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Visokonapetostne stikalne in krmilne naprave – 100. del: Izmenični odklopniki – Revizija TRV in posebni preskusi za odklopnike za napetosti nad 1 kV in do 100 kV

High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers – Revision of TRV and special tests for circuit-breakers with rated voltage above 1 kV and less than 100 kV

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COMMITTEE DRAFT FOR VOTE (CDV)
PROJET DE COMITÉ POUR VOTE (CDV)

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Titre du CE/SC: APPAREILLAGE A HAUTE TENSION	TC/SC Title: HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR	
Secretary: Mr. A. Bosma (Sweden) Secrétaire: E-mail: anne.bosma@se.abb.com		
Also of interest to the following committees Intéresse également les comités suivants SC 17C, SC 32A	Supersedes documents Remplace les documents 17A/686/CD – 17A/701/CC and item 6.1 of 17A/715/RM	
Functions concerned Fonctions concernées ☐ Safety / Sécurité ☐ EMC / CEM ☐ Environment / Environnement ☐ Quality assurance / Assurance qualité		

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Titre : Amendement 2 à la CEI 62271-100, Ed.1: Révision des Tensions Transitoires de Rétablissement et essais spéciaux pour disjoncteurs de tension assignée supérieure à 1 kV et inférieure à 100 kV

Title : Amendment 2 to IEC 62271-100, Ed.1: Revision of TRV and special tests for circuit-breakers with rated voltage above 1 kV and less than 100 kV

Note d'introduction
*** Anciennement CEI 62271-100, A2, f1, Ed.1**
**** La date de clôture du vote reste inchangée.**

Introductory note
*** Former IEC 62271-100, A2, f1, Ed.1**
**** The closing date remains unchanged.**

IEC CO note: The NC comments and observations in document 17A/701/CC were discussed, as mentioned above, at the SC 17A plenary meeting held in Seoul. Further information on these discussions and subsequent modifications to the observations can be found in document 17A/715/RM, item 6.1.

This document cancels and replaces document 17A/719/CDV. This document is also of interest to SC 17C and SC 32A.

ATTENTION	ATTENTION
CDV soumis en parallèle au vote (CEI) et à l'enquête (CENELEC)	**Parallel IEC CDV/CENELEC Enquiry**

Revision of TRV and special tests for circuit-breakers with rated voltage above 1 kV and less than 100 kV

Introductory note (not part of the amendment)

Following the decision taken at the SC 17A meeting in Beijing (CN) in October, 2002, IEC SC 17A/WG 35 has prepared a proposal for the revision of TRVs for circuit-breakers rated above 1 kV and less than 100 kV. In this CDV the decisions taken during the SC17A meetings in Montreal (CA) in October, 2003, and Seoul (KR) in October, 2004, are implemented.

This proposal uses the input coming from former Working groups of CIGRE Study Committee A3 (Switching Equipment) that have studied the necessity to adapt the TRV requirements for circuit-breakers rated less than 100 kV. In 1983, a CIGRE SC A3 Task Force reported on Transient Recovery Voltages in Medium Voltage Networks. The results of the study have been published in Electra 88. Another working group, WG 13.05, studied the TRVs generated by clearing transformer fed faults and transformer secondary faults. The results have been presented in Electra 102 (1985). In 1992, together with CIRED, CIGRE SCA3 created the Working group CC-03 to investigate again the definition of TRVs for medium voltage switching devices. The outcome of these investigations has been published in CIGRE Technical Brochure 134 (1998) and is in line with earlier studies.

The main modifications introduced in this amendment are summarized below.

a) In order to cover all types of networks (distribution, industrial and sub-transmission) in the range of rated voltages higher than 1 kV and less than 100 kV, and for standardization purposes, two types of systems are defined:

- **Cable systems**

Cable-systems have a TRV during breaking of terminal fault at 100% of short-circuit breaking current that does not exceed the two-parameter envelope derived from Table 24 of this standard.

Note 1: This definition is restricted to systems of rated voltages higher than 1 kV and less than 100 kV.

Note 2: Circuit-breakers of indoor substations with cable connection are in cable-systems.

Note 3: A circuit-breaker in an outdoor substation with cable-connection to overhead-lines is considered to be in a cable-system if the total length of cable connected on the supply side of the circuit-breaker is at least 100 m.

Note 4: The capacitance of cable-systems on the supply side of circuit-breakers is provided by cables and/or capacitors and/or insulated bus.

- **Line systems**

Line systems have a TRV during breaking of terminal fault at 100% of short-circuit breaking current defined by the two-parameter envelope derived from Table 25 of this standard.

