INTERIM REPORT

Accession No. 7911120391

Contract Program or Project Title:	Fire Protection in Operating Nuclear Power Stations
Subject of this Document:	The Methodology of Manual Fire Fighting as Applied to Operating Nuclear Power Plants
Type of Document:	Informal Report
Author(s):	R.E. Hall, J. Riopelle, and J. Townley
Date of Document:	August 1979
Responsible NRC Individual and NRC Office or Division:	R.L. Ferguson Plant Systems Branch U.S. Nuclear Regulatory Commission Washington, D.C. 20555

This document was prepared primarily for preliminary or internal use. It has not received full review and approval. Since there may be substantive changes, this document should not be considered final.

Brookhaven National Laboratory
Upton, NY 11973
Associated Universities, Inc.
for the
U.S. Department of Energy

Prepared for
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555
Under Interagency Agreement EY-76-C-02-0016
NRC FIN No. A-3107

INTERIM REPORT

LIMITED DISTRIBUTION

BNL-NUREG 26739

INFORMAL REPORT

THE METHODOLOGY OF MANUAL FIRE FIGHTING AS APPLIED TO OPERATING NUCLEAR POWER PLANTS

R.E. HALL, J. RIOPELLE, J. TOWNLEY

POOR ORIGINAL

DATE PUBLISHED - AUGUST 1979

DEPARTMENT OF NUCLEAR ENERGY BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Contract No. EY-76-C-02-0016

1313 289

1313 290

BNL-NUREG-26739
INFORMAL REPORT
LIMITED DISTRIBUTION

THE METHODOLOGY OF MANUAL FIRE FIGHTING AS APPLIED TO OPERATING NUCLEAR POWER PLANTS

R. Hall, J. Riopelle, J. Townley

Engineering and Advanced Reactor Safety Division
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, New York 11973

Original Manuscript February 1979

Revised August 1979

Prepared for
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
Under Interagency Agreement EY-76-C-02-0016
NRC FIN No. A-3107

1313 292

NOTICE: This document contains preliminary information and was prepared primarily for interim use. Since it may be subject to revision or correction and does not represent a final report, it should not be cited as reference without the expressed consent of the author(s).

TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	1
1. INTRODUCTION	2
2. GENERAL DISCUSSION AND CONCEPTS	4
3. ADMINISTRATIVE CONTROLS	8
3.1 Flammable and Combustible Liquids	8
3.2 Liquefied Gases	10
3.3 Cryogenic Gases	11
3.4 Solid Combustibles	11
3.5 Administrative Fire Prevention Practices	12
4. THE FIRE BRIGADE	14
4.1 Personnel	14
4.1.1 Composition and Duties	14
4.1.2 Training	18
4.1.3 Utilization of Public Fire Fighting Service and of Offsite, Call Back, Personnel	23
4.2 Tactical Procedures	25
4.2.1 Pre-fire Procedures	29
4.2.2 Fire Drills	32
4.2.3 Development of Strategies	34
5. FIRE FIGHTING EQUIPMENT	39
5.1 Water Supply	39
5.2 Hoses and Nozzles	43
5.3 Extinguishers	46

1313 293

TABLE OF CONTENTS (Cont'd)

	Page
5.4 Emergency Breathing Air	47
5.5 Mechanical Smoke Ventilation	50
5.6 Fire Fighters' Protective Clothing	52
5.7 Tools and Appliances	[illegible]
6. CONCLUSIONS	[illegible]5
REFERENCES	57
APPENDIX A - Recommended Fire Brigade Training Outline	58

1313 294

EXECUTIVE SUMMARY

The commercial nuclear power industry, to date, has successfully utilized the concept of "defense-in-depth" to reduce the probability of severe accidents that could release radionuclides to the biosphere. This report extends this methodology to the analysis of the necessary fire protection as applied to the operation of currently designed nuclear power stations. In the four levels of fire protection developed, the need for manual intervention on each plane in the fire scenario becomes evident. Because of the uncertainties in the state-of-the-art of fire protection engineering, complicated by the complex geometrical structures of a nuclear power station, special concern is warranted in the development of the methods of manual fire fighting.

This report is based on one part of a three year program in which Brookhaven National Laboratory assisted the Division of Operating Reactors of the U.S. Nuclear Regulatory Commission in the detailed review of fifty-five operating nuclear power stations on a site specific basis. The report includes the various aspects of the atypical problems found in the nuclear station that may impact the manual fire fighting capabilities along with recommendations as to how to develop a responsive, independent manual fire fighting capability. It is hoped that by utilizing the sections of this document, along with their references, a comprehensive baseline program can be developed and effectively implemented.

1313 295

1. INTRODUCTION

Nuclear power plants have been in operation in the United States since the early 1960's. In the approximately 16 years of commercial operation, there have been an estimated 59 reported fires in 34 of these plants. Just as in other types of property, these fires started from a variety of causes. Likewise, the results of these fires varied from minor inconvenience to serious damage.

On March 22, 1975, a major fire occurred at the Browns Ferry Nuclear Power Plant operated by the Tennessee Valley Authority and located near Decatur, Alabama. The material which contributed most to this fire was electrical cable insulation. Although cable insulation had been significantly involved in a number of fires before Browns Ferry, the magnitude of this particular fire, and its implications regarding the safety of nuclear power plants have led to the initiation of numerous programs for the evaluation of fire protection as related to the nuclear power industry.

One method of establishing the need for fire protection level of safety is to utilize the proven technique of defense-in-depth. This concept, when applied to fire protection, can be subdivided into four levels of defense:

1. Prevention
2. Detection
3. Suppression
4. Containment

Each level of defense, being independent from the others, supports the defense against safety significant fires. If one level fails, the others provide for an active redundancy.

If the administration controls were perfect, such that there were no combustibles and/or ignition sources, perhaps the other levels of protection would

1313 296

not be needed. Based on experience, we know this is not the case. Therefore, in spite of the prime objective of fire prevention, fires are expected to occur and means must be provided to detect, extinguish, and control them.

To carry out the above principles, fixed detection and suppression systems are normally provided in areas where safe shut down equipment or components are adequately separated and backup manual fire fighting is provided to limit the extent of a fire by having portable fire extinguishing equipment available for use by properly trained fire fighting personnel. In relation to suppressing fires that occur in the plant, the fire brigade, manual fire fighting capability, can be considered as both the first line of defense for the extinguishment of incipient fires and as the ultimate line of defense for the extinguishment of fires that have not been suppressed by the automatic fire suppression systems. Between this wide spectrum is a vast area where the adequately sized, properly equipped and fully trained fire brigade plays a vital part in the defense-in-depth principles of nuclear plant fire protection. This report will explore this area in the attempt to clarify standard fire fighting practice in light of the complexities of a nuclear power station.

1313 297

2. GENERAL DISCUSSION AND CONCEPTS

It is expected that the manual fire fighters will be capable of extinguishing most fires that occur while they are in the incipient stage and in many instances before the automatic suppression system functions. This expectation relates directly to the objective of "extinguishing them quickly and limiting their damage."

It is further expected that the fire brigade will be capable of taking proper, quick action to limit the fire spread and control possible damage that may occur following the operation of the automatic suppression system. This also places the brigade in a position of major importance in relation to the objectives mentioned in the above paragraph.

Ultimately the need for a fully trained, adequately supplied fire brigade becomes essential when a fire has reached the magnitude that it cannot be readily extinguished and the brigade must carry out a confine and control operation while awaiting the arrival of additional assistance, or in the extreme until the plant is safely shut down and the fire area can be abandoned to the fire. Even then the brigade and other available assistance will be required to protect the exposures surrounding the fire area to prevent an unmitigated fire from resulting in completely uncontrolled circumstances that affect maintaining the safe shut down of the plant.

There is a recognized "principle" in fire suppression that states that there are only three major objectives directly related to fire suppression:

1. Rescue
2. Extinguish, and
3. Confine, control and extinguish.

Which of these objectives that are to be selected depend upon the critical factors that are present at any fire. The order of these objectives never changes; however, where there is no need for rescue, the first objective can be "extinguish." Even where it is necessary to first confine the fire, then bring it under control the final step is extinguishment.

In order that any one, or all, of the major objectives can be carried out, there are a great many "minor" objectives that lead to accomplishment of the major goal, such as:

Locate the fire and ascertain its potential

Localize the fire, alleviate smoke and heat conditions, improve visibility and facilitate the advance of hose lines.

Extinguish the fire by application of the correct extinguishing medium in sufficient amount to accomplish. Minimize damage; judiciously use water or other extinguishing agent.

Protection of personnel, provide ventilation, self-contained breathing equipment and protective backup capability.

Coordinate activities through adequate supervision and communication.

All fires include certain primary factors that must receive attention. Some of these are:

Life hazard for occupants	Time of discovery
Life hazard for personnel	Time of alarm
Location of fire	Time of response
Extent of fire on arrival	Heat conditions
Construction of fire building	Visibility
Construction of exposures	Smoke conditions
Area of exposures	Exposure hazard
Proximity of exposures	Class of fire
Structural collapse of fire building	Auxiliary applicances in the fire building

and in the case of a fire in a nuclear plant, the ultimate release of radionuclide to the biosphere. The combination of effects that each has upon the other are many, all of which require the attention, to some degree, of the

1313 299

fire commander (the fire brigade leader) and of the fire brigade.

It is not difficult from the above to see that there are special problems in nuclear plant manual fire fighting. Perhaps the most significant of the factors listed is that of CONSTRUCTION OF THE FIRE BUILDING. The construction of the major portions of nuclear power plants are usually of reinforced concrete, often seismically qualified and are generally WINDOWLESS, having an extremely limited potential for emergency removal of the products of combustion. Additionally these structures are constructed in such a way that many floor levels of the plants are either below, or in some cases at great heights above, the ground level. Ground level access to the various structures is often limited for security and/or operational reasons. Internal access to many areas is made difficult by the design of the structure and/or by operational conditions and security measures.

Access to specific equipment or to specific portions of a given area are often obstructed by the concentration of cable trays, cables, conduits, piping, cabinets and consoles and other equipment. Some plants have areas where concentrations of cable trays cover large square foot areas and extend to great heights above the floor area and where access to the upper areas is extremely difficult.

Each of the problems mentioned has a singular direct bearing on the manual fire fighting capability of a nuclear plant; however, since each can be considered a primary factor, each one will have an effect upon or will be affected by the others. For example, any fire that occurs at a level below the access route of the fire brigade will cause problems in relation to the natural tendency of smoke and heated gases of combustion to rise upward through an accessible area. If the accessible area happens to be the stairway or stairwell, the fire fighters will have to penetrate downward through the smoke/gas to reach the fire. In this example, the more serious the fire, the more difficult this problem becomes.

Associated with the above problem could be the serious question of where and how the fire brigade is going to vent the smoke and gases of combustion to facilitate the control and extinguishment of the fire without creating additional damage to equipment in other areas or a release to the atmosphere of contaminated smoke if the fire is in a controlled area. The outstanding need to understand the site specific problems of nuclear plant fire fighting makes the requirement for pre-fire procedures and strategies more readily understood.

All of the minor objectives, listed previously, in this report should be considered special problems in nuclear plant manual fire fighting. There are other complications that are to be expected in nuclear power plant fire fighting and it is imperative that each facility make a detailed evaluation of the conditions specific to the site and use this information in the development of pre-fire strategies and procedures. (See Section 4.2).

The following sections of this report will discuss accepted manual fire fighting methodology, as modified by the complications of the commercial power stations environment.

