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FIRE PROTECTION DURING CONSTRUCTION . . . A CRITICAL TIME

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Introduction and Background

The potential for fire is greater during construction than at any other time. A large number of fires occur which result in property loss and personnel injury. Factors contributing to this vulnerable period are accumulation of combustible materials and debris, the presence of ignition sources, and limited means to control or extinguish fires. Regardless of the type of building, fires are preventable or at least controlable.

In 1981, the National Fire Protection Association (NFPA) reported a total of 17 large-loss construction fires with a total loss valued over $105,000,000. Table I shows the large-loss fires as a function of property use for 1981. Table II shows the construction fires and losses for 1978-1981. Considering that the construction period is 2-10 years while the building life is 20-50 years, the construction losses are disproportionately higher than at any other time. In 1981, construction fires represent 6 percent of those reported and 13 percent of the total dollar loss.

A major insurance carrier for nuclear properties reported 92 fires in nuclear power plants under construction and only 13 fires in operating plants (1955-1977) (2). Two-thirds of the damage was sustained by plants under construction. The area of fire protection during construction is often overlooked or given meager consideration. Statistics, however, indicate a need for an emphasis on adequate fire protection.

Buildings are constructed for availability by a certain date to meet the owner's requirements for specific operations. Fire-delayed completion of a building or project can result in costly revisions, disruption of future plans and/or contracts, and even the economic viability of the owner. Expected occupancy of the building, delivery of products, or contractual commitments to supply materials may be affected. For example, in March 1975, a fire at the TVA Browns Ferry Nuclear Plant started with the testing of cable fire stops (with a lighted candle) in the unit under construction. Two operating units were also involved and the direct loss was

ABSTRACT

The need for adequate fire protection during a construction project is reviewed. Specific suggestions are made in fire protection program development - responsibilities, requirements, and standards; fire equipment and systems - water suply, hydrants, standpipes, sprinklers and extinguishers; human resources - fire brigade and watchmen; and administrative control of combustibles and work methods - housekeeping, temporary facilities, tarps, crating and packing materials, scaffolding and framework, temporary heating devices, welding and cutting, flamable liquids and lay down areas.

Table I

Large-Loss Fires* - 1981

Property Use	Number Fires	Loss
Public Assembly	27	$ 15,625,000
Educational	23	$ 44,625,000
Institutional	3	$ 4,465,000
Residential	13	$ 31,897,000
Stores and Offices	42	$109,796,500
Basic Industry - Utility/Defense	14	$ 89,580,000
Manufacturing	79	$193,786,800
Storage	47	$104,669,200
Under Construction	17	$105,196,200
Other	15	$ 83,050,800
Total	280	$818,691,500

Source

NFPA, Fire Journal, September 1982, pp. 37-38 Table 3

*Large-Loss fire is defined as over $1,000,000 (1980 & 1981) and over $500,000 (before - 1980)

Table II

Large-Loss Fires During Construction

	1978	1979	1980	1981
Number	16	26	15	17
Loss ($)	$18,767,000	$27,665,000	$35,708,000	$105,196,000
Percent of Total Fires	3.4%	4.2%	4.6%	6%
Percent of Total Loss ($)	2.6%	2.7%	4.6%	13%

$10,000,000. An additional indirect loss of at least $30,000,000 related to business interruptions was sustained. The fire resulted in a lengthy schedule delay of the unit under construction.

A study (2) of a number of construction fires accounting for financial loss traced the origins to the following:

o	portable heating equipment	25%
o	cutting, welding, and plumbing torches	20%
o	matches and smoking	15%
o	other	40%

Misuse of the first three items was responsible for 60 percent of the fires studied. These items are found on all construction sites varying in size and level of sophistication from a small office building to a large nuclear power plant. Controls to prevent misuse should be included in the overall fire protection program to significantly reduce the incidence of fires.

The architect/engineer, construction manager, and owner have a stake in the successful and timely completion of a project. Although the levels of responsibility and relationships between these participants may vary according to the type and complexity of the project, this team must acknowledge and accept the responsibility to establish fire protection during construction.

Significant areas to be addressed for effective fire protection during construction are the following:

1. Fire Protection Program Development
2. Fire Suppression Equipment and Systems
3. Human Resources
4. Administrative Control of Combustibles and Work Methods

This report will review fire protection and fire prevention principles. Application of these principles should minimize the frequency and severity of fires occurring during construction.

