SEP Topic No. III-10A, Thermal-Overload Protection
for Motors of Motor-Operated Valves

Oyster Creek Nuclear Generating Station
Docket No. 50-219

Thermal Overload Set Points for Safety Related Motor Operated Valves

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1.0 INTRODUCTION

This study was initiated as a result of the SEP TOPIC III-10-A on thermal overload (TOL) protection of the motor operated valves (MOV) on safety related systems. A generic method for establishing the TOL set points was developed to satisfy the requirements of Regulatory Guide (RG) 1.106 position C2, i.e., the trip setpoint of the thermal overload protection devices should be established with all uncertainties resolved in favor of completing the safety-related action.. This method was based on the factors that influence the sizing and performance of thermal overload relays at the Oyster Creek Nuclear Generating Station (OCNGS). A sample calculation was performed for a safety related (SR) motor operated valve at the OCNGS. The results were reviewed and demonstrate compliance with RG 1.106 position C2.

2.0 REFERENCES:

2.1 Telecon w/Denny Custodio - Plant Engr. OCNGS. - dt: 11/02/83

2.2 Limitorque Valve Actuator Test Reports: -

- 01 BWR Containment Qualification Report No. 600376A
- 02 Outside Containment Qualification Report #B0003
- 03 DC Actuator Qualification Report No. B0009
- 04 Limitorque Test Report #F-C3271 - "Qualification Test of Limitorque Valve Actuator in a Steam Environment" - February 1972.

2.3 EDS Report No. 02-0990-1085, July 1981 - "Post Accident Environmental Mapping of the Reactor Bldg".

2.4 Oyster Creek Qualified Equipment Locations and Environments - TDR No. 297

2.5 "Voltage Drop Analysis Study for OCNGS" - Burns & Roe. Inc., DCC File No. #20.3003-4370-ET310

2.6 GE Heaters Selection Guide - GET2G81H

2.7 Limitorque Bulletin LM-77, Limitorque Motors.

2.8 Limitorque Bulletin FC-77, Fast Closing Valve Operators

2.9 "The Dangers of Bypassing Thermal Overload Relays in Nuclear Power Plant Motor Operated Valve Circuits." A paper by Farouk Baxter presented at IEEE PES Winter Meeting in New York, Feb. 3-8, 1980.

2.10 OCNGS - Plant Procedures #610.4.003.

2.11 Field Verification of Operator Motor data for Core Spray Valves V-20-15, V-20-40, V-20-20, V-20-41.TR #002998 Response - ATMCGARRIGUE to A. Baig dated 3/2/83.

2.12 "Nema Code Letters" - Nema Standards MG1-10.36.

2.13 OCNGS - Maintenance Procedure #700.2.010.

3.0 METHODS:

Thermal overload (TOL) relays are current sensitive devices which, when properly sized, protect motors against overheating due to overloads. The relays operate on a thermal principal in which the heat that causes relay operation is obtained from a TOL "heater" which is in series with the motor winding. When a motor is overloaded, due to locked rotor or running overload condition, it draws more than the rated full load current (FLC) and the "heater" develops sufficient thermal energy to move the bi-metal strip of the relay and cause its operation. The relay trips and de-energizes the holding coil of the motor starter causing the opening of the starter main contacts and disconnection of the motor from its power source.

Motor operated valves (MOV) are powered from motor control centers (MCC) which may be located in a different environment than the operator. In order to effectively protect the motor winding, TOL relays should simulate the operator environment and its heating effect on the motor winding. Section 3.1 lists the Reg. Guide 1.106 requirements for the TOL set points and the uncertainties which influence their performance. These factors are discussed under Section 3.2 on a generic basis for OCNGS, and corresponding multipliers are applied to arrive at the modified values of motor full load current (I_B) and the motor locked rotor current (I_{LRC}) which are then used to calculate the proper TOL heater sizes. Section 3.3 establishes the acceptance criteria for the TOL set points. Section 3.4 describes a step by step generic approach for sizing the TOL heaters at the OCNGS. In Section 3.5 sample calculations are performed for a safety related MOV by applying the generic method of 3.4 and the acceptance criteria of Section 3.3. Requirements of Section 3.1 are then applied to these setpoints to see if they meet the Reg. Guide 1.106 position C2 with all uncertainties resolved. This is discussed under Section 3.5.

3.1 REQUIREMENTS OF REG GUIDE 1.106:

Position #C2 of Reg Guide 1.106 is applied to arrive at the acceptable setpoints for the TOL relays. Its requirements are:

3.1.1 The TOL setpoints shall allow the MOVs to go to the fully closed or fully open position and vice-versa to complete their safety function for a safe shutdown.

3.1.2 The following uncertainties should be resolved for acceptance of the TOL setpoints:

3.1.2.1 Variations in the ambient temperature at the installed location of the overload protection devices and the valve motors.

3.1.2.2 Inaccuracies in motor heating data and the overload protection device trip characteristics and matching of these two items.

3.1.2.3 Set point drift.

3.2 CRITERIA FOR SIZING THE TOL's:

This section discusses the effect of various factors that influence the sizing and performance of TOL's. Multipliers to the nameplate rated motor full load currents are applied to compensate for the affect of these factors.

3.2.1 MOTOR FULL LOAD AMPERES (MFLA):

Motor nameplate current, rather than the current from NEC tables or any calculated value should be used in sizing the TOL heaters. NEC tables represent only an average value of the motor full load current.

3.2.2 MOTOR SERVICE FACTOR (MSF):

A higher than unity (1.0) service factor offers following inherent motor design advantages.

(a) Longer insulation life expectancy when the motor is operated at the nameplate rated standard horsepower (HP), and ambient temperature.

(b) Operation of the motor at higher ambient temperature at the base rated HP with the assurance of full normal insulation life expectancy.

(c) Continuous overload capability (e.g. 15% more for a 1.15 SF motor) within the motor rated ambient and with normal service factor insulation life expectancy.

(d) A motor with a higher than unit service factor can deliver higher than the nameplate rated HP and motor current.

The multiplier for adjusting the MFLA is the

Motor Service Factor(MSF).

At OCNGS, Limitorque operators are used on MOV's. The motors on these operators have a service factor (SF) of 1.0. This means the motor shall be able to provide all the above described design advantages for the duration of the motor duty rated time. If the MOV stroke time is less than the motor duty time, the additional design advantages are due to the inherent motor service factor for which no additional credit is taken. This service factor is given by the following:

$$\frac{\text{Duty Rating}}{\text{Operating Time}} = \text{inherent service factor}$$

For a conservative approach the MSF is taken to be = 1.0

3.2.3 AMBIENT TEMPERATURE: (AT)

The MOV operator may experience a higher or lower ambient than its design. To compensate for the affect of this temperature differential the MFLA and motor locked rotor current (MLRC) to be used in sizing the TOL heaters should be adjusted as follows:

(i) Decrease the MFLA and MLRC by 5% for every 5^{o}C the operator motor ambient exceeds its qualification ambient.

(ii) Increase the MFLA & MLRC by 5% for every 5^{0}C the operator qualification ambient exceeds its accident operating ambient.

The multiplying factor ATo in this case = ($1\pm0.01T_o$, where T_o is the temperature differential in steps of 5^oC.

Similarly when TOL relays and operator motor are located in a different ambient, the MFLA and motor locked rotor current (MLRC) should be adjusted by using a multiplying factor of $AT_d = (1\pm0.01T_d)$.

When the TOL are located in a varying ambient and non-ambient compensating TOL relays are used, a similar multiplying factor $AT_c = (1\pm0.01T_c)$ should be applied to compensate for its affect on the performance of TOL relays.

At OCNGS the MOV operators are by Limitorque Corporation. The TOL relays and TOL heaters are G.E. type CR-124A and CR-123 respectively (Ref. #1). The GE reversing starter for the operators has coil type CR-109. These TOL-relays are rated for -20° thru 60°C ambient.

