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(Supplement to IEEE C37.09-1979)

Supplement to IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Sponsor

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On page 25 of IEEE C37.09-1979, add the following paragraph at the end of **4.6.5.4:**

Short-Line Fault Test Conditions. The saw-tooth recovery voltage on the short-line fault transient is delayed by substation capacitance adjacent to the circuit breaker and the line. The time delay t_d is 0.5 μs for breakers rated 242 kV and above and 0.2 μs for breakers rated below 242 kV. (See 5.11.4.2 of IEEE C37.04-1979.) The first line-side crest voltage *e* and the line-side rate of rise of recovery voltage R_L are the same as previously calculated but the time to first crest voltage is modified.

The ramp voltage rising at a rate R_L is delayed by the time delay t_d. The voltage then rises linearly to nearly crest voltage but the crest occurs at a time $(T_L + 2t_d)$ as shown in Fig a.

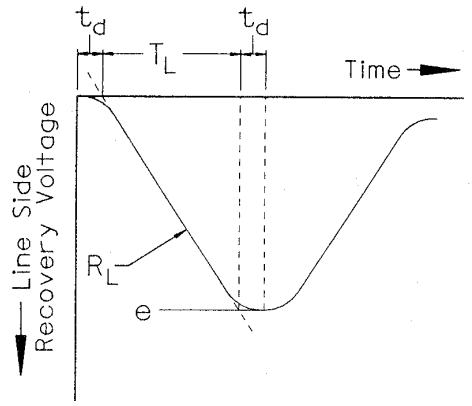

Figure a —Short-Line Fault Transient Recovery Voltage With Time Delay

The following is the new section for the initial transient recovery voltage:

4.6.5.X Initial Transient Recovery Voltage Test Conditions

[Editorial note: This section follows **4.6.5.4** *as a new section. The remaining section numbers will be modified as required in a future revision.]* The initial transient recovery voltage capability may be demonstrated in conjunction with short-line fault testing. Suitable circuit impedance may be used on the source side to obtain the initial transient recovery voltage as specified in 5.11.4.3 of IEEE C37.04-1979.

Testing complexity may be reduced by using an alternate test method to demonstrate the initial transient recovery voltage capability as follows. In the case where the initial transient recovery voltage ME_i exceeds the reduced exponential-cosine transient for current MI at time $(T_L + t_d)$, the source-side initial transient recovery voltage can be simulated by a line-side linear ramp transient without time delay t_d. The crest of the line-side transient shall also be increased such that the total peak voltage across the circuit breaker at time $(T_L + t_d)$ is equal to the sum of the normal short-line fault crest voltage e and the initial transient recovery voltage ME_i.

The alternate test method is explained with the aid of Figs b and c. The required line-side crest voltage e and time to crest with time delay is calculated as explained in 4.6.5.4 previously. The reduced initial transient recovery voltage for the fault current *MI* and the total circuit-breaker stress is then determined at the time $(T_L + t_d)$ as shown in Fig b. An equivalent line-side transient recovery voltage is then calculated assuming only an expontential-cosine envelope for the reduced current *MI* for the source-side transient. The crest line-side test voltage would be $(e + e_a)$ and the voltage should rise linearly to the value at time $(T_L + t_d)$ *without* a time delay as shown in Fig c.

In the case where the reduced exponential-cosine transient for current *MI* exceeds ME_i at time $(T_L + t_d)$, then the initial transient recovery voltage can be simulated by a line-side linear ramp transient without time delay t_d, and the crest shall simply be e at time $(T_L + t_d)$.

A change should be made to **4.6.6, Methods of Demonstrating the Short-Circuit Current Rating of a Circuit Breaker.** *The penultimate paragraph in the left column of page 28 presently reads: "Test Duties 15 and 16 demonstrate the performance of the circuit breaker during the interruption of short-line faults. When…" The following will replace the first sentence:*

Test Duties 15 and 16 demonstrate the performance of the circuit breaker during the interruption of short-line faults and may also be used to demonstrate the performance of the circuit breaker with initial transient recovery voltage. (See 4.6.5.X.)

Table 1 *on page 20 and* **Table 2** *on page 22 will be modified as follows:*

- Test Duty 16 will be eliminated since $K = 1$ for all circuit breakers rated 121 kV and above in C37.06-1987.
- An additional short-line fault test will be added at a test current of 0.9–0.95 I and designated as Test Duty 15. See corrected tables in this supplement.