3. ADMINSTRATIVE CONTROLS

The first level of defense in this multi level approach, is to prevent the incident, fire, from occurring. Adequate controls of fuel and ignition sources, in the form of documented administrative controls, are needed when considering the complex mass of structures, systems, and paper flow that is called a nuclear power station. The more realistic and customized to the specific facility that the operating guidelines are the more dependable they will prove. If restrictive controls are truly needed perhaps written guidelines are not the solution. In all cases the administrative controls are only as effective as their implementation. Once the guidelines are written and implemented, it is recommended that the other levels of defense are designed predicated on the failure of the controls.

In the following subsections, classes of liquids, gases and solids that are commonly found in a commercial nuclear power station are discussed along with recommendation as to their safe usage. These descriptions and definitions are directly applicable when attempting to develop meaningful administrative controls of fuel and ignition sources that are present during operation and maintenance of the plant.

3.1 Flammable and Combustible Liquids

The safe storage and use of a variety of flammable and combustible liquids commonly available and generally in use in nuclear power plants depends primarily on their fire characteristics, particularly on each product's flash-point. As a guide and for this purpose a flammable liquid may be simply defined as a liquid having a flash-point below 100°F. Typical examples are gasoline, acetone, benzene, hexane, and methyl alcohol. A combustible liquid may

1313 302

be simply defined as a liquid with a flash-point above 100°F. Typical examples are lubricating oils, diesel oil, and kerosene. For more precise definitions, and detailed explanations of the classification of flammable and combustible liquids, see Section 3, Chapter 3, of the NFPA Fire Protection Handbook, 14th Edition[1], and Section 1-2, NFPA Number 30-1976, Flammable and Combustible Liquids Code[2].

A flammable or combustible liquid in itself is not a fire cause but rather the vapor from a flammable or combustible liquid when exposed to air, or under the influence of heat, in the presence of an ignition source may cause a fire.

To prevent flammable and combustible liquid fires (and "explosions") one or more of the following measures should be embraced:

Exclude all sources of ignition.

Exclude air or inert the space.

Keep the liquids in closed containers or systems.

Ventilate to prevent the accumulation of vapor within flammable range

Since some flammable and combustible liquids are essential in most industrial operations, methods of minimizing the impact of flammable liquid fires and explosion accidents have been developed to reduce the fire and explosion risks associated with product use. These include:

a. Limiting the volumes of flammable and combustible liquids exposed.

b. Safe storage methods i.e. as with approved flammable and combustible liquid containers, storage cabinets and rooms.

c. Controlling ignition sources.

d. Providing good ventilation to prevent the accumulation of flammable vapors.

NFPA No. 30-1976[2] provides excellent criteria for the handling and storage of flammable and combustible liquids, however, the quantities permitted in Chapter 5, (for) "Industrial Plants," generally exceed the amounts acceptable in safety related areas of nuclear power plants.

Specific controls should be established to:

a. Prohibit the storage, handling, and use of unstable (reactive) flammable or combustible liquids within the nuclear power station's complex of primary and secondary facilities as listed in Sections 2-1, a. and b. of NFPA No. 803-1978[3].

b. Require that the storage and transfer of bulk supplies of flammable and combustible liquids be accomplished in approved flammable and combustible liquids storage and handling areas (or rooms) outside of the nuclear power station's complex of primary and secondary facilities, as listed in Sections 2-1, a. and b. of NFPA No. 803-1978[3].

c. In all safety related areas limit the quantities of flammable and combustible liquids to the amounts essential to function over holidays and weekends, or an essential maintenance operation, whichever is greater.

d. Require all flammable and combustible liquids which must be held in, and be readily available for use in safety related areas, to be stored in, and dispensed from, FM approved, or UL listed, containers and cabinets.

3.2 Liquefied Gases

Those gases which are held partially in the fluid phase and partially in the gaseous phase in a pressure vessel at normal temperatures are called liquefied gases (LP-Gases). Liquefied gases present high potential for high levels of energy release. The disasterous phenomenon which occurs when a liquefied gas container fails from fire exposure is known as a Boiling Liquid-Expanding Vapor Explosion; it is called a BLEVE. Common examples are propane, butane, and propylene.

A good criteria for the storage and use of LP-Gases are provided in NFPA No. 58[5] with some exceptions.

1313 304

LP-Gas container capacities authorized under Section 334 of NFPA No. 58- for Buildings Housing Industrial Occupancies[5], are considered excessive for safe use in the primary and secondary facilities of a nuclear power station.

The use of portable LP-Gas systems should be limited to laboratory, and artisan's needs whenever possible. LP-Gas fuel to operate laboratory burners, and to ignite oil-fired boilers should be supplied from outdoor containers through approved piping systems if possible. Containers used for indoor service with a water capacity greater than 2-1/2 pounds should be equipped with shut-off and excess-flow valves. Dispensing, or refilling, LP-Gas containers within nuclear power station buildings, should be prohibited.

3.3 Cryogenic Gases

A cryogenic gas for the purpose of fire brigade training is a liquefied gas which exists in its container at temperatures far below normal atmospheric temperature, and which cannot be retained indefinitely in a container by virtue of the container's strength alone. Because of this fact, special precautions are required in the storage and use of a cryogenic gas. For a fuller discussion of the classification and behavior of gases encountered by industrial fire fighters, see Section 3, Chapter 4, NFPA Fire Protection Handbook, 14th Edition[1].

3.4 Solid Combustibles

Administrative Controls should be developed to control the use and storage of solid combustible materials and supplied in the primary and secondary plant facilities to include, but not limited to: All staging, dunnage, pallets, benches, cabinets, chests, shelving, and rad-control dressing-station furniture when fashioned from wood products should be fabricated of approved pressure impregnated, fire retardant lumber. In addition, combustible wastes and soiled clothing should be stored in non-combustible containers with normally closed lids. Where metal oil drums are used as trash containers, metal lids held open with approved fuzible-link closing devices may be used. Paper drums and boxes should not be permitted for the storage of combustible wastes.

Where limited amounts of essential combustible supplies must be held in readiness for immediate operational and maintenance use on operating floors which do not have fire-rated sprinklered storerooms, they should be enclosed in rigid ferrous-metal walk-in storage structures, protected with automatic sprinklers with supervised water-flow alarms annunciated to the Control Room. An approved automotive spray-paint booth or equivalent may be considered as meeting this requirement. Where the volumes of combustibles to be stored are small, an unprotected ferrous metal chest of not to exceed 60 cu. ft., with a tightly fitted self-closing lid, may be used.

3.5 Administrative Fire Prevention Practices

Good fire prevention measures and procedures should be established in Administrative Controls, and enforced. Excellent minimum criteria for the development of administrative procedures and controls essential to the fire protection in depth concept for nuclear power plants are enumerated in Chapter 8, NFPA No. 803-1978[3].

The most sophisticated automatic and manual fire extinguishing systems, fire separation systems, fire detection systems, fire alarm systems, and fire suppression plans are not fully reliable unless they are administratively controlled to assure fire readiness.

1313 306

Fire doors may be controlled by various methods, to prevent the spread of fire, or fire gases, between areas, including locking or closure devices, electrical supervision to alert the Control Room or a security guard when an essential fire door is opened, and more particularly when it is not promptly closed. Locked fire doors, while helpful for security needs, may obstruct fire fighter access and may trap fire fighters attempting to make a quick exit through a padlocked door. Systems for locking doors must assure safe and ready exit from spaces protected with suffocating fire extinguishing agents or charged with heat and toxic gases produced by fire.

1313 307

4. THE FIRE BRIGADE

4.1 Personnel

4.1.1 Composition and Duties

The composition of a fire brigade for operating nuclear power plants is dependent upon a number of considerations in arriving at a specified number for a given plant. Considerations that should be taken into account when developing the brigade are:

1. The plant is protected in all vital areas by early warning detection and approved automatic suppression systems.
2. The fire brigade training program is adequate to meet all plant conditions. (See Appendix A).
3. Manual fire fighting equipment is adequate for the needs of the specific areas of the plant.
4. The off-site fire suppression assistance is of sufficient quality and quantity, and is reasonably trained to fight fires in nuclear power plants.
5. The configuration of the physical plant itself is such that it will not create undue hardship for the fire brigade operations.

With the provision that the operating nuclear power plant meets the above considerations, the minimum number of personnel assigned as fire brigade members on each shift should be five trained fire fighting personnel. (See Appendix A).

It should be clearly understood, however, that this recommendation of five fire brigade members does not preclude the possible need for additional fire brigade personnel if the operating plant does not meet the considerations listed above, the fire protection requirements of the U.S. NRC and recognized standard fire protection practices.

In the selection of personnel to be assigned as members of the fire brigade, the complexities of the special problems encountered in nuclear plant manual fire fighting (see 2.3) should be given consideration. The need for the fire brigade members to be adequately trained is discussed in Section 4.1.2 and in Appendix A. The need for those assigned to be knowledgeable of the operating conditions of a nuclear power plant suggests that the process should be highly selective.

A very important criteria not often given sufficient consideration in the selection process is that of the attitude of the individual. It would be far better to have a fire brigade made up of personnel who have volunteered for the assignment than to merely assign individuals as a part of their job requirements.

It is suggested that those members of the operations group would be the best group from whom the fire brigade should be selected. Others knowledgeable in the plant operation including health physics and plant maintenance personnel would also prove adequate. It should be understood, however, that as long as the fire brigade leader is a person with full knowledge of the operation of the plant, the other members of the brigade can be any employee who is physically capable and adequately trained to carry out the functions of a fire fighter.

The physical qualifications of members of the fire brigade need to be fully understood by the medical department of the utility.

All fire brigade members should be provided with a periodic physical examination to screen out personnel with heart or respiratory disorders. Inasmuch as fire fighting is a strenuous and physically exhausting activity, consideration should be given to these stresses as a part of the annual medical examination.

Any member of the brigade who does not fully meet the medical examination, particularly in regard to heart and respiratory conditions, should not remain a member of the fire brigade.

There is a prevailing feeling within the staff of the licensees that the annual or bi-annual medical examination given to operating personnel is sufficient to insure that members of the fire brigade will be medically qualified to perform as fire fighters. The normal duties of operating personnel, even while involved in strenuous emergency repair work, in no way comes close to the conditions found in fire fighting situations. To provide the best possible protection for the physical well being of the fire brigade members, the utility should require that no individuals are assigned to the fire brigade until after they have taken and satisfactorily passed a medical stress test. Once an individual has passed the stress test and is assigned to the fire brigade, thorough annual medical examinations should be given and any brigade member who shows any abnormality at the annual medical examination should be required to take and pass another stress test in order to continue as fire brigade members.

Specifically the duties or actions of the members of the fire brigade are determined by the fire situation as it occurs. Table 1 outlines the various duties or actions of members of a fire brigade and indicates the number of personnel required to carry out the required duty.

The specific duty of fire brigade leader is of sufficient importance and complexity that he/she must be especially trained to perform the duties in an effective and efficient manner. The leader and/or assistant leader should be thoroughly familiar with each area of the plant and be capable of making decisions and taking actions that will assure that the safe shutdown integrity of the plant is not violated through any action by the fire brigade. He should become qualified in the art of attacking and extinguishing interior fires.

TABLE 1

MANPOWER REQUIRED FOR FIRE FIGHTING ACTIVITY

OBJECTIVE: To extinguish a realistic fire as rapidly as possible.

