2.0 METHODOLOGY - FIRE HAZARDS ANALYSIS AND APPENDIX R EVALUATION

2.1 Introduction

A major task within the Fire Protection Evaluation program is the Plant Fire Hazards Analysis Update. This task consists of assessing a postulated fire at any location within TMI-1 based upon the plants updated combustible inventory, comparing this with the construction features of the fire area or fire zone boundaries and determining the adequacy of the installed fire protection and detection systems available for that fire area or fire zone.

In addition, the objective of the Appendix R Section III.G evaluation is to evaluate whether a single fire within a fire area or fire zone might jeopardize the capability of the plant to bring the reactor to hot and subsequently cold shutdown. Where a single fire might jeopardize safe reactor shutdown, a modification or compensating feature is provided to retain safe shutdown capability. This evaluation includes a review of the effect of fire spread through non-fire rated boundaries.

The Plant Fire Hazards Analysis Update includes review of all the modifications in the plant to update the combustible inventory (including characterization, quantity and location of combustibles per Appendix R, Section III.K.1-8) and analysis and effects evaluation, which considers the adequacy of fire protection features that have been installed.

This revision addresses requirements of Section III.G., III.J., III.L., and III.O. of Appendix R, and considers later guidance documents issued by the NRC, including Generic Letter 86-10.

The Appendix R review was conducted in three stages. During the first stage an in-depth analysis was performed to identify the systems and components required for safe shutdown and to define the redundancy of equipment. The second stage was to determine the components and their cables, which required attention with respect to the Appendix R requirements, and evaluate the need for protection from damage caused by a fire in a specific plant area. A 100% electrical associated circuit review was made to clear the concern over the effect of associated circuit failure on the shutdown capability. Specific fire protection modifications or compensating features were developed and implemented in the third stage to provide protection in accordance with Appendix R. All three stages involved both an information collection process and the actual evaluation process.

2.2 Information Collection

2.2.1 Information for Appendix R Evaluation

During the course of the Appendix R review, plant information was gathered to identify the required safe shutdown systems and equipment, and to determine methods to achieve Appendix R compliance. Since the data collection activities were actually interrelated with the evaluation activities, the Appendix R review was a continuous process.

2.2.1.1 Shutdown System and Equipment

Identification of required safe shutdown systems and equipment for each area of the plant was the logical starting point for assessment of Appendix R compliance. The systems and equipment needed for post-fire safe shutdown are those systems necessary to perform the shutdown functions defined in Section III.L. of Appendix R.

The analysis established the basic functions required to maintain and monitor safe hot shutdown and to achieve, maintain and monitor safe cold shutdown. Systems and equipment necessary for those functions were then identified.

The equipment required for safe shutdown within each system, and the necessary supporting functions were defined based on reviewing NRC guidance and the following TMI-1 documents:

a. Final Safety Analysis Report (FSAR).

b. System flow diagrams.

c. TMI-1 Fire Hazards Analysis Report.

d. GPUN TDR 500, Rev. 0, "Appendix R Modifications."

e. System Design Description for remote shutdown.

f. Piping drawings.

g. Operating procedures.

h. System design descriptions.

i. TDRs and other verified analyses, and calculations.

The list of equipment required for safe shutdown is described in Attachment 3-3.

2.2.1.2 Component Locations

After the systems and components required to achieve safe shutdown were identified, the component locations were determined by reviewing piping drawings, layout drawings, and conduit drawings.

Mechanical components such as pumps, valves, and fans were located, and if required redundant components were located in the same fire area/zone, a noncompliance was assumed with separation criteria, as defined in Appendix R, Section III.G. Passive components such as tanks and piping were considered to be unaffected by the fire. Electrical components such as diesel generators, switchgear, motor control centers, instrumentation, electrical buses, and batteries were also located, including support and auxiliary equipment.

Loss of off-site electrical power was assumed in the evaluation. For components required for safe shutdown powered off non-vital busses, compensatory measures were considered for fire in any plant location concurrent with loss of off-site power. Normally, redundant electrical components are in separate rooms bounded by fire barriers.

Similarly, process monitoring instruments, including transmitters and signal conditioning equipment, were also located.

2.2.1.3 Circuit Search

All Appendix R circuits (including associated circuits) were evaluated for their effects on safe shutdown. This search was performed by reviewing the following types of documents:

a. Internal wiring diagrams.

b. External cable termination diagrams.

c. Block diagrams.

d. Conduit layout diagrams.

e. Tray layout diagrams.

f. Cable termination sheets.

g. Pull slips.

h. Ac and dc elementary diagrams.

i. Single line diagrams.

j. Instrument loop diagrams.

