



IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations

STANDARDS

IEEE Power and Energy Society

Developed by the
Nuclear Power Engineering Committee

IEEE Std 741™-2022
(Revision of IEEE Std 741-2017)



IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations

Developed by the

Nuclear Power Engineering Committee
of the
IEEE Power and Energy Society

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IEEE SA Standards Board

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Abstract: Criteria that establish protection requirements for Class 1E power systems and equipment are prescribed in this standard. The purpose of and the means for obtaining protection from electrical and mechanical damage, or failures that can occur within a time period that is shorter than that required for operator action, are described. Testing and surveillance requirements are included. Plant physical design requirements to protect against events such as pipe whip, fire, dropped load, etc., are not included.

Keywords: Class 1E, electrical equipment, IEEE 741™, nuclear power generating stations, power systems, protection

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Introduction

This introduction is not part of IEEE Std 741-2022, IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations.

The IEEE Power Engineering Society has developed this standard to provide the principal design criteria, design features, and testing requirements for the protection of Class 1E power systems and equipment supplied from those systems. It is of particular use in identifying the need for special protection features where the requirements of nuclear power generating stations (NPGS) necessitate supplementing accepted industry practices.

Wherever possible, this standard identifies other standards or documents that provide more explicit guidance for specific protection requirements. By definition, the protection shall be adequate to sense and to determine the presence of an unacceptable condition and to execute the operations required in order to limit degradation effects. In this role, this standard pays special attention to the requirements for design verification documentation to support the protection performance.

This standard also addresses the electrical penetration assemblies installed as part of the containment structure that may require special considerations for protection. Also included are the criteria used to establish the necessity for special considerations and the resulting protection requirements.

The revision of this standard includes the following principal changes:

The nuclear industry open phase issue was the basis for updating information for impact of power quality on protection scheme function. This was accomplished by recognizing protection from adverse power quality issues in IEEE Std 308™.^{6,7} Specifically, the General Design Criteria 4.0 and Principal Design Criteria and Requirements 5.1.2 were revised.

⁶Information on references can be found in [Clause 2](#).

⁷IEEE publications are available from the Institute of Electrical and Electronics Engineers (<https://standards.ieee.org/>).

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IEEE Standard for Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations

1. Overview

1.1 Scope

This standard provides the principal design criteria, design features, and testing requirements for the protection of Class 1E power systems and equipment supplied from those systems. It identifies special protection features that are needed where the requirements of nuclear power generating stations ([NPGS](#)) necessitate supplementing accepted industry practices.

1.2 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{8,9}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

⁸The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

⁹The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 141TM-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants(*IEEE Red Book*TM).[10,11](#) ~~1,2~~

IEEE Std 142TM, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (*IEEE Green Book*TM).

IEEE Std 242TM, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (*IEEE Buff Book*TM).

IEEE Std 308TM, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

IEEE Std 317TM, IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

IEEE Std 336TM, IEEE Standard Installation, Inspection, and Testing for Power, Instrumentation, and Control Equipment at Nuclear Facilities.

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IEEE Std 338TM, IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety.

IEEE Std 384TM, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.

IEEE Std 415TM-1986 (Reaff 1992), IEEE Guide for Planning of Preoperational Testing Programs for Class 1E Power Systems for Nuclear Power Generating Stations. [12](#) [3](#)

IEEE Std 446TM, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (*IEEE Orange Book*TM).

IEEE Std 487TM, IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations—General Considerations.

IEEE Std 518TM-1982 (Reaff 1997), IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources. [13](#) [4](#)

IEEE Std 603TM, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

IEEE Std 666TM, IEEE Design Guide for Electric Power Service Systems for Generating Stations.

IEEE Std 765TM, IEEE Standard for Preferred Power Supply (PPS) for Nuclear Power Generating Stations (NPGS).

