NUREG-1296

Thermal Overload Protection for Electric Motors on Safety-Related Motor-Operated Valves - Generic Issue II.E.6.1

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

O. Rothberg

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O. Rothberg

Division of Engineering
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ABSTRACT

NRC regulatory positions, as stated in Regulatory Guide 1.106, Revision 1, have been identified by the Office for Analysis and Evaluation of Operational Data (AEOD) as potential contributors to valve motor burnout. AEOD is particularly concerned about the allowed policy of bypassing thermal overload devices during normal or accident conditions. Regulatory Guide 1.106 favors compromising the function of thermal overload devices in favor of completing the safety-related action of valves. The purpose of this study was to determine if the guidance contained in Regulatory Guide 1.106 is appropriate and, if not, to recommend the necessary changes.

This report describes thermal overload devices commonly used to protect safety-related valve operator motors. The regulatory guidelines stated in Regulatory Guide 1.106 along with the limitations of thermal overload protection are discussed. Supplements and alternatives to thermal overload protection are also described. Findings and conclusions of several AEOD reports are discussed. Information obtained from the standard review plan, standard technical specifications, technical specifications from representative plants, and several papers are cited.

Thermal overload devices can provide useful protection for valve motor operators; however, the characteristics and limitations of these devices must be thoroughly understood by the user. The positions outlined in Regulatory Guide 1.106 allow sufficient flexibility to protect safety-related valve operators without degrading system function.

The difficulties encountered in the use of thermal overload devices to prevent valve motor burnout are partly related to a lack of standards and uniform guidance for the design, installation, maintenance, and testing of motor overload protection devices. These difficulties are also related to the inherent competing risk of protecting a particular component from failure or degradation versus possibly preventing the system from performing its safety function.

NRC is currently processing a proposed Revision 2 to Regulatory Guide 1.106 in an effort to encourage use of thermal overload devices and to provide an alarm function. Nuclear industry standards should be developed or revised to include uniform instructions for the detailed design, installation, maintenance, and

devices for motor-operated valves. ANSI/IEEE Standard 741-1986 entitled "IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations" is being revised to provide detailed design guidance for thermal overload protection of motor-operated valves. NRC/RES will contact several nuclear standards organizations, as part of the resolution of Generic Issue II.E.6.1, to suggest that detailed guidance be developed for installation, maintenance, and testing of thermal overload devices for motor-operated valve protection.

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Owen O. Rothberg
Task Manager, Generic Issue II.E.6.1

5-31-88

Frank Cherny, Section Leader
Section B
Engineering Issues Branch

5/31/88

Robert L. Baer, Chief
Engineering Issues Branch

for 6/10/88

Guy A. Arlotto, Director
Division of Engineering
Office of Nuclear Regulatory Research

TABLE OF CONTENTS

contained in Regulatory Guide 1.106 is appropriate and, if not, to recommend the necessary changes.

The general conclusions and recommendations of this report are summarized as follows:

A. The positions outlined in Regulatory Guide 1.106, Revision 1, are technically correct. However, these positions may have been applied by individual licensees in a manner that emphasized bypassing or oversizing of thermal overload devices. This may have resulted in failure or premature degradation of a number of valve motor operators because of the misadjustments, excessive wear, defective parts, or poor maintenance to which the operators were subjected. It is possible, within the guidance stated in the regulatory positions of Regulatory Guide 1.106, to provide thermal overload protection for valve motor operators without unacceptably compromising the safety function of the system. However, emphasis should be placed on proper engineering and use of thermal overload devices rather than indiscriminate bypassing or oversizing.

B. Additional guidance should be included in Regulatory Guide 1.106 concerning use of alarms to indicate an overload situation whether or not the valve operator is disabled by the thermal overload device. A proposed Revision 2 of the regulatory guide is now under consideration. If adopted, that revision would provide guidance for the use of thermal overload devices as nondisabling alarms. As part of the revision to the regulatory guide, consideration is being given to eliminating the current position that allows thermal overload devices to be bypassed at all times, except during stroke testing.

C. The design, sizing, and circuitry logic for thermal overload protection devices for valve motor operators can vary quite widely. Many thermal overload problems involve improper engineering in the choice, sizing, placement, or maintenance of thermal overload devices. Industry guidance in this area is lacking.

D. Use of thermal overload devices is only one method of ensuring that valve operators are not subjected to overload. Recent advances in diagnostic techniques for motor-operated valve surveillance offer supplements and alternatives to the use of thermal overload devices.

E. Nuclear industry standards should be developed or revised to include uniform instructions for the design, installation, maintenance, and testing of thermal overload devices for motor operators. IEEE is currently revising one of its standards in order to provide design guidance; however, development of guidance in the other areas is also needed. NRC/RES will contact several nuclear standards organizations, as part of the resolution of Generic Issue II.E.6.1, to encourage development of such guidance.

These conclusions and the supporting arguments are discussed in detail in this report.

Section 2 of this report describes thermal overload protection devices used in safety-related motor-operated valves in nuclear power plants. Section 3 provides a discussion of the requirements of the current version of Regulatory Guide 1.106 along with some historical background concerning NRC requirements prior to publication of the regulatory guide. In Section 4, the findings and conclusions of the various AEOD reports are outlined along with other findings of this investigation. Finally, Section 5 discusses the information outlined in this report, and the resulting conclusions that were summarized above are offered.

major features of bimetal overload relays. (All figures are reproduced from Ref. 8 with the permission of Furnas Electric Co., Batavia, Ill.)

In the melting alloy device, a eutectic solder melts at a precise temperature and releases a spring that opens or closes a circuit. This circuit can energize an alarm or disable the motor or both.

The bimetal overload responds to increased temperature by deflecting to open or close a circuit. Again, an alarm and/or disabling mechanism for the motor can be activated by the opening or closing of the circuit.

In Figure 2, "compensated" refers to compensation for variations in ambient temperature. Such compensation does not account for the effect of any differential temperature that may exist between the motor and the motor starter.

Figure 3 shows examples of melting alloy overload relays along with several types of heater elements. Figure 4 shows examples of bimetal overload relays along with several types of heater elements.

Another means of providing overload protection is by the use of temperature-sensing elements embedded in the motor windings. These can be classified as thermostats or thermistors. The thermostat consists of a bimetallic element that deflects to break a contact when excessive temperature is encountered. The thermistor is a small semiconductor resistance with a very pronounced temperature coefficient. The resistance is minimum at low temperature and increases by several powers of ten when hot. Thermostats or thermistors respond directly to high temperatures in motor windings that are caused by excessive electrical loads.

Limitorque and Rotork have different design preferences in the choice of thermal overload protection devices for valve operator motors. Limitorque endorses the use of thermal overload relays while Rotork's preference is for the thermostat-type embedded temperature-sensing element. Each vendor gives somewhat different arguments for their choice but both endorse providing thermal overload protection for their valve operator motors. Limitorque's preferred method for choosing and sizing thermal overload devices is outlined in Reference 9 while that of Rotork is summarized in Reference 10.

Limitorque does not supply motors with an embedded temperature-sensing element nor does Limitorque provide the thermal overload relay. The choice and installation of a thermal overload relay in the motor starter (which, on safety-related operators, is usually remote) is left to the end user who sizes the device and designs the circuit.

Rotork provides and recommends the use of a thermostat-type embedded temperature-sensing element on their motors. However, for nuclear power plant use, the embedded temperature-sensing element is not usually wired up by the purchaser. Rather, it is left to the end user to provide a thermal overload relay on the motor starter along with the required circuit. Thus, in practice, in spite of the different preferences between Rotork and Limitorque, the thermal overload protection for valve operator motors used in nuclear power plants, where provided, is in the form of a thermal overload relay on the motor starter. Usually, no embedded temperature-sensing element in the motor is used in safety-related applications.

Proper sizing of the heaters for the thermal overload relays is of critical importance. Heaters of improper size can cause either spurious trips or motor damage. The motor overload relays and their attendant heaters for valve operator motors must be sized for the intermittent duty rated motors that are used in such applications. Use of the procedures for common continuous duty motors will result in improperly sized heaters that will provide ineffective protection for the motor. Reference 9, which was provided in the literature supplied by both Limitorque and Rotork, describes methods for sizing thermal overload heaters for overload relays used to protect valve operator motors.

