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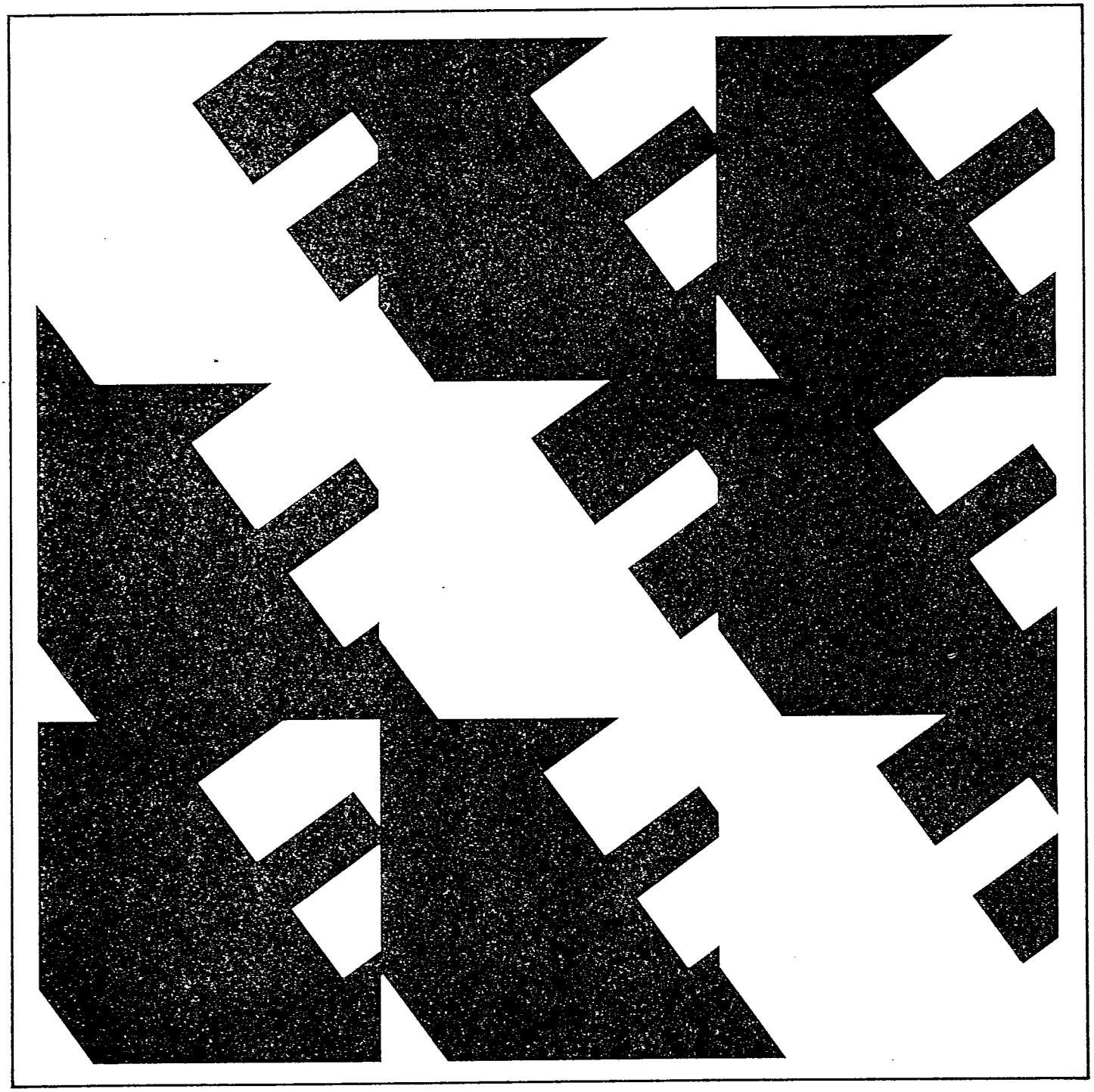
IEEE Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards



IEEE Std 833-1988

Published by The Institute of Electrical and Electronics Engineers, Inc 345 East 47th Street, New York, NY 10017, USA

October 24, 1988

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IEEE Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards

Sponsor

**Nuclear Power Engineering Committee
of the
IEEE Power Engineering Society**

Approved June 9, 1988

IEEE Standards Board

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Foreword

(This Foreword is not a part of IEEE Std 833-1988, IEEE Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards.)

