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(Corrigendum to
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IEEE Standards

C37.60™ Corrigendum

IEEE Standard Requirements for Overhead, Pad-Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems up to 38 kV—Corrigendum 1

IEEE Power Engineering Society

Sponsored by the
Switchgear Committee

IEEE

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Switchgear Committee
of the
IEEE Power Engineering Society

Approved 23 September 2004

IEEE-SA Standards Board

Abstract: Required definitions, ratings, procedures for performing design tests, production tests, and construction requirements for overhead, pad-mounted, dry vault, and submersible automatic circuit reclosers and fault interrupters for alternating systems up to 38 kV are specified.
Keywords: dry vault, fault interrupter, overhead, pad-mounted, recloser, submersible, standard operating duty, switchgear

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Introduction

This introduction in not part of IEEE Std C37.60™-2003/Cor 1-2004, IEEE Standard Requirements for Overhead, Pad Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems up to 38 kV—Corrigendum 1.

This Corrigendum to IEEE Std C37.60-2003 includes both technical and editorial corrections to the original document.

In Table 7 the changes are editorial to conform to the IEEE Style Manual. No substantive changes were made.

In Tables 10a, 10b, 10c, and 10d, editorial changes in the units row. No substantive changes are made.

In Tables 10e and 10f, the values for time t3 and Rate of rise U_c / t_3 were changed by approximately 4.5% for the three lines pertaining to the 27 kV rating only.

Also in Tables 10e and 10f, the definitions for k_{af} (T50), k_{af} (T20), and RRRV(T50) and RRRV(T20) were corrected to match the numbers in the tables. The matching numbers themselves were not changed.

In Annex A, Equation A.1 for instantaneous current was corrected. The definitions for the angles φ and θ were changed to agree with traditional usage and signs were corrected.

In Annex B, Figure B.1 was changed and simplified.

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Contents

IEEE Standard Requirements for Overhead, Pad-Mounted, Dry Vault, and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems up to 38 kV—Corrigendum 1

This corrigendum is based on the current edition of IEEE Std C37.60-2003.

NOTE—The editing instructions contained in this corrigendum define how to merge the material contained therein into the existing base standard and its amendments to form the comprehensive standard.

The editing instructions are shown in ***bold italic.*** Three editing instructions are used: change, delete, and replace. ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). ***Delete*** removes existing material. ***Replace*** is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editorial notes will not be carried over into future editions because the changes will be incorporated into the base standard.

5. Rating

5.9 Rated control voltage and ranges

Change Table 7 as shown:

Table 7—Preferred rated control voltage and ranges

Direct current (Note 1), control voltage ranges (Notes 4 and 5)		
Nominal Voltage	**Closing and Auxiliary Functions**	**Tripping Function**
24 (Note 2)	—	14–28 (Note 6)
48 (Note 2)	38–56	28–56 (Note 6)
125	100–140	70–140
250	200–280	140–280
Alternating current control voltage ranges (Notes 3, 4, and 5)		
Nominal voltage ~~(50/60 Hz)~~ (50 Hz or 60 Hz) single phase	**Closing, tripping and auxiliary functions**	
120	104–127 ~~(3)~~ (Note 3)	
240	208–254 ~~(3)~~ (Note 3)	
480	416–508 ~~(3)~~ (Note 3)	
Polyphase		
~~208Y/120~~ 208 (Wye)/120	~~180Y/104~~ – ~~220Y/127~~ 180 (Wye)/104–220 (Wye)/127	
240	208–254	
480	416–508	
~~480Y/277~~ 480 (Wye)/277	~~416Y/240 – 508Y/292~~ 416 (Wye)/240–508 (Wye)/292	

6. Design tests (type tests)

6.5 Rated symmetrical interrupting current tests

Change Table 10a, Table 10b, Table 10c, Table 10d, Table 10e, and Table 10f as shown:

Table 10 a)—Standard values of prospective transient recovery voltage representation by two parameters for <u>three-phase</u> reclosers with rated fault currents > 4000 A rms in overhead line connected circuits