According to the text and examples found in Reference 9, thermal overload heaters for the intermittent duty motors used in valve actuators are ideally sized to trip in 10 seconds in response to a locked-rotor current of about 600 percent of normal continuous duty load current. Also, a trip is supposed to occur when 200 percent of normal continuous duty load current is experienced for 480 seconds. Normal continuous duty load current is theoretically sustainable by the thermal overload device without time limit. However, it is expected that heat would build up in the relay due to sustained operation and ultimately cause the thermal overload device to trip.

Thermal overload relays are subject to some variation in trip setpoint. As noted in Regulatory Guide 1.106, this is inherent to the design of the devices, which are planned to trip either slightly below or at their trip setpoint. Bimetallic-type relays are subject to deterioration over time because of permanent set or excessive deflection if subjected to high temperature and must be periodically monitored to prevent this from affecting the accuracy of the device.

Maintenance and testing of thermal overload relays are very important elements. Unless checked periodically, there is no assurance that a correctly rated and installed relay will continue to provide the same degree of protection as when it was calibrated and installed originally. Experience has shown that the bimetal elements in thermal overload relays can become insensitive to heat because of metal fatigue and can fail to operate under sustained overloads. Eutectic devices may experience a change in characteristics when actuated because of displacement of the melting alloy.

The use of thermal overload relays to provide the means to automatically protect valve operator motors from damage is only one means of accomplishing this task. NRC does not explicitly require the use of thermal overload protection in the regulations, standard review plans, or regulatory guides.

Several of the remarks contained in Reference 11 are pertinent in this regard and are reproduced below:

"IMPROVED THERMAL OVERLOAD PROTECTION

Presently in the industry, thermal overload protection of a typical VMO is provided by a snap action bimetallic switch which is installed in the 115 Vac control circuit. The bimetallic switch is exposed to an electrical resistance heater through which motor winding current flows. In cases where the current increases inordinately and for a sufficient period of time, the additional heat from the resistance heater causes the bimetallic switch to open, thereby opening the motor starter coil and shutting down the motor. Both the bimetallic switch and electric resistance heater are normally mounted in the motor control center (MCC).

The technique described above is the subject of great dissatisfaction in the industry. The method is indirect, with resistance heating simulating thermal conditions within the motor winding itself. Simulated conditions are not actual conditions, so there is always doubt as to whether proper overload protection is being provided. This technique is more normally used for continuous duty motors. Because of this, manufacturers' recommendations for sizing of heaters and selection of bimetallic switches are not suitable for the VMO motors which are only used intermittently. If it has been determined that the thermal overload protection for a particular VMO is not appropriate, then removal and replacement of components is required.

This situation could be improved significantly if a direct, rather than indirect, measurement of the motor current were employed. This would be more consistent with typical VMO manufacturers' recommendations for operation which include limitation of motor stalled or locked rotor current to a certain period of time in seconds, depending on size, model number, application, etc. Monitoring of motor current, which increases as resistance to motor rotation increases, would also yield important trending data as the valve strokes. Observing motor current rise as the valve disc enters the valve seat, for instance, could provide an indication as to how energetically the two valve components are being driven against each other.

A potentially more useful control parameter would be motor load, a complex function of motor current and motor voltage, which can be expressed as follows:

$$\text{Motor Load} = KV \cos \theta$$

K = Constant
V = Motor Voltage
I = Motor Current
θ = Phase angle between the current and voltage waveforms.

Use of motor load will allow tracking of supply voltage as well as instantaneous motor current. By continuous calculation of motor load, and comparison with other applicable control variables, valve stem position, and load, a more accurate determination of the nature of an abnormal condition can be made. For instance, if motor load is excessively high, but stem load is normal, it could be concluded that there is a mechanical binding in the drive gear train. On the other hand, if motor load is excessive, and there is a noticeable increase in stem load while the valve is in midstroke, then it could be concluded that there is increased stem friction impeding motion caused, for example, by excessive tightening of valve stem packing or by a stem burr."

The point here is not whether the methods recommended in Reference 11 are to be preferred, but rather that there are now available alternatives and supplements to thermal overload devices that can be used to protect the function of the valve operator without interfering with safety functions. Some of these techniques are described in References 3 and 12 as well as in Reference 11.