Note 1: This definition is restricted to systems of rated voltages higher than 1 kV and less than 100 kV.

Note 2: In line-systems, no cable is connected on the supply side of the circuit-breaker, with the possible exception of a short length of cable between the circuit-breaker and the line(s) or the supply transformer.

Note 3: Systems with transmission lines directly connected to a busbar (without intervening cable connections) are typical examples of line-systems.

b) A particular test duty T30 is specified for the special case of circuit-breakers intended to be connected to a transformer with a connection of small capacitance (cable length less than 20 m), in order to verify their capability to interrupt transformer-limited faults. This is covered in a new normative Annex M.

   In the general case where the capacitance of the connection is high enough, the normal test duty T30 demonstrates the capability to interrupt transformer-limited faults.

c) Short-line fault is a mandatory duty for circuit-breakers with rated voltages 15 kV and above and directly connected to overhead lines. As specified for circuit-breakers rated 52 kV and above, the rated short-circuit current must be higher than 12,5 kA (i.e. I_{sc} ≥ 16 kA).

d) The special case of circuit-breakers installed immediately in series with a reactor is covered in a new subclause 8.103.7.

The main content of this introductory note and additional technical explanations on the introduced changes in TRVs for circuit-breakers rated less than 100 kV are given in a new informative Annex L. This Annex should be transferred later to the application guide to IEC 62271-100.

It is to be noted that a corresponding revision of TRVs is undertaken by ANSI/IEEE, and that both revisions would lead to fully harmonized TRVs for circuit-breakers rated higher than 1 kV and less than 100 kV.

In addition, WG35 proposes to modify Figure 13 (Three-phase short-circuit representation) and figure 14 (alternative representation of Figure 13), to indicate that the source neutral impedance is not necessarily an inductance, but could be also a capacitance or a combination of impedances.

FOREWORD

This amendment has been prepared by subcommittee 17A: High-voltage switchgear and controlgear, of IEC Technical Committee 17: Switchgear and controlgear.

The text of this amendment is based on the following documents:

FDIS	Report on voting
17A/XX/FDIS	17A/XX/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above Table.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until (*to be completed later*). At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

Page 7

Contents

Add new annexes L and M to the list of contents

Annex L (informative) Explanatory notes on the revision of TRVs for circuit-breakers of rated voltages higher than 1 kV and less than 100 kV.

Annex M (normative) Requirements for breaking of transformer-limited faults by circuit-breakers rated higher than 1 kV and less than 100 kV.

Page 33

Add the following definitions after 3.4.118:

3.4.119
cable system
cable-systems have a TRV during breaking of terminal fault at 100% of short-circuit breaking current that does not exceed the two-parameter envelope derived from Table 24 of this standard.

NOTE 1 This definition is restricted to systems of rated voltages higher than 1 kV and less than 100 kV.

NOTE 2 Circuit-breakers of indoor substations with cable connection are in cable-systems.

NOTE 3 A circuit-breaker in an outdoor substation with cable-connection to overhead-lines is considered to be in a cable-system if the total length of cable connected on the supply side of the circuit-breaker is at least 100 m.

NOTE The capacitance of cable-systems on the supply side of circuit-breakers is provided by cables and/or capacitors and/or insulated bus.

3.4.120
line system
line systems have a TRV during breaking of terminal fault at 100% of short-circuit breaking current defined by the two-parameter envelope derived from Table 25 of this standard.

NOTE 1 This definition is restricted to systems of rated voltages higher than 1 kV and less than 100 kV.

NOTE 2 In line-systems, no cable is connected on the supply side of the circuit-breaker, with the possible exception of a short length of cable between the circuit-breaker and the line(s) or the supply transformer.

NOTE 3 Systems with transmission lines directly connected to a busbar (without intervening cable connections) are typical examples of line-systems.

3.4.121
circuit-breaker class CS
circuit-breaker intended to be used in a cable system.

3.4.122
circuit-breaker class LS
circuit-breaker intended to be used in a line-system .

Page 57

3.8 Index of definitions

Add the following definitions after circuit breaker class M2

Cable system	3.4.119
Line system	3.4.120
Circuit-breaker class CS	3.4.121
Circuit-breaker class LS	3.4.122

Page 65

4. Rating

Replace the existing item p) by the following:

p) characteristics for short-line faults related to the rated short-circuit breaking current, for circuit-breakers designed for direct connection to overhead transmission lines and rated at 15 kV and above and at more than 12,5 kA rated short-circuit breaking current;

Page 75

4.102.2 Representation of TRV

Replace the existing items b) and c) by the following:

b) Two-parameter reference line (see figure 11):

u_c = reference voltage (TRV peak value), in kilovolts;

t_3 = time in microseconds.

