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INTERNATIONAL STANDARD

NORME INTERNATIONALE

AMENDMENT 2
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Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1: Electrical testing

Valves à thyristors pour le transport d'énergie en courant continu à haute tension (CCHT) – Partie 1: Essais électriques

IEC 60700:1998/A2:2008

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Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1: Electrical testing

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FOREWORD

This amendment has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

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

CDV	Report on voting
22F/154/CDV	22F/164/RVC

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 this amendment and the base publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be reconfirmed.

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- withdrawn,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

Page 3

CONTENTS

On page 7, replace the title of Clause 13 by the following:

13 Testing of special features and fault tolerance

Delete Annex C.

Page 11

2 Normative references

Replace the fourth reference by the following:

IEC 60071-1, *Insulation co-ordination – Part 1: Definitions, principles and rules*

Replace the sixth reference by the following:

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

Page 15

3.2 Valve construction terms

Add the following term and definition after 3.2.6 (introduced by Amendment 1):

3.2.7
multiple valve unit
MVU
single physical structure comprising more than one valve with a common mechanical support structure

Page 19

4.2 Atmospheric correction

Replace the first dash by the following:

– pressure:

a) If the insulation coordination of the tested part of the thyristor valve is based on standard rated withstand voltages according to IEC 60071-1, correction factors are only applied for altitudes exceeding 1 000 m. Hence, if the altitude of the site a_s at which the equipment will be installed is ≤1 000 m, then the standard atmospheric air pressure (b_0=101,3 kPa) shall be used with no correction for altitude. If a_s >1 000 m, then the standard procedure according to IEC 60060-1 is used except that the reference atmospheric pressure b_0 is replaced by the atmospheric pressure corresponding to an altitude of 1 000 m ($b_{1\ 000\ m}$).

b) If the insulation coordination of the tested part of the thyristor valve is not based on standard rated withstand voltages according to IEC 60071-1, then the standard procedure according to IEC 60060-1 is used with the reference atmospheric pressure b_0 (b_0=101,3 kPa);

4.4 Criteria for successful type testing

In the first line, replace “ascertains that” *by* “shows that”.

Page 21

4.4.1 Criteria applicable to thyristor levels

*In item c), insert the word “*programme*” at the end of the sentence.*

*In item f), the second dashed item, insert the words “*where applicable*” at the end of the sentence.*

*In item f), the fourth dashed item, insert the words “*where applicable*” at the end of the sentence.*

Page 23

Tableau 2 – List of type tests

Replace, in the last line, "Testing of special features" *by* "Testing of special features and fault tolerance".

Page 27

6.3.2 Valve support a.c. voltage test

Delete the first paragraph.

6.3.3 Valve support switching impulse test

Replace the first paragraph by the following:

The test shall comprise three applications of positive polarity and three applications of negative polarity switching impulse voltages between the main terminals, which are in common, and earth.

Page 29

6.3.4 Valve support lightning impulse test

Replace the first paragraph by the following:

The test shall comprise three applications of positive polarity and three applications of negative polarity lightning impulse voltages between the main terminals, which are in common, and earth.

Page 31

7.3.2 MVU a.c. voltage test

In the second paragraph, delete the first sentence.

In the third paragraph, second line, replace the sentence by the following:

…raised to the specified 1 min test voltage in approximately 10 s, kept constant…

In the fourth paragraph, replace the first sentence by the following:

During the last 1 min of the specified 30 min test, the level of partial discharge shall be monitored and recorded.

Page 39

8.3.2 Valve a.c. voltage test

Delete the first paragraph.

In the second paragraph, replace the last two sentences by the following:

During the last 1 min of the specified 30 min test, the level of partial discharge shall be monitored and recorded. The value of partial discharge shall not exceed 200 pC (see Annex B).

In the line before the note, replace the sentence by the following:

k_8 = 1,10.

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8.3.6 Valve steep front impulse test

In the third paragraph after the note, replace the formula by the following:

$$U_{tsfv} = \pm STIPL_V \times k_{12}$$

Replace the sentence in the second line after the equation by the following:

$STIPL_V$ is the steep front impulse protective level of the valve arrester as determined by the coordinating current from system studies;

Page 49

9.3 Test requirements

Add, on page 51, at the end of the last paragraph, the following sentence:

If less than three items of a type of component are installed in a valve, all components of this type in the valve shall be monitored.

Page 57

9.3.4 Temporary undervoltage test

*Replace, in the second line of the second paragraph, the words "...*steady-state α_{min} *..." by the words "...*steady-state minimum α*...".*

*Replace, in the third line of the second paragraph, the words "...*at transient α_{min} *..." by the words "...*at minimum transient value of α*...".*

Page 61

10.3 Test requirements

*Replace, in the third line of the second paragraph, the words "...*steady-state γ_{min}*" by the words "...*steady-state minimum γ*".*

Page 63

11.1 Purpose of tests

Add, to item b), the following sentence at the end of the paragraph:

This test covers the – normally rare – case where phase shifts or transients in the AC system prevent the conditions needed for the valve to block the fault at the end of the first cycle.