Separate engineering evaluations were performed on the heat sink protection systems (HSPS) and the remote shutdown (RSD) system to determine their effects on the Appendix R safe shutdown strategy.

The original analysis is described in more detail in Report No. GAI 2586. All Appendix R concerns were identified and resolved. This report included:

1) Appendix "R" Circuit Analysis of Heat Sink Protection System

2) TMI-1 Appendix R Safe Shutdown Equipment and Circuit Evaluation Summary Report.

2.2.1.4 Circuit Classification

In accordance with the requirements of Appendix R, the cables were assigned to one of the following four classifications:

Circuit Classification	Nature of Circuits
Required Circuits	- Power cables of required equipment - Control cables of required equipment - Required instrumentation cables
Associated Circuits by Spurious Operations (Spurious Circuits)	- Control cables of equipment whose spurious operation could be detrimental to shutdown - Instrumentation cables that could cause spurious operation of shutdown equipment
Associated Circuits by Common Power (AP Circuits)	- Power cables not required for safe shutdown, but connected to safe shutdown electrical buses
Associated Circuits by Common Enclosure (AE Circuits)	- All other cables connected to or enclosed in component enclosures of safe shutdown equipment including cable raceways

2.2.1.5 Determination of Equipment/Cable Fire Area/Zone Locations

The fire area/zone locations of the safe shutdown equipment and cables were established using the tray layout drawings, tray coordinates, the conduit layout drawings, piping drawings, fire zone drawings, and field inspection.

2.2.1.6 Computer Program Application

Existing computer programs were refined and new programs were developed to compile and to sort TMI-1 cable routing data stored in the existing computer files, and to establish the additional data for the Appendix R evaluation. The computer generated cable routing and classification worksheets show location of the cables by fire area/zone.

The computer searched essential cables routed through all the fire areas/zones and provided a list of essential cables located in these fire areas/zones.

2.2.1.7 Component and Cable - Fire Area/Zone Matrices

Matrices showing location of evaluated components and cables in all fire areas/zones were prepared by using the fire area/zone information from the cable routing worksheets. These cable matrices (Attachment 3-6) became the basis for circuit evaluation.

2.2.1.8 Field Walk

An extensive field walkdown was performed during the Appendix R evaluation to gather pertinent data on raceway systems, and information on field conditions. The results of the field information were utilized to assist in determining the most effective and practical method of circuit protection. Information gathered from the field survey included:

a. Sealing of fire stops (seals, doors and dampers).

b. Apparent tray fills.

c. Structural limitations.

d. Presence of external hazards.

e. Availability of space for new raceways.

f. Availability of space for Rockbestos Firezone R cables and associated splices.

g. Availability of space for fire barrier wraps.

h. Constructability and maintainability.

2.2.2 Plant Fire Hazards Analysis Inventory of Combustibles

The types of combustibles considered included petroleum products, cable insulation, charcoal filters, and maintenance and operating supplies.

a. Petroleum Products

Petroleum products are defined, for the purposes of this report, as lubricants and diesel fuel utilized at TMI-1. Lubricants were tabulated for all equipment containing one quart or more. Lubrication of equipment requiring smaller quantities of oil is normally accomplished through sealed bearings or oil/grease cup arrangements and is required in negligible amounts.

All transformers within TMI-1 buildings are of the dry construction type and, hence, contain no petroleum products.

b. Cable Insulation

Cable insulation for power, control, and instrumentation cable installed in cable trays within the reactor building was included in the fire loadings. These loadings were considered even though vendor test reports confirmed the non-flame propagating properties of the cable insulation. In the remaining areas of TMI-1, only the control and instrument cable installed in cable trays was considered, since the power cable is provided with an interlocked armored jacket and is not considered to contribute to the fire loading. Cables installed within conduit were not considered to contribute to the fire loadings. Cable insulation is primarily Kerite and is fire resistant and non-flame propagating. The Kerite cable has been qualified by tests to be of fire resistant construction. Copies of these tests are on file with Metropolitan Edison. The instrument cable that is not Kerite is Continental Wire silicone rubber with a fiberglass outer covering or similar. This cable is also fire resistant and non-flame propagating. Although the cabling has been demonstrated by test to be of fire resistant construction to meet the conservative requirements imposed by Appendix A, the cable insulation has been assumed to be combustible with a calorific value of 10,000 BTU/lb.

Control and instrument cables installed in cable trays are multiple layer, random fill, whereas power cables are generally installed in a single layer.