Rated voltage	Test-duty	First-pole-to-clear factor	Amplitude factor	TRV peak value	Time	Time delay	Voltage	Time	Rate of rise
U_r		k_{pp}	k_{af}	U_c	t_3	t_d	u'	t'	U_c/t_3
(kV)		~~(p.u.)~~	~~(p.u.)~~	(kV)	(μs)	(μs)	(kV)	(μs)	(kV/μs)
12	T100	1.5	1.54	22.6	29.4	4	7.5	14	0.77
12	T50	1.5	1.68	24.7	17.0	3	8.2	8	1.45
12	T20	1.5	1.77	26.0	11.8	2	8.7	6	2.21
15.5	T100	1.5	1.54	29.2	33.2	5	9.7	16	0.88
15.5	T50	1.5	1.68	31.9	19.3	3	10.6	9	1.65
15.5	T20	1.5	1.77	33.6	13.3	2	11.2	6	2.53
17.5	T100	1.5	1.54	33.0	35.1	5	11.0	17	0.94
17.5	T50	1.5	1.68	36.0	20.4	3	12.0	10	1.77
17.5	T20	1.5	1.77	38.0	14.1	2	12.7	7	2.70
24	T100	1.5	1.54	45.3	41.5	6	15.1	20	1.09
24	T50	1.5	1.68	49.3	24.1	4	16.4	12	2.05
24	T20	1.5	1.77	52.1	16.6	2	17.4	8	3.13
27	T100	1.5	1.54	50.9	44.7	7	17.0	22	1.14
27	T50	1.5	1.68	55.5	25.9	4	18.5	13	2.14
27	T20	1.5	1.77	58.6	17.9	3	19.5	9	3.27
36	T100	1.5	1.54	67.9	53.5	8	22.6	26	1.27
36	T50	1.5	1.68	74.0	31.0	5	24.7	15	2.39
36	T20	1.5	1.77	78.1	21.4	3	26.0	10	3.64
38	T100	1.5	1.54	71.7	55.4	8	23.9	27	1.29
38	T50	1.5	1.68	78.1	32.2	5	26.0	16	2.43
38	T20	1.5	1.77	82.4	22.3	3	27.5	11	3.70

SPECIFIED VALUES in the TABLE	CALCULATED VALUES in the TABLE	
U_r = Rated Voltage	U_c =	TRV peak value
k_{pp} = First-pole-to-clear factor = 1.5	U_c =	$k_{pp} \times k_{af} \times \text{sqrt}(2/3) \times U_r$
k_{af} = Amplitude factor	U_c =	$k_{pp} \times k_{af} \times 0.8165 \times U_r$
k_{af} (T100) = Specified = 1.54	t_3 =	Time to *Uc*
k_{af} (T50) = k_{af} (T100) × 1.09 = 1.68	t_3 =	*Uc* / RRRV
k_{af} (T20) = k_{af} (T100) × 1.15 = 1.77	t_d =	Time delay for the delay line
RRRV = Rate of Rise of Recovery Voltage	t_d =	0.15 × t_3
RRRV(T100) = Specified	u' =	Voltage point for the delay line
RRRV(T50) = RRRV(T100) × 1.88	u' =	U_c / 3
RRRV(T20) = RRRV(T100) × 2.87	t' =	Time to u'
NOTE—The TRV values are calculated for ungrounded systems and cover grounded systems as well.[1]	t' =	$t_d + u'$ / RRRV

[1] Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

Table 10 b)—Standard values of prospective transient recovery voltage representation by two parameters for single-phase reclosers with rated fault currents > 4000 A rms in overhead line connected circuits

