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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

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

IEC 61975:2010-07+AMD1:2016-09+AMD2:2022-10 CSV(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HIGH-VOLTAGE DIRECT CURRENT (HVDC) INSTALLATIONS – SYSTEM TESTS

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IEC 61975 edition 1.2 contains the first edition (2010-07) [documents 22F/221/FDIS and 22F/227/RVD], its amendment 1 (2016-09) [documents 22F/375/CDV and 22F/394A/RVC] and its amendment 2 (2022-10) [documents 22F/670/CDV and 22F/691/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 61975 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronic systems and equipment.

This version constitutes a technical revision incorporating engineering experience.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under 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- withdrawn,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.

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INTRODUCTION

The standard is structured in eight clauses:

~~a)~~ Clause 1 – Scope

~~b)~~ Clause 2 – Normative references

~~c)~~ Clause 3 – Terms and definitions

~~d)~~ Clause 4 – ~~General~~ Objectives of system tests

~~e)~~ This clause addresses the purpose of this standard, the HVDC system structure, the control and protection structure, the logical steps of commissioning, the structure of the system test and that of the system commissioning standard.

~~f)~~ Clause 5 – Converter station test

~~g)~~ This clause addresses the commissioning of converter units and verifies the steady state performance of units as well as switching tests.

~~h)~~ Clause 6 – ~~Power~~ Transmission tests

~~i)~~ This clause concerns the commissioning of the transmission system, and verifies station coordination, steady-state and dynamic performance, interference, as well as interaction between the ~~d.c.~~ DC and ~~a.c.~~ AC systems.

~~j)~~ Clause 7 – Trial operation

~~k)~~ After completion of the system test, the period of trial operation is normally specified to verify the normal transmission.

~~l)~~ Clause 8 – System test plan and documentation

Clauses 5 to 7 comprise individual sections providing an introduction and covering ~~objects~~ objectives, preconditions and procedures and general acceptance criteria as well as detailed descriptions of the individual tests.

HIGH-VOLTAGE DIRECT CURRENT (HVDC) INSTALLATIONS – SYSTEM TESTS

1 Scope

This International Standard applies to system tests for high-voltage direct current (HVDC) installations which consist of a sending terminal and a receiving terminal, each connected to an ~~a.c.~~ AC system.

The tests specified in this standard are based on bidirectional monopolar and bipolar high-voltage direct current (HVDC) installations which consist of a sending terminal and a receiving terminal, each connected to an ~~a.c.~~ AC system. The test requirements and acceptance criteria should be agreed for back-to-back installations, while multi-terminal systems and voltage sourced converters are not included in this standard. For monopolar HVDC installations, the standard applies except for bipolar tests.

For the special functions or performances that are claimed by specific projects, ~~some~~ extra test items not included in this standard should be added according to the technical specification requirements.

This standard only serves as a guideline to system tests for high-voltage direct current (HVDC) installations. The standard gives potential users guidance, regarding how to plan commissioning activities. The tests described in the guide may not be applicable to all projects, but represent a range of possible tests which should be considered.

Therefore, it is preferable that the project organization establishes the individual test program based on this standard and in advance assigns responsibilities for various tasks/tests between involved organisations (e.g. user, supplier, manufacturer, operator, purchaser etc.) for each specific project.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For ~~updated~~ undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60633:~~1998~~2019, ~~*Terminology for*~~ *High-voltage direct current (HVDC)* ~~*power*~~ *transmission – Vocabulary*

IEC/TR 60919-2:2008, *Performance of high-voltage direct current (HVDC) systems with line commutated converters – Part 2: Faults and switching*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60633 as well as the following terms and definitions apply.

3.1 Test classifications terms

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

3.1.2
system test
test verifying functions and performances of HVDC system as a whole as well as the interaction with adjacent ~~a.c.~~ AC systems

3.1.3
transmission tests
test verifying functions and performances of HVDC system when transmitting power between both terminals

NOTE It is also referred to as an “end to end test”.

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

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

3.2.1
earthed
state in which the pole or converter is isolated and earthed on the ~~a.c.~~ AC and ~~d.c.~~ DC sides and no energizing of the pole or converter equipment is possible

NOTE The earthed state provides the necessary safety for carrying out maintenance work, and is the only one that permits the pole or converter maintenance. In this state maintenance work is possible on the converter transformers, the isolated and earthed part of the ~~a.c.~~ AC high voltage bus equipment, ~~d.c.~~ DC and valve hall installed equipment of this pole or converter.

3.2.2
stopped/isolated
state in which the pole or converter is isolated from the ~~a.c.~~ AC and ~~d.c.~~ DC side, but all the earthing switches are open

NOTE In this state the ~~d.c.~~ DC yard can be prepared for power transmission (earth electrode line, pole and ~~d.c.~~ DC line connect).

3.2.3
standby
state which is to be used when the ~~d.c.~~ HVDC system is not being utilized but is ready for power transmission

NOTE In this state the converter transformer is to be ready; tap-changer is automatically brought to the start position, which ensures that the transformer will be energized with minimum voltage to minimize the inrush current. The disconnector of the ~~a.c.~~ AC bay should be closed, but the circuit breakers in the feeding bay of the converter transformer should be open. In this state the ~~d.c.~~ DC configuration can still be changed (earth electrode line, pole and ~~d.c.~~ DC line connect). The standby state is also referred to as "Ready for energization".