	Function	Manpower Required (not cumulative)	
1.	Evaluate the fire situation and the area involved to determine the effective actions to be taken and maintain communication with control room. (Required for all fires.)	1 (leader)	*
2.	Respond to fire with portable fire extinguishers.	2 (1 man/unit)	**
3.	Respond to fire with self-contained breathing apparatus.	2 (1 man/unit)	**
4.	Locate fire or source of smoke.	2-5 (all avail.)	***
5.	Operate fire extinguishers on the fire.	2-5 (1/unit)	***
6.	Extend and prepare to operate a single 1-1/2" hose line from interior standpipe (No add'l hose required)	2 (per line)	***
7.	Where additional hose must be added.	3	
8.	Extend and prepare to operate a 1-1/2" hose line or a single 2-1/2" hose line from an exterior hose house.	3	
9.	Extend and be prepared to operate backup 1-1/2" hose line.	2 interior 3 exterior	
10.	Take steps to cover electrical equipment with plastic sheeting to prevent water damage.	2	
11.	Provide rescue of endangered personnel or fire brigade members	2-? (all avail.)	***
12.	Obtain special equipment for fire fighting operations - Ladder, Foam, Ventilation.	2 each	
13.	Obtain fire fighting protective clothing for fire brigade members. (if not brought on 1st response)	2	
14.	Brief offsite fire fighters on situation occurring	1 (leader)	
15.	Serve as guide, coordinator and control person for offsite fire department.	1 per team	

1313 311

* The fire brigade leader should not engage in the physical activity of extinguishing the fire except when he is <u>first</u> to arrive and can extinguish or control the fire by taking immediate action. Once a fire has gone beyond the incipient stage, the fire brigade leader should devote his entire effort to strategies, tactics and command of the brigade.

** Each responding member should bring an extinguisher and a self-contained breathing apparatus, if both can be done without causing undue delay.

*** Operations in fire areas should always be a team effort of at least two members for the purpose of improved operation and personal safety.

NOTE: Items 1 through 5 are required for any fire that may occur that is not extinguished by the person/s who discover and report the fire.

Items 1 through 9 are required for any fire that is not readily extinguished in the incipient stage by a direct attack with the extinguishers.

Items 1 through 13 are required for any fire that demands operation of 1-1/2" or larger hose lines.

Items 1 through 15 are required for any fire that is not extinguished before the arrival of offsite fire fighting assistance.

4.1.2 Training

The following is quoted directly from the 14th edition of the NFPA Fire Protection Handbook, Section 10, Chapter 3, subsection B, page 10-12[1]

"A schedule of training should be established for members of the brigade. Members should be required to complete a specified program of instruction as a condition to membership in the brigade.

Training sessions should be held at least monthly.

Members of the brigade should be instructed in the handling of any and all of the fire and rescue apparatus provided. The training program should be adapted to the purpose of the particular brigade. It should include fire fighting with portable fire extinguishers, the use of hose lines, ventilation of buildings, salvage operations, and performing related rescue operations. The training program should keep up with problems presented by new fire hazards in the property and new fire extinguishing equipment and methods provided for its protection.

Assistance in setting up and training the fire brigade can be obtained from outside agencies. Among these are the municipal fire departments, state fire schools, state educational extension services, state fire marshals' departments, state insurance inspection bureaus, colleges. and any other agency where fire service training is given. Members of the brigade should be afforded opportunities to improve their knowledge of fire fighting and fire prevention through attendance at meetings and special training classes, where available.

Where the number of men participating in the fire brigade training program warrants such arrangement, a special space or room in the property for fire brigade use should be available for that part of a training program requiring lecturer or classroom instruction. Training aids such as books, literature, and films should be kept at such a location. The provision of a space or room for members of the brigade is one way in which membership in the brigade can be made attractive.

Practice drills should be held to check the ability of members to conduct the operations they are expected to perform with the fire equipment provided. Drills should occasionally be held under adverse weather conditions to work out special procedures needed under these conditions. During drills, equipment should be operated whenever possible. For example, portable extinguishers should be discharged, respiratory protective equipment should be operated, and water should be turned into hose lines. Under the control of the chief and leaders of companies, practice drills should always be carried out at a moderate pace with emphasis on effectiveness rather than speed. This should assure proper technique and safe operation, as required, at a fire.

At the conclusion of practice drill, equipment should be promptly placed in readiness to respond to a fire call."

Training of fire brigades for nuclear power plants requires an adequate course of instruction with specific scheduling of training sessions, meetings, practice drills and plant wide fire drills. Additionally those individuals who are assigned authority and responsibility for fire brigade actions should receive specialized training in fire fighting leadership, strategy and fire control tactics.

The training of the fire brigade should be designed to meet the guidelines contained in attachment 2 of "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance,"(6) issued by the NRC.

A minimum course of instruction for all fire brigade members, and all other plant operating personnel who might be called upon to assist in a fire emergency, should be developed using the International Fire Service Training Association manual No. 200, "Essentials of Fire Fighting,"(7) as a basic text. Although this text is not designed for fire brigade training, it provides adequate detail without being too technical. This basic training course should cover the required subjects within the needed time frame. (See Appendix A).

Personnel specifically assigned to the fire brigade should receive additional training under actual fire conditions, either onsite or at offsite fire training facilities where available.

In the event that training under actual fire conditions cannot be carried out, every effort should be made to provide simulated fire training conditions that are as realistic as possible. The purpose of this type training is to allow for the application of the basics learned in Section A of the training program.

Offsite facilities providing actual fire conditions might be found at municipal fire departments, county or state fire training schools, university or college extension courses and at other utility or industrial plants.

Refresher training sessions should be held on a quarterly basis for all brigade members designed to cover the basic subjects over a two year period of time. The purpose of the quarterly sessions being to maintain the skills level of the fire brigade members.

An annual retraining should be conducted covering the hands-on type fire training that allows the brigade members to actually fight fires under real life conditions.

The training program for any nuclear plant should be designed to provide a continuing training that will maintain a high level of skill and at the same

1313 314

time permit the brigade members to keep in constant preparedness for any fire emergency. The need to involve the offsite fire fighting assistance forces in the continuing training is obvious.

Those members of the fire brigade who are or may be designated as fire brigade leaders should receive specialized training in fire fighting strategy, leadership and fire control tactics covering: Objectives of the fire operation, activities essential to achieve objectives, evaluation of pertinent factors, development of an action plan, directing fire fighting operations and supervision of fire fighters. (Note: Recommended text for leadership training should include IFSTA manuals and "Fire Fighting Strategy and Leadership, 2nd edition" by Charles V. Walsh and Leonard Marks, available from McGraw-Hill Publishing Co., Heightstown, New Jersey)[8].

This training should be given by competent instructors obtained either from the onsite training division or from area public fire protection services, county or state fire schools, community colleges, state colleges or universities, or private fire training agencies.

In the event that this training can be given at sessions conducted onsite, the recommendation is that all members of the brigade receive the training so they will all be familiar with the complexities of fire brigade leadership and have a better understanding of the fire control operations.

Fire brigade meetings should be held on a monthly basis, where possible, for the purpose of familiarization with and review of fire fighting plans and strategies, and for the evaluation of problem areas peculiar to the individual plant.

Fire brigade meetings can be used to provide refresher courses as needed or as indicated by evaluation of drills and practice sessions.

1313 315

Fire brigade drills and practice sessions should be held as stipulated in the NRC guidelines "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance,"(6) attachment 2

The purpose of these drills and practice sessions is to permit the brigade to utilize the training they received, and to demonstrate that they have been adequately trained and are capable of carrying out their required functions.

Offsite fire suppression forces should be invited to participate in the drills and practice sessions to develop teamwork and to establish an understanding of the fire fighting tactics to be employed and of the command authority while operating at fires on the plant site.

Practice sessions should be held for fire brigade members on the proper methods of fighting various types of fires of similar magnitude, complexity and difficulty as those which could occur in a nuclear power plant. These sessions should provide brigade members with experience in actual fire extinguishment and use of emergency breathing apparatus under strenuous conditions. These practice sessions should be provided at regular intervals, but not to exceed one year for each fire brigade member. These sessions are not to be confused with the fire brigade training sessions and/or fire drills. These practice sessions should include "fire fighting strategies."

Because of the possible direct relationship to the fire brigade and its functions, each nuclear power plant should be required to develop and conduct a brief fire training program for all employees which could be designated "An Introduction to Fire Safety." This program should cover the "Fire Behavior" and "Extinguisher" portions of the basic fire brigade training and should provide for a review of the plant emergency plans as they concern all personnel. Further all outside contractor personnel should be required to attend a

1313 316

briefing on the plant fire safety regulations, fire alarm procedures, and fire prevention rules before being permitted to work in the plant.

Additionally they should be required to show that all their personnel have been trained in the use of extinguishers.

4.1.3 Utilization of Public Fire Fighting Service and of Offsite, Call Back, Personnel

Nuclear power plants are frequently located in remote areas, at some distance from public fire departments. Also, first response fire departments are often volunteer. Public fire department response should be considered in the overall fire protection program. However, the plant should be designed to be self-sufficient with respect to fire fighting activities and rely on the public response only for supplemental or ba... capability.

Procedures should be established that will coordinate fire fighting activities with offsite fire departments, including: Identification of individual responsible for assessing situation and calling in outside fire department assistance when needed, identification of individual who will direct fire fighting activities when aided by offsite fire fighting assistance, provisions for including offsite fire fighting organizations in fire brigade drills at least once per year, compatibility of fire hose threads and provisions for training offsite fire department personnel in basic radiation principles, typical radiation hazards, and precautions to be taken in a fire involving radioactive materials in the plant. The procedures should also describe the offsite fire department's resources and estimated response time by the offsite fire department to provide assistance to the station.

The degree to which the licensee can depend on the offsite public fire fighting service is directly related to the extent of familiarization and joint training that the nuclear plant has established with the public fire department. Each nuclear plant should involve the public fire fighters in frequent plant visits and in coordinated joint training to improve both parties knowledge and skills needed to cope with a plant fire.

Typically the public fire service at most plant locations is such that they can be considered minimally adequate for assisting the plant fire brigade in the case of a major plant fire. Most are volunteer fire companies who have little or no experience in fighting fires in structures similar to those at the plant. To expect these fire fighters to be efficient is unrealistic unless they have had concentrated training onsite, and are provided with adequate direct supervision and guidance by members of the plant fire brigade.

Each nuclear power plant should have functional administrative procedures that provide for the call-back of off-duty fire brigade members for any fire that is not immediately extinguished by the initial fire brigade operations. The call-back procedure should be set up so that those brigade members who reside closest to the plant receive first notification to return to the plant site.

The basic value of a call-back plan and of the assistance offered by the public fire fighters is that of having an early and adequate response to fires in the plant. The responsibility for initiating a call-back or request for assistance should be with the fire brigade leader. The fire brigade leader should initiate the call for offsite assistance immediately upon his determination that the fire cannot be extinguished by the initial attack. A general rule might be that the offsite assistance will be called for any fire that requires the use of a hose stream. This should not be taken to mean that there may not be times when hose streams are not being used, but obviously are of a potentially serious nature that may require assistance.

1313 318

A most serious error in fire fighting tactics is to wait too long to call for assistance. It is far better to initiate a call-back and find that the men are not needed than it is to wait those few minutes longer, and realize that the fire is beyond the immediate control and extinguish capability of the assistance when it arrives.

Each nuclear plant fire brigade leader should have available to him a listing of any special fire fighting equipment that the public fire service has which could be used for a fire in the plant. Often the public fire service has special equipment the brigade leader might want used at the initial stages of a fire rather than wait to see if the plant equipment will do the job. For example, a public fire department having foam application equipment should be called immediately for any fire in the plant involving combustible liquids.

