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INTERNATIONAL STANDARD

NORME INTERNATIONALE

AMENDMENT 1
AMENDEMENT 1

High-voltage direct current (HVDC) installations – System tests

Installations en courant continu à haute tension (CCHT) – Essais systèmes

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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/375/CDV	22F/394A/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 stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

General:

Replace throughout the text the abbreviations "a.c" *and* "d.c" *by the abbreviations* "AC" *and* "DC" *respectively*.

Introduction

Delete listing using a) to l).

Replace, in c), the word "Definitions" *by the words* "Terms and definitions"

Replace, in d), the word "General" by the words "Objectives of system tests".

Delete, in h), the word "Power".

Replace, in the first line of the last paragraph, *the word* "objects" *by the word* "objectives".

1 Scope

Add, in the first sentence of the second paragraph, the word "monopolar" *after the word* "bidirectional"

Delete, in the third paragraph, the word "some".

2 Normative references

Replace, in the last sentence of the first paragraph, the word "updated" *by the word* "undated".

3. Terms and definitions

3.1.1
station test

Replace the existing term and definition by the following new term and definition:

3.1.1
converter station tests
converter station system test including items which verify the function of individual equipment of the converter station in energized state

Add, after 3.1.3, the following new terms and definitions:

3.1.4
on-site tests
tests which are performed at the final construction site consisting of converter station test and transmission test

3.2 Operation state terms

Replace the first sentence by the following note:

NOTE There are five defined states in the HVDC system: earthed, stopped, standby, blocked, de-blocked.

3.2.3
standby

Replace, in the definition, "DC" by "HVDC".

Add, after the last sentence of the note, the following new sentence:

The standby state is also referred to as "Ready for energization".

3.2.4
blocked

Replace the second sentence of the note by the following new sentence:

The valve cooling system is in operation, and the cooling water conductivity, flow rate and water temperature are within the specified limits.

Add, at the end of the note, the following new sentence:

The blocked state is also referred to as "Ready for operation".

3.2.6
off-site tests

Add, after the definition, the following new note:

EXAMPLE Routine and type tests performed at the suppliers' factory.

4 General

Replace the existing title by the following new title:

4 Objectives of system tests

4.1 Purpose

Replace the existing title by the following new title:

4.1 Categories of system tests

Replace, in the fourth paragraph, the word "test" *by the word* "testing".

Add, at the beginning of the second paragraph after Figure 1, the following new sentence:

Acceptance tests are the acceptance requirements for a successful completion of works and a basis for the final acceptance of the HVDC system by its users.

4.2 Structure of the HVDC system

Replace, in the second sentence of the first paragraph, the word "converters" *by the words* "converter units".

Add, before the last sentence of the first paragraph, the following new sentences:

Two terminals in connection constitute a HVDC system. If the configuration comprises a single pole, it is defined as a monopolar HVDC system. If the configuration comprises two poles of opposite polarities with respect to earth, it is called a bipolar HVDC system.

