SAFETY EVALUATION

BY THE

DIVISION OF OPERATING REACTORS

SUPPORTING THE OPERATION AFTER THE

RESTORATION AND MODIFICATION OF THE

BROWNS FERRY NUCLEAR PLANT, UNITS 1 AND 2

FOLLOWING THE MARCH 22, 1975 FIRE

DATE: February 23, 1976

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1.0 Introduction

On March 22, 1975, a fire at the Browns Ferry Nuclear Plant caused a shutdown of Units 1 and 2. The facility subsequent to the shutdown was found to have incurred substantial damage to power, control, and instrumentation wiring. All three units are presently in the shutdown condition with the fuel removed from the vessels for Units 1 and 2; the Unit 3 reactor is still under construction with operation for that unit scheduled for early 1976. An overall program has been developed by the licensee delineating the necessary activities required to restore damaged portions of the facility to a safe level so that operation of Units 1 and 2 can be resumed. This program has been described in "Plan for Evaluation, Repair and Return to Service of Browns Ferry Units 1 and 2 (March 22, 1975 Fire)" dated April 13, 1975, and revisions thereto up to and including Revision 37 (the Plan).

As a result of the fire an NRC review program was developed consisting of three major and parallel elements. The first element was the investigation conducted by the Office of Inspection and Enforcement (OI&E) of events leading to the fire, fire fighting efforts, sequence of operational events and problems experienced with the nuclear steam supply system, interaction between units, and the response of TVA, and State and Local authorities. This phase of the NRC program has been completed and the results are given in the OI&E Investigation Report of the March 22, 1975 Fire at the Browns Ferry Nuclear Station, dated July 25, 1975.

The second element of the program, being performed by the Office of Nuclear Reactor Regulation has as its objectives (1) to assure that a safe plant configuration was attained and is being maintained subsequent to the fire, (2) to assure safety during removal of fuel from Units 1 and 2, (3) to assure plant safety during fire damage removal and restoration, and (4) to determine that the design changes that are required for restoration of these plants to operational status are acceptable. (See Attachment 1 for Chronology)

The third element of the NRC program consists of the review being performed by the Special Browns Ferry Review Group established on March 26, 1975. Efforts of this review group will be to prepare for NRC, recommendations to change, as required, NRC policies, procedures, and technical requirements in regard to fire protection at nuclear power plants. The Review Group's report is anticipated about March 1, 1976.

The NRR reviewers of Browns Ferry Plant restoration and modifications have had the benefit of informal discussions with members of the Special Review Group (SRG). In this way, the NRR reviewers have been aware of the recommendations to be made by the SRG. These recommendations were considered and appropriately implemented in Browns Ferry. In some cases, the SRG recommended that further generic consideration be given to certain aspects of fire protection or recommended that consideration be given to changing NRC requirements or guidelines. In the areas that require additional future consideration, the Browns Ferry modifications will be reevaluated when any new position has been developed.

The SRG also had the benefit of the ongoing TVA and NRC evaluations of the Browns Ferry fire and the proposed restoration and corrective modifications. Copies of the Plan and all revisions thereto were supplied to the SRG, as well as NRR correspondence, meeting summaries, and safety evaluations for NRR licensing actions during the course of restoration.

A comparison of the Special Review Group's recommendations with the modified Browns Ferry Plant will be presented in a supplement to this report.

Thus far there have been three significant licensing actions taken to meet the objectives of the review performed by the Office of Nuclear Reactor Regulation. First, the plant Technical Specifications were changed to Temporary Technical Specifications designed to assure that a safe configuration was maintained following the fire, while further corrective action plans were under development. These Temporary Technical Specifications and the associated safety evaluation were issued with Amendment 9 to License DPR-33 (Unit 1) and Amendment No. 6 to License DPR-52 (Unit 2) on May 9, 1975.

The Technical Specifications were again changed to provide for the removal of fuel from both Unit 1 and 2 reactor vessels and placement into the respective storage pools. These changes and their associated safety evaluation were issued with Amendment 10 to License DPR-33 and Amendment 7 to License DPR-52 on June 13, 1975. These changes also assure that the necessary protective equipment to assure protection of the fuel in the storage pools from damage would be available with adequate redundancy and would be protected against adverse interaction with the fire affected wiring and cables, while such fire damage was removed and when the damaged wiring and cabling was replaced.

On September 2, 1975, NRC issued Amendment 14 to License DPR-33 and Amendment 11 to License DPR-52 that authorized restoration and modification activities described in the Plan up to and including Revision 20. The safety evaluation accompanying those amendments describes the work that was authorized and presents our conclusions as to its acceptability. Part of our conclusion at that time was that additional measures would be required to enable us to find that the plant was acceptable for return to operation. By letter dated August 29, 1975, TVA agreed to provide further improvements in fire protection. The revisions to the Plan from Revisions 22 to 37 included provisions of the implementation of the commitments made in the August 29, 1975 letter.

This Safety Evaluation Report presents the results of our evaluation regarding the acceptability of the restoration and modifications at the Browns Ferry Nuclear Plant Units 1 and 2 to establish that the facility may be operated in the restored and modified condition without endangering the health and safety of the public. Although some of these activities were the subject of the September 2, 1975 evaluation, a complete evaluation will be presented herein. This will present a total picture of the substantial enhancement of the capability of the facility that is now provided to prevent and withstand a fire. In our evaluation, we made use of our own consultants and those of the licensee. (See Attachment 2)

The TVA modification program related to fire detection and extinguishment is being conducted in two stages. The first stage covers those changes to be accomplished prior to restart, which is currently scheduled by TVA for the end of March 1976. Section 7.5 of this report discusses these changes and provides the staff evaluation for approval. Section 7.6 discusses the second stage modifications which are intended to be completed at the first refueling outage of either unit. It provides the staff evaluation for approval of the design criteria.

A letter from the Office of Inspection and Enforcement will provide confirmation that all of the work described in the Plan as being required prior to restart has been completed before the authorization for return to operation will be issued.

2.0 Results of Investigation of Damage

2.1 Description of Fire Affected Area

Substantial detail concerning the cause of the fire and the extent of damage to structures, systems and components is provided in the previously noted OI&E report. The following brief summary is provided as background for the discussion of the repair and replacement activities described in this Safety Evaluation.

After ignition, the fire propagated through the penetration in the wall between the cable spreading room and the Unit 1 reactor building. As a result of the pressure differential which is maintained between the reactor building and the cable spreading room, and because an installed carbon dioxide (CO_2) fire extinguishing system was used in the cable spreading room, only a small amount of burning occurred in the cable spreading room. Damage to the cables in this area was limited to a few feet immediately adjacent to the penetration where the fire started. The major damage occurred in the reactor building outside the cable spreading room, in an area roughly 40 feet by 20 feet, where a very high concentration of electrical cables exists. There was very little other equipment in the fire affected area, with the only direct damage other than cables being the melting of a soldered joint on an air line.

In order to provide a basis for assessing damage within the fire affected area TVA developed a program for determining temperature zones. Six zones were established on the basis of physical evidence ranging from buff colored concrete (1500°F) to paint softened but not blistered (300°F). These zones were utilized by other study teams to determine the temperatures to which various pieces of equipment may have been subjected.

The investigation of damage was conducted throughout the reactor building in both Units because the spread of soot and products of combustion extended beyond the immediate fire affected area.

2.2 Circuits Damaged

The electrical cables, after insulation had been burned off, shorted together, and grounded to their supporting trays or to the conduits, resulting in the loss of control power for much of the installed equipment such as valves, pumps, blowers and the like.

Exhibit C1 of the OI&E report is the TVA report of physical damage to the electrical cables and raceways. It identifies 1611 cables that were damaged or assumed damaged. Exhibit C3 of the OI&E report lists the Unit 1 systems lost during the fire resulting from cable damage.

The most significant aspect of the damage was that it resulted in the loss of redundant safety equipment. However, adequate cooling to remove decay heat was always available. Our assessment of plant safety during and after the fire was included with Mr. Benard Rusche's testimony at the September 16, 1975 Hearings before the Joint Committee on Atomic Energy concerning the Browns Ferry fire.

As discussed in Section 3 of this SER, although the units were safely shut down and cooled, the staff has required considerable change in administrative actions, isolation* of redundant safety circuits, and fire detection and extinguishment capabilities. These changes minimize the possibility of loss of more than one division of cooling equipment.

*The term isolation of redundant circuits is used in this report to mean those design features, such as barriers or separation, employed to prevent a fire in one division from affecting the other division.

2.3 Electrical Equipment Other Than Cable

The Browns Ferry damaged electrical equipment identification program encompasses a three pronged approach. The investigation considers equipment exposed to high temperatures, equipment contaminated by smoke and soot, and equipment exposed to abnormal electrical power conditions. An elevated temperature zone has been established by visual inspection of the areas around and adjacent to the fire. All electrical equipment within the established zone has been identified and thoroughly checked for any degradation. Either during or following cleanup of the identified equipment, a visual inspection has been made for signs of distress or overheating damage sustained by insulating components. If necessary, components were disassembled to verify observations. Non-destructive electrical tests appropriate for the type of equipment involved will have been made and the results will have been evaluated prior to startup. Preoperational tests will then be performed to verify the correct functional performance of the equipment, controls, or circuits involved. (See Section 9.2).

A larger zone than the high temperature zone has been established for the purpose of removing soot and smoke residues from electrical equipment. Equipment in this zone beyond the boundaries of the high temperature zone also underwent physical inspection during cleanup. The equipment will undergo a similar verification program as outlined above for equipment in the high temperature zone prior to operation.

The third area of investigation is abnormal electric power conditions. Due to the extensive cable damage in the cable trays and the fact that most cables were energized, the possibility exists that excessive transient voltages and current, short circuits, and ground faults occurred. The Plan states that all power circuits and most control circuits are protected by relays, fuses or circuit breakers which operate for overcurrent or fault conditions and thus protect the electrical equipment. While this is true, absolute credit for overcurrent devices cannot be given under these circumstances. We have taken the position that with the possibility of hot shorting within the trays, proper circuit protective action may not have been effective on some circuits. TVA committed to perform diagnostic electrical tests on all electrical equipment that may have been exposed to abnormal electrical power conditions. This is a result of our position that visual inspection alone was insufficient to ensure all degraded electrical equipment would be identified. TVA states that this requirement will be satisfied by performing the inspections and tests specified in the cleaning procedure* or by performing satisfactory functional tests after cable restoration.

*Part V, Section B.2 of the Plan.

Any equipment found damaged, to have failed, or to be unsuitable for continued service shall be repaired if repair is technically feasible, not extensive, and economically justifiable. Equipment not fitting into the above categories will be replaced. When repairs or replacements are completed, surveillance tests or pre-operational retests will be performed to demonstrate satisfactory performance. To date no fire related damage to electrical equipment other than cable has been found.

We find this program gives reasonable assurance that all damaged electrical equipment will be identified and properly restored and is therefore acceptable.

2.4 Evaluation of the Integrity of Piping, Structural and Mechanical Components for Continued Operation

We have considered potential adverse effects to the metallic materials of safety related mechanical components from heat and combustion product release from the fire. Effects identified as requiring detailed evaluation were (1) stress corrosion due to chloride contamination from combustion products, (2) liquid metal embrittlement from liquefaction of low melting point metals, and (3) elevated temperature exposure effects on materials.

The burning of the polyvinyl chloride electrical insulation produced an estimated 1400 pounds of chloride in the form of hydrochloric acid droplets mixed into a soot-like residue. Chloride containing residue was deposited throughout the Unit 1 reactor building and in limited areas in the Unit 2 reactor building. Chlorides are corrosive to most materials but the principal concern is the possibility of their initiating stress corrosion cracking in austenitic stainless steels or high strength ferritic steels. Chemical analysis of the residue indicated that it was 20% chloride with zinc, lead, tin and copper each present in concentrations of less than one percent.

The licensee identified all components susceptible to possible stress corrosion damage and implemented a program of cleaning, cleanliness verification, inspection, evaluation and surveillance. The combustion product residue was removed by dry cleaning followed by wet detergent cleaning. The procedures were repeated until measured chloride levels were below 0.08 mg per dm^2. This is recognized as an acceptable level for chloride in contact with stainless steel and is incorporated as the acceptance level in ERDA/RDT standard Number F5-1T, "Cleaning and Cleanliness Requirements for Nuclear Components." All components (except electrical) have been cleaned to this standard.

After cleanliness was verified, precautions were taken to prevent recontamination. Locations where chloride contamination could have been trapped were identified. For example, porous thermal insulation was removed and replaced with new insulation. Metal covered non-porous insulation has little potential for acting as a trap for contamination but it will have been tested to assure that chlorides have not penetrated.

2.4.1 Piping

Insulated and uninsulated piping were both used within the zone of influence of the fire. Since all uninsulated piping within the heat affected zone contained water during the fire their temperature increases were limited. All piping was evaluated on the basis of temperature effects and chemical corrosion effects before acceptance for continued service. Replacement with new piping was used as an alternative to the evaluation procedure.

The possibility of austenitic stainless steel piping being heated into the sensitization range (800 to 1200°F), which would increase its susceptibility to stress corrosion, was investigated. It was determined that no stainless steel pipe was exposed to these temperatures. In a few instances, carbon steel piping (4 inch diameter maximum) was replaced because of heat effects. Any aluminum piping determined to have been exposed to a temperature in excess of 340°F was replaced. One run of aluminum pipe was replaced because of pitting and corrosion. Penetrant inspection was performed on the carbon steel and aluminum tubing on a sampling basis with no significant problem areas detected. All small diameter copper instrument lines in the region of the fire were found to be discolored and were replaced without further evaluation.