There should be no reluctance on the part of the fire brigade leader to call the public fire fighters or to call-back off duty personnel. Fires of a serious magnitude do not, and should not, occur at any frequency that would create any hardship on those being called. The far more likely condition is that the call-back procedure will have to be made part of a drill to test its effectiveness and the public fire fighters will only be called as part of the training/drill procedures at the plant. In any regard the concern should be to be sure the plant can cope with the unexpected fire that may never occur.

4.2 Tactical Procedures

Tactical procedures for a fire in a nuclear power plant are based upon the actions required of a fire brigade when a fire occurs in the plant. To illustrate this point, the following outline of fire brigade actions is suggested.

1313 319

1. All brigade members initiate response to the announced fire area.

   a. If the brigade members will pass by the personal protective clothing storage area, they should obtain their fire fighting gear and bring it to the fire scene.

2. The fire brigade leader responds directly to the announced fire area with portable radio to evaluate the situation, advise the control room and formulate an action plan.

   a. If the fire brigade leader passes by either or both the self-contained breathing apparatus storage or the personnel protective clothing storage, he should bring either or both items to the fire scene.

3. Each member of the fire brigade including the leader should obtain and bring a fire extinguisher to the fire area. These should be brought from a remote location to insure that sufficient extinguishers will be available. (Those in the immediate fire area could have been used by the discoverer of the fire).

4. Each member of the fire brigade should also bring a self-contained breathing apparatus for use by the brigade members.

   a. If conditions are such that SCBA masks will have to be worn by the brigade members, no member should enter the fire area without a mask. If necessary one or more, depending on the need, brigade members should be sent to obtain additional SCBA in sufficient number so that each brigade member will have a unit.

   b. If masks will be needed, the brigade leader should send at least one man to obtain spare air cylinders assuming the SCBA system used requires cylinders, at least one per SCBA being used. (Note: Recent practical tests at Syracuse Fire Department Training Academy demonstrated that the 1/2 hour rated mask, pressure demand type, was breathed down in as little as 7 to 15 minutes during fire fighting activities).

5. If the source of the fire or smoke can be readily determined, the brigade leader should order the following simultaneous actions.

   a. A direct attack should be made by at least two men with suitable extinguishers and,

   b. The remaining two men should be directed to prepare to assist with additional extinguishers and/or to stretch at least one 1-1/2" standpipe hose line to be used as a backup to the extinguishers.

6. If the fire is readily extinguished by the initial extinguisher application, the brigade leader should make a careful examination of the

fire area to insure that the fire has been completely extinguished and to try to determine the point of origin and the cause of the fire. He should be assisted by at least one brigade member.

a. The remaining brigade members should be directed to return the fire fighting equipment brought to the fire location to its proper storage area, insuring that it is in proper working order and in readiness for another fire.

b. A critique of the fire fighting operation should be held immediately after the fire to evaluate the pre-fire strategies for the fire area and to determine the efficiency of the fire brigade and the effectiveness of the operation.

7. If the smoke conditions are such that the location of the source of the fire and smoke cannot readily be determined, the fire brigade leader should order the following simultaneous actions:

a. The control room to notify the offsite fire department and plant on-call personnel.

b. Two brigade members and the leader to put on SCBA, take suitable extinguishers and enter the fire area to attempt to locate the fire.

c. The remaining brigade members to put on SCBA and stretch a 1-1/2" hose line from the closest standpipe location assuring that the hose will have sufficient length to effectively reach all parts of the fire area if necessary.

d. After the hose line is stretched and ready to be operated, at least one member should remain with the line while the other/s go to obtain additional equipment such as smoke ejectors, ladders if necessary, spare air cylinders, plastic sheeting and any other items that would be of need in the fire and damage control effort.

e. If while the above activity is going on, the fire source is located by the leader and the two brigade members, they should immediately attempt to extinguish the fire with their extinguishers. (If successful, the steps outlined in #6, a & b would be followed).

8. In the event that the fire is not readily extinguished by the use of extinguishers as in #7 above, the following actions should be undertaken by the fire brigade as ordered by the fire brigade leader.

1313 321

a. The 1-1/2" hose line that has been stretched as a precautionary measure should be advanced into the fire area by at least two brigade members and

b. The remaining brigade members should simultaneously stretch an additional 1-1/2" hose line from the closest available standpipe location to the area immediately outside or adjacent to the fire area and be prepared to use this line to provide protective spray and/or as a backup attack line if the fire severity demands. (Note: It is likely that the second 1-1/2" hose line will have to have additional hose added to reach the fire area).

c. Once the second line is readied for use and if its immediate use is not required, the fire brigade leader may direct one or more of the backup men to take steps to provide protection for electrical equipment or to set up portable ventilation equipment to evacuate smoke and heat, or to obtain additional special equipment that may be required if the fire is not controlled and extinguished in a short time.

d. If the brigade leader and the men attacking the fire with the 1-1/2" hose line are successful in extinguishing the fire, the steps outlined in #6, a & b should be followed.

9. In the event that the fire is not extinguished by the attack with 1-1/2" hose lines, the area may become untenable as a result of either heat or smoke or both. In this situation the fire brigade leader should order the following actions by the fire brigade.

a. All personnel should back out of the fire area and take positions where they can either keep the fire contained by the use of the hose lines from the perimeter openings or

b. The area should be sealed off, if possible, by closing the fire doors and the hose lines should be used by brigade members to attempt to keep the fire from passing through any penetrations, ducts, fire doors, or the exterior walls by spraying water on the potentially dangerous areas to keep them cooled down.

c. If the situation develops to this extent in a relatively short time period (less than 15-20 minutes) it may be necessary for the brigade leader to direct that one individual hold, not direct, the 1-1/2" hose line from a suitably braced position while the other members are sent for additional backup hose lines, additional air supply, and to check surrounding areas and floors above the fire for possible extension.

d. The fire fighting objective would now become a matter of confine, control and extinguish (or allow to burn out). When this occurs there will be a very serious problem of smoke and heat removal which will require the efforts of all available personnel as they arrive from offsite.

e. Decisions will have to be made regarding the direction the smoke and heat is to be routed with serious consideration given to the possible damage the smoke and/or heat might cause to equipment that is relatively remote from the fire.

The manpower required for the various fire fighting actions is covered in Table 1 included with this report.

4.2.1 Pre-fire Procedures

Pre-fire procedures should be developed and made part of the administrative controls of the utility at the plant site; these include the following.

There should be administrative procedures that cover in specific detail the actions to be followed by anyone who discovers a fire in the plant. An area of understanding that needs to be made clear to all plant employees and to contractor personnel is the need for proper action. First priority should be to assure that all personnel recognize and understand a basic principle regarding the discovery of a fire in the plant, that is to first extinguish immediately, if possible; second if immediate extinguishment is not possible to confine the fire by closing the doors of the cabinet, room or area; third to report the fire to the control center and fourth to go back and attempt to control the fire with either extinguishers or hose lines.

A most important point to emphasize to all plant personnel is to confine the fire by closing any doors that will help to keep the fire from spreading out of the area of origin.

The procedure to be followed by the control room operators on receipt of an indication of a fire in the plant, either via automatic detection or through verbal reports should be clearly defined. These procedures should require that the plant fire alarm which summons the fire brigade be sounded immediately on

1313 323

receipt of indication of a fire. If the alarm is received via the automatic systems, there should not be a preliminary investigation made to determine the validity of the call before notifying the fire brigade. If the spurious nature of false alarms are such that dispatching the fire brigade causes an operational or nuisance problem, then steps should be taken to correct the deficiencies of the detection system.

The procedure that identifies what the fire alarm consists of in relation to sounds, visual indication or the like, should also clearly define the way the control operators are to verbally announce the type fire and its location. This procedure should also define what actions are to be taken by plant employees, other than the fire brigade, visitors and contractor personnel.

The procedure that establishes the fire brigade should clearly identify the members who will compose the brigade, who is the fire brigade leader and what his authority and responsibilities are. The make-up of the brigade should establish a command structure that will provide continuity to the fire fighting operation in the event of the injury or absence of the fire brigade leader for any reason.

The procedural steps to be taken by the individual fire brigade members (Positions) should be clearly set out, but at the same time, be designed with flexibility consideration so that rigid adherence to specific actions will not be required at all times.

Procedures and policies should be developed relating to the use of the various fire extinguishing media for fires of specific nature and location. Caution should be exercised in this regard to insure that the policy and procedures do not prohibit the use of any extinguishing medium available if the nature of the fire warrants. There may be areas where specific extinguishing materials would never be used. This information must be included in the pre-fire strategies for these areas.

Procedures establishing a call-back system for off-duty fire brigade members should identify where the authority for the recall rests, who is to carry out the recall, the method to be followed and the responsibility of the fire brigade members to respond when recalled. This call-back system should be separate from any other plant recall procedure by having a specific listing of fire brigade members available to the persons responsible to carry out the call-back and with considerations of the distance to be traveled by those recalled. (Call-back the closest first).

Procedures for calling for assistance from the public fire fighters should include who makes the decision to call for assistance; what are the factors that need to be considered when contemplating a call for assistance; who is responsible for actually making the call and how the receipt of the call, by the public fire fighters, is to be verified.

The procedure for calling for assistance should also include the utility policy regarding access to the plant by the fire fighters; where they are to assemble; how they are to be identified for security purposes; what equipment will be allowed into the security area of the plant; who will serve as guides; who will function as advisor/supervisors and guides during the actual fire fighting operations, and what is to be done when the fire situation no longer requires outside assistance and the public fire fighters are to be released.

A specific and very important part of the procedure for offsite assistance is to clearly establish the authority and responsibility for the fire fighting operations within the plant following the arrival of the offsite fire fighters. It is of vital importance that the overall authority is clearly understood and agreed to by both the utility and the public fire fighters. The correct policy should be to have the overall command authority and responsibility rest with the fire brigade leader, or the plant fire chief, with the provision that he is directed to look to the public fire chief or commanding officer for advice and direction related to the actual fire fighting effort. The final decision is the responsibility of the fire brigade leader, or the plant fire chief.

In all cases, all policies and procedures that involve the offsite fire fighters in any way must have their input during the development of them to assure that there will be agreement and full understanding by both parties.

4.2.2 Fire Drills

Section B, subsection 5, paragraph (b) of Appendix A to Branch Technical Position APCSB 9.5-1[9] states in part, "...can only be accomplished by conducting drills several times a year (at least quarterly) so that all members of the fire brigade have had the opportunity to train as a team, testing itself in the major areas of the plant. The drills should include the simulated use of equipment in each area and should be pre-planned and post-critiqued to establish the training objective of the drills and determine how well these objectives have been met. These drills should periodically (at least annually) include local fire department participation where possible. Such drills also permit supervising personnel to evaluate the effectiveness of communications within the fire brigade and with the on-scene fire team leader, the reactor operator in the control room, and the offsite command post."

In an effort to clarify the intent of the above position, the NRC guidelines "Nuclear Plant Fire Protection Functional Responsibilities, Administrative Controls and Quality Assurance,"[6] attachment 2, part 3.0 which relates to the subject "drills," attempts to clearly define what the requirements are.

1. Fire drills should be performed at regular intervals, but not to exceed 3 months for each fire brigade. At least one drill per year should be performed on a "back shift" for each fire brigade. A sufficient number of these drills, not less than one for each fire brigade per year, shall be unannounced to determine the fire readiness of the plant fire brigade leader, brigade, fire protection systems and equipment.

