the loss of important records and accounts, valuable patterns, and irreplaceable contents, and possible disorganization through the loss of skilled employees.

C. SAVINGS IN INSURANCE COSTS

The construction of a safe plant and the establishment of safe operations may be expected to result not only in the prevention of fires but also reductions in insurance rates. The savings in insurance premiums may be substantial; the reduction in insurance rates for the installation of automatic sprinklers, for example, may often amount to 50 percent or more. Such savings constitute reductions in overhead costs which are always of interest to executives.

Some companies have found it profitable to include in their staffs trained men to see that fire insurance is adequate and also to keep a close check on the fire insurance rates.

II. CONTROL OF FIRE LOSSES

Some instructive conclusions may be drawn from a study which included a comparison of results obtained by different fire insurance groups on the basis of the ratio of fire losses paid by insurance companies to the value of property insured.

One group insuring all kinds of risks, varying from fire-resistive buildings with adequate inside and outside fire protection, to those of low resistance to fire and with different degrees of fire protection, had a loss experience of 17 cents per hundred dollars of value.

Another group, insuring for the most part dwellings or farm properties of low resistance to fire and with a wide range as to protection, varying from regular municipal protection to little if any protection, gave a similar rate of loss, namely, 17 cents per hundred dollars of value. For this group there was a compensating factor in that periodic inspections were made by representatives of the insurance companies.

A different result was obtained by a third group insuring manufacturing properties involving considerable hazard in their operations, but which are generally isolated from other plants, have construction above the average, and are equipped with modern fire-fighting equipment. In this group there is close cooperation between the assured and the insurance companies, with the latter providing periodic inspections by trained technical personnel. The annual fire loss for this group amounted to 1.4 cents per hundred dollars of value.

The experience of the three groups is of interest because it shows what can be accomplished where ordinary protection measures are taken and the results to be expected when extra precautions are taken. The results obtained by the third group indicate rather conclusively that fire losses can be controlled even in hazardous occupancies; however, a real effort is required for this accomplishment. In considering fire control measures for specific cases, it is important that the value of the risk be weighed against the costs of protection in order that the protection may be economically sound.

III. RECOMMENDED MANAGEMENT PROCEDURES FOR SAFEGUARDING PROPERTIES AGAINST FIRE

A. DESIGNATION OF RESPONSIBLE OFFICIAL

Management's first step in the safeguarding of properties against fire is to designate a responsible official to carry out the program. This official may sometimes combine his fire-protection activities with the handling of the company's fire insurance or he may combine fire protection with general safety work. If the plant is large enough, or if the company has a number of isolated plants, it is not unusual to have an organization developed and trained to handle the program.

Some large companies are self-insurers; that is, they have a sufficient distribution of their risks so that they feel justified in carrying their own insurance. Self-insuring companies are very likely to be even more scrupulous in the protection of their plants than those who place their insurance with fire insurance companies. Some self-insuring companies employ a staff of trained men to see that fire hazards are kept under control.

B. REVIEW OF PLANS OF NEW BUILDINGS

The wisdom of reviewing plans of new buildings for fire-protection features prior to construction of the buildings has been demonstrated by experience. It is less costly, as well as more efficient, to make changes in drawings than it is to make physical improvements after construction. The review of plans for special hazard installations or for buildings which are to house hazardous operations may be expected to result in improvements which have been found to be essential from the standpoint of safety. There are, however, certain typical defects that are worthy of special consideration as they are applicable to the review of a large number of plans.

1. REPRESENTATIVE DEFECTS

(a) **Location of standpipes.**—In the location of standpipes inside of a building a distinction should be drawn between those provided for the use of the fire department and those intended for use by the plant fire brigade or occupants of a building. The standpipe provided for the fire department is designed to permit fire flows sufficient for use with 2½-inch hose of the fire department. Such standpipes are usually placed in stairways where connections may be made conveniently by the fire department. Small standpipes equipped with 1½-inch hose at the outlets are installed for use by the plant fire brigade and for occupants of buildings as first-aid equipment. The recommended location for such standpipes is in corridors where the use of the hose will not interfere with the use of the stairways for exit purposes. If first-aid standpipes were placed in enclosed stairways it would be necessary to open the door and pull the hose through the doorway of the stairway enclosure, and in doing so smoke would be permitted to enter the stairway. Occupants of a building using a smoke-filled stairway might be suffocated and the objectives of the enclosed stairway as a safe means of egress and as a retardant to the spread of fire would be lost.

(b) **Inadequate or inconsistent protection of structural steel.**—Unprotected steel exposed to fire may fail at a temperature as low as 900° F. Tests of intensity and duration in building fires have shown temperatures of 2,000° F. by thermocouple measurement. It is not unusual, therefore, to see unprotected structural steel that is severely warped as the result of exposure to fire. Very often structures are designed as fire-resistive buildings with the exception of the exposed steel trusses or beams supporting the roof. Such buildings may be seriously damaged by fire if the steel is not protected or if superior fire-protection installations, such as automatic sprinklers, are not provided.

Construction with exposed steel trusses and wood roof decks may be justifiable in many cases, but the limitations in the event of fire should be understood.

Typical behavior of unprotected structural steel when exposed to fire. Note the warped, twisted, and bent structural steel. Failure of the steel upon exposure to high temperatures resulted in collapse of the structure before the combustible contents were consumed.

(c) **Vaults for protection of records.**—The weak link in the construction of a vault intended for the protection of valuable records seems to be the vault door. The walls, floor, and ceiling of the vault, as designed in recent years, are usually of adequate fire resistance, but the door may be of sheet steel. The door in such construction is inferior to the walls. Vault doors are available for different endurance intervals of fire resistance. Doors having a fire resistance of 2, 4, and 6 hours are available, and such doors should be provided, the choice between 2-, 4-, or 6-hour doors to be made on the required protection desired as determined from the nature of the records.

Record vaults in basements should be avoided as the records may be subject to damage from dampness as well as to water damage during fires or floods.

(d) **Isolation of hazardous operations.**—The plant layout should be studied with the view to isolating hazardous operations with respect to damage from fire or explosion. Special attention should be given to equipment such as oil-cooled transformers in which combustible oil is used. The latter equipment has a good record, but when a transformer fire occurs it is likely to be very serious. When transformers in which combustible oil is used are located within buildings it is essential that they be placed in a fire-resistive room in accordance with the requirements of the National Electrical Code.

The loss of more than 37,000,000 pounds of rubber in the Fall River, Mass., fire of October 11, 1941, is a convincing reminder that strategic or irreplaceable material should also be isolated in the interest of protection against loss by fire.

(e) **Safeguarding of heating equipment.**—Stoves, furnaces, and draft pipes need to be checked for clearance between such equipment and combustible construction. For metal stacks, close attention should be given to the clearances between the stack and the roof, particularly where the stack passes through the roof. For brick chimneys, clearances should be allowed between the woodwork and the exterior surfaces of the chimney.

(f) **Liquefied petroleum gas systems.**—Liquefied gas (butane or propane or a mixture of the two) is becoming increasingly popular as fuel for gas ranges, water heaters, refrigerators, and other appliances.

Butane and propane gases are heavier than air and tend to flow toward low points where the vapors may accumulate. The mixture of gas and air, if ignited, may result in a serious explosion. For domestic use, propane has an advantage over butane in that it will vaporize at all temperatures commonly experienced in the United States. Butane, on the other hand, if below 33° F., needs heating to assure vaporization. Where frosts are encountered, butane gas installations require vaporizers.

