

DAVIS-BESSE NUCLEAR POWER STATION

UNIT 1

FIRE HAZARD ANALYSIS REPORT

REVISION 27

DAVIS-BESSE NUCLEAR POWER STATION

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Davis-Besse Unit 1 Fire Hazard Analysis Report

DAVIS-BESSE NUCLEAR POWER STATION UNIT NO. 1

SECTION 1.0

INTRODUCTION AND SUMMARY

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1.0 INTRODUCTION

Appendix A of Branch Technical Position APCS 9.5-1 provides guidelines for a Nuclear Power Plant to reduce the possibility of a serious fire and limit the damage of a fire. 10CFR50, Appendix R requires that a Nuclear Power Plant demonstrate through analysis that the plant can shut down after a serious fire.

This report is to document the analysis conducted to ensure that Davis-Besse can be shutdown safely to Cold Shutdown after a serious fire. The report also documents the analysis done to reduce the consequences of a fire and control fire propagation.

Evaluation of the Dry Fuel Storage Facility is described in the Davis-Besse Dry Fuel Storage Basis Manual.

This report presents a detailed review and assessment of the Davis-Besse 1 design against the requirements of 10CFR50, Appendix R Section III.G, "Fire Protection of Safe Shutdown Capability", III.J, "Emergency Lighting", III.L, System "Alternative and Dedicated Shutdown Capability" and III.O, "Oil Collection for Reactor Coolant Pumps" and BTP APCS 9.5-1, Appendix A.

1.1 Purpose of Report

The purpose of this report is to document the analysis performed for Davis-Besse to ensure compliance to the requirements of 10CFR50, Appendix R, Sections III.G, III.J, III.L, III.O. In certain areas, exemptions have been granted from specific requirements where it has been determined that existing fire protection features provide equivalent protection to that required by Appendix R. In addition, this report documents the review and assessment of Davis-Besse 1 (DB-1) against the design requirements of BTP APCS 9.5-1 Appendix A.

1.2 Review Methodology

This report was prepared in several steps, the first of which was the identification of Safe Shutdown Systems at DB-1. An analysis was then performed to identify the Safe Shutdown Systems necessary to achieve and maintain Hot Standby and subsequent Cold Shutdown in the event of a postulated fire. After the requisite systems were identified, the related components and circuits were identified and located in the individual fire areas. At this time, the Associated Circuits review was also conducted.

The fire area determinations were performed concurrent to this effort by evaluating the adequacy of the fire area boundaries and review of fire hazards. New areas and redefined areas were added to existing defined fire areas to support this evaluation.

The Safe Shutdown components and circuits were then reviewed for compliance with the specific separation criteria of 10CFR50, Appendix R, Section III.G.2.

The Emergency Lighting Review and Alternate Shutdown Capability evaluation were performed once the above-mentioned activities were completed.

The Reactor Coolant Pump Oil Collection System Review was performed prior to the Section III.G.2 review.

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The methodologies for these reviews are described in their respective sections of this report. All reviews determined the degree of compliance with Appendix R, Sections III.G, III.J, III.L, III.O, as applicable. For those areas not in compliance, studies were completed to determine whether:

1. Protection of Safe Shutdown features were required to bring the area into compliance; or
2. Alternative or Dedicated Shutdown capability was required to bring the area into compliance; or
3. An exemption was justified for the specific fire area in question.

1.3 Summary of Results

Within the Fire Hazard Analysis Program, the system, component and circuit separation aspects and the existing plant fire protection features have been integrated to achieve compliance to the extent possible, with the requirements of Sections III.G, J, L, and O of Appendix R to 10CFR50 and BTP APCS 9.5-1 Appendix A. As a result of this effort the Fire Hazard Analysis Program has achieved the desired outcome in that no single fire will prevent Safe Shutdown or jeopardize the safety of the general public.

The following is a summary, by section, of the results stemming from the various evaluations which comprise this report:

Section 3 Summary

The evaluation performed as specified within Section 3 culminated in a list of Safe Shutdown components and circuits which are required to be addressed for Appendix R Section III.G separation requirements. Also included in the Section 3 review is the adequacy of plant security systems.

Section 4 Summary

This section contains an area by area analysis which which summarizes the fire hazards, fire barriers, fire detection and suppression systems, and summarizes the Safe Shutdown analysis.

The Table 1's summarize the method of achieving compliance for individual fire areas with 10CFR50 Appendix R.

Section 5 Summary

The Associated Circuits Review determined those circuits that pose common power source, common enclosure, and/or spurious actuation concerns relating to Safe Shutdown Systems. This effort culminated in a list of Associated Circuits (Appendix C) which was factored in the Section 4 fire area evaluations.

Section 6 Summary

The emergency lighting and communication evaluation consisted of systematically reviewing the adequacy of emergency lighting and communication against the

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access/egress routes and the procedural action locations identified from the Section 4 fire area evaluations.

Section 7 Summary

The adequacy of the existing Reactor Coolant Pumps oil collection hold-up capacity to accommodate the entire lubricating oil system inventory, as required by Section III.O of Appendix R, is discussed in this section. An exemption was requested and approved from the requisite criteria.

Section 8 Summary

This section provides the operating specifications for the Davis-Besse Fire Protection Program.