Cable insulation quantity for the initial Plant Fire Hazards Analysis was estimated using the following procedure. For each tray considered within an area, the number of circuits contained was determined from the tray circuit listing. The insulation quantity was then determined by multiplying the number of circuits, by the tray length, by the weight of the insulation of an average cable size representative of the tray loading. The total insulation weight for an area was the result of the summation of the individual trays. Since most circuits do not run the full length of a tray, this process yields a conservative (high) estimate of cable insulation quantities.

Instrument and control cabinets, motor control centers, and switchgear equipment were evaluated to determine their potential contribution to the fire loading. Considering the small amounts of fire resistant and non-flame propagating wiring in this type of equipment, together with the metal enclosure, the contribution to the fire loading is considered negligible.

c. Charcoal Filters

The quantity of charcoal in the filters was determined from the filter manufacturer's data.

d. Maintenance and Operating Supplies

Maintenance and operating supplies consist of paper, cloth, plastic, combustible and flammable liquids, and other items required for normal operations. In contrast to the first three categories of combustibles, which are permanent and part of the design, these supplies are transient, may vary with time, and can be moved about. Because of these characteristics, they are subject to administrative control. Certain areas of TMI-1, however, require a continual replenishment of these supplies. The controlled access dressing area, for instance, will always contain clothing and associated supplies. For the fire hazards analysis, a survey of the transient combustibles is included with the combustible loading summary for each fire area or fire zone in Section 4.0 of this report. The fire loadings used for these transient supplies are representative of what was determined during that survey.

For each update of the Plant Fire Hazards Analysis Report, plant modifications which were installed since the previous update are reviewed utilizing the same criteria for inventorying combustibles as described above. Any proposed plant modifications, or modifications installed while this report was being prepared, may not be included in this report and will be reflected in subsequent revisions.

2.2.3 Structural Fire Barrier Review

The structural review consisted of determining fire ratability of existing fire barriers and structures between fire areas within TMI-1. Included in this review was a survey of wall and floor penetrations between fire areas.

2.2.4 Fire Detection/Protection Systems Review

The existing TMI-1 fire detection and protection systems were reviewed to determine their adequacy with respect to fire hazards present as well as adequacy in terms of enhancing the plants capability to achieve safe shutdown.

2.2.5 Fire Hazards Analysis Layout Drawings

These drawings, numbered 1-FHA-001 through 1-FHA-046, show each fire area/zone, separating fire barriers, fixed fire protection features, fixed 8-hour emergency lights, cable, and conduit which are being protected with fire barriers, or Rockbestos Firezone R cables, or radiant energy heat shields, as a result of the Appendix R Section III.G. Safe Shutdown Evaluation. Some cables being rerouted outside the respective fire area/zone are not shown in the drawings. Components requiring manual actions for hot shutdown (i.e. from Attachment 3-7A) are also shown on the drawings. These drawings form the basis for the Fire Hazards Analysis presented in Section 4.0.

2.2.6 Water Damage Study

The water damage study consisted of identifying all components required for safe shutdown, which are subject to fire suppressant damage due to fire fighting activities. The study also applies to inadvertent actuation of a fire suppression system that could incapacitate components. Existing features that protect components are described in Section 6.0 of this report.

Additionally, the effects of fire suppressant discharge on safety related equipment have been analyzed and water intrusion seals have been provided as a result. These water intrusion seals have been identified in a preventative maintenance procedure (PM-E-126 "Water Intrusion Seal Inspection) and incorporated in the Fire Protection program via Administrative Procedure 1038 "Administrative Controls - Fire Protection Program".

2.3 Evaluation

2.3.1 Appendix R Evaluation

Appendix R requires at least one train of safe shutdown equipment for hot shutdown to be "free of fire damage" and capable of performing its intended function before, during, and after the postulated fire. Appendix R, Section III.G.2 defines "free of fire damage" to mean the required components or circuits in the fire-affected area are protected by one of the options specified in that section. The object of this evaluation activity was to establish the redundancy of shutdown equipment and determine the circuits and/or components requiring protection from fire damage in each fire area/zone.

2.3.1.1 Fire Safe Shutdown Strategy

The following functions were maintained to establish the safe shutdown strategy. The descriptions here provide an overview of how those functions are performed.

a. Reactivity Control

Reactivity trip capability is provided by manual scram of the control rods from the control room. Shutdown reactivity margin is maintained during cooldown by addition of boron by the makeup system using water from the borated water storage tank (BWST).

b. Reactor Coolant Inventory Control

Inventory control is provided by the makeup system. At least one makeup pump and an HPI flow path is available for all fires. The normal MU flowpath will be used if available, and isolated if it cannot be controlled. Makeup functions may have to be delayed due to manual valve alignments in certain fire areas. The BWST is the water source for RCS inventory.