3.2.4
blocked
state in which the pole is prepared to transmit power at a moment’s notice

NOTE The converter transformer is connected to the energized ~~a.c.~~ AC bus by means of closing of the respective circuit breaker. The valve cooling system is ~~ready for~~ in operation ~~if~~, and the cooling water conductivity, flow rate and water temperature are within the specified limits. A defined ~~d.c.~~ DC configuration shall have been established. Further changes are not possible in this state. The thyristor pre-check is carried out after the converter transformer has been energized. The pre-check is considered as passed when in every valve the redundancy is not lost. To change the blocked state, the states stopped, standby and de-blocked are selectable. The blocked state is also referred to as "Ready for operation".

3.2.5
de-blocked
state representing the following two operating modes: power transmission and open line test

NOTE Power transmission is the normal operating mode. In the de-blocked status the pole transmits power in normal operating mode if both terminals are in the deblocked stage and there is a voltage difference between the terminals. A minimum number of ~~a.c.~~ AC filters should be available.

3.2.6
off-site tests
tests which are performed before on-site testing

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

4 ~~General~~ Objectives of system tests

4.1 ~~Purpose~~ Categories of system tests

System test completes the commissioning of an HVDC system.

The supplier can verify the suitability of the station equipment installed and the functional completeness of the system. Moreover, adjustments and optimizations can be made.

It is shown for the user that the requirements and stipulations in the contract are met and that there is correlation with studies and previous off-site tests.

For the user, the completion of system testing marks the beginning of commercial operation of the HVDC system.

When adapting the HVDC system to the connected ~~a.c.~~ AC systems, there may be various constraints which require coordination within the economic schedules of the ~~a.c.~~ AC system operators. System tests prove to the public that tolerable values of phenomena concerning the public interest are not exceeded.

Five major aspects are subject to system tests:

a) HVDC station equipment and ~~d.c.~~ DC line/cable/bus including earth electrode, if any;
b) HVDC control and protection equipment and their settings;
c) environmental considerations;
d) ~~a.c./d.c.~~ AC/DC system interaction;
e) system performance when jointly operated with a connected ~~a.c.~~ AC system.

The interrelation between these aspects is shown in Figure 1.

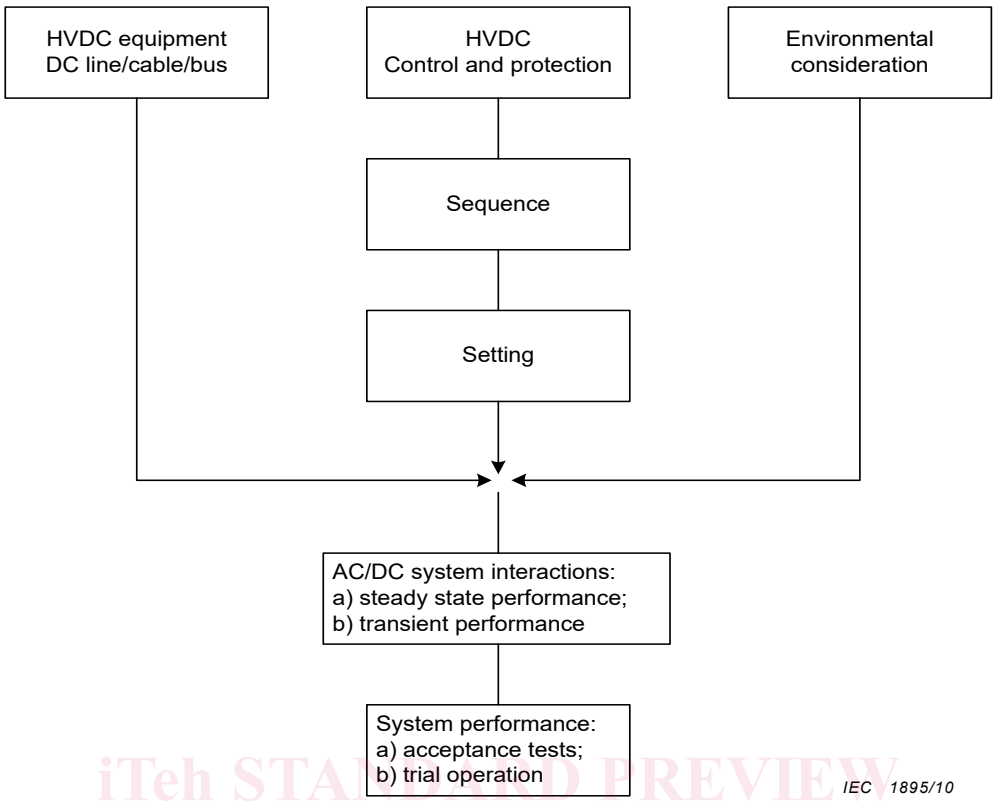

Figure 1 – Relation among five major aspects of system test

Thorough and complete system test of the above components can be achieved with the tests described in the standard.

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

System tests may affect more than the actual contract parties. Those parties shall be informed in time.

The complexity and the diversified areas concerned during system test require thorough planning and scheduling, cooperation of all involved parties, as well as complete and organized documentation.

NOTE The suggested "Test Procedures" are recommendations and alternative test procedures may be used subject to the agreement between supplier and user.

4.2 Structure of the HVDC system

From a functional point of view an HVDC system consists of a sending terminal and a receiving terminal, each connected to an ~~a.c.~~ AC system. The two terminals have one or several converter~~s~~ units connected in series on the ~~d.c.~~ DC side and in parallel on the ~~a.c.~~ AC side. The terminals are connected by a transmission line or cable or a short piece of busbar (back-to-back station). 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. Multi-terminal systems are not addressed in this standard.

The structure of the HVDC system is shown in Figure 2.