Appendix A Summary

This Appendix provides a list of the components required for Safe Shutdown.

Appendix B1 and B2 Summary

These Appendices provide a list of Safe Shutdown circuits and subcomponents.

Appendix C1 and C2 Summary

These Appendices provide a list of the associated circuits which are not coordinated and their routings.

Appendix C3 Summary

This Appendix provides a list of the Safe Shutdown power supplies and associated power supplies and identifies whether they are coordinated.

Appendix D Summary

This Appendix provides a detailed comparison of Davis-Besse to BTP APCSB 9.5-1 Appendix A.

1.4 Alternate Shutdown Capability

Paragraph 50.48(b) of 10CFR50 requires all nuclear plants licensed to operate prior to January 1, 1979 to comply with the requirements of Section III.G of Appendix R to 10CFR50. Section III.G.1 requires that fire protection features be provided for those systems, structures and components important to Safe Shutdown.

Section III.G.3 requires that alternative or dedicated Shutdown capability and its Associated Circuits, independent of cables, systems or components in the area, room, or zone under consideration, shall be provided when:

1. The protection of systems whose function is required for Hot Shutdown does not satisfy the requirements of Paragraph G.2; or

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2. Where redundant Trains of systems required for Hot Shutdown located in the same fire area may be subject to damage from fire suppression activities or from the rupture or inadvertent operation of fire suppression systems.

In several fire areas, certain Safe Shutdown components required to be operable to maintain Hot Standby were potentially damaged by a fire in that fire area. However, in these instances, operators are to perform the necessary actions locally to provide the same function that would otherwise be remotely performed. For example, an operator will manually open a valve locally if its operation in the Control Room could potentially be impaired due to damage to its circuits by a fire in a particular fire area. Specific procedural guidelines are provided in procedures for these actions. These are not considered Alternative Shutdown capabilities in that the local operation results in the equivalent Safe Shutdown system response as would result from the remote operation.

Those systems or components and the fire areas that require Alternative Shutdown capability for Hot Shutdown are identified below and addressed in the specific fire areas (Section 4 of the FHAR).

| <u>Fire Area</u> | <u>Alternative Shutdown Component or System</u> |
|------------------|---|
| BF | Backup Service Water Pump |
| DD/FF | Alternate Shutdown Panel |
| EE | Motor-Driven Feedwater Pump |
| HH | Alternate Shutdown Panel |

TABLE 1

SUMMARY OF EXEMPTIONS

The following is a summary of the NRC approved exemptions from certain requirements of 10CFR50, Appendix R.

1. Fire Area FF - (FHAR Section 4.6.FF)

An exemption has been approved from Section III.G.3 to the extent it requires full, fixed fire suppression in an area for which Alternate Shutdown capability is provided. The Alternate Shutdown capability is physically and electrically independent of Fire Area FF.

2. Fire Area T - (FHAR Section 4.6.T)

An exemption has been approved from Section III.G.2 to the extent it requires separation of redundant Safe Shutdown components with a one-hour-rated fire barrier where less than 20 feet of separation exists. The Component Cooling Water Pumps are not separated by a one-hour-rated fire barrier.

3. Fire Area E and F - (FHAR Sections 4.6.E and 4.6.F)

An exemption has been approved from Section III.G.2 to the extent it requires separation of redundant Safe Shutdown components by a fire barrier having a three-hour rating. Door 215 between the two fire areas is not three-hour rated but provides an equivalent level of protection.

4. Fire Area A - (FHAR Section 4.6.A)

An exemption has been approved from Section III.G.2 to the extent it requires separation of redundant Safe Shutdown components by a 3-hour rated fire barrier. Specifically, Train 1 circuits in Rooms 123 and 124 are not separated from Train 2 circuits in Room 115 by a complete 3-hour rated barrier.

5. Fire Area AB - (FHAR Section 4.6 AB)

An exemption has been approved from Section III.G.3 to the extent it requires fixed fire suppression and detection in an area for which Alternate Shutdown capability is provided. Specifically, alternate Shutdown capability is provided for circuits controlling ECCS Room Cooler Fans C31-1 and C31-2 within Fire Area AB. The Alternate Shutdown capability is physically and electrically independent of Fire Area AB.

6. Fire Area D - (FHAR Section 4.6.D)

An exemption has been approved from Section III.G.3 to the extent it requires 20 feet of horizontal separation between redundant Safe Shutdown components (Containment Air Cooling System Fans) with no intervening combustibles inside Containment.

TABLE 1 (Continued)

SUMMARY OF EXEMPTIONS

7. Fire Area EE - (FHAR Section 4.6.EE)

An exemption has been approved from Section III.G.3 to the extent it requires area-wide fixed fire suppression in an area for which Alternate Shutdown capability is provided. Specifically, Alternate Shutdown capability is provided for circuits and electrical components for the Main Steam Inlet Isolation Valve MS106 for the Auxiliary Feedwater Pump Turbine 1. The Alternate Shutdown capability (Motor-Driven Feedwater Pump) is physically and electrically independent of Fire Area EE.

8. Fire Area MA - (FHAR Section 4.6.MA)

An exemption has been approved from the requirements for fire protection features for the manhole 3001 required by Section III.G.2.