Stress corrosion cracking related to the chloride contamination from combustion products could occur immediately or in the future due to residual effects. Each stainless steel safety-related component or pipe that was exposed to possible chloride contamination was subject to liquid penetrant examination and will be monitored by a surveillance program. The penetrant inspection included 100% inspection of the core spray line, control rod drive hydraulic return line, reactor water cleanup line, reactor water level monitor line, HPCI and RCIC instrumentation lines and each of the attached valve bodies. The other stainless steel components were examined on a sampling basis as described in Part V of the Plan, Section B. 1, App. B to Mechanical Maintenance Instruction 46, which we found acceptable. No indications of damage were found and these items are now under a surveillance program.

To completely evaluate the effects of the combustion product residue, 11 metallurgical samples were removed from Unit 1 stainless steel components. One sample from a high strength steel core spray hanger spring was also taken. The examination included a boat sample containing the weld and heat affected zone from the core spray elbow. Samples were taken also from high residue areas outside of the fire zone. Surface replicas are included in the program because this is a non-destructive technique that would provide greater sampling.

In addition to conventional metallography, scanning electron microscopy and qualitative spectroscopy were used for the evaluation. Only one minor indication that could be attributed to the initial stages of stress-assisted corrosion was found. This was slight intergranular attack on a small diameter sampling line located on the fire level. Additional metallographic evaluation will be conducted on thin wall instrument tubes in the fire area with results submitted for review to NRC prior to startup to confirm that there is no damage.

The qualitative spectrograph is extremely sensitive to small concentrations of elements. It detected trace levels of chlorine on three samples. None of the embrittling elements such as zinc, lead or tin were detected by the spectrograph. These elements were found in the combustion product residue but to cause embrittlement, they would have to be in contact with the steel while in the liquid state. We conclude that liquid metal embrittlement is not a factor and that the trace indications of chlorides are not significant.

While we conclude that the cleaning procedures and subsequent inspections were adequate, there is no assurance that corrosion assisted effects will not appear at some later time. The licensee has committed to a surveillance program for the first two years. Quarterly, after the unit is returned to power, a general visual examination of the piping systems for evidence of leakage, cracking and other distress will be conducted by qualified personnel. At the first refueling, liquid penetrant inspection will be conducted in the same areas as in the original inspections discussed above. In addition, surface replication will be conducted in the same areas as the original metallographic examinations; e.g., areas with heavy deposits of residue. Any adverse findings will increase the scope of the examination.

We are in basic agreement with the licensee's surveillance program approach, however, we are in the process of evaluating the need for an increased scope and longer period of surveillance. The details of the full program will be finalized prior to the return to operation and will be included in a supplement to this report.

We have had the benefit of the comments and recommendations of the licensee's two consultants (Part V of Plan) in the area of fire effects on materials. We are satisfied that the licensee has been responsive to these comments and recommendations. (See Attachment 2)

We have reviewed and evaluated the program that the licensee has implemented to demonstrate the absence of detrimental effects on the metallic materials of construction of safety related mechanical components. We conclude that the licensee has conducted an adequate program of investigation of problem areas, component cleaning, cleanliness verification, evaluation and testing.

2.4.2 Mechanical and Structural

Safety related heating ventilating and air conditioning ducts were evaluated on the basis of exposure to temperature of 500°F or greater as gaged by the established temperature zones and visible distortion of the ducts. All ducts showing visual distortions have been replaced or reworked to original specifications. All duct work influenced by the fire has been cleaned regardless of temperature exposure.

Evaluation of cable trays, cable tray supports and fixed members of pipe supports was based on exposure temperatures and stress analysis considering material strengths reduced by any possible annealing affects of higher temperature exposure. Any structural steel found to have been immersed in a temperature of $1000^{o}F$ or higher was replaced without further evaluation.

In general all cable trays in direct and near contact with cables actually consumed by the fire were replaced without further evaluation. The larger cable tray supports were re-evaluated based on the actual load to be sustained. The acceptable stress levels for these analyses were set at either 75% of the original design allowable stress or based on the measurement of actual physical properties from a sample of the material exposed to the actual fire conditions.

The requirements specified above for acceptance of cable tray supports were also employed for acceptance of the fixed members of pipe supports. Additional requirements have been established for acceptance of the variable elements of pipe supports. In the absence of variations in setting from the effects of the fire and the absence of actual fire damage the support setting was corrected to give a properly aligned piping system. Setting changes as a result of the fire with no visible evidence of heat damage required evaluation of spring characteristics to assure the necessary range of support as required by the system design. Visible heat damage required replacement of the spring mechanism and if necessary the entire support. We find that the procedures set forth for the evaluation and restoration of the safety related HVAC ducts cable trays, cable tray supports, and the fixed and variable members of pipe supports provide adequate assurance that these items will be capable of performing as designed throughout the range of loads and functions specified in the design bases for Browns Ferry Units 1 and 2.

With respect to the structural steel components and the reinforced concrete structures which either support the cables or were in the vicinity of the burning cables TVA conducted a restoration program which consisted of:

1. Identification of the affected structures;
2. Establishment of the most probable temperature to which each structure was subjected during the fire;
3. Evaluation of the extent of damage of each structure;
4. Establishment of criteria for the requirement of replacement or repair of the damaged structure; and
5. Development of procedures for detailed repair.

The structural steel components affected consisted of miscellaneous structural steel supports, steel embedment, and portions of the building superstructure steel. The reinforced concrete structures affected consisted of walls, columns, and floor slabs, which form the permanent building superstructure.

The temperature zones were established on the basis of the color of the structures of different materials of construction, melting of metals and burning of other materials. The extent of damage of each structure was evaluated on the basis of the temperature to which the structure was subjected and the physical condition of the structure.

The criteria for the requirement of replacement or repair of damaged structures are as follows:

1. Steel Structures

   Structural steel components will be replaced or will continue to be used depending upon whether their thermal sensitivity is lower or higher than the temperature to which the structural component was subjected during the cable fire. In addition any steel structure found to have been immersed in a temperature zone of 1000°F or more shall be replaced.

2. Concrete Structures

   For reinforced concrete structures, the procedures for the evaluation of the concrete will consist of detailed visual inspection, comparison of temperature zones and testing of samples from core borings. For reinforcing steel, the procedures of evaluation will consist of the following:

   (a) Analyze the adequacy of the structure by neglecting the steel bars exposed to high temperatures, and if found adequate no further evaluation will be done; and,

   (b) Conduct sampling and testing of steel bars to determine their material characteristics. The measured material characteristics will be evaluated by rechecking the design of the affected structure. If the reduced characteristics are still adequate to resist the loads imposed on the structure, no modifications are necessary.

On the basis of the above criteria, the floor slab at elevation 621 feet in the reactor building which appeared to be most seriously damaged was evaluated by TVA. Reinforcing steel bar and concrete core samples were taken and tested. The results of the tests showed that the material characteristics of the reinforcing steel and concrete were not adversely affected by the fire. On the basis of these findings, TVA concluded that the fire damage to reinforced concrete was structurally minor. Consequently, the repairs to be undertaken were considered non-structural.

We have concluded that the criteria, methods and procedures that were used in the evaluation of damage of structures and in the replacement of structural steel components assures that all structural components affected by the fire have been returned to their originally acceptable condition.

2.4.3 Summary of Inspection Results

The investigations regarding piping, structural and mechanical components indicated a minimum of damage outside of the cables, conduit, cable trays and cable tray supports in the immediate fire area. The piping replaced included only six small non-safety related lines. Three sections of HVAC duct were replaced. No structural repairs were necessary. Two spring hangers were repaired and one pipe support was replaced.

2.5 Cable Replacement and Repair

The major effort in restoring the facility to a condition in which it will be able to operate, is the replacement and repair of damaged wiring and cables. This amounts to some 9500 conductors to be replaced or spliced. All divisional cabling (reactor protection system, primary containment isolation system, and engineered safeguards) and 4160 v. power cables will be replaced from terminal to terminal (without splicing). Only non-divisional control and instrumentation cables will be considered for splicing. Of these, the specific repair requirements provide for protection against high temperature that could result from a poor splice. The procedures proposed call for splicing at undamaged locations determined by measurements made on the insulation material; for splices in accordance with applicable codes; for accessibility to facilitate inspection; and for measures that assure no mechanical loading exists on the splices. Appropriate fire stops are provided along the cable trays away from the splice. In-line splices within the cable trays have been allowed for those cables that have been demonstrated incapable of supplying sufficient energy to a poorly constructed splice to cause cable insulation ignition. All other cables shall be spliced in metallic enclosures outside the cable trays.

The specific criteria which we and the licensee arrived at for the replacement and repair of cables are as follows:

1. Reactor protection system, primary containment isolation system, and engineered safeguards system (divisional) cables shall be replaced terminal-to-terminal.

2. Damaged nondivisional cables in 4160-volt circuits in cable trays shall be replaced terminal-to-terminal.

3. Cables in 480-volt circuits shall not be spliced in the cable spreading room.

4. There shall be no splices within the 15-foot zone containing trays of both Division I and II identified in Figure 4 of Appendix 3.3A, Part X, Section A, of the Plan.

5. Cables in medium- and low-level signal cable trays shall be spliced in-line in the trays without boxes. Medium-level signal cable trays carry instrument control loop cables, digital computer cables, shielded annunciator input cables used with solid-state equipment, and instrument signal cables associated with transmitters, recorders, and indicators other than thermocouple cables, strain gauge cables, vibration detector cables,

thermal converter cables, and resistance-type temperature detector signal cables. Medium- and low-level signal cable trays correspond to those in items (4) and (5) respectively of paragraph (c) on page R7.5-11 of the FSAR.

6. Cables in control cable trays shall be spliced in-line in metal enclosures that meet the requirements of Article 370 of the 1975 National Electric Code. Control rod position cables, which are medium-level signal cables routed in control cable trays, may be spliced as permitted by Criterion 5. Control cables correspond to those of item (3) of paragraph (c) on page R7.5-11 of the FSAR.

7. Cables in 480-volt trays outside the spreading room shall be spliced in metal enclosures that meet the requirements of Article 370 of the 1975 National Electric Code.

8. Where cables are terminated on equipment within the reactor building fire area, and have any portions of the cables routed in cable trays, the cables shall be replaced from the equipment such that there is no more than one splice per conductor.

9. Cables routed in conduit within the zone of influence of the fire area shall be replaced and spliced in the nearest splice box outside the zone of fire damage containing undamaged cables. Branch lighting circuits are exempt from this criterion.

10. Spliced cables shall be accessible for inspection.

11. Spliced cables shall be supported so that there is no mechanical load on the splice.

12. A fire stop, consisting of a Factory Mutual approved fire retardant cable coating, shall be applied for a distance of 3 feet along the cable trays at both ends of the cable spliced areas but shall not coat the cable splice.

We concluded that thecriteria used for replacement and repair of cables were acceptable because they provided protection against the effects of a high temperature that could be produced in a poor splice in a circuit carrying a sufficient amount of power and provided protection against the effects of an interruption to a divisional circuit by requiring terminal to terminal replacement. We further conclude that the acceptable restoration criteria in conjunction with the special training and quality control developed for splicing as well as the extensive testing of all equipment associated with replaced and repaired cable provides for an acceptable program for restoration to an operable condition.

3.0 Approach for BFNP Fire Protection

Units 1 and 2 share a common control room with a shared cable spreading room located beneath the control room. Cables carrying signals between the control room and various pieces of equipment in the plant are routed into the cable trays in the cable spreading room. The fire caused extensive damage to wiring located immediately outside of the cable spreading room.

Some sharing of equipment exists between all three units; the sharing of electrical systems is most extensive in Units 1 and 2. The electrical design concept employed in the design of Units 1 and 2 is based on using a two-division concept. The purpose of dividing each Unit's electrical system into two divisions was to assure that the facility could be maintained in a safe configuration even with the postulated loss of one entire division.

Consideration of the consequences of fires requires that the capability be maintained during and following the fire to safely shutdown the reactor and remove the decay heat. Previous analyses (PSAR and FSAR) have shown that only one division of electrical equipment is required to assure that the facility is maintained in a safe condition. The control rod system in a BWR is designed to be fail safe. That is, a loss of electrical power results in initiating a scram of the control rods and shutdown of the reactor. Therefore, the major objective for protection of the reactor from the effects of fire is to assure that necessary equipment to remove decay heat remains operable in the event of a fire.

Thus, it is important to limit fire induced failures to one division of the safety related equipment for shutdown heat removal from each reactor which provides for each reactor at least one core spray system with two associated pumps and valves, and one RHR system with associated pumps, heat exchangers, and valves, together with enough relief valves for reactor system blowdown to low pressure. (It should be noted that non-safety grade equipment is normally used to perform this function). In order to assure that a fire could not cause a loss of both divisions, some changes in the facility design and equipment were necessary.

Although the fire that occurred caused damage to the electrical system greater than that which had been considered in our original evaluation of that facility, our current evaluation has shown that even with this extensive damage, considerable flexibility remained with respect to methods available to remove the decay heat from the reactor and assure the reactor was maintained in a safe condition.

In spite of the capability already inherent in the facility, the fire demonstrated that additional emphasis on the protection of the facility from a fire is needed. In this connection we have considered those features, actions and design approaches that should be a part of fire protection capability. The three basic considerations in minimizing the effects of the fire are: (1) administrative actions that can prevent a fire from occurring; (2) use of isolation as a mechanism to prevent a fire from damaging redundant safety equipment; and (3) incorporation of a means to detect and extinguish a fire quickly. No one of these three elements can be relied upon to completely eliminate problems associated with fires and no one of them can be practically achieved to perfection. However, we would emphasize that each of these elements should be considered by itself to the extent practical. The degree of practicality is affected by the fact that we are assessing the design features, such as physical separation and installed extinguishing systems, of a plant that is already designed and built.