Page 65

11.3.1 One-loop fault current test with re-applied forward voltage

Replace, in the second paragraph, the existing equation by the following:

$$U_{tfvd} = U_{v0max} \times \sqrt{2} \times k_n \times k_r \times k_{17}$$

Replace, after the equation, the explanation of U_{v0m} by the following:

U_{v0max} is the maximum steady-state no-load phase-to-phase voltage on the valve side of the transformer;

Replace, in the third paragraph, the 4th dashed item by the following:

– the most critical of the following combinations:
  – the lowest delay angle at fault initiation corresponding to the maximum steady-state operating voltage referred to the valve side,
  – the lowest operating voltage referred to the valve side at fault initiation corresponding to the minimum transient delay angle;

Delete, in the third paragraph, the 6th dashed item.

Page 67

11.3.2 Multiple-loop fault current test without re-applied forward voltage

Replace, in the third paragraph, the existing equation by the following:

$$U_{tfvr} = U_{v0max} \times \sqrt{2} \sin \psi \times k_n \times k_r \times k_{18}$$

Replace, after the equation, the explanation of U_{v0m} by the following:

U_{v0max} is the maximum steady-state no-load phase-to-phase voltage on the valve side of the transformer;

Page 69

12.1 Purpose of tests

Replace, in the second paragraph, the text "8.3.3 to 8.3.6" in the second line by the following:

"8.3.3 to 8.3.5".

Add the following new text at the end of the last sentence of the second paragraph:

...because the events reproduced by these tests can be expected during normal operation of the converter station and do not normally cause the converter station to be tripped.

Page 71

13 Testing of special features

Replace the title of Clause 13 by the following:

13 Testing of special features and fault tolerance

Replace the existing text of 13.1 by the following:

13.1.1 General

These tests are intended to verify the design and performance of any special features of the valve. Special features may include, but are not limited to, those in the following two categories.

13.1.2 Circuits to facilitate the proper control, protection and monitoring of the valve

Generally, these features can be demonstrated as part of the other tests.

13.1.3 Features included in the valve to provide fault tolerance

Fault tolerance capability may be defined as the ability of an HVDC thyristor valve to perform its intended function, until a scheduled shutdown, with faulted components or subsystems or

overloaded components, and not lead to any unacceptable failure of other components, or extension of the damage due to the faulted condition. Special features may be required in the design to ensure fault tolerance. Examples of faults for which fault tolerance may be required include, but are not limited to, those given below.

a) Short circuit of a thyristor

Even though a short-circuited thyristor will shunt the other components at the thyristor level, in some designs there may be a danger of overloading gate pulse transformers, overloading of current connections (where parallel thyristors are used), or changing the clamping load.

b) Continuous operation of protective firing at one thyristor level due to loss of normal firing pulses to that level

Continuous operation of protective firing can lead to overload of the damping resistor and other components at the affected level.

c) Insulation failure of a pulse transformer (if feeding two or more series-connected thyristors), damping capacitor, damping resistor or grading capacitor

Insulation failure of any component in parallel with the thyristors can attract load current into it, leading to a hazardous condition.

d) Leakage of small quantities of valve coolant

If the valve is liquid cooled, small leaks may not be easily detected. Escaped coolant can contaminate sensitive components, leading to malfunction, and can increase the probability of insulation failure.

The purchaser shall review the design offered with the supplier to determine the probability and likely consequences of certain failures. Where appropriate, consideration shall be given, in the type test programme, to the performance of special tests to verify critical aspects of the fault tolerance capability of the valve. Such tests shall be agreed between the purchaser and supplier on a case-by-case basis.

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Annex A – Test safety factors

Page 85

A.2.2 AC and d.c. temporary and long-term voltage tests

Add the following new paragraph:

In the case of the short-duration valve a.c. voltage test, the test can unrealistically over-stress valve components in the reverse direction because, for practical reasons, the test must be performed with a.c. (hence giving a large voltage-time area) but the service condition only results in a short duration at high voltage (commutation overshoot). For this reason, a lower test safety factor than normal practice is used. The test safety factor k_8 is based on voltage measuring error (3 %), tolerance on test voltage (3 %), measuring tolerance of surge arrester characteristics (3 %), ageing allowance for arrester (5 %) and an inherent contingency margin, or allowance for other unknown effects (7,5 %)

A.3 Test safety factors for operational tests

Replace the second equation by the following:

$$k_s = 1 - \sqrt{0{,}03^2 + 0{,}03^2} = 0{,}957, \text{ rounded down to } 0{,}95$$

Page 95

Annex C – Fault tolerance capability

Delete this annex.

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