Rated voltage	Test-duty	First-pole-to-clear factor	Amplitude factor	TRV peak value	Time	Time delay	Voltage	Time	Rate of rise
U_r		k_{pp}	k_{af}	U_c	t_3	t_d	u'	t'	U_c/t_3
(kV)		~~(p.u.)~~	~~(p.u.)~~	(kV)	(μs)	(μs)	(kV)	(μs)	(kV/μs)
12	T100	1.732	1.54	26.1	33.9	5	8.7	16	0.77
12	T50	1.732	1.68	28.5	19.7	3	9.5	10	1.45
12	T20	1.732	1.77	30.1	13.6	2	10.0	7	2.21
15.5	T100	1.732	1.54	33.8	38.4	6	11.3	19	0.88
15.5	T50	1.732	1.68	36.8	22.2	3	12.3	11	1.65
15.5	T20	1.732	1.77	38.8	15.4	2	12.9	7	2.53
17.5	T100	1.732	1.54	38.1	40.5	6	12.7	20	0.94
17.5	T50	1.732	1.68	41.5	23.5	4	13.8	11	1.77
17.5	T20	1.732	1.77	43.8	16.2	2	14.6	8	2.70
24	T100	1.732	1.54	52.3	48.0	7	17.4	23	1.09
24	T50	1.732	1.68	57.0	27.8	4	19.0	13	2.05
24	T20	1.732	1.77	60.1	19.2	3	20.0	9	3.13
27	T100	1.732	1.54	58.8	51.6	8	19.6	25	1.14
27	T50	1.732	1.68	64.1	29.9	4	21.4	14	2.14
27	T20	1.732	1.77	67.6	20.7	3	22.5	10	3.27
36	T100	1.732	1.54	78.4	61.7	9	26.1	30	1.27
36	T50	1.732	1.68	85.5	35.8	5	28.5	17	2.39
36	T20	1.732	1.77	90.2	24.7	4	30.1	12	3.64
38	T100	1.732	1.54	82.8	64.2	10	27.6	31	1.29
38	T50	1.732	1.68	90.2	37.2	6	30.1	18	2.43
38	T20	1.732	1.77	95.2	25.7	4	31.7	12	3.70

SPECIFIED VALUES in the TABLE

U_r = Rated Voltage

k_{pp} = First-pole-to-clear factor = 1.732

k_{af} = Amplitude factor

k_{af} (T100) = Specified = 1.54

k_{af} (T50) = k_{af} (T100) × 1.09 = 1.68

k_{af} (T20) = k_{af} (T100) × 1.15 = 1.77

RRRV = Rate of Rise of Recovery Voltage

RRRV(T100) = Specified

RRRV(T50) = RRRV(T100) × 1.88

RRRV(T20) = RRRV(T100) × 2.87

NOTE—The TRV values are calculated for ungrounded systems and cover grounded systems as well.

CALCULATED VALUES in the TABLE

U_c = TRV peak value

U_c = $k_{pp} \times k_{af} \times \text{sqrt}(2/3) \times U_r$

U_c = $k_{pp} \times k_{af} \times 0.8165 \times U_r$

t_3 = Time to *Uc*

t_3 = *Uc* / RRRV

t_d = Time delay for the delay line

t_d = $0.15 \times t_3$

u' = Voltage point for the delay line

u' = $U_c / 3$

t' = Time to u'

t' = $t_d + u' / \text{RRRV}$

Table 10 c)—Standard values of prospective transient recovery voltage representation by two parameters for three-phase reclosers with rated fault currents > 4000 A rms in cable connected systems

Rated voltage	Test-duty	First-pole-to-clear factor	Amplitude factor	TRV peak value	Time	Time delay	Voltage	Time	Rate of rise
U_r		k_{pp}	k_{af}	U_c	t_3	t_d	u'	t'	U_c/t_3
(kV)		~~(p.u.)~~	~~(p.u.)~~	(kV)	(μs)	(μs)	(kV)	(μs)	(kV/μs)
12	T100	1.5	1.54	22.6	59.6	9	7.5	29	0.38
12	T50	1.5	1.68	24.7	34.5	5	8.2	17	0.71
12	T20	1.5	1.77	26.0	23.9	4	8.7	12	1.09
15.5	T100	1.5	1.54	29.2	66.4	10	9.7	32	0.44
15.5	T50	1.5	1.68	31.9	38.5	6	10.6	19	0.83
15.5	T20	1.5	1.77	33.6	26.6	4	11.2	13	1.26
17.5	T100	1.5	1.54	33.0	70.2	11	11.0	34	0.47
17.5	T50	1.5	1.68	36.0	40.7	6	12.0	20	0.88
17.5	T20	1.5	1.77	38.0	28.1	4	12.7	14	1.35
24	T100	1.5	1.54	45.3	83.8	13	15.1	41	0.54
24	T50	1.5	1.68	49.3	48.6	7	16.4	23	1.02
24	T20	1.5	1.77	52.1	33.6	5	17.4	16	1.55
27	T100	1.5	1.54	50.9	89.3	13	17.0	43	0.57
27	T50	1.5	1.68	55.5	51.8	8	18.5	25	1.07
27	T20	1.5	1.77	58.6	35.8	5	19.5	17	1.64
36	T100	1.5	1.54	67.9	107.8	16	22.6	52	0.63
36	T50	1.5	1.68	74.0	62.5	9	24.7	30	1.18
36	T20	1.5	1.77	78.1	43.2	6	26.0	21	1.81
38	T100	1.5	1.54	71.7	110.3	17	23.9	53	0.65
38	T50	1.5	1.68	78.1	63.9	10	26.0	31	1.22
38	T20	1.5	1.77	82.4	44.2	7	27.5	21	1.87