In the following sections, the evaluation of these three elements of the fire protection at Browns Ferry are discussed. The significant modifications made to enhance the fire protection capabilities are identified.

How these modifications compare with the Nuclear Energy Liability-Property Insurance Association (NELPIA) recommendations is presented in Attachment 3.

4.0 Plant Fire Protection Reanalysis

The licensee has performed a reanalysis of the total plant fire protection requirement considering permanently installed combustible materials, location of these materials in the plant, identification of the installed fire fighting and monitoring systems, evaluation of each area to determine if a postulated fire could affect safe shutdown capability of the reactors, and identified and proposed modifications to the fire protection and detection systems to ensure the safe shutdown requirements. The methodology, assumptions and criteria are set forth in Part X, Sections 5.1.2 and 5.1.2.1 of the Plan. The descriptions of the types of fire extinguishing capabilities used in the evaluation are set forth in Section 5.1.3.

Since the major combustible material involved in the March 22, 1975 fire was cable insulation and jacketing, the licensee made a concentrated effort on identifying critical areas containing this material and in addition analyzed all other areas of the total plant for combustible material and determined their relationship to the safe plant shutdown requirement.

In performing the analysis the licensee developed a table indicating the location of combustible materials, the quantity of material present, the class of fire it presents, the fire detection and extinguishing methods that are or will be provided for each area containing combustible material, the resulting fire load that the material can place on the area, location of the specific areas as related to plant layout drawings, and a safety classification for each area, such as safety related, not safety related and safety related exposure fire potential. This Table is presented in Part X of the Plan and identified as Table 5.1-1, Sheets 1 through 9 with three attachments. The location of each area is shown on drawings following the table.

The results of the reanalysis are set forth in Part X, Section 5.1.5 and the design modifications are described in Sections 5.2 and 5.3. Our evaluation of these modifications is presented in later sections of this report.

The basic approach to the fire hazard reanalysis was to survey the plant and determine the combustible materials present and then calculate the fire load that they presented to the area. If critical areas that could affect safe shutdown were involved then the fire load was used to determine the adequacy of installed monitoring and fire extinguishment systems. If the installed systems were not adequate based on the fire load for the area, modifications to the plant were proposed to protect the critical areas.

An example of the licensee's approach is for the area where the March 22, 1975 fire occurred. The cable insulation and jacketing for this area was determined to be 228 cubic feet of high density combustibles and 417 cubic feet total. The fire load was calculated assuming that the fire retardant coating that will be installed on the cables was not present and was only taken credit for in retarding the rate of spread of the postulated fire in the area. The calculated fire load for the high density area was 58,160 BTU per square foot of floor area and the remainder of the total was calculated to be 15,900 BTU per square foot of floor area. Based on the fire load the licensee decided to install a fire water deluge system for the high density area and a preaction sprinkler system for the remainder of the area. Using the fire load values the proposed systems were designed to NFPA Standards. The resultant fire water application was determined to be 0.3 gpm per square foot of projected area of the cable trays in the high density area and 0.3 gpm per square foot per 5000 square feet of floor area for the sprinkler system.

The other areas of the plant with installed fire extinguishment systems were evaluated in the same way. Where fire hoses and portable extinguishers are the primary fire extinguishing method, total BTU fire load has been calculated and evaluated against the extinguishing capability. Our review of these areas indicates that the areas noted are not related to safe shutdown of the reactors and that provisions such as diking, drain pits or physical separation would not permit the spread of these fires to critical areas.

It should be noted that as a result of the fire hazard reanalysis the licensee expanded the smoke and heat detection system throughout the plant.

We have reviewed the fire hazard reanalysis presented in Part X of the Plan and have also made site visits to survey some of the critical areas described by the licensee. Based on our review, we conclude that the licensee has defined and located the critical areas of the plant that could be affected by a postulated fire and potentially affect safe shutdown of the reactors. The analysis is considered conservative since no credit was taken for the fire retarding properties of the coating material that will be applied to all cable trays located in critical areas. In addition, the design modifications that resulted from the reanalysis are reasonable and will provide a defense in depth to the fire detection and extinguishment for the plant when coupled with the new and revised administrative procedures for fire prevention, the revised fire brigade training and other design changes and procedures that are directly related to fire protection.

5.0 Fire Protection System Impairment Analysis

The licensee has performed an impairment analysis of the high pressure fire water system and the CO_2 system as they will be installed at the time of restart of Units 1 and 2. Any other modifications to the systems that will be made at the first refueling will have included in their design considerations, potential single impairments which could render the system inoperative.

The guidelines for the analysis are set forth in Part X, Section 5.4.1 of the Plan and the results are described in Section 5.4.3. Table 5.4-1 lists the impairments considered, the system impaired, the specific potential consequences, and the proposed correction. The proposed modifications to correct the problems identified are described in Section 5.4.4.

The licensee's analysis has included the potential impairments that were determined from our review of the fire system process diagrams and from detailed discussions with the licensee. As a result the following modifications will be incorporated in the systems, prior to restart or as noted. Our evaluation of each is included:

1. The isolation valve in the discharge line from the pump header (valve 0-26-528) will be removed from the system to preclude a potential impairment of loss of pump flow to the yard loop. We agree with the licensee that this valve is not required since other yard loop isolation valves are installed and can serve the same function. Therefore, we conclude the modification is acceptable.

2. The electrical power supplies for the three fire pumps are run in a common cable tunnel and if postulated events occurred, such as a fire in the tunnel, all the fire pumps could be lost. The licensee proposes to install a diesel-engine driven fire pump at another location in the yard loop and take its water from another source other than the pumping station intake structure. The addition of this pump will provide an alternate fire water source and pumping capacity of a minimum of 2600 gallons per minute to the yard loop. This capacity is adequate to provide all water needs for fire extinguishment in all areas critical to safe shutdown of the plant. The licensee plans to add the diesel driven pump at some time after restart of Units 1 and 2 and, therefore, will develop, implement and test a casualty procedure for running temporary power cables from the Unit 3 shutdown boards to the fire pumps and reestablishing the pump operation within two hours.

We have reviewed the proposed modification of the addition of the diesel driven pump and conclude that when installed it will provide an alternate fire water source and pumping capability to maintain an operational high pressure fire water system for the critical areas of the plant required for safe shutdown. The casualty procedure proposed, to provide temporary power to the installed fire pumps appears reasonable on the basis that only certain events can be reasonably postulated that would cause loss of the normal power supply. The one event that appears the most probable is a fire in the cable tunnel. With the current design of the fire water system, the raw service water system would provide the required fire water to extinguish a fire in the tunnel. The casualty procedure would then reestablish high pressure fire water protection for the plant within a two hour period. The requirement for reactor shutdown has been included in the proposed technical specifications for each unit of the plant in the event of loss of the fire pumps. We conclude that, for the interim period between restart and installation of the pump, the casualty procedure is an acceptable method to maintain fire protection in the event of this postulated impairment. Since the fire that may result in a loss of the fire pump power cables would be wholly confined to areas not relying for fire protection solely on high pressure fire water, we find the two hours that the plant may not have full fire water pressure to be acceptable.

The Technical Specifications for the plant will require that in the event of this impairment prompt action shall be taken to restore the fire pump capability or to place the reactor in a standby condition.

3. The fire hose racks for the Diesel Generator Buildings were determined by the licensee to have a potential impairment which would prevent fire water being available to the areas they serve by a sectionalizing valve being closed. The licensee proposes to modify the hose rack water supply system by the addition of a redundant fire water line from the reactor building fire water loop. These hose racks will be relied upon in the interim period to provide fire fighting capability in the pipe and electrical tunnel of the buildings.

   The primary purpose of these hose racks is to extinguish small postulated fires in this area, and if required, to cool the fire door of a diesel generator compartment in the event the automatic CO_2 system in the diesel compartment should be impaired at the time of a fire in the compartment.

   We conclude the modification to add a redundant fire water line to the hose racks will eliminate the original impairment and is, therefore, acceptable.

4. The impairment of the manual, electrically actuated CO_2 system valves for the cable spreading rooms is covered by the fire brigade using the manual valve provided to discharge the CO_2 system into the cable spreading rooms. As a back-up fire hoses are installed in the control building, located such that they can be brought into any of the spreading room doors.

   Considering the redesign of the spreading rooms' fire stops, the application of Flamemastic to all cable trays in the rooms, the addition of smoke detectors in the rooms and the administrative procedures to maintain the rooms free of combustible materials, we believe that manual fire fighting means are adequate for this impairment. Test data included in Part X of the Plan indicates that fires originating from cable trays coated with Flamemastic will not spread and will be contained to a local area.

5. The impairment of automatic operation of the CO_2 system serving the Diesel Generator Building electrical board rooms for the two Diesel Generator Buildings could result in the loss of one of the electrical board rooms. The licensee has proposed to install an automatic fire door between each board room that will close on actuation of either of two smoke detectors that are placed on each side of the door at ceiling level. The CO_2 system can be operated by manual actuation of the valve at the local control station. If this cannot be accomplished the fire door will protect the redundant electrical board room from the postulated fire. The fire door is considered adequate to contain the fire resulting from the fire load in each electrical board room.

   Based on our review of the Diesel Building area, the fire extinguishing systems available and the addition of the fire door; we conclude that the postulated impairment would not jeopardize the safe shutdown of the plant.

6. The impairment of the valve in the discharge line of the head tank, connected to the fire water system, (Valve 25-32) by failing open would result in a drop of pressure and flow rate in the fire water system when the high pressure fire pumps were turned on. Therefore, the performance of the high pressure fire water system could be degraded to a point where required

flows and pressures would not be available to the plant. The licensee proposes to modify an existing series valve (Valve 25-720) to be a remotely operated isolation valve. This modification would then result in two valves in series to isolate the head tank from the fire water system when required.

Our review of the modification indicates that the addition of the second remotely operated valve will eliminate the original postulated impairment and, therefore, we conclude it is acceptable.

6.0 Administrative Changes

6.1 Training (Fire Related)

Since the March 22, 1975 fire, the licensee has re-evaluated the training provided to the operations personnel to determine what changes, additions or new requirements should be incorporated in the training programs. Based on this re-evaluation the training program has been modified. These include revision of the Fire Brigade Leader Training Course, the Fire Brigade Member Refresher Training Course, the Fire Brigade Member Training Course and the Student Generating Plant Operator Training Program to include added training on the use of water to extinguish electrical fires and/or fires in cables, cable tunnels and cable trays through the use of water fog; the proper use of self-contained breathing apparatus; the proper procedure to recharge the breathing apparatus air cylinders; the use of ventilation systems for smoke control; and the relationship between the Fire Brigade Leader, the Shift Engineer and any off-site fire fighting personnel that may be called to assist the Fire Brigade.

Since the fire a number of the Shift Engineers and Assistant Shift Engineers have completed the revised Fire Brigade Leader Training Course. In addition, a Fire Brigade Member Refresher Training Course has been given to all operating plant personnel that could be assigned to the Fire Brigade.

Periodic drills will be conducted at the plant and evaluated by the plant supervision and members of the Safety Engineering Services Office of the Division of Power Production. These drills will include use of the pre-fire plans that will be developed for the critical areas of the plant required for safe plant shutdown. In addition, the Fire Brigade will be familiar with and practice the casualty procedures.

Implementation of a formal indoctrination program has been instituted to familiarize construction workers and contractors that may perform work in operational areas at the plant. This will include personnel that have received the plant and security orientation. This program will emphasize fire reporting and emergency procedures.

Our review of the deficiencies that were reported as a result of the March 22, 1975 fire indicates that the licensee has made adequate modifications or revisions to the formal training programs that should minimize future difficulties. In addition, training and drills that will be accomplished for the unique features of the Browns Ferry Nuclear Plant will assist in providing a well organized Fire Brigade function. This, in conjunction with the procedural changes being implemented for fire prevention, fire watches, control of temporary combustible material, work plan control and the pre-fire plans, provides the basis for our conclusion that the training of personnel in the operating plant is acceptable for prompt and effective Fire Brigade and reactor operator actions to extinguish fires and place the reactors in a safe shutdown condition.

6.2 Procedures (Fire Related)

As a re·ılt of the March 22, 1975 fire, the licensee has revised or developed improved procedures aimed at correcting or preventing conditions from developing that could become a fire potential. In addition, as a result of the design modifications and additions, new procedures have been developed to implement actions that are required to provide appropriate fire prevention, fire fighting, operational requirements, maintenance and testing and other fire protection related measures.

