Low-Voltage AC Testing of Hydraulic Reclosers

R280-90-2

INTRODUCTION

Kyle® reclosers are designed for operation under conditions encountered on distribution circuits having a minimum rating of 2400 volts. Any test performed at a lower voltage than this should be termed a low-voltage test. A low-voltage test is subject to inadequacies, and the lower the voltage, the more pronounced these inadequacies become. Recloser operation can, however, be checked by this method if limitations of the test equipment are recognized.

Kyle reclosers can be grouped in two classes:

- Group 1 includes Types H, 3H, 4H, 6H, V4H, V6H, E, 4E, L, V4E, and V4L. These reclosers draw tripping and closing energy from the fault current itself by means of the series-trip coil.
- Group 2 includes Types D, DV, R, RV, RX, VW, VWV27, VWV38X, W, WV27, and WV38X. These reclosers also employ series-trip coils, but they draw only enough energy to trip the recloser mechanism. Opening and closing energy is drawn from normal line potential.

SOURCES OF ERROR LOW-VOLTAGE TESTING

Group 1 Hydraulic Reclosers

Current Measurement

Because the series-trip coil draws energy from fault current for tripping and closing the recloser, ampere-turn requirements are high and, consequently, coils have relatively high impedance. As the plunger travels through the coil to open the recloser, the magnetic path changes and coil impedance rises sharply.

Table 1 shows the plunger-up and the plunger-down impedance values (resistance neglected) for 25 amp reclosers at rated current.

TABLE 1
Recloser Reactance Change for 25 amp Reclosers

Recloser Type	Plunger Up X_L ohms	Plunger Down X_L ohms
H, 3H, 4H, 6H, V4H, V6H	.297	.603
L, E	.685	1.765

If coil impedance is large with respect to total test circuit impedance, the change in reactance as the plunger moves down causes test current to decrease. This effect is shown in Figure 1.

A decreasing current envelope (Figure 1) introduces error into current measurement. In operation on an actual distribution line, current magnitude would be unaffected by changes in the plunger's position. Another error in current measurement can be introduced by the use of an indicating ammeter. If considerable current decay occurs, the ammeter will not respond fast enough to indicate initial current. Furthermore, if the recloser is operating on the A curve, the interval of current flow may be too small to permit a reading.

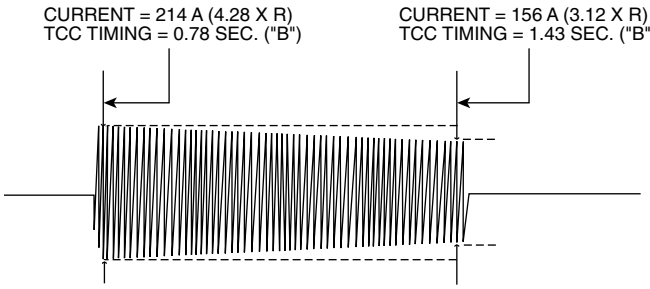

Figure 1.
Decreasing current envelope.

Decay of current can be minimized if series resistance is added into the test circuit to damp out the change in reactance. This will necessitate a test source having higher voltage and kVA.

Accurate current measurements can be made by use of an oscillograph.

Incomplete Mechanical Operation

Group 1 recloser contacts are operated by a toggle mechanism actuated by the series-trip solenoid plunger. Contacts open before the mechanism overtoggles, and overtoggling occurs before the plunger completes its stroke. Because arcing time at low voltage is less than normal, the plunger may not complete its stroke (Figure 2). This result is particularly evident on delayed operations when plunger speed is slow and momentum is insufficient to carry the plunger to the end of its stroke. The decreasing current envelope described previously further decreases plunger momentum. Two adverse conditions are thus encountered:

- Incomplete plunger travel also means incomplete pumping action; therefore, extra operations to lockout may be required.
- If the plunger stops before the mechanism overtoggles, the contacts will close again and chattering or telegraphing will occur.

These problems can be minimized or eliminated if test currents used are large with respect to the recloser's rating. Test current at least four times rating is recommended.