SPECIFIED VALUES in the TABLE

U_r = Rated Voltage

k_{pp} = First-pole-to-clear factor = 1.5

k_{af} = Amplitude factor

k_{af} (T100) = Specified = 1.54

k_{af} (T50) = k_{af} (T100) × 1.09 = 1.68

k_{af} (T20) = k_{af} (T100) × 1.15 = 1.77

RRRV = Rate of Rise of Recovery Voltage

RRRV(T100) = Specified = ½ × RRRV overhead lines

RRRV(T50) = RRRV(T100) × 1.88

RRRV(T20) = RRRV(T100) × 2.87

NOTE—The TRV values are calculated for ungrounded systems and cover grounded systems as well.

CALCULATED VALUES in the TABLE

U_c = TRV peak value

U_c = $k_{pp} \times k_{af} \times \text{sqrt}(2/3) \times U_r$

U_c = $k_{pp} \times k_{af} \times 0.8165 \times U_r$

t_3 = Time to Uc

t_3 = Uc / RRRV

t_d = Time delay for the delay line

t_d = $0.15 \times t_3$

u' = Voltage point for the delay line

u' = $U_c / 3$

t' = Time to u'

t' = $t_d + u' /$ RRRV

Table 10 d)—Standard values of prospective transient recovery voltage representation by two parameters for single-phase reclosers with rated fault currents > 4000 A rms in cable connected systems

Rated voltage	Test-duty	First-pole-to-clear factor	Amplitude factor	TRV peak value	Time	Time delay	Voltage	Time	Rate of rise
U_r		k_{pp}	k_{af}	U_c	t_3	t_d	u'	t'	U_c/t_3
(kV)		~~(p.u.)~~	~~(p.u.)~~	(kV)	(μs)	(μs)	(kV)	(μs)	(kV/μs)
12	T100	1.732	1.54	26.1	68.8	10	8.7	33	0.38
12	T50	1.732	1.68	28.5	39.9	6	9.5	19	0.71
12	T20	1.732	1.77	30.1	27.6	4	10.0	13	1.09
15.5	T100	1.732	1.54	33.8	76.7	12	11.3	37	0.44
15.5	T50	1.732	1.68	36.8	44.5	7	12.3	21	0.83
15.5	T20	1.732	1.77	38.8	30.7	5	12.9	15	1.26
17.5	T100	1.732	1.54	38.1	81.1	12	12.7	39	0.47
17.5	T50	1.732	1.68	41.5	47.0	7	13.8	23	0.88
17.5	T20	1.732	1.77	43.8	32.5	5	14.6	16	1.35
24	T100	1.732	1.54	52.3	96.8	15	17.4	47	0.54
24	T50	1.732	1.68	57.0	56.1	8	19.0	27	1.02
24	T20	1.732	1.77	60.1	38.8	6	20.0	19	1.55
27	T100	1.732	1.54	58.8	103.2	15	19.6	50	0.57
27	T50	1.732	1.68	64.1	59.8	9	21.4	29	1.07
27	T20	1.732	1.77	67.6	41.3	6	22.5	20	1.64
36	T100	1.732	1.54	78.4	124.4	19	26.1	60	0.63
36	T50	1.732	1.68	85.5	72.2	11	28.5	35	1.18
36	T20	1.732	1.77	90.2	49.9	7	30.1	24	1.81
38	T100	1.732	1.54	82.8	127.3	19	27.6	62	0.65
38	T50	1.732	1.68	90.2	73.8	11	30.1	36	1.22
38	T20	1.732	1.77	95.2	51.0	8	31.7	25	1.87

