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IEC  
PAS 61975

Pre-Standard

First edition  
2004-08

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**System tests for high-voltage  
direct current (HVDC) installations**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SYSTEM TESTS FOR HIGH-VOLTAGE DIRECT CURRENT (HVDC) INSTALLATIONS**

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IEC-PAS 61975 was submitted by the CIGRÉ (International Council on Large Electric Systems) and has been processed 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 PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
22F/96/NP	22F/101/RVN

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## PART 0: EXECUTIVE SUMMARY

### Abstract

This document which gives guidance on all aspects of system tests for HVDC installations (excluding multiterminal HVDC systems), has been prepared by CIGRE WG 14.12. It is structured in eight parts.

The guide should give potential users guidance, regarding which course of action should be taken in planning commissioning activities.

Structure of the tests and a brief statement of the purpose of the individual group of tests is presented.

### Introduction

Commissioning an HVDC system is a very complex task which may affect more than the actual contract parties. The complexity and the diversified areas of concern during system testing require thorough planning and scheduling, cooperation of all parties involved, and complete and structured documentation.

System testing completes commissioning of an HVDC system.

It allows the supplier to verify the suitability of the station equipment installed and the functional completeness of the system; adjustments and optimization can be made.

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



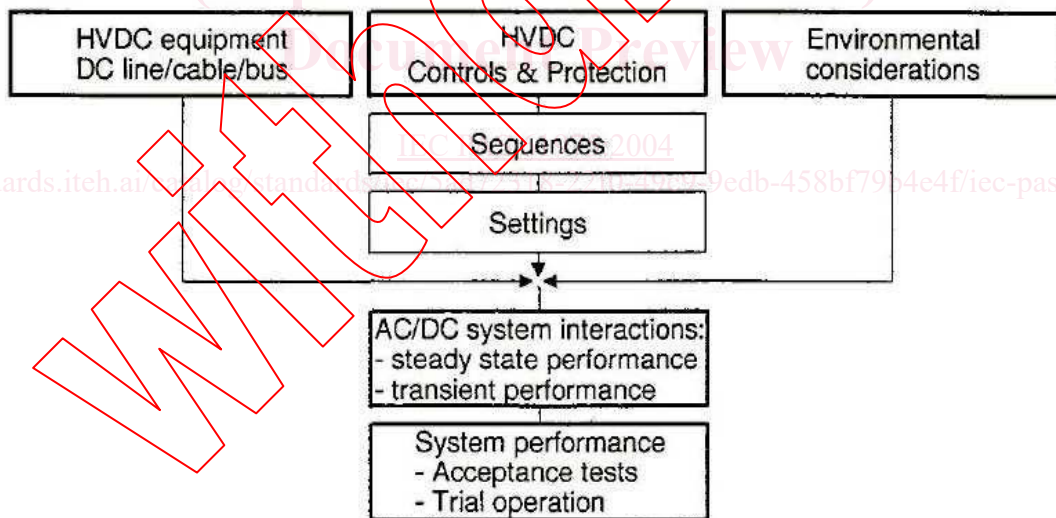
In adapting the HVDC system to the "real world" (the connected AC systems) various constraints may exist, which require coordination within the economic schedules of the AC system operators.

System testing proves to the public that tolerable values of phenomena concerning public interest are not exceeded.

Five (5) major aspects are subject to system testing:

- HVDC station equipment and DC line/cable/bus incl. earth electrode, if any
- HVDC controls and protection
- Environmental considerations
- AC/DC system interaction
- System performance

The following diagram shows the interrelation between these aspects:



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

The testing sequence is best scheduled starting at local level with simple tests before involving additional locations and the transmission system and more complex tests,

A system test plan has proven itself as a good means for planning and scheduling.

