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THERMAL OVERLOAD PROTECTION FOR ELECTRIC MOTORS ON MOTOR-OPERATED VALVES

A. INTRODUCTION

This regulatory guide describes a method acceptable to the U.S. Nuclear Regulatory Commission (NRC) staff for complying with the following criteria with regard to the application of thermal overload protection devices that are integral with the motor starter for electric motors on motor-operated valves. This method would ensure that the thermal overload protection devices will not needlessly prevent the motor from performing its safety-related function.

Criterion 1, "Quality Standards and Records," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," (Ref 1) requires, in part, that components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed.

Criterion 4, "Environmental and Missile Design Bases," of Appendix A to 10 CFR Part 50 requires, in part, that structures, systems, and components important to safety be designed to accommodate the effects of and be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents including loss-of-coolant accidents.

Criterion 13, "Instrumentation and Control," of Appendix A to 10 CFR Part 50 requires that instrumentation be provided to monitor variables and systems over their anticipated ranges for normal operation and for postulated accident conditions and that controls be provided to maintain these variables and systems within prescribed operating ranges.

The NRC issues regulatory guides to describe and make available to the public methods that the NRC staff considers acceptable for use in implementing specific parts of the agency's regulations, techniques that the staff uses in evaluating specific problems or postulated accidents, and data that the staff needs in reviewing applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public.

Regulatory guides are issued in 10 broad divisions—1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

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Criterion XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires, in part, that a test program be established to ensure that systems and components perform satisfactorily and that the test program includes operational tests during nuclear power plant operation.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. This regulatory guide is a rule as designated in the Congressional Review Act (5 U.S.C. 801-808). However, OMB has not found it to be a major rule as designated in the Congressional Review Act.

B. DISCUSSION

Typical valve actuator motors are intermittent-duty, high-torque motors. When an actuator motor receives a signal to operate, the motor must attain operating speed quickly with sufficient force to deliver the equivalent of a hammer blow to the valves stem to initiate movement. If a valve is tightly sealed or must operate under a high differential pressure or flow condition, the initial period of operation when opening the valve calls for a high torque at low speed demand on the motor. During the period of time when the valve is unseating or initially opening, the motor may draw high current. Starting current (which is usually assumed to be equivalent to locked-rotor current) drawn by a motor may be 4 to 10 times higher than the motor's continuous current rating. A similar condition may exist when a valve begins its closing stroke because of interaction with the backseat. During closing stroke, the motor experiences a relatively high-speed/low-torque condition until the disc begins to interact with fluid flow. Thereafter, a low-speed/high-torque motor operating condition can occur during the last half of the valve stroke and as the valve disc is being seated.

Both high-torque/low speed and low-torque/high speed conditions generate heat that, if excessive, can cause deterioration of the insulation in the motor winding. If the heat buildup is severe, it can cause burnout of the winding insulation in a matter of seconds. Damage to the rotor also may occur. Moreover, degradation of the winding insulation and the rotor may occur in small increments and then fail under some particular demand depending on the degree and recurrence of the heat buildup. Thermal overload protection devices can be used to protect against such deficiencies by cutting off power to the motor to avoid degradation of the winding insulation and the rotor.

Following a motor shutoff by the thermal overload protection device, the motor could be restarted for a later attempt to open or close the valve. Appendix A, "LERs Pertinent to Thermal Overload Protection Issue" of NUREG 1296, "Thermal Overload Protection for Electric Motors on Safety Related Motor-Operated Valves – Generic Issue II.E.6.1" (Ref 2), lists a number of Licensee Event Reports related to thermal overload protection. Moreover, Institute of Electrical and Electronics Engineers, Inc. (IEEE) Standard 279-1971 referred to in the regulatory position of Regulatory Guide 1.106, Revision 1, "Thermal Overload Protection for Electric Motors on Motor-Operated Valves," has been superseded by IEEE Standard 603-2009, "Criteria for Safety Systems for Nuclear Power Generating Stations" (Ref 3).