c. Reactor Coolant Pressure Control

Pressure control is normally maintained with a pressurizer steam bubble. Pressurizer heater group 8 or 9 will be preferably used for pressure control if either heater is available. However, if heaters are not available, RCS pressure will be controlled hydraulically by controlling RCS makeup.
Letdown enhances hydraulic RCS pressure control and should be used when recovering a pressurizer steam bubble (e.g. after HPI cooling). Letdown, when required to maintain RCS pressure control, may be manually restored if lost. Letdown may not be available for a fire where the intermediate cooling pumps are located (AB-FZ-7) or where specific cable faults could prevent manual re-opening of IC-V-2 (See Attachment 3-5J). Letdown restoration is only required where HPI is credited for decay heat removal (IB-FZ-3 or IB-FZ-8) or where pressurizer heater groups 8 and 9 are both lost and cannot be restored (RB-FZ-1D, RB-FZ-2, AND TB-FA-1). See Attachment 3-7C for zones where repair of a pressurizer heater group is credited.

d. Reactor Coolant Pump Seal Cooling

RCP seal cooling is an important element of RCS inventory control. RC pump seal cooling is provided by either seal injection with the Makeup system or thermal barrier cooling with the Intermediate Closed system. RC pumps will be tripped within 30 minutes if both means of RCP seal cooling are lost. Seal injection can be restored in all fire zones.
If seal injection cannot be restored within 1 hr, then controlled bleed off flow will be isolated to eliminate the challenge to MU pump operation from a high inlet water temperature. Seal injection will be restored within 2.5 hrs to assure emergency accessibility of the Reactor Building.

e. Decay Heat Removal

Decay heat removal is accomplished during hot shutdown by natural circulation of the reactor coolant, by using the emergency feedwater system to supply

feedwater to at least one steam generator and by exhausting steam through the atmospheric dump valves. The atmospheric dump valves (MS-V-4) and block valves (MS-V-2) are not protected. Steam may be dumped through the main steam safety valves until spurious closure of the dump block valves can be manually corrected or the dump valve is manually controlled.

In IB-FZ-3 or IB-FZ-8, High pressure injection (HPI) cooling will be used if required until the EFW valves can be manually realigned after the fire is extinguished.

Both OTSGs and one Decay Heat Removal train (DH/DC/DR) are used for cooldown to reach CSD. The condensate supply available in CO-T-1A and CO-T-1B exceeds the volume required for the evaluation period (72 hours).

f. Process Monitoring Instrumentation

Process monitoring is provided for reactivity, RCS temperature and pressure, pressurizer level, steam generator level and pressure, and others. At least one loop each of required process monitoring function is available for a fire in all fire areas/zones.

g. Supporting Electrical and Mechanical Systems

Systems required to support the shutdown systems are:

(1) ICCW: The intermediate closed cooling system is available to support letdown in all zones except AB-FZ-7 or where specific cable faults could prevent manual re-opening of IC-V-2 (See Attachment 3-5J). ICCW is required in zones where letdown is required.
(2) NSCCW: The nuclear services closed cooling system is available for all fires. NSCCW is required in fire zones where MU-P-1B is the only MU pump potentially available (i.e. AB-FZ-5, AB-FZ-7, ISPH-FZ-1, and ISPH-FZ-2).
(3) NR: The nuclear service river water system is available for all fires. The NR system is required to support the required functions of ICCW & NS.
(4) DC & DR: One of the decay heat close cooling systems and its associated decay heat river water system are available to provide MU-P-1A or MU-P-1C cooling in each fire zone as required to ensure at least one MU pump is available in all fire zones.
(5) DH, DC, & DR: One train of decay heat removal is available or will be restored in each fire zone to provide the capability to reach cold shutdown.
(6) ISPH ventilation: The installed system or temporary equipment will provide ventilation and cooling to support operation of required river water systems equipment.
(7) The on-site electrical distribution system will provide power of all safe shutdown functions.

h. Instrument Air

The normal Instrument air system is used for safe shutdown where available. The two-hour backup instrument air bottles and local air bottles are required to provide air to operate critical components until manual operation can be established.

A detailed evaluation, based on a system approach, was performed to identify all components that are required for safe shutdown or those whose spurious operation as a result of the fire could adversely affect the ability to achieve safe shutdown. Attachment 3-3 identifies the components required for safe shutdown as FSSD “Yes”. These components have an active function to directly support achieving safe shutdown or have an active function to mitigate the consequences of some adverse affect of the fire on the ability to achieve safe shutdown. Attachment 3-3 also identifies whether the component is required for hot shutdown (HSD), cold shutdown (CSD), or both.