Fire Protection Program Development

Responsibility

The fire prevention and protection program should be administered and enforced by either the construction manager or the owner's representative. Fire hazards can thereby be corrected immediately. These corrections will not be subjected to the delays which frequently accompany contract changes and subsequent negotiations. If the project is large, a fire safety directory or safety committee is appointed to assure compliance with the fire protection program. Their duties include the following:

1. Inspections
2. Resolution of recommendations resulting from inspections
3. Job-site meetings
4. Maintenance of records
5. Fire drills
6. Assignment of responsibility for correction of deficiencies
7. Appropriate record keeping

As litigation becomes more popular and as federal, state, and local regulations become more stringent, complete record keeping is a necessity.

Program Requirements

The construction fire protection program must address all aspects of the project. The basic considerations involved are site preparation, control of temporary buildings, fire protection, and control of inherent construction hazards (3). The program must include the following:

1. Early planning for fire protection
2. Fire protection measures in appropriate contract specifications and drawings
3. Early progressive installation of fire protection systems

4. Close control of combustibles and work methods
5. Oranization and training of a fire brigade

Details of the program are established early in project planning. The local fire department and insurance carrier must become involved in this phase to insure a good working relationship during the entire project. Early changes or improvements are then permitted without adverse financial or schedule impacts.

Standards

There are a number of comprehensive standards, guidelines and specifications which addess fire protection needs during construction. The source of most of these guidelines can be divided into 3 categories, consensus standards or organizations, regulatory agencies, and insurance companies. General guidelines exist which are applicable to all industries. The "Standard for Safeguarding Building Construction and Demolition Operations" (NFPA 241) is one of the primary sources of information and a major reference for many of the guidelines. More specific guidance exists for particular industries such as nuclear power, whose regulations are promulgated by the Nuclear Regulatory Commission and the nuclear insurance industry. Table III lists various agencies and their guidelines.

Contract Requirement

Construction contracts should detail the practices of the fire protection and prevention program followed by the contractor. These practices include requirements for trash removal, the storage of flammable liquids, restrictions on smoking, and methods of transmitting fire alarms. The requirements for the control and proper use of welding, cutting or other heat producing appliances should be specified. Control can be achieved through a permit system, regulations, guidelines or rules of conduct. Preplanning with the contractor to determine the exact method of control of the heat producing appliances prior to their use should be required. Particular requirements for the project are specified, such as the type of construction materials and the installation schedule for both temporary and permanent fire protection.

The inclusion of a fire program in the construction contract eliminates claims and counterclaims for responsibility for delays, cost extras, and various liability problems after project completion. An ounce of prevention is worth a pound of excuses.

Fire Suppression Equipment and Systems

Protection for the building should be installed in the early stages of construction and should progress with the work. The permanent fire protection system should be installed and utilized as early as possible.

The fire equipment and systems for providing construction fire protection include the following.

Water Supplies and Distribution

To provide early protection, temporary systems incorporating portions of the permanent system components should be installed. Since a permanent water supply is sometimes not available until late in the construction schedule, the water main and distribution system should be installed as soon as combustible material starts to arrive on the jobsite. The minimum water supply should be chosen according to the specific type of construction, site layout, project size, and hazards. A minimum supply of 500 gpm must be provided. The local fire department or authority having jurisdiction, as well as the insurance carrier, may require a larger water supply and should be consulted in the early planning stage.

Hydrant Protection

Outside hose stations (protected from freezing in colder climates) and hydrants should be strategically located. The hydrants should be provided with a hose house

Table III

Guidelines
Fire Protection During Construction

Agency	Title of Publication
Consensus Standards Organization	
NFPA	Standard No. 241 - "Safeguarding Building Construction and Demolition Operations"
	Other applicable Standards (Nos. 10, 12, 13, 24, 58, 70 etc.)
ANSI	American National Standards Institute - Appliable Standards
Regulator Agencies	
U.S. Department of Labor	Occupational Safety & Health Administration (OSHA) 29CFR1926 - Construction Industry Sub-Part F - Fire Protection & Prevention
State & Local Agencies	Safety/Fire Protection Codes
Insurance Industry	
American Nuclear Insurers	"Basic Fire Protection for Nuclear Power Plants"
Nuclear Mutual Limited	"Property Loss Prevention Standards for Nuclear Generating Stations"
Industrial Risk Insurers	"Overview - Management Program for Loss Prevention & Control" formerly "Recommended Good Practice for Protection of Buildings Under Construction"
Factory Mutual System	"Loss Prevention Data - Safeguards During Building Construction"

containing a full complement of tools, nozzles, and appliances. These are particularly valuable in protecting temporary contractor buildings in the vicinity of the permanent construction work. The protection of outlying lay-down and contractor work areas by temporary underground water mains is desirable but may not be economically justifiable. In assignment of work areas, high value combustible storage and major contractor buildings should be located where water main protection can be obtained economically.