Replace Figure 2 *by the following new figure:*

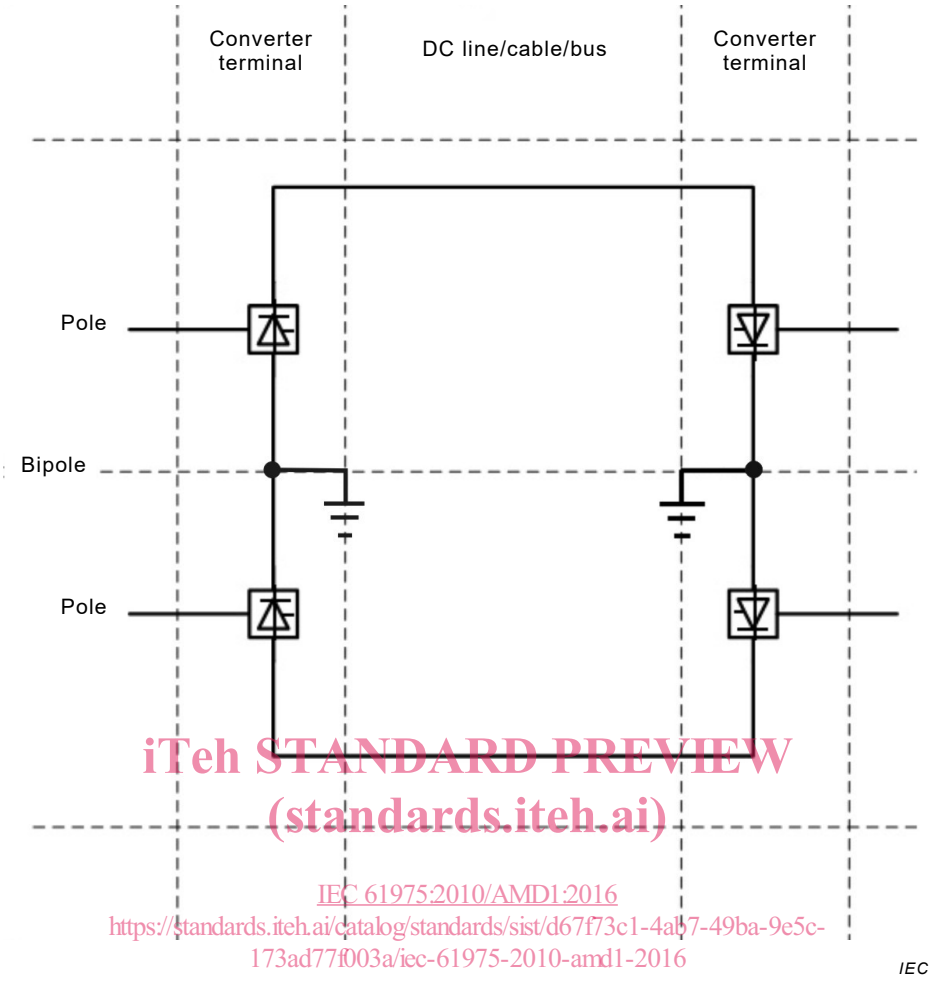

Figure 2 – Structure of the HVDC system

4.4 Logical steps of system test

Replace the existing text by the following new text:

To ensure proper functioning, the type test and functional performance test shall be conducted in factory in order to debug and test the control system before the site test.

In order to provide the power grid data and help to compile the system test plan, the off-line digital simulation shall be conducted before and during the simulation test, especially analysis on the power flow, stability and overvoltage.

Considering the complexity of the HVDC system, all limiting design cases may be conducted on the digital simulator in a similar way to those done on site.

Commissioning an HVDC system may affect more than the actual contract parties. The complexity and the diversified areas concerned during system testing require thorough planning and scheduling, cooperation of all involved parties and complete and structured documentation. Before a system test can begin on site, the following preconditions shall be fulfilled concerning subsystem tests, operator training and safety instructions, system test plan and test procedures, and all necessary test equipment.

a) All subsystems shall have been tested and commissioned, including AC filters and the converter transformers.

b) Operating personnel shall be sufficiently trained.

c) Operating instructions for the station shall be available.

d) Personnel, plant safety and security instructions shall be available.

e) System test plan and documentation (Part 8) shall be available and agreed upon.

f) AC/DC power profiles shall have been agreed for each test.

g) Any AC/DC system operating restrictions shall have been identified.

h) Operator voice communications shall be available

i) All necessary test equipment shall have been calibrated and in service.

j) Procedures for the preparation and evaluation of test results shall have been agreed upon.

Site system tests shall follow the structure of the HVDC system, starting from the smallest, least complex operational unit, usually a 12-pulse converter, and shall end with the total system in operation. The test sequence shall be scheduled starting at the local level with simple tests before involving additional locations and the transmission system and more complex tests.

After all preconditions are fulfilled, converter station tests shall be conducted and begin from the converter unit test, including the energization of AC filter and DC yard, changing the DC system configuration, electromagnetic interference, trip test, open line test, etc.

The power transmission (also called end-to-end) test shall start on a monopolar basis, continuing with bipolar operation, with full power transmission being the final step.

Having the complete system running properly, performance of the steady state can be verified. With normal operating ramp settings and automatic switching sequences in place, the effect of a number of disturbances on the DC side of the system as well as in the AC systems may be checked, and the transient and fault recovery performances may be verified.

Acceptance tests shall be defined between supplier and user in advance and may be performed at an appropriate time during the test schedule.

Correct operation of the HVDC system over an extended period of time is checked during the trial operation.

Complete and organized documentation of the system tests, which benefit both the supplier and the user, shall form part of the project documentation and contain all necessary data records, logs, etc, and if necessary a commentary and references.

After all the above HVDC system tests have been completed, all functions have been verified and the HVDC system can be handed over to the users.

4.5 Structure of system test

Replace the existing sentence by the following new sentence:

The overall structure of the system tests is shown in Figure 4.

4.6 Precondition for site test

Replace the existing title by the following new title:

4.6 Precondition for on-site test

4.6.1 Factory system test

Replace, in the first paragraph, *the words* "site tests" *by the words* "the off-site tests" *and the words* "commissioning" *by the words* "partial commissioning".

Add, at the end of the fifth paragraph, the following new sentence:

Off-line simulation software can be used to analyse short circuit capacity, overvoltage and power flow, while the real-time simulator may be used for the complete functional performance tests of the control system.

Replace, in the first sentence of the sixth paragraph, the words "complete control system" *by the words* "complete control and protection system"*.*

4.6.2 Additional simulation test before site system test

Delete, in the existing title, the words "before site system test".