2. The drills should be pre-planned to establish the training objectives of the drill. The drills should be critiqued to determine how well the training objectives have been met. Unannounced drills should have their critiques performed by members of the management staff responsible for plant safety and security.

3. Fire brigade drills should be performed in the plant so that the fire brigade can practice as a team. Drills should include the following:

> Assessment of fire alarm effectiveness, time required to notify and assemble fire brigade; and selection, placement and use of equipment.
>
> Assess each brigade member's knowledge of his role in the fire fighting strategy for the area assumed to contain the fire. Assess the brigade members conformance with established plant fire fighting procedures and use of fire fighting equipment, including self-contained emergency breathing apparatus, communications equipment, and ventilation equipment, to the extent practicable.
>
> Assessment of brigade leader's direction of the fire fighting effort, as to thoroughness, accuracy and effectiveness.

The simulated use of fire fighting equipment required to cope with the situation and type of fire selected for the drill. The area and type of fire chosen for the drill should be varied so that brigade members are trained in fighting fires in all safety related areas containing significant fire hazards. The situation selected should simulate the size and arrangement of a fire which could reasonably occur in the area selected, allowing for fire development due to the time required to respond, to obtain equipment, and organize for the fire, assuming loss of automatic suppression capability.

4.2.3 Development of Strategies

Fire fighting strategies need to be developed for all areas of the plant where conditions exist that are such that they would create either difficult fire fighting problems or where the vital nature of the area as related to safe shut down requires special actions to suppress a fire.

There has been considerable divergence of opinion in regard to pre-fire planning and what actually constitutes a pre-fire strategy. For the most part the licensee tends to confuse a pre-fire plan with a pre-fire procedure, and therefore believes that the varying factors of a fire situation preclude the development of fire fighting procedures for each specific area of the plant. To a degree this is a correct analysis of the complexity of fire fighting operations; however, the main consideration is that plans and strategies are not procedures.

The basic difference between a procedure and a strategy is better understood if we define each as they relate to fire fighting.

Procedures are sequence outlines to action rather than thinking. Procedures detail the manner in which activities are to be carried out, with emphasis on chronological sequence. Procedures are exacting in nature because there is a reduced need for discretion and routine actions are done more efficiently through the prescription of one best way. Hence there is a procedure for reporting fires.

A strategy, in fire fighting activity, encompasses the use of the knowledge of fire fighting, knowledge of the area where the fire occurs and knowledge of

1313 328

the specific conditions to be expected. The efficient employment of fire fighting skills that will be needed in relation to this know...ge results in a strategy to be employed as a guide to thinking by the fire brigade leader.

In the development of tactical procedures and in the development of pre-fire plans, the fire brigade leader should employ a planning process that is directly related to fire fighting actions. In the fire service this process is known as a fire control action plan. The plan consists of the following steps:

1. Note and evaluate as accurately as possible the primary factors that are pertinent in the given situation
2. select objectives and activities on the basis of the evaluation made
3. assign activities
4. coordinate activities by adequate supervision and communication, and
5. establish a command position.

The pre-fire plan, including fire strategies, need not be a complex document with detailed procedural specification or with data that is common knowledge or obvious to the observer. Rather it should be a document that concisely lists those facts and conditions that the fire brigade should be aware of in order that the fire fighting activity might be expedited.

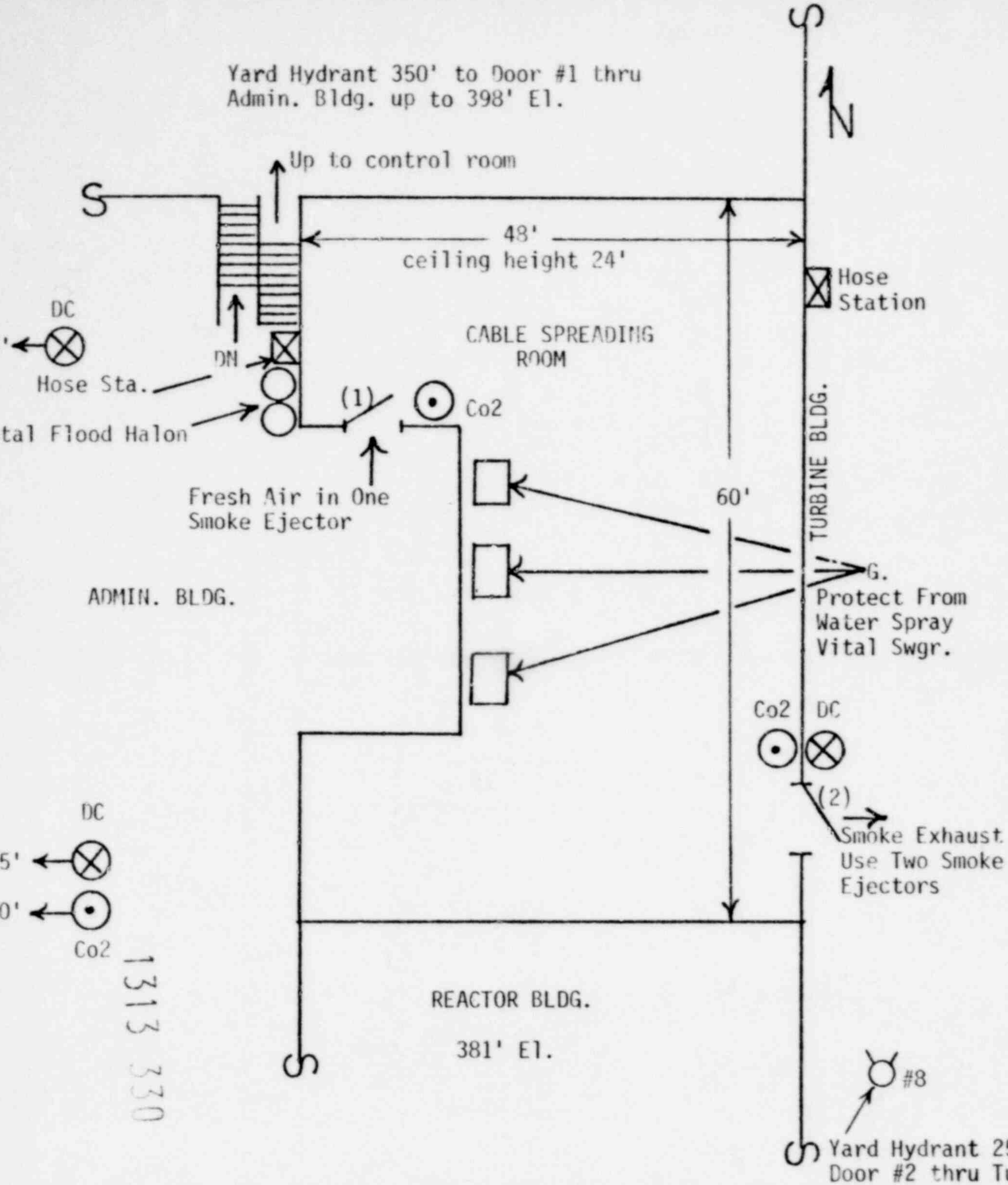
The suggested form for the pre-fire strategy is to use a simplified line drawing of the fire area that the pre-fire strategy will cover, and indicate on this drawing those particular conditions that will aid the fire brigade in both efficient and effective fire and damage control. Figure 1 is a sample of a pre-fire strategy drawn as recommended.

Transparencies for an overhead projector made from the line drawing type pre-fire strategy allows for the use of the drawing during training sessions

FIGURE 1

FIRE FIGHTING STRATEGY

Cable Spreading Room



Notes:

A. Normal ingress thru door (1)

B. 18' ladder required to reach upper cable trays. Ladders in turbine bldg. 360' el.

C. Self contained breathing equipment necessary (halon)

D. Normal smoke exhaust thru door (2) into turbine bldg. - out roof vents.

E. Secondary ingress thru door (2) from turbine bldg.

F. Manual hose line from hydrant #8 thru door #(2).

G. Cable trays floor to ceiling - 18" clearances around north west, and south parameter.

and during the critique of drills conducted in the fire area. Pre-fire strategies should be developed jointly by members of the fire protection staff, the engineering department, the HVAC department and the members of the fire brigade. The purpose of this joint effort being to insure that all areas of knowledge are utilized to develop an effective strategy. Input from the chief of the public fire fighter forces could be an asset to the development of the strategy.

Pre-fire strategies should be developed for all areas of the plant where a fire could jeopardize the ability of the plant to be safely shut down and maintained in a safe condition. Also for all areas of the plant where specific conditions of construction, congestion or hazardous materials would result in unusual difficulty in controlling a fire should one occur. Specific conditions that should be included in the pre-fire plan, but are not limited to, are the following:

a. vital equipment that must be protected.

b. access to the area, both primary and secondary.

c. type of automatic fire protection for the area, and correct manual interface

d. locations and type of fire fighting equipment available to the area.

e. accessibility of all portions of the area.

f. locations of backup fire fighting equipment adjacent to the immediate fire areas.

g. ventilation methods.

h. the need for equipment of a specialized nature.

These conditions and others should be illustrated on the line drawing whenever possible. Preferably the pre-fire plan drawing should be a single page with copy only on one side. Where the complexity of the area requires so much information that it cannot be accomodated on a single page, then the additional information should be placed on a second sheet and arranged so that the information and the drawing are on facing pages. A caution to be observed is to avoid having too much information on the strategy sheet. There is no need for listing data that is common knowledge or that has no appreciable bearing on the strategy or plan.

As pre-fire strategies/plans are developed for the various areas, they should be made part of the training program of the fire brigade and the offsite fire fighting forces. Each plan should be tested by a fire drill for the area and modifications should be made if the test drill shows that changes are warranted. Any important change in the equipment, protection or construction of an area would require a review of the plan to determine if it is still suitable. All strategies should receive an annual review.

As a minimum, copies of the strategies and plans should be maintained in the control room, the fire protection offices and the training offices of the plant. The posting of the strategy and plans immediately outside the area of concern is a recommended method of providing familiarity for members of the fire brigade and other interested plant staff. The strategy and plans should be posted at the closest point to the fire area most logically suitable as the command post for the fire brigade leader.

1313 332

5. FIRE FIGHTING EQUIPMENT

The type of manual fire fighting equipment selected for nuclear power plants should be determined by a thorough analysis of the intended use of the equipment and the maintenance and testing needs associated with it.

The dependence on manual fire fighting as a backup to the automatic suppression systems for the protection of the safe shutdown capability of the plant places greater emphasis on the adequacy of the fire fighting equipment provided.

The need to minimize damage to equipment near but not involved in the fire situation is also a serious consideration. All equipment used in fire fighting efforts must be reliable and suitable for the work to be done. With this in mind, the following sections suggest the most effective equipment and systems to manually extinguish any fires that occur.

5.1 Water Supply

Section E, Fire Detection and Suppression, subsection 2, a through g of Appendix A to Branch Technical Position APSSB 9.5-1 "Guidelines for Nuclear Power Plants Docketed Prior to July 1, 1976,"[9] contains the requirements for water supply for operating nuclear power plants. The following is offered in an attempt to clarify some of the more common problems encountered in this area of protection.