Where spurious operation of a component could affect safe shutdown but operation of that component is not required to mitigate the consequences of that failure, then the component is described as FSSD “No (S)”. Other components which had the potential to affect safe shutdown, but further evaluation, design changes or operational changes eliminate the need for this component to support safe shutdown, the component is described as FSSD “No”. The fire zone specific availability/potential fire impact of FSSD “Yes” or “No (S)” components is described in Attachment 3-5 (except where exclusion is described on Attachment 3-3).

2.3.1.2 Component and Circuit Evaluation

Fire areas/ zones are analyzed in Section 4 and are considered as fire areas for purposes of evaluation.

Where redundant equipment and circuits are in separate fire zones, it was considered that adequate separation existed and no protection or further analysis was required. The justification for the use of fire zones is contained in Section 4. The acceptability of this evaluation was contingent upon NRC approval, which was provided in NRC letter dated December 30, 1986. The fire zones selected are based on those zones previously accepted during the review for conformance to BTP APCSB 9.5-1, Appendix A and may not meet Appendix R requirements for a fire area basis (with 3-hour rated boundaries).

The circuit evaluation was based on the cable matrices (Attachment 3-6) and the computer list of essential cables in the fire zone. The cable matrices were reviewed along with the computer printout and system flow diagrams (listing in Attachment 3-4). The shutdown components and cables which may be disabled by a postulated fire in a designated fire area/zone were identified and a combination of shutdown components which can provide safe shutdown and which at the same time requires the least

protection of equipment and cables was selected for each fire zone. The combination selected utilizes both "A" and "B" channel equipment. The redundant "A" and "B" channel components were, therefore, mixed to take advantage of the existing separation.

In most of the fire areas/zones, most of the components are available for safe shutdown. In some areas, some form of circuit protection is required to ensure that one train of safe shutdown components and circuits is free of fire damage. Four types of circuit protection are normally used. Radiant energy heat shielding (REHS) is used in the reactor building. Fire-rated Rockbestos Firezone R cables are also used in the reactor building as a substitute for REHS. Most of the modifications required outside the reactor building use either Rockbestos Firezone R cables or cable tray (or conduit) fire barrier wraps.

The required and spurious circuits which were determined to require protection from fire damage by this circuit evaluation and circuits which are isolated by design modification or control scheme modification that can prevent spurious operation of valves due to a hot short on the cable are denoted in the cable matrices. The availability of shutdown components is shown in the component availability matrices (Attachment 3-5).

Attachment 3-0 shows the shutdown systems available for a fire in each of the fire area/zones. The systems are listed by the shutdown function required.

2.3.1.3 Philosophy of Protection

Normally, an electrical cable is subject to three types of faults by a fire: 1) a hot short, 2) an open circuit, and 3) a short between conductors or conductors and ground. The cables required for the operation of safe shutdown equipment (the required circuits) must be protected from all three types of faults. The associated circuits by spurious operation (spurious circuits) would also need protection if the spurious operation of the equipment would be detrimental to safe shutdown. For motor-operated and solenoid-operated valves, control power is required to change the valve position. Only a hot short on the control circuit could cause spurious alignment of valve position. These spurious circuits are being protected against a hot short when the spurious operation has been determined to be detrimental to safe shutdown.

Except for the high-low pressure interface valves, only one hot short has been assumed to occur per fire scenario; however, the hot short could happen to any one unprotected (from a fire) cable. For series valves in the high-low pressure boundary, multiple hot shorts have been addressed, however multiple hot shorts on all three phases of 3 phase AC circuits in the proper sequence to cause spurious operation has been considered sufficiently low in probability so as not to be considered credible.

Although consideration of spurious operation by hot short has been limited to only one instance (or redundant valves in any one high-lo pressure interface line), other types of faults have been assumed to happen to all unprotected electric cables in the fire. It has been assumed that all unprotected cables may be open or short circuited or shorted to ground by the fire.

A voluntary initiative to consider Multiple Spurious Operations (MSO) was completed by Exelon per the guidance in NRC Reg. Guide 1.189, Rev. 2 and NEI 00-01, Rev. 2. That initiative drove supporting TMI specific analysis C-1101-911-E420-002 “TMI Multiple Spurious Operations (MSO) Scenario Analysis” and Technical Evaluation 1059893-05 “TMI MSO Fire Modeling” and produced design changes (ECRs 12-00389, 12-00412, and 12-00553). This analysis remains external to the site’s licensing basis, except for unique cases where the licensing basis was impacted (such as the three ECRs described).