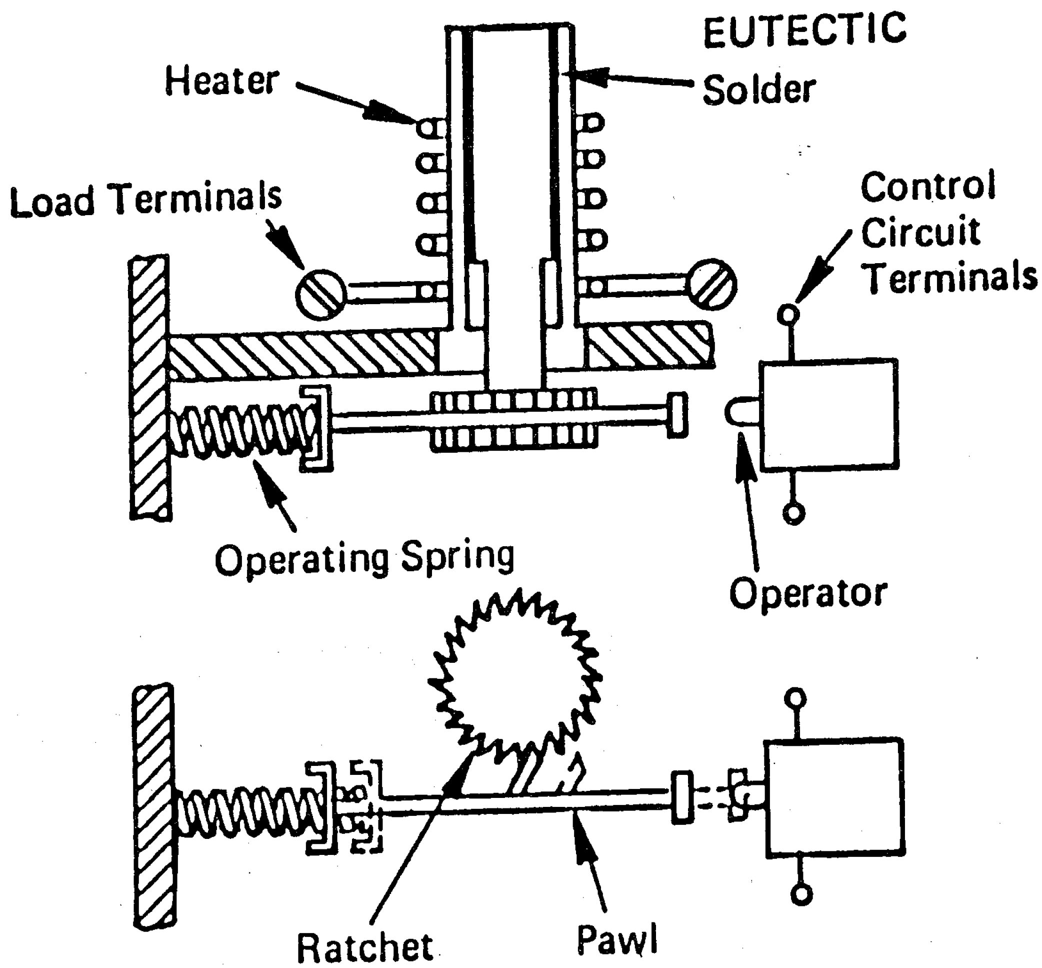


FIGURE 1. MELTING ALLOY OVERLOAD RELAY DIAGRAM

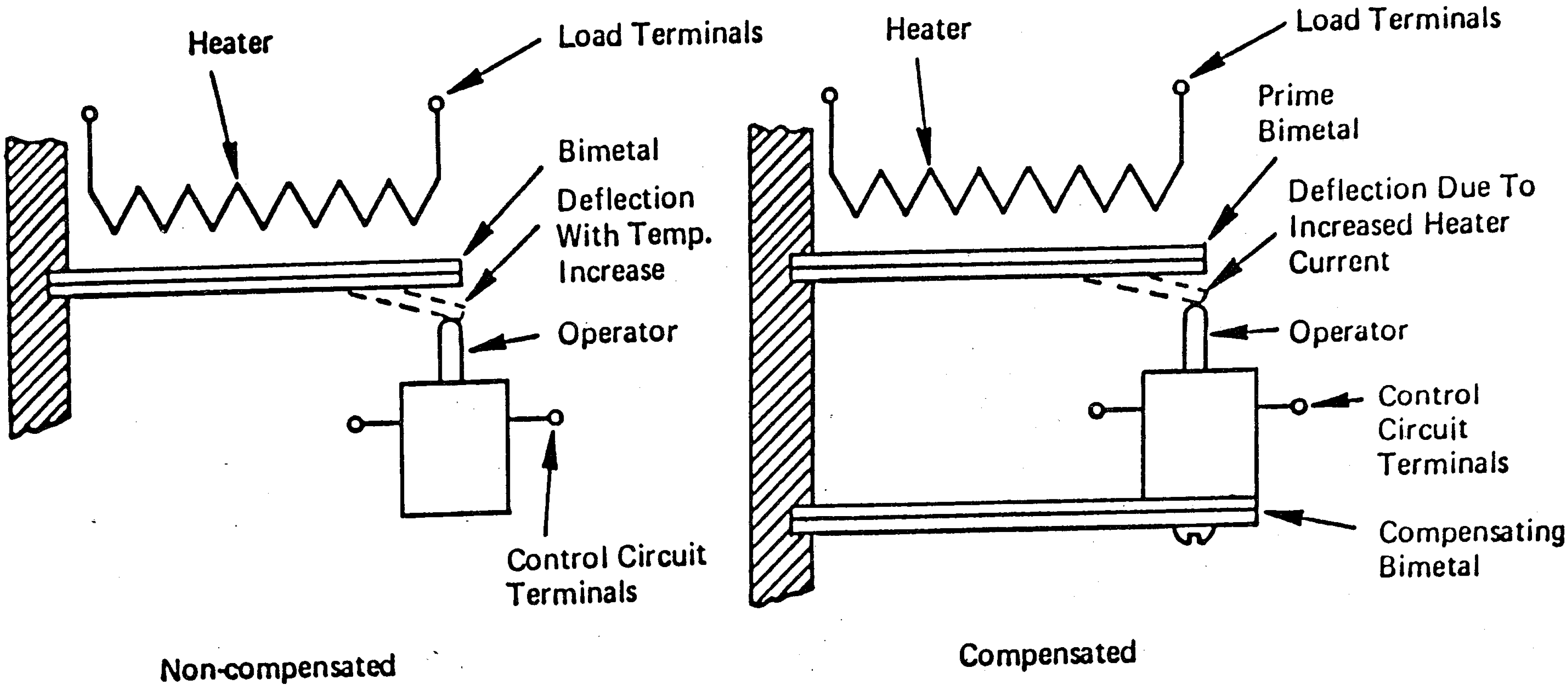
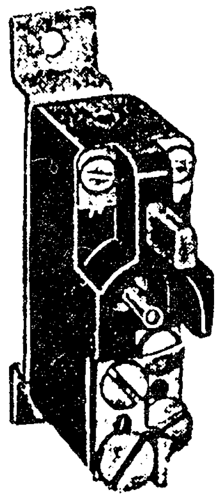
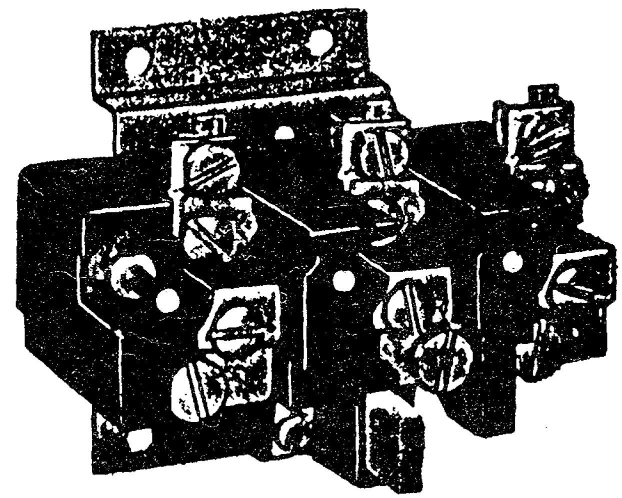


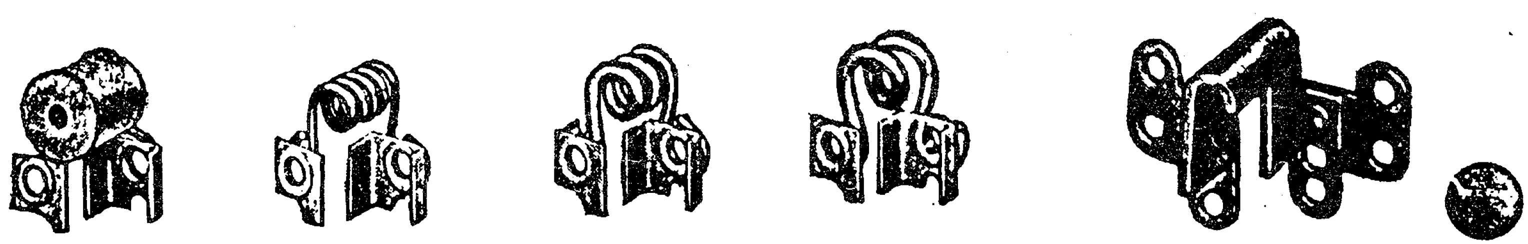
FIGURE 2. BIMETAL OVERLOAD RELAY DIAGRAM



25 AMP Single Element

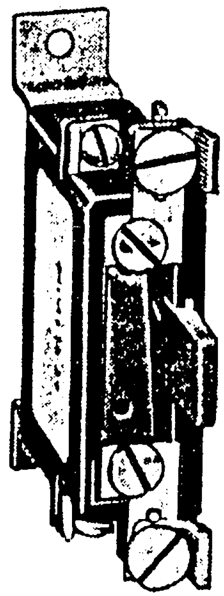


30 AMP Tri-Element Panel Mount



H Type

FIGURE 3. MELTING ALLOY OVERLOAD RELAYS AND TYPICAL HEATER ELEMENTS



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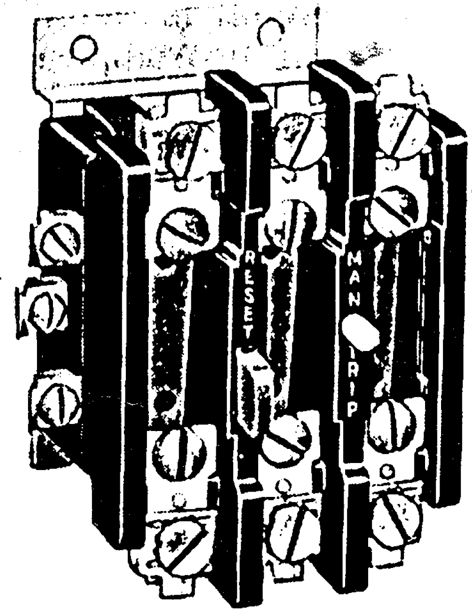

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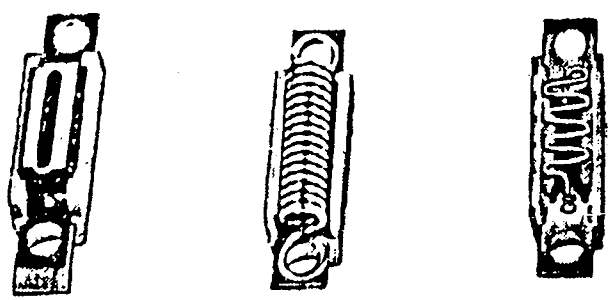
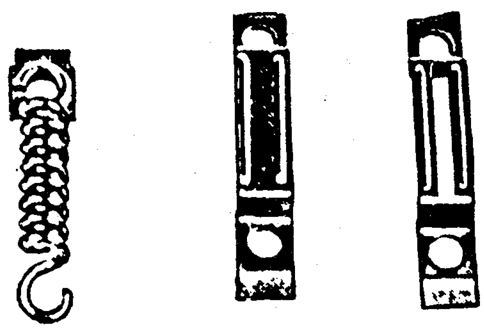


Standard Trip E Type



Quick Trip K Type

FIGURE 4. BIMETAL OVERLOAD RELAYS AND TYPICAL HEATER ELEMENTS

3. DISCUSSION OF GUIDANCE CONTAINED IN REGULATORY GUIDE 1.106, REVISION 1, AND HISTORY OF REQUIREMENTS PRIOR TO 1977

Regulatory Guide 1.106 (see Appendix C) presents three alternative regulatory positions for the use of thermal overloads to protect valve operator motors. The three positions are:

1. Continuously bypass the thermal overload protection device except when the valve motor is undergoing testing.

2. Bypass thermal overload protection only under accident conditions.

3. Keep the thermal overload protection device in the circuits continuously, but be sure that all uncertainties in trip point setting are adjusted in favor of completing the safety-related action.

