4. Element Testing

We've finally reached the part that most people call relay testing. Follow the test plan created in the previous chapter and test all of the elements that create any kind of output from the relay. Try to group similar functions together that will require the minimum number of connection and relay test set configuration changes. For example, some relays can have many overcurrent elements enabled. Instead of performing pickup testing and timing testing for each overcurrent element in order, try performing all of the pickup tests first, then perform the timing tests for all elements. You can also speed up your testing and minimize connection changes by testing all elements for one phase and moving on to the next phase.

Instead of following a dogmatic approach to testing, think about the reason for the tests. For example, we perform a time overcurrent test to ensure the settings are correct, we've entered the settings correctly, and the relay will operate correctly on each phase. Following the testing procedure from electro-mechanical relays, you would test for pickup on all three-phases, then time each phase at 2x, 4x, and 6x the pickup value. This is a perfectly acceptable test procedure today, but most modern relays use the same timer for all three-phases. Testing pickup on all three-phases and performing the 2x timing test on AØ, 4x timing test on BØ, and 6x timing test on CØ will prove all of our criteria and remove 6 tests from our test plan. Standard timing test values were used in the past because results were based on graphs and it was easier and more accurate to determine the expected result from the graph using whole numbers. You can choose any two or three multiples between the pickup value and the 50 element in modern relays to prove the correct curve has been applied.

Many problems during impedance pickup testing occur because modern relays do not believe your test values are actually a fault because the correct pre-fault polarizing has not occurred. Test impedance element pickup using 3-phase values to obtain the most accurate pickup results and then perform 3 quick phase-phase tests for each phase combination.

Most transformer differential relays internally compensate for delta-wye shifts and differential pickup values can vary depending on your test connection and the internal compensation. Most three-phase, balanced current pickup tests will match the pickup setting. Perform a timing test for each phase after the three-phase pickup test to prove each element will create a differential fault.

Document all of your tests on your test sheet. The test sheet for our example would look like the following.

PHASE CURRENT TEST RESULTS							
TIME PICKUP:	1	INST1 PICKUP:	9				
TIME CURVE:	NI	INST1 DELAY:	0.10				
TIME MULTIPLIER:	3.00	INST2 PICKUP:					
TIME RESET:	INST	INST 2 DELAY:					
PHASE CURRENT PICKUP TESTS (in secondary Amps)							
TEST	A PHASE PU (A)	B PHASE PU (A)	C PHASE PU (A)	MFG (A)	% ERROR		
TIME PICKUP	5.01	5.02	4.99	5.00	0.20	0.40	-0.20
INST PICKUP	44.987	44.999	44.975	45.00	-0.03	0.00	-0.06
TIME OVERCURRENT TIMING TESTS (in seconds)							
MULT	AMPS	A PH TRIP (s)	B PH TRIP (s)	C PH TRIP (s)	MFG (s)	% ERROR	
2	10.00	5.315			5.30	0.34	
3	15.00		2.278		2.26	0.72	
4	20.00			1.567	1.54		1.87
INSTANTANEOUS OVERCURRENT TIMING TESTS (in seconds)							
MULT	AMPS	A PH TRIP (s)	B PH TRIP (s)	C PH TRIP (s)	MFG (s)	% ERROR	
1.1	49.50	0.145			0.10	OK	
COMMENTS:							
RESULTS ACCEPTABLE:	☑ YES	☐ NO	☐ SEE NOTES				

Figure 22-4: Example Overcurrent Test Sheet

UNDER VOLTAGE TEST RESULTS							
B-U/V 1 PICKUP:	0.9	B-U/V 2 PICKUP:	0.85				
B -U/V 1 CURVE:	DT	B-U/V 2 CURVE:	DT				
B-U/V 1 DELAY:	60.00	B-U/V 2 DELAY:	20.00				
B-U/V 1 PHASES::	ANY ONE	B-U/V 2 PHASES:	ANY ONE				
B-U/V 1 MIN VS:	0.30	B-U/V 2 MIN V:	0.30				
UNDERVOLTAGE PICK UP TESTS							
TEST	A PHASE PU (V)	B PHASE PU (V)	C PHASE PU (V)	MFG (V)	% ERROR		
B-U/V 1 PICKUP:	107.9	107.95	107.99	108.00	-0.09	-0.05	-0.01
B-U/V 1 MIN V:	35.80			36.00	-0.56		
B-U/V 2 PICKUP:	102.01	101.9	101.95	102.00	0.01	-0.10	-0.05
B-U/V 2 MIN V:		35.9		36.00		-0.28	
UNDERVOLTAGE 1 TIMING TESTS (in seconds)							
MULT	AMPS		3 PHASE (s)		MFG (s)	% ERROR	
1.1			60.21		60.000	0.35	
UNDERVOLTAGE 2 TIMING TESTS (in seconds)							
MULT	AMPS		3 PHASE (s)		MFG (s)	% ERROR	
1.1			20.13		20.00	0.65	
COMMENTS:							
RESULTS ACCEPTABLE:	☑ YES	☐ NO	☐ SEE NOTES				

Figure 22-5: Example Undervoltage Test Sheet

5. Final Output Tests

Output checks are the most important part of hands-on relay testing. If the outputs are not correctly set, the relay may as well not be installed. More mistakes are made when assigning outputs than any other part of the relay settings. Simple mistakes in output logic schemes can completely disable a relay or cause unintended interaction between devices. These problems are aggravated by the lack of common standards between manufacturers or product lines, relay logic complexity, and poor interpretation of the relay logic. It seems every relay has a different element label, logic scheme, or rules for data entry that create problems that cannot be caught without the final logic test.

Many relays allow output contacts to be easily assigned and a common trap for relay testers occur when they use a spare output for all element tests to prevent interference from other elements and to make sure that they're testing the correct element. They finish testing and remove all test settings and the elements have been thoroughly tested, but there is no guarantee that the relay will actually operate until the output logic is tested.