Concerns have been expressed relative to failures of electric equipment in operating nuclear power plants resulting from water or moisture intrusion. (See Appendix for references that document these occurrences.) The purpose of this document is to recommend practices that respond to these concerns and that are in addition to those that may already be required or in place to protect the electric equipment or systems from water hazards.

It would be desirable to specifically define when a water hazard exists and should be treated, and to give specific directions as to how to deal with that hazard; however, the individuality of each nuclear power plant structure makes this difficult. Further, it may not be reasonable to provide protection for all possible flooding scenarios. Examples of such scenarios are multiple or simultaneous pipe breaks, valve leaks, or deliberate operation of fire hoses to extinguish fires in equipment. Where it can be determined by analysis or experience that a malfunction of equipment or loss of a system function is likely to result due to inadvertent water or moisture intrusion, and where that loss threatens the continued operation of the plant, appropriate steps should be taken. It is the responsibility of the user to make this determination and select the appropriate means of protection.

This document does not address the ability of the electric equipment to withstand a "loss-of-coolant" accident, high energy line break, or the physical forces resulting from jet impingement, or other line breaks which are covered by other analyses, standards, or requirements.

The working group recognizes that the state of the industry is such that these recommendations may be considered for operating plants, new plants, or during plant modifications. The user is encouraged to consider all of the recommendations in the application of this document.

At the time this document was approved, members of Working Group 4.8 were as follows:

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Contents

SECTION			PAGE
1.	Scope		7
2.	Purpose		7
3.	Definitions		7
4.	References		7
5.	Electric Equipment Protection		8
	5.1	Location	8
	5.2	Equipment Design	8
	5.3	Sealing and Shielding	8
6.	Design and Construction Features for Electric Equipment Rooms		8
	6.1	General	8
	6.2	Room Construction	8
7.	Electric Equipment Located in Open Areas Subject to Water Hazards		9
8.	Electric Equipment Enclosures		9
	8.1	Application	9
	8.2	Enclosure Designations	9
	8.3	Special Conditions	9
9.	Electric Equipment Installation Practices		9
	9.1	General	9
	9.2	Electric Equipment Installed in Locations that have no Direct Source of Water Hazard	9
	9.3	Electric Equipment Installed in Locations where Water-Hazard Sources are Present	10
10.	Sealing		10
	10.1	Methods	10
	10.2	Materials	10
	10.3	Procedures	10
11.	Maintenance, Surveillance, and Testing Activities		11
APPENDIX			12

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IEEE Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards

1. Scope

This document presents recommended practices for providing the electric systems and equipment in nuclear power plants with protection from water hazards.

2. Purpose

This document recommends methods and design features that, if implemented, would provide water-hazard protection to class 1E and non-class 1E systems and equipment from direct sources of water (for example, water spray from decontamination activities) and indirect sources of water (for example, water running along cables and raceways). It is not the purpose of this recommended practice to classify water-hazard protection features as nuclear safety related or non-nuclear safety related. This determination is application specific and is made by the user utilizing the specific nuclear generating station design basis and guidance from other standards.

3. Definitions

The following definition should be understood throughout the document:

water hazard. The abnormal presence of a quantity of water, either in the form of condensation, accumulation, flow, or spray; not postulated to be associated with any design basis event; and considered likely to cause the loss of desired function of electric equipment in nuclear power plants if it enters such equipment.

All other terms used in this document conform to ANSI/IEEE Std 100-1984 [2].[1]

4. References

The following publications shall be used in conjunction with this standard:

[1] ANSI/IEEE C.57.12.01-1979, IEEE Standard General Requirements for Dry-Type Distribution and Power Transformers.

[2] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.[2]

[3] ANSI/IEEE Std 323-1983, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

[4] ANSI/IEEE Std 634-1978, IEEE Standard for Cable Penetration Fire Stop Qualification Test.

[5] NEMA ICS 6-1983, Enclosures for Industrial Controls and Systems.[3]

The appendix contains a list of other documents providing additional information that may be useful in applying the recommendations contained in this document.

[1] The numbers in brackets correspond to those of the references listed in Section 4.

[2] ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Institute of Electrical and Electronics Engineers, Service Center, Piscataway, NJ 08854.

