SARGENT & LUNDY ENGINEERS	Calc. For Second-level Undervoltage Relay Setpoint			Calc. No. 8982-17-19-2	
	X	Safety-Related	Non-Safety-Related	Rev. 0	Date 2/6/92
				Page 1	of 20

Client Commonwealth Edison Company	Prepared by Andrew J. Rinde — Date 2-6-92
Project Dresden Unit 3	Reviewed by Greg N. Hinshaw — Date 2/6/92
Proj. No. 8982-64 Equip. No.	Approved by Jan B. Wisniewski — Date 2/6/92

I. REVISION SUMMARY

Rev. 0, First Issue, Pages 1-20

II. METHOD OF REVIEW

QA CALCULATION REVIEW CHECKLIST
TYPE OF CALCULATION

☑ Hand-Prepared Design Calculation Only

☐ Computer-Aided Design Calculation Only

☐ Both hand-Prepared and Computer Aided Design Calculation

FOR HAND-PREPARED DESIGN CALC
(check the appropriate items)

☑ Detailed review of the original calculation.

☐ Review by an alternate, simplified or approximate method of calculation.

☐ Review of a representative sample of repetitive calculations.

☐ Review of the calculation against a similar calculation previously performed.

FOR COMPUTER-AIDED DESIGN CALC
(check the appropriate items)

☐ A review to determine if the engineering design and analysis computer program(s) used have been validated and documented and that the calculation, regardless of the program used,contains all the necessary documentation for reconstruction at a later date. (MUST BE PERFORMED)

☐ A review to verify that the computer program is suitable to the problem being analyzed. (MUST BE PERFORMED)

☐ A review to determine if the input data as specified for program execution is consistent with the design input, correctly defines the problem for the computer program algorithm and is sufficiently accurate to produce results within any numerical limitation of the program. (MUST BE PERFORMED)

☐ A review to verify that the results obtained from the program are correct and within stated assumptions and limitations of the program and are consistent with the input. (MUST BE PERFORMED)

☐ Validation documentation for temporary changes to listed programs or developmental programs or unique single application programs shall be reviewed to assure that methods used adequately validate the program for the intended application. (WHERE APPLICABLE)

REVIEWER: Greg J. Hinshaw DATE: 2/6/92

III. TABLE OF CONTENTS

Section	Contents	Page No.

IV. SCOPE / PURPOSE

The scope and purpose of this calculation is to determine a setpoint for the second-level undervoltage relays at Dresden Unit 3 based on post LOCA voltage analysis. This setting will be reevaluated based on an expanded scope analysis of the auxiliary power system or a redesign of the second-level undervoltage relay scheme.

The setpoint will consider the setpoint error of the circuit that monitors the voltage at the 4.16 kV safety-related switchgear. The circuit consists of a GE type JVM-3 4200-120 volt potential transformer (PT) and an ITE-27N undervoltage relay (catalog number 411T4375-HF).

The calculation addresses the following topics:

Instrument channel configuration,

Process range and Analytical Limit,

Loop element data,

Calibration instrument data,

Assumptions,

Scaling considerations (PT ratio),

Process errors,

Trip unit errors,

Calibration setpoint and Allowable Value.

V. INPUT DATA

A. **Instrument Channel Configuration** (per Reference A.1)

The circuit consists of a 4200-120 volt PT and a trip unit. The 4200 volt side of the PT is connected to two phases of the 4160 volt source at the safety-related switchgear. The trip unit is connected to the 120 volt side of the PT. The trip unit is powered by a 125 volt dc source.

B. **Loop Element Data** (per Reference A.3, G, H, & L)

1. The PT is a GE, type JVM-3 (see Reference A.3 & H)

Voltage ratio:	4200-120
Accuracy class:	0.3W,X,M,Y
Frequency:	50 Hz, 60 Hz
Burden:	750 VA @ 30 C Ambient
	500 VA @ 55 C Ambient

2. The trip unit is an ABB/ITE, type 27N undervoltage relay with a Harmonic Filter (catalog number 411T4375-HF)

<u>Setpoint Ranges</u>	(per Reference L)
Pickup:	70 V - 120 V
Dropout:	70% - 99.5% of Pickup
Dropout Delay:	1 - 10 sec.