At OCNGS the affect of ambient temperature is reviewed as follows:

3.2.3.1 LIMITORQUE OPERATOR AMBIENT (AT_o)

Equipment qualification reports of Ref. 2.2 from Limitorque corporation list the thermal aging performances for the valve actuators of various types and sizes of MOVs on a generic basis. Motor winding thermal withstand ratings from these reports can be used to ascertain if they will be able to withstand the accident condition ambient temperatures listed in Ref. #2.3 & 2.4. These references list the aging temperatures representing the conservative plant operating temperatures and the maximum temperatures expected during a postulated accident. If the qualification temperature of the operators is higher than their postulated accident condition maximum temperature, no multipliers are used to take credit for the extra temperature withstand capability of the operators. This action is in a

conservative direction and in compliance of RG 1.106. If the qualification temperature is less than the accident ambient, the multiplier "AT_O" for MFLA and MLRC is as follows:

$$AT_O = (1-0.01T_O)$$

At OCNGS, all the Operators for the safety related systems are qualified for Class 1E application, the operators qualification ambient, therefore, will be at least equal to or better than the accident ambient temperatures, they could be called upon to experience. In either case, the multiplier AT_O is taken to be = 1.

3.2.3.2 OPERATOR VS. MCC AMBIENT (AT_d)

Ref. #2.3 & 2.4 document the ambient temperatures during normal power and the accident conditions in different plant locations.

If the MCC and the operator are located in the same area, they will experience the same ambient during normal power and accident conditions. No correction factor is needed to be applied to the MFLA.

If the operator is located in a higher ambient than the MCC which is located in a non-varying ambient, no correction factor is applied. By ignoring any correction factor, which would have resulted in lowering the size of TOL heaters, the approach is in a conservative direction, to allow the valve to perform its safety function and satisfy the Reg. Guide requirement.

3.2.3.3 Varying MCC Ambient (AT_C)

Multiplier "AT_C" is applicable when the MCC is located in a varying and different ambient than the operator. The multiplier "AT_C" is taken to be unity, if ambient compensating type of TOL relays are used

and the highest expected temperature is within the TOL relay design limit. For the non-ambient temperature compensating type of relays, if the operating ambient at all times is less than their design basis, the TOLs will trip at a higher motor operating current. No credit is taken for this extra capacity. If the operating temperature at any time is higher than the design basis, the multiplier for MFLA and MLRC is taken to be as "AT_c" = $(1-0.01T_c)$.

At OCNGS, the operating temperatures as documented in Ref. 2.4 are well within the operating range of the TOL-relays (-20°C to 60°C or 0°F to 128°F) the multiplier "AT"c, therefore, is taken as = 1.

3.2.4 DEGRADED PLANT VOLTAGE (V)

The effect of lower than the equipment's rated nominal voltage is to increase the running motor current and decrease the motor starting current. This change in current at running load is inversely proportional to the percentage change in the motor terminal voltage from the motor rated nominal voltage. The valve operator motors at OCNGS are rated at 440 VAC and 460 VAC.

The voltage drop study of Ref #2.5 revealed that the most critical low voltage at a 460V bus is 403V. This means approximately 14% increase in the MFLA for the 460V rated motors and about 9% increase in MFLA for the 440V rated motors. The multiplying factors for the MFLA will be as follows

VOC_1 - for 460 VAC motors = 1.14
VOC_2 - for 440 VAC motors = 1.09

3.2.5 MOTOR DUTY: (MD)

As discussed earlier the TOLs are basically current sensitive devices which respond to a thermal effect by the flow of current irrespective of the motor duty. The TOL heater selection tables by the supplier are prepared for continuous duty motors. By using a multiplier for the MFLA as suggested by the supplier, the same tables can be used to select a TOL-heater size to protect an intermittent duty motor.

The frame size and motor duty rating of the Limitorque operator motors is based upon the short stroke time of the operators and an optimum combination of motor frame size for 3-phases and a single phase AC or DC motors Limitorque valve operator motors are rated at 15- minutes and 5-minutes respectively. The multiplier MD for various duty motors as per Ref. # 2.6 is as follows:

Multiplier	Motor Duty
1.0	For Continuous Duty Motors
0.8	For 60 minutes rated AC/DC motors
0.75	For 30 minutes rated AC/DC motors
0.70	For 15 minutes rated AC/DC motors
0.60	For 5 minutes rated AC/DC motors

3.2.6 TYPE OF ENCLOSURE (N): - The Nema type of enclosure, housing the TOLs have an effect on the TOL ambient and their heat dissipation. Heater Selection tables by some vendors use a multiplying factor (N) to be applied to MFLA to compensate for this effect. The MCCs housing these TOLs at the OCNGS have a Nema 1 enclosure the multiplying factor according to Ref. # 2.6 Page 3, is = 0.9.

3.2.7 CALCULATIONS OF IB & ILRC: - The modified values of MFLA (IB) and the motor locked rotor current (ILRC) can be calculated as follows:

$$IB = MFLA \times (\text{Multiplying Factors})$$
$$= MFLA \times AT \times MSF \times (VOC_1 \text{ or } VOC_2) \times MD \times \frac{1}{\text{CT RATIO}} \times N$$

$$ILRC = MLRC \times (\text{Multiplying Factors})$$
$$= MLRC \times AT \times MSF \times (Voc_1 \text{ or } VOC_2) \times MD \times \frac{1}{\text{CT RATIO}} \times N$$

The resolution on these multiplying factors is based on the discussions of Sections 3.2.7.1 and 3.2.7.2.

3.2.7.1 At OCNGS these factors can be applied as follows:

As per discussions of 3.2.2 and 3.2.3, "MSF" and "AT" each factor is = 1.0. There are no C.Ts used on the MOV motor feeder circuits. The factor "N" according to Section 3.2.6 is = 0.9.

3.2.7.2 As discussed under Section 3.2.4 the effect of degraded voltage conditions is to increase the running MFLA and decrease the LRC. Similarly, the effects of applying the "MD" factors of Section 3.2.5 is to decrease the TOL-heater size. The maximum multiplying factor for this from Section 3.2.4 will result in 14% increase in IB and proportionate decrease in the ILRC. This means the effect of the degraded voltage condition is to lower the TOL-heater size for normal running conditions. In order to protect the motor under all conditions and compensate for the effect of degraded voltage on MLRC only the higher value of MLRC will be used.

Application of a "MD" factor of Sec. 3.2.5 will result in a decrease in the TOL-heater size by 40% for 5 minutes rated AC/DC motors and 30% for the 15-minutes rated AC motors. A worst case cumulative affect due to the factors AT and MD will be an overall decrease in the TOL-heater size by up to a maximum of 26%.

According to Ref. #2.7, 5 or 15 minute rated operator motors can deliver the rated running torque (20% of starting torque) for at least the 5 or 15 minutes respectively without exceeding its allowable Nema temperature rise for the insulation system used. The same motor, therefore, can be used for much higher running loads for shorter periods of time, provided the Nema insulation rating for the corresponding running duty or the starting duty is not increased. Again according to Ref. #2.7, Limitorque motors have ample

thermal capacity to operate at twice the standard 20% rated running torque which is the nameplate listed torque, for periods of five (5) or fifteen (15) minutes.

Based on the above, the following conclusions can be applied:

3.2.7.2.1 Do not include the cumulative affect of plant degraded voltage and motor duty. This will result in a higher TOL heater size and the effect will be in a conservative direction in allowing the MOV to perform its safety function, and thereby satisfy the Reg. Guide requirement.

3.2.7.2.2 The motor shall be able to supply 200% of the running torque (40% of the name plate rated or the starting torque) for a time period required for stroking the valve from fully open to fully close position or vice-versa.

This conclusion is further modified under Section 3.3.2 by applying a safety factor, to contain the running overloads to be within the motor windings safe thermal limits.

3.2.7.3 Based on the above discussions the modified values of motor starting current (ILRC) and the motor full load running current (IB) to be used in the heater sizing can be calculated as follows:

$$IB = MFLA \times AT \times MSF \times (VOC_1 \text{ or } VOC_2) \times MD \times \frac{1}{\text{CT RATIO}} \times N$$

$$MFLA \times 1 \times 1 \times 1 \times 1 \times 1 \times 0.9$$
$$= MFLA \times 0.9$$

Similarly

$$I_{LRC} = MLRC \times 0.9$$

3.3 ACCEPTANCE CRITERIA: -

The TOL-heaters selected according to the procedures of Section 3.4.2 shall be subject to the following acceptance criteria. This acceptance criteria applies to only a single full stroking application of an MOV.

3.3.1 WHEN CARRYING LRC THE TOL RELAY SHOULD ACTUATE IN LESS THAN OR EQUAL TO 80% OF MOTOR'S LIMITING TIME FOR CARRYING THE LRC.