At least one licensee has elected to not provide any thermal overload protection for the valve operator motors. Regulatory Guide 1.106 does not explicitly require use of thermal overload protection devices. A search of the standard review plan and standard technical specifications revealed no specific requirement to provide thermal overload protection for safety-related valve operator motors. The operator manufacturer's recommendations regarding thermal overload protection are the only explicit guidance that would mandate installation and use of thermal overload protection devices.

Regulatory Guide 1.106 was originally published in response to concerns regarding spurious trips of thermal overload devices that led to disabling of the valve operator when the operator was otherwise capable of performing its intended safety function. Although the events that caused the original concern have not been identified, evidence of the spurious trip phenomenon is available in the current licensee event report (LER) data base. Items 9, 10, and 11 in Appendix A provide descriptions of such events.

The regulatory guide is written so as to balance the need to protect the valve operator motor against the necessity to ensure that the operator protection is not a hindrance to performance of a safety function. The problem is one of competing risk.

Use of any of the three positions stated in the regulatory position would satisfy the stated requirements of NRC. The first position of Regulatory Guide 1.106 would be appropriate to protect those valves whose function is to open or close to perform a single safety-related action and which do not change position thereafter. In effect, the only time that such valve operators would not have thermal overload protection, along with the attendant risk of being spuriously disabled by the thermal overload device, would be when the valve operator is performing its single safety function. When such a valve is being exercised, for test or after maintenance, the thermal overload device would be available to protect the motor and indicate that some anomoly was preventing or hindering movement of the operator.

The second position can be advantageously applied to those valves that are automatically actuated in order to prevent or mitigate an accident. These valves might have to move during normal operation and, of course, for test or after maintenance. During normal plant operation and during stroke testing, the thermal overload protection would be in force. The application of this policy depends on having valve actuation circuitry that recognizes and responds reliably to an accident or emergency signal. Such circuitry may not be available at a particular plant. Bypass circuitry and autoactuation circuitry are also subject to failure, as documented by AEOD in Reference 2. However, it must be noted that the bypass circuitry is less subject to common mode failure.

The third position is universally applicable and appears to be widely misinterpreted in spite of clear direction provided in Regulatory Guide 1.106. This position does not mean that thermal overloads should be engineered so that no trip will ever occur, in effect removing the device from the circuit (or, by extension of this logic, removing the need to provide the device). The uncertainties to be resolved are explicitly stated in the regulatory guide and, if resolved as indicated therein, should not destroy the effectiveness of the thermal overload device.

It was recently observed by a representative of one utility that it may be difficult to design a thermal overload device so that it will protect the motor as well as the safety-related operation of the valve. This may be so but the purpose of the regulatory guide is not to advocate policies leading to burnout of the motor in a futile attempt to perform a safety-related function. Such a policy makes no sense. It is ideally desirable that the thermal overload device should trip and protect the motor when the motor cannot move the valve as, for example, when the valve disk is stuck on the seat. Since thermal overload devices are not perfect, their design is subject to compromise, and the policy stated in Regulatory Guide 1.106 favors a compromise in favor of completing the safety-related action rather than protecting a motor where a choice must be made. There is no logical reason to provide a thermal overload device designed so that it will not trip under any circumstances, and Regulatory Guide 1.106 does not specify such a policy.

Regulatory Guide 1.106 applies to thermal overload relays in the motor starter (or control center) and not to thermal overload protection embedded in the motor windings. No guidance is provided in the regulatory guide governing the use of embedded thermal overload devices and, as noted in Section 2, such devices are not known to be used in safety-related motor operators.

The phrase in the regulatory position of Regulatory Guide 1.106 that prefaces the first two positions is also to be noted. That phrase states, "Provided that the completion of the safety function is not jeopardized or that other safety systems are not degraded, . . ." It would appear from the criticisms of the regulatory guide that the meaning of this phrase has been widely ignored. Bypassing of a thermal overload device, where such bypassing might jeopardize the safety system or the completion of the safety function, is to be avoided. Obviously, if an operator might be rendered inoperable before its safety-related function could be fulfilled, the source of inoperability should be removed. The question is whether burnout will occur or an overload will trip first. In such cases the first two positions might best be avoided and the third position (paragraph 2 of the regulatory position) would be applicable. It is not logical to advocate destroying a valve motor in a futile attempt to complete a safety-related action. Regulatory Guide 1.106 does not endorse such a policy.

The discussion in the regulatory guide points to several limitations of thermal overload relays such as variations in thermal characteristics of intermittent duty motors and differences in ambient temperature between the motor and the overload relay due to their being located in different environments. These factors are to be considered in choosing the policy to be used for the design and sizing of the relays.

The history concerning NRC-recommended practice regarding use of thermal overload devices prior to the issuance of Regulatory Guide 1.106 in 1977 is of interest because of several proprietary references to a policy to size thermal overload devices to "300% of full load." An LER from Fitzpatrick (Ref. 13) refers to this policy and infers that it is still in force at that plant. As discussed in the following paragraphs, References 14 through 17 describe the policy used by NRC prior to 1975 as applied to one licensee. It is assumed that this policy was applied, more or less generically, by the NRC (then AEC) to other plants.

The references to TMI-1 and Metropolitan Edison in the following paragraphs are made only because the available documentation to illustrate several points comes from them.

In Reference 14, the AEC stated two alternative positions for design of overload heaters. These were:

"1. Use conventional size (125%) for preoperational testing, and replace with 300% rated overload heaters before initial criticality, or
2. Use conventionally sized heaters for preoperational and periodic testing, with the overload heaters bypassed when a reactor protection signal exists, i.e., under accident conditions."

The second position stated above is similar to the second position found in Regulatory Guide 1.106 and described previously in this section. The first position of Reference 14 was a source of confusion from its inception. The confusion centered around the precise meaning of "300% rated overload heaters." In Reference 15, GPU expressed this confusion and in Reference 16, Gilbert Associates (the architect/engineer for TMI-1) offered an interpretation. That interpretation was that the heaters would be sized to actuate if 300 percent of full load current were experienced by the motor for a period of time equal to the "operating time" of the valve.

By Reference 17, the AEC was informed that Metropolitan Edison would size their thermal overload heaters at TMI-1 to activate when 300 percent of full load current was experienced for the "operating time" of the valve.

The phrase "operating time" was not defined in Reference 17 and apparently not questioned by the AEC. From a study of sample calculations furnished by the licensee, it appears that "operating time" is the time required to stroke the valve in one direction.

It was also observed from the study of those calculations that the above criterion was applied to ensure that the relay did not trip until the motor experienced at least 300 percent of full load current for the operating time of the valve.

Sometime between 1974 and 1977 the NRC published Regulatory Technical Position (EICSB) No. 27 (Ref. 18). This position called for choosing the trip setpoint of thermal overload protection devices for motor-operated valves to be set at least at 300 percent of motor full load current. Reference 19 provided General Electric's proposal for satisfying this position and pointed out that the implementation of such a policy would provide no protection for the motor during testing. General Electric proposed an alternative solution. This was to remove thermal overload protection during "normal" operation and invoke realistic thermal overload protection during testing. Reference 20, which is a General Electric Service Information Letter, also recommended this alternative. Revision 1 of Regulatory Guide 1.106 allows this alternative position. At the present time the NRC staff intends to eliminate this regulatory position as part of a proposed revision to Regulatory Guide 1.106. The purpose of the proposed change is to encourage the use of thermal overload protection. Bypassing thermal overload protection except during testing may, in some cases, allow undetected degradation of the operator to occur. It was recently learned that at least one licensee was bypassing thermal overload protection, even during testing, in order to avoid removing and re-installing the bypass wires (jumpers).