IEEE Std 944TM-1986 (Reaff 1996), IEEE Recommended Practice for the Application and Testing of Uninterruptible Power Supplies for Power Generating Stations. [14](#) [5](#)

[12](#) [3](#) IEEE Std 415-1986 (Reaff 1992) has been withdrawn; however, copies can be obtained from The Institute of Electrical and Electronics Engineers, ~~445 Hoes Lane, Piscataway, NJ 08854, USA~~ ([https](https://standards.ieee.org/) ~~http~~://standards.ieee.org/).

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IEEE Std 946TM, IEEE Recommended Practice for the Design of DC Auxiliary Power Systems for Generating Stations.

IEEE Std 1050TM, IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations.

IEEE Std 1290TM, IEEE Guide for Motor Operated Valve (MOV) Motor Application, Protection, Control, and Testing in Nuclear Power Generating Stations.

IEEE Std 1375TM, IEEE Guide for the Protection of Stationary Battery Systems.

IEEE Std 1792TM, IEEE Recommended Practice for Nuclear Power Generating Station Preferred Power Supply Reliability.

IEEE Std C37.91TM, IEEE Guide for Protecting Power Transformers.

IEEE Std C37.96TM, IEEE Guide for AC Motor Protection.

IEEE Std C62.22TM, IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems.

[IEEE Std C62.22aTM, IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems Amendment 1: Supplement to Consider Energy Handling Capabilities.](#)

IEEE Std C62.23TM, IEEE Application Guide for Surge Protection of Electric Generating Plants.

IEEE Std C62.41TM, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.

IEEE Std C62.45TM, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and less) AC Power Circuits.

IEEE Std C62.92.3TM, IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems, Part III—Generator Auxiliary Systems.

NEMA ICS 2-~~2000~~, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts. ¹⁵ ~~6~~

NEMA MG 1-2014, Motors and Generators.

3. Definitions, acronyms, and abbreviations, ~~and acronyms~~

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* ~~and IEEE C37.100TM [B9]~~ should be consulted for terms not defined in this clause. ¹⁶ ~~7,8~~

analytical limit: A limit of a measured or calculated variable, established by the analysis to ensure that a safety limit is not exceeded.

anticipated overloads: Those values of motor current in excess of motor nameplate rating that are expected to be realized during valve actuation due to the varying torque nature of the load.

degraded voltage relay (DVR): Undervoltage relays; part of the (second level of) undervoltage protection (with time delay) provided to protect the Class 1E equipment from damage or becoming unavailable upon transfer to an alternate source (NUREG 0800 [B10] ~~US NRC Branch Technical Position, PSB-1 [B16]~~). These protective relays monitor the Class 1E safety bus voltages and automatically initiate the disconnection of offsite power whenever the voltage setting⁴ and time delay limits have been exceeded.

¹⁵ ~~6~~ NEMA publications are available from the National Electrical Manufacturers Association ~~Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA~~ (<https://www.nema.org/> ~~http://global.ihs.com/~~).

¹⁶ ~~7~~ IEEE Standards Dictionary Online ~~subscription~~ is available at: <http://dictionary.ieee.org/>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page. http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

⁸ ~~The numbers in brackets correspond to those of the bibliography in Annex E~~

duty cycle of a valve actuator: The duty cycle of a valve actuator consists of the number of valve strokes needed for its intended service. Plant operation or testing may require successive stroking of the valve.

duty cycle time of a valve actuator: The time required for a valve to complete one stroke multiplied by the duty cycle.

DVR dropout setting: The voltage setpoint of the degraded voltage relay (DVR) that causes the relay to actuate and automatically disconnect offsite power, after the DVR voltage [setpoint](#) ~~limit~~ and the DVR time delay [setpoint are exceeded](#). ~~limit is reached~~ Also, the minimum voltage at which all Class 1E loads are capable of starting and running indefinitely.