This will establish an upper limit on the TOL setpoints and protect the motor from LRC under all conditions - including frozen bearing, tight packing or any other mechanical obstruction during starting. The 80% of motor's limiting time gives a 20% safety margin for the inaccuracies of the motor windings thermal curves. As discussed under Section 3.2.7.2, the LRC calculated under 3.2.7.3 shall be used for this analysis. For a given Nema class of insulation, motor torque rating and motor ambient rating this time can be easily calculated from the locked rotor thermal limit curve of a motor similar to the typical curve of attachment #1.

3.3.2 FOR RUNNING OVERLOADS OF UP TO 200% OF RUNNING TORQUE, THE MINIMUM TRIP TIME OF TOL RELAYS SHOULD BE MORE THAN THE VALVES STROKE TIME AND THE TORQUE SWITCH TRIP TIME, PROVIDED IT'S WITHIN 80% OF OPERATOR MOTOR'S LIMITING TIME CORRESPONDING TO 200% FULL LOAD TORQUE.

According to the discussions of Section 3.2.7.2 Limitorque motors have ample thermal capacity to supply running overloads of up to 200% for periods corresponding to the operator motor duty rating.

Again, for a given Nema class of insulation, motor torque rating and motor ambient rating, this time to carry 200% running load can be easily established from the motor's 40% thermal limit curve for that motor, similar to the typical curve of attachment #1. This time should be greater than the operator stroke time to perform its safety function. Also the MOV operator circuit trip time due to the torque switch setting should be less than the TOL-relay trip time, which in turn should be less than 80% of the operator motor's limiting time for running overload corresponding to 200% torque. Again, the 80% of the

motor's limiting time gives a 20% safety margin for the inaccuracies of the motor winding's thermal curves. This can be demonstrated by plotting all three on the time - current (T-C) axis.

3.4 PROCEDURE FOR TOL-HEATER SIZING: -

This procedure is based on the methods of Ref. #2.9 and is divided into following sections.

3.4.1 OPERATOR DATA:

3.4.1.1 Operator Motors Name Plate Data:

MFLA, HP, MSF, Volts - AC or DC, Nema code letter or MLRC, rated ambient at rated Nema class of insulation, starting torque, running full load and 200% of full load torques.

3.4.1.2 Operator Type and Size.

3.4.1.3 MOV Stroke Time.

3.4.1.4 TOL Relay Information:

TOL relay type, TOL heater type, TOL heater selection tables, TOL-relay time-current characteristic curves.

3.4.1.5 Torque Switch Setting.

3.4.1.6 MOTOR CHARACTERISTIC CURVES

Motor winding thermal limit curves at locked rotor, full load running torque and at 200% of full load torque.

3.4.1.7 Ambient Temperatures

MOV operator motor's design basis accident ambient. MOV operator motor's qualification ambient. Maximum ambient of the MCC housing the TOL relays.

3.4.1.8 MCC's Nema enclosure type.

3.4.1.9 Motor Thermal Limit For Locked Rotor

From the MOV data find the operator motor's temperature rise over and above the motor's rated ambient for its Nema class of insulation. From the motor's thermal limit curve for locked rotor conditions (similar to the curve of attachmentt #1 marked LKD - Temp.) find the time corresponding to the temperature rise. 80% of this time is the safe stall time for a locked rotor condition. This time will be used for calculating the high setpoint for the TOL relay.

3.4.1.10 Motor Current For Calculating The Lower Setpoints Of TOL:

Find the amps (Is) corresponding to the 40% of the MOV's rated torque and the amps (ITS) corresponding to TS setting. Use the lower of the two values for calculating the lower setpoints. The 'IS' and 'ITS' can be calculated as follows:

3.4.1.10.1 IS: The motor nameplate rated torque for a MOV represents the rated starting torque and 20% of this torque represents the rated full load running torque (TFL) (Ref. 2.7). The amps 'IS' can be calculated from the following relationship:

Motor Torque (T1) is proportional to the square of the motor Current $(I1)^2$. If we know the amps at 20% torque, the amps at 40% torque can be calculated from: $(\text{Is - at } 40\% \text{ torque})^2 = (\text{I at } 20\% \text{ torque})^2 \times 2 = (\text{MFLA})^2 \times 2$.

3.4.1.10.2 ITS: Find the TS setting in ft-lbs. from the vendor supplied data or plant procedures. Find the amps 'ITS' from the torque-amps curve of Attachment #1 for the torque setting of the TS.

3.4.1.11 Motor Thermal Limit Corresponding to IS/ITS:

For a five (5) or fifteen (15) minute rated motor, the stroking time of a valve is generally very small in comparison to its rating. The inherent service factor from Ref. #2.7 is given by

$$\frac{\text{Motor Duty}}{\text{Stroke Time}}$$

A MOV motor can easily sustain temporary overloads of up to 200% of the normal running full load for the duration of its stroking period. Therefore, the motor thermal limit for either IS or ITS can be based on the 40% curve (Attachment #1) instead of the thermal curve corresponding to a lower value of torque for the TS setting. This thermal limit can be calculated from the 40% torque curve in a similar way to that of Section 3.4.1.8.

3.4.1.12 Torque Switch Trip Time:

This is the time in seconds it will take for the torque switch to actuate at its predetermined setting plus the motor starter drop-out time. From Ref. #2.8 the TS contact parting time including the mechanical play in the fixed and moving contacts of the TS, is approximately 50 milli seconds (ms). Depending upon the Nema size of starter, the starter drop-out time after a torque switch is actuated, varies from 25-50 ms. Total time from TS actuation to the starter drop-out could be a maximum of 100 ms.

3.4.2 STEP BY STEP METHOD:

3.4.2.1 On the T-C curve of TOL relay (Attachment #2) draw a horizontal line at thermal time limit for carrying locked rotor current from Section 3.4.1.8.

3.4.2.2 This line intersects the curve at multiples of relay trip currents X1 and X2. Due to relay tolerance the multiples X1 and X2 will have minimum and maximum trip times of t1-t2 and t3-t4 respectively. Select the multiple which gives the maximum trip time within the acceptance criteria #1. Let this multiple be X2.

3.4.2.3 The Locked Rotor Current = X2 x Relay Trip Current or the Relay Trip Current = $\frac{I_{LRC}}{X2}$ = X3

3.4.2.4 Select the applicable heater from heater selection tables of Attachment #3. Select the appropriate heaters and find the minimum trip current for this heater. Let this current be = X4.

3.4.2.5 LRC corresponding to the selected heater = $\frac{I_{LRC}}{X4}$ = X5

x (times) the minimum relay trip current.

From Attachment #2 find the maximum trip time for X5. If this time meets the acceptance criteria #1, this will represent the acceptable upper limit of the TOL set point. If not, go back to step 3.4.2.4 and select a heater one size lower.

3.4.2.6 For evaluating the lower set point of the TOL relay, select the motor current IS or ITS. The corresponding relay trip current will be $\frac{\text{IS or ITS}}{X4}$ = X7 x the minimum relay trip current.

If 80% of the minimum trip time (t7) corresponding to X7 is greater than the MOV stroke time to perform the design basis safety function, then X7 meets part of the criteria #2 for the lower setpoints.

