# TECHNICAL EVALUATION REPORT ON THE PROPOSED TECHNICAL SPECIFICATION CHANGES ON DEGRADED GRID VOLTAGE PROTECTION FOR THE RANCHO SECO NUCLEAR GENERATING PLANT

(Docket No. 50-312)

By

James C. Selan
Lawrence Livermore National Laboratory

## 1. INTRODUCTION

By letter dated July 26, 1983 [Ref. 1], Sacramento Municipal Utility District (SMUD), the licensee, requested to modify the License Amendment No. 46 on this subject which was approved by the NRC on March 21, 1983 [Ref. 2]. The changes are required to make the station load-shedding system operable because of the difference in the 'as designed' and 'as built' time delays which are shown in Technical Specification (TS) Table 3.7-1. All load-shedding systems per TS 3.7-1 must be operable before the unit is brought critical.

By numerous telephone conferences [Ref. 3] and telecopied supplements [Refs. 4 to 6], the licensee submitted a revised proposal dated July 29, 1983 [Ref. 7], to the licensee amendment request.

The purpose of this report is to evaluate the proposed Technical Specification changes to determine whether the proposed time delays will provide the required operability of the nuclear services load-shedding systems.

## 2. REVIEW BASIS CRITERIA

The review basis criteria that were applied in determining the acceptance of the proposed TS changes were contained in the following:

(1) NRC letter (R. W. Reid) to SMUD (J. J. Mattimoe), dated June 3, 1977 [Ref. 8]. Letter subject on Degraded Grid Voltage Protection.

(2) NRC letter (W. G. Gammill) to all Power Reactor Licensees, dated August 8, 1979 [Ref. 9]. Letter subject on the Adequacy of Station Electric Distribution System Voltages.

## 3. BACKGROUND

### 3.1 DEGRADED GRID VOLTAGE PROTECTION

A previous Lawrence Livermore National Laboratory (LLNL) report [Ref. 10] concluded that the licensee met all of the NRC staff positions as required in the June 3, 1977 letter [Ref. 8]. Specifically, these positions are:

(1) To provide an undervoltage/overvoltage protection scheme which will protect all Class 1E equipment from sustained voltages outside the equipment's design limits. This scheme was designed based on the voltage requirements of of the equipment, IEEE standards, and to reduce the possibility of spurious separations from the preferred offsite sources due to short duration voltage transients.

(2) To prevent any adverse interaction of the onsite and offsite sources as a result of the load-shedding scheme.

(3) To include Limiting Conditions for Operation (LCOs), and Surveillance Requirements in the TS.

### 3.2 ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGES

Two previous LLNL reports [Refs. 11 and 12], concluded that the requirements of the NRC Letter dated August 8, 1979 [Ref. 9] has been met. These reports evaluated the licensee's voltage analyses and proposed modifications with respect to the NRC guidelines identified in Reference 9. The licensee's analysis demonstrated that the offsite sources, in conjunction with the onsite distribution system, has sufficient capacity and capability to automatically start and continuously operate all required Class 1E equipment within the equipment's voltage ratings under worst-case conditions. These conditions were maximum load-demand/minimum expected normal grid voltage and minimum load-demand/maximum expected grid voltage. The normal operating grid voltage range was identified as 221 kV to 239 kV. For voltages outside the normal operating range, the undervoltage/overvoltage protection schemes will provide the required protection so that the Class 1E equipment will not be subjected to sustained abnormal voltages. Continued plant operation with the grid voltage below 218 kV (upper tolerance on the undervoltage setpoint) was limited by the plant's TS to 24 hours. In addition, the evaluation concluded that spurious operation of the undervoltage/overvoltage protection schemes will not occur as a result of motor starting transients under the worst-case conditions analyzed.

Also, as part of the report, the licensee committed to perform further analyses on the 480-volt MCC overload protection devices and to report any required changes.