A number of these procedures are classified as fire prevention procedures. They include the following:

1. Cutting, welding and open flame work permit control, which requires that potential fire considerations must be made by the authorizing supervisor and a determination made of the fire fighting equipment available in the area of work and whether a fire watch is required;

2. Procedures for control of all fire related testing, maintenance, record keeping and assistance to the various operations groups by an individual assigned to these specific duties;

3. Procedures for performing the required maintenance and testing of the fire protection system and equipment. This procedure designates the responsible plant staff individual for this procedure;

4. Procedure for valve supervision program and record as related to the fire water and CO_2 systems, including the yard loop and pumping station;

5. Procedures for the requirements when a fire stop is breached for any purpose. These include the requirement for a fire watch at the location until the fire stop has been restored to its original design condition;

6. Procedures for housekeeping to reduce or eliminate combustible materials from areas required for safe plant shutdown;

7. Procedures requiring a roving fire watch during the interim between restart and the completion of all fire protection modifications. This procedure will require clock registers be used by the fire watch at points in the plant that are critical to safe plant shutdown. The inspection interval for the clock register stations will be every two hours;

8. Procedure for controlling flammable liqu'd storage in the plant and requirements for the type of containers that can be used when such liquids are required for plant operation. These containers are small and are Underwriters Laboratory approved;

9. Procedures for a formal plant self-inspection program for fire safety. This procedure will require plant supervisory inspections using prepared fire safety checklists on a periodic interval;

10. Procedure for assessing transient fire loads that are required for plant operation and maintenance. This procedure is being developed to reduce and control temporary fire loads in the plant that could present a potential fire hazard to critical areas of the plant required for safe plant shutdown. The development of this procedure is in progress and the plant supervision is being assisted by TVA's Safety Engineering Services to establish guidelines for use of the plant operating staff. These guidelines are to be based on the maximum temporary fire load that can be located in a critical area and be protected by the existing or future fire extinguishing systems. If the temporary fire load exceeds this capability then the guidelines will state the additional fire protection required while the temporary loading is in the plant. We have concerns in this procedural area that we believe must be considered in developing the guidelines. The major concern is that these temporary materials may be located in a critical area and credit taken for a fire extinguishing system that may not be effective where the materials are located. Specifically, areas that contain critical systems or cabling that are protected by a deluge or sprinkler system, but because of cable tray, ventilation ducts or piping obstructions located between the fire extinguishing system and the location of the temporary material they may not be covered by the systems and therefore present an exposure fire potential to the critical area. We will require a continuous fire watch with charged hoses available until the temporary materials are removed from such areas;

11. Procedures for outside or independent fire protection/loss prevention inspection program to be performed on a periodic basis. This is a revision to a current procedure and will require an independent inspection by utilizing either proper TVA personnel or an outside fire protection firm. This inspection program is to be instituted and the first inspection performed prior to restart of the reactors and annually thereafter. This inspection is in addition to the plant self-inspection procedure.

Other procedures are being revised or will be developed to provide for written and approved controls for fire protection requirements. These include the following:

1. Procedures for assuring maintenance of the pressure-seal fire stops by periodic leak detection tests at the penetrations. This procedure will provide a record of the potential deterioration or leakage of the fire stops and provide a basis for corrective action;

2. Procedures for reestablishing high pressure fire water to the yard loop if power is lost to the fire pumps. This procedure will include the requirement for temporary connections from the Unit 3 shutdown boards and t[illegible] connections will be fabricated and tested prior to plant startup. In addition, the procedure will include measures to be taken, if needed, to bring in backup fire truck pumpers to establish fire water to the yard loop;

3. Procedures for the use of existing ventilation systems for smoke control. This procedure will include instructions on the remote manual or manual use of ventilation systems that may be used for smoke control. The automatic capabilities for isolation for all isolation signals will be maintained.

4. F.ocedures that will include pre-fire plans for the critical areas of the plant required for safe reactor shutdown. These pre-fire plans will be incorporated into the fire brigade in-house drills to provide a direct approach to a potential fire area. They will also include plans for providing recharged breathing air cylinders to the fire brigade;

5. Procedures for semi-annual chemical treatment of the fire water system, periodic flushing to assure clear piping and annual inspections for removal of crustacean accumulation where needed. This procedure is being added to existing procedures for crustacean control of all water systems;

6. Update procedure for providing supplemental fire protection measures when an installed system, including monitoring, is taken out of service for maintenance, repair or testing. This procedure requires a sign-off method for getting approval to cause the impairment and to inform the designated responsible individual that the impairment has been corrected and the system has been placed in service.

We have made an overall review of the procedure outlines and commitments made by the licensee to update, revise or develop procedures for fire prevention and for fire protection requirements. These procedures are being coordinated by the responsible Divisions of the TVA organization. In addition, our review considered the organizational changes that will result in a plant-wide review of the fire related procedures being developed and implemented. Based on this review and our requirement as stated in Item 10, we conclude that the licensee is taking the required actions to provide assurance that adequate administrative controls are being implemented.

6.3 Organization (Fire Related)

TVA has made some organizational changes as a result of the fire that increase significantly the attention that will be given to fire protection in the future. A Fire Protection and Prevention Board has been formed with representatives from the Division of Engineering Design, Division of Power Production and the Division of Construction. This Panel will provide coordination between these divisions for the plans and policies concerning fire protection at all TVA power plants.

TVA has hired two fire protection engineers to work under the Supervisor Safety Engineering Services in the Division of Power Production. They are temporarily assigned to Browns Ferry until the Engineering Aid (Safety) position has been filled at the plant Their permanent duties in the Safety Engineering Services group include conducting fire training and drills for plant personnel, reviewing and developing fire preplans for emergency situations, reviewing and evaluating work practices at the plants, and conducting periodic inspections and audits at TVA plants.

At Browns Ferry, the Plant Superintendent is responsible for implementing the Division of Power Production procedures for fire protection and prevention, and for developing operator procedures for fire emergencies and fire protection system operations.

The BFNP Operations Supervisor has been given the responsibility to review all work packages for fire hazards and to identify controls needed before approval of the work. An Engineering Aid (Safety) position has been established and is temporarily being filled by the Safety Engineering Services engineers as mentioned above. The duties of this position include routine in-plant fire inspections and maintenance of all fire equipment in an operable condition.

The Fire Brigade at the plant has been reorganized. The Brigade Leader is now the Assistant Shift Engineer for Unit 2 instead of the Shift Engineer. Two Assistant Unit Operators from each of Units 1 and 2 are assigned as Brigade members. The Shift Engineer no longer has the dual responsibility of safe operation or shutdown of the plant and directly leading the Fire Brigade. Specific assistant unit operators are now assigned to the Brigade so that other operators may concentrate on plant operation or shutdown.

Finally, a position of Restoration Coordinator has been created that will remain in effect until all the restoration work, including the modifications to be completed in the future, are completed. He will have available to him expertise in fire protection methods and system design. Responsibilities of the Restoration Coordinator include the following:

1. Principal coordinator for all design, construction, and operational activities relative to restoration of Units 1 and 2,

2. Review and approval of all documents submitted by TVA to NRC in connection with restoration, and fire protection and prevention improvements,

3. Overall planning, establishment, and maintenance of a critical path schedule for restoration and completion of modifications, and

4. Coordination and approval of TVA's overall efforts in fire protection and prevention improvements, including design and installation of new systems and changes necessary in fire fighting methods and techniques.

We have concluded that the above organizational changes and additions provide an improved degree of management in the fire protection aspects of plant safety from the highest level of management down to the working level for fire prevention, fire fighting, fire protection system design, training, testing, inspections and audits. We have concluded that these organizational changes are acceptable.

6.4 Quality Assurance

TVA's Quality Assurance Program for the restoration activities at Browns Ferry Nuclear Plant Units 1 and 2 has been previously reviewed and found acceptable prior to the restoration work as described in the Safety Evaluation Report issued with Amendments 10 to DPR-33 and 7 to DPR-52 on June 13, 1975 authorizing the commencement of clean-up and restoration following unloading of fuel.

The licensee has described the Quality Assurance Program For Station Operation in Section D.4 of Appendix D to the FSAR in Amendment 62. In Appendix D.4A, the licensee commits to follow the guidance contained in the WASH documents 1283 (5/24/74) "Guidance on Quality Assurance Requirements During Design and Procurement Phase of Nuclear Power Plants - Revision 1", 1284 (10/26/73) "Guidance on Quality Assurance Requirements During the Operations Phase of Nuclear Power Plants", and 1309 (5/10/74) "Guidance on Quality Assurance Requirements During the Construction Phase of Nuclear Power Plants" based on his understanding that the term "shall" denotes a requirement and the term "should" denotes a recommendation.

We find this general exclusion unacceptable as stated and will require that each recommendation, "should", that is not being followed be specifically identified by TVA in the QA Program and justification provided for our evaluation. We will resolve this open item prior to authorizing return to operation and will include our evaluation of the QA Program in a Supplement to this report.

7.0 Design Modifications

7.1 Electrical Changes

In addition to replacement and repair of damaged wiring and cables, TVA proposed design changes to enhance fire protection and eliminate the source of the loss of redundant safety equipment which occurred as a result of the March 22, 1975 fire.

The most significant loss of redundant equipment was associated with failures of their power sources which were caused by short circuits to lamp circuits leading from the control circuits of Reactor Motor Operated Valve (MOV) boards. These cables were originally considered to be non-divisional because a dropping resistor was provided in the lamp circuit for the purpose of isolating this circuit from the control circuit. Several of these cables from both divisions were therefore allowed to be run together in common trays and were, subsequently, damaged by the fire. TVA has proposed to remove the cables leading from Reactor MOV board control circuits to breaker indication lamps to eliminate the major problem which was the loss of ability to operate the boards in both divisions. We agree with this approach and conclude that these circuit changes will eliminate the loss of redundant division MOV board controls.

The second most significant cause for loss of redundant equipment was due to the proximity of conduits containing division I and division II cables to cable trays which were the primary source of combustible material. Although the use of conduit may provide adequate protection against some effects of fire and other hazards for a short time, the fire which occurred proved that conduit protection alone was insufficient for a fire of that magnitude without additional protection in the form of additional separation or fire barriers. To remedy this TVA is modifying the cabling and wiring systems. The modifications include physical moving of certain conduits, use of Flamemastic to provide an effective barrier, and the addition of fixed fire water systems.

TVA's analysis of the plant, as described in Part X of the Plan, indicated 90 conduits associated with the three units which ran parallel to cable trays within their established "move zone". Conduits crossing cable trays were not considered in the analysis on the basis of it being impractical to move those conduits. Of the 90 conduits identified, 44 are being relocated. This will be accomplished prior to restart. Considerations leading to the judgement that conduit would not be relocated included physical limitations and the potential for creation of new divisional interactions. The use of Flamemastic as a barrier is discussed in the following section. Although there are locations in which conduit crosses or runs parallel to cabling of another division, the limited area involved where conduit crosses cables, the thorough protection provided by the Flamemastic coating, and the enhanced fire detection and fighting capability of the facility lead to our conclusion that all identified potential cross divisional fire effects due to proximity of conduits have been eliminated. The additional fixed fire water system which will be installed at the first refueling outage, will be specifically designed to ensure that divisional conduit will be thoroughly wetted where both divisons could be affected. This automatic system when installed will enhance the fire extinguishing capability provided by the fire brigade.

In evaluating the TVA modifications concerning divisional isolation we recognize that complete physical independence cannot be achieved. We conclude that the TVA approach which includes the complete coating of all exposed cables with Flamemastic and the addition of the fixed, automatic fire water system to cover all areas of possible cross divisional fire effects provides sufficient protection against loss of more than one division of safety equipment in the event of a postulated fire.

A third cause for loss of redundant equipment was damage to their cables sharing the same cable tray contrary to the stated criteria. This third significant cause for loss of equipment will be remedied by separating the involved cables. Selective changes are also being made in the electric power system to improve isolation. These changes will provide individual normal feeders to the 4KV/480-V transformers. One change will eliminate sharing between units of the 4KV feeder that was the normal supply to 480-V Shutdown Board 2A and 2B through TS3E. Other changes will provide individual 4KV feeds to transformers TDA and TDB which supply 480-V Diesel Auxiliary Boards A and B, respectively. The only shared 4KV feeder will be the alternate supply to transformers TSIE and TDE. These changes will be accomplished prior to restart. We have reviewed these changes and find that they are acceptable.

7.2 Use of Flamemastic 71A (Fire retardant coating)

The licensee proposes to use Flamemastic 71A, (described to be a non-flammable, non-toxic, odorless, waterbase compound consisting of thermo-plastic resinous binders, flame retardant chemicals, and inorganic non-combustible reinforcing fibers), to provide a fire retardant barrier on all exposed cable in the secondary containment area of the reactor building, cable spreading room, diesel generator building, the water pumping station, and the pumping station cable tunnel. These are the only areas containing safety related equipment necessary for safe shutdown. The coating is to be applied to all cable types, including non-divisional cabling, to a wet thickness of 1/4 inch to effect at least a 1/8 inch dry cured thickness. This thickness of coating has been demonstrated by tests to be more than adequate for the application. The manufacturer recommends a 1/8 inch wet thickness for this type of application. This coating will greatly reduce the potential for a fire and will also limit the propagation of a postulated fire.

A number of tests that have been performed to determine the effectiveness of Flamemastic 71A as a fire retarding barrier for electrical cabling, similar to or the same as utilized in the Browns Ferry Nuclear Plant, and to determine its capability to retard propagation of a fire. Some of the tests were performed using short time period (up to 15 minutes) fire initiators, such as, gasoline, naphtha, gas, oil and transformer oil. The results from these tests demonstrated that, for the test fires, Flamemastic 71A would protect the cabling and effectively prevented propagation of the fire to the coated cables. Longer time fire tests (up to 2 hours) were performed by TVA where the fire initiator was a gas burner with a flame temperature of 1500°F and exposed cable insulation was available as a fuel contributor. These tests demonstrated the effectiveness of Flamemastic 71A to stop propagation of a fire from burning cables and also demonstrated that for temperatures of 1500°F the Flamemastic 71A protected the cable and a fire could not be initiated. In the degraded test performed by TVA, where the fire stop had been dismantled up to the penetration sleeve, it required the Flamemastic 71A to be broken up and additional combustible materials added, in addition to the gas burner, to develop a fire for testing the penetration seal. This provides further evidence that the coating is fire retardent and will provide an effective barrier to fire for an extended period of time. For the types of fires that could be postulated to occur in critical areas in the Browns Ferry Nuclear Plant, temperatures in the same range as the test temperatures are expected.