<u>Operating Ranges</u>	(per Reference G & L)
Control Voltage:	38-58 Vdc (48 Vdc nominal)
	100-140 Vdc (125 Vdc nom.)
Temperature:	-20 to +55 C (normal)
	-30 to +70 C (accident)
Seismic:	6g ZPA
Humidity:	0 to 100% no condensation
	(see Assumption A.7)
Pressure:	Atmospheric, to 5000 ft
Radiation:	Gamma 100k rads over 40 yrs

V. INPUT DATA (cont.)

B. Loop Element Data (cont.)

Repeatability Tolerances (per Reference L)

@ const temp & control volt:		+/-0.1%
for volt. range 100 - 140 Vdc:		+/-0.1%
for temp. range	+10 to +40 C:	+/-0.4%
	0 to +55 C:	+/-0.75%
	-20 to +70 C:	+/-1.50%

The 3 tolerances are cumulative and are considered to be 2(sigma) values (see Assumption B.1 and reference I).

For the tolerance over temperature range, the repeatability effect is linear over the range of 0 to +55 C, as indicated in reference I.

C. Calibration Instrument Data (per Reference D)

It is assumed that a Fluke 45 Digital Multimeter will be used for the calibration of the trip unit (see Assumption A.4).

Reference Accuracy:	+/-0.2% + 10 digits
Full Scale:	300 Vac, 5 digits
Minimum Gradation:	0.01 V

D. Calibration Procedure Data

The setting tolerance when setting the trip unit voltage is considered to be 0.2 V or about 0.182% for a setpoint near 110 V. (Refer to Assumption A.1)

V. INPUT DATA (cont.)

E. Station Data

The circuits for these two processes are located entirely in the Reactor Building in Environment Zone 26 per Reference A.2. The following are the conditions that the circuits will be subject to:

Normal Conditions

Control Voltage Range:	100-140Vdc (see Assumption A.2)
Temperature Range:	+5 - +40 C (see Assumption A.3)
Humidity Range:	0 - 90%
Radiation Level:	<10k rads over 40 years

Accident Conditions

Control Voltage Range:	100-140Vdc (see Assumption A.2)
Temperature Range:	+5 - +40 C (see Assumption A.3)
Humidity Range:	0 - 100% non-condensing
Radiation Level:	<35k rads over 1 year

As noted in reference J, the actual temperatures seen by the relay will be approximately 15 C higher than the ambient temperature.

The relay has already been qualified for humidity variation, seismic events, radiation exposure, and pressure variation as discussed in References A.2. and G. (Also, see Assumption A.7)

F. Allowable Value of Switchgear Voltage

The minimum voltages required at the 4160 V safety-related switchgear for adequate auxiliary system performance are taken from References E & F as:

3832.3 V or 92.1% of 4160 V at Switchgear 33-1 (Div I)
3791.7 V or 91.1% of 4160 V at Switchgear 34-1 (Div II)

Although a higher voltage is required at Swgr 34-1 to satisfy the starting voltage requirements for the CCSW Pump Cubicle Cooler Fans, it is our understanding that CECo is preparing a safety assessment for the CCSW system without Cubicle Cooler Fan availability. (Refer to Assumption A.6)

VI. ASSUMPTIONS

A. Assumptions requiring verification

1. The setting tolerance used for setting the trip unit voltage is assumed to be +/-0.2 V, which corresponds to about +/-0.182% for a setpoint expected to be near 110 V.

2. The dc control voltage for the undervoltage relays will be within the relay's acceptable range of 100-140 Vdc during both normal and accident conditions.

3. The temperature during both normal and accident conditions in the zone that the undervoltage relays are located in is assumed to be in the range of +5 to +40 C. Therefore, the relays will experience temperatures in the range of +20 to +55 C (see section V.E).

4. It is assumed that the voltmeter used for setting the relay is a Fluke 45 Digital Multimeter.

5. It is assumed that the multimeter is calibrated to meet its technical accuracy specifications as identified in the Fluke 45 literature (Reference D). Furthermore, it is assumed that the relay is calibrated at a temperature that is within the range of 21 to 24 C. This assumption is necessary to limit the conservatism in the error due to relay temperature effect to a reasonable level.

6. The CCSW Pump Cubicle Cooler Fans need not be considered in determining the minimum allowable 4.16 kV system voltage.

7. Reference A.2 indicates that the relay may be subject to a humidity of up to 100% with no condensation during an accident condition. It is our understanding that additional testing has been performed to qualify the relay for such a condition, but the report is not yet available. Therefore it is assumed that the relay is qualified for 100% humidity with no condensation until this information can be verified by the test report.