SPECIFIED VALUES in the TABLE

U_r = Rated Voltage

k_{pp} = First-pole-to-clear factor = 1.732

k_{af} = Amplitude factor

k_{af} (T100) = Specified = 1.54

k_{af} (T50) = k_{af} (T100) × 1.09 = 1.68

k_{af} (T20) = k_{af} (T100) × 1.15 = 1.77

RRRV = Rate of rise of recovery voltage

RRRV(T100) = Specified = ½ × RRRV overhead lines

RRRV(T50) = RRRV(T100) × 1.88

RRRV(T20) = RRRV(T100) × 2.87

NOTE—The TRV values are calculated for ungrounded systems and cover grounded systems as well.

CALCULATED VALUES in the TABLE

U_c = TRV peak value

U_c = $k_{pp} \times k_{af} \times \text{sqrt}(2/3) \times U_r$

U_c = $k_{pp} \times k_{af} \times 0.8165 \times U_r$

t_3 = Time to Uc

t_3 = Uc / RRRV

t_d = Time delay for the delay line

t_d = $0.15 \times t_3$

u' = Voltage point for the delay line

u' = $U_c / 3$

t' = Time to u'

t' = $t_d + u' / \text{RRRV}$

Table 10 e)—Standard values of prospective transient recovery voltage representation by two parameters for <u>three-phase</u> reclosers with rated fault currents ≤ 4000 A rms in both overhead and cable connected systems and <u>three-phase</u> fault interrupters of all interrupting ratings in cable connected systems

Rated voltage	Test-duty	First-pole-to-clear factor	Amplitude factor	TRV peak value	Time	Time delay	Voltage	Time	Rate of rise
U_r		k_{pp}	k_{af}	U_c	t_3	t_d	u'	t'	U_c/t_3
(kV)		~~(p.u.)~~	~~(p.u.)~~	(kV)	(μs)	(μs)	(kV)	(μs)	(kV/μs)
12	T100	1.5	1.54	22.6	117.6	18	7.5	57	0.193
12	T50	1.5	1.54	22.6	117.6	18	7.5	57	0.193
12	T20	1.5	1.54	22.6	117.6	18	7.5	57	0.193
15.5	T100	1.5	1.54	29.2	132.9	20	9.7	64	0.220
15.5	T50	1.5	1.54	29.2	132.9	20	9.7	64	0.220
15.5	T20	1.5	1.54	29.2	132.9	20	9.7	64	0.220
17.5	T100	1.5	1.54	33.0	140.5	21	11.0	68	0.235
17.5	T50	1.5	1.54	33.0	140.5	21	11.0	68	0.235
17.5	T20	1.5	1.54	33.0	140.5	21	11.0	68	0.235
24	T100	1.5	1.54	45.3	166.1	25	15.1	80	0.273
24	T50	1.5	1.54	45.3	166.1	25	15.1	80	0.273
24	T20	1.5	1.54	45.3	166.1	25	15.1	80	0.273
27	T100	1.5	1.54	50.9	~~186.9~~ 178.6	28	17.0	90	~~0.273~~ 0.285
27	T50	1.5	1.54	50.9	~~186.9~~ 178.6	28	17.0	90	~~0.273~~ 0.285
27	T20	1.5	1.54	50.9	~~186.9~~ 178.6	28	17.0	90	~~0.273~~ 0.285
36	T100	1.5	1.54	67.9	213.9	32	22.6	103	0.318
36	T50	1.5	1.54	67.9	213.9	32	22.6	103	0.318
36	T20	1.5	1.54	67.9	213.9	32	22.6	103	0.318
38	T100	1.5	1.54	71.7	222.2	33	23.9	107	0.323
38	T50	1.5	1.54	71.7	222.2	33	23.9	107	0.323
38	T20	1.5	1.54	71.7	222.2	33	23.9	107	0.323