Based on the test results from the Watts Bar cable tray fire tests, and from the other tests performed and included in Part X of the Plan, we find that Flamemastic 71A is an effective barrier against the initiation and propagation of fires and is a significant improvement over the one hour thermal barrier originally proposed by TVA. The use of the coating in conjunction with other fire extinguishing systems, discussed in later sections of this report, will provide the defense in depth protection for the essential divisional cabling that controls or powers the equipment required for safe shutdown of the reactors.

Part X of the Plan contains the results of ampacity tests utilizing a Flamemastic 71A coating on the cables to determine appropriate derating factors. Ampacity of the installed cables has been reviewed and based on the test results, a reduction of 1 to 10 percent in ampacity of the coated cables is indicated. TVA has utilized the maximum reduction of 10 percent as a criterion for all coated cables. A study of power cables in trays shows that a 10 percent reduction in the ampacity of the cables would still allow maximum design current to be carried with an adequate margin.

7.3 Cable Spreading Room Ventilation

The licensee proposes to install two dampers in the exhaust ducts from Unit 1 and 2 cable spreading room and Unit 3 cable spreading room. This modification was required to provide separation between the cable spreading rooms where a common exhaust system is installed. The new dampers are installed in each exhaust duct from each spreading room upstream of the common exhaust duct. Additional dampers are installed in the discharge ducts of the two exhaust fans serving the spreading rooms. Therefore, with actuation of the CO_2 system in either spreading room the room will be isolated automatically.

The control and power circuits for the ventilation system are being rerouted through areas outside their respective spreading rooms and therefore provide increased assurance that the ventilation system will be automatically isolated upon manual actuation of the CO_2 system.

In view of the additional dampers and the new penetration-seal fire stop design, TVA re-evaluated the cable spreading rooms to assure that when the CO_2 system is discharged, the rooms would not be pressurized above the tested pressure of the penetration-seal fire stops. As a result of the re-evaluation, TVA proposed to install a counter weighted back draft damper in the spreading room wall common with the turbine building. This damper would release a pressure buildup above five inches of water, which is the pressure to which the fire stops have been tested, and vent the room until the CO_2 system has discharged the amount of CO_2 to reach the design concentration in the room. The back draft damper would then close to maintain the CO_2 concentration.

Based on our review of the proposed changes to the cable spreading room ventilation system, we conclude that the licensee has now provided for better isolation of the room to enable proper operation of the CO_2 system.

7.4 Fire Stop Designs

The licensee has proposed a new, improved penetration seal - fire stop design for use wherever the secondary containment function for the reactor must be maintained. The penetration seal - fire stop design function is to provide for the maintenance of at least a 1/2 inch of water negative pressure differential between the secondary containment boundary and the environment and to provide a fire stop.

The proposed design uses a silicone room-temperature-vulcanizing (RTV) foam material to make the seal around the electrical cables and conduit that pass through the secondary containment boundary. Based on tests performed by the licensee, the seal material cannot be classified as non-combustible and therefore must be protected by other materials to retard the spread of a postulated fire that could contact the seal material. The licensee's Watts Bar Tests showed that fires completely consuming the cabling materials on one side of the fire stop did not affect the seal. Burning periods in excess of one hour at the face of the penetration seal-fire stop were involved.

No direct comparison can be made between the flammability and/or fire resistance as related to full scale fire conditions for the original polyurethane seal material and the silicone RTV compound based on standard testing methods. These testing methods are limited to laboratory type tests and as such are extremely limited in their ability to confirm the uses of these materials in their installed configuration. However, general experience in the use of polyurethane and silicone RTV compounds in industrial applications has indicated that while polyurethane has shown itself to present an unacceptable fire potential in many cases, the widespread industrial use of silicone RTV has not been identified as presenting any particular fire problems. Thus general experience coupled with the licensee's Watts Bar full-scale tests, discussed below, indicates the acceptability of the silicone RTV compound as an acceptable material when utilized in accordance with the proposed design.

The proposed penetration seal-fire stop design provides the fire retarding and fire resistant materials that protect the seal material. The proposed design is described in Part X, Section 4.1.1 of the Plan and shown in Figures 4.1-1 through 4.1-4. Through the use of the combined fire resistant materials (Cera-Form, Cera-Felt, Cera-Fiber and Cera-Kote) and Flamemastic 71A (the fire retardant coating material), the silicone RTV seal material is protected. The testing performed at the licensee's test facility at Watts Bar confirms that for the types of cable fires used in the tests, the penetration seal - fire stop is acceptable for its intended function when used in the configuration specified by the proposed design.

Other fire stop designs are utilized throughout the plant that are not required to perform a pressure-seal function. The licensee has proposed a design for this application and it is described in Part X, Section 4.1.3 of the Plan. It consists of a fire resistant board installed on each side of the penetration with the void between the boards being filled with an inorganic fiber for a maximum depth of up to one foot. The entire exterior surface of the assembly will be coated with Flamemastic 71A. Based on test data provided by TVA, tests performed by others that used the silicone RTV compound instead of the inorganic fiber and no Flamemastic coating, and preliminary results from a test performed on the type of fire stop proposed by TVA, we find that the proposed design is acceptable and will delay the spread of a postulated fire through the penetration for a sufficient period of time to permit extinguishment of the fire in the areas utilizing this design.

We therefore conclude that, with a sound quality assurance program to assure that the designs are installed in the plant as described, the penetration seal - fire stop and the non-pressure seal - fire stop designs are acceptable for use in the Browns Ferry Nuclear Plant.

7.5 Design Changes Related to Fire Detection and Extinguishment that are to be Completed Prior to Startup

7.5.1 Fixed Water Systems

As a result of the reanalysis of the fire hazards that could result from combustible materials that are a permanent part of the plant, the licensee has proposed several changes or modifications to the fixed high pressure fire water system for each unit. We do require additional information in regard to TVA's consultant's disagreement with the hydraulic calculations for the fire water system. (See Attachment 2) These changes and modifications are set forth below and include our evaluation of each.

1. Provisions will have been made to permit fire pump performance tests at regular intervals, the pressure which the high pressure fire pumps will maintain on the water system will have been increased from 130 psi to 175 psi and the high pressure piping that has not been hydro-tested to 225 psi will have been so tested.

   These three items represent changes to the existing system that resulted from the reanalysis. We agree with the licensee that these changes are necessary and acceptable to assure that the high pressure fire water system can perform its design function.

2. Additional zoned fixed deluge systems will be installed in areas where a high concentration of cable trays exist and where access to these areas is restricted due to congestion of trays. These areas are the North Wall of the Reactor Buildings on Elevation 593.0 ft.,the area at column line R2 and P on Elevation 565.0 ft.,and all penetrations from the cable spreading rooms into the Turbine Building. The design basis spray rate for these systems is 0.3 gpm/ft^2 of projected area of the cable tray stack. This rate was based on the fire load discussed in the fire hazard reanalysis of this report.

   Consideration was given to the existing building drainage capability in establishing the zone areas. Consideration was also given to location of safety related components in the areas covered by the deluge system. We conclude that no safety related equipment will be affected by operation of the deluge system.

   For the restart of Units 1 and 2 these systems will be manually actuated at locations in the area of the deluge systems. Smoke and heat detectors will alarm in the control room and locally for each zone to permit the prompt dispatch of the fire brigade to the area. Other areas of the plant will be protected by the Flamemastic coating, expanded smoke detection, and manual fire fighting during the interim between restart and the first refueling of the Unit.

Based on our review of the deluge systems and considering the addition of smoke detection systems (Sec. 7.5.3), augmented procedures (including pre-fire plans), testing, fire brigade training, and the requirement for a roving fire watch who will monitor all critical areas at least every two hours until these systems are automated, we conclude that the manually operated zoned deluge systems provide an acceptable fire protection capability for these areas.

3. The reanalysis indicated that certain areas of the plant required additional fire hose racks to provide backup to existing fire suppression systems and to cover others not heretofore covered. Additional 1-1/2 inch hose racks will have been installed at each end of the diesel generator buildings pipe and electrical tunnels. These racks will have been installed to cover two areas of the plant not previously provided with high pressure water hose protection. Three additional 1-1/2 inch hose racks will have been installed at Elevation 550.0 ft. of the pumping station. These hoses will provide backup coverage to the cable tray installation in the pumping station and provide general coverage for the entire floor of the pumping station. Three additional 1-1/2 inch hose racks will have been installed in the control building at Elevation 593.0 ft. and are located on the turbine building wall side of the building. These hoses will provide high pressure water for the rooms located at this elevation and in addition can provide hose coverage through each door of the cable spreading rooms.

   All hoses throughout the plant are neoprene lined hose, with some of the existing linen hoses being replaced. Hose and nozzle connections will have been made compatible with equipment used by the local fire department which in some cases of existing hose stations will require adapters at the stations to convert from the Standard Iron Pipe Threads to American National Standard Fire Hose Threads. In addition, all nozzles are suitable for use in fighting electrical fires.

   Based on the licensee's consultant's recommendation,the hose reels have been rewound using the double relap methods and preconnected to the high pressure fire water system. The licensee will also make a survey of the plant and determine that at least two hose racks, with appropriate hose lengths, will be capable of providing water for fire fighting especially for the cable trays and other areas covered in this section.

   Based on our review of the design requirements and the plant drawings in Part X of the Plan, we conclude that the licensee has provided the necessary additional hose racks and has demonstrated that the hose coverage is or will be adequate for the areas of the plant that are required for safe shutdown of the reactors in the event of a fire requiring hose protection. It is recognized that this hose protection plays an important role in the fire fighting capabilities during the interim between restart and the first refueling. During this interim period the Flamemastic coating will retard cable fires and the smoke detection system will provide early warning for prompt fire brigade response. Pre-fire plans for critical areas will also be instituted prior to return to operation and a roving fire watch is required to monitor these areas of the plant at least every two hours to ensure prompt response to any fire. This, combined with the accessibility of these areas for manual fire-fighting, leads to our conclusion that these measures are acceptable for the interim period until the first refueling.

7.5.2 Heat Detection System

Heat detection cables are to be installed on cable trays that will have the manual zoned fixed deluge system installed and at other congested cable tray areas as described in Part X, Section 5.3.1.1 and shown on Figures 5.3-1 and 5.3-2 of the Plan. The basic principal of the heat cable operation is two conducting paths normally separated by a low melting point salt compound, which when heated to 250°F, will melt and form a conductive link and set off the alarm system connected to it. The proposed system will be installed on a zoned basis and will cause alarms in the control room and at the local deluge system valve stations. The indicating system in the control room will give the local panel location by elevation and coordinates. The local panel will identify the subzone that is in the alarmed condition, thus giving the fire brigade detailed location of the alarm condition.

The system design is such that a break in a heat cable will not preclude the detector from functioning. In addition, the system will be monitored and will indicate a power failure in the control room. The power supply for the system will be provided by the Instrumentation and Control system bus which has multiple power supplies connected to it to assure the monitoring systems function even with loss of off-site power.

We have reviewed the proposed heat detection system for its current application and conclude that for the congested areas it serves is acceptable for restart, pending resolution of the concern raised by TVA's consultant regarding the design and installation requirements. (See Attachment 2)

7.5.3 Smoke Detection System

The licensee proposes to install an expanded smoke detection system throughout a number of areas of the plant. The system is described in Part X, Section 5.3.1.2 and shown on Figures 5.3-3 through 5.3-6. The additional detectors are the ionization type, that are preset at the manufacturer's plant to the Underwriters Laboratory Standard UL167 specified sensitivity of 6 milligrams of combustion products per cubic foot of air. This sensitivity is sufficient to detect the smoke from the combustible materials located within the plant and provide an alarm. The detectors will be located on a 30 foot grid with some changes to provide adequate coverage where there are obstructions or to provide a more concentrated coverage for certain areas. The areas are zoned with no less than two detectors per zone. These zoned areas will alarm in the control room for either smoke or trouble. Local panels are provided which will give indication of up to four zones that will indicate the area where the smoke detectors actuated. The trouble indicators for both the control room and the local panel will indicate a line break or loss of power to the detector system in that zone.

Additional smoke detectors are being installed in the cable spreading rooms to provide adequate detection in air pockets formed by overhead I-beams and will take into consideration air flow within the rooms. These detectors plus the originally installed detectors will detect smoke in the rooms and alarm in the control room. The entire fire detection system will be maintained and tested in accordance with National Fire Protection Association (NFPA) Standard No. 72E.

Our review of the smoke detection system that is being added to the existing system has indicated that all the areas that have been identified as required for safe plant shutdown will be monitored by smoke detectors. Detectors for Elevation 621 ft. will be incorporated into the system prior to exceeding one percent power level. With this coverage and the annunciation system being provided in the control room and at local panels, the system will provide prompt early detection of a fire and enable the fire brigade to take immediate action to extinguish the fire and is therefore acceptable, pending resolution of the concern raised by TVA's consultant regarding the design and installation requirements. (See Attachment 2)

7.5.4 Self-Contained Breathing Equipment

The licensee has reviewed the use of the self-contained breathing apparatus during the March 22, 1975 fire and based on this review has made several changes to the requirements for the apparatus. These changes include increasing the total number of useable apparatus from 24 to 39 and the number of charged extra air cylinders from 27 to 57. In addition, 6 Chemox Oxygen Breathing Apparatus will be maintained available for emergency use only.

Emergency equipment cabinets are located in the control room and provide for storage of 10 air mask units and 15 extra air cylinders. The remaining units are stored in the shop area and maintained by the Health Physics Section.

Due to the improper use of the air mask units during the fire, a two-hour training course has been conducted for operations employees to assure thorough familiarity with the proper operation of the units. In addition, training with air masks is now an integral part of the Fire Brigade Training Courses.