Cables and components of one train of a redundant system with its supporting systems are protected from fire damage if cables and components of both trains are located in the same fire zone. The basic criteria of circuit protection are:

a. Hot shutdown components and cables of one train of a redundant system and its support systems are always protected unless an exception can be taken and exemption request identified without jeopardizing the safe shutdown.

b. When the protection of components or cables for hot shutdown is not feasible in certain fire areas/zones, then another system or other equipment has been substituted to provide the same function, or the function is being delayed if timing is not critical and operator manual action is used to establish the function.

c. When cable protection is not feasible for certain pumps, motor operated valves, or solenoid operated valves which must be prevented from spuriously operating, control scheme modifications are made. For control scheme modifications see Section 3.13.

d. Motor-operated valves or air/solenoid-operated valves whose operation can be delayed for shutdown are manually aligned to the shutdown position, provided that the valves are equipped with handwheels and are accessible.

   When manual action is required in this report for the operation of a motor operated valve (MOV), two separate actions must be taken to accomplish the task. First, the electrical power must be de-energized; then the valve must be hand operated. This will prevent an automatic feature of the MOV from declutching the hand operating mechanism and automatically moving to the wrong position when it is energized.

e. Cables and components required only for cold shutdown will not be protected, but will be repaired if the repair is feasible and the repair can be made within 72 hours for III.G.2 areas or repairs can be made within sufficient time to support achieving

cold shutdown in 72 hours for III.G.3 areas. The repairs involved are primarily cable replacement. Spares to accomplish the repairs are in protected inventory and subject to periodic inventorying by procedures.

2.3.1.4 Associated Circuit Review

The associated circuits of concern are those circuits whose fire-induced failure could affect shutdown capability and thus prevent post fire safe shutdown. Three types of associated circuits of concern have been defined by the NRC. One group of associated circuits, circuits associated by spurious operation, has been individually analyzed along with the required safe shutdown circuits for the consequence of fire damage (see section 2.3.1.2). Since all mechanical and electrical components whose spurious operation could adversely affect shutdown capability had been included in the shutdown system analysis, the analysis of the circuits associated by spurious operation was considered to include 100 percent of the spurious circuits. Two other types of associated circuits (circuits associated by common enclosure and circuits associated by common power) were also completely identified.

To meet the intent of the NRC with regards to Appendix R associated circuits, GPUN reviewed all Auxiliary electrical circuits at TMI-1. This commitment was docketed to the NRC in GPUN Letter No. 5211-86-2214, dated November 23, 1986. The review is contained in Gilbert Commonwealth Study "Auxiliary Electrical Studies", dated March 17, 1987. The results of the review were submitted to NRC in GPUN letter 5211-87-2070, dated March 20, 1987, and subsequently identified as acceptable in NRC Inspection Report No. 50-289/90-20 dated January 11, 1991.

Based on industry operating experience, an additional review was performed in 2014 and control circuit fuses were installed to protect the control cable for GN-P-2 (ECR 14-00279), LO-P-6 (ECR 14-00255), and LO-P-9A/B (ECR 14-00279). The fuse rating was determined using the cable emergency rating of 250 degrees C verses the continuous rating of 90 degrees C, as was used in the previous Gilbert Commonwealth review. The larger fuse rating was desired to protect the circuit from a postulated fire induced short circuit as well as provide reasonable assurance that the pumps will not trip themselves off prematurely when needed to protect the asset.

2.3.2 Plant Fire Hazards Analysis

The fire hazards analysis presented in Section 4.0 was performed using the steps discussed below.

2.3.2.1 Identification of Fire Areas and Zones

TMI-1 was divided into fire areas in accordance with the definitions of Appendix A to Branch Technical Position APCSB 9.5-1. For analytical purposes, certain fire areas were subdivided into fire zones. Each fire area and zone is identified and described in Section 4.0. The zones and areas may be irregular in shape, however approximate description is provided for length, width and height. The area of each zone/area is derived by calculations.

The following are the definitions of a fire area and fire zone as provided in Branch Technical Position APCSB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Plants."

Fire Area -
That portion of a building or plant that is separated from other areas by boundary fire barriers (walls, floors or roofs) with any opening or penetrations protected with seals or closures having a fire resistance rating equal to that of the barriers.

Fire Zones -
Subdivisions of fire areas in which the fire suppression systems are designed to combat particular types of fires. The concept of fire zone aids in defining to the fire fighter the fire parameters and the actions which would be necessary."