DVR reset setting: The voltage [setpoint](#) ~~value~~ that causes the degraded voltage relay (DVR) to reset following relay initiation. If this voltage [setpoint](#) ~~value~~ is reached prior to DVR timeout, it will prevent automatic disconnection of offsite power.

loss of voltage relay (LVR): Undervoltage relays; part of the (first level of) undervoltage protection scheme provided to detect loss of offsite power at the Class 1E buses.

LVR dropout setting: The voltage setpoint of the loss of voltage relay (LVR) that causes the relay to actuate and automatically disconnect offsite power after the LVR voltage [setpoint](#) ~~limit~~ and LVR time delay [setpoint are exceeded](#). ~~limit is reached~~ Also, minimum voltage at which all Class 1E loads are capable of running for a defined period of time.

minimum required grid voltage: The minimum switchyard voltage required to maintain an operable preferred offsite power supply such that the supply can perform its intended safety function per GDC-17. This requires the offsite supply to have sufficient capacity and capability to perform its intended function, including the ability to maintain voltage while accepting the accident loads. It also requires the supply to safety-related loads without causing the DVR to time out and trip thereby causing separation from the offsite power supply.

valve actuator motor nominal current: The current that the motor is rated to carry for the duration of its rated duty, commonly known as the motor nameplate current.

valve actuator motor nominal torque: The torque that corresponds to the valve actuator nominal current.

valve stroke: Complete travel distance of a valve from either fully open to fully closed position, or vice-versa.

3.2 Acronyms ~~Abbreviations~~ and abbreviations ~~acronyms~~

CT current transformer

DVR degraded voltage relay

LTC load tap changing

LVR loss of voltage relay

~~MOV motor-operated valve~~

~~NEMA National Electrical Manufacturer's Association~~

~~NERC Nuclear Energy Regulatory Committee~~

NPGS nuclear power generating stations

NPP nuclear power plant-

PPS preferred power supply-

PU per-unit

SSO solid-state overload

TOR thermal overload relay

VAM valve actuator motor

4. General design criteria

4.1 Criteria

As used in this standard, protection refers to the sense, command, and execute features with their associated interconnections (see IEEE Std 603¹⁷) that are provided to minimize equipment damage and any interruption of electrical service resulting from mechanical or electrical failures or other unacceptable conditions.⁹ Protection includes equipment required to support the Class 1E power system in the performance of its safety function, and components whose function is to increase the availability and reliability of the safety-related equipment.-

The protection scheme principal purpose shall be to initiate action(s) for Class 1E power systems that enable the systems to meet their functional requirements consistent with IEEE Std 308:

- Restore operating conditions to within the acceptable ranges as developed in accordance with IEEE Std 308, and/or;
- Prevent the consequential failure (i.e., damage) of multiple safety related end utilization components.

Protection shall limit sustained operation outside the specified acceptable ranges determined from analysis required in IEEE Std 308. Variations of voltage, frequency, and waveform (including the effects of harmonic distortion) in Class 1E power systems during any mode of plant operation shall not degrade the performance of any safety system load below an acceptable level as defined in IEEE Std 308.

¹⁷ ⁹Information on references can be found in Clause 2.

The protection shall be capable of the following:

- a) Preventing failures in safety systems and equipment from disabling safety functions to below an acceptable level. The protective actions of each load group shall be independent of the protective actions provided by redundant load groups (see IEEE Std 308).
- b) Operating the required devices upon detection of unacceptable conditions to reduce the severity and extent of electrical system disturbances, equipment damage, and potential personnel and property hazards.
- c) Monitoring the connected preferred power supply ([PPS](#)) and, where an alternate [PPS](#) ~~preferred power supply~~ is provided by the design, of automatically initiating a transfer or alerting the operator to manually transfer to the preferred alternate power supply.
- d) Providing indication and identification of the protective operations.
- e) Periodic testing to verify logic schemes and protective functions.
- f) Being designed in such a way that the availability of protection control power is monitored.
- g) Periodic testing to verify setpoints- (this requirement is not applicable to fuses).