Standpipes

As the permanent building is erected, temporary 1-1/2 in. hose stations and standpipes should be installed at each elevation. The piping should be heat-traced or insulated for freeze protection, as required. As the permanent standpipes are installed, those temporary stations are relocated to utilize the permanent system. The standpipes should have a 2-1/2 in. outlet with a reducer to 1-1/2 in., and particular care should be taken to insure the use of local fire department hose thread on the standpipe outlets.

Standardized hose threads are nonexistent throughout the United States and in certain areas vary from town to town. An early meeting with the fire department to determine the correct hose threads is very important since incorrect hose thread can delay the fire department's ability to extinguish a fire.

Hose stations are frequently blocked by stored parts, construction tools, and other construction material. Contractors frequently make permanent connections to the 1-1/2 in. outlets to obtain construction water. These problems require frequent inspections and must be corrected immediately.

Sprinkler Systems

Sprinkler systems are provided in some areas of the permanent building and are installed as the work progresses. Large temporary and permanent warehouses, contractor engineering offices, and other highly valued buildings should be supplied with sprinkler systems.

Extinguishers

A wide distribution of portable fire extinguishers is extremely important. Pressurized water, dry chemical, and CO_2 extinguishers should be provided in the proper areas.

Multi-purpose dry chemical extinguishers (rated at least 2A-20B:C) are popular with some construction managers and workers. Constant surveillance is required to restock missing or discharged units because units often appear to "walk off the site" by themselves.

Special Systems

Some projects have special hazards and unique requirements. In nuclear power plant construction, a large volume of important paperwork in generated. Quality assurance records and documents are an important prerequisite in obtaining an operating license from the Nuclear Regulatory Commission. Consequently, records vaults are located in the owner's field engineering offices and in some contractor buildings. These vaults are constructed with a minimum rating (3-hour firewall) and are provided with either Halon 1301 or sprinkler protection.

Fire Apparatus

For large construction sites it may be desirable to have some type of fire apparatus such as a pickup truck with a water tank and 100 gpm pump. This will allow some remedial fire fighting in outlying areas where hydrant protection is not cost effective. An equipment truck or trailer can be kept under close supervision and can respond to fire emergencies with adequate and reliable equipment.

Human Resources

Fire Brigades

Unless locations are within a municipal fire district and are quite close to the nearest fire station, a large measure of protection rests with the people at the construction site. A minimum of 20 key people, familiar with the water supply system, electrical power system, and other fire protection features, is the desired brigade manpower level. Training of all contractor personnel in the use of first aid fire equipment is desirable. A fire brigade, composed of watchmen and other key personnel, should be organized for each shift and trained to a written, pre-fire plan. This pre-fire plan includes instruction for activation and use of the fire protection equipment, and use of communication equipment needed to notify other personnel and the local fire department. Monthly drills are conducted with particular emphasis on hose lines for inaccessible areas.

Watchman Service

Watchman service is often taken for granted but it is important. Watchmen protect the property against trespassers and arsonists, control the orderly movement of people during working hours, and are responsible for the overall safety of the property.

Approximately 12 percent of the large loss fires (1981) were discovered by watchmen making their rounds. Many fires occurring on construction sites after hours are discovered by watchmen and are extinguished at the incipient stage.

Administrative Control of Combustibles and Work Methods

Administrative control over accumulated combustibles and hazardous work is essential. The human factor must be considered because of the large number of construction people on the site. It is often difficult to secure the cooperation of the contractors for so called "nonproductive activities." Problems to be overcome include the following.

Housekeeping

Combustible waste should not be allowed to accumulate or be stored within the building or the immediate vicinity but should be removed from the premises as quickly as possible. On one project the prime contractor conducted weekly inspections of all critical areas resulting in substantial improvement in the overall housekeeping.

Temporary Facilities

If temporary facilities used as contractor offices, tool or material storage are within the permanent building, these facilities should be made of noncombustible construction.

Tarps, Crating, and Packing Material

The use of fire retardant, plastic matrials provides an excellent tool for fire prevention in construction areas. Plastic tarps can be used to cover equipment inside the permanent buildings and to form enclosures for heating areas during the curing of concrete. Packing matrials such as plastic pellets, shredded paper, straw, and excelsior are particularly vulnerable to ignition from welding or smoking sources. Prompt removal is necessary. The heavy waterproof plastic covering found on some large equipment crates should be examined for flammability.

