UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

January 21, 1998

NRC INFORMATION NOTICE 98-03: INADEQUATE VERIFICATION OF OVERCURRENT TRIP SETPOINTS IN METAL-CLAD, LOW-VOLTAGE CIRCUIT BREAKERS

Addressees

All holders of operating licenses for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees that inadequate verification of overcurrent trip setpoints for metal-clad, low-voltage circuit breakers may result in the loss of multiple safety functions. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On September 16, 1996, an Asea Brown Boveri (ABB) Company type K600S 480-Vac circuit breaker prematurely tripped on overcurrent at Centerior Energy Company's Perry Nuclear Power Plant and de-energized a safety-related motor control center (MCC). The circuit breaker's SS-5 solid-state trip device (Power Shield) sensed an overcurrent even though actual MCC current at the time of the trip was well below the Power Shield's expected trip setpoint. Subsequent inspection of the circuit breaker revealed that the leads from one of the three current transformers (CTs) used to sense fault currents were reversed. The reversed CT leads caused the Power Shield's long time overcurrent trip setpoint to shift downwards from 660 amps of primary current to approximately 330 amps and caused the breaker to trip inadvertently on overcurrent.

Discussion

Three-phase solid-state and microprocessor trip units are sensitive to the polarity (or phase) of the signal from the phase sensor CTs. The signal can be effectively shifted 180° out of phase if the CT leads are reversed (or connections between the lower CT terminals and the Power Shield unit terminals are reversed) or if the CT coil is installed upside down. Normally, the signals from the three phase sensor CTs are separated by 120° of phase. However, when a single 180° phase shifted signal from an incorrectly wired or installed CT is combined in the processor with

the other two, the sensed peak amplitude of the combined signal can be effectively doubled. In at least one instance, as described above, this condition has caused the solid-state trip unit to actuate at a primary current level significantly below the expected level.

However, such an unexpected phase shift in CT secondary output current is not detected during single-phase primary current calibration and testing. Therefore, additional inspections or tests may be necessary to adequately verify proper operation of circuit breakers equipped with solid-state trip units. ABB's procedure to check phase sensor polarity for solid-state trip devices, Types SS-3, -4, -5, -13, -14, and -15 is as follows:

1. On the static trip (Power Shield) unit terminal strip, connect an analog meter (i.e., conventional electromechanical d'Arsonval meter movement), set to measure current (100 mA scale) as follows to check the phase sensors for each pole: Negative test lead at Terminal 5, Positive test lead successively for each test at Terminals 6, 7, and 8 for the left, center, and right poles respectively.

2. Connect the NEGATIVE (-) terminal of a 1.5-volt battery to the finger assemblies of the breaker's LOWER primary disconnects for each of the above corresponding poles for each test. Then while observing the meter, touch a test lead from the POSITIVE (+) battery terminal to the corresponding pole's UPPER primary disconnect successively for each test.

3. Check that there is a momentary deflection of the meter needle in the positive direction as the positive battery lead is touched to each upper primary disconnect. A positive deflection indicates that the polarity of the signal from the CT as read at the static trip unit is correct.

Normally, this test will confirm that both the wiring and the Phase Sensor CT orientation are correct. However, it should be noted that if both the wiring and the CT orientation on the same pole are reversed, this will also produce a signal of the correct polarity or correct phase relationship to the other two poles, but this is not the preferred condition. The factory uses this test as a troubleshooting procedure, not a substitute for good visual inspection of the assembly. In addition, the test will confirm correct CT winding, internal lead-to-winding connections and cover marking, which would not otherwise be readily apparent if incorrect on new CTs from the CT manufacturing facility.

The circuit breaker that tripped prematurely on overcurrent at Perry was a new circuit breaker supplied by ABB Power T&D Co., Inc. On March 26, 1997, ABB notified the NRC in a 10 CFR Part 21 report that a potential exists for new low-voltage, K-line circuit breakers, equipped with the Power Shield solid-state trip device, to trip well below the device's trip setting if the circuit breaker's overcurrent sensing CTs are incorrectly connected to the Power Shield trip device. Although the circuit breaker that tripped prematurely at Perry was a new circuit breaker, the

potential exists for refurbished breakers to have a similar wiring defect. The NRC is aware of instances in which ABB K-line circuit breakers have been sent to ABB service centers for refurbishment, and the service center returned the circuit breakers to the licensee with the CTs incorrectly wired.

A typical metal-clad ABB K-line circuit breaker has six CTs. Three of these six CTs are referred to as "phase sensors," and are used to detect fault currents. The remaining three CTs are referred to as "power sensors," and are used to develop a trip reference signal within the Power Shield trip unit. Two CTs, a phase sensor and a power sensor, are installed on each phase of the circuit breaker. The leads from all six CTs are terminated on three terminal blocks attached to the front of the moulded CT mounting board near the bottom of the circuit breaker. These three terminal blocks, in turn, are connected to the Power Shield solid-state trip unit by a multiconductor wiring harness. Attachment 1 to this notice is a copy of ABB Wiring Diagram 709551, Revision 16, for reference. Attachment 2 to this notice is a photograph of the CT mounting board at the bottom of a K-line breaker to aid in interpreting the drawing. Typical wiring and assembly errors that have been discovered in ABB K-line circuit breakers include the following:

- CT leads were terminated on the wrong terminals of the lower terminal blocks.
- Multiconductor cable conductors were terminated on the wrong terminals of the lower terminal blocks, or on the wrong terminals of the Power Shield Trip Unit.
- CTs were installed upside down but were correctly terminated on the lower terminal blocks (same effect as reversing the leads).
- After the wires on terminals 6, 7, and 8 of the Power Shield trip unit are lifted to perform continuity checks of the phase sensors, or the wires on terminals 11, 12, 13, and 14 are lifted to conduct calibration tests, the wires are relanded incorrectly.

Circuit breaker wiring or assembly errors can be introduced by the original equipment manufacturer, companies performing circuit breaker refurbishment services, or utilities during testing. Incorrectly wired or assembled circuit breakers may be currently in service or stored in a warehouse for service at a later date. Because single-phase calibration testing cannot detect the CT wiring or installation errors described herein, the potential exists for incorrectly wired or assembled circuit breakers to pass normal single-phase calibration testing but to trip load currents less than the desired trip setpoint (e.g., on startup of the breaker's safety-related load during a design-basis accident) resulting in a loss of safety functions.

This information notice establishes no new NRC requirements; therefore, no specific action or written response is required by this notice. However, recipients are reminded that they are required by 10 CFR 50.65 to take industry-wide operating experience (including information presented in NRC information notices) into consideration, where practical, when setting goals and performing periodic evaluations. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate NRR project manager.

DBMatthews
for Jack W. Roe, Acting Director
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Office of Nuclear Reactor Regulation

Technical contacts: Donald Kosloff, RIII
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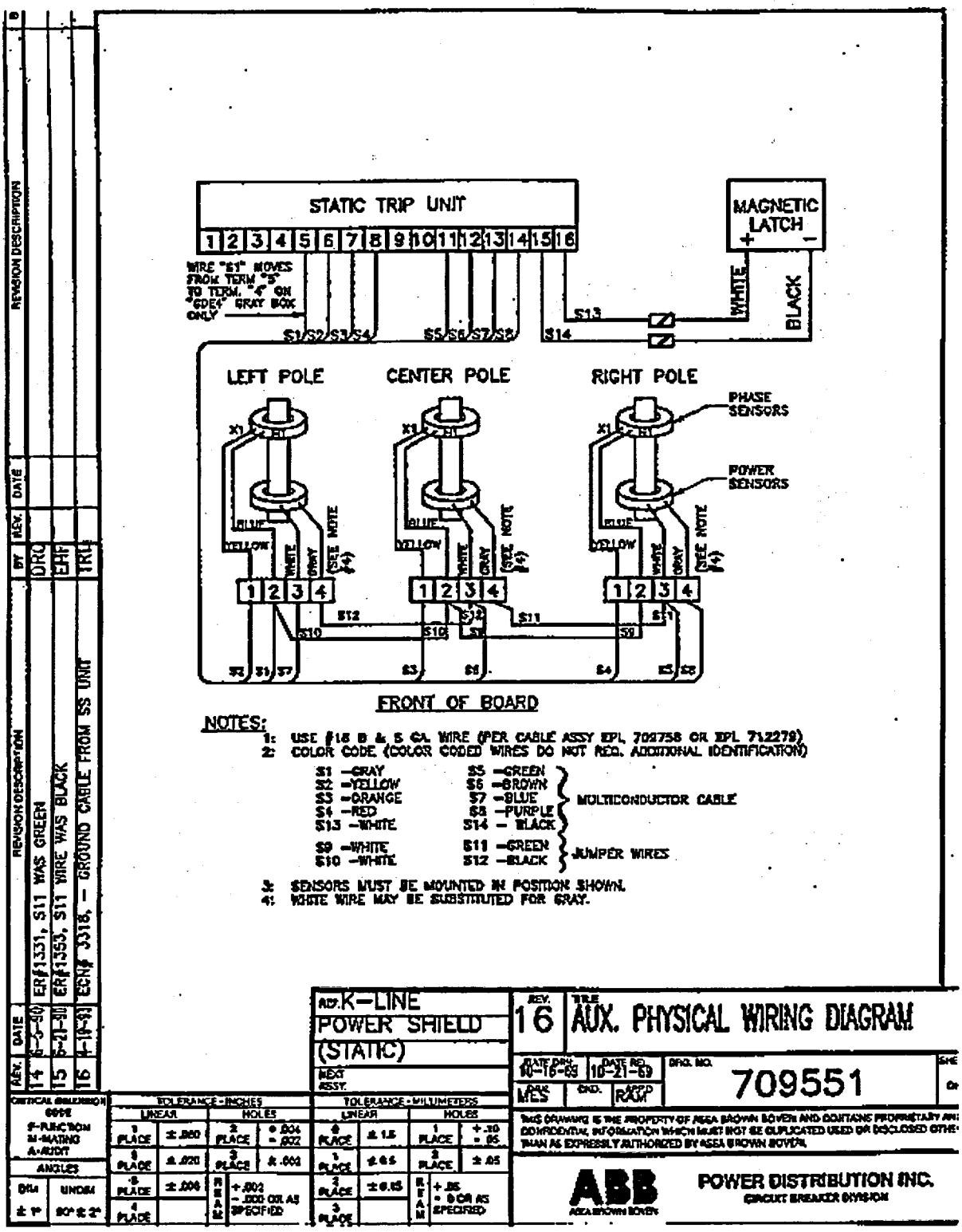
Attachments:
1. ABB K-Line Power Shield Auxiliary Wiring Diagram 709551, Revision 16
2. Photograph of the CT Mounting Board at the Bottom of a K-Line Breaker
3. List of Recently Issued NRC Information Notices

ATTACHMENT filed in JACKET



NOTES:

1. USE #16 B & S GA. WIRE (PER CABLE ASSY EPL 709758 OR EPL 712279)
2. COLOR CODE (COLOR CODED WIRES DO NOT REQ. ADDITIONAL IDENTIFICATION)

S1 –GRAY	S5 –GREEN	MULTICONDUCTOR CABLE
S2 –YELLOW	S6 –BROWN	
S3 –ORANGE	S7 –BLUE	
S4 –RED	S8 –PURPLE	
S13 –WHITE	S14 – BLACK	
S9 –WHITE	S11 –GREEN	JUMPER WIRES
S10 –WHITE	S12 –BLACK	

3. SENSORS MUST BE MOUNTED IN POSITION SHOWN.
4. WHITE WIRE MAY BE SUBSTITUTED FOR GRAY.

REV.	DATE	BY	REVISION DESCRIPTION
14	8-3-90	DRL	ER#1331, S11 WAS GREEN
15	5-21-91	EHF	ER#1353, S11 WIRE WAS BLACK
16	4-16-93	TRL	ECN# 3318, – GROUND CABLE FROM SS UNIT

ADV. K-LINE POWER SHIELD (STATIC)
NEXT ASSY.

REV. 16 TITLE AUX. PHYSICAL WIRING DIAGRAM

DATE DRN. 10-16-89 | DATE REQ. 10-21-89 | DRWG. NO. 709551 | SHEET

DRN. MES | CHD. | APPD. RAW

CRITICAL DIMENSION CODE: F-FUNCTION M-MATING A-AUDIT

ANGLES: DEC ± 1° | UNDEC 90° ± 2°

TOLERANCE - INCHES

LINEAR		HOLES	
1 PLACE	± .060	2 PLACE	+ .004 - .002
2 PLACE	± .020	3 PLACE	± .003
3 PLACE	± .006	REM	+.002 -.000 OR AS SPECIFIED
4 PLACE			

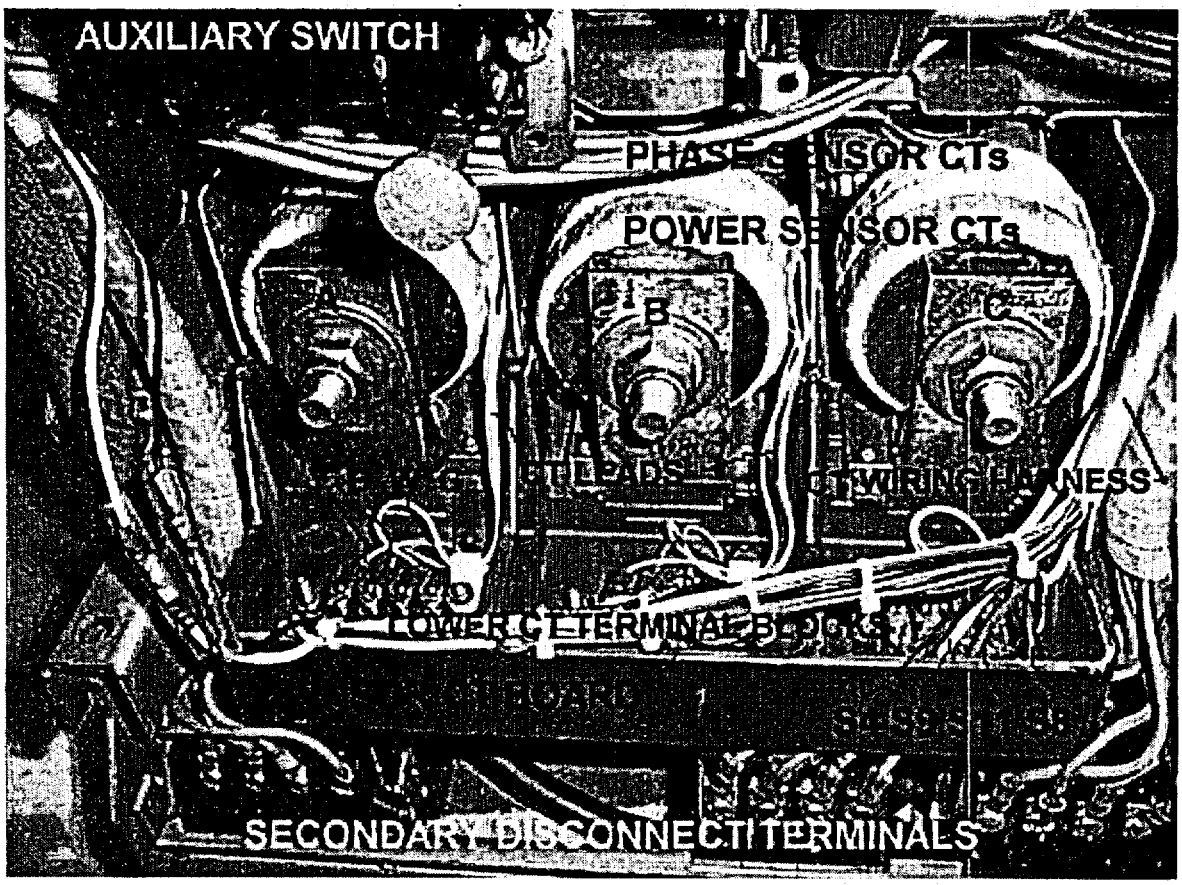
TOLERANCE - MILLIMETERS

LINEAR		HOLES	
0 PLACE	± 1.5	1 PLACE	+ .10 - .05
1 PLACE	± 0.5	2 PLACE	± .05
2 PLACE	± 0.15	REM	+ .05 - 0 OR AS SPECIFIED
3 PLACE			

ABB ASEA BROWN BOVERI

POWER DISTRIBUTION INC.
CIRCUIT BREAKER DIVISION

PHOTOGRAPH OF CT MOUNTING BOARD AT BOTTOM OF K-LINE BREAKER



LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
98-02	Nuclear Power Plant Cold Weather Problems and Protective Measures	1/21/98	All holders of operating licenses for nuclear power reactors
98-01	Thefts of Portable Gauges	1/15/98	All portable gauge licensees
97-91	Recent Failures of Control Cables Used on Amersham Model 660 Posilock Radiography Systems	12/31/97	All industrial radiography licensees
97-90	Use of Nonconservative Acceptance Criteria in Safety-Related Pump Surveillance Tests	12/30/97	All holders of OLs for nuclear power reactors except those who have ceased operations and have certified that fuel has been permanently removed from the vessel
97-89	Distribution of Sources and Devices Without Authorization	12/29/97	All sealed source and device manufacturers and distributors
97-88	Experiences During Recent Steam Generator Inspections	12/16/97	All holders of OLs for pressurized-water reactors except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor
97-87	Second Retrofit to Industrial Nuclear Company IR 100 Radiography Camera, to Correct Inconsistency in 10 CFR Part 34 Compatibility	12/12/97	All industrial radiography licensees

OL = Operating License
CP = Construction Permit