Note (21) of Table 1 on page 21 and **Note (22) of Table 2** on page 24 have been changed to exclude breakers that are not sensitive to ITRV. The revised notes will read as follows:

Table 1, Note (21). This demonstration test is not required for circuit breakers rated 72.5 kV and below. The initial transient recovery voltage is not required for breakers rated below 31.5 kA or if it can be demonstrated that the breaker is not sensitive to this requirement.

Table 2, Note (22). This demonstration test is not required for circuit breakers rated 72.5 kV and below. The initial transient recovery voltage is not required for breakers rated below 31.5 kA or if it can be demonstrated that the breaker is not sensitive to this requirement.

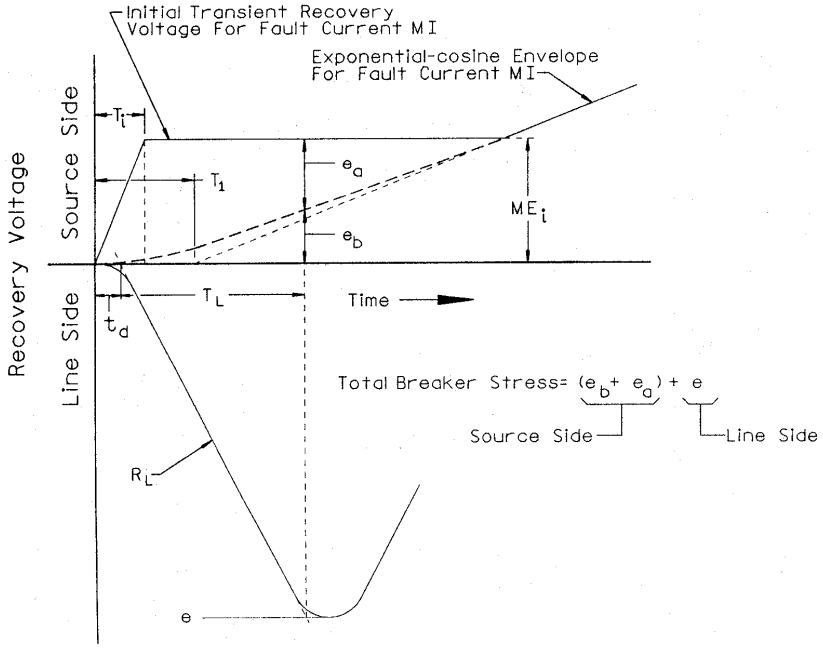

Figure b —Illustration of Initial Transient Recovery Voltage on Source Side With Time-Delayed Short-Line Fault Transient Voltage on the Line Side

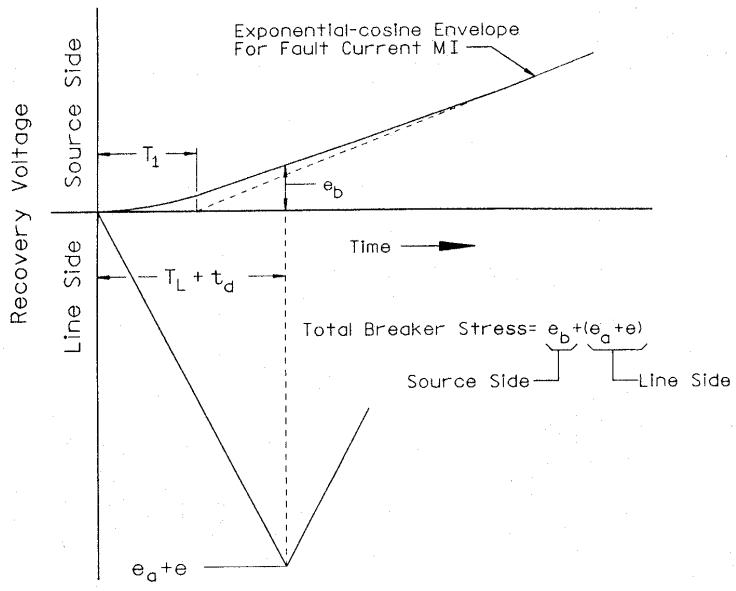

Figure c —Illustration of Equivalent Short-Line Fault Transient Recovery Voltage on the Line Side Without the Initial Transient Recovery Voltage on the Source Side

Table 1— Test for Demonstrating the Short-Circuit Rating of an ac High-Voltage Circuit Breaker by Method I (Testing a Three-Pole Breaker on a Three-Phase Circuit)