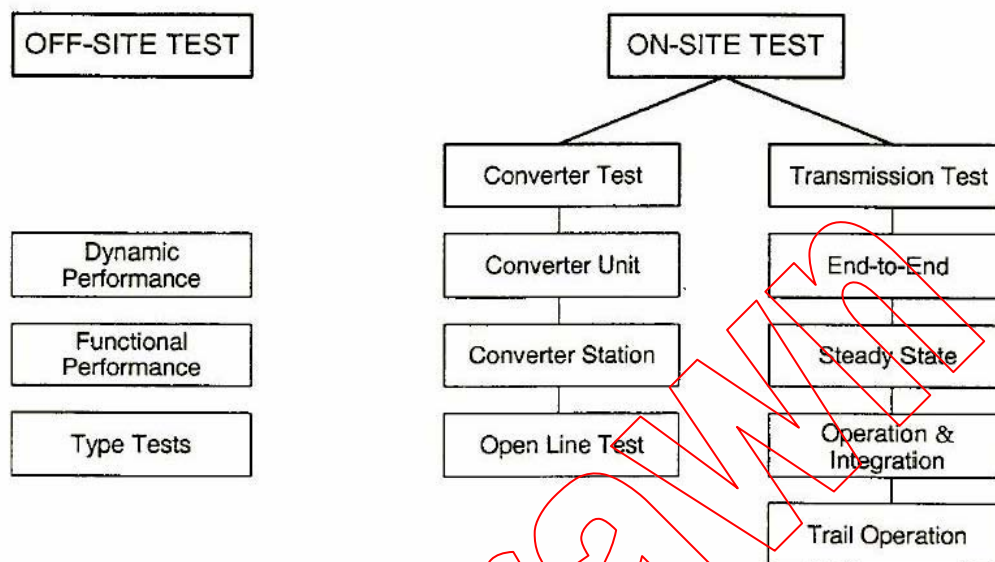
Complete and organized documentation of the system tests is to the benefit of both the supplier and the user, it shall form part of the project documentation and contain all necessary oscillograms, logs, etc, and if necessary a commentary and references.

### **Structure of System Testing**

System testing should follow the structure of the HVDC system, starting from the smallest, least complex operational unit and shall end with the total system in operation.

The first step, to ensure proper function, is to debug and to test the control system during off-site tests. Because of the complex nature of the HVDC system, this requires a simulator. Where applicable it is recommended to run commissioning tests and acceptance tests during the off-site tests in a similar way to those performed later at site. In such a way off-site tests can serve as reference for the site tests.

## System Tests for HVDC Installations



Before system commissioning can begin at site, preconditions concerning subsystem tests, operator training and safety Instructions, system test plan and test procedures, and all necessary test equipment must be fulfilled.

After all preconditions are fulfilled, each converter unit is commissioned separately during the converter unit test. Open-circuit tests and/or short-circuit tests are possible for this purpose. Converter station tests also include energization of the AC filter, DC yard energization and back-to-back tests.

Back-to-back tests allow full active power with the nominal DC voltage, firing angles, harmonics, etc. whilst still disconnected from the second AC system. Certain control, relaying and instrumentation changes as well as temporary DC switchyard changes may be required for back-to-back tests.