Although contractors may claim that their tarp materials are fire retardant and that equipment containers shipped by vendors have fire retardant wrapping, an informal fire test of samples is advisable. The results often prove that the contractor has been misled or is unaware of the flammable properties of the materials. Testing and sampling of materials or documentation review must be made to insure that fire retardant material is provided. This attention will force the contractor to comply.

Scaffolding and Formwork

Combustible scaffolding and formwork present the greatest threat of a widespread, disastrous fire inside the building. Use of metal or fire retardant forms, treated timbers, and planking is advisable. Exclusive use of fire retardant materials is the ideal solution. As this is usually more costly than insurance premium savings, it is not popular with contractors. Purchase orders for fire retardant materials should be checked and samples of scaffolding and formwork checked to insure compliances with these requirements.

Serious time delays resulting from fires should also be considered when making this decision. At the very least scaffolding and planking in congested areas should be fire retardant. The type of treatment should be evaluated according to the nature of the project. For example, the fire retardant treatment for a nuclear power plant must be free of chlorides or other halogenated compounds and must be leach resistant since permanent stainless steel piping and vessels could be adversely affected by these chemicals. This consideration may also apply to some chemical refineries and petrochemical plants.

Temporary Heating Devices

Every imaginable temporary heating device, including open drum wood fires, closed steel drums fired by scrap lumber, and homemade propane fired perforated cans, can be found inside buildings under construction. Only UL listed heaters should be permitted and under no circumstances should gasoline devices be allowed.

Many fires caused by temporary heating devices are due either to faulty propane hose installations or to combustibles stored too close to heaters. Constant surveillance is required since these devices are moved on a daily basis.

Every effort should be made to locate propane tanks for heaters outside the permanent buildings.

Welding and Cutting

Welding and cutting is by far the greatest construction activity contributing to fires. The NFPA cutting and welding permit system should be used under the supervision of the responsible fire safety director. A permit should not be issued unless:

1. It has been determined that cutting and welding can be safely conducted at the desired location
2. Combustibles have been moved away or safely covered
3. A fire watchman with extinguishers is posted during the work period and for at least 30 minutes after completion when the possibility of sparks or drops of hot metal starting a fire is possible

Flammable/Combustible Liquids

On-site storage of solvents, oil-base paints, and thinners should be controlled and held to one-day's consumption. Proper ventilation should be provided in areas where flammable liquids are used.

Contractor Areas and Lay-Down Areas

There is usually a proliferation of combustible shacks, shops, and outside storage areas at all major construction sites. Protection should be provided by temporary water mains with hydrants and hose houses, as well as by sprinkler protection of major structures.

Spacing individual units at least 10 feet apart and maintaining at least 30 feet of clear space around clusters of buildings having an aggregate area over 3,000 square feet reduces fire and loss potential. At least 30 feet of clear space is required around permanent buildings. Greater clearances should be considered in high-wind areas or where the water supply is limited. Storage inside designated lay-down areas should have fire breaks at frequent intervals.

Decision Process

The decision-making process in planning a fire protection and prevention program for construction must consider the following:

1. Combined value of buildings and installed equipment
2. Length of construction period
3. The building's proximity to municipal fire protection
4. Insurance rate penalties for an inadequate program
5. Costly retrofit work to comply with regulatory or insurance requirements
6. Length of delays in replacement and/or requalification of damaged equipment
7. Increased costs due to major fire losses or repetitive smaller fire losses

Conclusions

In order to be effective, a fire protection and prevention program must include the following:

1. The assignment of responsibility for planning and administration of the program by the owner or construction manager
2. The early development of specific program requirements for a project
3. The use of available industry standards and specifications for the details of implementation of the program requirements
4. Inclusion of fire protection program requirements into construction contracts
5. The early and progressive installation of fire protection equipment and systems
6. Establishment of a trained fire brigade and watchman service
7. The control of combustibles and work processes

Fire protection is needed during the critical construction phase. The owner, construction manager, and design professional must work together to implement these fire protection principles and concepts.

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ABOUT THE SOCIETY . . .

Organized in 1950, the Society of Fire Protection Engineers is the professional society for engineers involved in the multifaceted field of fire protection engineering. The purposes of the Society are to advance the art and science of fire protection engineering and its allied fields, to maintain a high ethical standing among its members, and to foster fire protection engineering education. Its world-wide members include engineers in private practice, in industry, in local, regional, and national government, as well as technical members of the insurance industry. Chapters of the Society are located in the United States, Canada, Europe, and Australia.

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