TRV parameters are defined as a function of the rated voltage (U_r), the first-pole-to-clear factor (k_{pp}) and the amplitude factor (k_{af}) as follows:

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

where k_{af} is equal to

1,4 for terminal fault in the case of cable systems;

1,54 for terminal fault and short-line fault, in the case of line systems;

1,25 for out-of-phase.

t_3 for the supply side circuit for short-line fault = t_3 (terminal fault)..

t_3 for out-of-phase = 2 × t_3 (terminal fault).

c) Delay line of TRV (see figures 10 and 11):

t_d = time delay, microseconds;

u' = reference voltage, in kilovolts;

t' = time to reach u', in microseconds

The delay line starts on the time axis at the rated time delay and runs parallel to the first section of the reference line of rated TRV and terminates at the voltage u' (time co-ordinate t').

For rated voltages lower than 100 kV:

t_d = 0,15 × t_3, for terminal fault and out-of-phase in the case of cable systems;

t_d = 0,05 × t_3, for terminal fault and short-line-fault in the case of line systems;

t_d = 0,15 × t_3, for out-of-phase in the case of line systems;

u' = u_c/3 ;

t' is derived from t_d and t_3 according to figure 11, t' = t_d + t_3/3.

For rated voltages equal or higher than 100 kV:

t_d = 0,21 × t_1 or 2 µs for terminal fault and short-line fault;

t_d = 0,1 × t_1 for out-of-phase;

u' = u_1/2 ;

t' is derived from u', u_1/t_1 (RRRV) and t_d according to figure 10, t' = t_d + u'/RRRV.

Page 77

4.102.3 Standard values of TRV related to the rated short-circuit breaking current

Replace the first paragraph by the following:

Standard values of TRV for three-pole circuit-breakers of rated voltages less than 100 kV make use of two parameters. Values are given in:

- Table 24, for cable systems;
- Table 25, for line systems;

Replace the existing 4th paragraph by the following:

The values given in the tables are prospective values. They apply to circuit-breakers for general transmission and distribution in three-phase systems having service frequencies of 50 Hz or 60 Hz and consisting of transformers, overhead lines and cables.

Replace the existing item b) by the following:

b) circuit-breakers directly connected to transformers without appreciable additional capacitance between the circuit-breaker and the transformer which provides approximately 50 % or more of the rated short-circuit breaking-current of the circuit-breaker. However the special case of circuit-breakers of rated voltage less than 100 kV with a connection of low capacitance to a transformer is covered in Annex M.

Replace the existing item c) by the following:

c) circuit-breakers in substations with series reactors (information is given in 8.103.7 and L.5 for circuit-breakers rated less than 100 kV);

Replace the 6th paragraph by the following:

The transient recovery voltage corresponding to the rated short-circuit breaking current when a terminal fault occurs, is used for testing at short-circuit breaking currents equal to the rated value. However, for testing with short-circuit breaking currents less than 100 % of the rated value, other values of transient recovery voltage are specified (see 6.104.5). Further additional requirements apply to circuit-breakers designed for direct connection to overhead transmission lines, rated at 15 kV and above and having rated short-circuit breaking currents exceeding 12,5 kA, which may be operated in short-line fault conditions (see 4.105).

Page 79

Table 1a

Replace Table 1a by the following Tables 24 and 25:

Table 24 – Standard values of transient recovery voltage for circuit-breakers in cable-systems - Rated voltage less than 100 kV – Representation by two parameters

Rated voltage	Type of test	First-pole-to-clear factor	Ampli-tude factor	TRV peak value	Time	Time delay	Voltage	Time	RRRV [a]
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
3,6	Terminal fault	1,5	1,4	6,2	41	6	2,1	20	0,15
	Out-of-phase	2,5	1,25	9,2	82	12	3,1	40	0,11
4,76 [b]	Terminal fault	1,5	1,4	8,2	44	7	2,7	21	0,19
	Out-of-phase	2,5	1,25	12,1	88	13	4,0	43	0,14
7,2	Terminal fault	1,5	1,4	12,3	51	8	4,1	25	0,24
	Out-of-phase	2,5	1,25	18,4	102	15	6,1	49	0,18
8,25 [b]	Terminal fault	1,5	1,4	14,1	52	8	4,7	25	0,27
	Out-of-phase	2,5	1,25	21,1	105	16	7,0	50	0,20