Those parts of the protection that have a safety function shall meet the requirements of IEEE Std 603 and IEEE Std 308. Documentation requirements for the protection of Class 1E power systems and equipment are found in IEEE Std 308. Those parts of the protection whose function is non-safety-related shall be designed such that their failure does not degrade the Class 1E power system below an acceptable level.

5. Principal design criteria and requirements

5.1 AC power distribution systems

5.1.1 Switchgear and bus protection

For recommended practices in application of overcurrent relays, directional relays, differential relays for bus protection, and ground fault relaying, refer to IEEE Std 141-1993, IEEE Std 242, and IEEE Std 666. The protection systems for the ac distribution system should be coordinated in accordance with IEEE Std 242. For supplementary information on ground protection practices, refer to IEEE Std 142.

If the power distribution system design cannot accommodate paralleling of bus supplies, or if paralleling can be allowed only under certain conditions, interlocks or procedural restrictions shall be provided to restrict such paralleling. Consideration shall be given to the higher fault current that could exist during parallel operation when selecting protective devices.

If the power distribution design allows for automatic bus transfers, consideration shall be given to the impact of the bus transfer on the coordination of protection devices (see Annex C).

5.1.2 Bus voltage monitoring schemes

Bus voltage monitoring schemes that are used for disconnecting the [PPS](#), ~~preferred power source~~ load shedding, and starting the standby power sources are part of the protection and shall meet the criteria that follow. Voltage monitoring schemes, which are used only for alarms, do not have to meet these criteria.

- a) Bus voltage shall be detected directly from the Class 1E bus to which the standby power source is connected.
- b) Upon sensing [PPS](#) ~~preferred power supply~~ degradation, the condition shall be alarmed in the main control room. Upon sensing [PPS](#) ~~preferred power supply~~ degradation to an unacceptable low voltage condition, the affected [PPS](#) ~~preferred power supply~~ shall be automatically disconnected from the Class 1E buses.
- c) Each division shall have an independent scheme of detection of degraded voltage and loss of voltage conditions. [The selection of setpoints, including time delays, shall be based on the variables and associated analytical limits established in support of IEEE Std 308.](#) Within each division, common equipment may be used for the detection of both conditions (see Annex A).
- d) [Variations in voltage, frequency, and waveform \(including the effects of harmonic distortion\) in Class 1E power system during any mode of plant operation shall not adversely affect the monitoring scheme function.](#)
- e) Each scheme shall monitor all three phases. The protection system design shall be such that a blown fuse in the voltage transformer circuit or other single phasing condition does not cause incorrect operation, nor prevent correct operation, of the scheme. Means shall be provided to detect and identify these failures.
- f) The design shall minimize unwanted operation of the standby power sources and disconnection of the [PPS](#). ~~preferred power supply~~. The use of coincident logic and time delay to override transient conditions is a way to accomplish this.
- g) Capability for test and calibration during power operation shall be provided.
- ~~g) The selection of undervoltage and time delay setpoints shall be determined from an analysis of the voltage requirements of the Class 1E loads at all on-site distribution levels (see Annex A).~~
- h) Indication shall be provided in the control room for any bypass incorporated in the design.

5.1.3 Feeder circuits

For recommended practice on motor protection, refer to IEEE Std C37.96, IEEE Std 242, and IEEE Std 666. See ~~clause~~ 5.5 of this standard for additional requirements associated with valve actuator motors (VAMs). The feeder circuit protection shall consider any expected operating conditions of the motor that could require current demands above the motor's nameplate rating such as operation into the motor service factor (see NEMA MG 1-2014), or operation at other than rated voltage.

For recommended practice on power transformer protection, refer to IEEE Std C37.91 and IEEE Std 666. For recommended practice on feeder circuit to power distribution panel protection, refer to IEEE Std 141-1993 and IEEE Std 242. For criteria on isolation and separation of non-Class 1E circuits from Class 1E circuits, refer to IEEE Std 384.

For use of high-speed magnetic circuit breakers in special applications, refer to Annex D.