A lesson learned from operating experience and testing programs for motor-operated valves used in nuclear power plants is that significant valve operating requirements can occur as a result of high differential pressure and fluid flow conditions. For example, tilting of a valve disc in a gate valve because of high differential pressure and flow can cause metal grinding or binding that results in operating requirements much greater than those associated with sliding friction. Subsequent to initial accident conditions, the high differential pressure and fluid flow conditions might be significantly reduced during

later stages of an accident. Therefore, a motor that is shut off by a thermal overload protection device might be capable of operating the valve later when the fluid conditions are less severe (such as lower differential pressure and flow). The need for a motor-operated valve to operate immediately at the outset of an accident or whether the safety function can be performed later during an accident should be considered in sizing and setting thermal overload protection devices.

Thermal overload protection devices for valve operator motors can be categorized as either thermal overload relays, usually housed in the motor starter, or temperature-sensing elements that are embedded in the motor windings. Thermal overload relays are available in a variety of designs and sizes with variations in features and accessories available for each. The basic components of a thermal overload relay are the heater element, which reacts to the current drawn by the motor, and the trip mechanism. Because the trip function in a thermal overload relay is dependent on temperature, the degree of overload protection provided is affected by change in ambient temperature at the motor or starter location. This aspect becomes more complex in nuclear power plant applications where, in some cases, the motor to be protected is located inside the containment and the overload protection devices are outside the containment. In such a situation, the temperature difference between the motor and the overload device could be as high as 200º F under design basis conditions. Thus, the selection of an appropriate trip set point for such a valve motor should take into consideration operation of the valve under various temperatures for both normal and postulated accident conditions including loss-of-coolant accidents.

The accuracy obtainable with the thermal overload relay trip generally varies from -5 percent to 0 percent of trip set point. Because the primary concern in the application of overload devices is to protect the motor windings against excessive heating, the above negative tolerance in trip characteristics of the protection device is considered in the safe direction for motor protection. However, this conservative design feature built into these overload devices for motor protection could interfere in the successful functioning of a safety-related system (i.e., the thermal overload device could open to remove power from a motor before the safety function has been completed or even initiated). In nuclear power plant application, the criterion for establishing an overload trip set point should be to complete the safety function (e.g., drive the valve to its proper position to mitigate the effects of an accident) rather than merely to protect the motor from destructive heating.

It is generally very difficult for any thermally sensitive device to approximate adequately the varying thermal characteristics of an intermittent-duty motor over its full range of starting and loading conditions. This is mainly caused by the wide variations in motor heating curves for various sizes and designs and also by the difficulty in obtaining motor heating data to an acceptable accuracy. Acceptable criteria on selecting an appropriate trip set point that will protect the motor windings against excessive heating without jeopardizing the motor-operated valve's ability to complete its safety function are provided in Section 5.5, "Valve actuator motors," and Annex B, "Guidelines for Selection of Overload Protection for VAM Circuits" of IEEE Standard 741- 2007, "Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations" (Ref 4).

Where the thermal overload protection devices are bypassed, it is important to ensure that the bypassing does not result in jeopardizing the completion of the safety function or in degrading other safety systems because of any sustained abnormal motor circuit currents that may be present. As an example, for small motors (1/2 horsepower or less), the magnetic trip devices provided in the motor combination starter-breaker may not adequately protect the circuit at all times against sustained locked-rotor currents.