[3] NEMA publications are available from the National Electrical Manufacturers Association, 2101 L Street, NW, Washington, DC 20037.

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5. Electric Equipment Protection

5.1 Location. It is recommended that first consideration be given to locating electric equipment such that direct or indirect sources of water hazard will not be present. Next, consider locations that can be enclosed to restrict the entry of a water hazard or where design features can direct water hazards away from the equipment.

5.2 Equipment Design. Where the foregoing preferred locations are not practical or desirable to implement, consider equipment design, selection or modifications to make the equipment resistant to water hazards.

5.3 Sealing and Shielding. Additional protection from sources of water hazard are best accomplished by proper sealing measures or physical shielding. This treatment should not interfere with ventilation or other design considerations (for example, seismic, thermal), or unduly restrict maintenance activities. It should be further understood that when water is to be applied directly to a specific item of electric equipment as a means of extinguishing a fire in or on that equipment, sealing or shielding should not prevent this; however, any other electric equipment in the vicinity should not be affected by this action (for example, battery and flammable battery-rack fires are best extinguished by flowing water over them to flush away contaminants, remove short circuits caused by contaminants, and to cool the equipment).

6. Design and Construction Features for Electric Equipment Rooms

6.1 General

6.1.1 Electric equipment rooms located adjacent to areas where potential water hazards exist that could reasonably be postulated to enter the rooms, should be designed and constructed to be resistant to the entry of water. Doors should open toward the source of water.

6.1.2 Penetrations through walls, floors, and ceilings (roofs) are high-risk areas and should be properly sealed to the extent necessary to preclude water-hazard intrusion.

6.1.3 Water-filled piping located within, or penetrating, electric equipment rooms should be avoided or assessed as to its potential to become a water hazard.

6.1.4 If a source of water, which can be reasonably postulated to be a water hazard, exists in or is added to an equipment room area, electric equipment should be protected in accordance with the recommendations in Section 7.

6.1.5 Proper sealing of penetrations should limit any transfer of water or moisture through those penetrations to an amount that would not prevent the equipment from functioning in an acceptable manner.

6.2 Room Construction

6.2.1 Floor Construction

6.2.1.1 The preferred method of room entry by raceways (including conduit) and pipe is through floor penetrations. These penetrations should be properly sealed to be resistant to water infiltration from beneath the floor if that potential for water hazard exists.

6.2.1.2 Equipment room floors at the same level or lower than surrounding areas that contain water sources may become a water hazard area. Electric equipment in such locations should be mounted on raised bases, or curbs should be provided, to direct water away from the electric equipment to floor drains.

6.2.1.3 Floor drains, where provided, should be sized by plant analysis to remove all simultaneous flows of water into the equipment room. Floor drains should be equipped with check valves or other suitable means if back flow can be realistically postulated and an unacceptable level of water would result and constitute a water hazard.

6.2.2 Wall Construction. Wall penetrations are the second choice for entering electric equipment areas. Where this presents a potential for a water hazard, they should be properly sealed.

6.2.3 Ceiling (Roof) Construction. The ceiling construction should be of a suitable design to be resistant to water due to rain, flooding from above, or piping system leaks. Where the ceiling structure design loads are heavy, vibratory, or abrasive, these conditions should be considered in the design of the waterproofing system. Where a drop ceiling is utilized, an analysis should be performed to determine whether it is concealing a potential water-hazard condition.

Penetrations through the ceiling by conduit, cable trays, piping, or ductwork are the least desirable. Where ceiling penetrations exist or

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are unavoidable, they should be sealed to be resistant to water seepage or leakage and should not be located directly above the equipment.

6.2.4 Doors or Other Openings. Doors or other openings in electric equipment rooms should be designed to be resistant to entry of water where there is a potential for water hazards from adjacent areas. Doors should be self-closing and self-latching and should open toward the potential water hazard.

7. Electric Equipment Located in Open Areas Subject to Water Hazards

Where electric equipment is in an open area subject to water hazards and a room cannot be constructed around it, the equipment should be protected by sealing its seams, joints, and penetrations to the extent necessary to prevent water intrusion. Where water might enter from top surfaces only, a waterproof metal shield extending beyond all sides of equipment may be suspended directly over equipment. Dikes or curbing may be added to prevent water intrusion from the floor.