Test Duty*	Operating Duty (15)†	Phases	Voltages, Initial and Recovery, Normal-Frequency phase-to-phase V, rms (1) (2) (14)	Making Current at First Major Peak (1) (3)		Current Interrupted at Contact Separation		Tripping Delay (Approximate, 60 Hz Base) Cycles	Control Voltage and Operating Pressure Before First Operation
				A, rms	A, Peak	Magnitude, A, rms	% Asymmetry		
1	2	3	4	5	6	7	8	9	10
1	One O and one CO	3	*V*	—	—	0.07 *I* to 0.13 *I* (3)	50 to 100 (3)	$^1/_2$	Rated
2	One O and one CO	3	*V*	—	—	0.2 *I* to 0.3 *I* (10)	Less than 20 (10)	—	Rated
3	One O and one CO	3	*V*	—	—	0.4 *I* to 0.6 *I* (3)	50 to 100 (3)	$^1/_2$	Rated
4(5) (18)	O-15 s (1)-O, O-15 s (1)-CO, or CO-15 s (1)-CO	3	*V*	—	—	*I* (1) (9)	Less than 20	(4)	Rated (17)
5(5) (18)	O-15 s (1)-O, O-15 s (1)-CO, or CO-15 s (1)-CO	3	*V/K*	—	—	*KI* (1) (9)	Less than 20	(4)	Rated (17)
6-1 (7)	CO-15 s (1)-CO	3	*V*	1.6 *KI*	2.7 *KI*	*SI* (1) (3)	50 to 100 (3)	$^1/_2$	Rated (16)
6-2 (7)	C	3	*V*	1.6 *KI*	2.7 *KI*	—	—	—	Rated (16)
6-3 (7)	O-15 s (1)-O	3	*V*	—	—	*SI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	Rated
	For circuit breakers 121 kV and above:								
7 A-1 (7)	CO-15 s-CO-15 min-CO-15 s-CO-1 h-CO	3	*V/K*	1.6 *KI*	2.7 *KI*	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$	Rated (6) (16)
7 A-2 (7)	C-15 s (1)-C-15 min-C-15 s (1)-C-1 h-C	3	*V/K*	1.6 *KI*	2.7 *KI*	—	—	—	Rated (16)
7 A-3 (7)	O-15 s (1)-O-15 min-O-15 s (1)-O-1 h-O	3	*V/K*	—	—	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	Rated (6)
	For all other breakers:								
7 B-1 (7)	CO-15 s-CO-1 h-CO	3	*V/K*	1.6 *KI*	2.7 *KI*	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$	Rated (6) (16)

7 B-2 (7)	C-15 s (1)-C-1 h-C	3	*V/K*	1.6 *KI*	2.7 *KI*	—	—	—	Rated (16)
7 B-3 (7)	O-15 s (1)-O-1 h-O	3	*V/K*	—	—	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	Rated (6)
8 (13)	Several O and CO operations-1 h-CO	3	*V/K*	—	—	(13)	Random	$^1/_2$	Rated (6)
9 (11) (12)	O-0 s-CO or CO-0 s-CO	3	*V*	—	—	*RSI* (1) (3)	50 to 100 (3)	$^1/_2$	Rated
10 (11)	O-0 s-CO or CO-0 s-CO	3	*V/K*	—	—	*RKSI* (1) (3)	50 to 100 (3)	$^1/_2$	Rated
11	C-*T* s-O	3	*V/K*	1.6 *KI*	2.7 *KI*	*KI*	0	*T*	Rated (16)
12	In closed position (8)	1	—	—	—	—	—	—	—
13	One O and one CO or two O	1	0.58 *V*	—	—	Smaller of 1.15 *I* or *KI*	Less than 20	(4)	Rated
14	One O and one CO or two O	1	0.58 *V*	—	—	Smaller of 1.15 *SI* or *KSI* (1)	50 to 100 (3)	$^1/_2$ (4)	Rated
15 (21)	O-15 s-O or O-15 s-CO or CO-15 s-CO	1	0.58 *V*	—	—	0.7 *I* to 0.8 *I* (19)	Less than 20	$^1/_2$ (4)	Rated (17)
16 (12) (21)	O-15 s-O or O-15 s-CO or CO-15 s-CO	1	0.58 *V*	—	—	0.9 *I* to 0.95 *I* (19)	Less than 20	$^1/_2$ (4)	Rated (17)

*.See 4.5.

†.Numbers in parentheses correspond to those of the explanatory NOTES on the following page.