9. Fire Area R - (FHAR Section 4.6.R)

An exemption has been approved from Section III.G.3 to the extent it requires fixed fire suppression in an area for which Alternate Shutdown capability is provided. Specifically, Alternate Shutdown capability is provided for circuits controlling the Service Water Pumps and Auxiliary Feedwater Pump Turbine Governor Valves within Fire Area R. The Alternate Shutdown capability (in the form of the Backup Service Water Pump and the Motor-Driven Feedwater Pump) is physically and electrically independent of Fire Area R.

10. Emergency Lighting - (FHAR Section 6.2.3)

An exemption has been approved from Section III.J to the extent it requires self-contained emergency lighting units with at least an 8-hour battery power supply in all areas needed for the operation of Safe Shutdown equipment, and in access and egress routes thereto. Specifically, to utilize existing 'hard-wired' AC/DC essential lighting in portions of the Auxiliary and Turbine Buildings, and to utilize hand-held portable units in outside plant areas.

11. Embedded Conduits - (FHAR Section 4.3)

An exemption has been approved from the requirement to have a rated 3-hour barrier separating embedded conduits in concrete from redundant trains of Safe Shutdown Circuits and Associated Circuits required by Section III.G.2.

12. Reactor Coolant Pumps Oil Collection System - An exemption has been approved from Section III.O to the extent it requires the oil collection system for the Reactor Coolant Pumps be capable of containing the oil from the four Reactor Coolant Pumps. The oil collection system is capable of collecting the oil from two Reactor Coolant Pumps.

An exemption has also been granted to use the remote fill system without a collection system. This is contingent on certain compensatory measures, outlined in the exemption request (reference 2.5.S) being implemented.

13. Deleted.

TABLE 1 (Continued)

SUMMARY OF EXEMPTIONS

14. Fire Area HH - (FHAR Section 4.6.HH)

An exemption has been approved from Section III.G.3 to the extent it requires full, fixed fire suppression and automatic detection in an area for which Alternate Shutdown capability is provided. The Alternate Shutdown capability is physically and electrically independent of Fire Area HH (Ref. 2.5.V).

1.5 Definitions, Abbreviations, and Equipment/Cable Numbering Systems

1.5.1 Definitions

The following definitions are for terms commonly used throughout the report.

Active Component - a component used to directly control (start, regulate or stop) a shutdown or support function, e.g., a flow control valve, a pump, or a normally closed isolation or stop valve.

Approved - signifies that devices or assemblies have been tested and accepted for a specific purpose or application by a nationally recognized testing laboratory.

Associated Circuit - safety-related and nonsafety-related cables that are associated by at least one of the following with equipment which is required for Safe Shutdown:

1. A common power source with the Shutdown equipment.
2. A connection of circuits for equipment whose spurious operation may adversely affect the Safe Shutdown capability (e.g., DHR/RCS isolation valves); or
3. A common enclosure (e.g., cable tray, panel, junction box) with shutdown cables.

Automatic Detection - a system whose detectors are located (usually at the ceiling) in a zone or area that transmits a signal to a remote location (usually the Control Room) indicating a presence of combustion products. Several types of detection devices are commonly utilized, such as smoke detectors (photo-electric and ionization), heat detectors (fixed temperature, rate of rise, or a combination of both) and flame detectors (ultra-violet, visible, or infrared).

Automatic Suppression - a fixed piping system of water or other fire extinguishing agent automatically actuated when the presence of combustion products or heat exceeds the setpoint established for the system in the area in which it is installed.

Channel Functional Test - The injection of a simulated signal into the channel as close to the primary sensor as practicable to verify OPERABILITY including alarm and/or trip functions.

Cold Shutdown - Reactor at zero power, K_{eff} less than 0.99 and RCS temperature at or below 200°F.

Combustible Material - material that does not meet the definition of noncombustible.

NOTE: Combustible is a relative term. Many so called combustible materials will burn under 1 set of conditions, but will not burn under others (e.g., steel used for structural purposes is noncombustible, but steel wool will ignite when brought in contact with an ignition source).

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Class A - ordinary combustible materials such as wood, cloth, paper products, rubber products, and plastics.

Class B - flammable liquids, oil, greases, tars, oil base paints, lacquers, and flammable gasses.

Common Power Source - a power source which feeds both Safe Shutdown and associated circuits.

Coordination - the selective automatic operation of the various circuit protective devices by which the interrupting device closest to the fault operates first to isolate the fault. As a result, a minimal portion of the electrical system is interrupted for a given fault.

Design Basis Fires - fires that cause the most damage or the most severe exposure to the area or systems being considered. They are fires that may develop in local areas assuming no manual, automatic, or other fire fighting action has been initiated, the fire has passed flashover (i.e., the temperature at which autoignition of other combustibles in the area will occur), and the fire has reached its peak burning rate.

Fire Area - that portion of a building or plant separated from other areas by boundary fire barriers (walls, floors, and ceilings) with any openings or penetrations protected with seals or closures having a fire resistance equal to that of the barrier or which have been previously approved.

Fire Barrier - a continuous membrane either vertical or horizontal, such as a wall or floor/ceiling assembly, that has a specified fire resistance rating to limit the spread of fire.

Fire Brigade - the team of plant personnel assigned to firefighting and who are equipped for and trained in the fighting of fires.