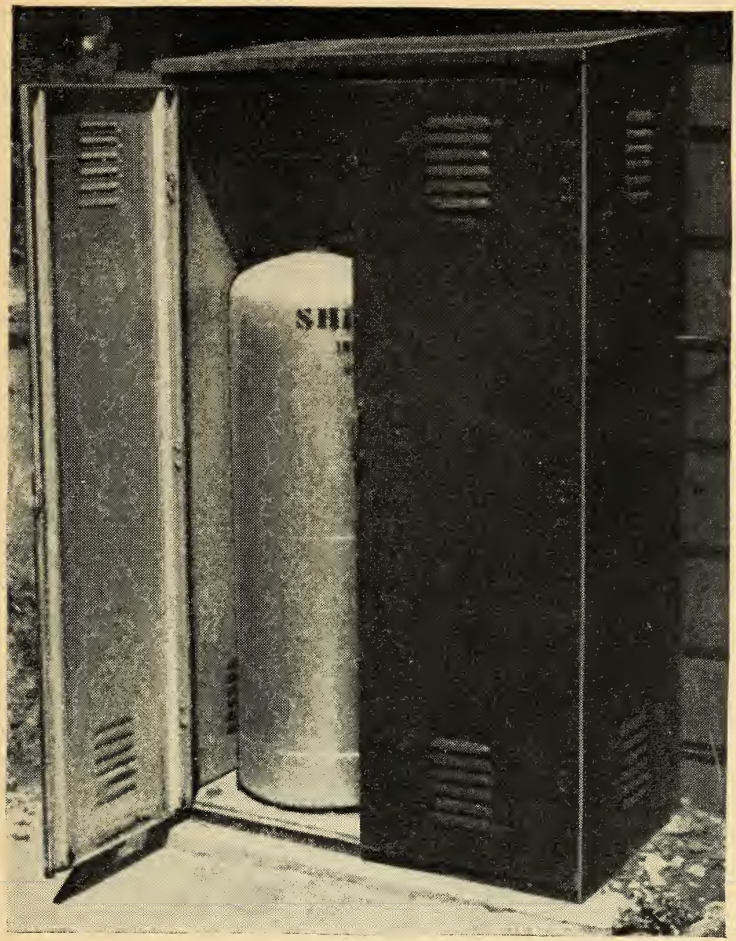
Butane and propane have little odor, and it is common practice to add an odorant in order that leakage of gas may be detected.

Where the liquefied gas is stored in cylinders (usually 100-pound capacity), they should be placed outside of buildings; it is desirable to have a concrete foundation for the support. A ventilated metal cabinet for the protection of portable cylinders is recommended.

Flexible copper tubing with flared connections has advantages over ordinary piping. It is less rigid and requires fewer fittings and connections than screwed iron pipe. The flared connections should be made by trained men equipped with special cutting and flaring tools. The connections are easily made, however, and the required training is simple.

It is essential that the cylinders be placed so that no opening to the buildings is near the cylinders, as leaking gas may flow under or into the building and, if ignited, cause an explosion.

Systems with large aboveground or underground tanks for



A good propane gas installation. Note concrete foundation and ventilated metal cabinet. Copper tubing with flared connections used for distribution line.

the storage of butane or butane-propane mixtures are more complicated than the small domestic installations. It is important that each butane or propane-butane installation be given careful study to see that the technical requirements of existing standards are followed.

(g) **Oil-storage buildings.**—Provision of a separate isolated building for the storage of oil of different types in drums is a good practice.

Such structures require attention to technical detail, including the use of vapor-proof globes, wiring in conduit, explosion-proof switches, and a special vent with the inlet close to the floor and the outlet above the roof of the building. A curb at the doorway to prevent the flow of leaking oil outside the structure is good practice. The use of a fire door for the opening is advisable, particularly if a fire in the oil-storage building may spread to other structures. In such cases metal sash and wire glass for windows also are recommended.

(h) **Paint-spraying rooms.**—Paint-spraying rooms should be isolated from other occupancies of a plant. Where a separate building is possible, this is advisable. The interior construction should have some fire resistance. Vapor-proof globes should be provided, wiring should be in rigid conduit, explosion-proof switches should be used, and a special exhaust system should be installed to remove the fumes and surplus spray.

The inlet to the exhaust system should be inspected and cleaned periodically as the residue that accumulates in the inlet has in some cases been ignited. The motor for the exhaust system should be placed outside of the structure.

(i) **Protection against fire exposures.**—The spacing of the buildings should be evaluated; for adequate protection liberal spacing should be allowed, particularly if the buildings are combustible. If the buildings are fire-resistive, openings in exposing walls should be either closed or have windows of metal sash and wire glass.

Buildings of corrugated iron on steel, while incombustible, may be seriously damaged by an exposing fire. Such buildings should be liberally spaced from other structures.

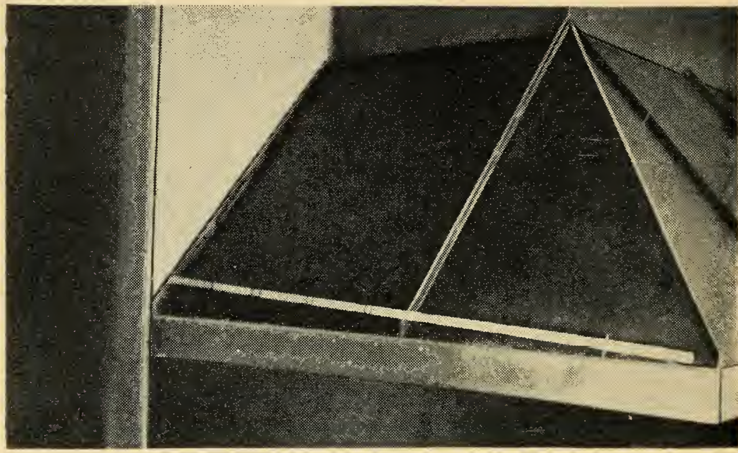
The spacing between buildings should be considered in connection with fire insurance rates so that the distances will be sufficient to at least avoid exposure charges. The distances will vary with the type of occupancy, the area of the building, the type of construction, and the fire protection provided.

(j) Oxyacetylene cutting and welding.—Numerous cases are on record where fires have been caused by inadequate precautions in oxyacetylene welding operations. Sparks or molten metal may lodge in cracks in the combustible construction and often ignite the woodwork after the workmen have left the plant. Fire-resistive floors and incombustible walls are desirable for rooms where oxyacetylene welding operations are carried on.

(k) Framing into chimneys.—The use of the chimney to support structural members is a dangerous practice. Settlement of the building may cause cracks in the chimney and eventually expose the combustible members to heat and cause ignition.

(l) Range installations in hotel or restaurant kitchens.—The range, hood, and hood vent constitute one of the hazards in a hotel or restaurant kitchen. In some cases the range has been placed upon a layer of concrete, which in turn rests upon a wood floor. In time the moisture has been absorbed from the concrete, a crack develops, and eventually the underflooring is ignited. A self-supporting concrete slab is justifiable for the support of large ranges for hotel or restaurant kitchens.

The hood and vent for the hood should be generously spaced from the combustible walls and ceiling and the space between the vent and any woodwork through which the vent passes should be adequate. A faulty installation may prove to be a hazard when a vat of grease ignites on the stove and the heat and flames pass through the hood into the vent, as the combustible construction near the hood or vent may be



Nonstandard hood for large kitchen range.

ignited. Properly installed, the hood and vent will withstand a fire without damage to the structure.