The recharging system for the air cylinders has been increased in volume from eight 800 cubic foot supply cylinders to 16. These cylinders are used in a cascade charging system. Based on the review performed by the licensee of the deficiencies in the use of the charging system a procedure for recharging the air mask cylinders has been issued and the operations personnel trained accordingly.

In order to provide essentially an unlimited air recharging capability, the licensee has installed a high pressure air compressor which has the capacity of providing breathing air at 20 cubic feet per minute at 2500-3000 psi pressure. An air mask air cyclinder requires 45 cubic feet of air at 2200 psi pressure to be considered full.

We have reviewed the events that were reported for the deficiencies of the self-contained breathing apparatus and the modifications and additions to the breathing air overall storage and supply that now exists at the plant. In addition, we have reviewed the procedure outline that will be incorporated into the plant operation, which includes the charging system, pre-fire planning that will incorporate a system for providing charged cylinders to the fire brigade, and the number of units available for immediate use with respect to the number of personnel required for the fire brigade. Based on our review, we conclude that the self-contained breathing equipment as currently installed in the plant is adequate for use of the fire brigade and control room personnel for a postulated fire.

7.5.5 Communication System

The plant communications systems that were available at the time of the March 22, 1975 fire consisted of (1) the main Bell Telephone system, (2) the Private Auxiliary Exchange (PAX) System that provides for an internal plant-wide telephone system and also connects to other TVA communications systems, and (3) Plant Wide Public Address System which provides for immediate dissemination of information and instructions into all areas of the plant and is used for directing fire brigade and support personnel activities.

A portable Radio Emergency Command Net has been added to the plant communications systems and tested to verify satisfactory plant coverage. The system provides for three 5-watt portable radios that are assigned to the plant emergency director, the fire brigade leader and the fire department chief (if required). Using this system in conjunction with the other communication systems described above, the plant has an assured means of communication during emergencies, including fires.

We conclude that with the addition of the radio system, the fire brigade and the control room will be able to effectively coordinate fire fighting requirements with the safe shutdown of the reactor units and is therefore acceptable.

7.5.6 Emergency Lighting

The lighting systems provided for the Browns Ferry Nuclear Plant are described in Part X, Section 8.0 of the Plan. These systems include (1) normal lighting, (2) standby lighting which provides normal lighting for essential areas of the plant and is powered from the on-site diesel generators, (3) emergency lighting which is a separate system from the normal system and provides lighting to the essential areas of the plant and to personnel passageways.

The level of emergency lighting is adequate for plant operation without a fire occurring. It is continuously lit and powered by the normal 240 volt AC power system and is automatically transferred to the 250 volt DC station battery. However, during a postulated fire that evolves smoke, this and other installed systems cannot be relied upon for adequate lighting for the fire brigade.

The licensee has added portable hand lamps for emergency use including that of the fire brigade. These lamps are stored in the emergency equipment cabinet in the Unit 2 control room corridor. A total of 12 portable lamps are provided which are powered by 6 volt batteries that have a use-life of 6 to 8 hours. This is a sufficient number for the fire brigade and the operating crew. Procedures will be written prior to startup to provide for quarterly voltage checks and replacement of the batteries every nine months.

With the addition of the portable hand lamps, we conclude that adequate emergency lighting is provided for use of the fire brigade to perform its function.

7.5.7 Ventilation Systems

The plant ventilation systems are described by the licensee in Part X, Section 9.0 of the Plan. The cable spreading rooms' ventilation systems, which included modifications such as rerouting of control and power cabling for the system and the addition of isolation dampers, have been evaluated in Section 7.3 of this report. With the power and control cabling rerouted outside the cable spreading room, its ventilation system will be operable and can be manually used for exhausting smoke from a fire in the cable spreading room when the isolation function is not required for CO_2 system operation.

The Reactor Building Ventilation System performs a function for Secondary Containment. It must isolate in order for the Standby Gas Treatment System to perform its function of maintaining a negative pressure in the Reactor Building to prevent exfiltration of radioactivity in the event of a release from the Primary Containment. Therefore, the Reactor Building Ventilation System is designed to fail in the isolated condition. In the event that the Reactor Building Ventilation System does fail as the result of a fire, the Standby Gas Treatment System can be used to exhaust smoke from the Reactor Building. The measures taken to protect against the two divisions of cabling from being affected by a fire as described throughout Section 7.0, ensure the availability of at least one Standby Gas Treatment System Train.

The Control Room's normal ventilation system is designed to isolate on an accident signal or high radiation in the intake duct to enable the Control Room Emergency Pressurization System to perform its function of maintaining habitability of the Control Room. The Emergency Pressurization System could also be used by manual initiation to prevent smoke intrusion into the Control Room from a fire external to the Control Room.

If the fire is in the Control Room, safe shutdown of the plant can be conducted from the Shutdown Board Rooms. The ventilation systems for the Shutdown Board Rooms have fire dampers in the ducts that would close to isolate the rooms from the fire. Cooling of the Shutdown Board Rooms is attained by self-contained air conditioning units in each room. Thus the Main Control Room could be evacuated and habitability of the Shutdown Board Rooms is maintained for shutting down the plant from the back-up control boards.

We conclude that the modifications made by the licensee to provide smoke venting are acceptable and we agree that for those systems required to isolate for Secondary Containment and for habitability of those control areas necessary for safe shutdown of the plant, no modifications should be made for purposes of smoke control to prevent any possible reduction in the reliability of these emergency features. For these systems, manual operation would be allowed for smoke control if isolation was not required at the time of the fire.

7.6 Design Changes Related to Fire Detection and Extinguishment Intended to be Completed at the First Refueling Outage of Either Unit

7.6.1 Automatic Deluge Systems

The licensee has proposed to install additional deluge systems in the areas where the cable trays of one division cross the trays of the other division and where two cable tray runs of opposite divisions approach each other directly to within a few feet and where non-divisional cable trays are within the boundary zone of both divisions (divisional gaps). These areas are shown on Figures 5.2-1 through 5.2-6 of Part X of the Plan. The manual deluge systems evaluated in subsection 7.5.1.b of this report will be automated.

The proposed systems use a design basis of 0.3 gpm/ft^2 of vertical projected area of the cable tray stack plus the flow required for one 1-1/2 inch hose connection. The nozzles will be located to provide complete coverage of the cable trays to the extent practical. This basis was derived from the fire hazard reanalysis discussed in a previous section of this report.

For automatic operation, the deluge systems will be zoned such that the water discharge plus the discharge from the sprinkler systems within the zone will be considered in the drainage requirements for the zone area.

Each zoned deluge system will be actuated automatically by the concurrent activation of both a smoke detector and heat detection cable in the zone. Local manual control will also be provided in the zone area.

Provisions will be made for (1) flow and pressure testing immediately adjacent to the dry pipes of the fixed system, (2) flushing of the systems, and (3) air flow tests to verify that the dry pipe portion of the system, including the nozzles, is free of obstructions.

The licensee has stated that the valves to be used with the pre-action systems are to meet NFPA requirements. We do not agree with the licensee that valves (the term valves as used in this section are considered to include their operators and initiating devices) not tested and approved by an independent laboratory are adequate to assure valve designs which satisfy NFPA requirements. This is based on the recommendations of the licensee's consultant and our fire protection consultant and fire protection personnel. It is recognized that these pre-action valves must be designed to operate under different flow, pressure and attached system requirements. It is standard practice in fire protection engineering to utilize approved valves that have been tested by an independent laboratory for the intended function. It is also recommended by NFPA that the pre-action valves used in automatic systems be of the approved type and also recommends independent testing. Therefore on these bases, we will require the licensee to utilize pre-action valves that have been tested and approved by an independent laboratory (such as Underwriters Laboratory or Factory Mutual) to be acceptable for their intended function.

We have reviewed the design criteria for the systems and the areas where they will be utilized. We conclude the criteria are acceptable pending resolution of the testing and approval of the pre-action valves as discussed above.

7.6.2 Automatic Pre-action Sprinkler Systems

The licensee has proposed to install automatic pre-action sprinkler systems in various areas of the plant. These areas are shown on Figures 5.2-7 through 5.2-15 of Part X of the Plan and include such areas as the entire area of the reactor buildings of elevation 565.0 ft. and the entire area of elevation 593.0 ft. except for the area on the north wall that is covered by the zoned deluge systems, areas of the diesel generator building and areas of the pumping station.

The design basis for the sprinkler systems is to provide a coverage of 0.3 gpm per square foot per 5000 square feet of floor area and that the fusible links on the sprinkler head will melt between 175°F to 225°F based on a maximum expected ceiling temperature of 150°F during plant operation without a fire. The flow rate for the sprinklers was established based on the fire hazard reanalysis discussed in a previous Section of this report.

The automatic actuation of any of the pre-action valves will be from smoke detectors within the area of the system. Local manual pushbuttons in the area for manual operation of the valve will also be provided. Alarm provisions will be made in the control room to indicate initiation of a pre-action system.

We have reviewed the design criteria for the pre-action sprinkler systems and the locations where they are proposed to be installed. Based on our review, we conclude that the design criteria are acceptable pending resolution of the testing and approval of the pre-action valves as discussed in Section 7.6.1.

7.6.3 Manual Dry Pipe Sprinkler System

The licensee has proposed to install a manual dry pipe sprinkler system in each spreading room as a backup to the installed CO_2 system. The proposed system will be designed to provide a fusible link sprinkler system in the spreading rooms which will be normally maintained as a dry pipe system. Water addition to the system will be accomplished by manually opening two series valves, located outside the spreading rooms, and charging the sprinkler system with water from the high pressure fire water system. If the CO_2 system has not put out the postulated fire then the fusible links on the sprinkler heads in the vicinity of the fire will melt and discharge fire water. Drain lines will be installed in the spreading rooms and will be normally closed by manually operated valves. The drains will discharge to the Turbine Building drainage system.

The design basis for the system is to deliver 0.3 gpm of water per square foot per 3000 square feet of floor area. The fusible link temperature rating is 175°F to 225°F. The flow rate for the sprinklers was established based on the fire hazard reanalysis discussed in a previous Section of this report.

Our review of the proposed system indicates that as a backup system to the CO_2 system, manual operation is acceptable and the dry pipe system is preferred to preclude potential water damage to equipment located below the spreading rooms. We therefore conclude that the design criteria for the system are acceptable.

7.6.4 Automatic CO_2 System in Cable Spreading Rooms

The licensee proposes to automate the installed CO_2 system in each cable spreading room. This will be accomplished by utilizing the expanded smoke detection system and the heat detector cable system to automatically actuate the CO_2 system. The manual actuation capability will be retained to permit fire brigade operation of the system.

The smoke detector and heat cable systems will be designed so that any smoke detector in coincidence with any heat detector will actuate the system. The smoke detector will also set off an evacuation horn and start a four minute time delay to permit evacuation of the room if occupied.

We have reviewed the design criteria for the automation of the spreading room CO_2 system and conclude they are acceptable.

8.0 Technical Specifications

The licensee has proposed technical specifications that set forth the limiting conditions for operation and the surveillance requirements for the fire protection systems. These specifications address the high pressure fire water system, the CO_2 system and the fire detection system for the interim period between restart and the first refueling of each Unit. We are currently reviewing these specifications and will have developed final specifications prior to issuance of a license amendment to authorize restart of Units 1 and 2.

9.0 Retest Program

9.1 Fire Protection Systems

The licensee has provided retest outlines and criteria for some of the fire protection systems. In particular, they cover those systems that are being modified or additions made to the original systems. The licensee has stated that it will provide a total pre-operational testing program including the above mentioned areas. When this information is made available to the staff we will complete our review and report our evaluation in a supplement to this report prior to issuing the license amendment that authorizes return to operation.

9.2 Program for Component and System Retests

The licensee has proposed a program for component and system retest which is described in Part XI of the Plan. The program establishes the administrative controls that will govern the development of test procedures and the conduct and evaluation of the tests and describes the tests that will be conducted prior to fuel loading (preoperational tests) and following fuel loading (startup tests).

The objective of the preoperational retest program is to verify that plant components and systems are in a status consistent with plant license requirements. Testing will be conducted on all systems and components that: (1) sustained direct or indirect fire damage, (2) were disrupted to comply with interim license requirements, (3) were potentially damaged by cleanup and restoration work, or (4) have received significant modifications and maintenance. TVA's Division of Power Production will be responsible for the overall retest program administration, including preparation of detailed test instructions, conduct of the tests, and review and approval of test results. TVA's Division of Engineering Design will prepare retest scoping documents, approve test instructions and also review and approve test results.

The licensee has not proposed to conduct preoperational load discharge tests of the 250 vdc unit batteries. The staff will require Tennessee Valley Authority to conduct these tests prior to fuel loading. The staff has concluded, with the exception noted above, that the preoperational retest program proposed by Tennessee Valley Authority will retest systems and components that were disrupted or potentially disrupted and verify that such systems will function in accordance with design.

Although both Browns Ferry Units 1 and 2 have previously completed their initial startup test programs, the licensee has proposed to repeat selective startup tests following fuel loading. The staff is currently reviewing this program and will complete the review and resolve any outstanding items with the licensee prior to issuing the license amendment that authorizes return to operation.

10.0 Conclusions

In summary, the fire damage at the Browns Ferry Units 1 and 2 has been removed, and the facility has been restored and modified. This has included substantial additional protection against adverse affects of fire. The circuity has been modified to assure adequate divisional isolation. The cabling will be thoroughly coated in all vital safety areas with Flamemastic. This fire retardant coating will assure that the combustible materials of the cabling do not become sources of fire propagation. The substantially enhanced fire fighting and fire detection capabilities along with the increased effectiveness of the fire brigade will assure that any fire that may occur will be extinguished promptly, well before any damage can occur to vital systems of the facility.