The current criteria used by this licensee for selecting overload heaters for valve actuator motors is as follows (Ref. 21):

"5.4 OL HEATER SELECTION FOR VALVE ACTUATOR MOTORS, SAFETY RELATED APPLICATION

5.4.1 Criteria

5.4.1.1 When carrying maximum motor stroke current, the OL relay trip time shall not be less than 125% of valve stroke time for AC motors and 185% for DC motors.

5.4.1.2 When carrying motor locked rotor current, the OL relay trip time should not exceed the allowable stall time.

5.4.1.3 If the requirements of Sections 5.4.1.1 and 5.4.1.2 cannot be met, priority shall be given to the requirement of Sec. 5.4.1.1."

Examination of these criteria indicates that the heater will be sized for locked-rotor current at stall time (about 15 seconds for Limitorque operators in most cases) unless the criterion of 5.4.1.1 results in a larger (higher rated) heater requirement. In that case, the larger heater would be used. The criteria used in 5.4.1 above are oriented toward selecting a thermal overload heater with a higher temperature trip setpoint than that which might be chosen if motor protection were the only consideration. However, it cannot be stated that this policy does not meet the requirements of the regulatory position stated in the regulatory guide. A criterion that resulted in thermal overloads that would trip sooner would also meet the requirements of Regulatory Guide 1.106. It is also to be noted that the regulatory position is applied uniformly to all safety-related valve operators at this plant. The regulatory guide does not require such uniform application. It would appear that the position to be applied to each valve operator should depend on its design or service.

The design philosophy described above favors sizing the thermal overload devices to trip at no less than a given temperature/time value. In using such a philosophy, the approach is to size the thermal overload to trip at a higher temperature/time value rather than a lower one. In effect, the thermal overload device might be rendered inoperable and useless if the designer sizes the device for too high a temperature. This is obviously done in response to the perception that the thermal overload device should never interfere with the safety-related actuation of the valve.

There are several advantages to be gained by the use of thermal overload devices that are sized to provide realistic motor protection. Deterioration of the motor insulation or rotor over a period of time, due to exercising the valve for test or operating the valve under "normal" conditions, can go undetected and will be allowed to continue because the condition is unknown. When the valve is then called upon to perform its safety-related function (which most probably will occur at higher demand, higher temperature, or other unusual circumstances), the valve might not operate. In any case, its condition is questionable. Tripping of a thermal overload device allows for the possibility of resetting, either manually or automatically, rather than allowing the valve operator to be disabled, and thus the safety-related function might be protected rather than compromised by including a properly sized thermal overload.

If the thermal overload is provided with an alarm capability, as an alternative to disabling the valve, then setting the thermal overload to trip at an unrealistically high value will compromise the alarm. The anomaly and/or deteriorated condition of the valve will remain undetected.

The thermal overload design philosophy used by TMI-1 is based on the premise that, in the event of an anomaly, the valve operator should be allowed to attempt to perform its safety-related function without interference from spurious, or in some cases even legitimate, trips of the thermal overload. In a safety-related actuation situation, even valid trips of the thermal overload that protect the valve operator would be considered to be less useful than allowing the operator to be damaged in completing its safety-related action. It appears that the expectation that the motor will complete its safety function although damaged, when confronted with an overload situation, is unrealistically optimistic, especially since there is no possibility of recovery if the motor burns out. For example, if the hammer blow that the operator delivers at each actuation fails to unseat the valve, the motor will draw locked-rotor current until it fails or until power is removed. There is no possibility of partial damage in such a situation.

An often repeated and simplistic misrepresentation of the regulatory positions stated in Regulatory GUide 1.106 is "let the valve operator die trying." Those who may offer such a statement envision a situation in which the motor-operated valve moves to the required safety-related position and then becomes inoperable. The idea that the safety-related system function is compromised equally by actuation of a thermal overload or failure of the motor is also implicit in the statement. However, Regulatory Guide 1.106 would explicitly require bypassing thermal overloads or setting them high enough that they would never function if its purpose was merely to render thermal overload protecton inoperable. The regulatory guide points out the limitations of thermal overload protection for the specialized, intermittent duty motors used in valve operators and recommends that these devices be set so as to compromise safety-related valve operations as little as possible. Further, since thermal overload devices may be reset, either automatically or manually, their actuation as an alternative to motor burnout and subsequent system failure is obviously to be preferred.

Regulatory Guide 1.106 guidance is sufficiently broad to allow a wide range of policies regarding use and design of thermal overload devices for valve motor operators. However, it appears that there is no consensus and possibly some confusion in the industry concerning proper design parameters to be used for these devices. There is also an almost total lack of standardized guidance regarding circuit design as well as installation, maintenance, and testing. Without such uniform guidance, wide variations of use and "conservative" sizing of overload devices are to be expected.

The NRC staff is proposing to revise Regulatory Guide 1.106. The proposed revision will advocate use of thermal overload protection for safety-related MOVs, advocate that alarms to indicate thermal overload trip be provided and, eliminate the first regulatory position (bypass thermal overload devices except for testing). This will clarify the position of NRC with respect to the use of thermal overload protection. Plant owners may desire to assess their current policies regarding the use of thermal overload protection although the NRC currently does not plan to recommend action for operating plants in the proposed revision to the regulatory guide.

4. DISCUSSION OF AEOD REPORTS, LERs, AND OTHER DOCUMENTS AND FINDINGS REGARDING THERMAL OVERLOAD PROTECTION FOR MOTOR-OPERATED VALVES

References 1, 2, 5, and 6 are AEOD reports that contain information and conclusions regarding the use of thermal overload devices to protect valve operator motors in nuclear power plants.

In Reference 1, AEOD surveyed a number of valve operator failures (characterized as "events" in the report) that occurred in the period 1978 to 1980. Some of the pertinent findings in this report regarding thermal overload protection for valve operator motors were:

1. Valve motor burnout is a common occurrence in nuclear plants.

2. A strong relationship exists between the practice of bypassing thermal overload devices and valve motor burnout.

3. The recommendations contained in Regulatory Guide 1.106 to bypass thermal overload devices should be reevaluated in order to determine if such bypassing is a contributor to operator failure and thus detracts from overall safety.

4. Emphasis should be placed on implementing the third position stated in the regulatory guide, namely, not removing the thermal overload from the circuit, but rather adjusting it to trip in response to a valve anomaly rather than oversizing the heater.

The response from NRR to the (then draft) AEOD Report C203 was highly divided, as evidenced by the individual branch responses contained in Reference 22. Members of those staff organizations responsible for plant system review were opposed to reevaluation of the regulatory guide recommendations. They disputed the conclusions contained in the AEOD report and AEOD's analysis of the events leading to those conclusions. The systems engineers argued that Regulatory Guide 1.106 balanced system function against overload protection appropriately. The Mechanical Engineering Branch (MEB) of NRR, whose primary concern was focused on the valves and operators as independent safety-related mechanical components, recommended reevaluation of the regulatory guide. This was based on the argument that allowing the valve motor to burn out rather than being tripped on thermal overload was usually less desirable since the chances for permanent loss of the operator were increased. AEOD and NRR/MEB argued that a thermal overload device could be reset more readily than a burned out motor could be replaced.

Another argument offered by AEOD to support the need for increased thermal overload protection was that long-term, nondisabling deterioration might lead to valve failure when the valve was challenged (for example, during a design basis event). Obviously, this phenomenon has been difficult to confirm from the currently available failure data bases. The disagreement within the NRC staff organizations centered around the assessment of reliability of thermal overload devices to protect the motor without interfering with the safety function. This is directly related to the question of the reliability of these devices to trip when required, but not spuriously or prematurely.