Fire Loading - the amount of combustible material present in a given room, zone, or area, usually expressed in the total heat released (Btu) per square foot of floor area.

Fire Protection Program - encompasses the components, procedures and personnel utilized in carrying out all activities of fire protection and includes such things as fire prevention, detection, annunciation, control, confinement, suppression, extinguishment, administrative procedures, fire brigade organization, inspection and maintenance, training, quality assurance, and testing.

Fire Rating - the time in minutes or hours that materials or assemblies have withstood a standard fire exposure as established in accordance with test procedures of ASTM E-119 (NFPA 251).

Fire Stop - a feature of construction that prevents fire propagation along the length of cables or prevents spreading of fire to nearby combustibles within a given fire area or fire zone.

Fire Suppression - refers to capability for control and extinguishing of fires (fire fighting). Manual fire suppression activities refer to use of hoses or portable extinguishers or manually actuated fixed systems by plant personnel. Automatic fire suppression refers

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to automatically actuated fixed systems such as water sprinklers, water spray or carbon dioxide.

Fire Zone - a subdivision of a fire area designated as a potential fire hazard zone for convenience of analysis and design of fire suppression systems.

Fixed Suppression - any water or gaseous suppression system activated either automatically or manually, but excluding manual hose stations and portable fire extinguishers.

Flammable - refers to any combustible material that ignites easily, burns intensely, or has a rapid rate of flame spread.

Hot Shutdown - Reactor at zero power, K_{eff} less than 0.99 and RCS average temperature (T_{avg}) greater than 200°F and less than 280°F.

Hot Standby - the initial Safe Shutdown state with the Reactor at zero power, K_{eff} less than 0.99 and RCS average temperature (T_{avg}) equal or greater than 280°F.

Incidentals - items not indicated on various equipment drawings but would contribute to the combustible loading. This is mainly room fixtures, phones, signs, step-off pads etc.

Intervening Combustibles - Intervening combustibles are considered any quantity of in-situ materials which will ignite, burn, support combustion or release flammable vapors when subjected to fire or heat. Neither transient materials nor cable in conduit are considered as an intervening combustible.

Manual Suppression - a means of controlling or extinguishing a fire requiring manual actuation and application.

Noncombustible Material - (a) a material which in the form in which it is used, and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat; or (b) material having a structural base of noncombustible material, as defined in (a), with a surfacing not over 1/8 of an inch thick that has a flame spread rating not higher than 50 when measured using ASTM E-84 Test "Surface Burning Characteristics of Building Materials."

Non-Rated Opening Justification - A fire protection engineering evaluation of a penetration seal or barrier component that does not duplicate a fire-tested arrangement to determine equivalency or adequacy.

Functional - Functionality - A system, subsystem, train, component or device shall be FUNCTIONAL or have FUNCTIONALITY when it is capable of performing its specified function(s). Implicit in this definition shall be the assumption that all necessary attendant instrumentation, controls, normal and emergency electrical power sources, cooling or seal water, lubrication or other auxiliary equipment, that are required for the system, subsystem, train, component or device to perform its function(s), are also capable of performing their related support function(s).

Permanent Transients - materials permanently stored within the plant area but not located in any permanent location; materials such as ladders, etc.

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Safe Shutdown System - A system identified as required to place the plant in a safe Hot Standby and/or Cold Shutdown condition as required by 10CFR50, Appendix R. A Safe Shutdown System includes all components, panels, cables, cable trays, conduits, etc., necessary for the system to perform its Safe Shutdown function. Necessary supporting auxiliary systems are included.

Sprinkler System - a network of piping connected to a reliable water supply that will distribute the water throughout the area protected and will discharge the water through sprinklers in sufficient quantity either to extinguish the fire entirely or to prevent its spread. The system, usually activated by heat, includes a controlling valve and a device for actuating an alarm when the system is in operation. The following categories of sprinkler systems are defined in NFPA 13, "Standard for the Installation of Sprinkler Systems:"

- Wet-Pipe System
- Dry-Pipe System
- Preaction System
- Deluge System

Staggered Test Basis - A staggered test basis shall consist of:

- a. A test schedule for n systems, subsystems, trains or designated components obtained by dividing the specified test interval into n equal subintervals,
- b. The testing of one system, subsystem, train or designated components at the beginning of each subinterval.

Standpipe and Hose System - a fixed piping system with hose outlets, nozzle and hose connected to a reliable water supply to provide effective fire hose streams to specific areas inside the building.

Water Spray System - a network of piping similar to a sprinkler system except that it utilizes open-head spray nozzles and protects a specific hazard.

1.5.2 Abbreviations

The following are abbreviations for terms commonly used throughout the report:

| | | |
|------|---|----------------------------------|
| AFP | - | Auxiliary Feedwater Pump |
| AFWS | - | Auxiliary Feedwater System |
| AOV | - | Air-Operated Valve |
| ADV | - | Atmospheric Dump Valve |
| ARTS | - | Anticipatory Reactor Trip System |
| ASP | - | Auxiliary Shutdown Panel |
| BWST | - | Borated Water Storage Tank |
| CACS | - | Containment Air Cooling System |
| CCWS | - | Component Cooling Water System |
| CFS | - | Core Flood System |
| CSS | - | Containment Spray System |
| CST | - | Condensate Storage Tank |
| CTMT | - | Containment |

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| | | |
|-------|---|--|
| CREVS | - | Control Room Emergency Ventilation System |
| DHRS | - | Decay Heat Removal System |
| ECCS | - | Emergency Core Cooling System |
| EDG | - | Emergency Diesel Generator |
| AS | - | Essential |
| FHAR | - | Fire Hazards Analysis Report |
| HPIS | - | High Pressure Injection System |
| HVAC | - | Heating, Ventilating and Air Conditioning |
| LOOP | - | Loss of Offsite Power |
| LPIS | - | Low Pressure Injection System |
| MCC | - | Motor Control Center |
| MDFP | - | Motor-Driven Feedwater Pump |
| MOV | - | Motor-Operated Valve |
| MSS | - | Main Steam System |
| MU | - | Makeup |
| MUP | - | Makeup and Purification |
| NFPA | - | National Fire Protection Association |
| NI | - | Nuclear Instrumentation |
| NNI | - | Non-Nuclear Instrumentation |
| NROJ | - | Non-Rated Opening Justification |
| PORV | - | Pilot-Operated Relief Valve |
| PWR | - | Power |
| RCP | - | Reactor Coolant Pump |
| RCS | - | Reactor Coolant System |
| RPS | - | Reactor Protection System |
| SFAS | - | Safety Features Actuation System |
| SFRCS | - | Steam and Feedwater Rupture Control System |
| SG | - | Steam Generator |
| SOV | - | Solenoid-Operated Valve |
| SV | - | Safety Valve |
| SWS | - | Service Water System |
| SWGR | - | Switchgear |
| USS | - | Unit Substation |
| VAC | - | Volts, Alternating Current |
| VDC | - | Volts, Direct Current |

In Appendices B and C of this report, when designations are given for electrical components (motor operators for valves or solenoid valves), the electrical numbering system is used (e.g., MV106 or SV1428, respectively). In all other sections of the report, the system designation is used, e.g., MS106 or SW1428, respectively, meaning a Main Steam (MS) valve or Service Water (SW) valve.

1.5.3 Equipment Numbering System

Prefix Letter - The equipment location numbers are developed by using a letter prefix on each number to designate the particular type of equipment, where cables terminate. The designations are as follows:

| | | |
|---|---|---|
| A | - | 4.16kV AC System Switchgear |
| B | - | 480V AC System Switchgear, Motor Control Center or Distribution Panel |
| C | - | Control Panel or Cabinet |
| D | - | D.C. System and Equipment |

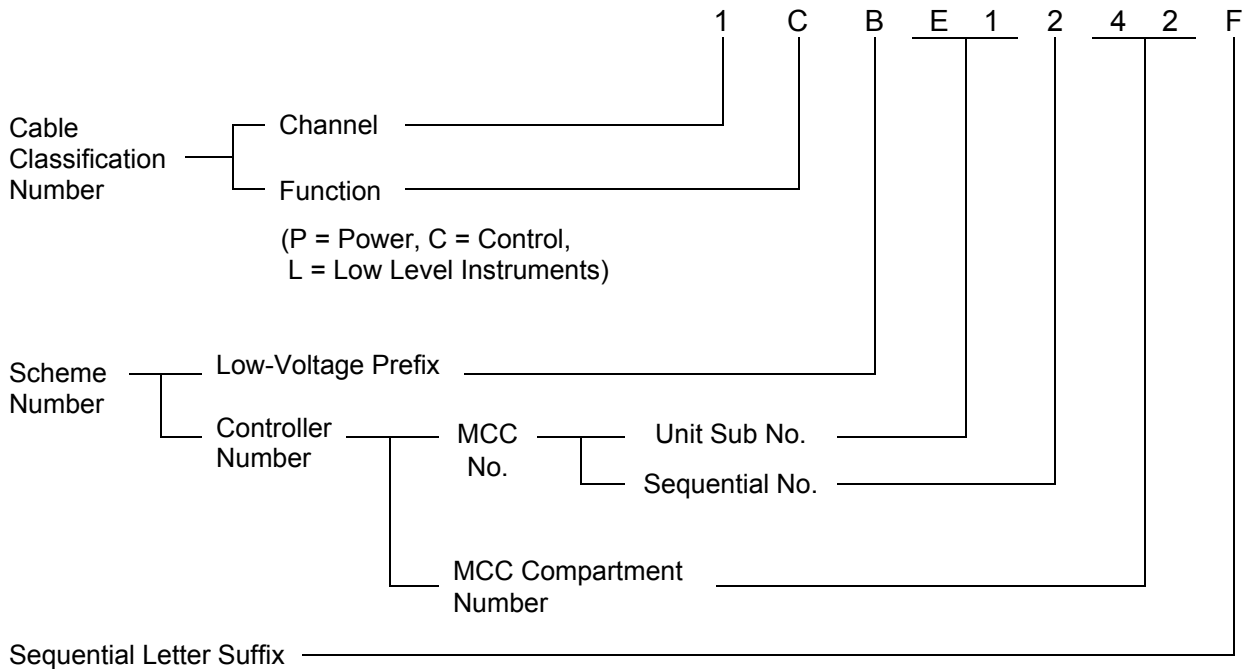
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- E - Local Terminal Box
- F - Digital (Switch) Output Instrument (Flow, Level, Pressure, Temperature)
- G - Generating Equipment including Driver, Excitation or Grounding Equipment
- J - Terminal Box or Pull Box
- K - Station Annunciator System
- L - Low Level Instruments (Transducer, Thermocouple, RTD, etc.)
- M - Motor
- N - Local Control Station or Device
- P - Penetration Terminal Box
- R - Instrument Rack or Panel
- RC - Relay Cabinet
- SV - Solenoid Valve
- V - Valve
- W - Welding Receptacle (WR), HVAC Duct Heater (WE), or Misc. Receptacle (ZSR)
- X - TRANSFORMER
- Y - 120V AC POWER SUPPLY