3.5 SAMPLE CALCULATION - CORE SPRAY ISOLATION VALVE V-20-41:

3.5.1 OPERATOR DATA (Ref. attachment #1)

MFLA=5.2, HP=3.2 @ 460 VAC, 60Hz, S.F. 1.0
Motor Locked Rotor Current (MLRC) = 40A (from Section 3.5.2)
RPM-1700, Motor Rated Amb.°C/INSUL = 40/B
Motor Torque=25 ft.-lb. (Ref. 2.11),
Operator - Limitorque type SMB-001 (Ref. 2.11)
Motor Stroke Time 22s (Ref. 2.10)
Motor Winding thermal Limit for locked rotor current =10.56s-(Sec. 3.53)
IB (from Sec. 3.5.5) = 4.68A
ILRC (from Sec. 3.5.5) = 36.0A
Is (from Sec. 3.5.4) Motor running current corresponding to 200% of the motor's full load running torque = 6.62 amps (Sec. 3.5.4)
Operator Motor FL running torque = 5 ft.-lbs.
Operator Motor 200% FL running torque = 10 ft.-lbs.
Motor winding thermal limit for 200% FL running torque (Sec. 3.5.4) =4.0 minutes
TOL-Relays - GE type CR-124A2)
TOL Heaters - GE type CR-123)Ref. 2.1
Combination Starter Coil - Nema Size #1, GE type CR-109C0)
T-C Characteristic Curve for Type CR124 TOL Relays)
MCC's enclosure - Nema Size #1

3.5.2 Motor LRC: - Only name plate value should be used. However, for the purpose of this calcs, for a given Nema Code letter the Av. value of motor LRC can be calculated from

$$MLRC = \frac{1000XHPXKVA/HP}{1.732XV}$$

For code letter 'L' use (9-10KVA/HP) (Ref. 2.12)

$$MLRC = \frac{1000X3.2X10}{1.732X460} = 40 \text{ Amps}$$

3.5.3 MOTOR THERMAL LIMIT (LRC CONDITION):-

Nema Class B insulation has a temperature rating of 130°C. The operator motor has Class B insulation and rated for operation in a 40°C ambient. The net rate of temperature rise the motor winding will be able to withstand is 90°C. From the LKD temp. rise - sec. curve of Attachment No. 1, the safe stall time is 13.2 seconds. Allowing a 20% margin of error in the motor heating curve accuracy due to sustained temperature condition, degraded motor ventilation and

the inaccuracy in duplicating the exact motor winding heating affects due to temperature rise, etc., the net safe stall time to be used in the calculations = 0.8 X 13.2 = 10.56s.

3.5.4 MOTOR CURRENT AND THERMAL LIMIT - CORRESPONDING TO T.S SETTING: -

For this study the approach is to limit the running overloads to a maximum of 200% of the full load torque. The motor current IS will be used for these calculations. From 3.4.1.10.1

$$I^2 = (MFLA)^2 \times 2$$

$$= (5.2)^2 \times 2$$

$$IS = 7.35 \text{ amps}$$

$$IS = 0.9 \times 7.35 = 6.62$$

The net current IS to be used in sizing the TOL heaters will be = 0.9 x 7.35 = 6.62 @ 460 VAC. The motor thermal limit for the 200% of full load torque of 10 ft.-lbs. is about five minutes. Again using a 20% safety factor, the net safe overload running time is = 5 X 0.8 = four minutes.

3.5.5 NET MOTOR LRC AND RUNNING CURRENT: From Ref. 3.2.7.3

IB = MFLA x 0.9
ILRC = MLRC x 0.9
Attachment #5 shows the temperature profile of the operator during an environmental test qualification. The maximum temperature sustained was 210°F for approximately six (6) hours. The maximum temperature sustained during an emergency condenser line break, the worst case accident condition, as seen from attachment #6 is approximately 190°F for about three (3) minutes. This means the equipment qualification temperature is higher and therefore the multiplier "ATO" is taken to be = 1

Ref. 2.4, the maximum ambient for MCC 1AB2 under all conditions is 95°F. According to Attachment #2, the performance of the TOL relay is not affected by the temperature variations, the maximum working range being 128°F. The multiplier "ATc" is, therefore taken to be = 1.

IB = 0.9 x MFLA = 0.9 x 5.2 = 4.68 amps
ILRC = 0.9 x MLRC = 0.9 x 40 = 36 amps

3.5.6 STEP BY STEP METHOD

1. On the T-C characteristic curve for TOL-relay CR-124A draw a horizontal line at 10.56 seconds (motor's safe stall time). This line intersects the characteristics band at 5.6 times and 9.8 times the relay pick up (PU) current.

2. At 5.6 times the PU the Minimum & Maximum trip times from the characteristics band are 10.56s (seconds) and 16s. At 9.8 times the pu the minimum and maximum trip times from the characteristics band are 7.2 & 10.56 seconds. Select the 9.8 times the pu current to size the TOL-heaters, because this gives the trip times within the safe motor-thermal limit for LRC.

3. LRC = 9.8 x Relay Trip Current

The Relay Trip Current $= \frac{I_{LRC}}{9.8} = \frac{36}{9.8} = 3.67$ amps

For TOL heaters type CR-123, TOL relays type CR-124 mounted directly on the starter and in a Nema #1 MCC enclosure, TOL-heaters selected from Table 46, Col. B of Ref. 2.6 = C-419A Minimum trip current for this heater = 3.35 amps.

6. LRC corresponding to the selected heater $= \frac{36}{3.35} = \frac{I_{LRC}}{3.35} = 10.75$

times the relay trip current.

Min. & max. trip times for this current = 7.0s & 9.8s The max. trip time of 9.8s is within the motor stall time of 10.56s. This meets the acceptance criteria #1 for the high setpoint of the TOL relays.

7. In order to find the lower trip point, find the Relay current corresponding to ITS. This trip current $= \frac{I_S}{3.35} =$

$\frac{6.62}{3.35} = 1.98$ times the relay current.

The min. & max. trip times for this current, from attachment #2 are 34s & 68s, again applying a 20% factor of safety, the

minimum time is = 0.8 X 34 = 27.2s. Because the minimum trip time is higher than the valve stroke time of 22s, it meets one of the requirements of acceptance criteria #2.

3.6 TOL SET POINTS REVIEW AGAINST REQUIREMENTS OF REG. GUIDE 1.106

The TOL setpoints as arrived at in Section 3.5 were reviewed for RG 1.106, position #C2 compliance. These requirements are stated in substance under Section 3.1. The uncertainties associated with this position are discussed below to see if they have been adequately resolved through the use of the methods of Section 3.4 and 3.5 for sizing the TOLs.

3.6.1 Ref. #2.4 lists the normal power aging temperatures and the maximum operating temperatures for a worst case postulated accident. The accident conditions temperature profiles for these areas are documented under Ref. 2.3. The affect of different ambient temperature factors of Sec. 3.2.3 as applied to the sample example is discussed as follows:

3.6.1.1 Operator Ambient Factor (ATO)

Attachment #5 (from Ref. #2.2.4) shows temperature test profile for the valve V-20-21 of the sample calculations in Section 3.5. As observed, the valve was subject to a test temperature of 210°F for almost six (6) hours. Attachment #4 (from Ref. 2.3) shows the ambient temperature profile inside the reactor building following an emergency condenser line break. The maximum sustained temperature here is about 190°F for a duration of 3 minutes. In this case the operator qualification temperature for the valve V-20-21 operator is 20°F higher than the maximum operator ambient. According to the discussion of Section 3.2.3.1, no credit is taken for a higher temperature withstand capacity of the operator motor in adjusting the IB & ILRC used in sizing the TOL heaters.

3.6.1.2 Operator Vs. MCC Ambient Factor (ATd)

The maximum post accident temperature for the V-20-21 operator from attachment #4 is 190°F (99°C) while the maximum operating temperature for MCC-1AB2 is 95°F (40°C) Ref. 2.3. The maximum temp differential could be 95°F (40°C). According to discussions of Section 3.2.3 (ii) the MFLA & MLRC would have required a multiplying factor of ----

$$ATd = 1 - 0.01 \times \left(\frac{40°C}{5}\right) = 1 - 0.01 \times 8$$

$$= 0.92$$

This could have resulted in a smaller heater size. By ignoring the factor Atd the resultant TOL heater size is .8% higher. This results in an action which is in line with the R.G. 1.106 requirement of completing the safety function.

3.6.1.3 Variations in MCC Ambient (ATc): (Ref. Sec. 3.2.3.3)

By ignoring the multiplier "Atd" above, the TOL heaters are sized on the basis of 95°F operating temperatures. The TOL relays are (see Attachment #2) rated for -20°C (0°F) to 60°C (128°F) operation. Therefore, no multiplying factor is applied.

This resolves the issue of the effects of ambient temperature variations, and the resolution is to size the TOL to complete the safety action, a prime requirement of the R.G. 1.106. As will be seen later, this is also accomplished within the operator motor winding's thermal limit at all times.

3.6.2 INACCURACIES IN MOTOR THERMAL CURVES & TOL-RELAY CURVES:

Inaccuracies in the motor thermal curves of attachment #1 under the LRC conditions and running

overload conditions are resolved in Sections 3.5.3 and 3.5.4 respectively. By using a 0.8 multiplier for the motors limiting time, there is a safety margin of 25% for the safe LRC and running overload operations of the motor. This more than adequately covers the motor thermal curve inaccuracies.