5.1.4 Standby power supply protection

For diesel generator protection recommended practice, refer to IEEE Std 242.

In the manual control mode, synchronizing interlocks should be provided to prevent incorrect synchronization whenever a standby power source is required to operate in parallel with the [PPS](#) ~~preferred power supply~~.

When a standby power supply is being operated in parallel with the [PPS](#), ~~preferred power supply~~ protection shall be provided to separate the two supplies if either [one](#) becomes degraded to an unacceptable level. This protection shall not lock out or prevent the availability of the power supply that is not degraded.

5.1.5 Load shedding and sequential loading

An automatic load shedding and sequential loading scheme may be included to ensure that the preferred or standby power sources can be loaded while maintaining voltage and frequency within acceptable limits.

The Class 1E bus load shedding scheme shall automatically prevent shedding during sequencing of the emergency loads to the bus when connected to the standby power source.

If the preferred or standby power source breaker is tripped during loading or subsequent to loading, the load shedding and sequential loading scheme shall be arranged to be automatically reset to perform its function in the event that the loads are to be reapplied.

5.1.6 Surge protection

For surge protection of equipment and systems, refer to IEEE Std 141-1993 or IEEE Std C62.23 for electric generating plants. For surge protection of induction motors, refer to IEEE Std C37.96. For guidance on protection of wire-line facilities used for protective relaying and data transfer circuits, refer to IEEE Std 487.

For recommendations in design and installation of low-energy, low-voltage signal circuits associated with solid-state electronic equipment, refer to IEEE Std 518-1982.

Surge protection shall be provided to protect the shunt field of dc VAMs. This surge protection may take the form of a resistor in the motor control center, wired in parallel with the shunt field to provide a discharge path for the shunt field's inductive voltage surges.

For guidance in the application of surge arresters to all types of power circuits and equipment, refer to IEEE Std C62.22-2 and [IEEE Std C62.22a](#). Refer to IEEE Std C62.41 for guidance in determining the surge voltage for low-voltage equipment, and to IEEE Std C62.45 to provide guidance for tests that should be used to determine the surge withstand capability of the equipment used on low-voltage circuits.

5.2 DC power system

The dc power distribution system shall be provided with coordinated protection. Refer to IEEE Std 946 for dc system design and IEEE Std 1375 for station battery protection. Coordination for dc power system circuits shall include the main bus protective devices and the protective devices used in branch circuits, in switchgear control circuits, in relay and process control panels, and in battery chargers. Care shall be taken to use appropriate correction factors or dc trip characteristic curves for protection devices. The current limiting characteristics of battery chargers shall be considered.

For criteria on isolation and separation of non-Class 1E circuits from Class 1E circuits, refer to IEEE Std 384.

Ground detection monitoring shall be provided for ungrounded systems.

Battery chargers shall be provided with current-limiting features or overload protection, reverse current protection, output undervoltage, and overvoltage alarms and/or trips. For additional guidance on the protection of battery chargers, refer to IEEE Std 446.

5.3 Instrumentation and control power system

For guidance on protection for inverters, refer to IEEE Std 446. For information on ground protection practices, refer to IEEE Std 142 and IEEE Std C62.92.3. For criteria for isolation and separation of non-Class 1E circuits from Class 1E circuits, refer to IEEE Std 384

Where a rectifier-type power supply is used as a source for an inverter, it shall be provided with reverse current protection, current-limiting features or overload protection, and output undervoltage and overvoltage protection.

The instrumentation and control power distribution system shall be provided with coordinated protection. Because inverters and motor generator sets are sources of limited short-circuit current, special attention shall be given to integrating protective device sensitivity and system available fault current. Coordination shall include the protective devices in the alternate supply, inverters, static switches, distribution panels, instrumentation panels and racks, and other equipment powered from the system.

Where an instrumentation and control power bus is supplied by an inverter with current-limiting characteristics and an automatic transfer has been provided to an alternate source with higher available current, this alternate source may be used in order to achieve the previously described coordinated protection.