As grease accumulates on the inner surface of the hood, it is good practice to clean the inside of the hood periodically. A safe cleaning solvent, such as trisodium phosphate, should be used for this purpose. Gasoline is not a safe cleaning agent.

When electric lights are installed inside the hood, the wiring should be in rigid conduit and the bulbs should be protected.

(m) Private garages attached to dwellings.—In the construction of a dwelling with attached private garage, some codes require that a concrete curb 1 foot high be provided at the doorway between the garage and the dwelling; that the door be metal-covered on the garage side; and that the interior finish for the garage have some fire resistance, such as metal lath and Portland cement plaster. With such construction, the interior finish of the garage is superior in fire resistance to that of the metal-covered wood door and to the jambs and header for the doorway whether protected or unprotected with metal.

Some inside finish for the garage is needed for the wall separating the dwelling from the garage to resist the passage of gases into the house.

It may be justifiable to be somewhat more rigid concerning the private garage attached to a dwelling where the basement floor of the dwelling is below the floor level of the garage; in such cases gasoline vapors may flow to the lower level and be ignited if the conditions are right.

It would seem reasonable to allow an inside finish of less fire resistance in a private garage than was formerly recognized. Perhaps a finish consisting of 1-inch tongue and groove boards for the interior walls and ceiling of the garage, protected with gypsum wall boards not less than ⅜-inch thickness with the joints protected with gypsum wall board strips, would be adequate.

To reduce the accident hazard it may be advisable to reduce the 12-inch curb at the doorway to an 8-inch curb.

(n) Transformer vaults.—Oil-cooled transformers, in which combustible oil is used, have had a good record from the standpoint of frequency of fire losses. However, when a transformer fire occurs it is usually a serious one. This fact necessitates superior construction, with safeguards to protect the hazard when transformers are placed inside of buildings.

The vault construction within a building in which transformers are to be housed should be fire-resistive; the doorway to the vault should be protected with a fire door which should be kept locked; and a sill or curb not less than 4 inches high should be provided for the doorway to keep the oil which may boil over in the fire from flowing outside the enclosure.

Ventilation for the vault is necessary. Where one wall of the vault is an exterior wall of the building, the usual procedure is to provide a louvered opening to the outside so located that in the event of fire, heat or flame will not expose combustible construction or windows.

Water pipes, sewer pipes, etc., should not be placed in a transformer vault. Storage in a transformer vault should be prohibited.

To drain the oil that may boil over in an oil-cooled transformer it is good practice to install a drain in the floor; and the pipe line from the drain should be equipped with a trapped connection.

Fixed carbon dioxide systems designed to discharge automatically at a predetermined temperature or by rate of rise devices are used in some cases for fire protection. As a general rule, however, no protection is provided on the theory that transformer fires are so infrequent that it is economically sound to depend upon the construction of the vault to withstand a fire.

(o) Storage of bituminous coal in bins.—Bituminous or semibituminous coal may ignite spontaneously when moist. Bins in which the coal may stand for more than 30 days should be protected. It is advisable to protect the woodwork of the bin with ½-inch asbestos board covered with sheet metal. The ceiling of the bin should be similarly protected. Fire-resistive construction should be provided for large storage facilities.

(p) Hotels.—The problem of fire prevention and fire protection for hotels may be considered under four classifications, namely, structural, management, fire protection, and guests.

Certain fundamental changes, where necessary, can be made in existing structures in the interest of safety. They include the enclosure of open stairways; enclosure of open elevator wells; protection of interior surfaces of linen chutes with incombustible material; improvements in electrical wiring; provision of incombustible fuse boxes, and fusing of electrical circuits to correspond to the safe loads of the circuits; incombustible roofing; and, in hotels of large area, provision of cut-offs to retard the spread of fire horizontally.

Special consideration is needed for hotel kitchens, where ignited grease vats or accumulations may be the cause of fires. Metal hoods with vents separate from all other flues are a necessity. Properly installed, such hoods and vents will withstand a fire without damage to the structure. Sometimes the hoods and vents are installed too close to combustible construction and in the event of a grease fire the heat from the hood and vent may ignite the nearby woodwork. A concrete foundation for the kitchen range is a justifiable and safe support. Incidentally, a wood floor covered with a concrete slab has been known to be ignited by the heat from a range above.

Exit doors are frequently a problem. They should, of course, be hung to open in the direction of exit travel. Many large dining rooms and lounges have inadequate exit facilities. Reliance upon windows as a means of egress for guests is a common mistake.

Employees' dormitories or other auxiliary structures near a hotel may seriously endanger the main building. Auxiliary buildings should be spaced a considerable distance from the hotel, especially if they are of combustible construction.

Certain management policies are important, irrespective of the type of construction of the hotel. Inexpensive, yet important, fire-prevention measures include the placing of a metal wastebasket and an ash tray in each room. It is unfortunate but true that many persons thoughtlessly throw lighted smoking materials into wastebaskets.

Diligence is important in seeing that housekeeping conditions in basements, attics, and storage rooms are kept at a high standard. Paint, carpenter, printing, and other workshops require special attention if the fire hazard is to be kept at a minimum. Closets under stairways introduce further risks. Since employees are prone to nelgect fire precautions in their own quarters, such buildings should be spaced a safe distance from the hotel. If practicable, workshops should also be isolated from the hotel structure.

Inspections made periodically by a trustworthy employee are recommended as a means of establishing and maintaining high standards of housekeeping.

In one hotel equipped with an excellent enclosed stairway it was found that the watchman each night propped open the door to the enclosed stairway at each floor and locked the exit door at the ground level. Careful supervision on the part of the hotel management is necessary to prevent such dangerous practices.

Resort hotels, dependent as they are on their own resources for proper action in emergencies, need standpipes and hose within the hotel, hand fire extinguishers, and outside water distribution systems with hydrants, hose houses, and hose for fire fighting. A trained brigade, with frequent drills, is required for proper use of the equipment provided. A manually operated fire-alarm system is recommended to arouse guests and to assemble the fire brigade.

Automatic sprinklers, with adequate water storage for fire protection, are the best means for fire control. They serve a three-fold purpose, namely, detection, spread of alarm, and extinguishment. As a rule, the expenditure for such systems is a good investment since the expense may be amortized in a reasonable period through savings in fire insurance premiums.

Guests should do everything possible to insure safety for themselves and for the other guests. Smoking in bed is dangerous, yet hotel owners know from burned sheets and blankets and from more costly experience that such smoking is a common practice. Guests should be cautious, also, about the disposition of smoking materials. Ash trays, not wastebaskets, should be used for this purpose.

2. USE OF EXISTING FIRE-PROTECTION STANDARDS

The review of plans for fire safety should be made in the light of commonly recognized standards. For most of the hazards named above standards are available which are recommended by the National Fire Protection Association and published by the National Board of Fire Underwriters. Some of the standards are approved also by the American Standards Association. As these standards are the recommendations of committees whose members are chosen for their ability to contribute to the development of a standard the results are usually reasonable. The procedure invites discussion of varied points of view and when approved such standards may be accepted as reasonable compromises that are fair to the user.

3. COOPERATION WITH LOCAL FIRE INSURANCE RATING ORGANIZATION

Cooperation with the local fire insurance rating organization by submitting plans for new structures is good business, as defects for which penalties may be made in the fire insurance rate can be corrected in the plans and more favorable fire insurance rates may be expected. It is a good practice to submit to such organizations the plans for sprinkler systems for review prior to installation.