Initially, the plant was analyzed based upon the guidelines established by Appendix A to BTP APCSB 9.5-1. The delineation of fire areas was established taking into consideration the location of redundant safety related components with respect to each other, existing building construction and the presence of in-situ fire hazards. For the purposes of analysis, certain fire areas were subdivided into fire zones taking into consideration the physical boundaries that exist between one fire zone and another within the same fire area. In the current fire area/zone arrangement, further support for the sub-division of fire areas into fire zones is obtained by the augmentation of the plant fire protection system which has been achieved due to the modifications which were made as a result of the NRC's safety evaluation (License Amendment 44 and Supplements) report with respect to the initial plant fire hazards analysis; e.g., fire zone boundaries bounded by fixed suppression systems. Appendix R suggests evaluation of the plant on a fire area basis while Appendix A to BTP APCSB 9.5-1 did not specifically require fire area separation of safe shutdown components.

The following criteria has been utilized in evaluating the adequacy of fire zone boundaries which permits analysis to determine compliance with Appendix R, Section III.G of fire zones by themselves.

In general, only those boundaries which are not continuous wall to wall, floor to ceiling boundaries of fire rated construction will be addressed.

Those boundaries which are of rated construction and controlled as rated boundaries are addressed where they constitute a portion of a fire zone boundary or where a justification is required for a specific penetrating element which is unrated. Justification of fully rated fire area boundaries is not the subject of this assessment. In addition, boundaries in fire areas not adjacent to any other fire area or fire zone are not the subject of this assessment. Those boundaries in fire zones which are adjacent to other fire areas or fire zones will be addressed as described below.

A. Examination beyond an evaluation of existing active and passive features is not required to support justification of the following zone boundaries:

A1. Any zone boundary which is not adjacent to other fire zones or areas. Basis - no interaction.

A2. Any zone boundary which is protected by automatic fire suppression on at least one side of the boundary.

A3. Any zone boundary contained within the area served by a common automatic suppression system.

B. Further examination of a zone boundary, as described below, not meeting the criteria of A above will establish acceptability provided the combustible loading on either side of that zone boundary is less than approximately 40,000 BTU/ft^2.

B1. The zone boundary consists of non-rated physical boundaries with penetrations sealed with at least one hour fire rated non-combustible material.

B2. The zone boundary is not relied on to separate/protect redundant trains of safe shutdown equipment on either side of that zone boundary.

B3. Partial non-rated barriers and separation distance provide adequate physical horizontal separation where vertical separation is not a concern.

Section 4 contains an evaluation that supports the individuality of fire zones for the purpose of safe shutdown analysis.

2.3.2.2 Calculation of Area or Zone Fire Load

The combustible materials located within each area or zone were listed, and the fire loading was calculated in BTU/ft2. This number was used to verify the adequacy of the existing fire rated barriers, in accordance with Table 6-8A of the NFPA Fire Protection Handbook, 14th Edition.

GPUN Calculation No. C9000-810-5360-001 provides the design basis energy heat release values for determining BTU content of combustible materials.

GPUN Calculation No. C-1101-810-5720-003 generates the floor areas for all indoor fire areas and zones.

Utilizing data from these two calculations, the fire loading for each zone was determined and entered into a computer database. Changes to the plant which increase the combustible load for an area/zone are entered into the database and reviewed against the description in the Fire Hazards Analysis Report. Updates to this database are controlled by CC-MA-209-1002, Combustible Loading Database Control for Oyster Creek and Three Mile Island.

For the purpose of description, throughout the Fire Hazards Analysis Report, the

following criteria has been established:

"Low" Combustible Load	-	0 to 80,000 BTU/ft.^{2}
"Moderate" Combustible Load	-	80,000 to 160,000 BTU/ft.^{2}
"High" Combustible Load	-	over 160,000 BTU/ft.^{2}

2.3.2.3 Review of the Ventilation Systems

Ventilation systems were evaluated by areas and zones based upon the following considerations:

a. What effect might the ventilation scheme have on a fire within an area or zone?

b. Where would products of combustion be routed through the ventilation system?

c. Would the ventilation system help to spread a fire to another area or zone?

d. What is the effect of shutting down the ventilation system in an area or zone in the event of a fire?

e. Are there any fire or smoke dampers in the ventilation ducts?

2.3.2.4 Examination of Existing Area or Zone Fire Detection/Suppression/Containment

Examination consists of determining how a fire within the area or zone would be extinguished, once detected. It was assumed that any permanently installed fire protection equipment would function as designed. Section 4 contains a discussion of the fire protection equipment provided for each area, a description of the fire area/zone boundaries, and a discussion of the individual fire zone boundaries which are not fire rated barriers and their features which would assist in the containment of a fire.

2.3.2.5 Containment of Radioactivity

The reactor, auxiliary, and fuel handling buildings house equipment that normally contain radioactivity. The methods of containing radioactive leakage and releases from these buildings are as follows:

a. Reactor Building

Liquid spillage or leakage from equipment within the reactor building drains into the building sump. From the reactor building sump, liquid drains to the auxiliary building sump where it is pumped to the miscellaneous waste storage tank in the auxiliary building for normal liquid waste processing. Section 11.2.1 of the FSAR details the handling and containing of liquid radioactive wastes.