8. Electric Equipment Enclosures

8.1 Application. Where the potential for a water hazard exists at the location of electric equipment, and the measures recommended in Section 7 are not utilized, the equipment enclosure should be selected or modified to make the equipment resistant to the entry of water. Outdoor equipment enclosures may be considered for indoor use where their application protects the equipment against the water hazard present. (See 8.2.)

8.2 Enclosure Designations. Water-resisting features of electric equipment enclosures considered in this document are generally described by the National Electrical Manufacturers Association (NEMA) designations (see NEMA ICS 6-1983 [5]). Transformers are covered in ANSI/IEEE C57.12.01-1979 [1]. An enclosure suitable for the water hazard present should be specified with a statement such as "electric equipment enclosures subject to dripping water should be furnished to meet the requirements of the NEMA 3R classification."

8.3 Special Conditions

8.3.1 Condensation

8.3.1.1 Motors, Panels, and Switchgear. Enclosures for electric equipment such as motors, panels, and switchgear located in areas where a build-up of condensation could occur within them and thereby constitute a water hazard, may be equipped with a controlled space heater to keep the enclosure dry. Proper sizing and placement is necessary to prevent overheating or creating hot spots. Space heaters may not be required for motors where the insulation system and motor enclosure design is specified for wet applications.

8.3.1.2 Terminations and Connections. Enclosures which are in areas subject to high humidity, and which contain equipment with terminations or bolted connections, should have entry points (such as conduits and cable trays) sealed and covers gasketed. The intention is to restrict the entry of moist air, which could condense and cause shorting or open circuiting due to corrosion of the electrical connections. When weep holes are used for pressure relief their use should not aggravate or cause a water hazard condition.

8.3.2 Enclosure Tops. The top of electric enclosures should not be penetrated unless they are properly sealed or there is no direct source of water hazard from above as described in 9.2.

8.3.3 Electric enclosures that require ventilation and must be located in an area subject to direct sources of water hazard should be shielded by deflectors such that water does not enter the enclosure. See also 5.3.

9. Electric Equipment Installation Practices

9.1 General. The following practices are recommended to restrict water hazards from flowing into electric equipment through cable or raceway openings.

9.2 Electric Equipment Installed in Locations that have no Direct Source of Water Hazard. Top cable entry or conduit entrances into electric equipment should be considered only when located in a room with a waterproof ceiling and where the room is free of all piping such as water, drains, or sprinklers. Typical applications may be relay rooms, control rooms, and switchgear rooms. In addition, sealing of

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openings in the floor and walls should be considered where the potential for external flooding exists. Conduits entering the bottom or side of equipment should be sealed if they originate at a higher elevation. This will prevent gravity flow of water through the conduit into the electric equipment.

9.3 Electric Equipment Installed in Locations where Water-Hazard Sources are Present

9.3.1 Electric equipment located in areas where water-hazard sources are present should have cable and conduit entrances in the bottom or the side of the equipment. Equipment doors should be gasketed to be water resistant.

9.3.2 Cables entering equipment from the side should be arranged to be resistant to water-hazard intrusion (for example, drip loops). Conduits entering the bottom or side of the equipment should be sealed if they originate at a higher elevation. This will prevent gravity flow of water through the conduit into the electric equipment.

9.3.3 The tops of electric equipment should have either a solid top or solid drip shield so that water will not flow through holes or small openings into the equipment. Where top entry is required or exists, conduits or cables, or both, should be properly sealed.

9.3.4 Cable fittings, if used in conjunction with bottom or side entry to restrict dust from entering the equipment, are not to be considered as water-hazard seals unless designed as such or experience indicates they will be effective against water hazards.

9.3.5 If plant design conditions subject a cable to a pressure differential between ends sufficient to cause probable water migration through the cable insulation system or conductor strands, and a water source exists at the end of higher pressure, equipment at the end of lower pressure should be analyzed for potential water damage even though no other source of water is available there. If there is potential for damage, the cable should be sealed using any of several current methods (for example, "blocked" cable or moisture-proof connectors).