C. REVIEW OF PLANS OF PRIVATE WATER SYSTEMS

The cost of a satisfactory water system for private fire protection represents a substantial investment which is justifiable only where the values of buildings and contents require the system. The economics of design must be considered in relation to the property to be protected. As in any other engineering project, it is essential that the system be designed with a view to future expansion of an area or plant. The investment in a water system for fire protection may represent 70 percent of the cost of a combined fire-protection and domestic-use water system. Where a water system for private fire protection is justifiable there are certain factors of the design that should be considered.

1. DEMANDS FOR FIRE STREAMS

The standard fire stream is generally recognized as 250 gallons per minute. This fire stream was determined as a standard as the result of painstaking research conducted by John R. Freeman in the 1890's. It was found that when water was supplied to a fire some of the water was lost in steam and that it was necessary to have large quantities of water to cool a fire for suppression purposes. The standard fire stream is obtained with a 1⅛-inch nozzle and a pressure at the nozzle of 45 pounds. In important groups of buildings, multiples of 250 gallons are necessary.

The standard fire stream and the possible use of multiple streams are important factors in the design of a water system intended for fire protection. While the day-to-day use for domestic consumption may be the criterion for the design of a water system intended for domestic use only, the design of a system that is intended for fire protection must be adequate for the heavy demands required for short periods during fire emergencies. For example, two standard fire streams (500 gallons per minute) discharged for 1 hour amount to 30,000 gallons of water. In such a case the storage should be adequate for the fire demand.

It should be emphasized that there are definite advantages in providing a separate and independent system for fire-fighting purposes. Some of the arguments for the independent system for fire protection may be stated as follows:

A separate fire-service system provides a definite supply of water for fire purposes only.

Pressures required for fire service are usually greater than for domestic or plant requirements and the limitations of pipe fittings and valves on domestic supply lines may prevent increased pressures at the time of the fire. If pressures are increased in a combined system the fittings for the domestic connections may fail.

An independent fire-service system makes possible the enforcement of more rigid rules regarding the operation of valves and it is, therefore, less likely for a valve to be improperly closed.

The use of spray or fog nozzles in recent years has increased and some favorable results have been reported. For incipient fires and on fires in open oil tanks, the spray or fog is effective. For situations involving fires of conflagration proportions, large quantities of water are necessary for fire suppression. The growing use of the fog nozzle does not supplant the design factors for a water system for fire protection.

2. LOOP SYSTEM OF DISTRIBUTION

For fire protection, the loop or gridiron system is recommended because in such a system the supply of water to a hydrant from two directions gives reduced friction losses. Distribution systems consisting of a single line, with hydrant connections off of the main line, may result in such heavy friction losses that the pressure near the end of the line may be too low for fire-fighting purposes. The loop system has the advantage of greater reliability also, as a break in one part of the loop may be shut off without shutting off the flows from the other sections of the loop, provided it is properly valved.

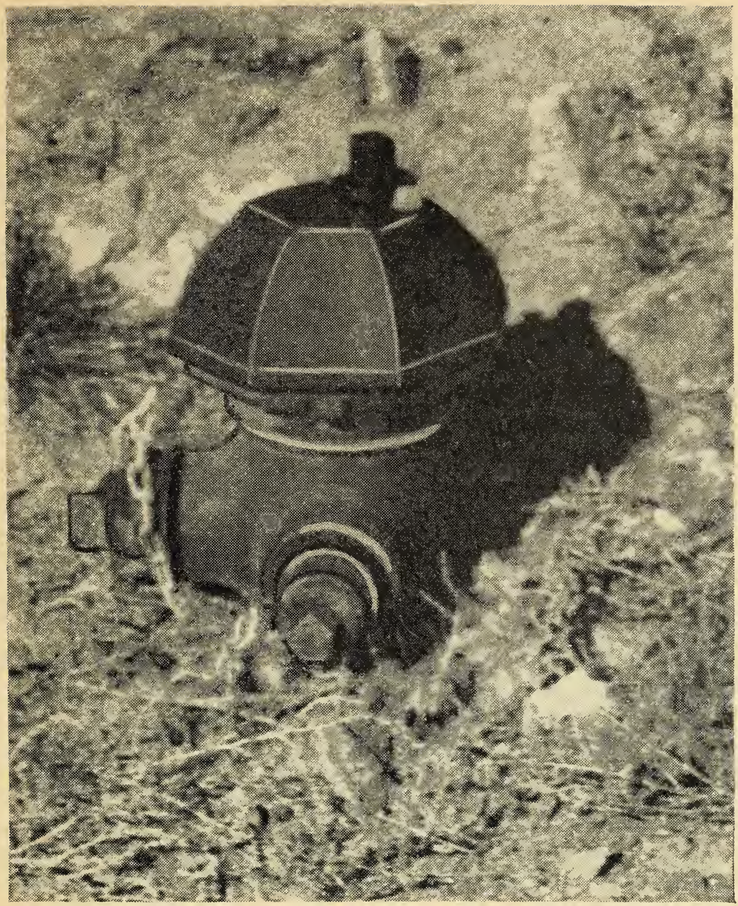
3. SIZE OF MAINS

As a general rule, in water systems for fire protection, pipe less than 6 inches in inside diameter should be avoided. The reason for this is that for sizes under 6 inches the heavy demands required for fire fighting result in large friction losses. For example, the friction loss in 6-inch pipe per 1,000 feet, with 500 gallons per minute flowing, is 15 pounds. The friction loss per 1,000 feet for 4-inch pipe for the same demand is 100 pounds.

4. FIRE HYDRANTS

Standard municipal-type hydrants, each with two 2½-inch outlets, should be provided. Where a possibility exists of a fire engine being used, a suction outlet also should be provided. This is usually 4½ inches in diameter, but it is wise to ascertain the size of the suction outlet used by the local or nearby fire departments to be sure that the suction hose coupling will fit.

Attention is directed to the need for care in the installation of hydrants. In general, no hydrant should be located less than 50 feet from a building to permit accessibility in case of fire. Numerous cases have been noted where the hydrants are placed so low that it would be difficult to make a hose connection to the hose outlet on the hydrant. In some private fire-protection systems flush hydrants have been noted. Such hydrants have disadvantages in that they are difficult to find at night; they may be covered with snow in



Hydrant rendered useless due to faulty installation. Outlets should be high enough to permit hose to be connected.

winter; and they may be covered with waste materials during storms. Flush-type hydrants are also more difficult to maintain than the standard fire hydrant.

Another detail that needs to be watched is the connection from the water main to the hydrant; to reduce the friction loss a 6-inch connection should be made to the hydrant if a 6-inch water main is provided.

5. WATER METERS

The water meter has been a controversial subject between water companies and fire insurance companies for the past 50 years. From the fire protection standpoint, the water meter is an obstruction to flow. Both the disc-type and the velocity-type meters result in considerable loss of head under heavy flow. The case from the standpoint of the water company includes charges that surreptitious use of water for purposes other than fire protection deprives the company of revenue. The argument against the meters by the fire insurance interests is that the ordinary type of meter reduces the available head and reduces the effectiveness of the fire protection system. In short, the fire insurance groups were not particularly interested in whether the water companies had a record of the consumption of water, and the water companies showed little interest in the availability of water for fire protection at adequate pressure.

Due largely to the diplomacy of one man, E. V. French, the fire-service meter was developed. This meter permits the full flow of water with negligible friction loss and the normal demand is measured by a disc or velocity meter; the heavy demands are recorded by proportional meters. Unfortunately, the cost of fire-service meters is considerably more than either the disc or velocity meter.