Provisions should be made to permit the use of a fire department pumper to augment the required fire water supply source in the event of emergency. At locations where there is a suitable open body of water to be used as a backup,

1313 333

the utility should take steps to provide a suitable location from which the fire department pumper can draft water. This could be a location close to the water, with an elevation not exceeding 15 feet from the water level to the pumper suction intake. Where it is not possible to position a pumper close enough to draft, the utility should provide a dry suction standpipe at a suitable location meeting the above elevation limits. To implement this procedure, the utility should have on hand tne necessary 2-1/2" double female adapters to permit the fire department to connect 2-1/2" hose from the pumper into the hydrant outlets. The fire brigade and the offsite fire department should conduct suitable training and practice sessions to assure that the emergency system will work as intended.

Hydrants should be protected by adequate impact preventing stanchions if the hydrant is located in close proximity to vehicular traffic or any nature. Impact stanchions should also be provided for exposed isolation valves.

Hydrants should typically be provided with a minimum of two gated outlets for two and one half inch fire hose. The hose thread on the hydrant outlets should be American national standard fire hose thread. Where three or four way hydrants are used, only the 2-1/2" outlets need to be gated. In those locations where the offsite fire department does not have American national standard fire hose thread, the utility should maintain a supply of hose thread adapters to permit interconnection of the NH and non-standard hose thread.

Hydrants should be flow tested when installed and following any repair or other work on the water mains or connections. Periodically hydrants should be flowed and the flow recorded and checked against the original flow tests to ascertain that there are no impediments to the water supply.

1313 334

Hydrants should be located on level surfaces with sufficient spacing from fences, buildings, etc. to permit their ready use. Hydrants should normally face the direction of the area to be protected; however when hydrants are provided with pumper suction outlets, the hydrant should face the road or driveway accessible to the pumper. Hydrants should not be located on or near the edge of any elevation change unless there is a level pad of sufficient area to permit the use of the hydrant without danger of injury to the fire fighters.

Hydrants should not be obstructed by vehicles, storage of materials, construction debris or any other reason. The area around all hydrants should be maintained clear to facilitate its use.

Exterior hose houses and/or cabinets should be designed and constructed so that they are suitable to contain the required equipment. Preferably the hose house should be designed to encompass the hydrant as a means of providing weather protection. Hose houses and/or cabinets should be designed to be weatherproof, with adequate ventilation to reduce moisture buildup, rust and mildew problems. Ventilation openings should be adequately screened to prohibit the nesting of insects such as wasps and to keep out other unwanted inhabitants. The hose house should be mounted in such a way that there is adequate drainage away from the hydrant and with sufficient clearance for the doors to prevent their obstruction by light accumulations of ice. In cold climates, there should be administrative procedures requiring the effective removal of snow and ice as soon as possible during and after storms.

The hose house or cabinet should have sufficient space to properly contain the required amount of fire hose in a storage mode that will permit rapid stretching of the hose lines without the need to couple each length separately.

The correct storage of both 2-1/2" and 1-1/2" hose is to have all lengths connected, accordion fold style, with the female butt positioned where it is accessible for quick connection to the hydrant. Where the design of the exterior hose storage cabinet is such that there is insufficient room to store the hose in accordion folds, all hose should be rolled in the donut roll fashion with both couplings to the outside of the roll. 1-1/2" hose should be connected in two lines to a 2-1/2" x 1-1/2" x 1-1/2" gated wye, each line should have a suitable nozzle attached. The 2-1/2" hose should not be attached to either the hydrant, the 1-1/2" wye or to the 2-1/2" nozzle; the reason being to have the hose ready for use in whatever way the situation dictates without the need to disconnect.

The amount of 2-1/2" and 1-1/2" hose stored in exterior hose houses should be sufficient to meet the needs of the specific plant; however the minimum should be 200' of 2-1/2" hose and 150' of 1-1/2" hose.

The requirements for interior hose standpipe systems are defined in Appendix A of BTP 9.5-1, section 3, subsections a through f[9]. The following are suggestions offered to aid the utility in providing dependable interior standpipe hose systems at all times.

Interior standpipe hose should be stored on hose reels designed to effectively contain the required amount of hose.

Each standpipe hose location should have a suitable universal type hose coupling wrench available. The wrench should be of a design that will permit its use as a lever to assist the opening of the standpipe hose outlet shut off valve. The hand wheel for the standpipe hose outlet shut off valve should be permanently affixed to the valve stem to avoid loss.

1313 336

Hose standpipe outlets should be located throughout the plant areas requiring protection, spaced so that the hose contained on the reel, a maximum of 100' of 1-1/2" hose, will reach all points of the area to be protected with sufficient hose to enable the fire fighter to direct an effective hose stream onto all portions of the area to be protected. Where the hose standpipe locations are not adequate to meet this requirement, additional standpipe locations are recommended.

Nozzle pressures of up to 100 psi are not considered excessive for trained fire brigade members to handle. The practice of using pressure reducing valves in the standpipe hose lines is not recommended in that they may reduce the flow to below the capacity of the nozzle and thereby reduce the effectiveness of the fire stream.

5.2 Hoses and Nozzles

Fire hose for use in nuclear power plants should be jacketed and lined type hose having a manufacturers test pressure based upon two times the expected working system pressure, but not less than 300 psi, and FM approved or UL listed.

A preferred type of hose for exterior and standpipe use is the all synthetic, mildew and heat resistant, single jacketed, lined hose. Double jacketed hose is acceptable; however the added weight and bulk can create problems. Another special type of hose that is available for 1-1/2" standpipe use is the rubber jacketed rubber lined, booster type fire hose. While this hose meets the standard for standpipe hose, it is not readily adaptable to extending the line by adding more hose particularly due to its bulk.

1313 337

Of particular importance in considering the method of containing the standpipe hose is to provide suitable racks or reels of sufficient capacity for the type of hose being used. Of the types available - reel, hump back rack or pin type rack; the latter is the least suitable.

All fire hose should be tested on an annual basis. The test pressure should be at least 50 psi. above the highest system pressure, but in no case less than 150 psi.

Each plant should have a suitable location for drying the hose after test or use, and should have a secure storage location where spare fire hose can be stored and yet be available to the fire brigade when needed.

The use of fire hose for purposes other than fire fighting should not be permitted. A suitable means of identifying discarded fire hose should be developed. Preferably all fire hose that is no longer suitable for fire fighting use should have both couplings painted a distinctive color for easy identification.

Fire hose nozzles should be of the design that permits the operation of the nozzle from a shut off position to a fog pattern without the necessity of passing through the straight stream mode. This may be accomplished by the use of nozzles designed to go from off, to fog only, to off or from off, to fog, to straight stream, to fog, to off. Another means of accomplishing this type of control is by the use of an independent nozzle shut off that is placed between the end of hose and the nozzle. This latter type allows for positive control of the discharge of water at all times regardless of the position of the stream pattern.

While it is possible to obtain fire hose nozzles for electrical areas that do not have a straight stream capability, commonly called all-fog nozzles,

1313 338

there are some areas in most nuclear plants where the range of the fog pattern would be insufficient to reach some of the higher portions of the room or fire area. Consequently there is a need for the nozzle that will provide both fog and straight stream in these areas.

In those areas of the plant where water damage could be of serious consequence, the use of the variable gallonage, adjustable pattern, combination nozzle with positive shut off capability is recommended. This nozzle permits the fire fighter to select the gallons per minute he desires and allows for a range of approximately 30-60-95-125 GPM's depending on the design of the nozzle and supplied pressure.

The type nozzle for use on large diameter and small diameter exterior hose lines should be of the combination fog and straight stream type, preferably with a positive shut off capability. The large diameter nozzle should be capable of at least a 250 GPM discharge at 100 psi nozzle pressure. The use of the smooth bore, solid stream type nozzle, commonly called the Underwriter Playpipe, should be avoided due to the possibility of electrical current following along a solid water stream and injuring the fire fighter.

Nozzles for use with special types of extinguishing medium such as foam should be carefully selected to insure that the nozzle is of a type suitable for its intended use. Consideration should be given to the range of the stream that the nozzle is capable of producing. It is often impossible for the fire fighter to get close to a flammable liquid fire of any magnitude; therefore he must have a nozzle that is designated to project the stream a sufficient distance to reach the fire.

1313 339

5.3 Extinguishers

Extinguishers should be located throughout the plant of sufficient size and number to meet the spacing and protection requirements of NFPA 10[11]. Consideration must be given to the type of equipment contained in the area to be protected and the selection of extinguishers should be made to provide the least damaging extinguishing agent that will suitably protect the hazard of the area.

While there is a strong reluctance on the part of the licensees' staff to sanction the use of water type extinguishers, there are many areas of nuclear plants where the primary hazard is the Class A type hazard where water is the best extinguishing agent. The present models of 2-1/2 gallon stored pressure water extinguishers permit a very selective control on the amount of discharge yet have considerable extinguishing capability for Class A type fires and in some instances could be less damaging than the all purpose dry chemical type.

A relatively recent innovation on the American fire extinguisher scene is the stored pressure Halon 1211 type extinguisher that dischargers a stream of liquid Halon in a manner similar to the stored pressure water type. While the Halon 1211 is a vaporizing liquid type extinguisher, the initial stream of liquid does have reach and a quenching effect, while vaporizing rapidly leaving little or no harmful residue.

A caution regarding fire extinguishers is to avoid obtaining extinguishers too small to be effective in the area to be protected. This does not mean that specific circumstances may not dictate that small units would be most suitable; however the effectiveness of a single large unit is recognized as being much more effective than multiple smaller units.

1313 340

5.4 Emergency Breathing Air

The fire service and the mining industry were the first to recognize the need for respiratory protection appliances. The first known self-contained breathing apparatus (SCBA) was developed and used in Germany before 1800. The Vienna Fire Brigade had an emergency breathing mask by 1830. Most of the early emergency breathing devices relied on filter systems including those used in the U.S.A. until the 20th centry. Shortly after World War I a self-contained, closed-circuit (SCBA) known as the Bibbs Oxygen Mask, was used in a limited way by some U.S. Fire Departments. U.S. Fire Departments were provided filter-type masks which removed carbon dioxide, and carbon monoxide, but did not resupply oxygen for breathing air; many fire fighters were injured, and many died. Only in the last generation have SCBA been supplied on a large scale to public fire fighters.

There are two primary types of self-contained emergency breathing apparatus (SCBA) now in use; the CLOSED-CIRCUIT, and the OPEN-CIRCUIT, SCBA.

With the closed-circuit type SCBA the wearer's exhaled breath is exhausted from the facepiece through a flexible tube into a "bag" or "mask chamber" where the carbon dioxide and water are "scrubbed" from the "air." Oxygen stored in a small pressure vessel is released into the closed-circuit breathing atmosphere to assure the proper mixture or ratio, of "air gases" for breathing. These units are known as "re-breather" type SCBA.

In the past, fire service personnel have opt for the open-circuit type SCBA which utilizes a cylinder of compressed breathing air released directly to the wearer's face piece as needed through a diaphram and pressure regulator air control mechanism. As the wearer breathes, all exhaled air is wasted outside the system, and all air inhaled is supplied from the compressed air stored in the heavy cylinder (pressure vessel) worn on the wearer's back.

The open-circuit type SCBA is most widely recommended and used in the U.S. fire service. This type offers the options of "pressure-demand" or "demand" apparatus. Controversy prevails as to the merits of each type. The "pressure-demand" configuration assures a positive pressure inside the facepiece, while the "demand" type does not, and as a result wastes less air. The fire fighter who is plagued with the "heavy bottle" and "short duration" of the breathing air prefers the "demand" type. NIOSH authorities knowing of the breathing perils firefighters face and their respiratory accident history, insist on the "pressure-demand" type and may force a conversion to that type to assure a positive pressure on the inside of the firefighter's facepiece as a requirement for occupational safety for industrial fire fighters.