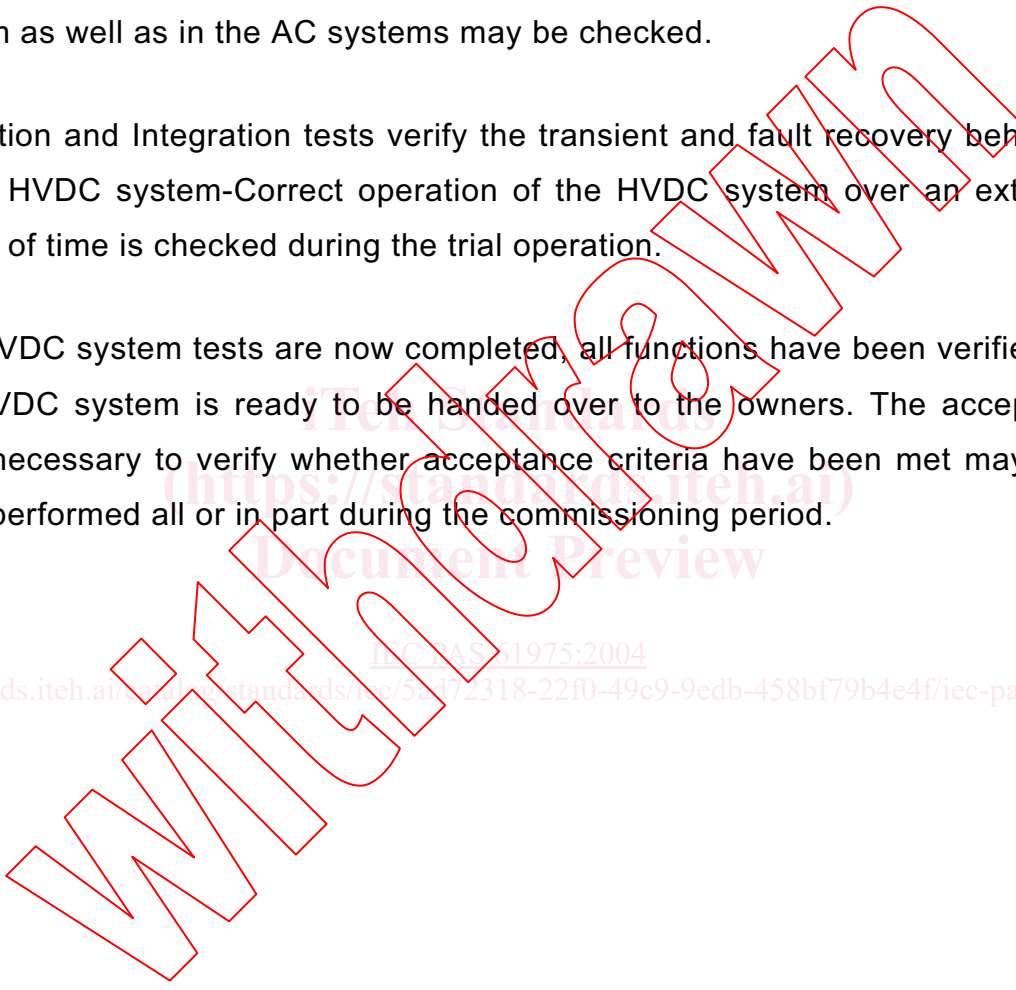
Before end-to-end tests are performed, it is advisable to perform an open line test and shorted line tests with the DC transmission line. This test can be repeated from both ends to verify the integrity of the DC line.

End-to-end tests involve both stations and the transmission line. With this operation, power is transmitted for the first time. This test usually starts on a monopolar basis, with full bipolar operation being the final step.

Having the complete system running properly, steady state verification tests can be performed. 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.

Operation and Integration tests verify the transient and fault recovery behaviour of the HVDC system. Correct operation of the HVDC system over an extended period of time is checked during the trial operation.

The HVDC system tests are now completed, all functions have been verified and the HVDC system is ready to be handed over to the owners. The acceptance tests necessary to verify whether acceptance criteria have been met may have been performed all or in part during the commissioning period.



## PART 1: GENERAL

### Introduction

This document deals with all aspects of system tests of HVDC systems. System tests start when all relevant subsystems have been precommissioned and are ready for operation. They end with full acceptance of the system for operation in the power systems.

This document provides background information for IEC to produce standards for system testing. It is structured in eight parts.

#### 1. General

#### 2. Off-site Tests

#### 3. Converter Tests

Commissioning of converter units, verification of steady state performance of units, switching tests

- converter unit tests
- converter station tests.

#### 4. End-to-End Tests

Commissioning of the transmission system, verification of station coordination.

#### 5. Steady-State Performance and Interference Tests

Verification of steady-state performance and interference caused by the HVDC-system.

## 6. Operation and Integration Tests

Operational and fault tests, verification of dynamic performance and interaction between the DC and AC systems.

## 7. Trial operation

## 8. System test plan and documentation

The guide also covers interrelation with off-site system tests. Preconditions of system tests will be established.

Part 1 General will address the purpose of this document, the HVDC system structure, the control and protection structure, the logical steps of commissioning and the structure of system testing of HVDC system. Parts 2 to 7 comprise individual paragraphs on general test objectives, information on test procedures, as well as detailed descriptions of the individual tests, including as appropriate the following;

- Specific objectives per test
- Test procedures
- Test acceptance criteria
- Preconditions for the test
- References to system studies/specifications
- References to off-site tests
- Special conditions

Part 8 describes the documentation normally required to adequately perform the system tests. This primarily consists of the following:

- Plant documentation
- Inspection and test plan (ITP)
- System study reports/technical specifications
- System test program
- Test procedures for each test
- Documentation of system test results