For fire protection it is desirable, of course, to have all water mains serving fire-protection needs unmetered. If it is essential that some measure be obtained of the consumption, then a fire-service meter is recommended. Where disc meters or velocity meters are used, provision should be made for bypassing the meter in case of emergency. This is a compromise, but it is better than having the available head reduced as it would be if the disc and velocity meters were not bypassed.

In Washington, D. C., a bypass is required around the fire-service meter also. This is done to permit removal of the disc and velocity meters for repairs and maintenance without shutting down the system. This would appear to be a sound practice but it is not a common one. Apparently in most places the bypass is omitted where a fire-service meter is installed. If a water meter of a disc or velocity type needs maintenance in an ordinary system—and it is well recognized that such meters do need such maintenance—there is no particular reason why periodic maintenance should not be provided for the disc and velocity meters installed as part of the fire-service meter.

6. OBJECTIONS TO PRESSURE TANKS FOR OTHER THAN AUXILIARY STORAGE

A pressure tank contains two-thirds water and one-third air. The largest size pressure tank has a capacity of 9,000 gallons and provides a maximum storage of 6,000 gallons of water. Such tanks have a useful field in water systems as auxiliary tanks to provide water at a pressure for initial needs for sprinklers and for standpipe systems in high buildings, where space is valuable, until other sources of supply are connected. The maximum storage of 6,000 gallons provided in a 9,000-gallon pressure tank is obviously so limited that it should not be considered as the main storage for a fire-protection water system. Apparently this limitation has not always been recognized as a number of water systems have been designed in which pressure tanks have been installed for the main storage.

As previously stated, a standard fire stream is generally recognized to be 250 gallons per minute and in many situations two, three, or even four streams may be needed. Assuming that two fire streams are required, 500 gallons per minute, it will be readily seen that the storage provided in the pressure tank would be discharged in 12 minutes. Such a short interval is insufficient for fighting a serious fire.

7. HOSE HOUSES

In private water supply systems it is a sound practice to provide hose houses at hydrants. Such houses should be equipped with at least 200 feet of hose and accessories, including lantern, spanner, and other tools. The advantage of the hose house thus equipped is that the hose is readily available for use by the fire brigade at a time when it will be most useful. Delayed alarms or misunderstood alarms sometimes result in tardy arrival of the fire engine at the point of the fire. In one case the fire was under control from a hose line in the hose house before the arrival of the fire engine.

8. USE OF EXISTING STANDARDS

Standards recommended by the National Fire Protection Association and published by the National Board of Fire Underwriters are available for the design and installation of outside fire protection and also for hose houses.

D. FIRE REPORTS AND THEIR ANALYSIS

The reporting of all fires on a carefully prepared fire report form is invaluable. Such reports may show weak spots that need attention and frequently contain information of value in the prevention of future fires from similar causes.

Where a fire report form is not available the tendency is for various persons to submit lengthy statements with considerable repetition. The material thus presented is difficult to analyze. With a suitable report form, it may be expected that the sifting of evidence will have been done prior to the submission of the report and that the data given on the report form will be a summary of all the facts.

E. COMPILATION OF FIRE-LOSS STATISTICS

Statistics of fire losses compiled from the individual fire reports, with classifications as to causes and information of unusual interest, are important. They furnish executives with a record which they should have as a matter of good management.

F. SELF-INSPECTIONS

So-called self-inspections of properties are an important part of a fire-prevention program. They are a real aid in the establishment and maintenance of a high standard of housekeeping; in the detection of electrical defects, such as overfused circuits, electric bulbs in contact with combustible material, and worn or defective extension cords hung over nails; in the detection of defective heating systems; in ascertaining the condition of extinguishing equipment; and in handling many other problems which enter into the maintenance of safe conditions. A self-inspection form for use in reporting the conditions of the property is a valuable aid.

The importance of good housekeeping cannot be overemphasized. A neat, well-kept property not only reduces the possibility of the starting of fires but it is an asset from the standpoint of appearance. Accumulation of combustibles in hazardous areas should be avoided; care in the disposition of oily rags by use of the self-closing metal waste cans should be exercised; and storage areas should be arranged in an orderly manner. Self-inspections are helpful in the detection and correction of faulty housekeeping.

G. THE HUMAN ELEMENT

It is not always possible to control the acts of individuals and this fact has a bearing on the design and arrangement of buildings for fire safety. Unsafe practices, such as tampering with electrical fuses, use of unsafe cleaning solvents, smoking in hazardous locations, and throwing cigarettes and matches into wastebaskets, are representative of hazards of the individual. Numerous others might be mentioned.

The human element plays a part also in the degree of maintenance that is given to equipment needing periodic attention. Many industrial electrical fires are caused by inadequate maintenance of motors. Closed valves in a water supply line have been a serious problem. Because of human fallibility, closed valves in a fire protection water supply have resulted in failures when the water was needed for fire fighting.

The records show examples of human behavior, good and bad, where watchmen have had to act in an emergency.

Alert management, competent supervision, and training programs should go far in controlling the acts of individuals in their places of employment.

There will still be the problem of the human element outside of the plant. Smoking in bed, for example, is a well-known fire hazard. How far the control that may be exercised in a plant may be extended to self-discipline outside of the plant, in the home, and in hotels is problematical.

H. PRIVATE FIRE BRIGADE

To be prepared to handle fire emergencies when they occur it is good practice to organize a plant fire brigade. The organization and equipment will vary with the size of the plant.

Essential prerequisites for an efficient fire brigade are training, fire drill, and occasional meetings, at which the plant's fire-fighting facilities are reviewed. Such discussions serve to make each member of the brigade familiar with the location of valves, available pressures, points of particular hazard, and methods of fighting fire in any part of the plant.

I. CARE OF EQUIPMENT

It is obvious that if fire-fighting equipment is to be effective for the purpose for which it was purchased attention must be given to the maintenance of the equipment. Some of the more common problems in the maintenance of fire-fighting equipment are discussed below.

1. HOSE

Rubber-lined hose should occasionally be tested with water flowing through the hose. Such use keeps the rubber lining flexible. It is customary to clean the jacket and dry the hose before rerolling.

Unlined linen hose, commonly used for standpipe connections inside of buildings, should not be wet except when needed for use in fire suppression. Maintenance consists chiefly of refolding the hose occasionally to avoid fixed folds and to see that the hose is dry, particularly near the valve coupling. A leaking valve may result in the rotting of the hose at the coupling.

A mildew-treated unlined hose, which is light in weight, durable, and satisfactory, has been developed for use in fighting forest fires. Wetting such hose does no harm and the necessity for thoroughly drying it is not so essential as is the case with the ordinary unlined linen hose. It would seem to be wise to use mildew-treated hose at standpipes within buildings, although existing standards do not recognize such hose for this purpose.

Maintenance of a soda-acid extinguisher consists of changing the contents of the extinguisher annually, including a new solution of bicarbonate of soda and water and a new supply of sulphuric acid. The soda-acid extinguisher must be used or kept in a place where it will not freeze.

The addition of common salt to the bicarbonate of soda solution to depress the freezing point should be prohibited. The chemical reaction between sulphuric acid and the bicarbonate of soda solution gives carbon dioxide which furnishes the pressure for the discharge of the contents of the extinguisher. When salt is added to the solution the chemical reaction is changed and some hydrochloric acid is formed; furthermore, the addition of salt to the solution does not lower the freezing point of the sulphuric acid. The freezing point of sulphuric acid varies with the density of the sulphuric acid. In some cases it will freeze at a temperature above the freezing point of water.