1.5.4 Cable Numbering System

The scheme number is used to identify each individual control and/or instrumentation network, including the associated wire, terminal, and equipment numbers. Where practical, the scheme number will be identical to the equipment number of the controller. A unique scheme number will be assigned when a controller is not an outstanding part of the circuit (for example a turbine trip circuit or communications system).

Cable numbers consist of the cable classification number followed by the corresponding scheme number plus a letter suffix. The letters will be assigned in a systematic order.



1.6 Characteristics and Behavior of Fire

Many common materials have some potential as fuel. The same material may be either toxic, reactive or explosive under certain conditions. Flammability is related to the combination of 4 factors (fuel, heat, oxygen, and uninhibited combustion chain reactions) which are necessary before combustion can occur. Take away any 1 of these factors and a fire cannot exist. Most methods of extinguishment are accomplished by the deliberate removal of the fuel, the heat, or the oxygen of a fire.

1.6.1 Fuels

Fuels are those substances that will burn when heat is applied to them. Some of the elements themselves are fuels. Carbon, hydrogen, sulfur, magnesium, titanium, aluminum, sodium, and other metals are examples of elements that can burn. But the most familiar combustible materials are not pure elements; they are compounds and mixtures.

1.6.2 Heat

Fire prevention and extinguishment are dependent on the control of heat energy. It is important to be familiar with the common ways in which heat energy can be liberated.

1.6.2.1 Chemical Heat Energy

Chemical heat energy can be produced by the breaking apart or building up of molecules (decomposition or polymerization) by heat of solution when materials are dissolved in a liquid or by combustion. Some principal ways in which chemical heat energy is produced are as follows:

- (1) Spontaneous heating is the process of increasing the temperature of materials without drawing heat from its surroundings. Spontaneous heating of a material to its ignition temperature results in spontaneous ignition or spontaneous combustion.

In general all organic substances are capable of combining with oxygen and will oxidize at some critical temperature with the evolution of heat. Usually the rate of oxidation at normal temperatures is so slow that the heat released is transferred to its surroundings as rapidly as it is formed and the combustible material being oxidized does not increase in temperature. But this is not true for all combustible materials. Certain oxidation reactions generate more heat than can be dissipated and, as a result, the ignition temperature of the material is achieved (e.g., zirconium powder in air).

In the combustible materials, additional heating can initiate spontaneous heating. The preheating increases the rate of oxidation so that heat is produced more rapidly than it can be dissipated. Thus, the result of the ignition temperature of the material is achieved.

- (2) Heat of combustion of a substance is the amount of heat released during its complete oxidation (combustion: the rapid oxidation of a combustible material in the presence of heat and light energy). The heat of combustion is commonly referred to as calorific or fuel value. The heat of combustion or calorific values are used in calculating fire loading. These values do not necessarily indicate the

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relative fire intensity of materials since the fire intensity is dependent on the degree of the materials flammability as well as the total heat produced.

1.6.2.2 Heat Transfer

Once heat is produced it is transferred to other combustible material in 3 ways:

(1) Conduction

Conduction is the transfer of heat energy from one body to another by direct contact or through an intervening solid, liquid, or gas heat conducting medium.

(2) Radiation

Radiation is the transfer of heat which is not dependent upon any medium. The energy form associated with radiation is wave motion. The wave lengths are from less than 10-12 cm to more than 109 cm. The radiant heat energy waves travel at the speed of light and upon arrival at a body, they are absorbed, reflected, or transmitted.

(3) Convection

Convection is the transfer of heat with a circulating medium. The medium becomes heated, moves to a cooler spot carrying the heat energy with it. The process may be repeated if the medium recirculates naturally or by force until the heat is dissipated. The hot air and combustion gasses are carried by convection to upper areas and, in multistory buildings, the fire may spread to floors above by convection.

1.6.3 Oxygen

The oxygen content to sustain combustion for hydrocarbon vapors and gasses must be greater than 15 percent by volume. Oxygen itself will not burn, but must be present for a rapid oxidation reaction (combustion) to take place.

1.6.4 Combustion Chain Reaction

The 4th factor associated with combustion is an uninhibited combustion chain reaction. The combustion chain reaction is present only with open flaming and is not a contributing factor with surface (glow) combustion. During flaming combustion, heat and newly formed products of combustion interact with the fuel's surface to form additional combustible materials and open flame.

1.6.5 Fire Propagation

Under fire conditions, if the rate of heat produced exceeds the heat loss, the fuel will heat and the fire will grow. This implies that some positive heat balance (ignition source) is used to preheat and fuel source. The flame is the result of the burning of pyrolytic distillate and flammable vapors from the fuel source.

A fire with a positive heat balance acts as an amplifier. That is, for every unit of heat input, several units of heat output result. If a constant percentage of the heat output is fed back to the

fire, the fire will increase exponentially. As a result, the amount of heat feedback will eventually exceed the heat input supplied by the ignition source, and the fire will continue to burn even if the original ignition source is removed. In general, if there is positive heat balance and the percentage is low, the fire will take longer to reach a given intensity level than if the rate is high. If a positive heat balance exists, however small, and any feedback exists at all, the fire will grow. But, if the ignition source is removed before the feedback is equal to or greater than the heat loss, the fire will die out.

Feedback depends on the arrangement of the fuel. When a burning match is held with the head downward, the flame flows around the unburned wood, rapidly heating it to its ignition point. But, if the match is held head upward, all the flame and convected heat output travels upward and away from the fuel source. Whenever the method of accomplishing feedback heating is by conduction, the burning continues very slowly, if at all.

The spread of fire involving a solid fuel medium generally travels upward vertically and the base of the fire increases in size horizontally. But with a fire involving a liquid fuel medium, the fire has the capability to travel vertically upward and/or downward and travel laterally in the horizontal plane. The horizontal and downward vertical fire spread of a liquid medium fire is dependent on the viscosity of the medium, the quantity of fuel involved, and the liquid's environmental surroundings.

1.6.6 The Chemistry of Fire Control and Extinguishment

The control and extinguishment of fire may be accomplished by the following methods:

1.6.6.1 Extinguishment and Control By Cooling

Water is the most effective means of removing heat from ordinary combustible materials. The extinguishment and control mechanism is dependent on cooling the solid fuel, thus, reducing and/or stopping the rate of release of combustible vapors and gasses.

1.6.6.2 Extinguishment by Oxygen Depletion

Fires involving hydrocarbon vapors and gasses (solid and liquid fuel sources) require the oxygen level of the atmosphere interfacing with the combustible process to be 15 percent or greater in order for the combustion reaction to endure.

The extinguishment of the fire is dependent on depleting the oxygen level to less than 15 percent. This may be accomplished by purging the atmosphere such as an atmosphere composed of carbon dioxide (CO₂).

1.6.6.3 Extinguishment and Control by Removing the Fuel

The simplest way to remove fuel is by consumption. This is where the fire consumes the fuel source and eventually burns itself out. But, with liquids and gasses there are better methods to accomplish this mode of extinguishment and control, such as removing threatened combustibles from the fire area (i.e., draining down a flammable liquid tank, or by shutting off a gas flow).

1.6.6.4 Extinguishment and Control by Chemical Flame Inhibition

When extinguishing agents, such as the halons or alkali metal salts, are injected into flames, the substances thermally dissociate into their anionic and cationic into free radicals and catalyze the

union of the OH and H combustion reaction chain carriers, thereby inhibiting the continuation of the flame.

1.7 Compliance with NRC Branch Technical Position APCS 9.5-1 Appendix A.

1.7.1 EVALUATION CRITERIA

The Davis-Besse Unit 1 fire protection program was developed to provide adequate assurance that in the event a fire occurred, it would not; 1) incapacitate the plant's ability to shut down, or; 2) significantly increase the risk of radioactive release to the environment, thereby causing undue risk to the health and safety of the public. The specific guidelines set forth for operating plants in Appendix A to the Branch Technical Position APCS 9.5-1 were used to evaluate the adequacy of the fire protection program. To broaden the overall scope of the fire protection program evaluation, the following additional criteria were applied:

1. General Design Criterion 3, "Fire Protection" of Appendix A to 10CFR50, "General Design Criterion for Nuclear Power Plants", requires that "structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions, noncombustible and heat resistant materials should be used wherever practical throughout the unit, particularly in locations such as the Containment and Control Room. Fire detection and suppression systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effect of fires on structures, systems, and components important to safety. Fire fighting systems shall be designed to assure that their failure, rupture, or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components."
2. Defense-in-Depth

With respect to the fire protection program, the principle is aimed at achieving an adequate balance in:

 - a. Preventing fires from starting.
 - b. Detecting fires quickly, suppressing those fires that occur, putting them out quickly, and limiting their damage.
 - c. Designing plant systems so that a fire that gets started, in spite of the fire prevention program, and burns for a considerable time, in spite of fire protection activities, will not prevent essential plant safety functions from being performed.
3. A single failure in the fire protection system or direct support systems should not impair both primary and backup plant fire protection capability.
4. Postulated fires or fire protection system failures need not be considered concurrent with other plant accidents or the most severe natural phenomena (e.g., LOCA and fire).
5. Total reliance should not be placed on a single automatic fire suppression system. Appropriate backup fire suppression capability should be provided.

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6. The overall fire protection program should be based on (1) the evaluation of potential fire hazards throughout the plant; (2) the effect of postulated fires relative to maintaining the ability to achieve a safe shutdown and condition; and (3) minimizing the potential of radioactive releases to the environment. Those systems utilized to achieve safe shutdown may be nonessential systems or essential systems, since the normal mode of shutdown utilizes, in some cases, nonessential systems.