Ground detection monitoring shall be provided for ungrounded systems.

The instrumentation and control power system shall be provided with undervoltage, overvoltage, and underfrequency protection. Where its power is supplied from a static inverter, overfrequency protection shall also be provided. For recommended practice on alarms and indication, refer to IEEE Std 944-1986.

5.4 Primary containment electrical penetration assemblies

An electrical penetration assembly shall be considered as part of the cable system between the load and the primary interrupting device. For guidance in the application of electrical circuit protection, refer to IEEE Std 242, which includes information also applicable to electrical penetrations. Short-circuit, overload, and continuous current ratings and capabilities of the electrical penetration are defined in IEEE Std 317.

The electrical penetration assemblies installed as part of the containment structure may require special consideration in the selection of their protection. This special consideration arises where the potential exists for a fault inside containment to result in a penetration seal failure, such that a breach of containment could occur. Where a penetration assembly can indefinitely withstand the maximum current available due to a fault inside containment, no special consideration is required.

Electrical penetrations requiring special consideration (i.e., where protection is required to ensure containment integrity) shall be provided with dual primary protection operating separate interrupting devices, or primary and backup protection operating separate interrupting devices.

The time-current curves of the dual primary protection or the primary and backup protection shall coordinate with the time-current capability curve of the electrical penetration to be protected.

Protection for non-Class 1E circuits using containment penetration assemblies do not need to be treated as Class 1E. The protection for these non-Class 1E circuits is acceptably provided by the previously specified requirements. ^{18 40} For protection circuits requiring special consideration, the surveillance requirements of 6.3 shall apply.

5.5 Valve actuator motors (direct gear driven)

The selection of a protective device for the direct geared VAM shall ensure that the time-current characteristic of the protective device is coordinated with the time-current characteristic of the motor, as derived from motor time-temperature data. In addition, the coordination shall ensure the allowable duty cycle of the valve (see Annex B) is completed without compromising the motor thermal withstand capability, while allowing margin for variations in current drawn by the motor, or in the thermal characteristics of the protective device, or both. Refer to Annex B for guidelines for selection of the protective devices. See also IEEE Std 1290. The criteria for setting mechanical devices within the valve actuator, such as torque and limit switches, are not within the scope of this standard.

The protective device(s) shall be selected to prevent the following:

- Motor overheating due to locked-rotor conditions
- Motor overheating due to overloads
- Nuisance trips during acceleration
- Nuisance trips due to anticipated overloads
- Nuisance trips during operation within the duty cycle of the valve

^{18 40} Designs that use dual protection for penetration circuits provide adequate assurance that the protection will function acceptably under all plant conditions. Since the plant design basis is that a seismic event will not cause a loss-of-coolant accident or high-energy line break inside containment, seismic qualification of protective devices for non-Class 1E circuits that penetrate the containment is not required.

To protect the motor during locked-rotor conditions, the protective device maximum trip time shall not exceed the allowable safe locked-rotor time, and the minimum trip time shall not be less than the acceleration time (typically less than 1 s).

Protective devices shall be coordinated with the motor allowable operating time corresponding to nominal torque and anticipated overloads. Typical anticipated valve overloads fall in the range of 150% to 300% of the VAM nominal torque, depending on the actuator type and application.

Short-circuit protection shall be provided for the VAM. If the device for short-circuit protection contains an overload element, this element shall be coordinated with the VAM thermal overload device.

The following shall also be considered in the derivation and coordination of the protective device setpoints:

- Tolerance (accuracy) of the protective device
- The effect of ambient temperature
- The effect of motor terminal operating voltage extremes

VAM current values shall be obtained from the valve actuator manufacturer at nominal torque, selected overload torque (150% to 300% of nominal torque), and locked-rotor torque. The current values shall be measured at nominal voltage, and either measured or calculated for anticipated voltages at the terminals of the motor. These current values shall be considered in the final selection of the overload protection device.