An examination of the soda-acid extinguishers where salt was used to depress the freezing point disclosed that the sulphuric acid was frozen; the extinguishers would have been of no use whatsoever in the event of a fire.

The hose for portable extinguishers should be watched to see that it is flexible, as it has been found in some cases that cracks have developed near the point where the hose is coupled to the extinguisher. The nozzle of a portable extinguisher should be inspected for accumulations at the tip.

Common Sizes and Types of Fire Extinguishers and their Uses and Limitations

Size	Type	Suggested Locations	Remarks
2½ gallon	Soda acid	In buildings where fires may occur in ordinary combustibles, such as paper, wood, rubbish, etc. Representative structures include office buildings, warehouses, hotels, schools, hospitals, dormitories, dwellings, etc.	To be used in heated buildings or in locations where contents of the extinguisher will not freeze.
2½ gallon	Calcium chloride	Same as Soda-acid extinguisher (See remarks)	Calcium chloride solutions may be mixed so that freezing will be avoided down to minus 40° F.
2½ gallon	Foam	Heated garages, heated oil houses, hotel kitchens, and other locations where flammable liquids are stored or handled.	Must be placed in location where contents of extinguisher will not freeze.

Common Sizes and Types of Fire Extinguishers and their Uses and Limitations—Con.

Size	Type	Suggested Locations	Remarks
1 gallon	Carbon tetrachloride, pressure type.	Unheated garages, unheated oil houses, power stations, buses, and transformer rooms.	Commercial carbon tetrachloride to be avoided. Carbon tetrachloride for fire extinguishment has a freezing point of minus 50° F. Is a nonconductor of electricity. Must not be used in confined spaces. Must not be used on hot metals.
15 pound	Carbon dioxide	Museums, motor boats, power stations, transformer rooms.	Nonfreezing type, rather expensive. Leaves no residue and is a nonconductor of electricity.
1 quart	Carbon tetrachloride.	Dwellings, automobiles, trucks, motor boats.	Limited capacity is a disadvantage. Must not be used in confined spaces. Must not be used on hot metals.

3. AUTOMATIC SPRINKLER SYSTEMS

For a standard automatic sprinkler system with an adequate water supply the most important single factor to be watched in the maintenance of a sprinkler system is the control of valves. Too often a fire has occurred when the sprinkler system was not able to function due to a closed valve. The indicator post valve which shows at a glance whether the valve is closed or open is a help. Failure of the human element has led to the adoption of supervised systems of control.

Other maintenance items include avoidance of the painting of sprinkler heads and checking to see that the heads are not corroded or loaded with accumulations of lint, dust, and the like. Low-test heads should not be used in locations where excessive heat from normal operation might result in discharge, even though a fire is not present.

Detailed instructions for the care and maintenance of sprinkler systems have been prepared by the Committee on Automatic Sprinklers of the National Fire Protection Association and have been published by the Association. The drain test of a sprinkler system is of utmost importance as the flow and gauge reading provide a means of ascertaining whether or not the piping system is obstructed.

J. PURCHASE OF SUITABLE EQUIPMENT

Many fire-protection devices have merit but all have their limitations, some being effective for one type of fire and not for others. The uninitiated may not realize that the soda-acid extinguisher, which is so serviceable for fires in ordinary combustibles, is not suitable for grease fires or oil fires and that when used for the latter purpose it has been a factor in the spread of fire.

It is important, therefore, in the purchase of equipment that devices that have no merit be detected and that careful discrimination be exercised to see that devices that do have merit are purchased for hazards for which they are suitable.

The purchaser has a means for protecting himself in buying fire-protection materials and equipment, and with some knowledge of the proper use of the different materials and equipment he is in a position to make satisfactory purchases. The Underwriters' Laboratories, Inc., of Chicago, Ill., publishes lists of equipment, materials, and devices that have passed tests and been approved. Similarly, the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, located in Boston, Mass., furnishes such lists based upon their laboratory tests.

K. TEMPORARY CONSTRUCTION

In times of pressure it is not an uncommon practice to erect temporary combustible partitions to serve a given purpose. In buildings of superior construction it is wiser to avoid temporary combustible construction as the latter may prove to be hazardous and costly. The so-called temporary construction may be as permanent as other structures or parts of structures. When alterations, changes, or new facilities are planned, it is a good practice to view the changes from the standpoint of possible hazards. A poor decision may jeopardize an entire operation.

L. PLAN OF FIRE-PROTECTION FACILITIES

A plan of fire-protection facilities serves a dual purpose. It furnishes the organization with essential data that may be used in fighting a fire before the fire occurs; it is also a serviceable tool for operating purposes.

Such a plan should include information on the location, capacity, and elevation of water storage; location, size, and type of water mains; location, size, and type of hydrants;

location, size, and type of valves; location of hose houses and hose; location of fire alarms; and location of other fire-fighting equipment.

In addition to serving as a means of utilizing the fire-protection system to its best advantage, such a plan is invaluable in the maintenance of the system. Very often one finds in an organization a maintenance man who has a good memory and in the event of trouble the location of mains, valves, etc., are in one man's mind. Obviously, this is not good administration, as the man may become sick or for other reason be required to be away from his regular assignment, or he may transfer to some other organization.

M. WATCHMAN'S SERVICE

The watchman, as shown by the record of his reactions in emergencies, may be a valuable asset or he may be a liability. He must frequently act on his own responsibility and without the assistance of others. It is important, therefore, that he be carefully selected.

Experience has established certain qualifications for a watchman and the procedures which should be followed in training him for his work. He should be reliable, physically fit, mentally alert, and capable of handling emergencies that may arise. Management should see that he is instructed in his duties; that he is familiar with the equipment that is provided for the protection of the plant; and that his rounds are made according to schedule and that each station is visited. Printed instructions or oral explanations are not sufficient for such training; the watchman must demonstrate his ability to handle the equipment provided. Supervision may vary from daily examination of the watch-clock discs to electrically supervised watchman's services.

N. FIRE-ALARM SYSTEMS

The selection of a fire-alarm system for a given property should be based on numerous factors, including the value of the property, availability of skilled maintenance men familiar with the alarm system, and the location of the property (i. e., in or near a community or isolated).

An alarm system of a municipal type may be justifiable for an isolated property of high value where a plant fire department is available. In or near a community with a fire department, the alarm may be of a local type connected to the community alarm system or connected to a supervised central-station system. The decision as to the proper equipment in a given case should be based on engineering studies which should include cost and an investigation of the numerous types of systems that are available. The standards that are available for alarm systems should be followed.

The use of the telephone as an alarm system has certain limitations which should be clearly understood. When a fire occurs there is always some confusion and this may result in erroneous telephone instructions, misunderstanding of the instructions, or incorrect relaying of the instructions. Cases are on record where delayed response of fire equipment has been due to inaccurate location of a fire when the alarm was given by telephone. The above comments are not made as a disparagement of the use of the telephone but are intended as reminders of the limitations of the telephone for fire-alarm purposes.

O. COOPERATION WITH LOCAL FIRE DEPARTMENT

If a fire department is to do its best work in extinguishing a fire, the responsible officers of the fire department should be informed concerning the fire protection of the plant, including the outside water system, important valves, sprinklered areas, and special hazards. Occasional inspections of the plant by fire department representatives will give such representatives a familiarity with the plant which should be helpful in planning the method of fire suppression to be used should a fire occur. In some States factory inspection services are conducted by law, but this is a different field from that suggested above, namely, voluntary cooperation with the local fire department.