VI. ASSUMPTIONS (cont.)

B. Assumptions not requiring verification

1. It is a general practice for vendors to provide device reference accuracy as a 2(sigma) value. Therefore, all reference accuracy specifications, unless otherwise noted, are assumed to be 2(sigma) values. Thus, the standard deviation, sigma, of an instrument's error is one half of the reference accuracy provided by the vendor.

2. The error due to calibration standards is considered negligible.

VII. ACCEPTANCE CRITERIA

The relay setpoints will be chosen such that the lowest possible voltage for relay operation, considering setpoint error, will be no lower than the Analytical Limits as identified in section V of this calculation:

3832.3 V or 92.1% of 4160 V at Switchgear 33-1 (Div I)
3791.7 V or 91.1% of 4160 V at Switchgear 34-1 (Div II)

VIII. METHODOLOGY

The methodology for determining the setpoints is based on the methods in References B & C. The nomenclature for the relay setpoint terms, such as pickup, dropout, and reset is taken directly from the relay instruction bulletin (Reference L).

A. The error associated with the PT will be established. The error for the PT is classified as a non-random process error and will be based on the accuracy assigned the PT by the manufacturer. It is not expected that the PT performance will be significantly affected by environmental factors. Therefore, no additional error for the PT will be introduced for environmental factors.

B. The error associated with the second-level undervoltage relay will be established. The following items will be considered in determining the setpoint error as a result of the relay:

Reference accuracy (defined by the manufacturer as repeatability at constant temperature and control voltage)

Calibration instrument error (defined by the manufacturer)

Temperature effect (defined by the manufacturer as repeatability over temperature range)

Control voltage effect (defined by the manufacturer as repeatability over the allowable dc control power range)

Relay setting tolerance (see Assumption A.1)

Reference accuracy, Calibration instrument error, and relay setting tolerance are classified as random errors, and will be combined by the "Square root of the sum of the squares"(SRSS) method.

Temperature effect and control voltage effect are classified as non-random errors since their variation is linear and their effect can be predicted. (See Reference J)

VIII. METHODOLOGY (cont.)

The following items will be evaluated for their effect on the relays' functional capability:

Seismic error

Humidity error

Pressure error

Radiation error

Drift error

C. The errors identified above will be combined into total error by adding the total random error to the total non-random error (per Reference B, Exhibit F).

All random error values as published by the manufacturer are considered to be a 2*(sigma) value, or twice the standard deviation (refer to Assumption B.1). When the random errors are combined by the SRSS method, the sigma values, or half of the published values, are used. The outcome of the SRSS method is then doubled to reintroduce the conservatism of the published values.

All non-random error will be added together by straight addition.

D. The nominal dropout for the two relays will be determined by adding the total error to the Analytical Limits. No margin will be considered in this calculation since all applicable components in the circuit have been accurately represented.

IX. CALCULATION

A. The error contributed by the PT is considered to be a process error since the PT is not a calibrated device. The process **error introduced by the PT is +/-0.3%.** This is classified as a non-random error.

B. The error introduced by the second-level undervoltage relay is developed below:

1. Reference accuracy (assumed to be a 2*sigma value):

   Repeatability at constant temperature and control voltage is +/-0.1%

   Therefore, **sigma for reference accuracy is 0.05%**

2. Calibration Instrument error (assumed 2*sigma values):

   Reference accuracy is +/-(0.2% + 10 digits) or +/-(0.2% + 10*0.01 V).

   If the relay is set near 110V, then 10*0.01V or 0.1V is equivalent to about 0.091%.

   Thus, the 2*sigma reference accuracy is 0.291%.

   Since the instrument has a digital readout, there is no reading error.

   Also, since the calibration instrument and the relay are calibrated within the allowable range as specified by the calibration instrument manufacturer, there is no temperature effect for the calibration instrument. (See Assumption A.5)

   Then the 2*sigma calibration error is 0.291%, and **sigma for the calibration error is 0.146%**

IX. CALCULATION (cont.)

3. Temperature effect:

The temperature effect is published as +/-0.75%, and the absolute effect is 1.5% over the temperature range of 0 to +55 C as discussed in section V.E of this calculation. Per Reference I, the relay operating voltage increases approximately linearly wth increasing temperature at a rate of 0.0273%/C over the 0 to +55 C temperature range.

Then, for a temperature range of +20 to +55 C and a relay calibration temperature range of 21 to 24 C (per Assumptions A.3 and A.5 respectively), the temperature effect is developed below:

Negative Temperature Effect:

In determining the negative error due to relay temperature effect, it will be considered that the relay is calibrated at a temperature of 24 C (see Assumption A.5). This will provide a conservative reference point from which the temperature effect for the relay can be incorporated into the determination of the nominal dropout. At 24 C, a larger portion of the error used in the calculation for relay temperature effect will be negative, which will provide a conservative nominal dropout.

Negative effect = (24-20 C)*0.0273%/C = 0.109%

Positive Temperature Effect:

In determining the positive error due to relay temperature effect, it will be considered that the relay is calibrated at a temperature of 21 C (see Assumption A.5). This will provide a conservative reference point from which the temperature effect for the relay can be incorporated into the determination of the maximum dropout of the relay. At 21 C rather than 24 C, a larger portion of the error used in the calculation for relay temperature effect will be positive, which will provide a conservative determination of the relay maximum dropout.

Positive effect = (55-21 C)*0.0273%/C = 0.928%

Thus, the **temperature effect is +0.928%/-0.109%**
This is classified as a non-random error.

IX. CALCULATION (cont.)

4. **Control voltage effect is +/-0.1%** over the dc control voltage range of 100-140 Vdc. This is classified as a non-random error.

5. The Relay setting tolerance is +/-0.182% (per Assumption A.1). This is a random error. Thus, **sigma for the setting tolerance is 0.091%.**

6. By comparison of the acceptable relay conditions provided in section V.B.2 with the expected station conditions provided in section V.E, it is evident that no effect on functional capability is introduced as a result of pressure variation, humidity variation, or radiation levels. (Refer to Assumption A.7)

7. As discussed in Reference A.2, section 1.7, no effect on functional capability of the relay is introduced as a result of a seismic event since the relay capability envelops the seismic requirement for the relay locations.

8. According to Reference I, no drift error is expected for the relay as long as the relay is calibrated at reasonable intervals.

IX. CALCULATION (cont.)

C. The random and non-random errors determined above are now combined.

Negative Non-random error = 0.3% (from PT) + 0.109% (from relay temperature effect) + 0.1% (from relay control voltage effect).

Positive Non-random error = 0.3% (from PT) + 0.928% (from relay temperature effect) + 0.1% (from relay control voltage effect).

Negative Non-Random Error = 0.509%
Positive Non-Random Error = 1.328%

Random error is determined by the "Square-root of the Sum of the Squares" method. The random errors include relay reference accuracy, calibration instrument error, and relay setting tolerance.

Random error= $\pm\sqrt{(0.05\%)^2+(0.146\%)^2+(0.091\%)^2} = \pm 0.179\%$

Then the Total Error is calculated using:

Total = Non-Random + 2*Random

Total Negative Error(TNE)=(0.509%+2*0.179%)= 0.867%
Total Positive Error(TPE)=(1.328%+2*0.179%)= 1.686%

IX. CALCULATION (cont.)

D. The nominal dropouts are then calculated below:

4160 V Swgr 33-1 (Div. I)

Nominal Dropout(DO) = Allowable Limit(AL) + TNE

AL = 3832.3 V / 4200 V * 100% = 91.2452%
(AL is also the relay minimum dropout voltage)

DO = 91.2452% + 0.867% = 92.1122%
= 92.1122% * 120 V = **110.53 V**

From the nominal dropout, the maximum dropout and pickup voltages can be determined:

Max. Dropout = DO% + TPE = 92.1122% + 1.686% = 93.7982%
= 93.7982% * 4200 V = 3939.5 V

Max. Pickup = Max. Dropout / (dropout/pickup ratio)
= 3939.5 V / 0.995 = 3959.3 V
(The Max. Pickup is the relay Max. Reset Voltage)

4160 V Swgr 34-1 (Div. II)

Nominal Dropout(DO) = Allowable Limit(AL) + TNE

AL = 3791.7 V / 4200 V * 100% = 90.2786%
(AL is also the relay minimum dropout voltage)

DO = 90.2786% + 0.867% = 91.1456%
= 91.1456% * 120 V = **109.37 V**

From the nominal dropout, the maximum dropout and pickup voltages can be determined:

Max. Dropout = DO% + TPE = 91.1456% + 1.686% = 92.8316%
= 92.8316% * 4200 V = 3898.9 V

Max. Pickup = Max. Dropout / (dropout/pickup ratio)
= 3898.9 V / 0.995 = 3918.5 V
(The Max. Pickup is the relay Max. Reset Voltage)

X. CONCLUSIONS / RECOMMENDATIONS

Based on the methods used in references B & C and the assumptions in section VI., the following are the recommended settings for the Division I and II second-level undervoltage relays:

4160 V Swgr 33-1 (Div. I)

Nominal Dropout = 92.1122% * 120 V = 110.53 V

Setting the Dropout/Pickup Ratio to the maximum published value of 99.5%, the pickup setpoint is calculated:

Pickup Setpoint = 110.53 V / 0.995 = 111.1 V

4160 V Swgr 34-1 (Div. II)

Nominal Dropout = 91.1456% * 120 V = 109.37 V

Setting the Dropout/Pickup Ratio to the maximum published value of 99.5%, the pickup setpoint is calculated:

Pickup Setpoint = 109.37 V / 0.995 = 109.9 V

If it is desired that one setting be used for both divisions, the second-level undervoltage relays should be set to pickup at 111.1 V.

The delay setting for the relay was not analyzed in this calculation nor was it intended to be. Thus, the delay of the relay should be set to the same value as previously required per the Dresden Unit 3 Technical Specifications (Reference K), which is 7 seconds.

Please utilize the Instruction Bulletin I.B. 7.4.1.7-7, Issue D (Reference L) when setting the relay since the setpoints and setpoint terminology in this calculation are based on this instruction bulletin.

XI. REFERENCES

A. DIT Number DR-EPED-0685-00, entitled "ITE-27N Undervoltage Relay and Potential Transformer Technical Data", dated 2-3-92. The following were included in the DIT:

1. Dresden Unit 3 Drawings:

   a. 12E-3301, Sheet 3, Rev. Z
   b. 12E-3334, Rev. K
   c. 12E-3345, Sheet 2, Rev. AB
   d. 12E-3346, Sheet 2, Rev. AF
   e. 12E-3655G, Rev. K

2. Work Request Number D-97546/D-97547, Rev. 0, entitled "Minor Plant Design Change Package for Commonwealth Edison Company, Dresden Unit 3, Replacement of Second-level Undervoltage Relays," dated 6-26-91.

3. 4160 V Switchgear Proposal Data Sheet (page 6) of Specification number K-2175 R.

B. CECO document Number TID-E/I&C-10, Rev. 0, entitled "Procedure for Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy", dated 12-01-91.

C. CECO document Number TID-E/I&C-20, Rev. 0, entitled "Basis for Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy", dated 12-01-91.

D. Facsimile from S. Gaconis of CECO-NED to A. Runde of S&L-EAD dated 1-24-92, containing pages 58 and 59 of the 1992 Fluke/Phillips Test & Measurement Catalog.

E. S&L Calculation Number 8982-17-19-1, Rev. 0, entitled "Calc. for Minimum Operating Voltage at 4.16 kV Bus 33-1 for Dresden 3/I Safety-related Continuous Loads," approved 1-21-92.

F. S&L Calculation Number 8982-19-19-1, Rev. 1, entitled "Calc. for Minimum Operating Voltage at 4.16 kV Bus 34-1 for Dresden 3/II Safety-related Continuous Loads," approved 2-2-92.

G. ABB document number RC-5039-A, entitled "Equipment Performance Specifications, 27N Undervoltage Relay."

H. GE document 7910, page 131, providing information for type JVM-3 Potential Transformer, dated 6-20-77.

XI. REFERENCES (cont.)

I. Memorandum of Telephone Conversation between S. Hoats of ABB and A. Runde of S&L concerning ITE-27N relay characteristics, dated 1-23-92.

J. S&L Standard ESA-104a, dated 1-5-87, entitled "Electrical Engineering Reference for Current Carrying Capacities of Copper Cables," Section 3.1.e.

K. Dresden Unit 3 Technical Specification Number DPR-25, Amendment number 103, specifically table 3.2.2, page 3/4.2-10. This reference provides the second-level undervoltage relay time delay requirement.

L. ABB Instruction Bulletin Number I.B. 7.4.1.7-7, Issue D for ITE-27N relays and others.