## 4. EVALUATION

### 4.1 PROPOSED UNDERVOLTAGE/OVERVOLTAGE SETPOINT CHANGES

#### 4.1.1 UNDERVOLTAGE SETPOINTS

During operational testing of the recently installed undervoltage/overvoltage protection schemes, the licensee determined that the performance requirements of the undervoltage relays, as defined in the TS (Table 3.7-1), could not be met. This is because the proposed trip setpoint of 3771 $\pm$ 38 volts with a time delay of 12 $\pm$ 1.2 seconds fell within the area of the relays' characteristic curves undefined by the manufacturer (290% of the trip setpoint). Therefore, testing at this setpoint voltage produced varying time delays to trip outside the tolerances specified in the TS table.

These varying trip times were directly related to the test voltage starting point. For voltage starting points near the upper relay tolerance or greater, the trip time was essentially independant to the starting voltage and would result in longer trip times. As the voltage starting point became nearer to the setpoint, the time delays became more dependent to the starting voltage and would result in shorter trip times. As a result, the licensee proposed an envelope of trip times [Ref. 1] which defined an upper and lower band limit. The lower band limits (e.g., 4.3 seconds at 98% of the trip setpoint) are such that the possibility of spurious actuations could occur during motor starting transients.

After discussions with the NRC staff, the licensee performed more than 100 tests on the undervoltage relay to establish the accuracy and repeatability of the relays' performance characteristics. The tests were conducted in three areas. The first test area centered on 99% to 101% of the trip setpoint with the second test area from 90% to 100% of the trip setpoint. These two areas covered the spectrum of the relays' performance curve which was not defined by the manufacturer. The final area tested covered the range of 0% to 90% of the trip setpoint where the relay's performance is defined. The results of these tests, which are shown in Attachment A, demonstrated that the relays' characteristics are as previously defined by the voltage/time curve [Ref. 13]. Therefore, a high level of confidence exists that the relay will trip in approximately 12 seconds at the trip setpoint. To ensure that the relays' performance characteristics are as required, the licensee is proposing [Ref. 7] the following surveillance points in TS Table 3.7-1 for the undervoltage protection scheme:

| Undervoltage Setpoint | Equivalent 4160 Bus Voltage | Time Delay (Seconds) |
|---|---|---|
| Trip Setpoint | 3771 ± 38 | (Not Tested) |
| 98% of Setpoint | 3695 | 8.2 ± .82 |
| 90% of Setpoint | 3394 | 5.2 ± .52 |
| 70% of Setpoint | 2640 | 3.1 ± .31 |
| 0% of Setpoint | 0 | 1.5 ± .15 |

For testing purposes, the above time delays are based on an initial starting bus voltage of 4160 volts.

A voltage analysis [Ref. 13] which was evaluated in Reference 11, demonstrated that starting the condensate pump at a grid voltage of 214 kV and 218 kV (± tolerance of the trip setpoint) under worst case load-demand conditions would not cause spurious tripping of the undervoltage protection scheme as designed. Further tests [Ref. 3] showed that starting the condensate pump at a bus voltage of 3771 volts (trip setpoint), the bus voltage would recover to 3733 (minus tolerance of the trip setpoint) in 2.0 seconds. This voltage recovery occurs in approximately half the time tripping would occur, thus precluding spurious tripping.

An evaluation of the test results indicates that the undervoltage relays' performance characteristics, as required, have been clearly defined and with sufficient repeatability in the area of 90% to 100% of the trip setpoint. Therefore, the licensee's proposed setpoints will provide the protection performance as previously evaluated of the Class 1E equipment from sustained degraded voltage and to preclude spurious trips from the preferred offsite sources.