By Reference 5, AEOD cited and evaluated eight additional motor-operated valve failures. That report was issued to support the findings of Reference 1. AEOD concluded that inadequate thermal overload protection was one of the factors leading to degradation and ultimately to failure of several of the operator motors.

By Reference 6, AEOD forwarded a report that evaluated 200 motor burnout events and the relationship of these events to thermal overload protection. One central finding was that there is a lack of valve motor protection and that thermal overload devices are not being used effectively to protect motors against overheating. Further, the thermal overload devices currently installed were considered not to provide adequate alarm functions in most cases. Finally, the report concluded that valve motor burnout was widespread and might be a common mode type of failure.

Reference 2 is an update and summary of previous AEOD reports. In this report, AEOD restated the need to reevaluate the policy stated in Regulatory Guide 1.106 to bypass thermal overload devices. An explanation and analysis of signature analysis techniques to diagnose root cause of misadjustments and deficiencies were also included.

The LER data base was examined as part of this study to find specific references to valve motor burnout involving thermal overload devices. In some of these records, thermal overload devices are mentioned; in others, the relationship of the failure to lack of thermal overload protection was inferred. To some extent, this work overlapped that done in the above-mentioned AEOD reports. However, an attempt was made to draw an independent conclusion of the usefulness of thermal overload devices to protect the valve operator without interfering with its safety-related function. Details of the LER search are contained in Appendix A.

It is concluded here and in Reference 6 that thermal overload devices are not being used effectively in nuclear power plants to protect valve operators. To the extent that Regulatory Guide 1.106 emphasizes bypassing thermal overloads, or setting them to trip at higher currents than might otherwise be chosen, the regulatory guide's positions could be held responsible for burnout events. It must be emphasized that the guidance contained in Regulatory Guide 1.106 is not incorrect. Rather, the interpretation by nuclear power plant owners of that guidance emphasized oversizing or eliminating thermal overload protection in an effort to eliminate any possibility of spurious tripping.

Another conclusion drawn from this study of LERs was that a tripped thermal overload device may be capable of being reset, either manually or automatically, allowing the operator another opportunity to function. Alternatively, failure of an operator motor allows no immediate option other than manual operation, which is sometimes not available. Thus, although the explicit regulatory position stated in Regulatory Guide 1.106 does not mandate that the thermal overload device be designed to provide inadequate or even no protection, the practical ramifications of implementing these policies have led to several motor burnout events. These are documented in the AEOD reports (Refs. 1, 2, 5, and 6).

The activation of a thermal overload device in a valve operator circuit indicates that some anomaly that causes the motor to draw current to the extent that the motor might be damaged has occurred. If the valve and operator are properly installed, adjusted, operated, and maintained, the thermal overload should not activate. Recently, in situ valve monitoring techniques have become available to allow for detection and correction of many misadjustments that would otherwise cause overloading of the valve operator motor. These signature analysis techniques are described in References 3, 11, and 12. To the extent that signature analysis techniques are successful in practice, they may decrease the need for thermal overload protection. When such techniques are used, the goal of Regulatory Guide 1.106, which is to protect the safety-related function of the valve without interference from needless activation of the thermal overload device, can be accomplished, provided the thermal overload devices are set to trip at realistic levels.

The standard technical specifications for Westinghouse, General Electric, Combustion Engineering, and Babcock & Wilcox plants contain provisions covering safety-related motor-operated valve thermal overload protection and bypass devices. Essentially, these technical specifications call for listing in a table all safety-related valves that contain a thermal overload device. A column in the table indicates the presence or absence of a bypass device. Further, technical specifications require that the thermal overload devices and the bypass switches be periodically tested in order to ensure their operability. If the thermal overload bypass device for any particular valve is found to be inoperable, the associated valve must be declared inoperable since the conservative assumption is made that if the thermal overload is active, it will disable the valve operator.

The standard technical specifications do not provide any guidance concerning which position of Regulatory Guide 1.106 is to be used for a particular application. There is no need to modify the standard technical specifications since they do not require the use of thermal overload devices or bypass devices or prohibit the use of either.

The proposed revision to Regulatory Guide 1.106 responds directly to AEOD's concerns. The revised regulatory guide will advocate use of thermal overload protection for safety-related motor-operated valves, advocate use of alarms to signal a thermal overload trip, and eliminate the regulatory position in the current regulatory guide that offers the alternative to bypass thermal overloads except for testing.

5. CONCLUSIONS AND RECOMMENDATIONS

A. The positions stated in Regulatory Guide 1.106, Revision 1, are technically correct. These positions allow a wide range of choices by plant owners for the use of thermal overload protection for safety-related motor-operated valves. These positions are a compromise between the competing risks of protecting the valve operator from undetected degradation and future burnout versus possibly preventing the system from performing its safety function. The regulatory guide emphasizes system function over protection of the operator.

Many plant owners adopted policies regarding the use of thermal overload devices that emphasized (and in some cases overemphasized) bypassing or oversizing these devices. This subsequently may have led to failure or premature degradation of a number of valve motor operators because of excessive wear, misadjustments, defective parts, or poor maintenance.

It was concluded from a study of choices by various licensees for the use of thermal overload protection (see Appendix B) that licensees are taking a very restrictive approach to the use of such devices for safety-related valve motor operators. For example, sometimes thermal overloads have been excessively oversized. In some cases, licensees have chosen one particular policy from Regulatory Guide 1.106 and applied that policy for all thermal overload devices even though the service and hardware are quite varied. In some cases, licensees have bypassed (or even omitted) thermal overloads in deference to a restrictive interpretation of the regulatory requirements.

The tripping of the thermal overload device only disables the operator temporarily, assuming that some kind of a reset feature is available, which is usually the case. Also, if the thermal overload device trips before damage or deterioration of the operator has occurred in normal use or during a test, the operator will be better able to perform its safety function because the potential deterioration will have been prevented. Further, tripping of a thermal overload device in normal service or during a test provides a warning that some anomaly has occurred, which can be attended to before a safety-related action is needed. Such action may also prevent an anomaly in the system serviced by the operator due to a future demand. Finally, thermal overload devices can be arranged to provide an alarm function instead of disabling the operator or in addition to disabling the operator. Therefore, thermal overload devices can serve very useful functions and should be provided. The regulatory guide allows sufficient options for provision of adequate thermal overload protection and is not excessively restrictive as written.

It is possible, within the guidance stated in the regulatory position of Regulatory Guide 1.106, to provide thermal overload protection for valve motor operators without compromising the safety function of the valve. However, emphasis should be placed on proper engineering and use of thermal overload devices rather than the usual practice of indiscriminate bypassing or oversizing. This conclusion is based on a study of programs now in force in several nuclear plants. These programs all involve efforts to make use of thermal overloads in compliance with Regulatory Guide 1.106 while at the same time providing protection for the motor operators.

B. Some plant owners now use thermal overloads as nondisabling devices to signal an alarm when the valve motor generates overcurrent (and thus heat) beyond the trip setpoint of the device. When used in such a fashion, the thermal overload device can be set to trip without particular concern that the setpoint may be too low. This is considered to be a very useful option for the application of thermal overload devices. Proposed Revision 2 to Regulatory Guide 1.106 is now being considered. As part of that revision, consideration is being given to recommending the use of thermal overload devices as nondisabling alarms.

Alternatively, the alarm function can be coupled with a disabling trip of the operator. In this situation, if the thermal overload is set so as to trip at a "conservatively" high level, the alarm would be given at that level. Care must be taken, if this policy is chosen, to set the thermal overload and balance the need to complete a particular safety-related valve function against the possibility of damaging the motor over time or perhaps destroying the motor in a single operation.

C. The philosophy to be preferred for the choice of regulatory position from Regulatory Guide 1.106, as well as for the selection and sizing of thermal overload devices for safety-related valve operator motors, should be to protect the motor without interfering with the safety function of the valve. Ideally, the operator should be allowed to function in a safety-related situation up to the point of just before failure without interference from the thermal overload device. However, because of such variables as design, installation, maintenance, and testing, thermal overload devices may not perform as expected.

The design sizing and circuitry logic for thermal overload protection devices can vary quite widely. Relay designs vary between manufacturers. The range of temperature over which the heater activates, as well as the error range, must be considered. Difference in ambient temperature that may occur between the location of the motor and the location of the thermal overload heater is an important consideration. Deterioration of thermal overload devices must be considered in design, maintenance, and testing. All these factors must be considered along with the necessity to not interfere with the safety-related operation of the valve motor.