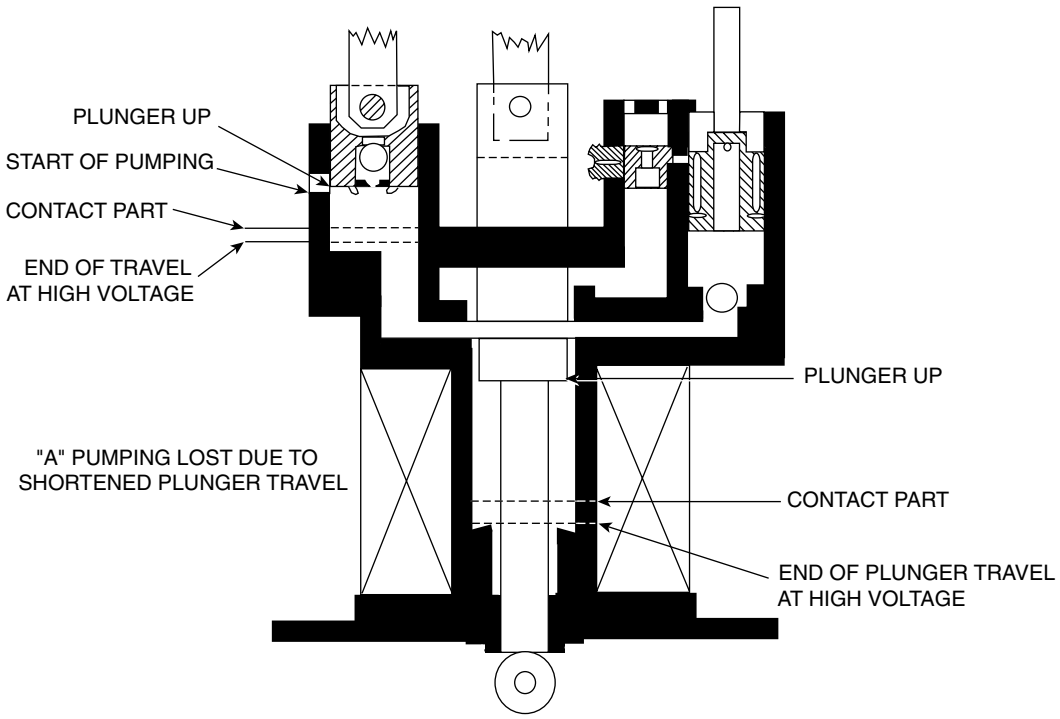

Figure 2.
Diagram of a typical Group 1 Recloser hydraulic mechanism.

Group 2 Hydraulic Reclosers

Series-trip coils in Types D, DV, R, RV, RX, VW, VWV27, VWV38X, W, WV27, and WV38X reclosers have much lower impedance than equivalent rated coils of Group 1 reclosers because energy requirements are much lower. Furthermore, once the mechanism trips, the recloser always completes the opening operation. Mechanical operation of Group 2 reclosers can be checked in a low-voltage test circuit without difficulty.

Low-Voltage Test Equipment Requirements

Test circuits are usually designed to utilize available equipment and to test particular types and sizes of reclosers. Therefore, only general requirements are listed and calculations are shown for one set of conditions. Variations from these recommendations can be made according to the results desired. Table 2 shows test voltage and kVA requirements calculated in accordance with the following specifications:

A. Minimum test current equals four times rated current of the recloser.

B. Series loading is resistive and is equal to five times coil reactance (X_L) when the plunger is up. Resistance loading is in quadrature with coil reactance so little decay of current should be encountered.

Satisfactory operation will generally be achieved if these conditions are met.

Table 2 was developed to show the voltage kVA, and series resistance required to test reclosers with reasonable accuracy. Test equipment having lower ratings can be used, but the effects of decreasing current and incomplete operation will be more pronounced. At higher test currents, series loading can be reduced because coil reactance decreases due to saturation.

A low-voltage test set-up having ratings shown in Table 2 could be used to establish check points or benchmarks for reclosers. These points could be established by testing a representative number of new reclosers of each type and size employed. Other reclosers then could be checked against the standards thus established. Care should be taken, however, to see that test conditions are always identical. Because test equipment varies considerably, Kyle cannot furnish information that will correlate these check points with the published time-current curves.

Additional Tests

Two simple tests applicable to all Group 1 reclosers can be performed to verify the reclosers are capable of proper operation. These tests should be adequate for most users of these reclosers.

Mechanical Operation Test

This test can be employed to determine the number of operations-to-lockout and the number of fast and delayed operations. To perform the mechanical operation test:

A. Move the operating lever to the CLOSED position and wait at least three minutes (longer in cold weather) to be sure the trip piston is at rest.