C. STAFF REGULATORY GUIDANCE

To ensure that safety-related motor-operated valves whose motors are equipped with thermal overload protection devices integral with the motor starter will perform their function, one of the three alternatives described in regulatory position 1 as well as regulatory positions 2 and 3, should be implemented:

1. Provided that the completion of the safety function is not jeopardized or that other safety systems are not degraded:

   a) For valves that are required to function immediately to open or close during a Design Basis Event (DBE) or Station Blackout (SBO) to perform a single safety-related action and that do not change position thereafter, the thermal overload protection devices should be continuously bypassed, and should be temporarily placed in service only when the valve motors are undergoing periodic or maintenance testing.

   b) For valves that operate during normal plant conditions and are automatically actuated to perform a safety-related function (whether to perform a single safety-related action or to modulate during an accident condition), the thermal overload protection devices should normally be in service during plant operation, testing, and maintenance, and should be automatically bypassed under DBE or SBO conditions.

   c) For motor-operated valves that do not have an immediate safety function to perform in response to an accident condition, the thermal overload protection device should be in service at all times (during normal operation, DBE or SBO conditions, and maintenance).

   The bypass initiation system circuitry should generally conform to the criteria of Sections 4(g), 4(h), 4(i), 4(j), 4(k), 4(l), 5, 5.1, 5.2, 5.3, 5.4, 5.5, and 5.7 of IEEE Std 603-2009, "Criteria for Safety Systems for Nuclear Power Generating Stations," and should be periodically tested.

2. The selection of the trip setting of the thermal overload protection devices should be established with all uncertainties resolved in favor of completing the safety-related action. With respect to those uncertainties, consideration should be given to (a) variations in the ambient temperature at the installed location of the overload protection devices and the valve motors, and (b) inaccuracies in motor heating data and the overload protection device trip characteristics and the matching of these two items. To ensure continued functional reliability and the accuracy of the trip point, the thermal overload protection device should be periodically tested.

   The trip setting of the thermal overload protection device should conform to the guidance provided in Annex B of IEEE Standard 741-2007, "Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations."

3. An alarm indication should be provided in the control room that generally conforms to criteria 5.8 provided in IEEE 603-2009, "Criteria for Safety Systems for Nuclear Power Generating Stations," when a safety-related valve motor generates overcurrent (and thus heat) and trips the thermal overload protection device.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[1] may use this guide and information regarding the NRC's plans for using this regulatory guide. In addition, it describes how the NRC staff complies with the Backfit Rule (10 CFR 50.109) and any applicable finality provisions in 10 CFR Part 52.

Use by Applicants and Licensees

Applicants and licensees may voluntarily[2] use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged.

Licensees may use the information in this regulatory guide for actions which do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59. Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this regulatory guide are part of the licensing basis of the facility. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised regulatory guide and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which

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1 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52; and the term "applicants," refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52, and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

2 In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the regulatory guide, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide, generic communication, or promulgation of a rule requiring the use of this regulatory guide without further backfit consideration.

Additionally, an existing applicant may be required to adhere to new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

Conclusion

If a licensee believes that the NRC is either using this regulatory guide or requesting or requiring the licensee to implement the methods or processes in this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409 and NRC Management Directive 8.4.

REFERENCES[3]

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.

2. U.S. Nuclear Regulatory Commission, "Thermal Overload Protection for Electric Motors on Safety Related Motor-Operated Valves – Generic Issue II.E.6.1," NUREG-1296, Washington, DC, June 1988, Accession No. 8807110511.

3. Institute of Electrical and Electronics Engineers, IEEE Std. 603-2009, "Criteria for Safety Systems for Nuclear Power Generating Stations" (Revision of IEEE Std. 603-1998), Piscataway, NJ.[4]

4. Institute of Electric and Electronics Engineers, IEEE Std. 741-2007, "Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations" (Revision of IEEE Std. 741-1997), Piscataway, NJ.

[3] Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections/. The documents can also be viewed on-line or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or (800) 397-4209; fax (301) 415-3548; and e-mail pdr.resource@nrc.gov.

[4] Copies of Institute of Electrical and Electronics Engineers (IEEE) standards may be purchased from the IEEE Standards Association, 445 Hoes Lane, Piscataway, NJ 08855-1331; telephone (800) 678 4333. Purchase information is available through the IEEE Standards Association Web site at http://www.ieee.org.