Table 2— Test for Demonstrating the Short-Circuit Rating of an ac High-Voltage Circuit Breaker by Method II (Testing a Single Pole of a Three-Pole Breaker on a Single-Phase Circuit)

Test Duty*	Operating Duty (15)†	Phases	Voltages, Initial and Recovery, Normal-Frequency Pole-Unit V, rms (1) (2) (14) (19)	Making Current at First Major Peak (1) (3)		Current Interrupted at Contact Separation		Tripping Delay (Approximate, 60 Hz Base) Cycles	Control Voltage and Operating Pressure Before First Operation
				rms	Peak	Magnitude, A, rms	% Asymmetry		
1	2	3	4	5	6	7	8	9	10
1	One O and one CO	1	0.87 *V*	—	—	0.07 *I* to 0.13 *I* (3)	50 to 100 (3)	$^1/_2$	(10)
2	One O and one CO	1	0.87 *V*	—	—	0.2 *I* to 0.3 *I* (3)	Less than 20 (3)	—	(10)
3	One O and one CO	1	0.87 *V*	—	—	0.4 *I* to 0.6 *I* (3)	50 to 100 (3)	$^1/_2$	(10)
4 (5) (18)	O-15 s (1)-O, O-15, s (1)-CO, or CO-15 s (1)-CO	1	0.87 *V*	—	—	*I* (9)	Less than 20	(4)	(10) (17)
5 (5) (18)	O-15 s (1)-O, O-15, s (1)-CO, or CO-15 s (1)-CO	1	0.87 *V/K*	—	—	*K* (9)	Less than 20	(4)	(10) (17)
6-1 (7)	CO-15 s (1)-CO	1	0.87 *V*	1.6 *KI*	2.7 *KI*	*SI* (1) (3)	50 to 100 (3)	$^1/_2$	(10) (16)
6-2 (7)	C	1	0.58 *V*	1.5 *KI*	2.7 *KI*	—	—	—	(10) (16)
6-3 (7)	O-15 s (1)-O	1	0.87 *V*	—	—	*SI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	(10)
	For circuit breakers 121 kV and above:								
7 A-1 (7)	CO-15 s-CO-15 min-CO-15 s-CO-1 h-CO	1	0.87 *V/K*	1.6 *KI*	2.7 *KI*	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	(6) (10) (16)
7 A-2 (7)	C-15 s (1)-C-15 min-C-15 s (1)-C-1 h-C	1	0.58 *V/K*	1.6 *KI*	2.7 *KI*	—	—	—	(10) (16)
7 A-3 (7)	O-15 s (1)-O-15 min-O-15 s (1)-O-1 h-O	1	0.87 *V/K*	—	—	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	(6) (10)
	For all other breakers:								
7 B-1 (7)	CO-15 S-CO-1 h-CO	1	0.87 *V/K*	1.6 *KI*	2.7 *KI*	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	(6) (10) (16)
7 B-2 (7)	C-15 s (1)-C-1 h-C	1	0.58 *V/K*	1.6 *KI*	2.7 *KI*	—	—	—	(10) (16)
7 B-3 (7)	O-15 s (1)-O-1 h-O	1	0.87 *V/K*	—	—	*KSI* (1) (3)	50 to 100 (3)	$^1/_2$ (4)	(6) (10)
8 (13)	Several O and CO operations-1 h-CO	1	0.87 *V/K*	—	—	(13)	Random	$^1/_2$	(10)

9 (11) (12)	O-0 s-CO or CO-0 s-CO	1	0.87 *V*	—	—	*RSI* (1) (3)	50 to 100 (3)	$^1/_2$	(10)
10 (11)	O-0 s-CO or CO-0 s-CO	1	0.87 *V/K*	—	—	*RKSI* (1) (3)	50 to 100 (3)	$^1/_2$	(10)
11	C-*T* s-O	1	0.87 *V/K*	1.6 *KI*	2.7 *KI*	*KI*	0	*T*	(10) (16)
12	In closed position (8)	1	—	—	—	—	—	—	—
15 (22)	O-15 s-O or O-15 s-CO or CO-15 s-CO	1	0.58 *V*	—	—	0.7 *I* to 0.8 *I* (20)	Less than 20	$^1/_2$ (4)	Rated (17)
16 (12) (22)	O-15 s-O or O-15 s-CO or CO-15 s-CO CO-15 s-CO	1	0.58 *V*	—	—	0.9 *I* to 0.95 *I* (19)	Less than 20	$^1/_2$ (4)	Rated (17)

*.See 4.6.
†.Numbers in parentheses correspond to those of the explanatory NOTES on the following page.