10. Sealing

10.1 Methods. In general practice, two methods are used to seal openings where cables, raceways, and other items penetrate walls, ceilings, and floors of rooms or enter equipment enclosures. These are the use of (1) prefabricated or (2) poured-in-place seals. Selection of the method and materials to be used to achieve a proper seal in each situation is left to the judgment of the user. If a seal is also required to serve as a fire stop, then its fire-retardant qualification is outside the scope of this document and the user is referred to ANSI/IEEE Std 634-1978 [4]. Where the seal is used to meet equipment qualification requirements in design basis accident conditions, its qualification is outside the scope of this document. The user is referred to ANSI/IEEE Std 323-1983 [3]. The effect, if any, of the sealing procedure or materials on component design limitations, cable ampacity, or equipment qualification should be taken into account.

10.2 Materials. Materials used in sealing to prevent water hazards from entering into electric equipment should have known characteristics and should, as a minimum

(1) Restrict the passage of water or moisture

(2) Be compatible with cable-jacketing materials

(3) Not degrade the function of the device being sealed

(4) Remain functionally unaffected when exposed to water or moisture

(5) Be removable without damaging the equipment being sealed

(6) Have a service life which can be calculated through recognized practices within the state-of-the-art

(7) Not add a potential fire hazard while being installed or during service life

(8) Withstand the environment, including radiation if present, at its location while continuing to provide its sealing function

(9) Allow regular inspection to determine whether degradation has taken place and be replaced as necessary.

10.3 Procedures. In general, the sealing should be done in accordance with the instructions of the manufacturer or supplier. Since the objective is to make electric equipment resistant to water or moisture, the seal should be placed at the point considered most effective in accomplishing this function. When sealing conduit or tray, it is important to seal around the conduit or tray as well as around the cables.

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11. Maintenance, Surveillance, and Testing Activities

The following practices are recommended when maintenance, surveillance, or testing activities will

(1) Disturb water-resistant barriers;

(2) Deactivate water-hazard diverting or removal means; or

(3) Place water-hazard sources in a location not designed for such a condition.

If water-hazard sources are found to be present at a location not designed for such a condition, then design changes should be initiated to accommodate the condition or to remove the water-hazard source.

11.1 Maintenance personnel should be trained in proper techniques for seal maintenance.

11.2 Seals and gaskets, if disturbed, should be re-assembled or replaced to re-establish the original seal integrity.

11.3 Routine surveillance procedures (walk-downs) should include the verification that water-hazard protection measures are intact (for example, seals intact, doors closed, covers in place, deflectors/shields in place, all fasteners installed, floor drains not blocked by debris).

11.4 Routine walk-throughs should identify the presence of water hazards in areas where electric equipment is located and procedures should establish the corrective measures to be taken. Surveillance intervals should be predicated on the potential for a water hazard to be present.

11.5 Consideration should be given to wrapping fire-retardant, waterproof covers around electric panels, control equipment, transformers, motors, and switchgear during any wash-down of the local area. Even if the equipment has been top-sealed, the wrapping is recommended to restrict water from reaching the interior of the equipment through any inadequately sealed openings. Immediately following the wash-down, the covers should be removed to prevent heat buildup in the electric enclosures.

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Appendix

(This Appendix is not part of the IEEE Std 833-1988, Recommended Practice for the Protection of Electric Equipment in Nuclear Power Generating Stations from Water Hazards and is included only to provide additional information that may be useful in applying recommendations of this standard.)

ANS 56.11-1988, Criteria to Accommodate Compartment Flooding in Light Water Reactors.

ANSI/ANS 2.8-81, Determining Design Basis Flooding at Power Reactor Sites.

ANSI/ANS 58.2-80, Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Postulated Pipe Rupture.

ANSI/IEEE Std 308-1980, Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

ANSI/IEEE Std 338-1977, Standard Criteria for Periodic Testing of Nuclear Power Generating Station Safety Systems.

ANSI/IEEE Std 344-1987, Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

ANSI/IEEE Std 384-1981, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.

ANSI/IEEE Std 603-1980, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

ANSI/IEEE Std 627-1980, IEEE Standard for Design Qualification of Safety System Equipment Used in Nuclear Power Generating Stations.

ANSI/IEEE Std 628-1987, IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations.

EL-ZEFTAWY, M. *Operating Experience Related to Moisture Intrusion in Electrical Equipment at Commercial Power Reactors.* Reactor Operations Analysis Branch, Office for Analysis and Evaluation of Operational Data, Nuclear Regulatory Commission. June 1984.

TMI-2 GEND 056, Reports prepared for the US Department of Energy, Three Mile Island Operations Office under DOE Contract No. DE-AC07-76ID01570.

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