We have indicated in the foregoing sections some items that must be resolved prior to authorizing return to operation. We will issue a supplement to this report to present our evaluation of the resolution of those items prior to authorizing such return to operation. We have concluded, subject to their satisfactory resolution, that the restoration of Browns Ferry Nuclear Plant Units 1 and 2 including the modifications, as described in TVA's Plan for Evaluation, Repair, and Return to Service of Browns Ferry Units 1 and 2 as a Result of the March 22, 1975 Fire, dated April 13, 1975 and Revisions thereto up to and including Revision 37, is acceptable and that there is reasonable assurance that the health and safety of the public will not be endangered by operation of the Facility as restored and modified.

ATTACHMENT 1

CHRONOLOGY

BROWNS FERRY NUCLEAR POWER STATION, UNITS 1 AND 2

RESTORATION RELATED CORRESPONDENCE

April 1, 1975	TVA letter re fire which occurred in cable trays on March 22, 1975, in Unit 1 spreading room and reactor building
April 13, 1975	TVA letter transmitting "Plan for Evaluation, Repair, and Return to Service of Browns Ferry Units 1 and 2 (March 22, 1975 Fire)."
April 15, 1975	TVA letter requesting amendment to licenses re the fire which damaged numerous control cables
April 17, 1975	Letter to TVA relating to restoration of fire-affected features, Units 1 and 2
April 22, 1975	TVA letter transmitting listing entitled, "Material to be Provided Formally for Nuclear Regulatory Commission Review of the March 22, 1975 Browns Ferry Nuclear Plant Units 1 and 2 Fire."
April 23, 1975	TVA letter transmitting Revision 1 to "Plan for Evaluation, Repair, and Return to Service ..."
April 23, 1975	TVA letter transmitting report "Physical Damage to Electrical Cables and Raceways Involved in the Browns Ferry Nuclear Plant Fire on March 22, 1975"
April 23, 1975	TVA letter transmitting a notebook of photos of fire affected zone
April 30, 1975	Summary of April 24, 1975 meeting re Safety Analysis for Removal of Fire-Damaged Components
May 2, 1975	TVA letter transmitting Revision 2 to "Plan for Evaluation, Repair, and Return to Service"
May 9, 1975	Letter to TVA transmitting Amendment No. 9 to DPR-33 and Amendment No. 6 to DPR-52 to ensure safe condition until restoration of facility
May 13, 1975	TVA letter transmitting Revision 3 to "Plan for Evaluation Repair, and Return to Service ..."

May 15, 1975	TVA letter transmitting Revision 4 to "Plan for Evaluation, Repair, and Return to Service..."
May 25, 1975	TVA letter transmitting Revision 5 to "Plan for Evaluation, Repair, and Return to Service..."
May 25, 1975	TVA letter transmitting Revision 6 to "Plan for Evaluation, Repair and Return to Service..."
May 29, 1975	TVA letter transmitting Revision 7 to "Plan for Evaluation, Repair and Return to Service..."
June 2, 1975	Letter to TVA transmitting comments on "Plan for Evaluation, Repair, and Return to Service..."
June 5, 1975	TVA letter transmitting Revision 8 to "Plan for Evaluation, Repair, and Return to Service..."
June 6, 1975	TVA letter transmitting Revision 9 to "Plan for Evaluation, Repair, and Return to Service ..."
June 9, 1975	TVA letter transmitting Revision 10 to "Plan for Evaluation, Repair, and Return to Service ..."
June 9, 1975	TVA letter advising that they will revise their procedures as necessary to comply with the requirements indicated
June 11 1975	TVA letter furnishing information regarding Quality Assurance Program for the restoration on Browns Ferry Units 1 and 2
June 13, 1975	Letter to TVA transmitting Amendment No. 10 to DPR-33 and Amendment No. 7 to DPR-52 authorization to commence restoration
June 20, 1975	TVA letter transmitting Revision 11 to "Plan for Evaluation, Repair, and Return to Service ..."
June 24, 1975	TVA letter transmitting Revision 12 to "Plan for Evaluation, Repair, and Return to Service ..."
July 9, 1975	TVA letter transmitting Revision 13 to "Plan for Evaluation, Repair, and Return to Service ..."
July 16, 1975	Summary of July 1, 1975 meeting re design criteria for restoration and electrical splicing

July 21, 1975	Summary of July 11, 1975 meeting re administrative controls
July 22, 1975	TVA letter transmitting Revision 14 to "Plan for Evaluation, Repair, and Return to Service ..."
July 25, 1975	TVA letter transmitting Revision 15 to "Plan for Evaluation, Repair, and Return to Service ..."
August 13, 1975	Letter to TVA requesting additional information in order to review "Plan for Evaluation, Repair, and Return to Service ..."
August 15, 1975	TVA letter transmitting Revision 16 to "Plan for Evaluation, Repair, and Return to Service ..."
August 18, 1975	TVA responses to NRC questions of August 13, 1975
August 18, 1975	TVA letter transmitting Revision 17 to "Plan for Evaluation, Repair, and Return to Service ..."
August 20, 1975	TVA letter transmitting Revision 18 to "Plan for Evaluation, Repair, and Return to Service ..."
August 21, 1975	TVA letter justifying total independence of redundant systems to the point that a fire could burn indefinitely without any reliance on fire-fighting activities
August 25, 1975	Summary of August 19, 1975 meeting re questions on restoration plan
August 25, 1975	TVA letter relating to removal of fire-affected equipment listing items critical to the schedule for startup
August 26, 1975	TVA letter transmitting Revision 1 to Design Criteria BFN-50-D703
August 26, 1975	TVA letter relating to their August 25, 1975 letter and Part VIII to "Plan for Evaluation, Repair, and Return to Service ..."
August 27, 1975	TVA letter transmitting Revision 19 to "Plan for Evaluation, Repair, and Return to Service ..."
August 28, 1975	Letter to TVA re general items of restoration work requiring approval

August 29, 1975	TVA letter requesting approval of restoration activities and revising the Plan
September 2, 1975	TVA letter transmitting Revision 20 to "Plan for Evaluation, Repair, and Return to Service ..."
September 2, 1975	Letter to TVA transmitting Amendment No. 14 to DPR-33 and Amendment No. 11 to DPR-52 re restoration work and design modifications proposed in the Plan
September 9, 1975	TVA letter transmitting Revision 21 to "Plan for Evaluation, Repair and Return to Service ..."
September 15, 1975	TVA letter transmitting Revision 22 to "Plan for Evaluation, Repair, and Return to Service ..."
September 15, 1975	TVA letter furnishing additional commitments relating to "Plan for Evaluation, Repair, and Return to Service ..."
September 17, 1975	Summary of August 28, 1975 meeting re TVA plans for restoration of BFNP
September 23, 1975	TVA letter transmitting Revision 23 to "Plan for Evaluation, Repair, and Return to Service ..."
September 26, 1975	TVA letter transmitting Amendment 62 to FSAR relating to quality assurance
September 30, 1975	Letter to TVA re transmitting Prenotice re authorization of operation of BFNP upon completion of work required to restore plant
October 2, 1975	TVA letter transmitting Revision 24 to "Plan for Evaluation, Repair, and Return to Service ..."
October 10, 1975	TVA letter transmitting Revision 25 to "Plan for Evaluation, Repair, and Return to Service ..."
October 10, 1975	Summary of October 1, 1975 meeting re electrical penetration seal and fire stop design
October 28, 1975	TVA letter transmitting Revision 26 to "Plan for Evaluation, Repair, and Return to Service ..."
October 31, 1975	Letter to TVA transmitting Amendment 15 to DPR-33 and Amendment 12 to DPR-52 re surveillance requirements for diesel generators

November 7, 1975	TVA letter transmitting Revision 27 to "Plan for Evaluation, Repair, and Return to Service ..."
November 14, 1975	TVA letter transmitting Revision 28 to "Plan for Evaluation, Repair, and Return to Service ..."
November 17, 1975	TVA letter transmitting "Procedures for External Flame Test Using a Full Scale Mockup"
November 21, 1975	TVA letter transmitting Revision 29 to "Plan for Evaluation, Repair, and Return to Service ..."
November 26, 1975	Summary of November 12 and 13, 1975 meeting, re resolution of outstanding items for fire protection
December 1, 1975	Letter to TVA re discussions held on November meetings re appointed coordinator, and access to expertise in fire protection
December 5, 1975	TVA letter naming J. R. Calhoun the responsibility of overall restoration coordinator
December 8, 1975	TVA letter advising of future design changes in order to meet the objectives of prior TVA commitments
December 8, 1975	TVA letter transmitting Revision 30 to "Plan for Evaluation, Repair, and Return to Service ..."
December 10, 1975	TVA letter transmitting Revision 31 to "Plan for Evaluation, Repair, and Return to Service ..."
December 15, 1975	TVA letter transmitting Revision 32 to "Plan for Evaluation, Repair, and Return to Service ..."
December 16, 1975	TVA letter requesting Amendment relating to overall Restoration Coordinator
December 19, 1975	Letter to TVA transmitting Amendment No. 18 to DPR-33 and Amendment No. 15 to DPR-52 re revision to the Interim Technical Specifications to remove requirements for cooling and ventilation equipment
December 31, 1975	TVA letter transmitting Revision 33 to "Plan for Evaluation, Repair, and Return to Service ..."
January 7, 1976	TVA letter transmitting Special Filing Instructions for Part X, Section A of Recovery Plan

January 9, 1976	TVA letter transmitting Revision 34 to "Plan for Evaluation, Repair, and Return to Service ..."
January 13, 1976	TVA letter advising it is unnecessary to perform a Type A primary containment leak rate test
January 13, 1976	Summary of December 3, 1975 meeting, re program for test of equipment prior to return to operation
January 15, 1976	TVA letter transmitting data from fire tests performed on electrical cable wall penetration seal/fire stop designs for use in restoration and in Unit 3
January 20, 1976	TVA letter transmitting Revision 35 to "Plan for Evaluation, Repair, and Return to Service ..." w/report "Metallurgical Examination of Piping and Piping Components Which Were Exposed to Residue from Plant Fire"
January 21, 1976	TVA letter requesting Amendment to add Tech Specs to cover fire protection system
February 3, 1976	TVA letter transmitting Revision 36 to "Plan for Evaluation, Repair, and Return to Service ..."
February 6, 1976	TVA letter transmitting Revision 37 to "Plan for Evaluation, Repair, and Return to Service ..."

ATTACHMENT 2

ROLE OF CONSULTANTS

Consultants have been utilized by the licensee and NRC in the investigation of the March 22, 1975 fire, review of methods used to assess the damage and cleanup of the fire effects and consultation on the restoration of the plant to operational status particularly with relation to fire prevention, protection and administrative procedures.

During the NRC investigation of the events and damage due to the fire, two consultants were used by NRC's Office of Inspection and Enforcement (I&E) to assist them in their investigation. These consultants provided reports that are included in the July 25, 1975 inspection report, which has been included in the Browns Ferry Nuclear Plant Docket File. These consultant reports covered preliminary material testing for fire potential that were installed in the plant and observations by a fire protection consultant of the fire protection program that existed prior to the fire.

The licensee also obtained the services of two consultants to assist and advise them on the plant cleanup methods and procedures and to advise on the chloride effects on structures, equipment and piping in the plant. These consultant reports are included in the licensee's "Plan for Evaluation, Repair, and Return to Service of Browns Ferry Units 1 and 2 (March 22, 1975 Fire)."

The licensee also obtained the services of a fire protection consultant firm to assist them in developing fire prevention controls and procedures and to advise them on the fire protection measures being proposed by the licensee to NRC and to assist in the design modifications that are being made to the Plant.

NRC has also obtained the services of a fire protection engineering consultant to advise it on the methods, procedures and modifications being made by TVA as presented in the Plan.

Both the licensee's and NRC's fire protection consultants have provided comments and recommendations that are either contained in the Plan submitted by the licensee or the public docket record for the Browns Ferry Nuclear Plant. Summary reports will be submitted by both consultants and copies will be included in the Docket File prior to NRC authorizing return to operation.

There are two areas raised by TVA's consultant where we do not yet have sufficient information to fully evaluate the Plan in regard to fire detection and protection. These are set forth below:

1. Based on the recommendations of the licensee's and NRC's fire protection consultant and NRC's fire protection engineer, we believe that the design and installation of the smoke and heat cable detection systems should be completely reviewed by the licensee to show how they conform with the requirements of Class 1 systems, including the supervisory requirements. These requirements are set forth in NFPA No. 70, 71, 72 series (A, B, C, D and E). The review should also include those portions of the systems that were installed prior to the March 22, 1975 fire and are now being utilized with the new systems to function in critical areas of the plant required for safe shutdown. The smoke detector being utilized should be shown to be compatible with the stated requirements. If the licensee takes exception to any

of the requirements they should be stated and justification provided NRC. Also, if the systems design and installation does not meet the requirements for Class 1 systems these areas should also be identified and proposals made by the licensee as to the resolution of each area.

Other recommendations made by the licensee's consultant, regarding the design of the detection systems, should be completely addressed by the licensee. These are recommendations 47 and 50 in Enclosure 1 of the document filed by the licensee which we received on January 26, 1976.

2. Based on our review of the licensee's consultant's recommendations and the licensee's responses to their recommendations, it is not clear what the differences are in the area of hydraulic calculations for the fire water system. In order for NRC to complete its review of this area, we require the licensee to provide a listing of the specific **differences** and their justification for the differences being acceptable. NRC will review the hydraulic calculations after the differences stated above are provided by the licensee.