The comparative merits of the open-circuit SCBA and closed-circuit SCBA should be examined by users of SCBA; each type has its strengths. Both types are now available in NIOSH approved models for industrial fire fighting.

The merits of the Open-Circuit type SCBA are:

The mask is more easily and quickly sanitized between uses.

The quality of stored breathing air can be easily verified by laboratory testing.

The mask does not have a "breathing bag" or chamber which may become contaminated in use.

The mask does not expose the wearer to a pressure vessel of stored oxygen on his person while fighting fire.

Handling oxygen in use and storage is more hazardous than compressed air.

The compressed air mask does not require changing a CO^2 scrubber cartridge (pak), with each use cycle.

The mask is less expensive to purchase and operate.

1313 342

The merits of the Closed-Circuit type SCBA are:

The mask is lighter in weight.

The mask affords longer service time between "refills" (i.e. new air or oxygen bottles)

The mask is available in 30 and 60 minute models and will more fully achieve its time rating.

The mask is less bulky and awkward to wear.

In addition to the open or closed SCBA type system, an approved hose-supplied breathing system can be provided personnel operating in a limited area like a Control Room. Such systems can be supplied by a local vendor or a Plant compressor. Breathing air produced on the Plant premises must meet NIOSH (OSHA) standards for safe breathing air.

To maintain a refill capability for open type SCBA, a storage volume of air or an air compressor is needed. If a breathing air compressor assembly is used, it requires a clean air intake location with a reliable source of compressor-driver intake location with a reliable source of compressor-driver energy, and an approved purification system; all requiring bottling and storage systems. Plant personnel must be provided and trained to service the mask and be prepared to resupply clean breathing air for all persons who must work within the fire area. Some "smokes" are almost invisible; some seem easy to breathe; all must be considered dangerous and avoided.

Provisions should be made to provide emergency breathing air capability to sustain an aggressive fire-attack and control operation for a period of 6 hours. (Six hours is an NRC "fire duration" time based on prior fire experience in nuclear power plants).

This reserve capability is needed since most nuclear power plants are located in sparsely settled areas where they are served by small, marginal, part-paid and volunteer fire departments with little or no industrial fire fighting experience which would require a strong emergency breathing air capability. As a result, most nuclear power plants cannot rely on obtaining emergency breathing air help from their local fire department, and may actually have to provide SCBA support to sustain the local fire department during a plant fire fighting operation lasting more than one hour.

5.5 Mechanical Smoke Ventilation

Ventilation is a fundamental tactical procedure universally used by qualified fire fighters to remove heated air, smoke, flammable vapors, toxic and combustible gases from fires in confined areas of buildings, tunnels, and vessels. Proper ventilation practices help fire fighters more rapidly and more safely locate and extinguish fires in structures. Whenever possible, NATURAL or GRAVITY ventilation should be used. However, since many structural fires occur in tunnels, below-grade areas or in windowless buildings, it is necessary to employ mechanical means to ventilate the structure.

There are two common means of mechanical ventilation available to fire fighters; they are: The use of power-driven mechanical directional fans with portable lightweight ducts; and the use of hand-held fog streams to induce air movement by the venturi-like action of the water particles as they move through the air. The improper use of either mechanical or "natural ventilation" may be harmful; the effective and timely use of mechanical (or natural) ventilation must be learned through proper training and practice.

Smoke Ejectors are practical portable mechanical fans designed for, and universally used in the public fire service. The fans are manufactured in several sized in both electrically and gasoline driven models. There is merit in choosing explosion-proof types. Gasoline-driven models will operate without local house power but they also produce carbon monoxide poisoning in poorly ventilated spaces or ignition hazards in spaces with combustible gases or vapors. The gasoline models are usually driven by 2-cycle engines, which may be "cranky" to start without strict fuel supply care and maintenance.

These fans are designed to "draw" or "push" air and can be used in "series" connected with portable light-weight ducts. Care should be used in sizing the units. Generally fans should be chosen as large as one man can easily carry, and which do not exceed the limits of the electrical system readily available to supply them. Fire departments carry portable generators to run these fans and emergency lighting. Three smoke ejectors with a combined capacity of 17,000 to 20,000 cfm are desired based on an initial engineering guess. One fan may be used to supply fresh air and another to exhaust air from a space. A third fan may be used in series with another to move air greater distances through portable ducting. Portable ducts are available in two or more sizes and lengths. There is a practical limit to the movement of low pressure air, consequently this limitation requires consideration in preplanning. Smoke ejectors can be used for industrial ventilation emergencies other than fire fighting. Since these fans may be used with portable ducts, choosing a common size to assure compatibility with one duct size should be considered.

Portable ducts must be constructed with a high tension wire coil to avoid collapsing. Contrary to some lay opinion these smoke ejectors are neither designed for, nor intended to be used in very high temperature atmospheres; they are constructed with light alloys; they cannot be used as "flues" for fire.

All members of the plant fire brigade must be trained and practiced in the art and use of portable smoke ejectors based on pre-planned strategies for areas of the property where they may be needed.

5.6 Fire Fighters' Protective Clothing

Protective clothing to include helmets, coats, gloves, and boots, should be provided to protect fire brigade members and enhance their operating efficiency. In the municipal fire service, where fire fighters fight many fires, each individual is carefully fitted. When providing protective clothing for an industrial fire brigade a good range of sizes is needed. Sufficient suits of various sizes should be required to reasonably fit not less than 5 fire brigade members as they report at random on any shift. Loose fitting coats are preferred to tight fitting coats. The same "size mix" applies to helmets and boots. While helmet sizes are adjustable, to adjust a helmet size after the fire starts is not acceptable practice.

Fire fighters helmets with face shields in a configuration which will accommodate the SCBA facepiece should be provided. A fire fighters' helmet has a downturned brim to protect the fire fighters' face and neck. A polycarbonate helmet of the "Philadelphia Pattern" with a visor and chin strap will meet the needs of brigade members. The size should be adjustable. Yellow color will reflect heat and light, and provide better visibility by other brigade members, white is usually assigned to the leader.

Turn-out coats are designed to protect a fire fighter from injury much as a football player's uniform is designed to protect the athlete. The coat

1313 346

shell should be fashioned from a tough fire-resistant fabric with a waterproof and flame-resistant inner-liner to protect the firefighter from radiant-heat, water, the outdoor cold, and impact trauma.

Since the use wear-and-tear on a nuclear fire brigade member's protective clothing will be nominal, a lightweight coat with a fire retardant army duck fabric should suffice. Light colors are preferred. Normally the leader wears white to readily identify and distinguish him.

Fire fighters in public service also use heavy "turn-out" pants which facilitate quick dressing when answering night alarms and afford physical protection as does the coat. For a nuclear power plant a pair of hip-length fire fighters' boots should be sufficient to complete the fire fighters' protective clothing inventory without protective pants. The rubber boots would afford better protection in contaminated area, and could be more readily decontaminated that heavy fabric pants. Fire fighters' boots are insulated with felt liners to protect from heat and cold, and are equipped with steel arch and sole reinforcements; they are too costly to use as utility work boots. Fire brigade members should rely upon fire fighters' boots to protect them from electric shock. In addition, a suitable pair of gloves should be provided to protect the fire fighters' hands from cuts, abrasions, and in some cases the cold climate.

5.7 Tools and Appliances

1313 347

In addition to the hoses, nozzles, tools and equipment distributed in hydrant hose houses and at hose stations, spare and specialized equipment should be immediately available to the fire brigade leader (in a centralized equipment storeroom) during a fire emergency. This should include but is not limited to the following:

Smoke ejectors, with portable ducting

Portable hand-held 2-way radios

Electric hand lanterns, 6-7.5 volt sealed beam type

Spare lengths each of 2-1/2" and 1-1/2" fire hose

Spare hose nozzles of each size and type installed

1-1/2" adjustable, metering-type, nozzle (municipal type) to provide optimum stream flows and patterns in a critical fire fighting situation

Spare 2-1/2" x 1-1/2" x 1-1/2" gated wye

Spare 2-1/2" hydrant hose gate

2-1/2" double female adapters

2-1/2" double male adapters

2-1/2" x 1-1/2" reducers

2-1/2" hose thread appliance caps, rocker-lug type

Spare hose gaskets for each hose size used

Spare hose spanners

Spare hydrant hose wrenches

Spare PIV gate wrenches

Sprinkler head wrench

Sprinkler head stopper kit

Spare sprinkler heads for each temperature rating used

Fire axe

Forcible entry tool, Halligan (Hooligan) type

Hose clamp

PIEZO meter ring and gauge (for determing the dynamic pressure of hose stations and hose lines)

Hydrant drain pump, hand operated, with 8' of suction hose. (Needed to bail-out flooded frost-proof hydrant barrels in cold regions where hydrants may fail to drain promptly)

Hand-held heat detector, hot-spot scanner.

This list is based on a typical plants needs as constructed from our past experience. The quantities may vary dependent on specific plant geometries.

1313 349

6. CONCLUSIONS

Manual fire fighting capabil ties are a major area of concern when evaluating the overall effectiveness of a nuclear power plants' fire protection program. Because of the high dependence on the fire brigade and on operational administrative controls, these areas require detailed analysis when establishing plant specific programs.

By utilizing the "defense-in-depth" concept, four levels of fire protection have been developed:

1. Prevent
2. Detect
3. Suppress
4. Contain

As each level is violated the next becomes of prime importance in the fire scenario. Each of the four levels has one common mode of operating, that of manual fire fighting. The correct governing procedures and fire brigade capabilities can help prevent, detect, suppress, and in the worst case of sequences, simply contain the fire. Manual techniques are utilized to extinguish the small, incipient fires before automatic systems actuate as well as to contain and suppress the large fire that can no longer be handled by the engineered automatic systems.

Due to the variability of nuclear power stations, general guidelines are discussed that allow the criteria developed by the professional fire service to be applied to the special conditions that exist within the present vintage nuclear station. The ultimate goal of reducing the probability of a fire initiating an undesired release of radionuclide to the biosphere can be accomplished by the application of the technique of administrative controls, fire brigade personnel, tactical procedures and the application of the necessary equipment.

REFERENCES

1. McKinnon, Gordon P., editor, Fire Protection Handbook, 14th Edition, National Fire Protection Association (NFPA), Boston, MA, (1976).

2. Flammable and Combustible Liquids Code, NFPA 30, (1976).

3. Fire Protection Practice for Nuclear Reactors, NFPA 803, (1978).

4. National Electrical Code, NFPA 70, (1975).

5. Bulk Oxygen Systems at Consumer s Sites, NFPA 58, (1974).

6. Nuclear Plant Fire Protection Functional Responsibility Administrative Controls and Quality Assurance, NRC Guideline, (1978).

7. International Fire Service Training Association manual No. 200, "Essentials of Fire Fighting."

8. Marks, L. and Walsh, C.V., Fire Fighting Strategy and Leadership, 2nd Edition, McGraw-Hill, Heightstown, NJ.

9. Branch Technical Position 9.5-1, Guidelines for Fire Protection for Nuclear Power Plants, NRC, (Aug . 1976).

10. Outside Protection, NFPA 24, (1973).

11. Portable Fire Extinguishers, NFPA 10, (1975).

1313 351

APPENDIX A - TRAINING

1. General

   a. Fire protection at a nuclear power station should involve management, staff, and all operations, maintenance and custodial personnel.

   b. The prime purpose of the fire brigade training program is to qualify a select group of physically fit on-site personnel, chosen by management, to function as an effective firefighting team, to control and extinguish on-site fires.

   c. In order to more surely achieve the prime goal of the fire brigade training program, additional and more advanced training is prescribed for brigade leaders.

   d. This program presumes that all on-site personnel are or will be trained adequately to report fires promptly and properly; and to effectively use all portable fire extinguishers. It is not considered either practicable or advisable to attempt to train all employees to function as fire brigade members.

   e. If members of the SECURITY force are to be used as fire brigade auxiliaries, they must be trained as are brigade members in those phases of fire fighting operations they may be called upon to perform.