It is recognized that some industrial companies do not take advantage of such cooperation on the score that their operations are of a secret nature and that visitors of any type should not be permitted in the plant. Even in such plants a practicable solution may be possible by conducting responsible fire department heads through the plant under competent supervision.

IV. APPENDIX

SAFETY PRECAUTIONS FOR OXYACETYLENE CUTTING AND WELDING

1. Keep hose and cylinder valves free from grease, oil, dust, and dirt.
2. Keep sparks and flame away from hose.
3. Keep cylinders away from stoves, furnaces, and other sources of heat.
4. Acetylene should not be used at pressures in excess of 15 pounds.
5. Wear suitable goggles when working with an oxyacetylene torch.
6. Protect combustible construction near oxyacetylene flames and always have a fire extinguisher in position for prompt use.
7. Always use "gas lighter" to light the torch.
8. Inspect hose frequently.
9. Avoid use of oxyacetylene flame in confined spaces.
10. Containers that have been used for storage of flammable liquids should be thoroughly cleaned with steam, or washed with hot water and soda, and thoroughly ventilated before welding.
11. If used at an elevation, be careful to safeguard persons and property at lower levels.
12. When testing for leaks, use only soapy water and watch for escaping bubbles.
13. When equipment is not in use see that all valves are closed.
14. Experienced men, only, should use welding equipment.
15. Do not use torch on painted surfaces—scrape the paint off first.
16. Caps for the cylinder valves should be screwed on firmly when cylinders are being moved or are not in use.

SAFE PRACTICE FOR PROPANE GAS INSTALLATIONS

1. Concrete foundation shall be provided.
2. Ventilated metal cabinet shall be provided.
3. Where heavy snowslides may cover the cylinder cabinet, make installation at gable end of building rather than under eaves or provide a shelter hood over the cabinet.
4. Cylinders shall be placed outside of buildings.
5. The discharge from safety relief valves shall be located not less than 5 feet from any building opening which is below the level of such discharge.
6. Cylinders shall be installed above ground.
7. The area in the vicinity of the cabinet shall be kept clean. Accumulation of combustible and other material, tools, or equipment in the vicinity of the cabinet shall not be permitted.
8. Copper tubing with flared connections shall be used to obtain flexibility in the distribution line and to reduce connections to a minimum.
9. Flared connections shall be made only by trained workmen equipped with proper flaring and cutting tools.
10. Appliances shall be equipped with burners suitable for propane gas.

SAFE PRACTICE FOR PRIVATE GARAGES ATTACHED TO DWELLINGS

1. Garage attached to or located under a dwelling shall be so separated from the dwelling as to restrict the passage of gases, smoke, or odor from the garage to the dwelling.
2. Interior finish shall be at least equivalent in fire resistance and gas tightness to 1-inch tongue-and-groove wooden boards, free of knot-holes, with gypsum wallboards not less than ⅜-inch in thickness nailed through the wooden boards into the studs or rafters, with 2-inch nails, and with 4-inch strips of gypsum wallboard similarly nailed over all butting joints of the gypsum wallboard.
3. Opening from garage into dwelling shall be limited to a single doorway; the doorway shall be provided with a flush-type wooden door, not less than 1¾ inches nominal thickness, equipped with an approved self-closing device.
4. Garage floor shall be of concrete and shall have a slope sufficient to allow natural drainage to the outside.
5. When doorway opens directly into room in which there is any direct-fired heating device or gas fixture such doorway shall have a curb or sill raised 8 inches above the garage floor level, or the doorway shall lead into a vestibule from which a second door opens into such room.
6. No stove, furnace, or similar heating device shall be installed in a private garage; except that unit gas or electric heaters approved for garage use and installed approximately at the eave level or near the ceiling may be permitted.
7. There shall be no pit in any garage floor.
8. There shall be no artificial light other than incandescent electric lights.

SAFE PRACTICE FOR OIL-STORAGE BUILDINGS

1. Exterior walls shall be of masonry if less than 50 feet from other buildings, or of combustible construction if more than 50 feet from other buildings.
2. Roofing shall be incombustible.
3. Interior finish shall be incombustible.
4. A concrete curb or ramp not less than 4 inches above the floor line shall be provided at exterior doorway.
5. Floor shall be incombustible.
6. A 4-inch floor drain shall be provided and it shall connect to a gravel bed or underground tank. A trap shall be provided between the drain and gravel bed or underground tank.
7. An 8-inch vent shall be provided. The inlet shall be screened and located 6 inches above the floor. The top of the vent shall be 2 feet above the ridge of the roof.
8. Electric wiring shall be in rigid conduit; vapor-proof globes shall be used; and inside switches shall be of the explosion-proof type.
9. Self-closing metal doors shall be used.
10. Windows shall be of metal sash and wired glass.
11. Shelving shall be incombustible.
12. Heating shall be low-pressure steam, or hot water. Heater shall not be located in the oil house.
13. One 1-gallon stored pressure carbon tetrachloride extinguisher shall be provided in cold climates, or one 2½-gallon foam extinguisher in locations where the extinguisher is not subject to freezing.

SAFE PRACTICE FOR STORAGE OF BITUMINOUS OR SEMIBITUMINOUS COAL

1. Prior to storage, clear ground or floor of leaves, grass, weeds, pieces of wood, cotton waste, or other foreign matter. Utmost precaution must be taken to prevent foreign matter from getting under, into, or on the coal pile.
2. There shall be no steam or other pipe, or sewer or other openings under, into, through, or adjacent to coal piles.
3. The floor, walls, and ceiling of coal-storage bins in buildings shall be of incombustible material for quantities of coal exceeding a 30-day supply.
4. In storing coal, avoid dropping any considerable distance; otherwise breakage will occur and it is thought that the surfaces of newly broken fine particles of coal are more than ordinarily susceptible to oxidation.
5. For storage of 50 tons or more, provide concrete bins divided into stalls, each stall holding 25 or 50 tons. It is recommended that the coal be piled not higher than 15 feet.
6. Large coal piles should be made by depositing the coal in layers of about 3 feet depth and compacted with a steam roller; after intervals of 3 days add other layers.
7. Avoid alternate wetting and drying; it is dangerous to have one part wet and another part dry.
8. At intervals of 15 to 20 feet it is permissible to have ½-inch or 1-inch pipes extending nearly to the bottom of the pile to allow the use of thermometers and thus determine temperatures. However, automatic heat alarms are preferable for the determination of temperature in storage coal piles.
9. "Wetting-down" the pile upon finding that it is heating is not a good policy unless the water can be directed at the seat of the fire or heating.

Reference: "Spontaneous Heating and Ignition of Coal and Other Mining Products" prepared by National Fire Protection Association Committee on Spontaneous Heating and Ignition. (1936)

SAFE PRACTICE FOR HEATING SYSTEMS

1. Prior to the heating season remove draft pipes connecting the furnace or stove to the chimney and clean accumulations of soot within the pipe.
2. Examine draft pipe for pinholes or soft spots and replace defective lengths of draft pipe with new sections.
3. In replacing the stove or draft pipes, all connections should be tight. The sections of stove or draft pipe should be riveted together or otherwise rigidly fastened. Close spaces between draft pipe and the chimney opening with furnace cement.
4. Remove ashes and soot from the furnace or stove and also from all flues in the furnace or range. Scale accumulations should be removed also in the interest of economy and better performance.
5. Remove soot in chimney below the connection from the draft pipe to the chimney.
6. For oil-burning units, check fuel-oil valves and steam-atomizing valves.
7. See that oil-burner tips are in good condition and clean.
8. Keep the premises around the furnace clean and watch closely for fuel-oil leaks.
9. Safety valves are designed to shut off the flow of oil automatically in case of emergency. Safety valves should be kept in good condition and adjustments of such valves should be made by men familiar with the equipment.

