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TECHNICAL SPECIFICATION

colour inside

UHV AC transmission systems – Part 302: Commissioning

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UHV AC TRANSMISSION SYSTEMS –

Part 302: Commissioning

FOREWORD

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The text of this Technical Specification is based on the following documents:

DTS	Report on voting
122/115/DTS	122/117/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 63042 series, published under the general title *UHV AC transmission systems*, can be found on the IEC website.

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- reconfirmed,
- withdrawn,
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INTRODUCTION

Due to the increase in voltage level and transmission capacity, the reliability and security of high voltage electric equipment and power system are facing new challenges. There is a need to have consensus on a series of technical criteria and requirements for commissioning tests for ultra-high voltage (UHV) AC transmission systems to check the proper and expected performance of substation equipment and transmission lines, to verify the function of the transmission system, to obtain the electromagnetic data and confirm the environmental impacts complying with relevant local regulations. By commissioning, the integrated performance and construction quality of the project before its commercial operation could be confirmed.

This document proposes relevant test items, test preconditions, test methods, and test acceptance criteria for pre-commissioning, system commissioning, and measurement during system commissioning.

UHV AC TRANSMISSION SYSTEMS –

Part 302: Commissioning

1 Scope

This part of IEC 63042 applies to the commissioning of UHV AC transmission systems.

It mainly specifies the test purposes, test items, test preconditions, test methods and test acceptance criteria during pre-commissioning and system commissioning. Also, the measurement requirements for system commissioning are specified.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60076-6:2007, *Power transformers – Part 6: Reactors*

IEC 60076-10:2016, *Power transformers – Part 10: Determination of sound levels*
IEC 60076-10:2016/AMD1:2020

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
IEC 61000-4-13:2002/AMD1:2009
IEC 61000-4-13:2002/AMD2:2015

IEC 61786-2:2014, *Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings – Part 2: Basic standards for measurements*

IEC TS 63042-301:2018, *UHV AC transmission systems – Part 301: On-site acceptance tests*

CISPR TR 18-2:2017, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
commissioning
tests and measurements performed to verify the quality of equipment installation and verify the system in an appropriate state before a transmission project being put into commercial operation, consisting of two parts of pre-commissioning and system commissioning

3.2
pre-commissioning
series of tests and measurements performed in a substation before system commissioning of a transmission project

Note 1 to entry: The tests include combined tests and communication tests to further assess the condition of equipment after installation and on-site acceptance test for a transmission project.

3.3
system commissioning
series of tests and measurements performed (or checked) for the equipment and the power system in the operating power grid after pre-commissioning

Note 1 to entry: The tests and measurements are implemented after completing on-site acceptance test and pre-commissioning test, in order to ensure the project fulfils the requirements of commercial operation.

3.4
loop closing
loop interconnecting
operation performed by closing circuit-breaker of transmission line or transformer to make the power grid of same or different voltage levels run in loop (synchronous interconnection) network

Note 1 to entry: The purpose of the test is to verify the correctness of the synchronous strategy set for the tested circuit-breakers, and to ensure security when the power grid is loop closed (interconnected).

3.5
loop opening
loop splitting
operation performed by opening circuit-breaker of transmission line or transformer to make the power grid of same or different voltage levels run out of loop (synchronous interconnection) network

Note 1 to entry: The purpose of the test is to verify the security when the power grid is loop opened (split).

4 General

4.1 Requirements

The overall requirements including main purpose, general method, scope of application, and technical preparation for UHV AC system commissioning are as follows in 4.2 to 4.5 to secure objectivity and transparency for evaluation and judgment of commissioning and to follow the regulation of each country for safety and environmental security.

4.2 Main purpose

Commissioning is performed to confirm the integrated performance capability and construction quality of the project before its commercial operation. The utilities should carry out commissioning tests for UHV equipment and system-oriented aspects before the operation. The purposes are as follows:

- to confirm the proper and expected performance of substation equipment and transmission lines;
- to verify the function of the transmission system;

- to obtain the data such as electromagnetic field, sound level, etc., and to confirm the environmental impacts complying with relevant local regulations.

4.3 General structure of commissioning

The general structure of on-site acceptance tests and commissioning is shown in Figure 1, to confirm the soundness of every equipment and transmission line, the communication test between protection, control, information equipment and control centre, and also the function of the power grid. The commissioning consists of pre-commissioning and system commissioning. Details of pre-commissioning and system commissioning are shown in Clause 5 and Clause 6 respectively.

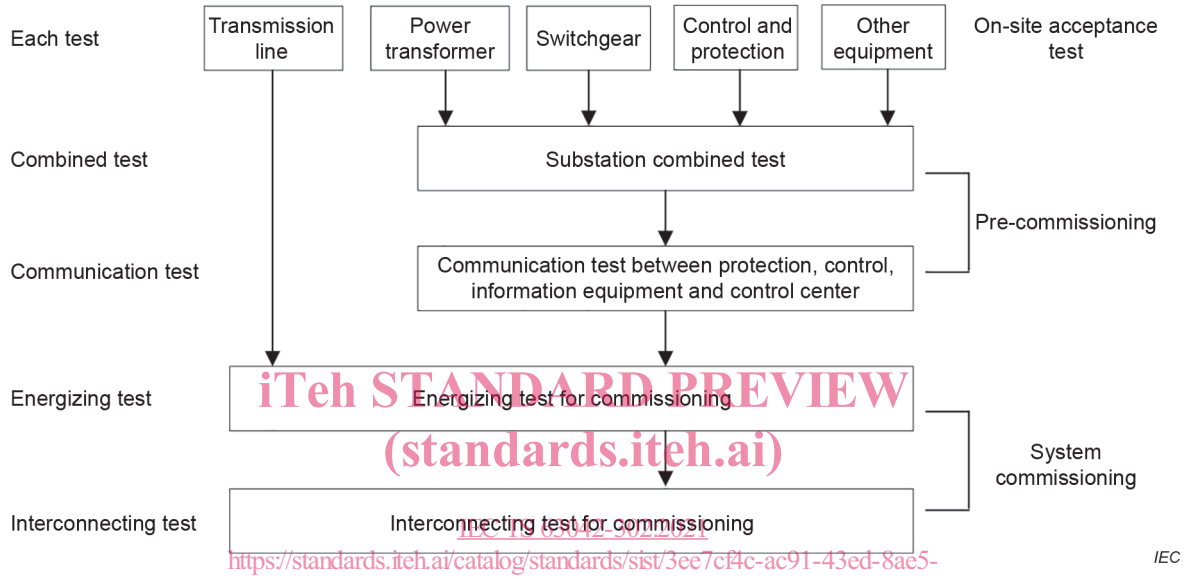

Figure 1 – General structure of on-site acceptance tests and commissioning

4.4 Scope of application

The scope of the application is shown in Table 1.

Table 1 – Scope of application

IEC documents	Each test	Combined test	Communication test	Energizing test	Interconnecting test
IEC TS 63042-301 UHV AC transmission systems – Part 301: On-site acceptance tests	Applied	-	-	-	-
IEC TS 63042-302 UHV AC transmission systems – Part 302: Commissioning	-	Applied	Applied	Applied	Applied

4.5 Technical preparation of system commissioning

With regard to the newly constructed UHV AC substations and transmission lines, simulation analysis should be carried out, as the necessary technical basis for evaluating the risks and ensuring the security and availability of system commissioning tests based on the practical conditions of equipment and nearby power grid including transmission lines.

The simulation analysis consists of two parts, power flow and stability analysis, and electromagnetic transient analysis. The power flow and stability simulation analysis focuses on power grid operation mode, power flow arrangement, fault current, voltage fluctuation, system stability performance during a disturbance, and security control measures. The electromagnetic transient analysis focuses on overvoltage and overcurrent for each commissioning test, and technical measures to ensure the security of equipment and system.

Commissioning program should be prepared prior to on-site implementation, which should specify the test purposes, test contents, test and measurement procedures, and on-site security measures, etc. The commissioning program should be compiled based on the simulation results, the practical connection wirings of the commissioned substations, and the characteristics of commissioned equipment and transmission lines.

5 Pre-commissioning

5.1 General

The conditions of pre-commissioning for UHV AC projects are as follows:

- the installation of equipment has been completed, and on-site acceptance tests are completed;
- the network connection of the protection and control system and the communication system in the station has been completed;
- the AC and DC power supply in the station has been installed and tested.

The test items and requirements of pre-commissioning for UHV AC projects should be specified and selected by utilities based on their regulations and design.

The recommended test items of pre-commissioning are listed in Table 2.

Table 2 – Recommended test items of pre-commissioning

Test items	
Combined test	Protection and control system test
	Instrument transformer test
	Switchgear and transformer test
	AC and DC power supply system test
Communication system test	Monitoring and control system test
	Protection and fault information system test

5.2 Combined test

5.2.1 General

The requirements for each combined test item should be specified.

5.2.2 Protection and control system test

The test contents and method of the protection and control system test are as follows:

- check the insulation of the secondary circuit and panel with a megohmmeter;
- check the signal of the protection and control system. The input/output binary signal is simulated one by one in each protection and control device and then checked at the receiving end (measuring and controlling device, control and monitoring system, or related equipment);

- check the protection and tripping function. The tripping logic of each protection device is tested one by one. Simulate all kinds of faults in each protection to make it trip, check and confirm the correctness of the tripping function between protection and circuit-breaker, the linkage logic between protections such as line protection and circuit-breaker failure protection, busbar protection and circuit-breaker failure protection;
- carry out an end-to-end test. For pilot protection or differential protection, check the sampling value, differential current, input and output contacts, remote signal, and telemetry of the protection devices on both sides, and simulate various faults to verify the logic of pilot or differential protection. Check whether the optical power, bit error rate, attenuation, and channel coding of the channel meet the requirements.

5.2.3 Instrument transformer test

Instrument transformers include current transformer (CT) and voltage transformer (VT). The test contents and method of instrument transformer test are as follows:

- check the insulation of CT and VT secondary circuit insulation with a megohmmeter;
- check the DC resistance of the CT secondary circuit. The balance bridge method or secondary injection method can be applied;
- check and confirm that the polarity of the instrument transformer is in accordance with the design drawings. It could be conducted in the CT primary injection test and VT energizing test;
- check the AC load resistance of the secondary circuit of the instrument transformer. Secondary current and voltage injection method could be applied;
- inject current into the primary system of the CT and check the phase sequence, polarity, and ratio of the current transformer, and the correctness of the display values of protection, measurement, metering, and other related equipment;
- energize the voltage transformer from primary or secondary, check the ratio of voltage transformer, and the correctness of the voltage display value of protection, measurement, metering, and other related equipment.

5.2.4 Switchgear and transformer test

Switchgear includes circuit-breaker, disconnector, and earthing switch. The test contents and method of switchgear and transformer test are as follows:

- under each redundant operating power supply, verify the correctness of local/remote tripping and closing operation of the circuit-breaker, and on-load tap changer (OLTC) remote operation of the transformer;
- simulate simultaneous opening and closing operations to verify the anti-pumping function of the circuit-breaker;
- check and confirm that the current of the opening and closing circuit of the circuit-breaker meets the requirements;
- check and confirm that the low SF_6 gas pressure locking functions of the circuit-breaker work correctly;
- for synchronous closing of the circuit-breaker, when the synchronous conditions are satisfied or not, the closing operation is carried out separately to verify the correctness of the synchronous function;
- for each circuit-breaker, related disconnectors, and related earthing switches, and for circuit-breaker and high-speed earthing switch (HSES) for secondary arc extinction, when the interlocking condition is satisfied or not, the interlocking operation is carried out separately to verify whether the interlocking function is correct. For the details of the interlock between circuit-breaker and high-speed earthing switch see Annex B.

5.2.5 AC and DC power supply system test

AC and DC power supply system refers to the auxiliary power supply of substations. The test contents and method of the AC and DC power supply system test are as follows:

- check insulation resistance of power source busbar and cable to ground;
- the functions of DC system switching, DC insulation monitoring, DC feeder power off, standby self-switching, accident lighting, UPS, control and protection interface should be tested and verified.

5.3 Communication system test

In the communication system test, the communication of all automation and protection systems should be tested. The test contents and method of the communication test are as follows:

- check the binary and analogue signals of each substation equipment, protection and control system, circuit-breaker, disconnector, and earthing switch, and verify the remote control operation;
- collect and record fault waveform, protection actions, and signals for protection and fault information system, which is connected with digital fault recorders and protection devices. Check the signals. Test the communication with the substation and the master station of the protection and fault information system;
- check the insulation of secondary circuit for other monitoring and/or control systems, such as digital fault recorder, fault location system, stability control system, synchronous phasor measurement system, time synchronization system, metering system, on-line condition monitoring system. Check the binary and analogue signals, verify the functions of each system, and test the communication with the master station and/or substation.

NOTE Some of the monitoring and/or control system tests mentioned above are described in Clause A.4.

6 System commissioning

6.1 General

The recommended test items of system commissioning are listed in Table 3, but no sequence is defined.

Table 3 – Recommended test items of system commissioning

Test items	
Energizing test	Energizing test of no-load UHV power transformer
	Energizing test of tertiary connected reactor
	Energizing test of tertiary connected capacitor
	Energizing test of UHV busbar shunt reactor
	Energizing test of UHV busbar
	Energizing test of no-load UHV transmission line
Interconnecting test	Loop closing (interconnecting)/opening (splitting) test

The test items and requirements of system commissioning for UHV AC projects should be specified and selected by utilities based on their own regulations and design.

For newly designed and constructed transmission lines, more information for system commissioning test is given in Annex A to Annex C.