Many thermal overload problems involve improper engineering in the choice, sizing, or placement of the devices. Maintenance may also be deficient.

There is little industrywide technical guidance and few standards available to aid in the selection of thermal overload protection devices for valve operators. Further, no standard guidance exists covering details of the installation, maintenance, and testing of these devices. Licensees have chosen various policies, hardware, setpoints, maintenance procedures, and test procedures. A large number of motor burnout events have occurred in safety-related valve operators. These events are likely to have been as the result of undetected degradation during normal operation and testing. There are a large number of operators, the operators are used in common modes and are similarly designed, maintained, and tested. Thus, the effect on safety could be severe. Therefore, a desirable goal would be to establish acceptable guidelines and standards for design, installation, maintenance, and testing of overload devices for valve motor operators. This would reduce valve motor burnout and the attendant risks in nuclear power plants.

D. The use of a thermal overload device is only one alternative method of ensuring that a valve operator motor will not be overloaded. Recent advances in diagnostic techniques allow for identification and correction of misadjustments and deteriorated conditions that might interfere with the normal or design basis operation of the motor-operated valve. To the extent that these methods are successful, they will preclude the need for motor protection because the motor will not be overloaded. These signature analysis techniques appear to provide reliable information on valve performance. Further, the signature analysis techniques are improving and may soon offer the option of continuous monitoring, thus making thermal overload protection redundant.

E. Nuclear industry standards should be developed or revised to include uniform instructions for the detailed design, installation, maintenance, and testing of thermal overload devices for motor-operated valves. Currently, ANSI/IEEE Standard 741-1986 entitled "IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations" (Ref. 23) is being revised to provide detailed design guidance for thermal overload protection of motor-operated valves. NRC/RES will contact several nuclear standards organizations, as part of the resolution of Generic Issue II.E.6.1, to suggest that detailed guidance for installation, maintenance, and testing of thermal overloads for motor-operated valve protection be developed.

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APPENDIX A

LERs PERTINENT TO THERMAL OVERLOAD PROTECTION ISSUE

The following LERs pertinent to the issue of thermal overload protection of safety-related valve motor operators were selected from an examination of 459 records concerning electric valve operators.

Item No.	Docket, Plant Name, LER	Event Description
1.	50-237, Dresden 2, 82-018	While performing quarterly valve timing surveillance, the isolation condenser steam supply inboard isolation valve, MO-2-13-1-1, failed to open. The failure was probably due to a thermal overload trip caused by slight binding in the valve. During subsequent testing, the valve (Crane Model 783UL, Limitorque SM82 Operator) operated properly. The valve is presently backseated open, and it will be repacked and tested during the next unit outage of sufficient duration.
2.	50-237, Dresden 2, 83-024	During refueling outage while performing core spray operability test, test valve MO-1402-4A failed to open. After several attempts to open the valve, the thermal overload contacts tripped. No past occurrences were reported. The cause of the event was due to a burned out motor. (Limitorque Type - P). A ground, due to a breakdown in the insulation, probably caused it. It was replaced with a like for like; the valve was satisfactorily cycled three times to verify operability.
3.	50-266, Point Beach, 81-004	While conducting inservice testing of containment spray valves (IT-50), valve 1-860D, containment spray discharge MOV, failed to open. The closing torque of the valve operator was excessive because of out-of-adjustment closing torque switch. When attempting to open the valve during testing, the motor stalled and caused the breaker

Item No.	Docket, Plant Name, LER	Event Description
		to trip on thermal overload. The closing torque switch was adjusted, the valve retested and returned to service.
4.	50-271, Vermont Yankee, 81-014	When returning RWCU to service, the outboard isolation valve V12-18 would not open. The operator manually took the valve off its seat and reset the overload, and the valve opened normally. Ten minutes later, RWCU pumps tripped and indication of V12-18 was lost. The system was then isolated per Tech. Spec 4.7.D.2. This event was most probably caused by the cooling of the RWCU line and jamming of the valve. This, in turn, opened the thermal overloads and burned out the motor. Corrective action was to replace the motor, inspect the breaker, and return the system to operation.
5.	50-280, Surry 1, 81-060	The outlet valve from the chemical addition tank would not cycle electrically. The motor operator overload protection thermalled open while attempting to cycle the valve. This is believed to have been the result of the valve having been overly tightened by hand approximately 24 hours earlier. The valve was opened by hand and satisfactorily cycled.
6.	50-293, Pilgrim 1, 80-042	During a timing surveillance, HPCI torus suction valve #MO-2301-35 did not operate. The tech spec required action and surveillances were immediately performed. An open field winding was found on the operating motor; due to its required service the motor has no thermal overload or torque switch protection. The motor was rewound, the valve mechanically tested for binding, electrical parameters found normal and returned to service on 10/3/82. The motor was last replaced in 1973.

Item No.	Docket, Plant Name, LER	Event Description
7.	50-298, Cooper, 82-003	During S.P. 6.3.5.2, an overload alarm condition was received while closing RHR-MO-26B valve. The valve did go fully closed; the overload contacts were reset and alarm cleared. Operator for subject valve is Limitorque SMB 0. The motor brake coil failed to release. This in turn caused the motor to overload and give overload alarm condition. New motor and brake were installed and tested satisfactorily.
8.	50-333, Fitzpatrick, 82-044	During the residual heat removal MOV operability surveillance test, the motor operator electrical breaker tripped while attempting to cycle an LPCI injection valve (10MOV25A). An electrical motor fault, resulting in insulation failure was created during the attempted valve cycling. Because of regulatory requirements, the safety-related motor must have 300 percent thermal overload protection rather than a typical 100 to 120 percent overload that would ensure no motor damage as a result of an electrical fault. The motor was replaced and the valve restored to service.
9.	50-318, Calvert Cliffs 2, 81-009	A motor-operated isolation valve (2-MOV-5251) in the salt water system supply to the circulating water pump room air coolers would not operate electrically. Similar events: None. Overload devices on Phases A and C were tripped. These were reset and the valve was stroked several times while monitoring motor current. The valve stroked satisfactorily; current readings were normal. No problems with valve operation were observed. The motor and breaker are tested annually.

Item No.	Docket, Plant Name, LER	Event Description
10.	50-317, Calvert Cliffs 1, 82-032	A motor-operated isolation valve (1-MOV-5251) in the salt water system supply to the circulating water pump room air coolers would not operate electrically and therefore would not have responded properly to an SIAS (Tech Spec 3.7.5.1). Investigation determined that the motor overloads were tripped. The overloads were immediately reset and the valve tested satisfactorily. Similar event: 50-318/81-009. Thermal overloads on Phases A and C were found tripped. These were reset and the valve operated satisfactorily. Investigation into the cause is continuing. Gearbox lubrication will be checked, and the overload devices will be functionally tested. The motor and breaker are tested annually.
11.	50-305, Kewaunee, 81-003	During testing of valve CC400B (component cooling water inlet to 1B residual heat exchanger) following the reinstallation of the motor operator, the supply thermal overloads tripped. The motor operator failure was attributed to a wiring error by a plant electrician, which resulted in the thermal overloads tripping. The wiring fault was identified and corrected, and the valve/operator tested satisfactorily. The procedure was reviewed with the electrician.
12.	50-315, D.C. Cook 1, 81-004	During a record review on 3/28/81, it was noted that the east motor-driven auxiliary feed pump was removed from service on two occasions to enable repairs to the EWS supply valve, WMO-754. On the first occasion, the system was tagged out to investigate seat leakage and, on the second occasion, the valve and the operator motor were replaced. This was the first occurrence of this type. The valve stem was seized in the body and twisted. The 4-inch centerline valve was replaced with a Pratt valve.

Item No.	Docket, Plant Name, LER	Event Description
		While adjusting the valve stroke, the motor on the Limitorque operator burned when the valve was driven into a stop. The motor was replaced and the valve was tested satisfactorily.
13.	50-315, D.C. Cook 1, 82-041	Feedwater isolation valve FMO-202 failed while being used to regulate feedwater flow. Auxiliary feed was placed in service to meet system requirements. Frequent cycling of the isolation valve apparently generated a heat buildup that resulted in seizure of the Limitorque stem nut (Item 20, Drawing 01-416-0029-4) to the valve stem and failure of the SB-3 Limitorque operator motor. The stem nut and motor were replaced. Procedural changes will be implemented to prevent the use of the feedwater isolation valve to control feedwater flow.
14.	50-324, Brunswick 2, 81-082	Following a reactor scram in which HPCI and RCIC systems autoinitiated on low reactor water level, it was discovered that suppression pool level had exceeded specifications (-27.0 inches) with the highest recorded value being -26.5 inches. Reactor water from an open safety-relief valve and water from the condensate storage tank via a failed-open HPCI system minimum flow valve, 2-E41-F012, caused the level to be exceeded. Within 25 minutes of discovery, both valves were closed and the level was returned to normal. The F012 valve was inoperable because of burned windings in the valve operator motor.
15.	50-333, Fitzpatrick, 86-003	Power level - 100%. On 3-12-86, the high-pressure coolant injection (HPCI) outboard steam supply valve bypass valve (23-MOV-60) failed to operate properly during surveillance testing. The motor was damaged by overheating. The motor was replaced and stroked satisfactorily. Inspection revealed the clutch mechanism was corroded, which is believed to have been caused

Item No.	Docket, Plant Name, LER	Event Description
		by steam from a packing leak. The corrosion caused the manual clutch to jam, thereby not allowing the motor to engage. The jamming of the clutch allowed the motor to operate in excess of its duty cycle until the heat generated by the operation damaged the winding insulation. The corroded parts were replaced and the drive shift cleaned. The valve was retested satisfactorily.
16.	50-333, Fitzpatrick, 86-014	On September 3, 1986, while at 100 percent power, the circuit breaker for the HPCI torus suction valve operator, 23 MOV-58, tripped on an open signal from the control room, thus rendering HPCI inoperable. An investigation revealed that the actuator's motor had failed because of overheating attributed to excessive stroking during a plant surveillance test entitled HPCI Subsystem Logic System Functional Test, "F-ST-4E." The motor was replaced under the plant's modification program and HPCI restored to service. Corrective actions include: (a) a review of surveillance tests to identify other DC motor-operated valves that could be subjected to overstroking, (b) an analysis to confirm operator size, configuration, and switch settings as adequate, and (c) the examination of a similar valve that underwent the same cycling frequency during the identified surveillance test.
17.	50-348, Farley 1, 81-049	The A train containment cooler 1B was declared inoperable when the associated motor-operated valve (MOV 3024B) failed to open when signaled. The event was caused by an MOV motor winding failure. The motor was replaced and following successful completion of the service water valves inservice test, the A train containment cooler 1B was returned to service.

Item No.	Docket, Plant Name, LER	Event Description
18.	50-373, LaSalle 1, 83-111	On 8-21-83 the RHR A pump suction valve 1E12-F004A would not operate properly from control room panel 1H13-P601. The LPCI mode of RHR A is required to be operable per Tech Spec 3.5.1 in the operational condition 3. All other ECC systems were operable. Valve 1E12-F004A was operable manually. Safe plant operation was maintained. The 1E12-F004A valve motor was found to be damaged. The torque switch within the motor operator was found to be broken and is the most probable cause of motor damage because it failed to stop the motor at the end of valve travel. Nuclear work request L27021 replaced the motor and torque switch. The valve was tested satisfactorily on 8-26-83.
19.	50-282, Prairie Island 1, 85-013	Power level - .002%. During startup, a containment isolation valve failed to open on demand. Repeated attempts to open the valve resulted in failure of the valve operator motor and tripping of its motor control center, which made several other safeguards motor-operated valves inoperable in one train. Damaged equipment was replaced.

APPENDIX B

SUMMARY OF POLICIES AT SEVERAL PLANTS REGARDING THERMAL OVERLOAD PROTECTION OF SAFETY-RELATED MOTOR-OPERATED VALVES

PLANT	POLICY
CATAWBA	Thermal Overloads (TOLs) bypassed except for testing. An alarm function is provided during plant operation.
CLINTON	TOLs bypassed except during valve testing.
GRAND GULF	Most TOLs are continuously by-passed except for test. Some are never bypassed; a few are by-passed for accident condition only.
LIMERICK	Alarms always in circuit. TOL disabling of valve not allowed during accident condition.
NORTH ANNA	TOLs continuously in service.
PILGRIM	Alarm function only during all plant conditions. TOLs used during testing but only with alarm (no disabling). Licensee is re-evaluating policy at this time.
SUSQUEHANNA 2	TOLs bypassed except during valve testing.
TMI-1	TOLs continuously in service. (See discussion in Section 3.)
VOGTLE	TOLs bypassed except during valve testing.
WNP-2	TOLs continuously in service. TOLs are selected two sizes larger than normal.

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REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.106

THERMAL OVERLOAD PROTECTION FOR ELECTRIC MOTORS ON MOTOR-OPERATED VALVES

A. INTRODUCTION

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," 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 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.

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 include operational tests during nuclear power plant operation.

* This regulatory guide describes a method acceptable to the NRC staff for complying with the above 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. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

Motor-operated valves with thermal overload protection devices for the valve motors are used in safety systems and in their auxiliary supporting systems. Operating experience has shown that indiscriminate application of thermal overload protection devices to these valve motors could result in needless hindrance to successful completion of safety functions.

Thermal overload relays are designed primarily to protect continuous-duty motors while they are running rather than during starting. Use of these overload devices to protect intermittent-duty motors may therefore result in undesired actuation of the devices if the cumulative effect of heating caused by successive starts at short intervals is not taken into account in determining the overload trip setting.

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.

* Lines indicate substantive changes from previous issue.

Since the trip function in a thermal overload device 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 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 200°F under design basis conditions. Thus, the selection of an appropriate trip setpoint 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% to 0% of trip setpoint. Since 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 setpoint 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. In some plants, the thermal overload devices are bypassed during normal plant operation, except that they are temporarily placed in force when the valve motors are undergoing periodic testing.

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. REGULATORY POSITION

In order 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 two alternatives described in regulatory position 1 or the one described in regulatory position 2 should be implemented:

1. Provided that the completion of the safety function is not jeopardized or that other safety systems are not degraded, (a) the thermal overload protection devices should be continuously bypassed and temporarily placed in force only when the valve motors are undergoing periodic or maintenance testing or (b) those thermal overload protection devices that are normally in force during plant operation should be bypassed under accident conditions.

The bypass initiation system circuitry should conform to the criteria of Sections 4.1, 4.2, 4.3, 4.4, 4.5, 4.10, and 4.13 of IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," and should be periodically tested.

2. The trip setpoint 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, (b) inaccuracies in motor heating data and the overload protection device trip characteristics and the matching of these two items, and (c) setpoint drift. In order to ensure continued functional reliability and the accuracy of the trip point, the thermal overload protection device should be periodically tested.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein is being and will continue to be used in the evaluation of submittals for construction permit applications until this guide is revised as a result of suggestions from the public or additional staff review.

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The NRC regulatory positions, as stated in Regulatory Guide 1.106, Revision 1, have been identified by the Office for Analysis and Evaluation of Operational Data (AEOD) as potential contributors to valve motor burnout. AEOD is particularly concerned about the allowed policy of bypassing thermal overload devices during normal conditions. Regulatory Guide 1.106 favors compromising the function of thermal overload devices in order to avoid interfering with the safety-related operation of motor-operated valves. This report describes thermal overload devices and their use. It is concluded that the policies stated in Regulatory Guide 1.106 are technically correct and allow sufficient flexability to allow the use of thermal overload protection without interfering with safety-related functions of motor-operated valves. However, it appears that licensees are needlessly bypassing or otherwise compromising the use of thermal overload protection. Some licensees are using inadequate design practices to size thermal overload devices. The problem of valve motor burnout is related to a lack of standards and uniform guidance for the design, installation, maintenance, and testing of motor overload protective devices. The NRC's Office of Nuclear Regulatory Research will contact several nuclear standards organizations to suggest that detailed guidance for thermal overload protection of motor-operated valves be developed.

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