SAFE OPERATING PRACTICES FOR MOTOR-BOATS

1. Keep boats clean, in good condition, and fitted with necessary equipment.
2. Before starting engine, precautions shall be taken to remove flammable vapors from engine compartment.
3. Before starting engine, make sure that all connections in gasoline piping or tubing are free of leaks.
4. Shut-off valve near gasoline tank shall be kept closed when engine is not in operation.
5. Boats shall not be fueled when engine is in operation.
6. Except in emergencies, boats shall not be fueled at night.
7. Open flames shall not be allowed in the vicinity of the gasoline tank while filling cap is removed. A flashlight shall be used if a portable light is needed.
8. Caps for filling connections shall be in place except when tanks are being filled.
9. Gasoline shall not be used for cleaning.
10. Oily rags shall be kept in a self-closing metal waste can.
11. An adequate set of tools for use in making emergency repairs shall be kept in the boat.
12. Spare parts for emergency repairs, also a list of such parts, shall be kept in the boat.
13. Manufacturer's instruction book for the engine shall be kept in the boat.
14. A first aid kit with adequate contents shall be kept in the boat.
15. One or more fire extinguishers shall be kept in the boat.
16. A serviceable life preserver for each person on board shall be kept in the boat.

Chimney damaged by lightning. Note cracks. Brick from chimney broke windows more than 100 feet away. Lightning-protection systems are needed in some areas.

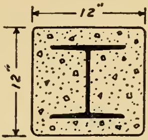
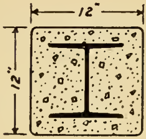
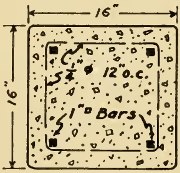
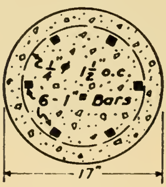
BEHAVIOR OF BUILDING MATERIALS IN EXPOSURES TO FIRE AND WATER

Source: Bulletin 370, "The Fire Resistance of Various Building Materials," of the U. S. Geological Survey, United States Department of the Interior, by Richard L. Humphrey

Building material	Exposure to fire	Exposure to water after fire
Brick	Has good record both in tests and in severe exposure to fire in conflagrations.	Water applied to hot wall results in spalling.
Granite	Will explode and fly off in fragments or disintegrate into sand when exposed to severe fires.	Face washed off to depth of ¼ inch. (Note: On removal from test panel specimens broke into small pieces.)
Limestone	Becomes calcined or decomposes into lime and cracks when subject to intense heat.	Face washed off to depth of 1¼ inches. (Note: On removal from test panel specimens broke into small pieces.)
Marble	Similar to limestone. In tests it calcined and became chalky white.	Face washed off to depth of 1 to 1½ inches. (Note: On removal from test panel specimens broke into small pieces.)
Sandstone	Varies. In tests deep seams developed and it was subject to spalling.	Face washed off to depth of ¼ inch. (Note: On removal from test panel specimens broke into small pieces.)

FIRE RESISTANCE
OF
REINFORCED CONCRETE COLUMNS

Source: "Fire Tests of Building Columns," technologic paper of the National Bureau of Standards № T 184, April 1921

TEST №	SECTION	PROTECTION	FIRE RESISTANCE
28 A*	 Rolled H	2" 1:2:4 Concrete (Limestone Aggregate)	7 hrs. 9¼ min.
30	 Rolled H	2" 1:2:4 Concrete (Joliet Gravel Aggregate)	7 hrs. 16" min.
70		2" 1:2:4 Concrete (Limestone Aggregate) (70)	8 hrs. 40¼ min.
71		2" 1:2:4 Concrete (Trap Rock Aggregate) (71)	7 hrs. 22¾ min.
74		2" 1:2:4 Concrete (Limestone Aggregate) (74)	8 hrs. 6½ min.
75		2" 1:2:4 Concrete (Trap Rock Aggregate) (75)	8 hrs. 1¾ min.

SELECTED REFERENCES AND STANDARDS

Crosby-Fiske-Forster Handbook of Fire Protection. National Fire Protection Association, Boston, Mass. Ninth Edition, 1941. $4.50.

Manual of Fire Loss Prevention of the Federal Fire Council. (National Bureau of Standards Handbook No. 19.) Superintendent of Documents, Washington, D. C. 1934. 20 cents.

Recommended Minimum Requirements for Small Dwelling Construction. (National Bureau of Standards Building and Housing Publication No. 18.) Superintendent of Documents, Washington, D. C. 1932. 10 cents.

Recommended Minimum Requirements for Fire Resistance in Buildings. (National Bureau of Standards Building and Housing Publication No. 14.) Superintendent of Documents, Washington, D. C. 1931. 10 cents.

Protection of Records. National Fire Protective Association, Boston, Mass. 1939. 50 cents.

Employee Organization for Fire Safety. National Fire Protection Association, Boston, Mass. 1942. 25 cents.

Specific Hazards, Parts I and II; Hazards, Their Development and Control, Parts I and II; and The Human Factor. Prepared by M. K. Rouse, Board of Fire Underwriters of the Pacific, San Francisco, Calif. 1941.

A Safety Program for the National Park Service, Office of Indian Affairs, and the Bureau of Reclamation. (Report to the Secretary of the Interior of the Interior Department Committee on Health and Safety.) 1937. Superintendent of Documents, Washington, D. C. 10 cents.

Fire Tests of Wood and Metal Framed Partitions, by S. H. Ingberg and Nolan D. Mitchell. (Report BMS 71, National Bureau of Standards.) 1941. Superintendent of Documents, Washington, D. C. 20 cents.

Building Exits Code approved by the American Standards Association. National Fire Protection Association, Boston, Mass. 1942. $1.00.

Design and Construction of Building Exits. (National Bureau of Standards Miscellaneous Publication M 151.) Superintendent of Documents, Washington, D. C. 1935. 10 cents.

Code for Protection Against Lightning. (National Bureau of Standards Handbook, H 21.) 1937. Superintendent of Documents, Washington, D. C. 15 cents.

Standards recommended by the National Fire Protection Association and published by the National Board of Fire Underwriters, New York, N. Y.:

- Centrifugal Fire Pumps.
- Containers for Storing and Handling Flammable Liquids.
- First Aid Fire Extinguishers.
- Garages.
- Gravity and Pressure Tanks.
- Internal Combustion Engines.
- Liquefied Petroleum Gas.
- National Electrical Code.
- Oil Burning Equipment.
- Outside Protection (Water System).
- Paint Spraying and Spray Booths.
- Photographic and X-ray Nitrocellulose Film (Storage and Handling).
- Private Fire Brigades.
- Protection of Openings in Walls and Partitions.
- Small Heating and Cooking Appliances.
- Sprinkler Equipments.
- Standpipe and Hose Systems.
- Water Spray Nozzles.

A Standard Ordinance for Chimney Construction. National Board of Fire Underwriters, New York, N. Y. Third Edition, 1927.

Hose Houses for Mill Yards. National Fire Protection Association, Boston, Mass. 1936.

INDEX

U. S. GOVERNMENT PRINTING OFFICE: 1943