SPECIFIED VALUES in the TABLE	CALCULATED VALUES in the TABLE	
U_r = Rated voltage	U_c =	TRV peak value
k_{pp} = First-pole-to-clear factor = 1.5	U_c =	$k_{pp} \times k_{af} \times$ sqrt(2/3) $\times U_r$
k_{af} = Amplitude factor	U_c =	$k_{pp} * k_{af} * 0.8165 \times U_r$
k_{af} (T100) = Specified = 1.54	t_3 =	Time to *Uc*
~~kaf(T50)= kaf(T100) x 1.09 = 1.68~~ k_{af} (T50) = Specified = 1.54	t_3 =	*Uc* / RRRV
~~kaf(T20)= kaf(T100) x 1.15 = 1.77~~ k_{af} (T20) = Specified = 1.54	t_d =	Time delay for the delay line
RRRV = Rate of rise of recovery voltage	t_d =	0.15 * t_3
RRRV(T100) = Specified = 1/4 × RRRV overhead lines	u' =	Voltage point for the delay line
~~RRRV(T50)= RRRV(T100) x 1.88~~ RRRV(T50) = RRRV(T100)	u' =	U_c / 3
~~RRRV(T20)= RRRV(T100) x 2.87~~ RRRV(T20) = RRRV(T100)	t' =	Time to u'
NOTE—The TRV values are calculated for ungrounded systems and cover grounded systems as well.	t' =	$t_d + u'$ / RRRV

Table 10 f)—Standard values of prospective transient recovery voltage representation by two parameters for single-phase reclosers with rated fault currents ≤ 4000 A rms in both overhead and cable connected systems and single-phase fault interrupters of all interrupting ratings in cable connected systems

Rated voltage	Test-duty	First-pole-to-clear factor	Amplitude factor	TRV peak value	Time	Time delay	Voltage	Time	Rate of rise
U_r		k_{pp}	k_{af}	U_c	t_3	t_d	u'	t'	U_c/t_3
(kV)				(kV)	(μs)	(μs)	(kV)	(μs)	(kV/μs)
12	T100	1.732	1.54	26.1	135.8	20	8.7	66	0.193
12	T50	1.732	1.54	26.1	135.8	20	8.7	66	0.193
12	T20	1.732	1.54	26.1	135.8	20	8.7	66	0.193
15.5	T100	1.732	1.54	33.8	153.4	23	11.3	74	0.220
15.5	T50	1.732	1.54	33.8	153.4	23	11.3	74	0.220
15.5	T20	1.732	1.54	33.8	153.4	23	11.3	74	0.220
17.5	T100	1.732	1.54	38.1	162.2	24	12.7	78	0.235
17.5	T50	1.732	1.54	38.1	162.2	24	12.7	78	0.235
17.5	T20	1.732	1.54	38.1	162.2	24	12.7	78	0.235
24	T100	1.732	1.54	52.3	191.8	29	17.4	93	0.273
24	T50	1.732	1.54	52.3	191.8	29	17.4	93	0.273
24	T20	1.732	1.54	52.3	191.8	29	17.4	93	0.273
27	T100	1.732	1.54	58.8	~~215.8~~ 206	32	19.6	104	~~0.273~~ 0.285
27	T50	1.732	1.54	58.8	~~215.8~~ 206	32	19.6	104	~~0.273~~ 0.285
27	T20	1.732	1.54	58.8	~~215.8~~ 206	32	19.6	104	~~0.273~~ 0.285
36	T100	1.732	1.54	78.4	246.9	37	26.1	119	0.318
36	T50	1.732	1.54	78.4	246.9	37	26.1	119	0.318
36	T20	1.732	1.54	78.4	246.9	37	26.1	119	0.318
38	T100	1.732	1.54	82.8	256.6	38	27.6	124	0.323
38	T50	1.732	1.54	82.8	256.6	38	27.6	124	0.323
38	T20	1.732	1.54	82.8	256.6	38	27.6	124	0.323

