Public Service Electric and Gas Company P.O. Box 236 Hancocks Bridge, New Jersey 08038

Nuclear Department

TITLE: SECOND LEVEL UNDERVOLTAGE PROTECTION SYSTEM REDESIGN

1.0 PURPOSE

This Design Memorandum is being written to document the requirements and design for the modification of the installed relaying to provide undervoltage protection for the Class 1E electrical equipment. This document will supersede CDS-4 (refer to Reference 3.7).

2.0 SCOPE

This Design Memorandum applies to Salem Units No. 1 and 2. It will be used to modify the Second Level Undervoltage Protection System (SLUVPS). The SLUVPS prevents the Class 1E electrical equipment from operating below their minimum voltage ratings.

3.0 REFERENCES

3.1 IEEE 279-1971 "Criteria for Protective Systems for Nuclear Power Generating Stations".

3.2 CDS-1 "Design Criteria for Independence and Separation of Safety Related Instrumentation, Controls and Protection Systems".

3.3 U.S.N.R.C. letter dated July 30, 1979 to General Manager - Electric Production.

3.4 U.S.N.R.C. letter dated June 2, 1977 to General Manager - Electric Production.

3.5 Letter dated February 4, 1980 from Manager - Salem Projects to General Manager - Electric Production.

3.6 Letter dated October 10, 1979 from General Manager - Electric Production to U.S.N.R.C.

3.7 PSE&G Functional Specification CDS-4 dated July 14, 1980.

3.8 10CFR50 Appendix "A" General Design Criterion 5 and General Design Criterion 17.

3.9 Letter dated February 4, 1987, NLR-I87038 from General Manager - Licensing and Reliability to General manager - Engineering and Plant Betterment, "Licensing Basis for the Salem Generating Station Electrical Distribution System".

3.10 Salem Nuclear Plant Voltage Study, PTI Report No. R11-87, dated February 1987.

3.11 10CFR21 Report, Rochester Instrument Systems to U.S.N.R.C. dated October 11, 1985.

3.12 Regulatory Guide 1.105, Instrument Setpoints.

3.13 Rochester Instrument Systems, Product Data Bulletin Number 2035 AC Protective Relay.

3.14 Salem Generating Station, Technical Specifications Unit 1.

3.15 Salem Generating Station, Technical Specifications Unit 2.

3.16 Letter dated January 19, 1981 from USNRC to PSE&G, Safety Evaluation Report - Salem Generating Stations Units 1 & 2 Degraded Grid Voltage Protection for the Safety Related A-C Power System.

4.0 DISCUSSION

On August 11, 1983 and again on August 26, 1986, the Second level of Undervoltage Protection System (SLUVPS) caused the class 1E 4160 volt buses to separate from the preferred offsite power source when the offsite power source was within expected limits. A review of the existing relay scheme indicates that the cause of separation is due to the reset values of the SLUVPS relays. The relays reset at a voltage of 95% and under the worst case accident and minimum grid condition the recovery was not expected to exceed 92%.

The existing SLUVPS relay design was based on a voltage profile study (Reference 3.6) which indicated the minimum recovery voltage was 92% under the worst case conditions of a degraded grid, a LOCA on one unit with a simultaneous trip of the other unit. The Licensing Department has reviewed the NRC regulations relative to the electrical distribution system in Reference 3.9 and has determined that the electrical distribution system must be capable of supplying the electrical loads to support a worst case accident on one unit and a controlled shutdown of the other unit.

A more recent voltage profile study, Reference 3.10, has been performed by Power Technologies Incorporated in accordance with the above licensing requirements. Section 3.2 of this study provides the worst case voltage recovery at the 4160 volt vital buses during the lowest expected 500KV grid voltage, a LOCA on one unit and a controlled shutdown of the opposite unit. The study was done with both Unit No. 1 and No. 2 Auxiliary Power Transformers in service. The 11A, 12B, 13A, 21A, 22B, and 23A circulators were offloaded to the presently installed temporary power source from the Hope Creek Island Sub Station and the #11, #12, #21 and #22 Station Power Transformers' Automatic Load Tap Changers adjusted to control at a minimum voltage of 4300 volts. Additionally, the plant buses were aligned to provide the worst case transient and worst case recovery voltages. The study indicates that the worst case recovery is caused by the transfer of group buses to the already LOCA loaded station power transformers on No. 2 Unit. The voltage recovers to 92.9% after all of the motors are up to speed in about 6 seconds. The voltage will remain at this value for about 30 seconds at which time the Automatic Load Tap Changer will operate to increase the electrical distribution system voltage. At the Salem Stations the electrical motors are the limiting component under steady-state conditions as they are designed to run continuously at 90% of nameplate voltage as identified in Reference 3.6. However, the present Technical Specification setpoint and minimum allowable value do not provide adequate protection to prevent the motors from being operated at voltages less than 90% nameplate ratings. The present ≥91% setpoint was found acceptable by the USNRC in Reference 3.16. The Class 1E motors were assumed to be rated at 4000 volts and the 91% setpoint of the 4160 volt bus would provide 94.5% protection for 4000 volt rated motors. The ≥90% minimum allowable value did not consider the voltage drop due to cabling from the switchgear to the farthest motor nor did it consider the accuracy of the potential transformers used for monitoring the switchgear voltage. Therefore, the minimum allowable value will be increased by .7% to account for the worst case motor cable voltage drop and .3% to account for the accuracy of the potential transformer. The new minimum allowable value will be ≥91%. The new setpoint selected in accordance with Reference 3.12 considers the tolerances of the potential transformer, relay and calibration uncertanties as shown in Attachment I. The new setpont will be ≥91.6%.

Since the SLUVPS function is to protect the Class 1E equipment during degraded grid conditions, separation from the offsite power source must occur when the bus voltage is equal to or less than 91% of rated bus voltage. Additionally, it is not acceptable to separate from the offsite source when the grid voltage is within expected limits. Therefore, the reset of the degraded grid relays must be less than the minimum expected recovery voltage of 92.9%. The Rochester Instrument Systems (RIS) PR-2035 undervoltage relay will again be used for the SLUVPS redesigr. The relay was identified in a 10CFR21 report (Reference 3.11). The report indicated that the relays did not maintain the manufacturer's reset repeatability specification when calibrated to the minimum deadband specification of .5% of range. In addition to this, RIS found that the relays did not meet the repeatability specification when calibrated at the low end of its operating range of 85 to 88 volts. RIS has corrected the identified deficiencies by redesign and by changing the minimum deadband specification. RIS has supplied PSE&G with certified replacement relays for the presently installed relays. The replacement relays have a minimum adjustable deadband of <1.0% of range. The installed relays will be changed out with the certified replacement relays supplied by RIS.

In addition to the excessive reset value of the relays, a problem of transferring back and forth between Station Power Transformers occurred during the August 26, 1986 event. In the original SLUVPS design the time delay settings and relay reset values were selected in an attempt to prevent the back and forth transferring between Station Power Transformers. The 91% transfer relays and the 91% vital bus relays were selected for time coordination and the reset values of the relays were also selected at 95% to prevent the "flip-flopping" phenomenon. (Refer to Reference 3.5) The original SLUVPS design required an attempted transfer from one station power transformer to the other to provide adequate protection for the single failure criterion. Normal vital bus alignment is to have two vital buses on one station power transformer and the remaining vital bus on the other station power transformer. Reference 3.5 provides a description of events which would be unacceptable if the station power transformer carrying the two vital buses had a degraded voltage condition with only a single 90% bus protection relay installed. Since the Safeguards Emergency Controller provides the 2 out of 3 logic and is operated by the bus protection relays, single failure of one of these 90% protection relays could allow 2 of the 3 buses to be operated at a degraded voltage value and, therefore, the attempted transfer of the vital bus was required. The Salem Technical Specifications, Reference 3.14 and 3.15, Section 3/4.3, Table 3.3-3 are presently written for the existing protection scheme as shown on Attachment "J". Therefore, to provide a timely redesign, the existing protection scheme described in the Technical Specification must be left intact to preclude a Technical Specification change. This may be accomplished by not altering the present sustained undervoltage protection relay interface with the Safeguards Emergency Controller and only altering the transfer scheme which was installed to prevent a single failure from providing adequate protection.

In order to positively prevent the possibility of "flip-flopping" the vital buses between Station Power Transformers, the existing 91% transfer scheme outlined in CDS-4 (Reference 3.7) must be abandoned. Since the transfer scheme was installed to provide protection for the single failure criterion, an alternate method to provide this protection is required. This will be accomplished by rewiring the PR-2035 undervoltage transfer relays to the vital bus potential transformers to provide (3) 91% undervoltage relays per vital bus. The three undervoltage relays will be wired to the two existing bus potential transformer secondaries. For example (1) undervoltage relay will be wired from ØA to ØB, another relay will be wired from ØB to ØC and the third relay will be wired from ØC to ØA. The U.V. protection relays will not be fused. The relay connection to the potential transformer secondaries through the existing knife switches is required to allow calibration and testing of the system. In addition to the existing 90% vital bus protection relay Safeguards Emergency Controller interface, each of (3) vital bus undervoltage relays will send an undervoltage signal to its Safeguards Emergency Controller (SEC) via the existing timers and an auxiliary relay. (Refer to Attachments "A" through "G".) The SEC will then make the decision based on 2 out of 3 logic to separate its bus from the offsite power source and load it to its diesel generator along with the present 2 out of 3 bus undervoltage logic.

The control power for the relaying will be supplied by its vital bus respective 125 volt D.C. battery system. The existing overhead annunciator bus undervoltage alarm will be operated when any one of the vital bus SLUVPS relays operate. Relay contacts from the three Undervoltage Auxiliary relays will be wired in series and provide an input to the existing undervoltage overhead annunciator window.

The bus voltage is expected to drop below the relay setpoint during group bus bulk load shifts. Therefore, the existing 13 second time delay to allow the voltage to recover is necessary prior to any automatic action by the SLUVPS. This time delay was justified and provided to the U.S.N.R.C. in Reference 3.5.

Since the relays are also expected to operate and time out when starting Reactor Coolant Pumps, the existing blocking feature provided by relay 62X to allow for the starting of these pumps will remain. A control console lamp is illuminated providing the control room operator indication that the protection has been successfully bypassed and that it is safe to start a Reactor Coolant Pump without operating the SLUVPS. The existing design uses contacts from the time delay relay to provide the lamp indication. In the new design contacts from the auxiliary undervoltage relays will be used. In addition an audible alarm will be installed to notify the operator that the protection has been defeated. This is required to alert the operator since possible malfunctions in the bypass circuitry could defeat the SLUVPS.

The redesign of the SLUVPS relaying must meet or exceed the design criteria identified in Reference 3.7. The criteria which were included were conformance to IEEE-279 and the single failure criterion, conformance to seismic I requirements, and provisions for testing the system. The redesigned system was analyzed in accordance with the single failure criterion, and the results are tabulated in Attachment H. The redesigned system as outlined above will not alter the testability of the system, although the procedure for testing the system must be revised.

5.0 Action

The Engineering and Plant Betterment Design Division, Instruments and Controls and Electrical will provide the Operational Design Change Notices (ODCN'S). The Engineering and Plant Betterment, Plant Engineering, Instruments and Controls and Electrical group will organize and be responsible for the design change package issue.

6.0 Schedule

The design change is an emergency. The DCR numbers are 1EC2271 and 2EC2271. The design group should complete their portion of the design change package by 2/25/87. The design change package must be ready for issue by 2/27/87.

7.0 Funding Authorization

The design change will be funded by O & M. The authorization and account numbers are E530.020, T00622.

8.0 Signatures

Michael Moroni 3/23/87
Originator Date

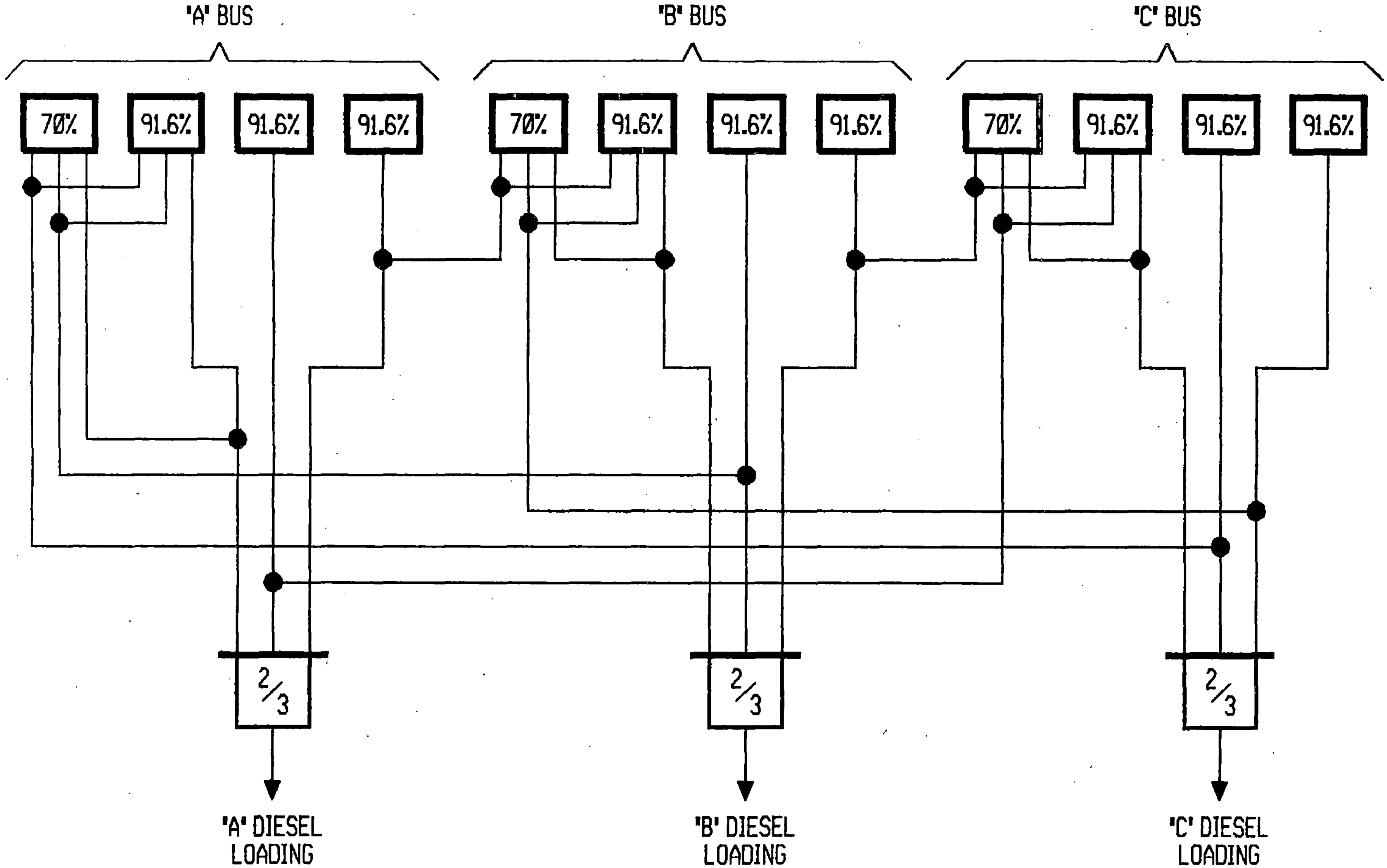
Walter G Drummond 3/23/87
Verifier Date

L. P. Calate 3/23/87
Originator's Group Head Date

C. W. [illegible] 3/23/87
SAG Group Head Date

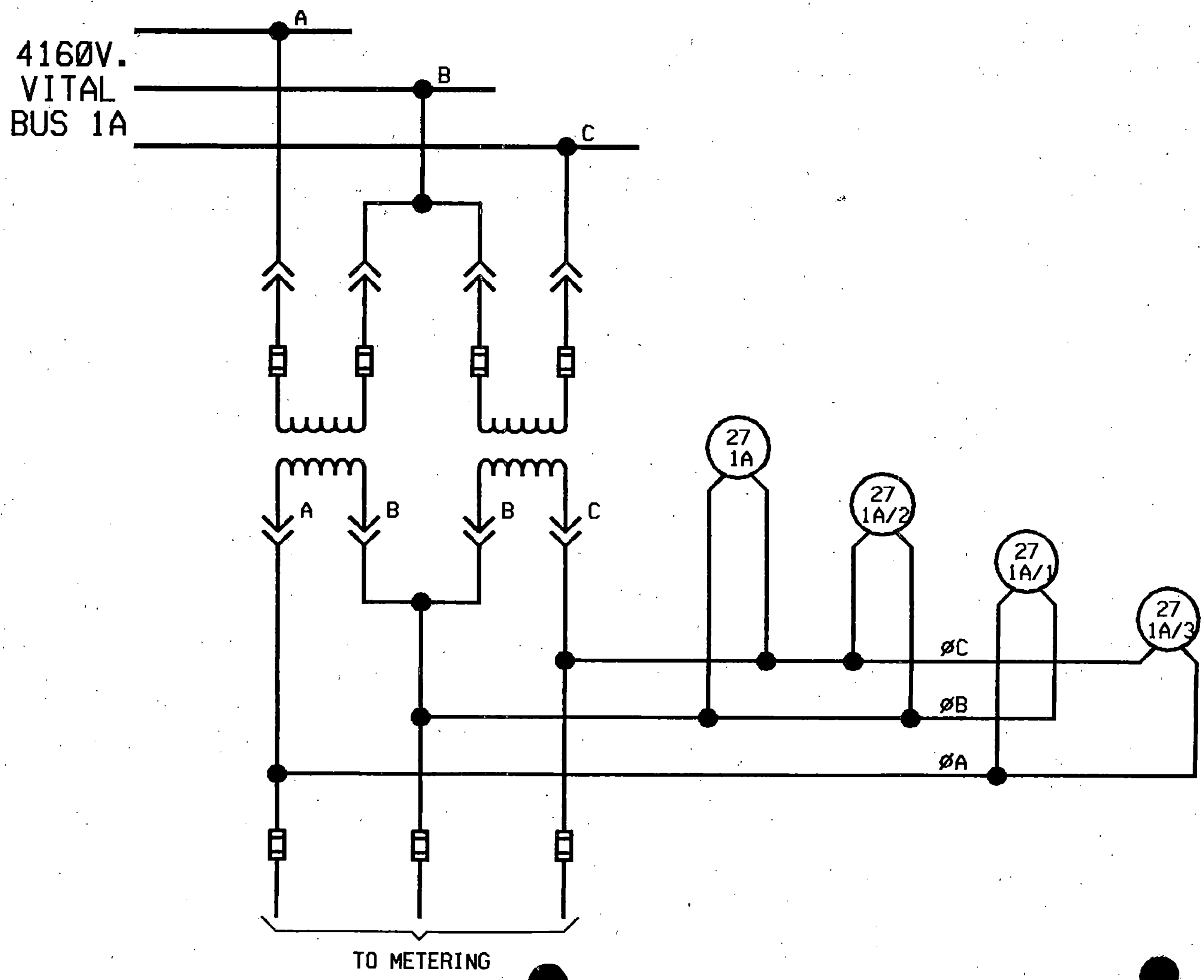
Robert [illegible] 3/23/87
Manager-
Plant Engineering Date

VITAL BUS PROTECTION RELAY LOGIC



ATTACHMENT 'A'

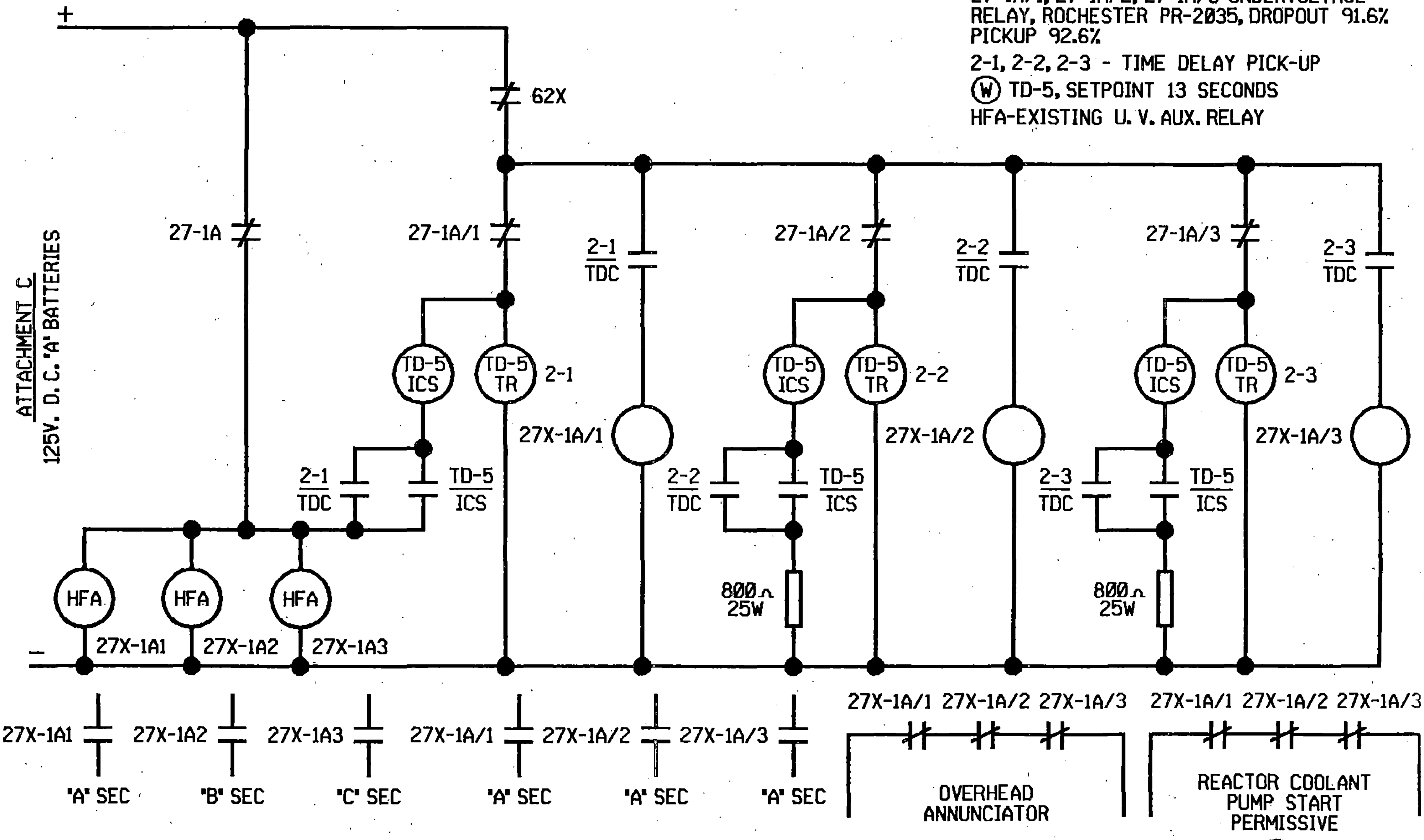
"A" VITAL BUS UNDERVOLTAGE SENSING CIRCUIT



ATTACHMENT B
4160V. VITAL BUS 1A

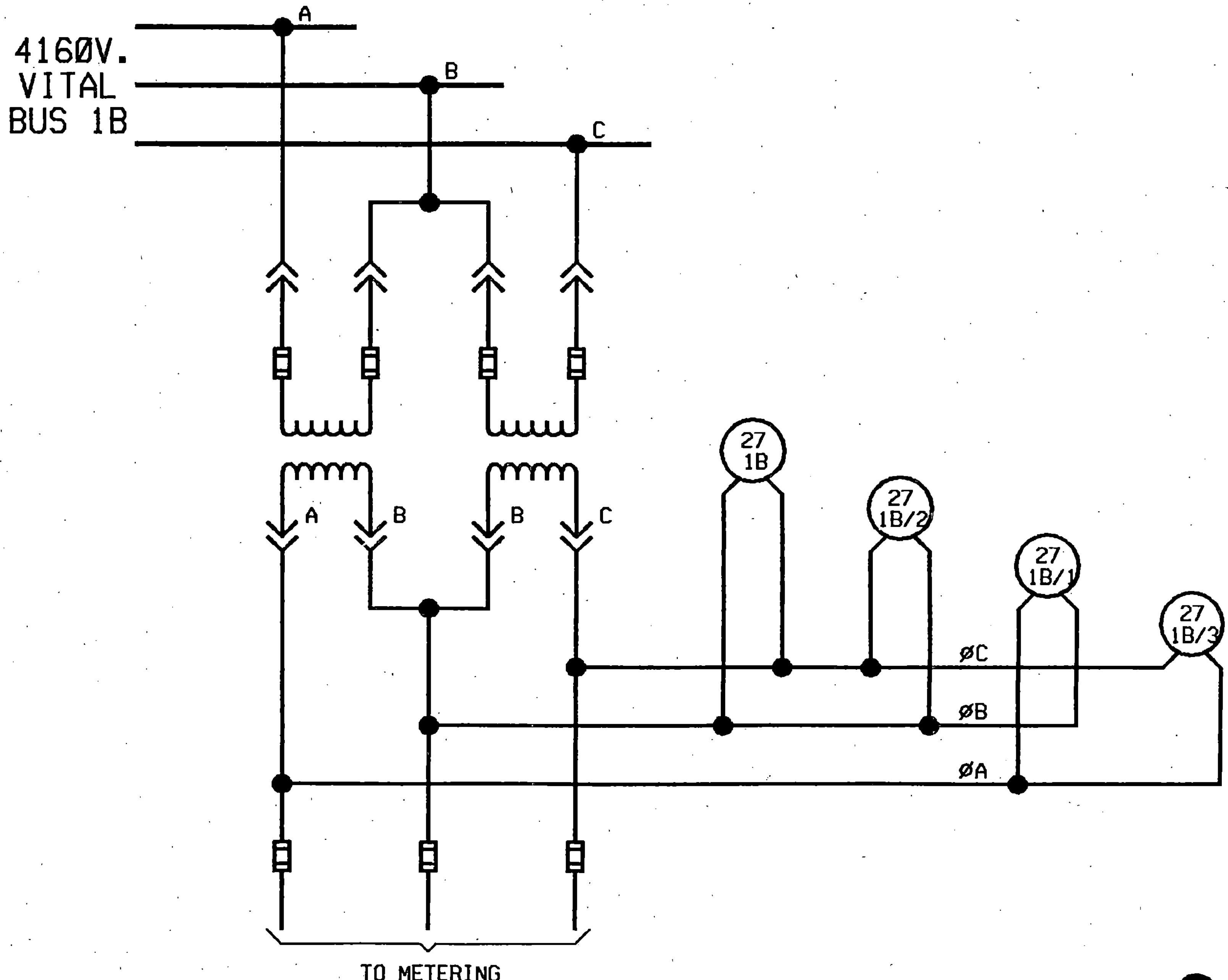
"A" VITAL BUS SECOND LEVEL UNDERVOLTAGE PROTECTION

27-1A 70% BLACKOUT RELAY
62X-PROTECTION DEFEAT RELAY
27-1A/1, 27-1A/2, 27-1A/3-UNDERVOLTAGE RELAY, ROCHESTER PR-2035, DROPOUT 91.6% PICKUP 92.6%
2-1, 2-2, 2-3 - TIME DELAY PICK-UP
(W) TD-5, SETPOINT 13 SECONDS
HFA-EXISTING U. V. AUX. RELAY



VB1

"B" VITAL BUS UNDERVOLTAGE SENSING CIRCUIT

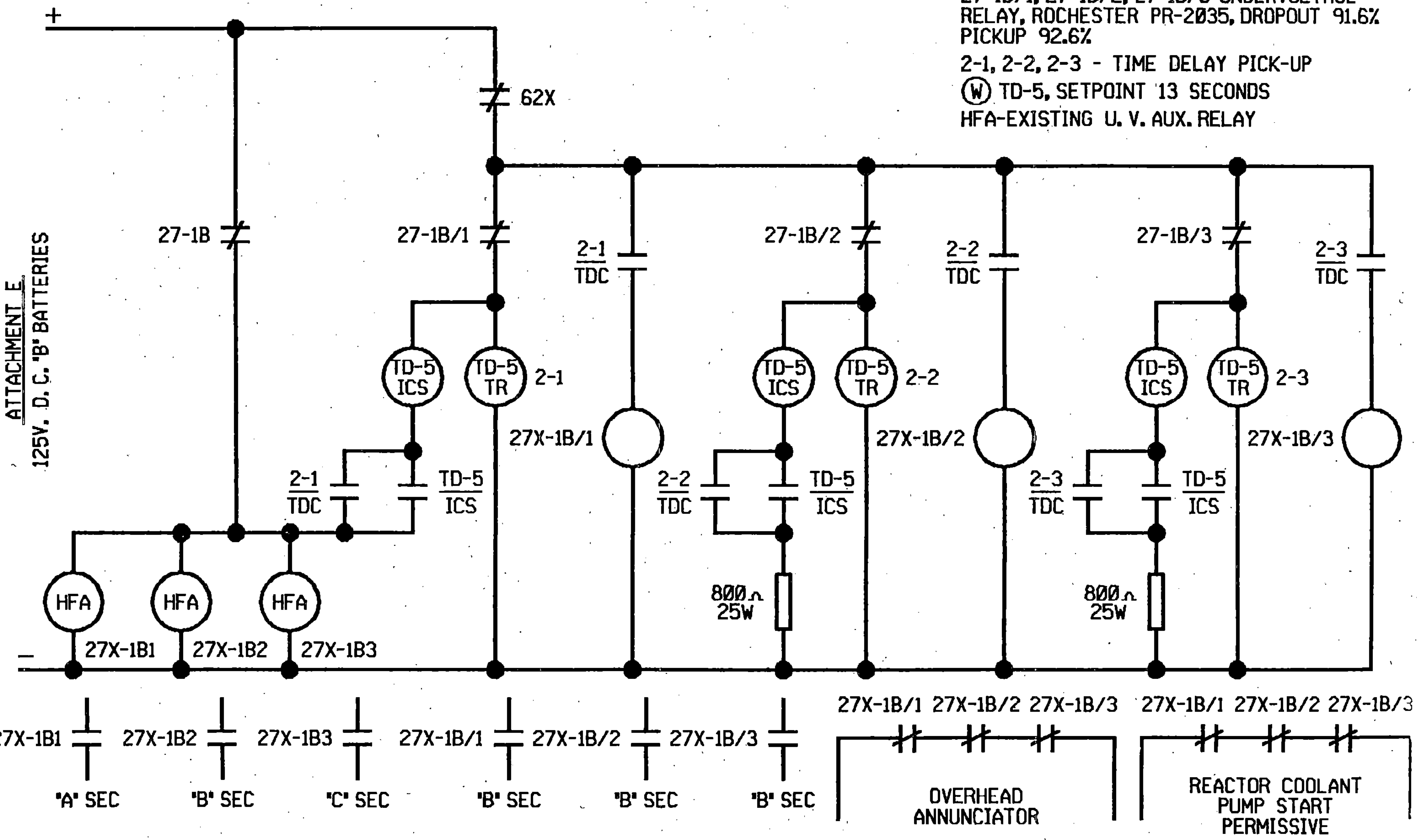


ATTACHMENT D
4160V. VITAL BUS 1B

"B" VITAL BUS SECOND LEVEL UNDERVOLTAGE PROTECTION

27-1B 70% BLACKOUT RELAY
62X-PROTECTION DEFEAT RELAY
27-1B/1, 27-1B/2, 27-1B/3-UNDERVOLTAGE RELAY, ROCHESTER PR-2035, DROPOUT 91.6% PICKUP 92.6%
2-1, 2-2, 2-3 - TIME DELAY PICK-UP
(W) TD-5, SETPOINT 13 SECONDS
HFA-EXISTING U. V. AUX. RELAY

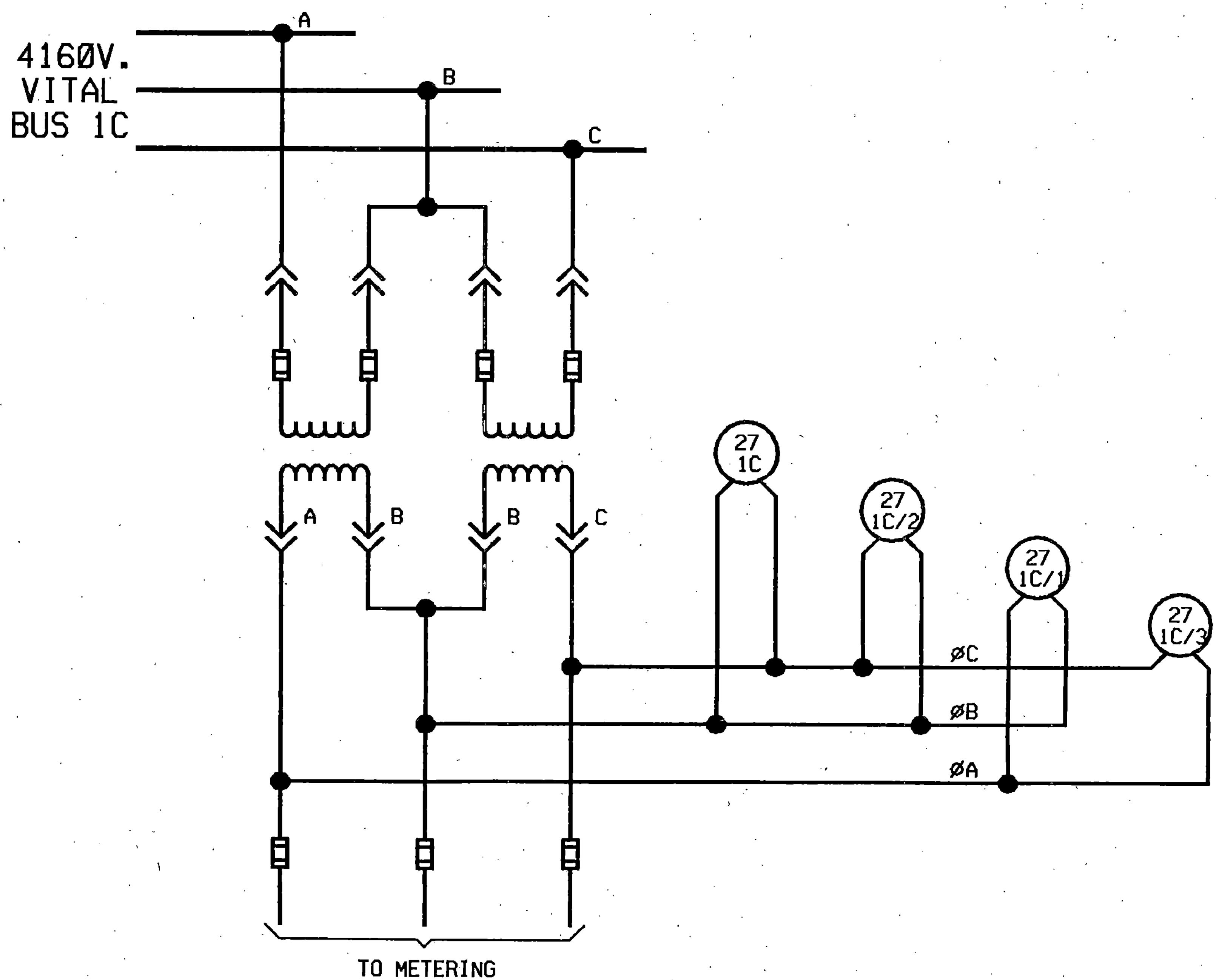
ATTACHMENT E
125V. D. C. "B" BATTERIES



VB2

"C" VITAL BUS UNDERVOLTAGE SENSING CIRCUIT

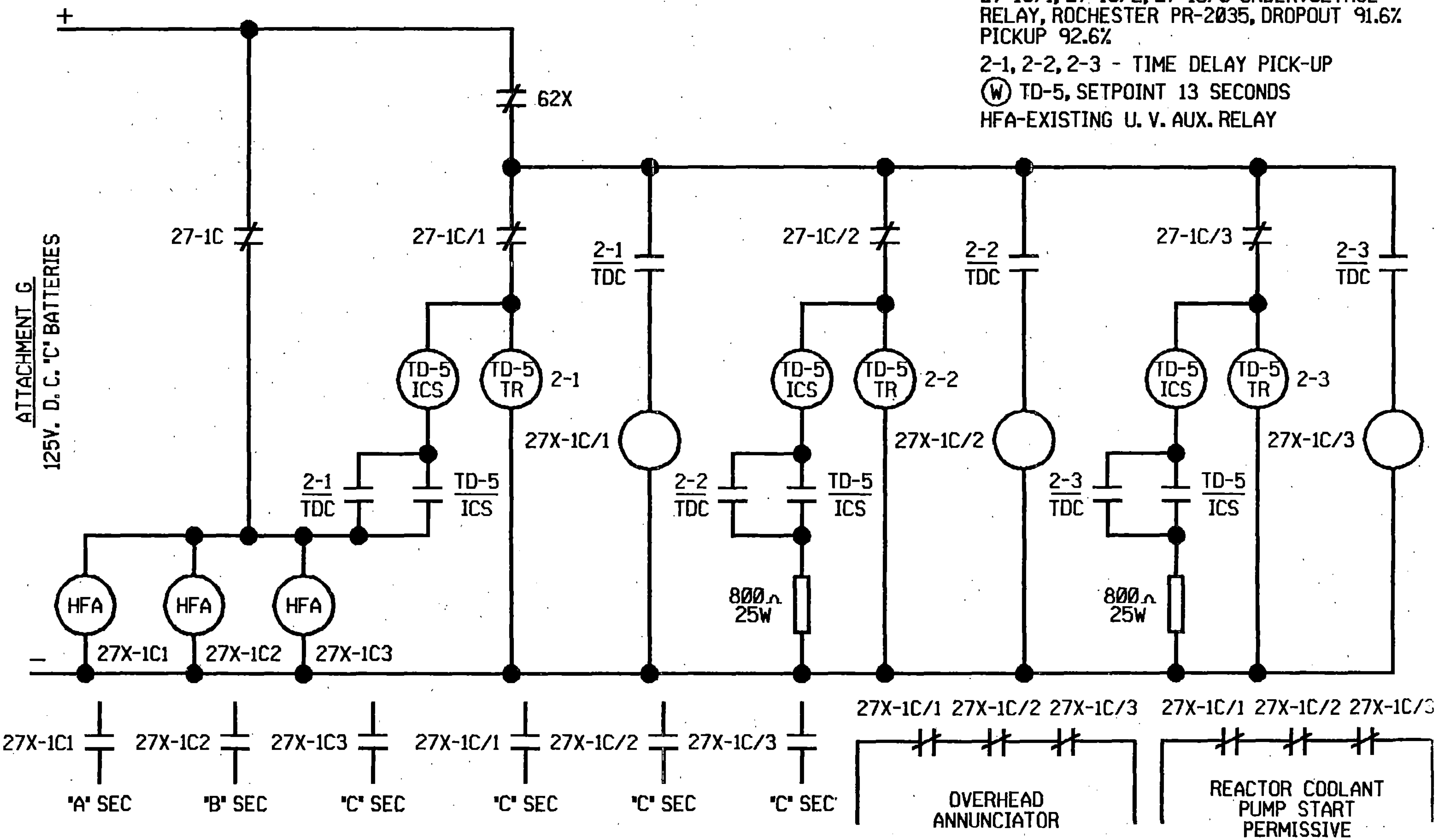
ATTACHMENT F
4160V. VITAL BUS 1C



ATTACHMENT G
125V. D. C. "C" BATTERIES

"C" VITAL BUS SECOND LEVEL UNDERVOLTAGE PROTECTION

27-1C 70% BLACKOUT RELAY
62X-PROTECTION DEFEAT RELAY
27-1C/1, 27-1C/2, 27-1C/3-UNDERVOLTAGE RELAY, ROCHESTER PR-2035, DROPOUT 91.6% PICKUP 92.6%
2-1, 2-2, 2-3 - TIME DELAY PICK-UP
(W) TD-5, SETPOINT 13 SECONDS
HFA-EXISTING U. V. AUX. RELAY



VB3

Attachment "H"
FAILURE MODE ANALYSIS

Failure	Normal Operation With Degraded Grid	LOCA & Degraded Grid
Undervoltage Relay	2 out of 3 logic will be made to load bus to diesel generator. Acceptable	2 out of 3 logic will be made to load bus to diesel generator. Acceptable
Timing Relay Failure	Same as above	Same as above
Undervoltage Auxiliary Relay Failure	Same as above	Same as above
HFA Relay Failure	Same as above	Same as above
Loss of 125 Volt Battery	Bus with failed battery system would maintain connection to grid. Buses without failed battery would load to diesel. Same as present design. Previously Analyzed	Bus with failed battery system would maintain connection to grid. Buses without failed battery would load to diesel. Same as present design. Previously Analyzed
Loss of 125 Volt DC Branch CKT	Same as above	Same as above
Loss of Cable from Bus to S.E.C.	Bus with failed cable would maintain connected to grid. Other buses would load to diesel. Two vital buses would be available for safe shutdown. Therefore previously analyzed.	Bus with failed cable would maintain connected to grid. Other buses would load to diesel. Two vital buses would be available for safe shutdown. Therefore previously analyzed.
62X Defeat Relay	Alarm in control room. Bus with failed 62X relay would maintain connection to grid. Other buses would load to diesel. Two Vital buses would be available for safe shutdown. Therefore previously analyzed.	Alarm in control room. Bus with failed 62X relay would maintain connection to grid. Other buses would load to diesel. Two Vital buses would be available for safe shutdown. Therefore previously analyzed.
Potential Transformer	Same as undervoltage relay failure	Same as undervoltage relay failure
Potential Transformer Primary Fuse	Same as undervoltage relay failure	Same as undervoltage relay failure

dm/mpml

Attachment "I"

SETPOINT CALCULATIONS

Potential Transformer Accuracy	±.3%
Relay Repeatability ±.1% of range	±.13%
Relay Temperature influence ±.5% - 20°C to 60°C	±.63%
Calibration uncertainty ±.5% of setpoint	±.45%
Relay deadband <1% of range - use .8% of range	1%

$$\text{Setpoint} \geq 90.7 + \sqrt{(.3)^2 + (.13 + .63)^2 + (.45)^2}$$

$$\text{Setpoint} \geq 90.7 + .9$$

$$\boxed{\geq 91.6\%}$$

$$\text{Relay Reset} = 91.6\% + 1\% = \boxed{92.6\%}$$

NOTES:

1. Tolerances used in square root of the sum of the squares are on the 4160 volt base across the 35:1 potential transformer.
2. A setpoint of 91% was assumed to calculate the tolerance for calibration uncertainties.
3. The entire temperature influence accuracy was used for conservatism. The relay will not see this type of temperature range when installed.
4. The range of the relay is 85 volts to 150 volts.

Attachment "J"

TABLE 3.3-3

Engineered Safety Features Actuation System Instrumentation

	Functional Unit	Total No. of Channels	Channels to Trip	Minimum Channels Operable	Applicable Modes	Action
	7. Undervoltage Vital Bus					
Existing	a. Loss of Voltage	3	2	3	1,2,3	14*
	b. Sustained Degraded Voltage	3	2	3	1,2,3	14*

SALEM GENERATING STATION

ELECTRICAL DISTRIBUTION SYSTEM IMPROVEMENT STUDY

Goal: Assure a Safe and Reliable Electrical Distribution System at Salem Generating Station

Objectives:

1) Develop a comprehensive Design Basis including:
   a) Design Documents
   b) Calculations
   c) Procedures
   d) NRC Licensing Issues
2) Analyze System Deficiencies/Weaknesses
3) Develop Feasibility Studies for System Improvement Options

<u>DESIGN ITEMS</u>

A. Data Collection

B. Short Circuit

C. Coordination

D. Relay & Transfer Scheme

E. Sizing (Equipment)

F. Voltage Profile

G. Motor Starting

H. Cable & Raceway Criteria

I. Coordinate with New REG's

J. Maintainability

K. Reliability/Availability

L. Summary & Recommendations

SYSTEMS

1. 25 kV (GEN)
2. 13.8/4.16 kV
3. 480/230/208 V
4. 115 VAC (Vital)
5. 125 VDC (Vital)
6. 28 VDC (Vital)
7. 250 VDC
8. Penetrations
9. Diesel Generator