Where redundancy of systems or components may be jeopardized by a fire, the availability of backup systems or components is evaluated. Operator action is considered, if deemed to be reasonable, based on system responses, plant layout, access provisions, time requirements, and other related criteria. The Davis-Besse program of fire tests is utilized where such test results can be applied to the behavior of the unit cabling system and where time to failure information is appropriate. The inherent unit design features, as well as the Davis-Besse administrative and security controls, are also considered where appropriate for the evaluation.

7. Failure or inadvertent operation of the fire suppression system should not incapacitate redundant safe shutdown systems or components required in the event of a fire.

Based on the above criteria and the guidelines of Appendix A of the BTP APCS 9.5-1, the fire protection program evaluation and the fire hazard analysis has been carried out for Davis-Besse Unit 1.

1.7.2 Conclusions

Compliance Matrix to BTP APCS 9.5-1 Appendix A

The Appendix D to this report represents a line-by-line comparison between the NRC guidelines of Appendix A to BTP APCS 9.5-1 and the design of the Unit. Methods of compliance and justification of deviation are also incorporated in the table.

1.8 NFPA Code Compliance

This Section documents that Davis-Besse, as a result of the July, 1983 NRC Appendix R Fire Protection Audit, has performed an NFPA Code Compatibility Review (formerly Appendix 3 of the FHAR).

This review documented the NFPA codes and code years committed to in such documents as the Updated Safety Analysis Report (USAR), Fire Hazards Analysis Report (FHAR), Station Technical Specifications, Fire Protection Procedures, Drawings and As-Built Plant Conditions.

A number of elements were determined to be needed to satisfactorily perform an in-depth NFPA compatibility review. First, was a review to determine exactly what NFPA Codes Davis-Besse was committed to in various documents. Second, was the development of separate subtasks to independently review NFPA code compliance; Davis-Besse Fire Protection Procedures versus the NFPA Code compliance; Davis-Besse Fire Protection Procedures versus the NFPA Codes referenced; and finally, a review of Fire Protection commitments. These reviews were performed using matrix type spreadsheets.

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The term "commitment" as used in this report is defined as a statement of action made by Davis-Besse in a docketed submittal to the NRC to meet a fire protection requirement in NRC regulations, or which was made in response to NRC inspection report items or to an NRC request for information.

Design bases of systems and components are commitments when they relate to the ability of a system to perform its intended design function.

Descriptive information in docketed submittals which does not affect the performance of systems were not considered as commitments. One time activities were also not considered as commitments.

The NFPA commitment compatibility review is based on the following editions of the NFPA Codes:

| | | | |
|-----|----------|-----------|--|
| 1. | NFPA 4 | (1971) | Organization for Fire Services |
| 2. | NFPA 4A | (1969) | Organization of a Fire Department |
| 3. | NFPA 6 | (1974) | Organization of Industrial Fire Loss Prevention |
| 4. | NFPA 7 | (1974) | Management Control of Fire Emergencies |
| 5. | NFPA 8 | (1974) | General Management Responsibility |
| 6. | NFPA 10 | (1975) | Standard for Portable Fire Extinguishers |
| 7. | NFPA 13 | (1978) | Standard for the Installation of Sprinkler Systems |
| 8. | NFPA 13A | (1981) | Recommended Practice for the Inspection, Testing and Maintenance of Sprinkler Systems |
| 9. | NFPA 14 | (1978) | Standard for the Installation of Standpipe and Hose Stations |
| 10. | NFPA 15 | (1977) | Standard for Water Spray Fixed Systems for Fire Protection |
| 11. | NFPA 20 | (1974) | Standards for the Installation of Centrifugal Fire Pumps |
| 12. | NFPA 24 | (1968/73) | Standard for Outside Protection |
| 13. | NFPA 26 | (1976) | Standard for the Supervision of Valves Controlling Water Supplies for Fire Protection Systems |
| 14. | NFPA 27 | (1975) | Recommendations for Organization, Training and Equipment |
| 15. | NFPA 30 | (1973) | Flammable and Combustible Liquids Code |
| 16. | NFPA 50A | (1973) | Gaseous Hydrogen System |
| 17. | NFPA 51 | (1974) | Standard for the Installation and Operation of Oxygen-Fuel Gas Systems for Welding and Cutting |
| 18. | NFPA 51B | (1971) | Fire Prevention in Use of Cutting and Welding Processes |
| 19. | NFPA 69 | (1973) | Standard on Explosion Prevention Systems |
| 20. | NFPA 72 | (1990) | Standard for the Installation, Maintenance and Use of Protective Signaling Systems |
| 21. | NFPA 72E | (1978) | Standard on Automatic Fire Detectors |
| 22. | NFPA 78 | (1975) | Lightning Protection Code |
| 23. | NFPA 80 | (1977) | Standard for Fire Doors and Windows |
| 24. | NFPA 90A | (1978) | Standard for Installation of A/C and Ventilating Systems |
| 25. | NFPA 92M | (1972) | Waterproofing, Draining of Floors |
| 26. | NFPA 204 | (1968) | Guide for Smoke and Heat Venting |

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27. NFPA 251 (1972) Standard Methods of Fire Tests of Building Construction and Materials

1.9 Fire Area Drawings

Fire areas and fire barriers are shown on Drawings A-221F through A-231F. For the latest drawing information consult the DCS or Document Control.