2. Fire Protection Systems Coordinator

The training program presumes that the station organization for fire protection includes a qualified fire protection system coordinator (fire marshal; fire chief) reporting directly to the station superintendant. The function of the fire marshal (fire chief) should be to coordinate all fire protection services on the site, including fire prevention, fire suppression, fire training, drills, inspections, and systems maintenance.

3. Training Aids and Resources

   a. Good training aids should be used to enhance lectures. Wherever possible, members should actually participate in hands-on training.

   b. Several fire oriented associations and corporations provide specific training materials, including 35 mm slides, 16 mm films, and other training aids at nominal costs.

   c. Qualified fire service instructors are available in most areas of the USA. Chief officers of active industrial fire departments should be consulted on fire fighting tactics and methods if practicable.

4. Training Frequency

   All assigned members of the fire brigade should complete the prescribed training within one year.

5. Practice Sessions

   a. Practice sessions should be held simulating types of fires which may occur in the nuclear power station. The sessions should provide actual practice using charged lines and other fire fighting equipment which might be required for the simulated fire.

   b. These practice sessions should include the use of emergency breathing apparatus while performing typical fire fighting operations.

   c. Practice sessions should be held at regular intervals but not to exceed one year for each brigade member.

1313 353

6. Fire Drills

a. Fire drills should be performed at the plant so the brigade can practice as a team. These drills should, when practicable include:

1. An assessment of fire alarm and response effectiveness
2. The performance of each brigade member
3. Performance in controlling a simulated fire
4. Conformance with procedures and plans
5. Operation of fire fighting tools and protective equipment
6. Evaluation of brigade leaders' performance

b. Drills should be performed by each brigade not less that 4 times a year; at least one drill should be performed on a "back-shift" for each brigade.

c. Drills should be pre-planned and critiqued by a management staff member.

7. Fire Training Records

Records of training provided for each brigade member should be available for review.

8. Fire Protection Library

A limited fire protection library should be provided for the use of the fire marshal, and to stimulate the interest and expertise of fire brigade leaders. As a minimum the library should include a current set of the NFPA Fire Protection Codes, the NFPA Fire Protection Handbook, IFSTA 200 "The Essentials of Firefighting" and all references listed in training programs.

1313 354

Table No. A1

RECOMMENDED TYPICAL

FIRE BRIGADE TRAINING PROGRAM

(All Brigade Members)

Session	Training Subject	Notes, References & Aids
No. 1 1-Hour	FIRE ALARM PROCEDURES & SYSTEMS AND FIRE BEHAVIOR	Instructor to explain how to report a fire when discovered, with a brief non-technical survey of the plant's fire alarm & detection system. Chapter 1, IFSTA 200; Sec. 2, Chapter 3, NFDA-FPHB
No. 2 1-Hour	PORTABLE FIRE EXTINGUISHERS (Including Wheeled Type)	Chapter 2, IFSTA 200; Explain site practices, locations, care and maintenance. Caution - All powders not compatible.
No. 3 1-Hour	PORTABLE FIRE EXTINGUISHERS (Hands on Training)	Trash & Panfires, refilling service. Chapter 2, IFSTA-200; Chapter 3, IFBTM-NFPA
No. 4 1-Hour	FIRE HOSE & STANDPIPES Construction & care of reels, racks, & testing; valves & connections. Stretches & carries, extending a line. Hose rolls & storage.	Lecture & demonstration. Use site-specific equipment. Chapter 5, pgs 99-130, plus pg 156; IFSTA-200.
No. 5 2-Hours	FIRE STREAMS Extinguishing Properties of H_2O; kinds of pressure; friction loss; types of streams; types & use of nozzles; handling fire streams; safety practices/hose streams; fire stream tactics; use of foams.	Chapter 6, IFSTA-200. Class room lecture aids (films, slides & devices), followed with actual hands on field session, laying & using charged lines.
No. 6 1-Hour	EMERGENCY BREATHING APP. Filter masks; self- contained B. App., Open Circuit-SCBA; Closed circuit-SCBA. Limitations; Safety Precautions; Recharging Procedures; Sanitizing; Care & Storage.	Instructor to give general information of the types. Then limit training to site-specific equipment. Selected sections Chapter 10, IFST 200. Manufacturer's manuals. Include fitting each member, and performing work fire fighter must do while wearing mask in contaminated atmosphere.

1313 355

FIRE BRIGADE TRAINING PROGRAM

(All Brigade Members)

Session	Training Subject	Notes, References & Aids
No. 7 45-Minutes	WATER SUPPLY Water Sources Bays, reservoirs & tanks Fire pumps The yard loop Mains, gates Hydrants, use & care Hose houses	 Site-specific data. Site-specific data. Factory data Plant engineering data Plant engineering data Selected sections, Chapter 5 of IFSTA-200
No. 8 1-Hour	VENTILATION PRACTICES Ventilation in fire fighting. Natural ventilation. Windowless structures. Forced ventilation; mechanical fans; fog streams.	Selected Sections of IFSTA-107; Chapter 9, IFSTA-200. Factory manuals
No. 9 1-Hour	FIXED EXTINGUISHING SYSTEMS Automatic Sprinkler Systems; CO_2 Systems; Halon Systems Foam systems Brigade's role in support, back-up, and restoration.	Selected sections, Chapter 16 IFSTA-200. Selected film or slides Manufacturer's data sheets Site-specific data Chapter 10, IFBTM
No. 10 1-Hour	SPECIAL HAZARDS Flammable & combustible liquids. Electrical systems Flammable gases Radiation hazards Windowless structures Basement fires-ventilation	 Films & slides Rad-Control offices Fire tactics by E. Fried Use qualified fire officer
No. 11 45-Minutes	FIRE ALARM COMMUNICATIONS Station fire alarm systems Fire detections systems Fire brigade radios The control room's function The PA system Action of the work force Action of the fire brigade Off-site fire forces	 Detailed explanation of how the systems work Station procedures Fire plan-all site specific

1313 356

FIRE BRIGADE TRAINING PROGRAM

(All Brigade Members)

Session	Training Subject	Notes, References & Aids
No. 12 45 Min.	FIRE PREVENTION PRACTICES Transient Fire loads Hot works precautions Smoking regulations Housekeeping practices Role of supervisors Role of brigade members Administrative Controls Role of security members Surveillance of contractors	 NFPA No. 51, also see Chapter 2, 5th Ed., IFBTM Site specific Plant procedures Plant specific
No. 13 1-Hour	RESCUE PRACTICES	Chapter 7, IFBTM Selected sections, Chapter 8, IFSTA-200; Emergency Care, R. J. Brady Co.
No. 14 30-Minutes	SALVAGE & OVERHAUL PRACTICES Searching for hidden fires, extinguishing hidden fires	 Selected sections, Chapter 11, IFSTA-200
No. 15 30-Minutes	FIRE DRILLS Participants Frequency Coordination/Off-site FDs Critiques Documentation	 All brigade members Set by plant procedure Invite off-site chief Management Keep records Instructor-Fire Marshal

1313 357

Table No. A2

FIRE BRIGADE TRAINING PROGRAM

(Brigade Leaders)

Assignment	Training Subject	Notes, Aids & Resources
No. 1	PRE-FIRE PLANNING Evaluating the fire problem	IFSTA 302 Chapter 5, FGT
1-Hour	The size-up	Suggested reading, FFT, by Lloyd Layman, NFPA
	Ventilation Practices	Suggested reading - Chapter 6, FGT
No. 2 Selected reading assigned by Fire Marshal	COMBUSTION EXPLOSIONS Flammable gases Smoke explosions Flammable liquid fires	 Sect. 2, Chapters 2, 3, 4, & 5 FPHB, Selected reading Sect. 3, Chapters 3 & 4, FPHB Selected readings. NFPA
No. 3 Selected readings to be assigned by Fire Marshal	THE ROLE OF THE BRIGADE IN SUPPORT OR IN LIEU OF AUTOMATIC EXT SYSTEMS Automatic sprinkler systems Special F. Ext. Systems Restoring auto-systems	 Chapter 16, IFSTA-200, Section 14, FPHB Section 15, FPHB Installers manuals and data sheets
No. 4	ATTACKING FIRE IN A CONFINED HOT SPACE	Seek qualified fire service instructor
1-Hour	Precautions in entering, use of fog smoke explosions	(Discussion of problems and techniques)

1313 358

FIRE BRIGADE TRAINING PROGRAM

SUGGESTED TRAINING REFERENCES & RESOURCES

Key		Publications and other Resources
1.	IFSTA	International Fire Services Training Assn., Oklahoma State University, Stillwater, Oklahoma 94074
2.	FPHB	Fire Protection Handbook, 14th Edition; National fire Protection Assn., (NFPA) 470 Atlantic Avenue, Boston, Mass. 02210
3.	IFBTM	Industrial Fire Brigades Training Manual, 5th Edition NFPA, 470 Atlantic Ave., Boston, Mass. 02210
4.	FGT	Fireground Tactics by Emanual Fried, H. Marvin Ginn Corp., 625 North Michigan Ave., Chicago, Illinois 60611
5.	A&EIF	Attacking and Extinguishing Interior Fires by Lloyd Layman, Fidelity Press, Boston, Mass., NFPA
6.	FFT	Fire Fighting Tactics by Lloyd Layman, Fidelity Press, Boston, Mass. NFPA
7.	FFS&L	Fire Fighting Strategy and Leadership, 2nd Edition by Walsh & Marks, McGraw-Hill Pub. Co., Hightstown, N.J.
8.	FPI	Flash Point Index Trade Name Liquids, 9th Edition, NFPA, 470 Atlantic Ave., Boston, Mass. 02210
9.	FPG-HM	Fire Protection Guide on Hazardous Materials; NFPA, 470 Atlantic Ave., Boston, Mass. 02210
10.	EC	Emergency Care by Grant & Murray, Robert J. Brady Co., Bowie, Maryland 20715.
11.		Handling Flammable Liquids (A training film explaining the hazards encountered, and safe methods for handling flammable liquids). The Protectoseal Co., 225 Foster Avenue, Bensenville, Illinois 60106
12.		Community Colleges, Insurance Service Offices, and Larger Fire Departments in most regions of the U.S.A. can advise when and how fire protection information and training assistance may be obtained.

NFPA offers a number of 16mm training films and 35mm slide programs.

1313 359

DISTRIBUTION

M. Antonetti	1
I. Aso	1
V. Benaroya	1
E. Blackwood	1
W. Butler	1
R. Cerbone	1
D. Eisenhut	1
R. Feit	1
R. Ferguson	5
R. Hall	1
S. Hanauer	1
E. Imbro	1
W. Kato	1
J. Klevan	1
G. Lainas	1
C. Long	1
E. MacDougall	1
J. Riopelle	1
V. Stello	1
T. Telford	1
H. Todosow	2
J. Townley	1
NRC - Division of Technical Information & Control	2