4.1.2 OVERVOLTAGE SETPOINTS'

In addition, the licensee determined the need to extend the time delay on the overvoltage setpoint of 4580 ± 46 volts from the original 3.0 seconds to approximately 8.0 seconds. This need for the time delay increase is to prevent spurious tripping when starting the reactor coolant pump (RCP). The RCPs are supplied by one winding of the startup transformers while the Class 1E buses are supplied from the other winding. The transformer design characteristics are such that when low voltage occurs on the one winding during RCP start, voltage compensation causes higher voltage on the other winding (to Class 1E buses). This increase in voltage exceeds the overvoltage 3-second trip setpoint and causes bus tripping. The licensee is proposing [Ref. 7] the following trip setpoints.

| Overvoltage Setpoint | Equivalent 4160 Bus Volts | Time Delay (Seconds) |
|---|---|---|
| Trip Setpoint | 4580 ± 46 | (Not Tested) |
| 102% of Setpoint | 4672 | 7.2 ± .72 |

The licensee defined the maximum expected switchyard voltage of 239 kV. To meet the equivalent of the upper tolerance of the overvoltage setpoint would require a grid voltage of 244 kV. Assuming no bus load, this this voltage equates to 4626 volts (111% of 4160 volts) and 521 volts (113% of 460 volts) on the Class 1E buses. As required equipment is loaded onto the buses, the voltage at the equipment terminals will become more within the + 10% upper design limit.

An evaluation of the additional time delay of 5 seconds from the previously evaluated 3 seconds (8 seconds maximum) to the equipment's voltage requirements, indicates that the proposed overvoltage trip setpoint will still provide the required protection of the Class 1E equipment and will preclude spurious separations from the preferred offsite sources. No significant effects will occur as a result of the increased time the equipment may be exposed to overvoltages.

## 4.2 PROPOSED DESIGN CHANGES

During the installation of the undervoltage/overvoltage protection schemes, the licensee determined that some minor circuitry changes from the original design [Ref. 13] would eliminate a conflict in some alarm annunciator circuits and would provide consolidation. Specifically, these changes included [Ref. 5]:

(1) The deletion of individual voltmeters on the undervoltage/overvoltage potential transformers to a common voltmeter with a selector switch.

(2) The deletion of an auxiliary time delay relay 62B and combined series time delays with 62A.

(3) The separation of the annunciator and undervoltage/overvoltage relay targets by a high speed auxiliary relay to assure target actuation.

(4) The deletion of the circuit inputs to the computer.

(5) The addition of an overvoltage alarm on the 480-volt buses with a setpoint of 504 volts.

An evaluation of the above design changes finds that the design requirements as stated in Reference 8 are still met.

## 4.3 PROPOSED LCO AND ADEQUACY OF STATION ELECTRIC DISTRIBUTION SYSTEM VOLTAGE ANALYSES CHANGES

The licensee's voltage analyses which were evaluated in References 10 and 11 demonstrated that for grid voltages at or abobve 218 kV (normal operating range of 221-239 kV), the Class 1E equipment can operate indefinitely at this voltage with no equipment degradation. For grid voltages at 214 kV (lower tolerance of the undervoltage relay), the Class 1E equipment could be degraded if this voltage persisted for longer than 12 seconds. From this, the undervoltage protection scheme was designed with a voltage trip setpoint with tolerances to correspond with the 214 kV and 218 kV grid voltage values.

While undervoltage relay trip can be assured to occur at some value from 214 kV to 218 kV, it cannot be guaranteed at a specified particular value within this band. Should the grid voltage degrade to 214 kV to 218 kV and the relay trip occurs, the Class 1E equipment will not be exposed to a harmful degraded voltage condition. If the relay trip does not occur, the Class 1E equipment could be exposed to such a voltage indefinitely. The licensee's analysis on the Class 1E equipment's voltage requirements demonstrated that the equipment could operate for a maximum of 24 hours in the band of 214 kV to 218 kV with no significant effects or degradation on the operability of the equipment. Therefore, the provision for limiting plant operation to 24 hours below 218 kV is included in the present TS.