The characteristics of a TOL relay, Attachment #2 are represented by wide band, which has a low and a high TOL relay trip setpoints. This implies that the TOL relay could trip anywhere between these two setpoints. The acceptance criteria of Section 3.3 is based on selection of these two points. Since the inaccuracy of the TOL relay characteristics, like that of any thermally actuated device, are represented by the wide band, no additional safety factor need be applied. The resolution of Sec. 3.5 on these setpoints assures the completion of the MOV safety function within the motor windings thermal limit. Hence, the issue is adequately resolved.

3.6.3 SET POINTS DRIFT:

This issue can be resolved by testing the adequately sized TOL-heaters prior to installation. The acceptance criteria shall be for the T-C test point for the heater to fall within its TOL-relay characteristic band. This test point can be reviewed under two adverse scenarios:-

First, if the test point is just within the lower limit of the TOL-relay setpoint, in actual use the heater could trip in less or more time than its tested set point. The downward drift could mean that at a running overload of 200% of full load, the heater may trip earlier than the testpoint. According to acceptance criteria #2, the application of a multiplier of 0.8 to the trip time from the curve provides a 25% safety factor for this downward drift. This ensures that even after accounting for a setpoint drift of 25% in the adverse direction, the TOL-trip time would be more than the MOV stroke time. This test point will allow the completion of safety function without tripping prematurely, and is, therefore, acceptable.

In the second case, the test point could lie within the TOL relay T-C curve band but close to the upper setpoint limit. A setpoint drift in an adverse

direction could mean that the heater trip time is more than the test time. Here the effect is to allow even more time to perform its safety function by applying the starting torque for a longer period of time to ensure the valve operation. At the same time it should be within the motor's safe thermal time limit. Again, 0.8 multiplier to the safe stall time for LRC condition (Section 3.3.1) provides a safety margin of 25% to ensure the safe thermal time limit for the motor winding. This test point will, therefore, be acceptable.

4.0 RESULTS:

4.1 A generic formula was developed for the modified value of motor running current (IB) and motor locked rotor currents (ILRC) for sizing the TOL setpoints to meet the RG 1.106 position C2. The formulae are:

$$IB = MFLC \times AT \times MSF \times (VOC1 \text{ or } VOC2) \times MD \times \frac{1}{\text{CT Ratio}} \times N$$

$$ILRC = MLRC \times AT \times MSF \times (VOC1 \text{ or } VOC\ 2) \times MD \times \frac{1}{\text{CT Ratio}} \times N$$

4.2 The generic expression for calculating the adjusted motor running currents I_B and motor locked rotor current I_{LRC} for sizing the TOL setpoints for the safety related MOVs at OCNGS are as follows:

$$I_B = MFLA \times 0.9$$

$$ILRC = MLRC \times 0.9$$

4.3 A generic step by step method was established to size the TOL's for safety related valves. This method was applied in sizing the TOL's for a safety related valve as a specific example. The results were found to be in compliance with the requirements of RG 1.106 position C2, demonstrating the validity of the approach.

4.4 The safety margins employed for the various factors that influence the sizing and performance of TOLs at the OCNGS are as follows:

4.4.1 AMBIENT TEMPERATURE: (AT)

In sizing the TOLs, no credit is taken for the extra safety margins provided by following conditions for various multipliers:

4.4.1.1 MULTIPLIER ATo:

Where the operator qualification is for higher temperatures than the postulated accident condition ambient and sustained for longer durations than the design basis action required of an MOV.

4.4.1.2 MULTIPLIER ATd:

By ignoring the compensating multiplier (1-0.01Td) for the motor currents where the operator is located in a higher ambient than the MCC housing the TOLs.

4.4.1.3 MULTIPLIER ATc:

By ignoring the compensating multiplier (1+0.01Tc) for the motor currents where the MCC ambient is less than its design basis.

4.4.2 DEGRADED PLANT VOLTAGES (VOC 1 OR VOC 2)

Ignoring the maximum multiplier of 1.14 for this condition provides a safety margin of 14%.

4.4.3 MOTOR DUTY (MD)

4.4.3.1 The maximum safety margin provided by ignoring the motor duty multiplier is 40% for five minutes rated AC/DC motors and 30% for the 15 minutes rated AC motors.

4.4.3.2 The safety margin provided by ignoring the inherent service factor of a five minute and 15 minute motor duty motor for a 60 second stroke time MOV will be 500% and 1500% respectively.

For MOVs with different stroke lengths, it will be different, but will always have more than sufficient safety margin.

4.4.4 MOTOR THERMAL LIMITS

By considering only 80% of the operator motor's thermal limit time for the locked rotor condition during starting and for a running overload condition corresponding to 200% of the full load torque, a 20% safety margin is provided.

5.0 CONCLUSIONS:

5.1 The traditional method of TOL sizing providing 125% of full load current protection does not take into account the intermittent motor duty rating, the application nature of the safety related MOV's and the special characteristics of the operator motors.

5.2 This study has established a generic method of developing the TOL setpoints that meet the RG 1.106 position C2.

Safety factors are employed in establishing these setpoints to help ensure completion of the valve operation (safety related function) without undesired tripping. These setpoints though still provide full time motor protection, particularly during surveillance testing without temporarily altering the circuitry (lifting bypass leads) and without complicating the circuitry with automatic bypass features.

5.3 This method is based upon the characteristics and application specifics of the operator motors for the safety related valves and could also be applied to non-safety related loads.

5.4 The sample example of sizing the TOL proves that the generic approach of section 3.4.2 assures the completion of the MOV's safety function within the operator motors safe thermal limit for the starting as well as the running overloads.

6.0 RECOMMENDATIONS

6.1 The generic approach of section 3.4.2 for sizing the TOL's should be formalized into Engineering Standards. These standards should include the acceptance criteria for the high and low TOL setpoints and the testing of the TOL's.

6.2 The TOLs on all safety related MOVs should be reviewed according to the new standards of Section 6.1. The TOL heater sizes should be documented as a part of the plant procedures.

6.3 TOL's should be tested before installation to meet the acceptance criteria of new standards. Also, the existing TOL - relays should be tested for their operability.

6.4 Ref. Sec. 3.3, the sizing of the TOL's is based on a single full stroke application of an MOV. For jogging duty appliclations, the adequacy of this method of TOL sizing should be analysed separately on a case by case basis. For continuous full stroking of the valve more than once, equal periods of "run" and "rest" between successive starts should be observed In any case, manufacturers limitations on the maximum number of starts in a given period shall always apply.

These limitations should be incorporated in the existing plant procedures.

7.0 <u>APPENDICES</u>

7.1 Attachment No. 1 - "AC Motor Performance Curves"

7.2 Attachment No. 2 - "TOL Relays Type CR-124, Time-Current Curves"

7.3 Attachment No. 3 - "Selection Tables For G.E. TOL-heaters"

7.4 Attachment No. 4 - Temperature Test Profile for Valve V-20-41 (from Ref. #2.3)

7.5 Attachment No. 5 - Temperature Profile For The V-20-41 Operator in the Accident Environment Ambient.

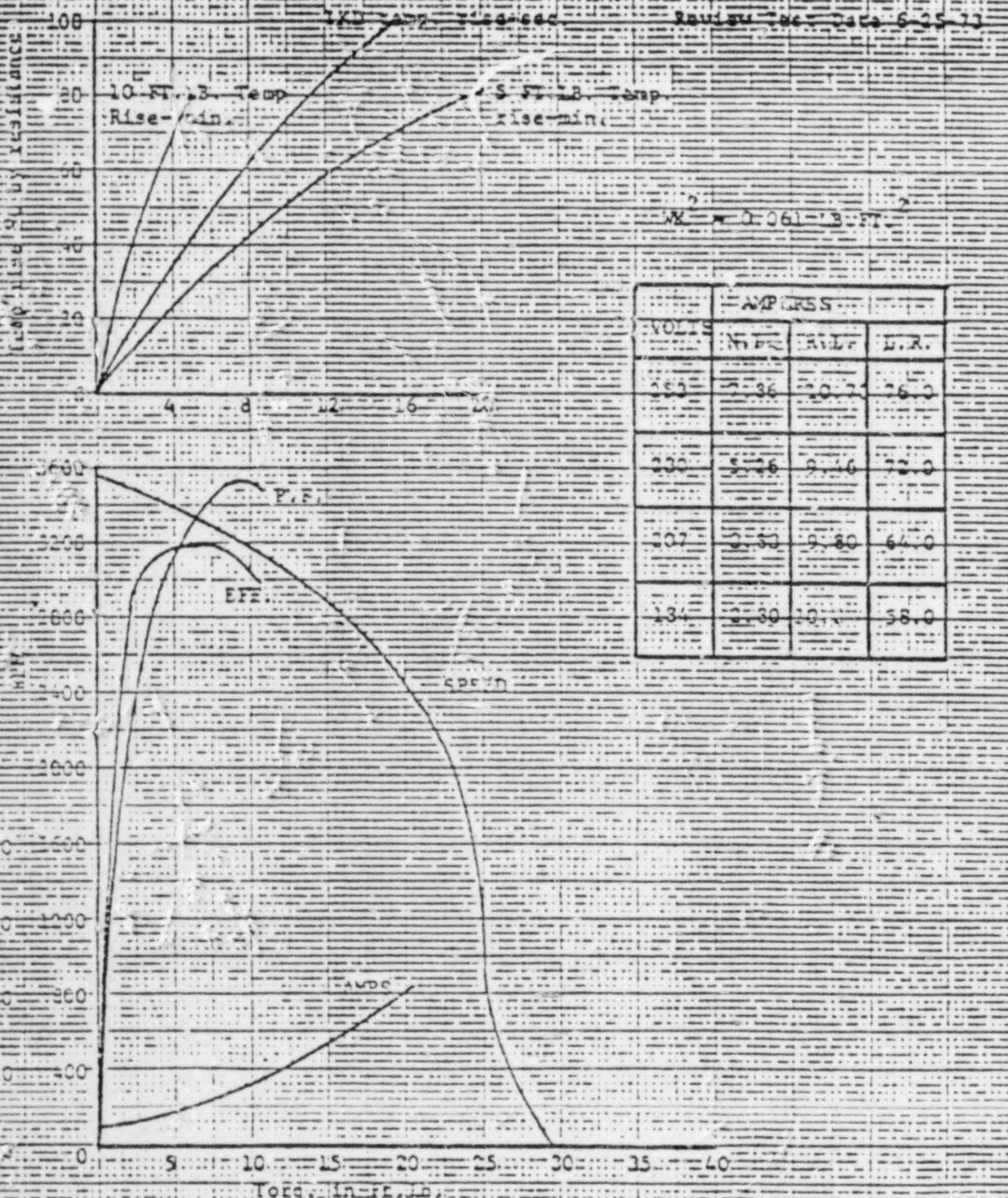
8.0 List of the Abbreviated terms frequently used in this report:

AT	-	Ambient Temperature Multipliers
ATO	-	For Limitorque Operator Ambient
ATd	-	For Operator VS MCC Ambient
ATc	-	For Varying MCC Ambient
FLC	-	Full Load Current
IB	-	Modified Values of MFLA, after applying the applicable multiplying factors of Section 3.2. This is the value which will be used in arriving at the TOL set points.
ILRC	-	Locked value of MLRC to be used in sizing the TOL heaters and modified in a similar manner to that of IB.
LRC	-	Locked Rotor Current
MCC	-	Motor Control Center
MD	-	Multiplier for Intermittent Duty Motor rating
MFLA	-	Motor Full Load Amps (from the motor name plate)
MLRC	-	Motor Locked Rotor Current (from the motor name plate) MOV - Motor Operated Valve
MS	-	Milli Seconds
MSF	-	Motor Service Factor Multiplier
N	-	Multiplier for Nema Type of enclosure
RG-1.106	-	Regulator Guide 1.106
SF	-	Motor Service Factor (from motor name plate)
TOL	-	Thermal Over Load - Wherever used the term is intended to be implied to include both, the relays and heaters.
TS	-	Torque Switch
VOC1	-	Multiplier for degraded voltage condition at 460 VAC MCC buses, at OCNGS
VOC2	-	Multiplier for degraded voltage condition at 440VAC MCC buses at OCNGS
TFL	-	Operator motor full load running torque.
TO	-	Temperature differential in °C between the Operator motor ambient and its qualification temperature.
Tc	=	Temperature differential in °C between the MCC design basis temperature and its highest ambient.
Td	=	Temperature differential in °C between the MCC and operator motors ambient.

ATTACHMENT NO. [illegible]
(TDR NO. 519)

25 FT.LB. LKD

S.O.		RPM	3400	S.F.	1.0	ROTOR	164B40
AME	56	VOLTS	230/460	NEMA DESIGN		TEST S.O.	E2149
	3.2	AMPS	10.4/5.2	CODE LETTER	L	TEST DATE	1/11/67
	P	DUTY	15 Min.	ENCLOSURE	TENV	STATOR RES. @ 25°C	230V
SE/HERTZ	3/60	AMB°C/INSUL	40°C/B	E/S	500200-52	.93	OHMS (BETWEEN LINES)



VOLTS	AMPERES		
	N.L.	F.L.	L.R.
253	[illegible].36	10.7[illegible]	[illegible]6.0
230	5.26	9.46	72.0
207	[illegible]	9.80	64.0
184	[illegible].30	10.[illegible]	58.0

AMPERES SHOWN FOR 230V CONNECTION. IF OTHER VOLTAGE CONNECTIONS ARE AVAILABLE, THE AMPERES WILL VARY INVERSELY WITH THE RATED VOLTAGE

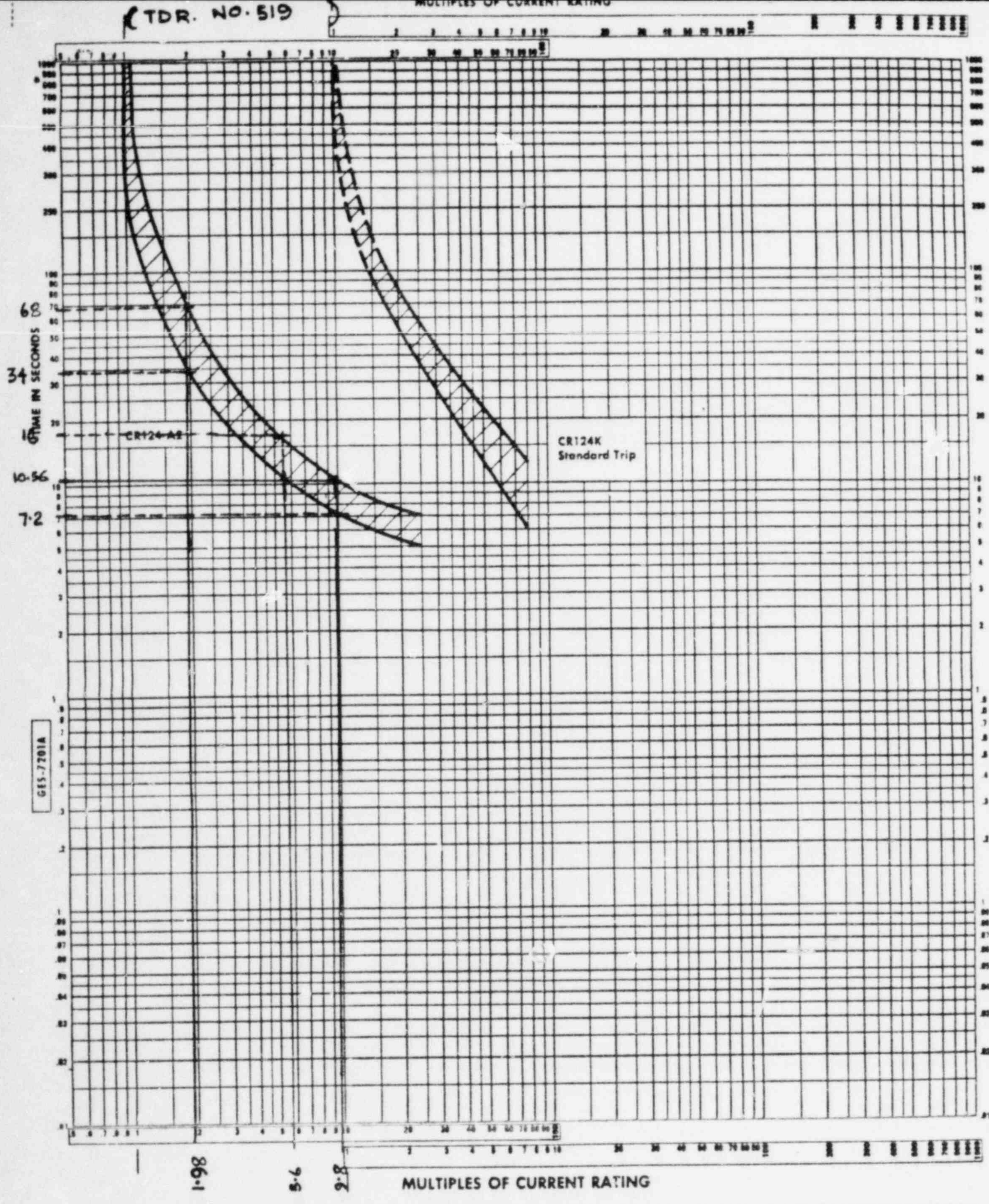
RELIANCE ELECTRIC COMPANY
CLEVELAND, OHIO 44117 U.S.A.