Replace the existing first paragraph by the following new paragraph:

If the AC network conditions in commissioning stage are different from that in the HVDC design stage, the additional simulation test shall be conducted, if specified by the user.

Delete the second paragraph.

Add, after 4.6.2, the following new subclause:

4.7 Acceptance tests

The acceptance tests necessary to verify whether acceptance criteria have been met may have been performed wholly or in part during the commissioning period. To avoid unnecessary duplication of such tests, careful consideration shall be given in advance as to when acceptance tests are carried out. If acceptance tests are still outstanding or have to be repeated due to modifications, they shall be performed during the transmission test, or following trial operation, if appropriate.

5.1.2.1 General

Replace, in the second paragraph, the words "divided into low voltage energizing" by the words "divided into trip tests, low voltage energization".

5.1.2.2 Low voltage energizing / Phasing verification

Replace the existing title by the following new title:

5.1.2.2 Low voltage energization/Phasing verification

5.1.2.3 High voltage energizing

Replace, in the title, the word "energizing" by the word "energization"

5.1.3 General precondition

Add, in the first paragraph, the word "station" *after the word* "converter"*.*

Add, in the last paragraph, the word "station" after the word "converter" and replace the words "should" by the words "shall".

5.2.1 Purpose of test

Replace the existing text by the following new text:

The test verifies that at the first energization of the converter unit the insulation withstand voltage is achieved, and that the electrical phasing is correct.

5.2.2 Test precondition

Replace, in item a) of the list, the word "energizing" *by the word* "energization".

5.2.3.1 Low voltage energizing

Replace, in the title, the word "energizing" by the word "energization".

5.2.3.2 High voltage energizing

Replace, in the title, the word "energizing" by the word "energization".

5.2.3.3 Test acceptance criteria

Replace the existing subclause number by the following new subclause number:

5.2.4 Test acceptance criteria

Replace, in item c*) of the list, the word "*should*" by the word "*shall*".*

5.3 Energizing of reactive components

Replace, in the title, the word "energizing" by the word "energization".

5.3.1 Individual energizing of reactive components

Replace the existing title by the following new title:

5.3.1 General

5.3.3 Test precondition

Replace, at the end of item a) of the list, the word "energizing" *by the word* "energization".

5.4.1 General

Add, in the first sentence, the word "unit" *after the word* "converter".

5.4.2 Purpose of test

Replace the existing text by the following new text:

The test verifies that the different DC system configuration available can be safely changed as specified prior to transmitting power for the first time.

5.5.1 General

Replace the existing title by the following new title:

5.5.1 Purpose of test

Add, after the existing sentence, the following new sentence:

The test verifies that there are no issues with electromagnetic compatibility of the equipment cubicles.

5.6.4.2 DC protection trip test

Replace, in the existing sentence, the word "should" *by the word* "shall".

5.7.1 General

Replace the existing title by the following new title:

5.7.1 Purpose of test

5.7.1.1 Necessity of the test

Delete the title of 5.7.1.1.

Add, after the existing paragraph, the following new paragraph:

The test verifies condition and stable energization of the DC yard and DC transmission circuit. It can excellently demonstrate the condition of the HVDC lines and cables. The tests shall be performed sequentially. Open line test of the DC switch yard shall be the first.

Add, after the above new paragraph, the existing paragraph of 5.7.1.2 and the first sentence of 5.7.1.3.

5.7.1.2 Open line test of the DC switchyard

Delete the title of 5.7.1.2.

5.7.1.3 Open line test with the DC transmission circuit

Delete the title of 5.7.1.3 and the last sentence of the existing paragraph.

5.7.3.2 Open line test with the DC transmission circuit

Replace the existing items c), d), e) and f) of the list by the following new items:

c) Keep the DC transmission circuit energized for a maximum of 30 min.

d) During the test, AC and DC voltage and current shall be recorded. Inspect the equipment during the test for abnormal sounds, corona discharge or partial discharge arcing.

e) After the successful completion of the test, decrease the DC voltage to zero and block the converter.

f) Repeat the test for each line or cable and each pole, if applicable.

5.7.4.1 Open line test of the DC switchyard

Make the last sentence "The designed DC voltage can be achieved." *into a new item* c) *of the list.*

5.8.1 General

Replace, in the third sentence of the first paragraph, the word "converter" *by the words* "pole terminal".

*Replace, in the fifth sentence of the first paragraph, the word "*should*" by the word "*shall"

6.1.1.1 General features

Add, after the last paragraph, the following note:

NOTE The low power transmission tests are also referred to as "Basic operation tests".