B. Move the operating lever to the OPEN position and listen for the opening of the main contacts. Move the operating lever to the CLOSED position and repeat this cycling until lockout occurs.

When lockout occurs, unlatching of the toggle mechanism can be heard. In addition, the operating lever will not latch in the CLOSED position after lockout has occurred.

- Fast operations can be identified because the contacts open immediately after the lever is moved to the OPEN position.
- On delayed openings, a noticeable lag occurs between the movement of the lever and the opening of the contacts.

Minimum Trip-Current Test

Perform the minimum trip-current test as follows:

A. Connect a variable voltage source having adequate current capacity to the recloser terminals and move the operating lever to the CLOSED position. An indicating ammeter must be connected to read test current.

B. Slowly raise the test voltage and observe the ammeter readings. As voltage and current increase, the plunger starts to move and, consequently, test current will decline. The maximum current noted before the current drops is the recloser's minimum trip current.

TABLE 2
Recloser Test Circuit Voltage, kVA and Series Resistance

Recloser	Coil	Current (4 x Coil Rating)	Coil X_L (Plunger Up)	Series R (Ohms) *	Voltage † Required	Test kVA ‡ (Short-Time)
H, 3H, 4H, 6H, V4H, V6H	5	20	7.48	37.4	750	15
	10	40	1.88	9.4	376	15.1
	15	60	.814	4.06	244	14.6
	25	100	.297	1.49	149	14.9
	35	140	.158	.79	111	15.6
	50	200	.073	.365	73	14.6
	70	280	.039	.195	55	15.4
	100	400	.020	.100	40	16.0
V4H, V6H	140	560	.011	.055	30.8	17.2
	200	800	.005	.025	20	16.0
E above serial number 52,000	5	20	18.603	93.0	1860	37.2
	10	40	4.538	22.7	908	36.3
	15	60	2.034	10.2	612	36.7
L, E above serial number 52,000	25	100	.685	3.42	342	34.2
	35	140	.341	1.71	240	33.6
	50	200	.168	.84	168	33.6
	70	280	.0833	.416	116	32.5
	100	400	.0414	.207	83	33.2
	140	560	.0215	.108	60.5	33.8
	200	800	.0108	.054	43.2	34.6
	280	1120	.0062	.031	34.7	38.8
E below serial number 52,000	5	20	13.7	68.5	1370	27.4
	10	40	3.44	17.2	688	27.5
	15	60	1.56	7.8	467	28.0
	25	100	.55	2.75	275	27.5
	35	140	.29	1.45	203	28.4
	50	200	.13	.65	130	26.0
	70	280	.063	.315	88	24.6
	100	400	.039	.195	78	31.2
4E, V4E, V4L	50	200	.285	1.42	285	57.0
	70	280	.136	.68	190	53.2
	100	400	.069	.345	138	55.2
	140	560	.038	.190	106	59.4
	170	680	.026	.125	85	57.8
	200	800	.019	.095	76	60.8
	280	1120	.011	.055	62	69.4
D, DV, R, RV, RX, VW, VWV27, VWV38X, W, WV27, WV38X	25	100	.0428	.428	42.8	4.28
	35	140	.0185	.185	25.9	3.62
	50	200	.0086	.086	17.2	3.44
	70	280	.0047	.047	13.2	3.7
	100	400	.00225	.0225	9.0	3.6
	140	560	.0011	.011	6.16	3.4
	160	640	.00092	.0092	5.89	3.8
	185	740	.00074	.0074	5.48	4.0
	225	900	.00056	.0056	5.04	4.5
	280		1120	.00040	.0040	4.48 5.0
	400 X	1600	.00034	.0034	5.44	8.7
	400	1600	.00027	.0027	4.32	6.9
	560 X	2240	.00022	.0022	4.93	11.0
	560	2240	.00015	.0015	3.36	7.4

* Loading resistance for Types D, DV, R, RV, RX, VW, VWV27, VWV38X, W, WV27, and WV38X reclosers calculated at 10 x coil reactance because reactance is low. Larger coil sizes may not require series loading because impedance of source, leads, and recloser may be large with respect to coil impedance.

† Voltage calculations simplified. Found by multiplying current by added series resistance. Coil impedance, source impedance, and test lead resistance neglected, so actual voltage required is greater.

‡ Test kVA shown found by multiplying current by voltage. Since voltage is actually somewhat greater, kVA is also greater. Test intervals are short so transformer rating can be smaller if short-time rating equals values shown in table.

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