The present TS allows operation for 24 hours below 218 kV, after which both electrical divisions would be powered by the emergency diesel generators. The licensee has proposed to revise this TS to explicitly require better controls. If the grid should fall to below 218 kV, preplanned actions to increase the grid voltage would be initiated immediately. If the grid remains below 218 kV for 8 hours, or if it falls below 216 kV, and undervoltage protective action has not occurred for either division, one of the redundant electrical divisions at the plant will be manually transferred to its associated onsite power source (i.e., diesel generator) and operate independent of the offsite power. The other electrical division will remain on the offsite power source, with the diesel generator associated with that division operable and in the normal standby status. Operation in this configuration would be allowed for up to 24 hours. This temporary plant configuration provides the maximum flexibility for the possibility that either a problem develops with the operating diesel generator or a problem develops with the offsite power or the non-safety-related portions of the onsite power distribution system. This configuration provides the greatest assurance that Class 1E loads will not be lost due to a degraded voltage and that at least one of the redundant electrical divisions will be provided in any eventuality. Therefore, I recommend that the NRC accept the licensee's proposed changes for administrative controls for grid voltages below 218 kV.

As required in Reference 11, the licensee further analyzed the 480-volt MCC overload protection devices for inadequacies when operating between 214 kV and 218 kV. The results of the analysis indicated that certain 4160-volt motors required an increased time delay for overcurrent from 6 cycles offset to 7.5 cycles total ± 1 cycle, and certain 480-volt MCC overload heaters required an increase to 1.15 times full load amperes [Ref. 4]. The licensee's analysis indicated that with these overcurrent device changes, the bus supply breakers will trip on undervoltage/overvoltage before any load trips on overcurrent and still provides the required equipment protection.

With the analysis results on the overload protection devices, the licensee has demonstrated the adequacy of the station's electrical distribution system voltages and the required equipment protection from sustained degraded voltages.

## 5. CONCLUSION

Based on the information submitted by SMUD, for the Rancho Seco Nuclear Generating Plant, it is concluded that:

(1) The proposed undervoltage relay setpoints will provide the design protection performance for the Class 1E equipment from sustained degraded voltage.

(2) The proposed overvoltage setpoint time delay will still provide adequate protection of the Class 1E equipment from sustained overvoltage.

(3) The design requirements are still met with the proposed design modifications.

(4) The undervoltage/overvoltage setpoints (voltage and time) will preclude spurious separations from the preferred offsite sources.

(5) The proposed TS LCOs for limiting plant operation below 218 kV provides the greatest assurance that the Class 1E equipment will not be exposed to sustained degraded voltages.

(6) The equipment overload protection device changes still provide the required equipment protection and yet allows bus supply breaker tripping on undervoltages/overvoltage conditions to occur first.

Accordingly, I recommend that the NRC accept the proposed Technical Specifications changes on the undervoltage/overvoltage trip setpoints and limiting conditions for operation.

## REFERENCES


1. SMUD Leter (R. J. Rodriguez) to the NRC (D. G. Eisenhut), dated July 26, 1983.
2. NRC Letter (J. F. Stolz) to PECO (J. J. Mattimoe), dated March 21, 1983.
3. Telephone Conferences; B. Dieterich, B. Daniels, D. Thorpe and F. Sheenan of SMUD, S. Miner and J. T. Beard of NRC, and J. Selan of LLNL, dated July 27, 28, and 29, 1983.
4. SMUD Design Basis Report (ECN No. A-2010, Rev. 2), dated July 22, 1983.

5. SMUD Engineering Change Notice (ECN No. A-2010E, Rev. 2), dated July 7, 1983.

6. Telecopy transmittal of Relay Instruction Manual, dated July 27, 1983.

7. SMUD letter (R. J. Rodriquez) to the NRC (J. F. Stolz), dated July 29, 1983.

8. NRC letter (R. W. Reid) to SMUD (J. J. Mattimoe), dated June 3, 1977.

9. NRC Letter (W. G. Gammill) to all Power Reactor Licensees, dated August 8, 1979.

10. Lawrence Livermore National Laboratory Report (UCID-18690), "Technical Evaluation of the Proposed Design Modifications and Technical Specification Changes on Grid Voltage Degradation (Part A) for the Rancho Seco Nuclear Generating Plant," dated October 1980.