SPECIFIED VALUES in the TABLE	CALCULATED VALUES in the TABLE	
U_r = Rated Voltage	U_c =	TRV peak value
k_{pp} = First-pole-to-clear factor = ~~1.5~~ 1.732	U_c =	$k_{pp} \times k_{af} \times \text{sqrt}(2/3) \times U_r$
K_{af} = Amplitude factor	U_c =	$k_{pp} \times k_{af} \times 0.8165 \times U_r$
k_{af} (T100) = Specified = 1.54	t_3 =	Time to *Uc*
~~kaf(T50)= kaf(T100) x 1.09 = 1.68~~ k_{af} (T50) = Specified = 1.54	t_3 =	*Uc* / RRRV
~~kaf(T20)= kaf(T100) x 1.15 = 1.77~~ k_{af} (T20) = Specified = 1.54	t_d =	Time delay for the delay line
RRRV = Rate of rise of recovery voltage	t_d =	$0.15 \times t_3$
RRRV(T100) = Specified = 1/4 × RRRV overhead lines	u' =	Voltage point for the delay line
~~RRRV(T50)= RRRV(T100) x 1.88~~ RRRV(T50) = RRRV(T100)	u' =	U_c / 3
~~RRRV(T20)= RRRV(T100) x 2.87~~ RRRV(T20) = RRRV(T100)	t' =	Time to u'
NOTE—The TRV values are calculated for ungrounded systems and cover grounded systems as well.	t' =	$t_d + u'$ / RRRV

Annex A

(informative)

X/*R* ratios

A.2 Asymmetrical Fault Current

Replace Equation (A.1) and the variable list with the following:

$$i = \sqrt{2}I\left[\sin(\omega t + \theta - \phi) - \sin(\theta - \phi)e^{-t/\tau_{cc}}\right] \quad \text{(A.1)}$$

where

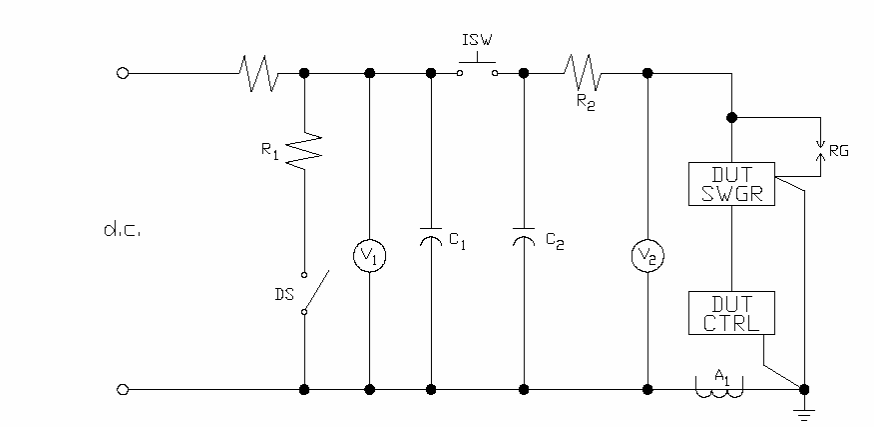
i is the instantaneous current
I is the rms value of the current
ω is the angular frequency ($2\pi f$)
ϕ is the circuit phase angle = $\tan^{-1}(X/R)$
θ is the angle between voltage zero and time that fault is initiated.
t is the time
τ_{cc} is the circuit time constant (L/R or $X/R\omega$) (see A.1)

Annex B

(informative)

Simulated surge arrester operation test

Replace Figure B.1 with the following:



A_1 – SURGE CURRENT
C_1 – CHARGE STORAGE CAPACITOR
C_2 – WAVE SHAPING CAPACITOR
DS – DISCHARGE SWITCH
DUT CTRL – DEVICE UNDER TEST (CONTROL)
DUT SWGR – DEVICE UNDER TEST (RECLOSER SWITCHGEAR)
ISW – INITIATION SWITCH
R_1 – DISCHARGE RESISTOR
R_2 – WAVE SHAPE – CURRENT LIMITING RESISTOR
RG – ROD GAP
V_1 – CHARGE VOLTAGE – (REF)
V_2 – TEST VOLTAGE – (CALIBRATION)

Figure B.1—Surge test circuit