6.1.1.2 General precondition

Replace the existing list a) to i) *by the following new list:*

a) Off-site tests shall have been completed.
b) Converter station tests for each station shall have been completed.
c) Where applicable, a back-to-back test or short circuit test shall have been completed.
d) Open line test with the HVDC transmission circuit shall have been completed if applicable.
e) Earth electrodes and earth electrode lines shall have been checked and cleared.
f) Inter-station telecommunication system and telephone system shall be in service.
g) The overall test procedures, safety rules, dispatch co-ordination and test responsibilities shall have been established.
h) Fire protection and detection systems shall have been checked and in service.
i) All control protection, metering, sequence of events and fault recording systems shall have been checked and in service.

Figure 5 – Sequence for low power transmission tests

Replace the existing Figure 5 by the following new figure:

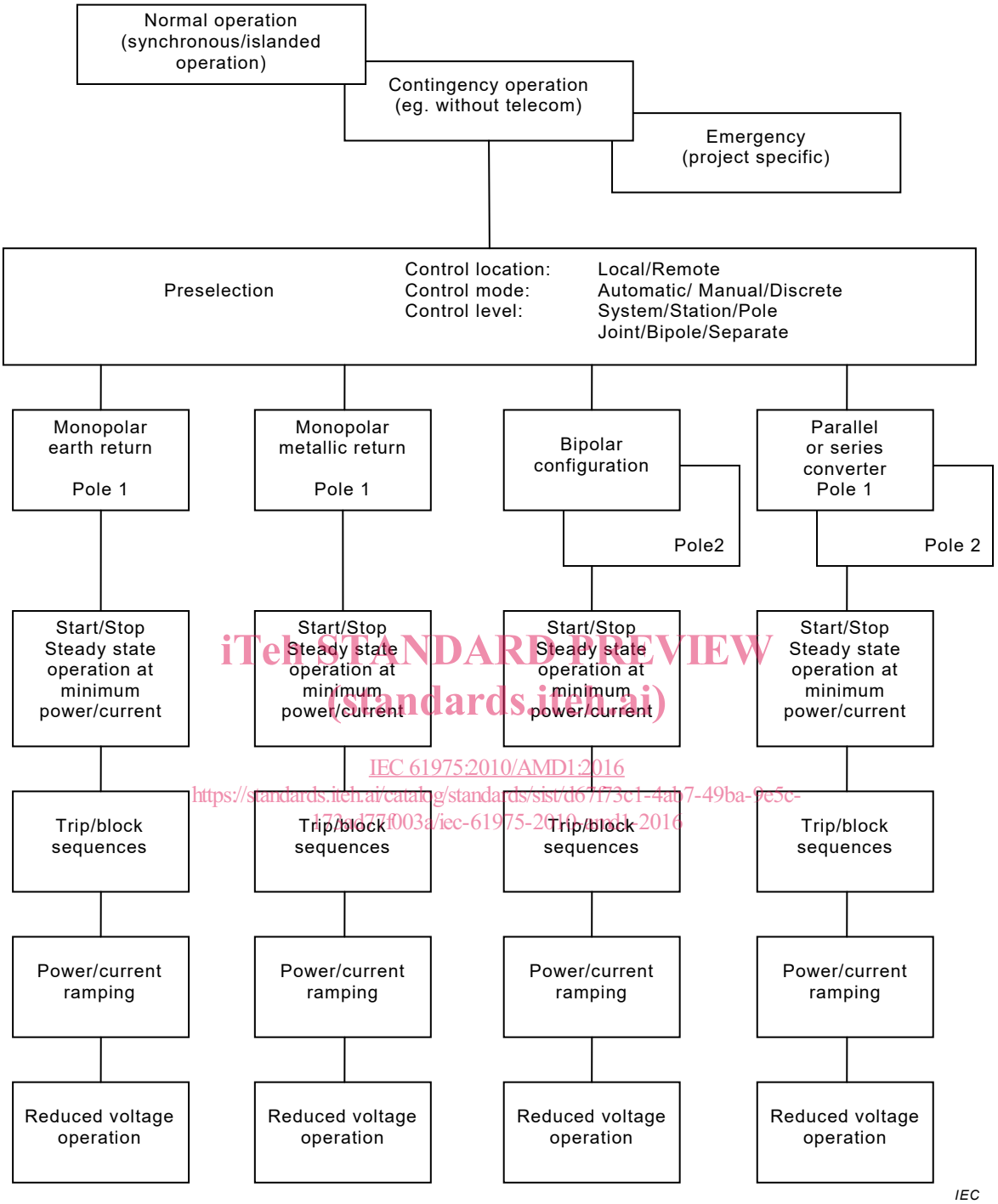

Figure 5 – Sequence for low power transmission tests

6.1.2.1 General

Replace the second existing paragraph by the following new paragraph:

The start and stop sequences of HVDC systems may vary with the design philosophies and the system requirements. The manufacturers' operating instructions shall always be consulted for the specific operating sequences.

6.1.2.3 Test precondition

Replace the existing, list a) to j) by the following new list: