FACILITIES INSTRUCTIONS, STANDARDS, AND TECHNIQUES

VOLUME 3-8

FIELD TEST PROCEDURE FOR PROTECTIVE RELAYS

Internet Version of This Manual Created
July 2000

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DENVER OFFICE
DENVER, COLORADO

The Appearance of the Internet Version of This manual May Differ From the Original, but the Contents Do Not

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
NOVEMBER 1991

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Field Test Procedure For Protective Relays

1. RELAY SETTINGS

At all new protective relay installations, the relays should be adjusted in accordance with the settings given in the relay data sheets furnished by the Denver Office, after which, tests should be made to determine if the actual operating characteristics check with the adjustments made. The Denver Office, Facilities Engineering Branch, must be advised of field changes of relay settings that become necessary from time to time as system operating conditions change to permit coordination with the Division of Design on future designs or revisions. **Relays and relay settings are not to be changed from what is indicated on current issues of relay data sheets unless authorized by regional or project personnel with the proper responsibility.**

2. APPLYING REVISED RELAY SETTINGS

It is necessary to revise relay settings upward from time to time at many stations in preparation for anticipated increased unit output or line loading. At such times it may also be necessary to make corresponding changes in backup protective equipment in order to maintain coordination. Under these conditions, the changes in the backup relays should be made first so that coordination will not be lost during the period between beginning and completion of tests. This would apply whenever increased backup relay settings accompany changes in first-line protective equipment.

One case has been brought to our attention where new settings were applied to line relays but, because of lack of time, the backup ground relay was not reset until the following day. In the meantime, a fault occurred on the line, and the entire station was interrupted because the coordination had been lost. If the backup ground relay had been reset before settings were changed on line breaker relays, this interruption would not have occurred.

In a few rare cases relay settings may be revised **downward** at a station; and, in such cases, the opposite sequence must be followed in order to maintain coordination. **When relay settings are revised downward, apply the new settings to the line breakers first and to the backup relays last.**

3. NEW INSTALLATIONS

Before placing a new installation into operation, polarity of instrument transformers and the wiring to the relays should be checked. In some cases, the manufacturer's polarity marking has been found to be incorrect. New relays should be inspected carefully and all blocking put in by the manufacturer removed. The test man should read instruction books furnished by the manufacturer to become familiar with construction and operating principle of the relays.

A sufficient number of initial operations should be made by manually operating relay contacts to make sure that all devices which should be operated by the relay, function freely and properly, including auxiliary contacts and targets within the relay. Breaker trip coils and other devices operated by the relay should be checked to see that proper operation is obtained at voltages considerably below normal (approximately 56 percent of normal voltage for breaker trip coils). The voltage drop in trip circuits and tripping current required should be checked. Factory adjustments on relays, other than taps, or other adjusting devices intended for customary adjustment should not be changed unless tests show that factory adjustments have been disturbed, in which case the manufacturers' instruction books should be followed.

4. TESTING EQUIPMENT REQUIRED

A good set of testing equipment and relay tools are important. Several manufacturers now produce portable relay test sets that will provided excellent results. If not available on the project, most of the equipment necessary can be borrowed from the Denver Office for making relay tests.

5. TESTING PRECAUTIONS

Before starting to test any relay on equipment in service, the person testing should become familiar with the relays and the circuits involved. Where test blocks are used, the person testing must make sure that in removing or inserting plugs that a current transformer circuit will not be opened, resulting in a voltage being built up which may be dangerous to personnel, property, or equipment, or cause an important circuit to trip out. In old installations where test blocks are not available, current transformer circuits must be short circuited by jumpers having reliable clamping devices which will not come loose, before the relay current circuit is opened.

6. FREQUENCY OF TESTING

It is recommended that protective and auxiliary relays be given a complete calibration test and inspection at least once a year. This schedule, however, sometimes cannot be met due to existing workloads and available manpower with the result that routine calibration tests intervals of many relays are longer than a year. Factors to be considered if changes to the test schedule are needed, are shown in table 1.

7. TEST RECORDS

A complete record should be kept of all test data and observations made during tests and inspections, including identifying numbers of test equipment used. The following relay test report forms are available at the Denver Office and one copy of each is included (see contents):

Form No.

PO&M 100 - *Overcurrent relay test report*

PO&M 101 - *Differential relay test report*

PO&M 102A - *Distance relay test report (Westinghouse)*

PO&M 102B - *Distance relay test report (General Electric)*

O&M 106 - *Miscellaneous test sheet*

8. ANNUAL INSPECTION

All relays shall be given an annual inspection. This inspection should include the following:

a. A visual inspection should be made of all relays on a terminal including the tripping auxiliaries and accessories. Any drawout type relay should be withdrawn from its case for a closeup examination. All other, including auxiliaries, should at least have covers removed. Included in this visual inspection should be a check for loose connections, broken studs, burned insulation, and dirty contacts. Each relay should be checked to be in agreement with its setting sheet. On some distance relays it may have been necessary to set the taps on something other than specified values in order to get proper calibration. Because of this, it may also be necessary to check the taps against the last calibration test report.

b. **A test trip** should be made of all relay systems. All relay elements which initiate some protective function should be checked. This includes reclosing, carrier starting, or any similar type function. After proving that tripping relays will successfully trip the circuit breaker and that all reclosing schemes work, continuity checks should be used, where applicable, to complete the checkout of the circuit breaker trip circuits.

9. TEST PROCEDURES

Tests to be performed during routine maintenance are determined by the type of relay to be tested. **The following tests should be included for all electromechanical relays.**

a. **A visual inspection** of the relay cover can reveal valuable information. Any excessive dust, dirt, or. metallic material deposited on the cover should be noted and removed, thus preventing such material from entering the relay when the cover is removed. A cover glass which is fogged should be cleaned. Fogging is in most cases a normal condition due to volatile materials being driven out of coils and insulating materials, and is not an indication of a problem. However if fogging

Table 1.- *Criteria to determine possible alteration of the test period for relays*

Relay System Variables	Factor Reducing Test Interval	Factors lengthening Test Interval
Type of Relays	Complex (distance, differential),	Simple (hinged armature plunger).
Age of Relays	New installations with little operating history. Systems 20 years or older where insulation aging, etc., can be a problem	5-10 years old with a good operating history
Environment	Dusty area, contaminated atmosphere, temperature extremes.	Clean and/or air conditioned area.
History and Experience	Subjected to severe or frequent faults. Often required adjustments when tested.	Subjected to moderate or few faults.
Current Rating	Relays rated 5 amperes which are called upon to carry 7 or 8 amperes due to load requirements.	Relays operated at or below their 5 ampere rating
Control Voltage	Relays operated in battery circuit more than 5 percent above nominal relay rated voltage of nominal relay rated voltage	Relays operated in battery circuit within _+ 5 percent
Station Service	Station service voltage supplied is more than 5 percent above nominal relay rated voltage.	Station service Voltage supply operated within + 5 percent of

appears excessive, since most relays are designed to operate in ambient temperatures not exceeding 40EC (104EF), a further check of the ambient temperature would be in order. Voltage and current supplied to the relay should be checked and compared with the name plate or instruction book ratings. Should evidence of overheating be found, the insulation should be checked for embrittlement and, where necessary, replaced. Removal of the connection plug in drawout relays may reveal evidence of severe fault currents or contaminated atmospheres, either of which may indicate the advisability of a change in maintenance schedule. The condition of the relay contacts can be equally revealing.

b. **Mechanical adjustments and inspection** should be made according to instructions shown following:

(1) Check to see that all connections are tight. Several loose connections could indicate excessive vibration which should be corrected.

(2) All gaps should be checked that they are free of foreign material. If foreign material is found in the relay, the case gasket should be checked and replaced if necessary.

(3) All contact or armature gaps should be measured and values compared with previous measurements. Large variations in these measurements may indicate excessive wear, and worn parts should be replaced. Also an adjusting screw could have worked loose and must be tightened. All of this information should be noted on the test record.

(4) All contacts except those not recommended for maintenance should be burnished, and measured for alignment and wipe.

(5) Since checking bearings or pivots usually involves dismantling the relay, it is recommended that such a test be made only when the relay appears to be extremely dirty, or when subsequent electrical tests indicate undue friction.

c. Electrical tests and adjustments should be made according to the instructions shown following:

(1) Contact function.-Manually close or open the contacts, and observe that they perform their required function; such as trip, reclose, or block.

(2) Pickup.-Gradually apply current or voltage to see that pickup is within limits. The current or voltage should be applied gradually in order to yield data which can be compared with previous or future tests and not be clouded by such effects as transient overreach.

(3) Dropout or reset.-To test for excess friction, reduce current until the relay drops out or resets. Should the relay be sluggish in resetting or fail to reset, then the jewel bearing and pivot should be examined. A four power magnification is adequate for examining the pivot, and the jewel bearing can be examined with the aid of a needle which will reveal any cracks in it. If dirt is the problem, the jewel can be cleaned with an orange stick and the pivot can be wiped clean with a soft, lint free cloth. No lubricant should be used on either the jewel or pivot.

10. AUXILIARY RELAYS

In addition to tests described in paragraph 9, auxiliary relays employing devices for time delay (for example, capacitors) should have an operating time test performed (either pickup or dropout, whichever is applicable).

11. TIME OVERCURRENT AND TIME OVERVOLTAGE RELAYS

All tests described in paragraph 9 should be performed for time-overcurrent and time-overvoltage relays where applicable. **These types of relays should always be tested in the case in order to duplicate "in-service" conditions or to match published curves since the relay case normally acts as a shunt for flux that the electromagnetic iron circuit cannot handle due to saturation.** Testing the relay out of the case will also produce results that would not check previous tests or future tests since changes in test conditions, such as being near a steel cabinet, will change results obtained if the relay is tested out of the case. The first electrical test made on the relay should be a pickup test. Pickup is defined as that value of current or voltage which will just close the relay contacts from the 0.5 time-dial position. Allowing for such things as meter differences and interpretations of readings, this value should be within ± 5 percent of previous data.

One or two points on the time-current curve are generally sufficient for maintenance purposes. Reset the relay to the original time-dial setting and check at two points such as 3 and 5 times pickup. Always use the same points for comparison with previous tests.

The instantaneous unit should be checked for pickup using gradually applied current. Whenever possible, current should be applied only to the instantaneous unit to avoid overheating the time unit. The target seal-in unit should also be

tested using gradually applied current. The main unit contacts must be blocked closed for this test.

12. DIRECTIONAL OVERCURRENT RELAYS

In addition to tests recommended for the overcurrent relay, the directional unit of the directional overcurrent relay should be tested for minimum pickup, angle of maximum torque, contact gap, and clutch pressure. A test should also be made to check that the overcurrent unit operates only when the directional unit contacts are closed.

13. DISTANCE RELAYS

When testing distance relays, tests should be made of pickup, angle of maximum torque, contact gap, and clutch pressure, in addition to the tests described in paragraph 9. (See appendix C for adjustment of Westinghouse Type KD relays).

14. DIFFERENTIAL RELAYS

A test of minimum pickup should be performed for differential relays. The differential characteristic (slope) should be checked, and where applicable, the harmonic restraint should be tested. Differential relays using ultrasensitive polarized units as sensing devices are slightly affected by previous history, such as heavy internal or external fault currents. **It is therefore recommended that for this type of relay two pickup readings be taken and the second reading be the one that is used for comparison with previous and future tests.**

15. STATIC RELAYS

Static relays should be tested in accordance with manufacturer's recommendations given in relay instruction books. As there are no moving parts in static relays, there is no physical wear due to usage and no need for lubricants. Prime causes of failure in electronic components are heat, vibration, and moisture. Overheating can be caused by voltage transients, current surges, excessive power, or high ambient temperature. Vibration can loosen or break leads and connections and can crack component casings or insulation resulting in equipment failure. Moisture can result in corrosion of metallic elements which can result in circuit discontinuities, poor contact, or shorts. Preventive maintenance of static relays should be directed toward removing causes of failure listed above by doing the following:

a. Keep equipment clean by periodic vacuuming or blowing out of dirt, dust, and other surface contaminants.

b. Keep the equipment dry and protected against moisture and corrosion.

c. Inspect to see that all connections, leads, and contacts are tight and free as possible from effects of vibration.

d. Check to see that there is adequate ventilation to conduct heat away efficiently.

Preventive measures should not be applied unnecessarily as this may contribute to failures. For example, printed circuit cards should not be pulled from their racks to be inspected if there is no real need. Operating test switches unnecessarily may introduce damaging voltage transients.

16. PORTABLE RELAY PANELS

Particular attention should be given to relays mounted on portable relay panels as these relays are subjected to more rough handling than those permanently installed on a switchboard. Therefore, whenever a portable panel of relays is installed, they should be thoroughly checked physically as well as electrically. If they are in bad condition, they should be repaired, or new relays installed before they are placed in service.

17. CIRCUIT BURDEN MEASUREMENTS FOR CT'S

When CT circuits are modified such as by addition of relays, meters, or auxiliary CT's, measurements should be taken to determine the burden of the overall CT secondary circuit. These measurements should normally be on a

phase-to-neutral basis. Measurements should be made at three current levels, such as 1, 3, and 5, while recording volts, amps, and phase angle. When auxiliary CT's are involved, additional and separate measurements should be taken on the secondary circuit of the auxiliary CT's.

18. EXCITATION CURVES FOR CT'S

Auxiliary CT's tend to saturate at much less secondary current and burden than large multi-ratio bushing type CT's. Excitation curves should be available on all CT's, especially on auxiliary CT's used in protective relaying circuits (fig. 1). Such curves can be derived by open-circuiting the primary, and driving the secondary with a 60-Hertz source while measuring voltage and current. Readings should be taken up to two times rated secondary current or to the point where voltage applied is 1500 volts.

19. GROUNDING CT AND PT CIRCUITS

The CT and PT circuits should be grounded at only one point. Relay misoperations can be caused by grounding the neutral at two points, such as one ground at the switchyard and another at the relay panel. At least once every 3 years with the primary deenergized, the known ground should be removed and the overall circuits should be checked for additional grounds and insulation breakdowns.

20. OPEN-SECONDARY CIRCUITS

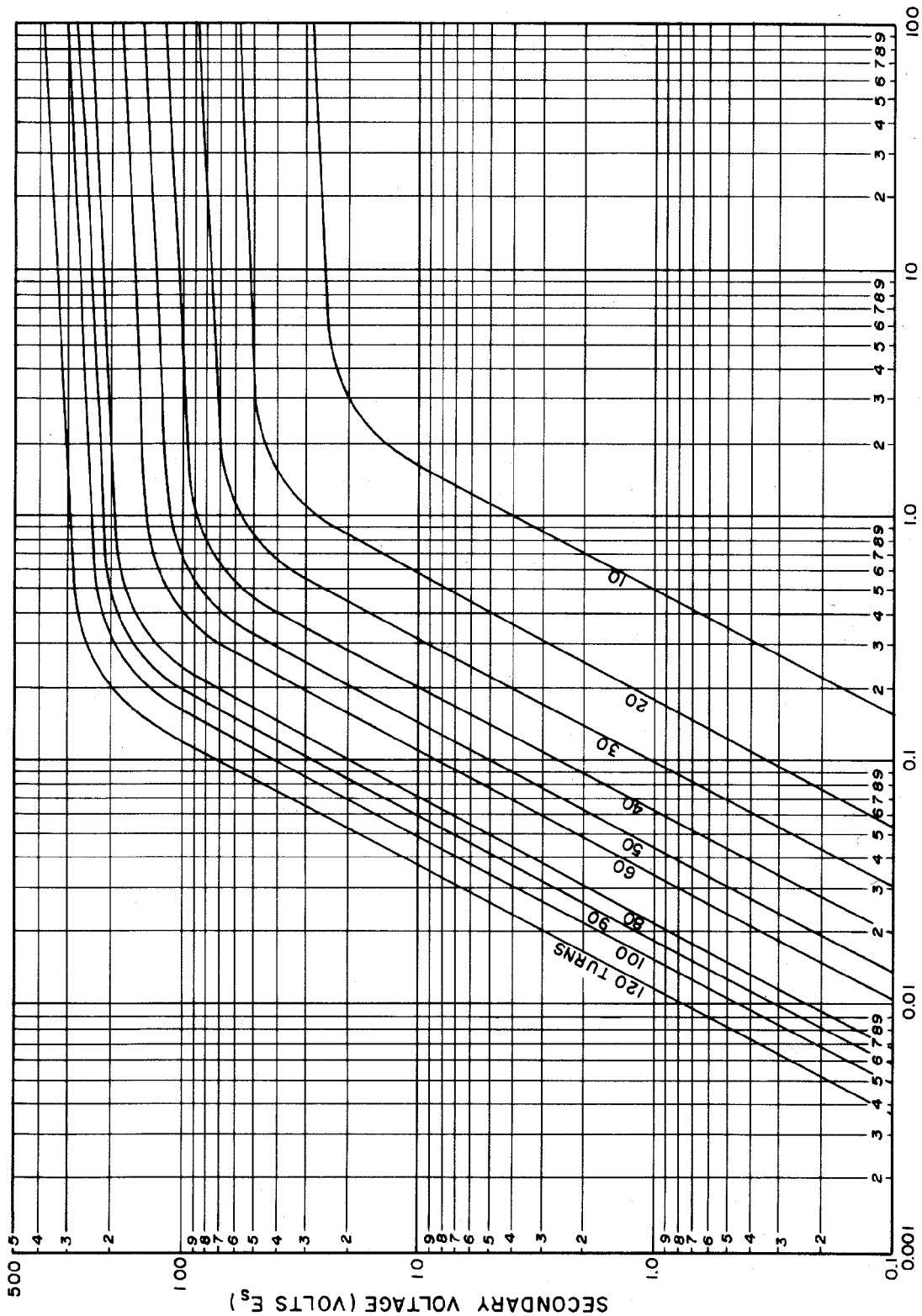
WARNING: **Secondary circuits of CT's must not be open while primary current flows.** Extreme care should be taken to avoid breaking the secondary circuit while primary current is flowing. If the secondary is open-circuited the primary current raises core flux density to saturation and induces a high voltage in the secondary which can endanger human life, and can damage connected apparatus and leads. If it is necessary to change secondary conditions while primary current is flowing, the secondary terminals must be short-circuited while the change is being made. **Caution should be exercised when working with differential circuits as shorting a current transformer in an energized differential relaying circuit could result in a relay operation.** It is recommended that the secondaries of all current transformers be kept short-circuited at all times when not installed in a circuit such as being held in stock or being transported.

21. TEMPERATURE RELAYS

Temperature relays used on bearings and for other important purposes should be checked for correct operation by placing the bulb in a pail of water with a thermometer, and gradually heating to the temperature at which the relay is set to operate. A mercury or alcohol thermometer should be used to read the temperature while the water is being stirred. Record temperature at which the relay operates on increasing temperature and at which it resets on falling temperature. Temperature relays operating from RTD's (resistance temperature detectors) should be checked by heating the detectors slowly in an enclosed air space since they should not be immersed in water or other liquid.

22. PRESSURE RELAYS

Pressure relays should be checked for correct operation by comparing with an accurate pressure gage. Pressure should be increased and decreased to determine the pressure at which the relay operates and resets. The above does not apply to sudden pressure relays, which should be maintained in accordance with the manufacturer's recommendations.



TYPICAL EXCITATION CURVES FOR 69 KV. MULTI-RATIO BUSHING TYPE CURRENT TRANSFORMERS

PO&M-100
(1-64)
Bureau of Reclamation

OVERCURRENT RELAY TEST REPORT

LOCATION_____ CIRCUIT_____ RELAY MFR._____ TYPE_____ STYLE OR MODEL NO._____

RELAY RATING.
TIME DELAY ELEMENT _____ TO _____ AMPERES _____ CHARACTERISTIC
INSTANTANEOUS ELEMENT _____ TO _____ AMPERES _____
DIRECTIONAL ELEMENT _____ AMPERES _____ VOLTS _____ DEGREES PHASE ANGLE

RELAY SERIAL NUMBERS. PHASE A _____ PHASE B _____ PHASE C _____

C.T. MARKED RATIOS _____ ACTUAL RATIO _____ P.T MARKED RATIOS _____ ACTUAL RATIO _____

	DATE SETTING DESIRED	19__			19__			19__			19__			19__		
		PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C
RELAY SETTING.																
TIME DELAY ELEMENT - AMP. TAP																
- TIME LEVER																
- PRIMARY AMPS. - KVA																
INSTANTANEOUS ELEMENT - AMPS. P.U.																
- PRIMARY AMPS. KVA																
DIRECTIONAL ELEMENT - AMPS. OR VOLTS.																
RELAY TEST.																
A. TIME DELAY ELEMENT - MIN. PICK-UP AMPS.																
INSTANTANEOUS ELEMENT - MIN. PICK-UP AMPS.																
DIRECTIONAL ELEMENT - MIN. PICK-UP AMPS.																
POLARIZING AMPS. OR VOLTS																
ANGLE OF MAX. TORQUE																
B. TIME DELAY ELEMENT - OPERATING AMPS.																
POLARIZING AMPS. OR VOLTS																
OPERATING TIME - SECONDS																
C. TIME DELAY ELEMENT - OPERATING AMPS.																
POLARIZING AMPS, OR VOLTS																
OPERATING TIME - SECONDS																
D. TIME DELAY ELEMENT - OPERATING AMPS.																
POLARIZING AMPS. OR VOLTS																
OPERATING TIME - SECONDS																
E. INSTANTANEOUS ELEMENT - OPERATING AMPS.																
OPERATING TIME- CYCLES																
DO TEST AGREE WITH MFR'S DATA?																
DO RELAYS TRIP BREAKERS?																
DO OPERATION INDICATORS OPERATE*																
DO AUXILIARY CONTACTS OPERATE*																

* RECORD MINIMUM PICK-UP AMPS.

NOTE. ALL DATA ARE FOR CONDITION AS LEFT UNLESS OTHERWISE NOTED.

TRIP CIRCUIT MEASUREMENTS:	DATE: 19__	19__	19__	19__	19__
MINIMUM AMPS. TO TRIP					
TOTAL RESISTANCE	OHMS AT °C	OHMS AT °C	OHMS AT °C	OHMS AT °C	OHMS AT °C
RESISTANCE OF TRIP COIL ONLY	OHMS AT °C	OHMS AT °C	OHMS AT °C	OHMS AT °C	OHMS AT °C
MAIN CONTACT GAP CLEARANCE	INCHES	INCHES	INCHES	INCHES	INCHES
GENERAL CONDITION OF RELAYS AS FOUND					
DUST OR DIRT INSIDE OF RELAYS?					
CONDITION OF CONTACTS?					
CONDITION OF PIVOTS:					
STICKING OR BINDING OF MOVING PARTS?					
MAGNETIC PARTICLES IN AIR GAP?					
CONDITION OF COILS?					
WHAT MAINTENANCE OR REPAIR WAS FOUND NECESSARY?					
WHAT CHANGES WERE MADE IN SETTINGS AND C.T. RATIOS?					
REMARKS					
TESTED BY:					
ASSISTED BY:					

PO&M-101 (5/56)
Bureau of Reclamation

DIFFERENTIAL RELAY TEST REPORT

LOCATION_____ CIRCUIT_____ DATE OF TEST_____

RELAY MFR._____ TYPE_____ STYLE OR MODEL No._____

RELAY RATING:

TAPS_____ AMPERES. % SLOPE_____

C.T. MARKED RATIOS_____ ACTUAL RATIOS_____

	PHASE A	PHASE B	PHASE C
RELAY SERIAL No.			
RELAY SETTING:			
TAP - AMPERES			
SLOPE - %			
MINIMUM PICK-UP CURRENT TESTS:			
RESTRAINING COIL No. 1 AMPS.			
RESTRAINING COIL No. 2 AMPS.			
RESTRAINING COIL No. 3 AMPS.			
OPERATING COIL AMPS.			
MEDIUM PICK-UP CURRENT TESTS:			
RESTRAINING COIL No. 1 AMPS.			
RESTRAINING COIL No. 2 AMPS.			
RESTRAINING COIL No. 3 AMPS.			
OPERATING COIL AMPS.			
HIGH PICK-UP CURRENT TESTS:			
RESTRAINING COIL No. 1 AMPS.			
RESTRAINING COIL No. 2 AMPS.			
RESTRAINING COIL No. 3 AMPS.			
OPERATING COIL AMPS.			
OVERCURRENT OPERATING TESTS:			
A. RESTRAINING COIL No._____ AMPS._____			
OPERATING COIL AMPS._____			
OPERATING TIME - CYCLES_____			
B. RESTRAINING COIL No._____ AMPS._____			
OPERATING COIL AMPS._____			
OPERATING TIME - CYCLES_____			
CURRENT BALANCE FOR THRU PRIMARY CURRENT:			
CIRCUIT No. 1 AMPS._____			
CIRCUIT No. 2 AMPS._____			
CIRCUIT No. 3 AMPS._____			
DO RELAYS TRIP ALL CONNECTED DEVICES?_____			
DO OPERATION INDICATORS OPERATE?*_____			
DO AUXILIARY CONTACTS OPERATE?*_____			

*RECORD MINIMUM PICK-UP AMPS

NOTE: ALL DATA ARE FOR CONDITION AS LEFT UNLESS OTHERWISE NOTED.

PO&M-101 - Differential relay test report

TRIP CIRCUIT MEASUREMENTS:

MINIMUM AMPS. TO TRIP_____TOTAL RESISTANCE_____OHMS AT_____°C

RESISTANCE OF TRIP COIL ONLY_____OHMS AT_____°C

MAIN CONTACT GAP CLEARANCE_____INCHES

GENERAL CONDITION OF RELAYS AS FOUND:

DUST OR DIRT INSIDE OF RELAYS?_____

CONDITION OF CONTACTS?_____

CONDITION OF PIVOTS?_____

STICKING OR BINDING OF MOVING PARTS?_____

MAGNETIC PARTICLES IN AIR GAP?_____

CONDITION OF COILS?_____

WHAT MAINTENANCE OR REPAIRS WAS FOUND NECESSARY?_____

WHAT CHANGES WERE MADE IN SETTINGS AND C.T. RATIOS?_____

REMARKS:_____

TESTED BY:_____ASSISTED BY:_____

PO&M-102A (2-69)
Bureau of Reclamation

DISTANCE RELAY TEST REPORT

(For W. relays type HZ and HZM)

LOCATION _____ DATE _____

CIRCUIT _____ AUX. DEVICES† _____

C.T. RATIO _____ MULT. TO CONVERT $\left(\frac{\text{C.T. RATIO}}{\text{P.T. RATIO}}\right)$ = _____

P.T. RATIO _____ PRI. TO SEC. OHMS

†*Calibration includes 5:8.66 L-L ratio Y-Δ aux. c.ts.*

RELAY DATA	ZONE 1	ZONE 2	ZONE 3
TYPE			
STYLE			
RANGE†			

DESIRED CHARACTERISTIC	ZONE 1	ZONE 2	ZONE 3
REACH: % OF LINE....ETC.			
PRI. OHMS AND ANGLE			
SEC. OHMS AND ANGLE (1)			
MAX. TORQUE ANGLE			
CHAR. RADIUS OHMS (2)			
DISPLACEMENT OHMS (1-2)			
MAX. KVA @ UNITY P.F.			
TIME			

SETTINGS	CALC	ACTUAL			CALC	ACTUAL			CALC	ACTUAL		
		A	B	C		A	B	C		A	B	C
RADIUS TS												
TAP												
SCREW												
DISPLACEMENT Z_R**												
VERNIER A**												
ANGLE R OR ϕ												
TIMER												

TESTS: BALANCE POINT	A	B	C	A	B	C	A	B	C
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REACH CALC.									
TIME @ 80% Z REACH									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
OHMS REACH @ 80% Z									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REVERSE REACH									
DIR. UNIT MIN. P.U. VOLTS									
AMPS.									
POWER FACTOR									

REMARKS _____

**SETTING OF TEST REACTOR AND RESISTOR*

***FORMULAS DIFFER WITH 60-90° AND 60-120° RELAY MODELS*

TESTED BY _____ ASSISTED BY _____

PO&M-102A - Distance relay test report (Westinghouse)

DISTANCE RELAY TEST REPORT

(For W. relays type KD and KS)

LOCATION _____ DATE _____

CIRCUIT _____ AUX. DEVICES _____

C.T. RATIO _____ MULT. TO CONVERT $\left(\frac{\text{C.T. RATIO}}{\text{P.T. RATIO}}\right)$ =

P.T. RATIO _____ PRI. TO SEC. OHMS _____

RELAY DATA	ZONE 1	ZONE 2	ZONE 3
TYPE			
STYLE			
RANGE			

DESIRED CHARACTERISTICS	ZONE 1	ZONE 2	ZONE 3
REACH: % OF LINE...ETC.			
PRI. OHMS AND ANGLE			
SEC. OHMS AND ANGLE			
REVERSE OHMS AND ANGLE			
CHAR. DIA. OHMS			
MAX. TORQUE ANGLE			
MAX. KVA @ UNITY P.F.			
TIME			

SETTINGS	ZONE 1 CALC	ZONE 1 ACTUAL Φ-Φ	ZONE 1 ACTUAL 3Φ	ZONE 2 CALC	ZONE 2 ACTUAL Φ-Φ	ZONE 2 ACTUAL 3Φ	ZONE 3 CALC	ZONE 3 ACTUAL Φ-Φ	ZONE 3 ACTUAL 3Φ
RADIUS: $TS/1 \pm m$									
T, T_A, T_B, T_C									
$T'_B + T_B$**									
S, S_A, R_B, S_C									
M, M_A, M_C									
ANGLE OF MAX. TORQUE									
TIMER									

TESTS: Φ-Φ BALANCE POINT	ZONE 1 1-2	ZONE 1 2-3	ZONE 1 3-1	ZONE 2 1-2	ZONE 2 2-3	ZONE 2 3-1	ZONE 3 1-2	ZONE 3 2-3	ZONE 3 3-1
VOLTS OR TEST BOX %									
AMPS. OR R+JX*									
PHASE ANGLE									
OHMS REACH CALC									
TIME @ 80% Z REACH									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
OHMS REACH @ 80% Z									

TESTS: 3Φ BALANCE POINT	ZONE 1 3Φ	ZONE 2 3Φ	ZONE 3 3Φ
VOLTS			
AMPS.			
PHASE ANGLE (∂+30°)			
OHMS REACH CALC			
TIME @ 80% Z REACH			
VOLTS OR TEST BOX %			
AMPS. OR TEST R+JX*			
OHMS REACH @ 80% Z			

REMARKS _____

TESTS: REV. OHMS	
VOLTS	
AMPS.	
ANGLE	
OHMS REACH	

SETTING OF TEST REACTOR AND RESISTOR

**APPLIES TO TYPE KS RELAY*

TESTED BY _____ ASSISTED BY _____

PO&M-102B (2-69)
Bureau of Reclamation

DISTANCE RELAY TEST REPORT

(For G.E. relays type GCX and GCY)

LOCATION _____ DATE _____

CIRCUIT _____ AUX. DEVICES _____

C.T. RATIO _____ MULT. TO CONVERT $\left(\frac{\text{C.T. RATIO}}{\text{P.T. RATIO}}\right)$ = _____

P.T. RATIO _____ PRI. TO SEC. OHMS _____

RELAY DATA	ZONE 1	ZONE 2	ZONE 3
MODEL NUMBER			
RANGE			

DESIRED CHARACTERISTIC	ZONE 1	ZONE 2	ZONE 3
REACH: % OF LINE....ETC.			
PRI. OHMS AND ANGLE			
SEC. OHMS AND ANGLE (1)			
MAX. TORQUE ANGLE			
OFFSET: SEC. OHMS (2)			
ANGLE			
CHAR. DIA. OHMS (1+2)			
MAX. KVA @ UNITY P.F.			
TIME			

SETTINGS	CALC	ACTUAL			CALC	ACTUAL			CALC	ACTUAL		
		A	B	C		A	B	C		A	B	C
INPUT %												
RESTRAINT %												
MAX. TORQUE ANGLE												
OFFSET TAP												
OFFSET ANGLE												
TIMER												

TESTS: BALANCE POINT	A	B	C	A	B	C	A	B	C
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REACH CALC									
TIME @ 80% Z REACH									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
OHMS REACH @ 80% Z									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REVERSE REACH									

REMARKS: _____

SETTING OF TEST REACTOR AND RESISTOR

TESTED BY _____ ASSISTED BY _____

(FIST 3-8 11/91)

PO&M-102B - Distance relay test report (General Electric)

DISTANCE RELAY TEST REPORT

(For G.E. relays type CEB and CEY)

LOCATION _____ DATE _____

CIRCUIT _____ AUX. DEVICES _____

C.T. RATIO _____ MULT. TO CONVERT $\left(\frac{\text{C.T. RATIO}}{\text{P.T. RATIO}}\right)$ =

P.T. RATIO _____ PRI. TO SEC. OHMS _____

RELAY DATA	ZONE 1	ZONE 2	ZONE 3
MODEL NUMBER			
RANGE			

DESIRED CHARACTERISTIC	ZONE 1	ZONE 2	ZONE 3
REACH: % OF LINE....ETC.			
PRI. OHMS AND ANGLE			
SEC. OHMS AND ANGLE			
MAX. TORQUE ANGLE			
OFFSET: SEC. OHMS			
ANGLE			
CHAR. DIA. OHMS			
MAX. KVA @ UNITY P.F.			
TIME			

SETTINGS	CALC	ACTUAL			CALC	ACTUAL			CALC	ACTUAL		
		1-2	2-3	3-1		1-2	2-3	3-1		1-2	2-3	3-1
INPUT %												
RESTRAINT %												
MAX. TORQUE ANGLE												
OFFSET TAP												
OFFSET ANGLE												
TIMER												

TESTS: BALANCE POINT	TOP (1-2)	MID (2-3)	BOT (3-1)	TOP (1-2)	MID (2-3)	BOT (3-1)	TOP (1-2)	MID (2-3)	BOT (3-1)
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REACH CALC									
TIME @ 80% Z REACH									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
OHMS REACH @ 80% Z									
VOLTS OR TEST BOX %									
AMPS. OR TEST R+JX*									
PHASE ANGLE									
OHMS REVERSE REACH									

REMARKS: _____

SETTING OF TEST REACTOR AND RESISTOR

TESTED BY _____ ASSISTED BY _____

O&M-106
(12-46)
Bureau of Reclamation

MISCELLANEOUS TEST SHEET

LOCATION _____ CIRCUIT _____ DATE OF TEST _____

DEVICE _____ MFR. _____ STYLE MODEL No. _____

TYPE OF TEST _____ RATING _____ CAT. SERIAL No. _____

TRANSF. RATIO: CURRENT _____ POTENTIAL _____ SEC. K. _____

SETTING: CURRENT _____ VOLTAGE _____ TIME LEVER _____

REMARKS: _____

TESTED BY: _____ ASSISTED BY: _____

PO&M-106 - Miscellaneous test sheet
(FIST 3-8 11/91)

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APPENDIX A

ELECTRICAL DEVICE NUMBERS AND FUNCTIONS

Devices in control and switching equipment are referred to by numbers, with appropriate suffix letters when necessary, according to the functions they perform.

These numbers are based on the IEEE standard for automatic switchgear and are incorporated in American National Standard C37.2-1970.

Device No.	Definition and Function

1. **Master Element** is the initiating device, such as a control switch, voltage relay, or float switch, which serves either directly or through such permissive devices as protective and time-delay relays to place an equipment in or out of operation.

2. **Time-Delay Starting or Closing Relay** is a device that functions to give a desired amount of time delay before or after any point of operation in a switching sequence or protective relay system, except as specifically provided by device functions 48, 62, and 79.

3. **Checking or Interlocking Relay** is a relay that operates in response to the position of a number of other devices (or to a number of predetermined conditions) in equipment, to allow an operating sequence to proceed, or to stop, or to provide a check of the position of these devices or of these conditions for any purpose.

4. **Master Contactor** is a device, generally controlled by device function 1 or equivalent and the required permissive and protective devices, that serves to make and break necessary control circuits to place an equipment into operation under desired conditions and to take it out of operation under other or abnormal conditions,

5. **Stopping Device** is a control device used primarily to shut down an equipment and hold it out of operation. (This device may be manually or electrically actuated, but excludes the function of electrical lockout [see device function 86] on abnormal conditions.)

6. **Starting Circuit Breaker** is a device whose principal function is to connect a machine to its source of starting voltage.

7. **Anode Circuit Breaker** is device used in anode circuits of a power rectifier for the primary purpose of interrupting the rectifier circuit if an arc-back should occur.

8. **Control Power Disconnecting Device** is a disconnecting device, such as knife switch, circuit breaker, or pull-out fuse block, used for the purpose of respectively connecting and disconnecting the source of control power to and from the control bus or equipment.

   NOTE: Control power is considered to include auxiliary power which supplies such apparatus as small motors and heaters.

Device No.	Definition and Function

9. **Reversing Device** is a device that is used for the purpose of reversing a machine field or for performing any other reversing functions.

10. **Unit Sequence Switch** is a switch that is used to change the sequence in which units may be placed in and out of service in multiple-unit equipments.

11. Reserved for future application.

12. **Over-speed Device** is usually a direct-connected speed switch which functions on machine overspeed.

13. **Synchronous-speed Device** is a device such as a centrifugal-speed switch, a slip-frequency relay, a voltage relay, an undercurrent relay, or any type of device that operates at approximately synchronous speed of a machine.

14. **Under-speed Device** is a device that functions when the speed of a machine falls below a predetermined value.

15. **Speed or Frequency Matching Device** is a device that functions to match and hold speed or frequency of a machine or of a system equal to, or approximately equal to, that of another machine, source, or system.

16. Reserved for future application.

17. **Shunting or Discharge Switch** is a switch that serves to open or to close a shunting circuit around any piece of apparatus (except a resistor), such as a machine field, a machine armature, a capacitor, or a reactor.

    NOTE: This excludes devices that perform such shunting operations as may be necessary in the process of starting a machine by devices 6 or 42, or their equivalent, and also excludes device function 73 that serves for the switching of resistors.

18. **Accelerating or Decelerating Device** is a device that is used to close or to cause closing of circuits which are used to increase or decrease the speed of a machine.

19. **Starting-to-Running Transition Contactor** is a device that operates to initiate or cause the automatic transfer of a machine from starting to running power connection.

20. **Electrically Operated Valve** is an electrically operated, controlled, or monitored valve used in a fluid line.

21. **Distance Relay** is a relay that functions when circuit admittance, impedance, or reactance increases or decreases beyond predetermined limits.

22. **Equalizer Circuit Breaker** is a breaker that serves to control or to make and break equalizer or current-balancing connections for a machine field, or for regulating equipment, in a multiple-unit installation.

Device No.	Definition and Function

23. **Temperature Control Device** is a device that functions to raise or lower temperature of a machine or other apparatus, or of any medium, when its temperature falls below, or rises above, a predetermined value.

    NOTE: An example is a thermostat that switches on a space heater in a switchgear assembly when temperature falls to a desired value as distinguished from a device that is used to provide automatic temperature regulation between close limits and would be designated as device function 90T.

24. Reserved for future application

25. **Synchronizing or Synchronism-Check Device** is a device that operates when two a-c circuits are within the desired limits of frequency, phase angle, or voltage to permit or to cause the paralleling of these two circuits.

26. **Apparatus Thermal Device** is a device that functions when temperature of the shunt field or amortisseur winding of a machine, or that of a load limiting or load shifting resistor or of a liquid or other medium, exceeds a predetermined value: or if temperature of the protected apparatus, such as a power rectifier, or of any medium, decreases below a predetermined value.

27. **Undervoltage Relay** is a relay that functions on a given value of undervoltage.

28. **Flame Detector** is a device that monitors the presence of pilot or main flame in such apparatus as a gas turbine or a steam boiler.

29. **Isolating Contactor** is a device that is used expressly for disconnecting one circuit from another for purposes of emergency operation, maintenance, or test.

30. **Annunciator Relay** is a nonautomatically reset device that gives a number of separate visual indications upon functioning of protective devices, and which may also be arranged to perform a lockout function.

31. **Separate Excitation Device** is a device that connects a circuit, such as shunt field of a synchronous converter, to a source of separate excitation during starting sequence, or one that energizes the excitation and ignition circuits of a power rectifier.

32. **Directional Power Relay** is a device that functions on a desired value of power flow in a given direction or upon reverse power resulting from arc-back in the anode or cathode circuits of a power rectifier.

33. **Position Switch** is a switch that makes or breaks contact when the main device or piece of apparatus which has no device function number reaches a given position.

34. **Master Sequence Device** is a device such as a motor-operated multi-contact switch, or equivalent, or a programming device, such as a computer, that establishes or determines the operating sequence of major devices in an equipment during starting and stopping or during other sequential switching operations.

35. **Brush-operating or Slip-ring Short-circuiting Device** is a device for raising, lowering, or shifting brushes of a machine, or for short- circuiting its slip rings, or for engaging or disengaging contacts of a mechanical rectifier.

36. **Polarity or Polarizing Voltage Device** is a device that operates, or permits operation of, another device on a predetermined polarity only, or verifies presence of a polarizing voltage in an equipment

37. **Undercurrent or Underpower Relay** is a relay that functions when current or power flow decreases below a predetermined value.

38. **Bearing Protective Device** is a device that functions on excessive bearing temperature, or on other abnormal mechanical conditions associated with the bearing, such as undue wear, which may eventually result in excessive bearing temperature or failure.

39. **Mechanical Condition Monitor** is a device that functions upon the occurrence of an abnormal mechanical condition (except that associated with bearings as covered under device function 38), such as excessive vibration, eccentricity, expansion, shock, tilting, or seal failure.

40. **Field Relay** is a relay that functions on a given or abnormally Iow value or failure of machine field current, or on excessive value of the reactive component of armature current in an a-c machine indicating abnormally Iow field excitation.

41. **Field Circuit Breaker** is a device that functions to apply or remove field excitation of a machine.

42. **Running Circuit Breaker** is a device whose principal function is to connect a machine to its source of running or operating voltage. This function may also be used for a device, such as a contactor, that is used in series with a circuit breaker or other fault protecting means, primarily for frequent opening and closing of the circuit.

43. **Manual Transfer or Selector Device** is a manually operated device that transfers control circuits in order to modify the plan of operation of switching equipment or of some of the devices.

44. **Unit Sequence Starting Relay** is a relay that functions to start the next available unit in a multiple-unit equipment upon failure or nonavailability of the normally preceding unit.

45. **Atmospheric Condition Monitor** is a device that functions upon occurrence of an abnormal atmospheric condition, such as damaging fumes, explosive mixtures, smoke, or fire.

46. **Reverse-phase or Phase-balance Current Relay** is a relay that functions when the polyphase currents are of reverse-phase sequence, or when polyphase currents are unbalanced or contain negative phase-sequence components above a given amount.

Device No.	Definition and Function

47. **Phase-Sequence Voltage Relay** is a relay that functions upon a predetermined value of polyphase voltage in the desired phase sequence.

48. **Incomplete Sequence Relay** is a relay that generally returns equipment to normal, or off, position and locks it out if normal starting, operating, or stopping sequence is not properly completed within a predetermined time. If the device is used for alarm purposes only, it should preferably be designated as 48A (alarm)

49. **Machine or Transformer Thermal Relay** is a relay that functions when temperature of a machine armature or other load-carrying winding or element of a machine or temperature of a power rectifier or power transformer (including a power rectifier transformer) exceeds a predetermined value.

50. **Instantaneous Overcurrent or Rate-of-rise Relay** is a relay that functions instantaneously on an excessive value of current or on an excessive rate of current rise, thus indicating a fault in apparatus or circuit being protected.

51. **A-C Time Overcurrent Relay** is a relay with either a definite or inverse time characteristic that functions when current in an ac-circuit exceeds a predetermined value.

52. **A-C Circuit Breaker** is a device that is used to close and interrupt an a-c power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

53. **Exciter or D-C Generator Relay** is a relay that forces the d-c machine field excitation to build up during the starting or which functions when the machine voltage has built up to a given value.

54. Reserved for future application.

55. **Power Factor Relay** is a relay that operates when the power factor in an a-c circuit rises above or falls below a predetermined value.

56. **Field Application Relay** is a relay that automatically controls application of field excitation to an a-c motor at some predetermined point in the slip cycle.

57. **Short-circuiting or Grounding Device** is a primary circuit switching device that functions to short-circuit or to ground a circuit in response to automatic or manual means.

58. **Rectification Failure Relay** is a device that functions if one or more anodes of a power rectifier fail to fire, or to detect an arc-back, or on failure of a diode to conduct or block properly.

59. **Overvoltage Relay** is a relay that functions on a given value of overvoltage.

60. **Voltage or Current Balance Relay** is a relay that operates on a given difference in voltage, or current input or output, of two circuits.

61. Reserved for future application.

62. **Time-delay Stopping or Opening Relay** is a time-delay relay that serves in conjunction with the device that initiates shutdown, stopping, or opening operation in an automatic sequence or protective relay system.

63. **Pressure Switch** is a switch which operates on given values, or on a given rate of change, of pressure.

64. **Ground Protective Relay** is a relay that functions on failure of insulation of a machine, transformer, or of other apparatus to ground, or on flashover of a d-c machine to ground.

    NOTE: This function is assigned only to a relay that detects flow of current from the frame of a machine or enclosing case or structure of a piece of apparatus to ground, or detects a ground on a normally ungrounded winding or circuit, it is not applied to a device connected in the secondary circuit of a current transformer, or in the secondary neutral of current transformers, connected in the power circuit of a normally grounded system.

65. **Governor** is the assembly of fluid, electrical, or mechanical control equipment used for regulating flow of water, steam, or other medium to the prime mover for such purposes as starting, holding speed or load, or stopping.

66. **Notching or Jogging Device** is a device that functions to allow only a specified number of operations of a given device, or equipment, or a specified number of successive operations within a given time of each other. It is also a device that functions to energize a circuit periodically or for fractions of specified time intervals, or that is used to permit intermittent acceleration or jogging of a machine at Iow speeds for mechanical positioning.

67. **A-C Directional Overcurrent Relay** is a relay that functions on a desired value of a-c overcurrent flowing in a predetermined direction.

68. **Blocking Relay** is a relay that initiates a pilot signal for blocking of tripping on external faults in a transmission line or in other apparatus under predetermined conditions, or cooperates with other devices to block tripping or to block reclosing on an out-of-step condition or on power swings.

69. **Permissive Control Device** is generally a two-position, manually operated switch that, in one position, permits closing of a circuit breaker, or placing of an equipment into operation, and in the other position prevents the circuit breaker or equipment from being operated.

70. **Rheostat** is variable resistance device used in an electric circuit, which is electrically operated or has other electrical accessories, such as auxiliary, position, or limit switches.

71. **Level Switch** is a switch which operates on given values or on a given rate of change, of level.

Device No.	Definition and Function

72. **D-C Circuit Breaker** is a circuit breaker that is used to close and interrupt a d-c power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

73. **Load-resistor Contactor** is a contactor that is used to shunt or insert a step of loading limiting, shifting, or indicating resistance in a power circuit, or to switch a space heater in circuit, or to switch a light or regenerative load resistor of a power rectifier or other machine in and out of circuit.

74. **Alarm Relay** is a relay other than an annunciator, as covered under device function 30, that is used to operate, or to operate in connection with, a visual or audible alarm.

75. **Position Changing Mechanism** is a mechanism that is used for moving a main device from one position to another in an equipment: as for example, shifting a removable circuit breaker unit to and from the connected, disconnected, and test positions.

76. **D-C Overcurrent Relay** is a relay that functions when current in a d-c circuit exceeds a given value.

77. **Pulse Transmitter** is used to generate and transmit pulses over a telemetering or pilot-wire circuit to the remote indicating or receiving device.

78. **Phase-angle Measuring or Out-of-step Protective Relay** is a relay that functions at a predetermined phase angle between two voltages or between two currents or between voltage and current.

79. **A-C Reclosing Relay** is a relay that controls automatic reclosing and locking out of an a-c circuit interrupter.

80. **Flow Switch** is a switch which operates on given values, or on a given rate of change of flow.

81. **Frequency Relay** is a relay that functions on a predetermined value of frequency (either under or over or on normal system frequency) or rate of change of frequency.

82. **D-C Reclosing Relay** is a relay that controls automatic closing and reclosing of a d-c circuit interrupter, generally in response to load circuit conditions.

83. **Automatic Selective Control or Transfer Relay** is a relay that operates to select automatically between certain sources or conditions in an equipment, or perform a transfer operation automatically.

84. **Operating Mechanism** is the complete electrical mechanism or servo-mechanism, including operating motor, solenoids, position switches, etc., for a tap changer induction regulator. or any similar piece of apparatus which otherwise has no device function number.

Device No.	Definition and Function

85. **Carrier or Pilot-wire Receiver Relay** is a relay that is operated or restrained by a signal used in connection with carrier-current or d-c pilot-wire fault directional relaying.

86. **Locking-out Relay** is an electrically operated hand, or electrically, reset relay or device that functions to shut down or hold an equipment out of service, or both, upon occurrence of abnormal conditions.

87. **Differential Protective Relay** is a protective relay that functions on a percentage or phase angle or other quantitative difference of two currents or of some other electrical quantities.

88. **Auxiliary Motor or Motor Generator** is one used for operating auxiliary equipment, such as pumps, blowers, exciters, rotating magnetic amplifiers, etc.

89. **Line Switch** is a switch used as a disconnecting, load-interrupter, or isolating switch in an a-c or d-c power circuit, when this device is electrically operated or has electrical accessories, such as an auxiliary switch, magnetic lock, etc.

90. **Regulating Device** is a device that functions to regulate a quantity, or quantities, such as voltage, current, power, speed, frequency, temperature, and load, at a certain value or between certain (generally close) limits for machines, tie lines or other apparatus.

91. **Voltage Directional Relay** is a relay that operates when voltage across an open circuit breaker or contactor exceeds a given value in a given direction.

92. **Voltage and Power Directional Relay** is a relay that permits or causes connection of two circuits when the voltage difference between them exceeds a given value in a predetermined direction and causes these two circuits to be disconnected from each other when the power flowing between them exceeds a given value in the opposite direction.

93. **Field-changing Contactor** is a contactor that functions to increase or decrease, in one step, the value of field excitation on a machine.

94. **Tripping or Trip-free Relay** is a relay that functions to trip a circuit breaker, contactor, or equipment, or to permit immediate tripping by other device, or to prevent immediate reclosure of a circuit interrupter if it should open automatically even though its closing circuit is maintained closed.

95. Numbers from 95 to 99 should be assigned only for those functions in specific
96. cases where none of the assigned standard device function numbers are
97. applicable. Numbers which are "reserved for future application" should
98. not be used.
99.

APPENDIX B

Definitions of Relay Terms

The following definitions include terminology and nomenclature in common use in the relay industry. They have been compiled using information from the IEEE and the National Association of Relay Manufacturers. In instances where different terms are used synonymously, one has been defined and others have been cross-referenced to it. When the phrase "sometimes used for" is employed, a preference is implied for the terminology following the phrase, when "same as" is used; no strong preference is inferred.

Air Gap.-Sometimes used for Contact Separation or for Magnetic Air Gap.

Ampere-Turns.-The product of the number of turns in a magnetic coil and the rms current in amperes passing through the coil.

Armature-Hinged or pivoted moving part of the magnetic circuit of an electromagnetic relay. Sometimes used in a general sense to means any moving part which actuates contacts in response to a change in coil current.

Armature Contact.-Sometimes used for Movable Contact.

Armature Relay.-A relay operated by an electromagnet which, when energized, causes an armature to be attracted to a fixed pole (or poles).

Auxiliary Relay.-A relay which operates in response to opening and closing of its operating circuit to assist another relay or device in performance of a function. Back Contacts.-Sometimes used for the stationary contact of single-pole normally closed contacts.

Back Contacts.-Same as Normally Closed Contacts.

Backstop.-The part of a relay which limits movement of the armature away from the pole piece or core.

Backup Relaying.-Supplementary relaying designed to operate if a primary relay should malfunction or a circuit breaker fail to operate. Back-up relaying usually disconnects more of the power system than just the part with the faulty element as this is necessary in order to remove the abnormal condition and to minimize effect on the remainder of the system.

Bar Relay.-A relay so designed that a bar actuates several contacts simultaneously.

Break-before-make Contacts.-Contacts which interrupt one circuit before establishing another.

Break Contact.-Same as Back Contact,

Break Delay.-Sometimes used for Release Time.

Bridging.-Bridging is a term used to describe a contact transfer in which the movable contact touches the normally open contact before leaving the normally closed contact during the transfer action, thus never completely opening the circuit of the movable contact.

Brush.-Sometimes used for Wiper.

Chatter.-A sustained rapid opening and closing of contacts caused by variations in the coil current, mechanical vibration and shock or other causes.

Clapper Relay.-Sometimes used for Armature Relay.

Close-differential Relay.-Sometimes used for Marginal Relay.

Coil.-A magnetic or thermal winding to which energy is supplied to activate the relay.

Contact Arrangement.-Contact arrangement refers to the combination of different basic contact forms to make up the entire relay switching structure.

Contact Bounce.-Uncontrolled making and breaking of contact when relay contacts are moved to the closed position.

Contact follow.-The distance two contacts travel together after just touching.

Contact Gap.-Same as Contact Separation.

Contact Nomenclature.-Each movable contact of a relay constitutes a pole of the relay.

A combination of stationary contact and a movable contact which are engaged when the coil is unenergized is referred to as back, break, form B, or normally closed contacts and is abbreviated NC. A combination of stationary contact and movable contact, which are engaged when the coil is energized is referred to as front, make, form A, or normally open contacts and is abbreviated NO.

A combination of two stationary contacts and a movable contact which engages one of them when the coil is energized and engages the other when the coil is unenergized is called transfer, form C, or double-throw contacts and is abbreviated DT.

Contrasted with double-throw contacts, NO and NC contacts are called single-throw contacts, abbreviated ST.

A combination in which a movable contact simultaneously makes and simultaneously breaks connection between two stationary contacts is called double-break contacts and is abbreviated DB. For normally open contacts, this combination may be called double-make contacts.

Relay contact notations are given in the following order:

I. Poles
2. Throws
3. Normal Position
4. DB, if double-break or double-make contacts

Examples: SPST NO DB designates single-pole, single-throw, normally open, double-break contacts.

All contacts are single break except when noted as double-break (DB). Relays having several sets of differently functioning contacts will have the contact forms listed in alphabetical order of their letter symbols.

Example: 1A2B refers to SPST NO contacts and DPST NC contacts.

For a relay on which the moving contact engages more than two stationary contacts during its cycle of operation, the contact arrangement is described as MPNT, where M is the number of poles and N is tile number of throws, e.g., 8P 20T.

Contact Overtravel. -Sometimes used for Contact Follow.

Contact Separation.-Maximum distance between mating relay contacts when the contacts are in the open position.

Contact Spring.-A current-carrying spring to which contacts are fastened.

Contacts.-Current-carrying ports of a relay which engage or disengage to make or break electrical circuits.

Contactor.-Sometimes used for a relay with heavy-duty contacts.

Continuity-transfer Contacts.-Same as Make-before-break Contacts.

Continuous-duty Relay.-A relay which may be energized with rated coil voltage or current at rated contact load for a period of 3 hours or more without failure and without exceeding specified temperature requirements.

Current Balance Relay.-Relay that allows tripping whenever there is an abnormal change in the division of current between two circuits. Current Rating-See Rated Coil Current and Rated Contact Current.

Current Relay.-A relay which is designed to operate at a particular rated coil current rather than at a given rated coil voltage.

Cycle Timer.-A controlling mechanism which opens or closes contacts according to a preset cycle.

Deenergize.-To deenergize a relay is to disconnect the relay coil from its power source.

Definite-purpose Relay.-A readily available relay which has some electrical or mechanical feature which distinguishes it from a general-purpose relay. Types of definite purpose relays are interlock, selector, stepping, sequence, latch-in and time-delay.

Delay Relay.-A relay that is intentionally designed for a time delay between energizing or deenergizing instant and the time that the relay contacts open or close.

Differential relay.-A relay having multiple windings which functions when voltage, current, or power difference between windings reaches a predetermined value.

Directional Relay.-A relay that allows tripping for current flow in one direction only.

Double-break Contacts.-See Contact Nomenclature.

Double-make Contacts.-See Contact Nomenclature.

Double-Throw Contacts.-See Contact Nomenclature.

Double-wound Coil.-A double-wound coil is a winding consisting of two parts wound on the same core.

Double-wound Coil.-A double-wound coil is a winding consisting of two parts wound on the same core.

Drop-out Values.-Drop-out current, voltage, or power is the maximum value for which contacts of a previously energized relay will always assume their unenergized positions.

Duty Cycle.-Rated working time of a device compared to its idle time.

Electric Reset.-A qualify term applied to a relay indicating that following an operation its contacts must be reset electrically to their original positions.

Electromagnetic Relay.-A relay whose operation involves use of a magnetic field which is produced by an electromagnet.

Electrostatic Spring Shields.-Metallic shields between two relay springs to minimize capacitance between them.

Enclosed Relay.-A relay which has both coil and contacts protected from the surrounding medium by a cover that is not airtight.

Energize.-To energize a relay is to apply rated voltage to its coil. Extension Spring-Same as Restoring Spring.

Fast-operate Relay.-A high-speed relay specifically designed for short operate time but not short release time.

Fast-operate, Fast-release Relay.-A high-speed relay specifically designed for both short operate time and short release time.

Fast-operate, Slow-release Relay.-A relay specifically designed for short release time but not short operate time.

Fast-release Relay.-A high-speed relay specifically designed for short release time but not short operate time.

Fixed Contacts.-Stationary contacts of a relay which are engaged and disengaged by moving contacts to make or break circuits.

Flight Time.-Sometimes used for Transfer Time.

Follow-through Contacts.-Contacts which have contact follow.

Frame.-The structure on which the coil and contact assembly are mounted.

Front Contacts.-Sometimes used for the stationary contact of single-pole normally open contacts. (See Contact Nomenclature).

Front Contacts.-Same as Normally Open Contacts.

Gasket-sealed Relay.-An airtight relay, the sealing of which involves the use of a gasket which is not bonded to the other sealing material.

General-purpose Relay.-A readily available relay which has design, construction, operational characteristics, and ratings such that it is adaptable to a wide variety of uses.

Hand-reset.-A qualifying term applied to a relay indicating that following an operation the contacts must be reset manually to their original positions.

Header.-The part of a hermetically sealed relay through which electrical terminals pass.

Hermetically Sealed Relay.-An airtight relay the sealing of which involves fusing or soldering but does not use a gasket.

High-speed Relay.-A relay specifically designed for short operate time, release time, or both.

Hold Values.-The hold current, voltage, or power is the minimum value for which contacts of a previously energized relay will always maintain their energized positions.

Homing.-Homing is a qualifying term applied to a stepping relay indicating that wipers, upon completion of an operational cycle, are stepped around or back to the start position.

Hum.-Hum, as applied to relays, is the sound caused by mechanical vibration resulting from alternating current flowing in the coil.

Impregnated Coils.-Coils which have been permeated with phenolic or similar varnish to protect them from mechanical vibration, handling, fungus, and moisture.

Inductive Winding.-An inductive winding, as contrasted with a noninductive winding, as a coil having an inductance.

Instrument Relay.-A relay, the operation of which depends upon principles employed in electrical measuring instruments such as the electrodynamometer, iron-vane and D'Arsonval.

Interlock relay.-A relay composed of two or more coils with their armatures and associated contacts so arranged that freedom of one armature to move or its coil to be energized is dependent upon position of the armature.

Intermittent-duty Relay.-A relay which must be deenergized at occasional or periodic intervals to avoid excessive temperature.

Latch-in Relay.-A relay having contacts which lock in either the energized or deenergized position until reset either manually or electrically.

Level.-As applied to a stepping relay, the term level is used to denote one bank or series of contacts.

Level Contact.-Sometimes used for Movable Contact.

Looking Relay.-Sometimes used for Latch-in Relay.

Low-capacitance Contacts.-A type of contact construction providing low intercontact capacitance. Make Contact.-Same as Front Contact.

Magnetic Air Gap.-A magnetic air gap is a nonmagnetic portion of a magnetic circuit.

Magnetic Freezing.-The sticking of a relay armature to the core, after deenergization, due to residual magnetism of the core.

Magnetic Switch.-Sometimes used for Relay.

Make-before-break Contacts.-Double-throw contacts so arranged that moving contact establishes a new circuit before disrupting the old one.

Make Delay.-Sometimes used for operate Time.

Marginal Relay.-A relay which functions in response to predetermined changes in the value of coil current or voltage.

Mercury-contact Relay.-A relay in which the contacting medium is mercury.

Motor-driven Relay.-A relay which is actuated by rotation of the shaft of some type of motor, for example, a shaded-pole, induction-disk, or hysteresis motor.

Movable Contact.-A contact which, when the relay is energized or deenergized, is mechanically displaced to engage or disengage one or more stationary contacts. Multiple-break Contacts.-contacts so arranged that, when they open, the circuit is interrupted in two or more places.

Multiple Pile-up.-An arrangement of contact springs which is composed of two or more separate pile-ups.

Multiple Stack.-Same as Multiple Pile-up.

Neutral Relay.-A neutral relay, in contrast to a polarized relay, is a relay in which the movement of the armature is independent of direction of flow of current through the relay coil.

Non-bridging.-A term used to describe a contact transfer in which the movable contact leaves one contact before touching the next.

Non-homing.-.A qualifying term applied to a stepping relay indicating that wipers, upon completion of an operational cycle, do not return to the home position, but are at rest on the last used set of contacts.

Non-inductive Windings.-a type of winding in which the magnetic fields produced by two parts of the winding cancel each other and provide a non-inductive resistance.

Non-magnetic Shim.-A non-magnetic material attached to the armature or core of a relay to prevent iron-to-iron contact in an energized relay.

Non-operate Value.-The non-operate voltage, current, or power is the maximum value for which contacts of a previously deenergized relay will always maintain their deenergized positions.

Normal Position.-Deenergized position, open or closed, of contacts due to spring tension or gravity.

Normal Sequence of Operation.-The sequence in which all normally closed contacts open before closure of normally open contacts of the assembly.

Normal-speed Relay. -A relay in which no attempt has been made either to increase or decrease the operate time or the release time.

Normally Closed Contacts.-A combination of a stationary contact and movable contact which are engaged when the coil is deenergized.

Normally Open Contacts.- A combination of a stationary contact and a movable contact which are not engaged when the coil is deenergized.

Off-limit Contacts.-Contacts on a stepping relay used to indicated when the wiper has reached the limiting position on its arc and must be returned to normal before the circuit can function again.

Off-normal Contacts.- Stationary contacts on a homing stepping relay used to indicate when the wiper is not in the starting position..

Operate Time.- If a relay has only normally closed contacts, its operate time is the longest time interval given by definition (a) below. If a relay has normally open contacts (regardless of whether or not it has normally closed contacts) its operate time is the longest time interval given by definition (b).

(a) **Operate Time for Normally closed Contacts.**-Operate time for normally closed contacts is total elapsed time from the instant the coil is energized until contacts have opened; i.e., contact current is zero.

(b) **Operate Time for Normally Open Contacts.**-Operate time for normally open contacts is total elapsed time from the instant the coil is energized until contacts are closed and all contact bounce has ceased

Operate Values.-Same as Pick-up Values.

Operating Frequency.-The rated a-c frequency of the supply voltage at which the relay coil is designed to operated.

Overload Relay.-A relay which is specifically designed to operate when its coil current reaches a predetermined value above normal.

Overvoltage Relay.-A relay which is specifically designed to operate when its coil voltage reaches a predetermined value above normal.

Partially Enclosed Relay.-A relay which has either contacts or coil (but not both) protected from the surrounding medium by a cover that is not airtight.

Partially Sealed Relay.-A relay which has either contacts or coil (but not both) sealed.

Pick-up Values.-Pick-up voltage, current, or power is the minimum value for which contacts of a previously deenergized relay will always assume their energized position.

Pile-up.-A set of contact arms, assemblies, or springs placed one on top of the other with insulation between them.

Plunger Relay.-A relay operated by energizing an electromagnetic coil which in turn operates a movable core or plunger by solenoid action.

Polarized Relay.-A relay which is dependent upon the polarity of the energizing current to operate.

Pole.-Seen Contact Nomenclature.

Pole Face.-The pole face is the part of the magnetic structure on the end of the core nearest the armature.

Pull-in Values.-Same as Pick-up Values.

Pull-on Values.-Sometimes used for Pick-up Values.

Ratchet Relay.-A stepping relay actuated by an armature-driven ratchet.

Rated Coil Current.-Steady-state coil current at which the relay is designed to operate.

Rated Coil Voltage.-Coil voltage at which the relay is designed to operate.

Rated Contact Current.-Current which the contacts are designed to carry for their rated life.

Relay.-A device which is operated by variation in conditions of one electric circuit to affect operation of other devices in the same or other electric circuits by either opening circuits or closing circuits or both.

Release Factor.-Ratio, expressed in percent, of drop-out current to rated current or the analogous voltage ratio.

Release Time.-If a relay has only normally open contacts, its release time is the longest time interval given by definition (a) below. If a relay has normally closed contacts (regardless of whether or not it has normally open contacts) its operate time is the longest time interval given by definition (b).

(a) **Release Time for Normally Open Contacts.**-Release time for normally open contacts is total elapsed time from the instant the coil current starts to drop from its rated value until contacts have opened, i.e., contact current is zero.

(b) **Release Time for Normally closed Contacts.**-Release time for normally closed contacts is total time from the instant the coil current starts to drop from its rated value until contacts are closed and all contact bounce has ceased.

Release Values.-Same as Drop-out Values.

Repeating Timer.-A timing device which upon completion of one operating cycle continues to repeat automatically until excitation is removed.

Residual Gap.-Length of the magnetic air gap between the pole-face center and nearest point on the armature when the armature is in the energized position.

Residual Pins or Screws.-Nonmagnetic pins or screws attached to either the armature or core of a relay to prevent the armature from directly contacting the magnetic core.

Residual Setting.-Value of the residual gap obtained by the use of an adjustable residual screw.

Residual Shim.-Same as Non-magnetic Shim.

Restoring Spring.-A spring which moves the armature to and holds it in the normal position when the relay is deenergized.

Retractile Spring.-Sometimes used for Restoring Spring.

Rotary Relay.-Sometimes used for Motor-driven Relay.

Rotary Stepping Relay.-Same as Stepping Relay.

Rotary Stepping Switch.-Same as Stepping Relay.

Sealed Relay.-A relay which has both coil and contacts enclosed in an airtight cover.

Self-cleaning Contacts.-Sometimes used for Wiping Contacts.

Selector Relay.-A relay capable or automatically selecting one or more circuits from a number of circuits.

Sequence Control.-Automatic control of a series of operations in a predetermined order.

Sequence Relay.-A relay which controls two or more sets of contacts in a definite predetermined sequence.

Shading Coil.-Sometimes used for Shading Ring.

Shading Ring.-A shorted turn surrounding a portion of the pole of an alternating current magnet, causing a delay of change of magnetic flux in that part, thereby preventing contact chatter.

Slave Relay.-Sometimes used for Auxiliary Relay.

Slow-operate, Fast-release Relay.-A relay specifically designed for long operate time and short release time.

Slow-operate Relay.-A slow-speed relay which has been specifically designed for long operate time but not for long release time.

Slow-operate, Slow-release Relay.-A slow-speed relay specifically designed for both long operate time and long release time.

Slow-release Relay.-A slow-speed relay specifically designed for long release time, but not for long operate time.

Slow-speed Relay.-A relay specifically designed for long operate time, release time, or both.

Slug.-A highly conductive sleeve placed over the core to aid in retarding the establishing or decay of Flux within the magnetic path.

Solenoid Relay.-Sometimes used for a Plunger Relay.

Solid State Relays.-Relays that use various low-power components - diodes, transistors, and thyristors, and associated resistor and capacitors. These components are designed into logic units used in many ways.

Special-purpose Relay.-A relay which has an application that requires special features which are not characteristic of conventional general-purpose or definite-purpose relays.

Specified duty Relay.-A relay which is designed to function with a specified duty cycle but which might not be suitable for other duty cycles.

Spring Buffer.-A bearing member made of insulating material which transmits motion of the armature to the movable contact and from one movable contact to another in the same pile-up. Spring Pile-up.-Same as Pile-up.

Spring Stud.-Same as Spring Buffer.

Stack.-Same as Pile-up.

Stationary Contact.-A contact member which is rigidly fastened to the relay frame and which is not moved as a direct result of energizing or deenergizing the relay.

Stepping Relay.-A relay whose contacts are stepped to successive positions as the coil is energized in pulses. Some stepping relays may be stepped in either direction. (The Stepping Relay is also called a Rotary Stepping Switch or a Rotary Stepping Relay.)

Telephone-type Relay.-Sometimes used for an armature relay with an end-mounted coil and spring pile-up contacts mounted parallel to the long axis of the relay coil.

Tension Spring.-Sometimes used for Restoring Spring.

Thermal Relay.-A relay which is operated by the heating effect caused by electric current flow.

Throw.-See Contact Nomenclature.

Time-delay Relay.-A relay in which a delayed action is purposely introduced.

Timing Relay.-A motor-driven time-delay relay.

Transfer Time.-Total elapsed time between breaking one set of contacts and making of another set of contacts.

(a) **Transfer Time on Operate.**-Transfer time on operate is total elapsed time from the instant the normally closed contacts start to open until the normally open contacts are closed and all contact bounce has ceased.

(b) **Transfer Time on Release.**-Transfer time on release is total elapsed time from the instant the normally open contacts start to open until the normally closed contacts are closed and all contact bounce has ceased.

Transit Time.-Same as Transfer Time.

Trip Values.-Trip voltage, current, or power is rated value at which a bistable polarized relay will transfer from one contact to another.

Undercurrent Relay.-A relay specifically designed to function when its coil current falls below a predetermined value.

Undervoltage Relay.- A relay specifically designed to function when its coil voltage falls below a predetermined value.

Unenclosed Relay.-A relay which does not have its contacts or coil protected from the surrounding medium by a cover.

Winding.-Same as Coil.

Wiper.-A moving contact on a stepping relay. Wiping Contacts.-Contacts designed to have some relative motion during the interval from the instant of touching until completion of closing motion.

Wiping Contacts. - Contacts designed to have some relative motion during the interval from the instant of touching until completion of the closing motion.

APPENDIX C

Adjustment of Westinghouse Type KD Relays

Reclamation personnel have experienced considerable difficulty with Westinghouse Type KD relays due to inadequate contact restraint upon loss of restraint potential. When the relay is adjusted in accordance with the manufacturer's instructions, the restraint in the contact opening direction is so slight that vibration or jarring of the switchboard panel will close the contacts, and they sometimes remain closed. This causes a problem on schemes where the restraint potential is obtained from the line (in a ring bas scheme, for example) or when loss of main bas potential occurs (when restraint potential is obtained from the bus) since it is impossible to close the breaker under this condition. Present design practice is to provide overcurrent supervision of distance relays where potential is line connected. In older installations where overcurrent supervision is not provided the existing relay adjustment instructions should be modified to insure that the relays will rest when they are deenergized. Westinghouse relay engineers have provided the following supplementary instructions.

If minimum voltage at the relay, for a fault at the balance point setting, is less than 30 volts secondary line-to-line, then the spring restraint should be adjusted as per pages 25 and 27 of I.L.41-491H for Type KD and KD-1 relays, or as per pages 24 and 25 of I.L. 41-491.4N for Type KD-4 and KD-41 relays. However, if with this adjustment the relay contacts fail to reset when relay is deenergized, the spring restraint should be increased only enough to hold the moving contact against the backstop while the relay is deenergized.

Where minimum voltage at the relay, for a fault at the balance point setting, is 30 volts line-to-line or more, the spring restraint for both three-phase and phase-to-phase element may be set as follows: Connect relay to Test No. 1 except reverse the voltage phase sequence by interchanging the connections to Brush 1 and Brush 2. Adjust voltages VlF2F and V2F3F for 3.5 volts each. Position the moving contact spring adjuster so that the moving contact just restrains against the backstop. This adjustment will make the three-phase unit characteristic somewhat nonlinear with respect to balance point voltage, but the effect is almost negligible at 30-volt line-to-line and above.

There is one other possible problem due to loss of potential on these relays. If the relays are deenergized because of the tripping of remote source circuit breakers, the contacts may momentarily blip closed due to the transient decay of energy in the potential circuit of the relay. If is desired to prevent tripping under such conditions where the relay can be deenergized without attendant opening of the "52 a" contact, the recommended solution is to use fault detectors as stated on Page 3 of I.L. 41-491H and page 1 of I.L. 41-491.4N.