12	Terminal fault	1,5	1,4	20,6	61	9	6,9	29	0,34
	Out-of-phase	2,5	1,25	30,6	112	17	10,2	54	0,27
15 [b]	Terminal fault	1,5	1,4	25,7	66	10	8,6	32	0,39
	Out-of-phase	2,5	1,25	38,3	132	20	12,8	64	0,29
17,5	Terminal fault	1,5	1,4	30	71	11	10,0	34	0,42
	Out-of-phase	2,5	1,25	44,7	143	21	14,9	69	0,31
24	Terminal fault	1,5	1,4	41,2	87	13	13,7	42	0,47
	Out-of-phase	2,5	1,25	61,2	174	26	20,4	84	0,35
25,8 [b]	Terminal fault	1,5	1,4	44,2	91	14	14,7	44	0,49
	Out-of-phase	2,5	1,25	65,8	182	27	21,9	88	0,36
36	Terminal fault	1,5	1,4	61,7	109	16	20,6	53	0,57
	Out-of-phase	2,5	1,25	91,9	217	32	30,6	105	0,42
38 [b]	Terminal fault	1,5	1,4	65,2	109	16	21,7	53	0,60
	Out-of-phase	2,5	1,25	97,0	217	33	32,3	105	0,45
48,3 [b]	Terminal fault	1,5	1,4	82,8	125	19	27,6	60	0,66
	Out-of-phase	2,5	1,25	123	250	38	41,1	121	0,49
52	Terminal fault	1,5	1,4	89,2	131	20	29,7	63	0,68
	Out-of-phase	2,5	1,25	133	262	39	44,2	127	0,51
72,5	Terminal fault	1,5	1,4	124	165	25	41,4	80	0,75
	Out-of-phase	2,5	1,25	185	330	50	61,7	159	0,56

[a] RRRV = rate of rise of recovery voltage

[b] Used in North America

Table 25 – Standard values of transient recovery voltage [c] for circuit-breakers in line systems - Rated voltage less than 100 kV – Representation by two parameters

Rated voltage	Type of test	First-pole-to-clear factor	Ampli-tude factor	TRV peak value	Time	Time delay	Voltage	Time	RRRV [a]
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
15 [b]	Terminal fault	1,5	1,54	28,3	31	2	9,4	12	0,91
	Short-line fault	1	1,54	18,9	31	2	6,3	12	0,61
	Out-of-phase	2,5	1,25	38,3	62	9	12,8	30	0,62
17,5	Terminal fault	1,5	1,54	33,0	34	2	11,0	13	0,97
	Short-line fault	1	1,54	22,0	34	2	7,3	13	0,65
	Out-of-phase	2,5	1,25	45	69	10	14,9	33	0,65
24	Terminal fault	1,5	1,54	45,3	43	2	15,1	16	1,05
	Short-line fault	1	1,54	30,2	43	2	10,1	16	0,70
	Out-of-phase	2,5	1,25	61	86	13	20,4	42	0,71
25,8 [b]	Terminal fault	1,5	1,54	48,7	45	2	16,2	17	1,08
	Short-line fault	1	1,54	32,4	45	2	10,8	17	0,72
	Out-of-phase	2,5	1,25	66	90	13	21,9	43	0,73
36	Terminal fault	1,5	1,54	67,9	57	3	22,6	22	1,19
	Short-line fault	1	1,54	45,3	57	3	15,1	22	0,79
	Out-of-phase	2,5	1,25	92	114	17	30,6	55	0,81
38 [b]	Terminal fault	1,5	1,54	71,7	59	3	23,9	23	1,21
	Short-line fault	1	1,54	47,8	59	3	15,9	23	0,81
	Out-of-phase	2,5	1,25	97	118	18	32,3	57	0,82
48,3 [b]	Terminal fault	1,5	1,54	91,1	70	4	30,4	27	1,30
	Short-line fault	1	1,54	60,7	70	4	20,2	27	0,87
	Out-of-phase	2,5	1,25	123	140	21	41,1	68	0,88
52	Terminal fault	1,5	1,54	98,1	74	4	32,7	36	1,33
	Short-line fault	1	1,54	65,4	74	4	21,8	28	0,88
	Out-of-phase	2,5	1,25	133	148	22	44,2	71	0,90
72,5	Terminal fault	1,5	1,54	137	93	5	45,6	36	1,47
	Short-line fault	1	1,54	91,2	93	5	30,4	36	0,98
	Out-of-phase	2,5	1,25	185	186	28	61,7	90	0,99

[a] RRRV = rate of rise of recovery voltage

[b] Used in North America

[c] For short-line faults: transient recovery voltage and time quantities are those of the supply circuit.