IEC 62927

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Voltage sourced converter (VSC) valves for static synchronous compensator (STATCOM) – Electrical testing

Valves de convertisseur source de tension (VSC) pour compensateur synchrone statique (STATCOM) – Essais électriques

IEC 62927:2017-07(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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VOLTAGE SOURCED CONVERTER (VSC) VALVES FOR STATIC SYNCHRONOUS COMPENSATOR (STATCOM) – ELECTRICAL TESTING

FOREWORD

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The text of this International Standard is based on the following documents:

CDV	Report on voting
22F/412/CDV	22F/431A/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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VOLTAGE SOURCED CONVERTER (VSC) VALVES FOR STATIC SYNCHRONOUS COMPENSATOR (STATCOM) – ELECTRICAL TESTING

1 Scope

This document applies to self-commutated valves, for use in voltage sourced converter (VSC) for static synchronous compensator (STATCOM). It is restricted to electrical type and production tests.

The tests specified in this document are based on air insulated valves. For other types of valves, the test requirements and acceptance criteria are agreed between the purchaser and the supplier.

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 60060 (all parts), *High-voltage test techniques*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*

IEC 60700-1:2015, *Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1: Electrical testing*

IEC 62501, *Voltage sourced converter (VSC) valves for high-voltage direct current (HVDC) power transmission – Electrical testing*

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 Insulation co-ordination terms

3.1.1
test withstand voltage
value of a test voltage of standard waveshape at which a new valve, with unimpaired integrity, does not show any disruptive discharge and meets all other acceptance criteria specified for the particular test, when subjected to a specified number of applications or a specified duration of the test voltage, under specified conditions

3.1.2
internal insulation
air external to the components and insulating materials of the valve, but contained within the profile of the valve or multiple valve unit

3.1.3
external insulation
air between the external surface of the valve or multiple valve unit and its surroundings

3.2 Power semiconductor terms

3.2.1
turn-off semiconductor device
controllable semiconductor device which may be turned on and off by a control signal, for example an IGBT

Note 1 to entry: There are several types of turn-off semiconductor devices, for example IGBT, IGCT and GTO, which can be used in voltage sourced converters for STATCOM. For convenience, the term IGBT is used throughout this document to refer to the main, controllable turn-off, semiconductor device. However, this document is equally applicable to other types of controllable semiconductor switch device.

3.2.2
gate turn-off thyristor
GTO thyristor
turn-off semiconductor device which can be turned on and off by its gate lead

Note 1 to entry: A GTO thyristor is a special type of thyristor, which is a high-power semiconductor device.

Note 2 to entry: Gate commutated thyristor (GCT) and integrated gate commutated thyristor (IGCT) are special types of GTO thyristor.

3.2.3
insulated gate bipolar transistor
IGBT
transistor provided for power switching having a conduction channel and a PN junction and in which the current flowing through the channel and the junction is controlled by an electric field resulting from a voltage applied between the gate and emitter terminals

3.2.4
free-wheeling diode
FWD
power semiconductor device with diode characteristic connected to an insulated gate bipolar transistor (IGBT) in inverse parallel

Note 1 to entry: An FWD has two terminals: an anode (A) and a cathode (K).

Note 2 to entry: The current through FWDs is in the opposite direction to the IGBT current.

Note 3 to entry: Concepts of "inverse parallel" and "anti-parallel" are identical.

3.2.5
IGBT-diode pair
arrangement of IGBT and FWD connected in inverse parallel

3.3 Operating states of converter

3.3.1
blocking state
condition of the converter, in which a turn-off signal is applied continuously to all IGBTs of the converter

3.3.2
de-blocked state
condition of the converter, in which turn-on and turn-off signals are applied repetitively to IGBTs of the converter

3.3.3
valve protective blocking
means of protecting the valve or converter from excessive electrical stress by the emergency turn-off of all IGBTs in one or more valves

3.3.4
voltage step level
voltage step caused by switching of a valve or part of a valve during the de-blocked state of the converter

Note 1 to entry: For a voltage source type valve, one half bridge cell corresponds to one voltage step level and a full bridge cell has two voltage step levels.

3.4 STATCOM construction terms

3.4.1
STATCOM
shunt connected reactive compensation equipment which is capable of generating and/or absorbing reactive power, whose capacitive or inductive output current can be controlled independently of the AC system voltage

Note 1 to entry: Previous alternative terms for the STATCOM have included static var generator (SVG), advanced static var compensator (ASVC) and static synchronous condenser (STATCON).

3.4.2
STATCOM valve
electrically and mechanically combined assembly of IGBT levels, complete with all connections, auxiliary components and mechanical structures, which can be connected in series with each phase of reactor of a STATCOM

Note 1 to entry: Depending on the converter topology, a valve can either have the function to act like a controllable switch or to act like a controllable voltage source. For controllable voltage source type converter, the STATCOM controllable voltage source type valve is a complete controllable voltage source assembly, which is generally connected between two AC phases. For switch type converter, the STATCOM switch type valve is an arrangement of IGBTs connected in series and arranged to be switched simultaneously as a single function unit between one AC phase and one DC terminal of the DC capacitor energy storage.

Note 2 to entry: For convenience, the term "STATCOM valve" is shortened as "valve" in this document.

3.4.3
diode valve
semiconductor valve containing only diodes as the main semiconductor devices, which might be used in some STATCOM topologies

3.4.4
submodule
part of a valve comprising controllable switches and diodes connected in a half bridge or full bridge arrangement, together with their immediate auxiliaries, storage capacitor, if any, where each controllable switch consists of one or more switched valve device(s) connected in series

Note 1 to entry: This definition is only applicable for converters of controllable voltage source type.

3.4.5
switch type valve
arrangement of IGBT-diode pairs connected in series and arranged to be switched simultaneously as a single function unit

3.4.6
controllable voltage source type valve
complete controllable voltage source assembly, which is generally connected between AC phases or between one AC terminal and one DC terminal

3.4.7
modular multi-level converter
MMC
multi-level converter in which each VSC valve (see 3.4.5, 3.4.6) consists of a number of MMC building blocks (see 3.4.9) connected in series

3.4.8
cascaded two-level converter
CTL
modular multi-level converter in which each switch position consists of more than one IGBT-diode pair connected in series

3.4.9
MMC building block
self-contained, two-terminal controllable voltage source together with DC capacitor(s) and immediate auxiliaries, forming part of a MMC

3.4.10
STATCOM valve level
the smallest indivisible functional unit of valve

Note 1 to entry: For any valve in which switch devices are connected in series and operated simultaneously, one valve level is one IGBT including its auxiliaries. For modular multilevel converter (MMC) type without IGBT connected in series, one valve level is one submodule (cell) together with its auxiliaries.

3.4.11
diode valve level
part of a diode valve composed of a diode and associated circuits and components, if any

3.4.12
redundant valve levels
the maximum number of series connected valve levels or diode valve levels in a valve that may be short-circuited externally or internally without affecting the safe operation of the valve as demonstrated by type tests, and which if and when exceeded, would require shutdown of the valve to replace the failed levels or acceptance of increased risk of failures

Note 1 to entry: In valve designs which contain two or more conduction paths within each cell and have series-connected VSC valve levels in each path, redundant levels shall be counted only in one conduction path in each cell.

3.5 Valve structure terms

3.5.1
valve structure
physical structure holding the levels of a valve which is insulated to the appropriate voltage above earth potential

3.5.2
valve support
part of the valve which mechanically supports and electrically insulates the active part of the valve from earth

3.5.3
multiple valve unit
MVU
mechanical arrangement of two or more valves sharing a common valve support, where applicable

3.5.4
valve section
electrical assembly defined for test purposes, comprising a number of valve levels and other components, which exhibits pro-rated electrical properties of a complete valve

3.5.5
valve base electronics
electronic unit, at earth potential, which is the interface between the converter control system and the STATCOM valves

4 General requirements

4.1 Guidelines for the performance of type tests

4.1.1 General

The tests described apply to the valve (or valve sections), the valve structure and those parts of the coolant distribution system and firing and monitoring circuits which are contained within the valve structure (internal insulation) or connected between the valve structure and earth (external insulation). Other equipment, such as valve control and protection and valve base electronics, can be essential for demonstrating the correct function of the valve during the tests but are not in themselves the subject of the tests.

4.1.2 Dielectric tests

The purpose of these tests is to verify the valve design for voltage stresses under normal and abnormal repetitive conditions as well as under transient conditions.

In the interest of standardization with other equipment, lightning impulse tests between valve terminals and earth and between phases of a multiple valve unit (MVU) are included. For tests between valve terminals, the only impulse test specified is a switching impulse.

4.1.3 Operational tests

The purpose of these tests is to verify the valve design for combined voltage and current stresses under normal and abnormal repetitive conditions as well as under transient fault conditions.

4.1.4 Electromagnetic interference tests

The principal objective of these tests is to demonstrate the immunity of the valve to electromagnetic interference from within the valve and from outside the valve.

4.1.5 Evidence in lieu

Each design of valve shall be subjected to the type tests specified in this document. If the valve is demonstrably similar to one previously tested, the supplier may, in lieu of performing a type test, submit a test report of a previous type test for consideration by the purchaser. This should be accompanied by a separate report detailing the differences in the design and demonstrating how the referenced type test satisfies the test objectives for the proposed design.

4.1.6 Test object

4.1.6 does not apply to tests on the valve support and multiple valve units. The test object for those tests may be a representative separate object including representation of the adjacent parts of the valve, or may form part of the assembly used for single valve or multiple valve unit tests.

a) Type tests may be performed either on a complete valve or, in certain circumstances, on valve sections, as indicated in Table 3.

b) The minimum number of valve levels to be tested, depending on the valve levels in a single valve, is as shown in Table 1.

Table 1 – Minimum number of valve levels to be tested as a function of the number of valve levels per valve

Number of valve levels per valve	Total number of valve levels to be tested
1 to 10	Number of valve levels in one valve
11 to 50	10 levels
≥ 51	20% of valve levels in one valve

c) Generally, the same valve sections are recommended to be used for all type tests. However, with the agreement of the purchaser and supplier, different tests may be performed on different valve sections in parallel, in order to speed up the programme for executing the tests.

d) Prior to commencement of type tests, the valve, valve sections and/or the components of them should be demonstrated to have withstood the production tests to ensure proper manufacture.

4.1.7 Test procedure

The tests shall be performed in accordance with IEC 60060 (all parts), where applicable.

4.1.8 Ambient temperature for testing

The tests shall be performed in accordance with IEC 60060 (all parts), where applicable.

4.1.9 Frequency for testing

AC dielectric tests can be performed at either 50 Hz or 60 Hz. For operational tests, specific requirements regarding the frequency for testing are given in the relevant clauses.

4.1.10 Conditions to be considered in determination of type test parameters

Type test parameters should be determined based on the worst operating and fault conditions to which the valve can be subjected, according to system studies.

4.1.11 Test reports

At the completion of the type tests, the supplier shall provide type test reports in accordance with Clause 14.

4.2 Atmospheric correction factor

When specified in the relevant clause, atmospheric correction shall be applied to the test voltages in accordance with IEC 60060-1. The reference conditions to which correction shall be made are the following.

– Pressure
  - If the insulation coordination of the tested part of the valve is based on standard rated withstand voltages according to IEC 60071-1, correction factors for site conditions are only applied for altitudes exceeding 1000 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 1000 m ($b_{1\,000\ \mathrm{m}}$).
  - If the insulation coordination of the tested part of the valve is not based on standard rated withstand voltages according to IEC 60071-1, then the correction factor for site conditions follows the standard procedure according to IEC 60060-1 with the reference atmospheric pressure b_0 (b_0 = 101,3 kPa).

– Temperature: design maximum valve hall air temperature (°C).

– Humidity: design minimum valve hall absolute humidity (g/m^3).

Realistic worst case combinations of temperature and humidity which can occur in practice shall be used for atmospheric correction.

The values to be used shall be specified by the supplier.

4.3 Treatment of redundancy

4.3.1 Operational tests

For operational tests, redundant valve levels shall not be short-circuited. The test voltages used shall be adjusted by means of a scaling factor k_n:

$$k_n = \frac{N_{tut}}{N_t - N_r}$$

where

N_{tut} is the number of series valve levels in the test object;

N_t is the total number of series valve levels in the valve;

N_r is the total number of redundant series valve levels in the valve.

4.3.2 Dielectric tests

For all dielectric tests between valve terminals, the redundant valve levels shall be short-circuited. The location of valve levels to be short-circuited shall be agreed by the purchaser and supplier.

NOTE Depending on the design, limitations can be imposed upon the distribution of short-circuited valve levels. For example, there can be an upper limit to the number of short-circuited valve levels in one valve section.

For all dielectric tests on valve section, the test voltages used shall be adjusted by means of a scaling factor k_o:

$$k_o = \frac{N_{tu}}{N_t - N_r}$$

where

N_{tu} is the number of series valve levels not short circuit connected in the test object;

N_t is the total number of series valve levels in the valve;

N_r is the total number of redundant series valve levels in the valve.