11. Lawrence Livermore National Laboratory Report (UCID-19113), "Technical Evaluation of the Adequacy of Station Electric Distribution System Voltages for the Rancho Seco Nuclear Generating Station," dated November 10, 1981.

12. Lawrence Livermore National Laboratory Report (UCID-19708), "Technical Evaluation Report on the tests conducted to verify the analysis performed on the Adequacy of Station Electric Distribution System Voltages for the Rancho Seco Nuclear Generating Station," dated July 15, 1983.

13. SMUD Letter (Wm. C. Walbridge) to the NRC (R. W. Reid), dated February 17, 1981.

ATTACHMENT A

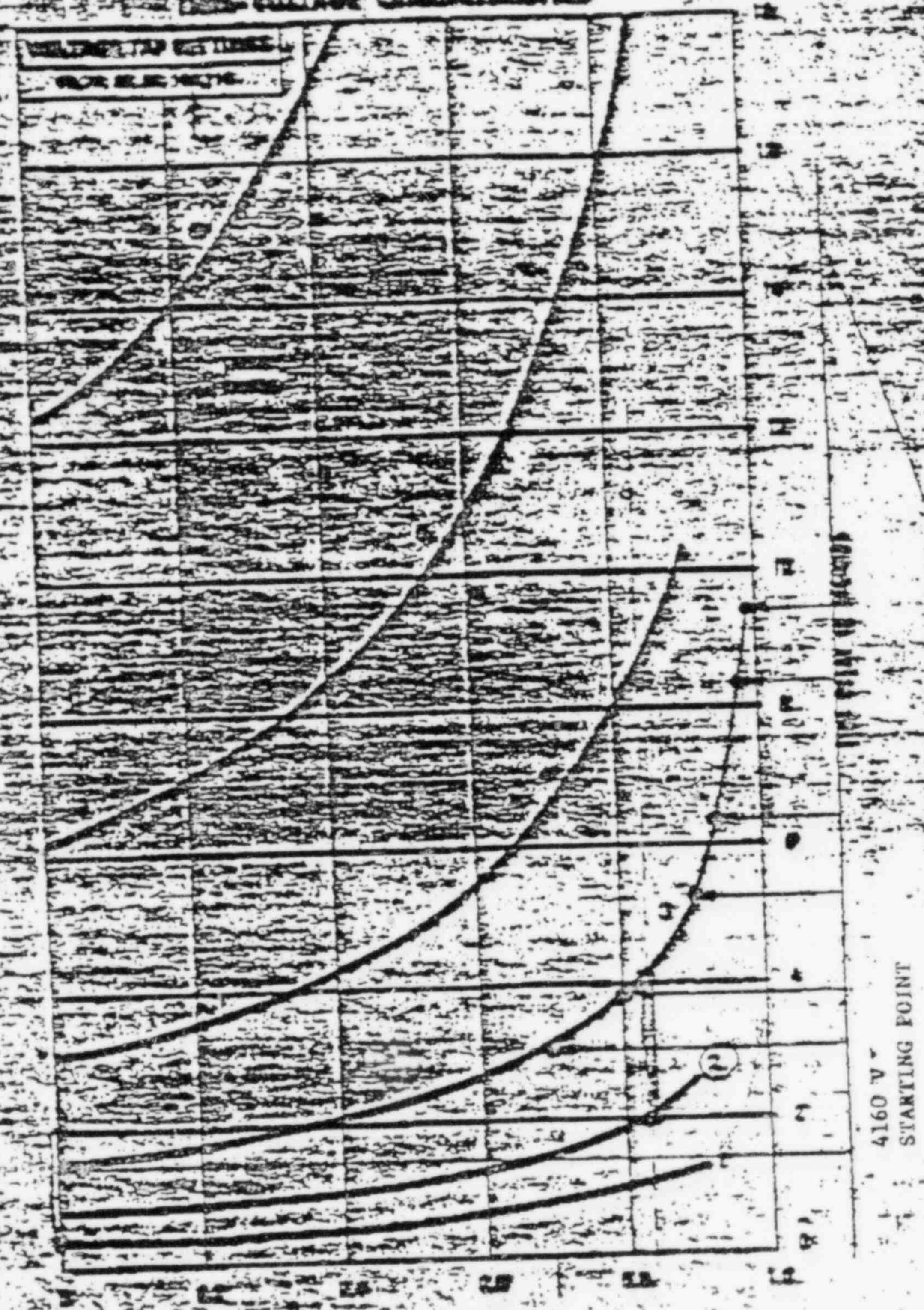
RELAY TEST DATA

4160 VOLTS STARTING POINT

| END PT. | % OF SETPOINT | TIME RANGE (10 RUNS) | SPREAD |
|---|---|---|---|
| 3775 volts | 100.1% | 11.563 - 11.79 | ± 0.1133 |
| 3770 volts | 100% | 11.244 - 11.498 | ± 0.127 |
| 3765 volts | 99.8% | 10.837 - 11.307 | ± 0.24 |
| 3760 volts | 99.7% | 10.505 - 10.662 | ± 0.08 |
| 3750 volts | 99.4% | 10.149 - 10.414 | ± 0.13 |
| 3740 volts | 99.2% | 9.723 - 10.026 | ± 0.15 |

| | | |
|---|---|---|
| 3728 volts | 99% | 9.36 |
| 3688 volts | 98% | 8.2 |
| 3540 volts | 94% | 6.2 |
| 3392 volts | 90% | 5.2 |
| 3016 volts | 80% | 3.8 |
| 2636 volts | 70% | 3.1 |
| 0 | 0 | 1.5 |

## TIME-VOLTAGE CHARACTERISTICS




MULTIPLES OF TAP SETTING

TYPE ITE 27 UNDERVOLTAGE RELAY
INVERSE (MEDIUM TIME)

THIS CURVE ALSO APPLIES TO THE UNDERVOLTAGE ELEMENT OF ITE 27/59 UV/OV RELAY.