DR. BY DNR
CK. BY [illegible]
APP. BY [illegible]
DATE 7-20-77

A-C MOTOR PERFORMANCE CURVES (Updated 413018-03-AV)

M1463

ISSUE DATE 7/20/77



GENERAL ELECTRIC

THERMAL OVERLOAD RELAYS

TYPE CR124

CR124-A2 and CR124K

Time-current Curves

GES-7201A

Replaces GES-7201

Current Ratings

2.0 to 16.3 Amperes

Frequency Rating

25 to 60 Hertz

(Tripping performance is not affected by changes in ambient temperatures. Working range −20 C to 60 C for CR124-A2 and −30 C to 80 C for CR124K.)

Adjustments

Current setting 85 to 115% of heater current rating. Curves shown at 100%.

Obsolete Devices *Note: If full load amperes falls between increments, use next higher rating.*

Table 46, NEMA Sizes 00, 0, & 1

Use Column A For:

- CR106, CR109①, Open, Types 4, 7, 9
- CR110, CR111①, All Enclosures
- CR124A1③④, Open or Type 1
- CR133C①

Use Column B For:

- CR106, CR109①, Types 1, 12
- CR107, CR108①, All Enclosures
- CR160C1⑤

Max. Motor Full-load Amperes: Column A	Max. Motor Full-load Amperes: Column B	Heater Cat. No. CR123
0.33	0.31	C036A
0.37	0.34	C039A
0.41	0.38	C043A
0.46	0.43	C048A
0.52	0.47	C054A
0.57	0.52	C060A
0.61	0.56	C066A
0.67	0.62	C071A
0.75	0.69	C078A
0.84	0.77	C087A
0.94	0.87	C097A
1.03	0.94	C109A
1.14	1.04	C118A
1.30	1.18	C131A
1.42	1.30	C148A
1.61	1.47	C163A
1.72	1.56	C184A
1.93	1.75	C196A
2.10	1.90	C220A
2.34	2.13	C239A
2.64	2.40	C268A
2.86	2.60	C301A
3.13	2.84	C326A
3.32	3.02	C356A
3.68	3.34	C379A
4.08	3.72	C419A
4.61	4.20	C466A
5.21	4.73	C526A
5.62	5.02	C592A
6.12	5.55	C630A
6.83	6.21	C695A
7.70	6.92	C778A
8.48	7.64	C867A
9.19	8.31	C955A
9.92	9.04	C104B
11.1	9.99	C113B
12.2	10.9	C125B
13.5	12.0	C137B
14.6	13.0	C151B
16.1	14.3	C163B
17.0	15.6	C180B
19.3	17.0	C198B
20.6	18.1	C214B
22.6	19.9	C228B
24.6	21.8	C250B
27.0	24.2	C273B
	26.3	C303B
	27.0	C330B

Table 47, CR106K, Size 1P④

Type Enclosure		Device
Open 4, 7, 9	1, 12	CR106
Max. Motor Full-load Amperes		**Heater Cat. No. CR123**
15.1		C151B
16.7	15.0	C163B
18.5	16.6	C180B
20.0	17.9	C198B
21.4	19.0	C214B
23.5	20.9	C228B
25.8	22.9	C250B
28.7	25.4	C273B
31.2	27.6	C303B
36.0	30.7	C330B
	33.5	C366B
	36.0	C400B

Table 48 NEMA Size 2

Use Column A For:

- CR106, CR109①, Open, Types 4, 7, 9
- CR110, CR111①, All Enclosures
- CR124B1③④, All
- CR131D, CR133D, CR134D①, All

Use Column B For:

- CR106, CR109①, Types 1, 12
- CR107, CR108①, All Enclosures
- CR160C2⑤

Max. Motor Full-load Amperes: Col. A	Max. Motor Full-load Amperes: Col. B	Heater Cat. No. CR123
6.63		C695A
7.59	6.89	C778A
8.39	7.76	C867A
9.20	8.63	C955A
9.93	9.53	C104B
11.2	10.7	C113B
12.5	11.7	C125B
14.1	12.8	C137B
15.5	14.3	C151B
17.4	16.1	C163B
19.8	17.9	C180B
21.2	19.3	C198B
22.7	21.4	C214B
24.9	22.6	C228B
27.3	24.6	C250B
29.7	26.7	C273B
34.2	30.0	C303B
40.2	34.8	C330B
45.0	40.1	C366B
	43.3	C400B
	45.0	C440B

Table 49, NEMA Size 3

Use Column A For:

- CR106, CR109①, Open, Types 4, 7, 9
- CR110, CR111①, All Enclosures
- CR131E①, All
- CR133E①, All Enclosures

Use Column B For:

- CR106, CR109①, Types 1, 12
- CR107, CR108①, All Enclosures

Max. Motor Full-load Amperes: Col. A	Max. Motor Full-load Amperes: Col. B	Heater Cat. No. CR123
23.1	20.9	F243B
26.3	23.5	F270B
28.5	25.5	F300B
30.9	27.7	F327B
33.8	30.3	F357B
36.5	32.6	F395B
41.1	37.1	F430B
47.6	42.9	F487B
52.5	47.0	F567B
56.6	50.1	F614B
61.9	54.5	F658B
67.9	58.5	F719B
75.5	64.1	F772B
79.6	68.6	F848B
87.9	77.5	F914B
90.0	83.2	F104C
	90.0	F114C

① Heaters for current devices are now selected by type of enclosure. See table NEMA Type Enclosures, page 10.

② Three heaters required. Single-phase—One heater. Two-speed controllers require six heaters.

③ Do not use table for CR124 relays mounted directly on magnetic starters. Refer to table for starter involved.

④ One he... required.

⑤ Three heaters required.

Table 50, NEMA Size 4

Use Column A For:

- CR106, CR109①, Open, Types 4, 7, 9
- CR110, CR111①, All Enclosures
- CR131F①, All
- CR133F①, All Enclosures

Use Column B For:

- CR106, CR109①, Types 1, 12
- CR107, CR108①, All Enclosures

Max. Motor Full-load Amperes: Col. A	Max. Motor Full-load Amperes: Col. B	Heater Cat. No. CR123
37.8	34.3	F395B
42.8	38.9	F430B
49.6	45.3	F487B
54.2	49.0	F567B
59.0	52.6	F614B
66.5	57.4	F658B
70.6	61.6	F719B
79.1	67.8	F772B
83.6	73.0	F848B
92.9	83.1	F914B
100	94.7	F104C
110		F114C
124	106	F118C
133	118	F133C
	133	F149C

Table 51, NEMA Size 5

Use Column A For:

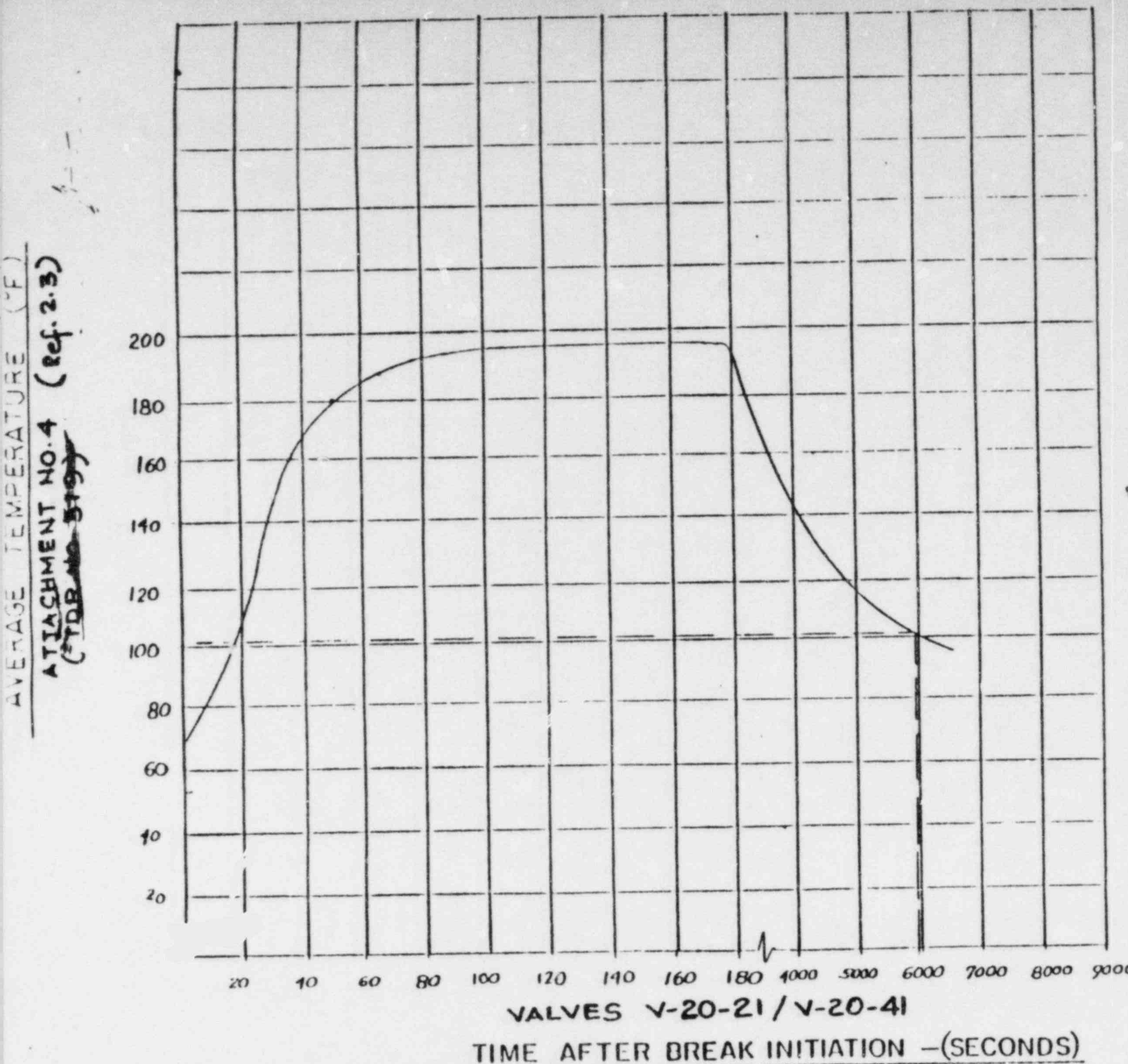
- CR106, CR109①, Open, Types 4, 7, 9
- CR110, CR111①, All Enclosures
- CR131G, CR133G①, All

Use Column B For:

- CR106, CR109①, Types 1, 12
- CR107, CR108①, All Enclosures

Max. Motor Full-load Amperes: Col. A	Max. Motor Full-load Amperes: Col. B	Heater Cat. No. CR123
76.2		C379A
84.2	79.9	C419A
94.6	90.1	C466A
106	100	C526A
111	107	C592A
122	114	C630A
137	127	C695A
153	137	C778A
170	147	C867A
185	159	C955A
201	170	C104B
223	185	C113B
244	202	C125B
266	218	C137B
270	231	C151B
	250	C163B
	270	C180B

ATTACHMENT NO. 4 (Ref. 2.3)
(~~TDR No. 319~~)



LONG TERM TIME HISTORY FOR NODE 17 FOLLOWING AN EMERGENCY CONDENSE[R] LINE BREAK REACTOR BUILDING

Report No. -02-0990-1025 July, 1981

using Structural Heat Sink

eds nuclear			
OYSTER CREEK NUCLEAR GENERATING STATION			
JOB No. 0990-001-671			
CALC No. 0990-001-005			
DWN	BY	CHK	DATE
CFY	CFY	MFB	7/31/81

FIGURE No. 8

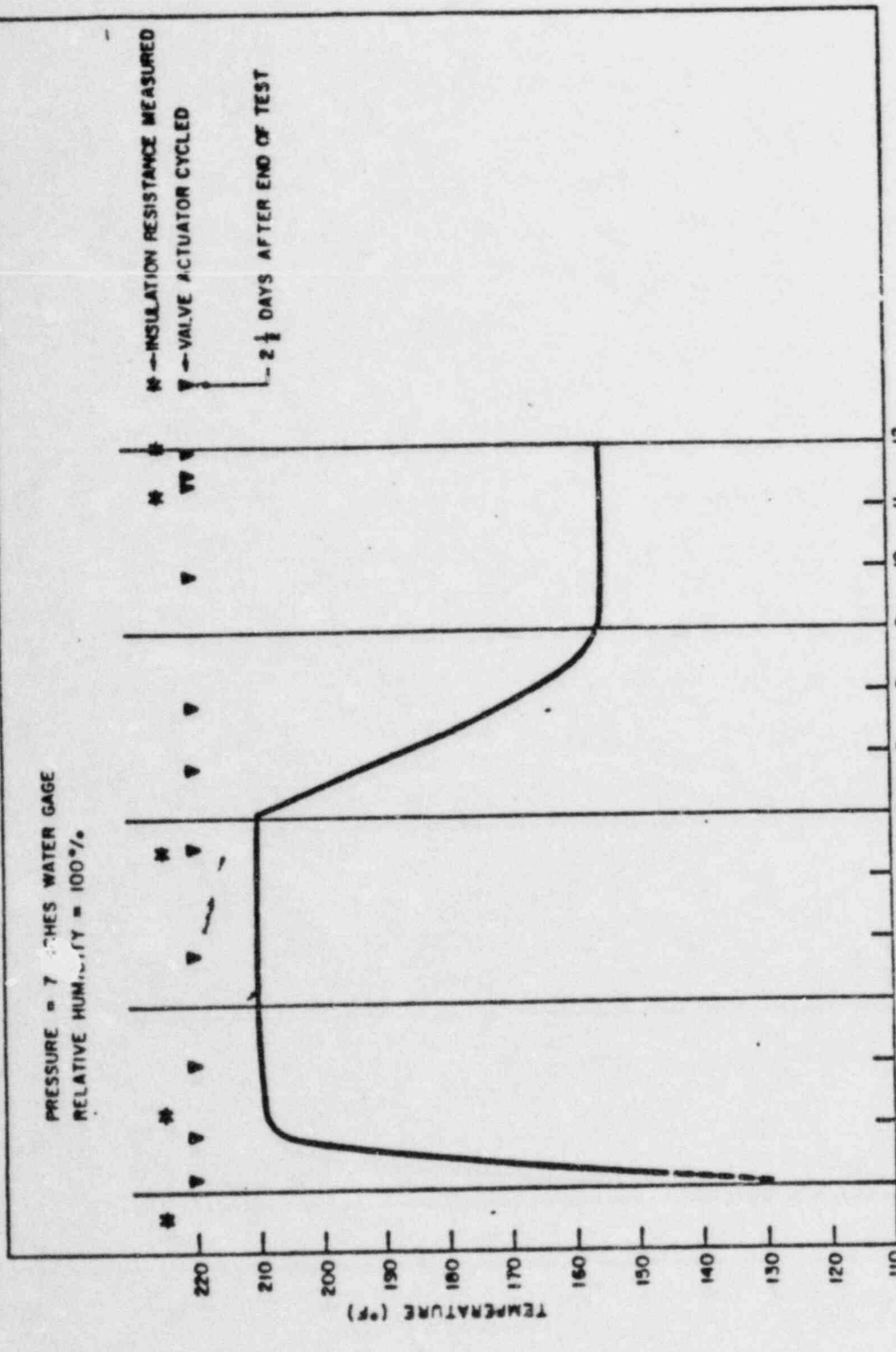


Figure 3. Test Profile
VALVES V-20-21/V-20-41