Gaseous release or leakage within the reactor building is retained within the

building until released in a controlled manner. These releases are controlled by existing procedures and are released into the environment through the containment purge exhaust system.

b. Auxiliary and Fuel Handling Buildings

Liquid spillage or leakage from equipment within these buildings drains into either the spent fuel pit sump or the auxiliary building sump. From either sump, it is pumped to the miscellaneous waste storage tank in the auxiliary building for normal liquid waste processing. Section 11.2.1 of the FSAR details the handling and containing of liquid radioactive wastes.

Radioactive gases from equipment leakage pass into the auxiliary and fuel handling exhaust ventilation systems and through the associated roughing, HEPA, and charcoal filters. The release of radioactive gases into the environment is controlled by existing procedures.

Radioactive liquids and gases are normally contained within piping and process equipment such as tanks, pumps, compressors, demineralizers, filters, and evaporator packages. The major sources of radioactivity would be the storage tanks, which are located in shielded cubicles having very low fire loadings.

Tanks are provided with overpressure devices, which will operate if a fire causes pressure buildup within the equipment. Liquid releases would be collected through the floor drain system and would be released as described above. Releases from the gaseous radioactive waste system would be limited to the waste gas decay tanks since the gaseous spaces of the other tanks are interconnected through the waste gas vent header system. This would allow the gaseous expansion due to a fire in one area to be accommodated throughout the entire system. The waste gas decay tanks, which are isolated from the vent header, are each located in a cubicle that has no permanent combustible fire loading. The cubicles are connected by access openings. Except for periods when maintenance is being performed, no combustible materials will be present in these cubicles. Therefore, no fire that cannot be readily extinguished is postulated.

Another possible problem resulting from a fire is that the water used to fight the fire may become radioactively contaminated. However, such contamination does not result in uncontrolled releases. The fire fighting water will be contained and controlled in the same manner as equipment spillage or leakage described above.

2.3.2.6 Basis for Conclusions

Conclusions regarding the adequacy of existing fire protection in the fire hazards analysis are based upon the following:

a. If the Appendix R, Section III.G., Safe Shutdown Evaluation (by fire areas/zones) identified noncompliance modifications were implemented or exemptions requested.

b. If the fire area/zone boundary separation between fire areas/zones containing redundant equipment or cable is considered sufficient to prevent a fire from causing loss of function of both items, then no further modifications were considered. A discussion of fire zone boundaries and their adequacy is contained in Section 4. The adequacy of fire rated barriers (fire area boundaries) for the calculated fire loadings are based upon requirements in the NFPA Fire Protection Handbook, 14th Edition, Page 6-81, Table 6-8A.

c. The existing fire suppression and detection equipment for each area or zone was reviewed to determine if it is adequate for the calculated fire loading and the type of potential fire that can be expected.

d. Where redundant electrical equipment with temperature limitations are located in adjacent rooms, closure of fire dampers which impede ventilation is considered correctable by the fire brigade, operations and/or emergency response personnel. For situations where fire induced loss of required ventilation systems is possible, mitigating features such as portable ventilation have been implemented.

e. In areas or zones where automatic fire suppression systems are installed, it is concluded that safe shutdown equipment and cables are adequately protected to prevent loss of function of both channels by the installation of additional fire barriers (or fire rated cable) in these areas/zones, and that the automatic fire suppression will prevent the spread of fire to areas containing redundant safe shutdown equipment or cables.

f. In areas or zones where automatic fire suppression systems are installed, it is not necessary to protect the supports of cable raceways (trays and conduit) that are being protected with fire barrier wraps or that contain fire rated cable on the basis that the automatic suppression system will protect the supports from failure. Also, it is not necessary to protect the supports of services in proximity to these raceways to prevent damage of safe shutdown due to falling debris.

   In addition, in these specific areas/zones, some cables in tray are directly protected with fire barrier wraps (without fire barrier wraps on the trays and supports) based on the philosophy of being equivalent protection to the use of fire rated cable.

g. In areas or zones containing some safe shutdown valves, it was concluded that manual operation, after the fire would be extinguished, is acceptable if the function can be delayed. An exemption request is identified for this.

h. Emergency lighting is provided as required, in accordance with the Appendix R, Section III.J criteria as modified by the exemption request in Section 3.14.

i. In fire zones with boundaries that are not completely sealed (designated as B2), the potential exists to perform manual actions in an adjacent fire zone due to conflagration.