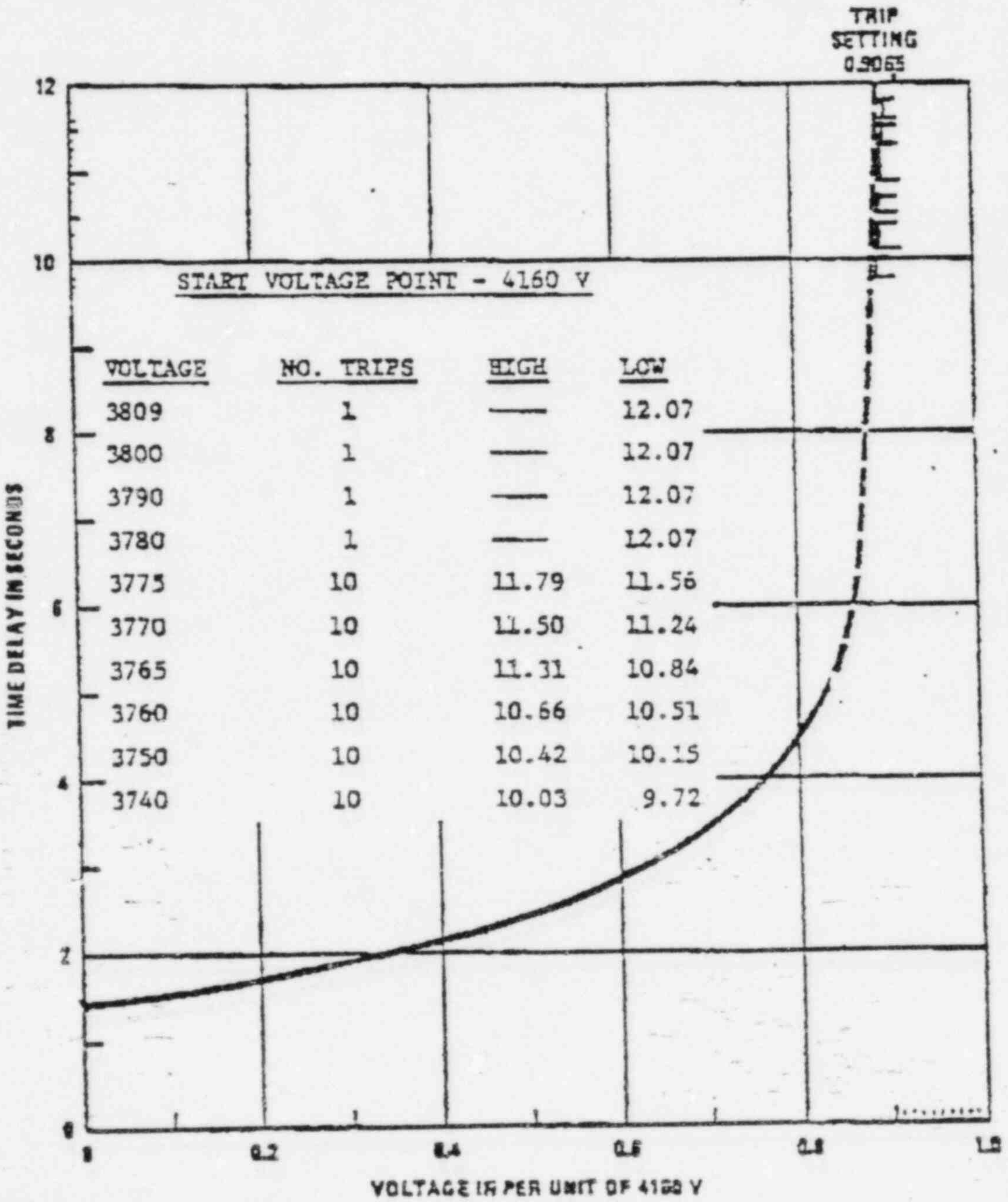
ITE Imperial

TVC-605877

MAY 1, 1975

ATTACHMENT A
RELAY TEST DATA

FIGURE 2
UNDERVOLTAGE RELAY
TIME-VOLTAGE CHARACTERISTIC




| VOLTAGE | NO. TRIPS | HIGH | LOW |
|---|---|---|---|
| 3809 | 1 | —— | 12.07 |
| 3800 | 1 | —— | 12.07 |
| 3790 | 1 | —— | 12.07 |
| 3780 | 1 | —— | 12.07 |
| 3775 | 10 | 11.79 | 11.56 |
| 3770 | 10 | 11.50 | 11.24 |
| 3765 | 10 | 11.31 | 10.84 |
| 3760 | 10 | 10.66 | 10.51 |
| 3750 | 10 | 10.42 | 10.15 |
| 3740 | 10 | 10.03 | 9.72 |

NOTE: AN EXTERNAL TIME DELAY RELAY (52A) SET AT 0.5 SECOND OPERATES IN SERIES WITH THIS RELAY.