ATTACHMENT 3

NRC COMMENTS ON NELPIA RECOMMENDATIONS

This comparison has been prepared on the basis of the Nuclear Energy Liability and Property Insurance Association recommendations contained in their report on the fire that occurred at the Browns Ferry Nuclear Plant. As such, it must be recognized that the NRC comments are specific to the Browns Ferry Nuclear Plant and do not necessarily apply to other operating plants or plants under construction.

A. Cable Spreading Room (CSR) (Cable Spreading Room and similar rooms)

NELPIA RECOMMENDATIONS

1. A CSR for each unit should be provided. Each spreading room should be cut off and arranged totally independent of other CSR's by a fire barrier wall of 3-hours' fire resistance rating.
2. At least one 3-foot wide, 8-foot high aisle should be provided the length and width of the CSR to insure fire fighting access. Class A fire doors should be installed at each entrance (at least two) into the room.

NRC COMMENTS

NRC has reviewed the above recommendations and does not consider them necessary for Browns Ferry. TVA has proposed to (a) automate the existing CO_2 system in each cable spreading room, (b) coat all exposed cable surfaces in the CSR's with a fire retartant coating (Flamemastic 71A) to retard and localize any postulated cable fire in the rooms, (c) install a manual dry-pipe sprinkler system and floor drains in the CSR's that will serve as a backup to the CO_2 system, (d) install additional smoke detectors and heat cable detectors in the CSR's to increase the capability to promptly detect a fire. We believe that these changes, in addition to those administrative changes proposed to reduce the probability of a fire, provide sufficient protection in this area. Moreover, the arrangement of the Browns Ferry CSR is such that the cost and downtime to accomplish such modifications would not be justified in view of the limited additional benefit that would result.

NELPHIA RECOMMENDATION

3. A standard installation of open-head, water spray sprinklers controlled by an automatic deluge valve and products-of-combustion actuated detectors should be provided in each CSR. The deluge valve should be located outside the room and connected to the station's annunciator system.

NRC COMMENTS

TVA has proposed to automate the existing CO_2 system in each CSR, and coat all exposed cable surfaces with a fire retardant coating. In addition, instead of a pre-action deluge system as recommended by NELPIA TVA proposes to install a manually operated dry-pipe sprinkler system in each CSR. The manual valves will be located outside the CSR. The proposed additional smoke and heat detection systems for the CSR's will provide annunciation in the control room and at the local stations. NRC finds this to be an acceptable alternate to the NELPIA recommendation.

NRC COMMENTS

The existing design is based on utilization of a CO_2 system as the primary means for fire extinguishment in the CSR. Accordingly, it is necessary to provide for isolation of the CSR from the ventilation system in the event a fire is detected. To assure isolation of a CSR for operation of the CO_2 system, modifications have been made which include the addition of dampers between CSR's and the rerouting of the ventilation system control and power cabling outside of the CSR. These changes will provide for increased reliability for smoke and heat venting of a CSR by manual means when CO_2 operation is not required.

B. Cable Construction

NELPIA RECOMMENDATIONS

1. A re-evaluation of current cable testing requirements should be made to establish the pass-fail criteria for flame propagation of "real-life" cable tray systems.
2. As a minimum requirement today only those cable constructions that will pass the current IEEE 383 flame test should be used.
   NOTE: This does not infer that cables passing this test do not require fire protection nor that certification of cables passing more realistic tests are not essential for tomorrow's cables.
3. Whenever practical, cables that do not liberate copious quantities of corrosive gases should be used particularly in strategic relatively inaccessible and highly susceptible areas.

NRC COMMENTS

NRC is accepting replacement cabling purchased to the standards existing at the time of construction. A change in cable materials is not considered to be necessary, by NRC, in view of measures being taken to reduce the probability of fire through application of Flamemastic on all exposed surfaces of cables, administrative changes, and fire detection and extinguishment systems in areas of cabling where a fire in one division could affect redundant safety equipment.

C. Cable Tray Protection

NELPIA RECOMMENDATIONS

1. Cable tray systems should be protected by automatic, zoned, open-head, water spray sprinkler systems arranged to discharge directly onto the cables in the trays.
2. An approved fast-acting products-of-combustion type detection system should be provided to actuate the deluge system having sectional control.
3. Adequate floor drains and curbs should be provided to safely remove discharged sprinkler water. Drainage water should be monitored for radioactive materials before being released to the environment. Curbs should be provided around all floor penetrations.
4. Approved noncombustible fire stop constructions should be located in each cable tray and spaced at maximum intervals of 10 ft. horizontally and 10 ft. vertically. NOTE: Cable derating should be given consideration when installing fire stops.

5. Wherever practical, isolate, shield, relocate water damageable equipment.

NRC COMMENTS

NRC agrees in principle. Outside of the CSR, which is covered under Item B, all of the above are being provided. In lieu of intermittent fire stops TVA is providing continuous fire stop by use of a fire retardant coating.

D. Indoor Hose Connections

NELPIA RECOMMENDATIONS

1. Fire protection equipment including hose, nozzles, standpipe valves, and hydrants should have compatible threads with existing equipment and the local fire department.
2. Combination spray-straight steam nozzles should be provided on each hose connection to effectively combat Class A fires normally inaccessible, e.g., cable tray fires.
3. Standpipe risers should be sealed on each floor to prevent smoke and corrosive gases from penetrating into areas normally unexposed to the effects of fire.

NRC COMMENTS

The recommendation D.1 has been corrected by TVA by providing for new installation, compatible threads with the local fire department. Adaptors are provided at all other stations to provide for thread compatibility. Recommendation D.2 has been considered and TVA has provided electrically safe spray nozzles for the hose stations. Recommendation D.3 is covered under Recommendation K.

E. Smoke and Heat Removal

NELPIA RECOMMENDATIONS

1. Approved smoke and heat venting facilities independent of the station's normal ventilation system should be provided throughout areas having a combustible occupancy. Each system should be actuated by products-of-combustion detectors and arranged to contain the release of radioactive materials.

2. The mechanical exhaust system should be powered from electrical feeders run outside the fire area. If inside wiring is necessary, mineral-insulated metal sheathed cable should be used.

3. Additional preventive measures outlined in the "International Guidelines for the Fire Protection of Nuclear Power Plants" should be implemented. Specifically Sections 6.1 (Extraction of Smoke and Heat) and 6.2 (Preventing Corrosion) are applicable.

NRC COMMENTS

The cable spreading rooms' ventilation systems, which included modifications such as rerouting of control and power cabling for the system and the addition of isolation dampers, have been evaluated in Section 7.3 of this report. With the power and control cabling rerouted outside the cable spreading room, its ventilation system will be operable and can be manually used for exhausting smoke from a fire in the cable spreading room when the isolation function is not required for CO_2 system operation.

The Reactor Building Ventilation System performs a function for Secondary Containment. It must isolate in order for the Standby Gas Treatment System to perform its function of maintaining a negative pressure on the Reactor Building to prevent exfiltration of radioactivity in the event of a release from the Primary Containment. Therefore, the Reactor Building Ventilation System is designed to fail in the isolated condition. In the event that the Reactor Building Ventilation System does fail as the result of a fire, the Standby Gas Treatment System can be used to exhaust smoke from the Reactor Building. The measures taken to protect against the two divisions of cabling from being affected by a fire as described throughout Section 7.0, ensure the availability of at least one Standby Gas Treatment System Train.

The Control Room's normal ventilation system is designed to isolate on an accident signal or high radiation in the intake duct to enable the Control Room Emergency Pressurization System to perform its function of maintaining habitability of the Control Room. The Emergency Pressurization System could also be used by manual initiation to prevent smoke intrusion into the Control Room from a fire external to the Control Room.

If the fire is in the Control Room, safe shutdown of the plant can be conducted from the Shutdown Board Rooms. The ventilation systems for the Shutdown Board Rooms have fire dampers in the ducts that would close to isolate the rooms from the fire. Cooling of the Shutdown Board Rooms is attained by self-contained air conditioning units in each room. Thus the Main Control Room could be evacuated and habitability of the Shutdown Board Rooms is maintained for shutting down the plant from the back-up control boards.

We conclude that the modifications made by the licensee to provide smoke venting are acceptable and we agree that for those systems required to isolate for Secondary Containment and for habitability of those control areas necessary for safe shutdown of the plant no modifications should be made for purposes of smoke control to prevent any possible reduction in the reliability of these emergency features. For these systems, manual operation would be allowed for smoke control if isolation was not required at the time of the fire.

F. Cable Penetration

NELPIA RECOMMENDATIONS

1. All wall and floor openings through which electrical cables or conduits penetrate should be protected against the passage of flame and smoke by devices and constructions approved or listed by recognized testing laboratories.

NRC COMMENTS

NRC agrees with the above protection requirements. For the applications required for the TVA plant as-built design, no known approved or listed devices or constructions exist. TVA has conducted extensive testing and developed a new cable penetration fire stop design that utilizes fire resistant inorganic materials, fire retardant coating and a silcone RTV compound for sealing the penetrations. The wall and floor openings will utilize this design where a pressure seal is required. Other penetrations will utilize a design which includes fire resistant board on each side of the penetration with the void being filled with an inorganic fiber. The outside of the fire stop, including the cabling, will be coated with a fire retardant coating.

NELPIA RECOMMENDATIONS

2. Temporary wall and floor openings should be sufficiently sealed with a noncombustible material at the end of each workday to insure the fire integrity of the wall or floor.
3. Open flames should never be used to check the installation, gas tightness and integrity of penetration seals. Whenever protected openings are examined, fire extinguishers should be immediately available to those checking for openings on both sides of the wall.

NRC COMMENTS

NRC agrees. These items have been corrected by revised plant procedures.

G. Self-Contained Breathing Apparatus

NELPIA RECOMMENDATION

1. Self-contained breathing apparatus approved by the United States Bureau of Mines and described in NFPA No. 19B should be provided for all fire fighting and control room personnel. Preferably, their service or operating life should be one hour.
2. On-site reserve air supply should be available and arranged to expediently replenish the supply of air in each unit so that the designed service life is available.

NRC COMMENTS

NRC agrees; however, the service or operating life of one hour does not appear practical to achieve. TVA has therefore increased the available air breathing units as well as standby air cylinders. In addition, the recharging capacity has been doubled and an air compressor has been added.

H. Physical Independence of Redundant Circuits

NELPIA RECOMMENDATIONS

1. All redundant Class IE circuits and the equipment served by these circuits should be separated from the primary Class IE circuits by a minimum three-hour fire wall. This will require that a redundant cable spreading room be constructed.
2. Mineral-insulated metal sheathed cable or equivalent fire resistant cables should be used in one of the two Class IE electrical circuits.

NRC COMMENTS

NRC does not believe these actions are necessary in light of other actions taken. (Please see responses given for Items A.1, A.2, and B.1, B.2 and B.3).

I. Cardox Total Flooding System

NELPIA RECOMMENDATIONS

1. The ventilation system in the CSR should be arranged to shut down whenever the Cardox system is discharged.
2. The Cardox system should be rearranged to operate automatically upon actuation of the ionization detection system. NOTE: A one-minute delay should be incorporated into the system to allow workers ample time to leave.
3. A written procedure and permit system should be adopted that would require employees to obtain written permission to impair fire protection equipment.
4. An acceptance test of the fire protected system, including a complete discharge, should be conducted and witnessed by the installer and authority having jurisdiction.
5. An investigation into the compatability of the ionization detectors with the products-of-combustion generated by the burning cable should be made to insure that the detectors will, in fact, operate during the incipient stages of the fire.

NRC COMMENTS

NRC agrees. All items have been accomplished. NOTE: In regard to Item 2, a four minute delay has been incorporated. In regard to Item 4, the testing was accomplished prior to initial startup of Units 1 and 2.

J. Control Room (CR)

NELPIA RECOMMENDATIONS

1. All floor openings between the CSR and CR should be sealed airtight with a material that will insure the fire resistance integrity of the floor. Only penetration seals listed by Underwriter's Laboratories or approved by the Factory Mutuals should be considered. Cellular concrete, and inorganic assemblies as described in the "International Guidelines" may also be considered.

NRC COMMENTS

NRC agrees with intent to seal floor openings between CSR and CR and as stated in our comments on recommendation F.1, TVA has developed and tested a design that will accomplish this function.

NELPIA RECOMMENDATION

2. Self-contained breathing apparatus approved by the United States Bureau of Mines should be located in the CR to insure an orderly station shutdown and to minimize breathing hazards to personnel. The supply should be sufficient for the number of operators and the time it takes to effect a safe shutdown.

NRC COMMENT

NRC agrees. TVA has emergency equipment cabinets that contain storage for approved self-contained breathing apparatus for the control room personnel and the fire brigade. Additional storage of available units is located in another area of the plant.

K. Stairwells, Vertical Opening, Mechanical Penetrations

NELPIA RECOMMENDATION

1. All stairwells, elevators, chutes and other vertical openings should be enclosed in approved masonry towers with airtight, automatic closing Class B fire doors at each opening into the building.
2. All unprotected vertical openings between floors (hoistways steam pipes, etc.) should be sealed airtight.

NRC COMMENT

The Reactor Building is a complex structure with requirements for established ventilation patterns to achieve proper distribution and control of potential radioactivity. There is no practical way to accomplish this recommendation for isolation of floors etc. The intent of the recommendation, however, i.e., to minimize the spread of the products of combustion, has been achieved by minimizing the contained combustible material including Flamemastic coating of exposed cables. In addition, improvements have been made in fire related administrative procedures and automatic detection and extinguishment systems have been added.