ATTACHMENT A

RELAY TEST DATA

FIGURE 2

UNDERVOLTAGE RELAY

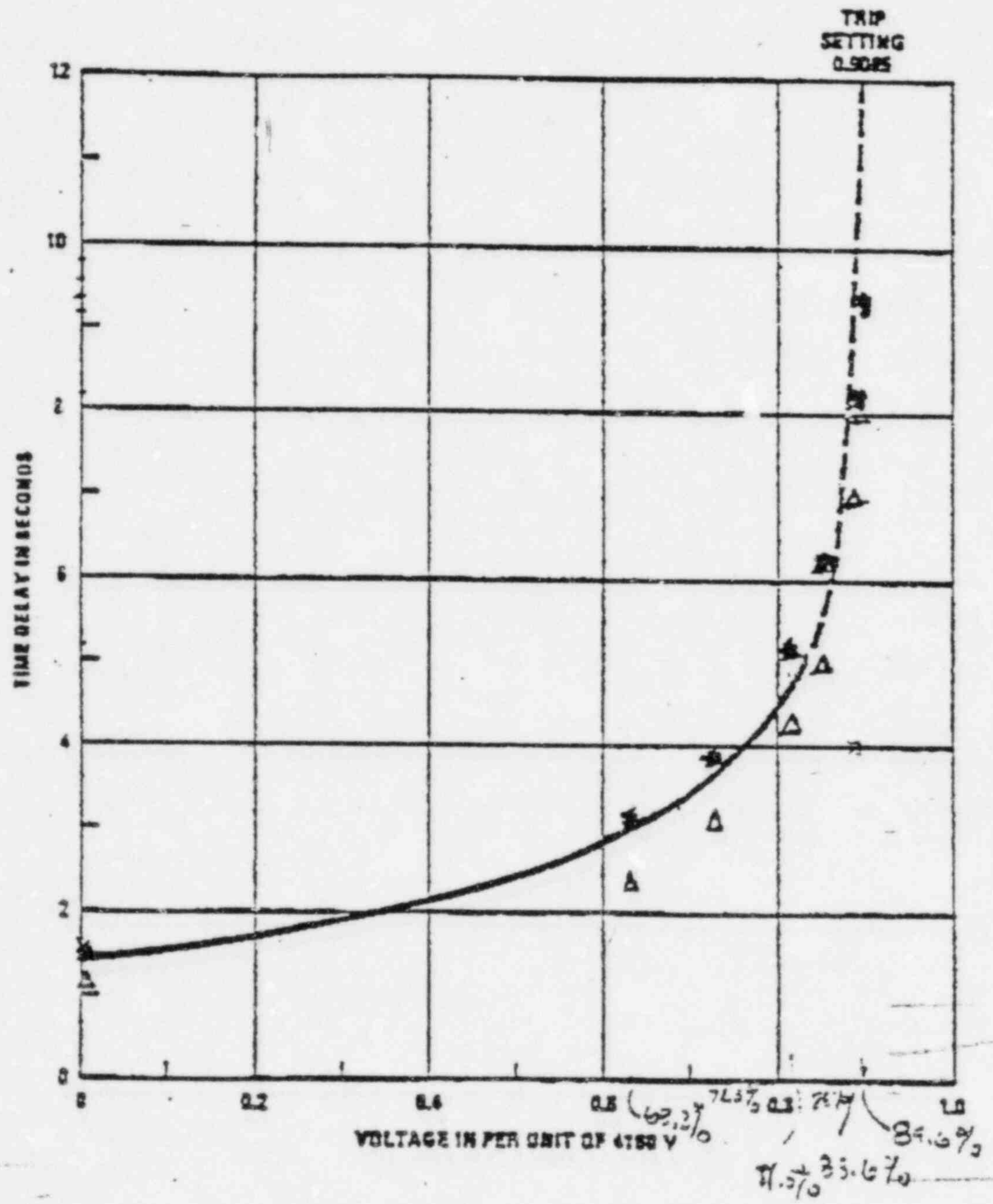
TIME-VOLTAGE CHARACTERISTIC

STARTING POINT

4534 V - *

4160 V - ●

3809 V - Δ




NOTE: AN EXTERNAL TIME DELAY RELAY (62A) SET AT 0.5 SECOND OPERATES IN SERIES WITH THIS RELAY.

ATTACHMENT A

RELAY TEST DATA

| END PT VOLTAGE | % SETPOINT | STARTING POINTS 4534 V (240 kV) | 4160 V (239-221 kV) | 3804 V (218 kV) |
|---|---|---|---|---|
| 3728 | 99% | 9.36 sec. | 9.36 sec. | 7.9 sec. |
| 3688 | 98% | 8.19 | 8.2 | 6.9 |
| 3540 | 94% | 6.2 | 6.2 | 5.0 |
| 3392 | 90% | 5.2 | 5.2 | 4.2 |
| 3016 | 80% | 3.85 | 3.8 | 3.0 |
| 2636 | 70% | 3.11 | 3.1 | 2.4 |
| -0- | -0- | 1.53 | 1.5 | 1.2 |