

# FINAL VERSION

# VERSION FINALE

---

**Static var compensators (SVC) – Testing of thyristor valves**

**Compensateurs statiques de puissance réactive (SVC) – Essais des valves à thyristors**



## CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions .....	7
4 General requirements for type, production and optional tests.....	9
4.1 Summary of tests .....	9
4.2 Objectives of tests.....	10
4.2.1 General .....	10
4.2.2 Dielectric tests .....	10
4.2.3 Operational tests.....	10
4.2.4 Electromagnetic interference tests .....	11
4.2.5 Production tests.....	11
4.2.6 Optional tests .....	11
4.3 Guidelines for the performance of type and optional tests .....	11
4.4 Test conditions.....	12
4.4.1 General .....	12
4.4.2 Valve temperature at testing .....	13
4.4.3 Redundant thyristor levels.....	13
4.5 Permissible component failures during type testing .....	14
4.6 Documentation of test results .....	14
4.6.1 Test reports to be issued.....	14
4.6.2 Contents of a type test report .....	15
5 Type tests on TCR and TSR valves.....	15
5.1 Dielectric tests between valve terminals and earth .....	15
5.1.1 General .....	15
5.1.2 AC test .....	16
5.1.3 Lightning impulse test .....	16
5.2 Dielectric tests between valves (MVU only).....	17
5.2.1 General .....	17
5.2.2 AC test .....	17
5.2.3 Lightning impulse test .....	18
5.3 Dielectric tests between valve terminals .....	18
5.3.1 General .....	18
5.3.2 AC test .....	18
5.3.3 Switching impulse test.....	20
5.4 Operational tests.....	21
5.4.1 Periodic firing and extinction test.....	21
5.4.2 Minimum a.c. voltage test .....	22
5.4.3 Temperature rise test.....	23
6 Type tests on TSC valves .....	23
6.1 Dielectric tests between valve terminals and earth .....	23
6.1.1 General .....	23
6.1.2 AC-DC test .....	24
6.1.3 Lightning impulse test .....	26
6.2 Dielectric tests between valves (for MVU only).....	26
6.2.1 General .....	26

6.2.2	AC-DC test .....	26
6.2.3	Lightning impulse test .....	28
6.3	Dielectric tests between valve terminals .....	29
6.3.1	General .....	29
6.3.2	AC-DC test .....	29
6.3.3	Switching impulse test.....	31
6.4	Operational tests.....	32
6.4.1	Overcurrent tests .....	32
6.4.2	Minimum a.c. voltage test .....	35
6.4.3	Temperature rise test.....	36
7	Electromagnetic interference tests .....	36
7.1	Objectives.....	36
7.2	Test procedures .....	36
7.2.1	General .....	36
7.2.2	Switching impulse test.....	37
7.2.3	Non-periodic firing test.....	37
8	Production tests.....	37
8.1	General.....	37
8.2	Visual inspection .....	37
8.3	Connection check.....	37
8.4	Voltage-dividing/damping circuit check .....	38
8.5	Voltage withstand check.....	38
8.6	Check of auxiliaries.....	38
8.7	Firing check .....	38
8.8	Cooling system pressure test .....	38
8.9	Partial discharge tests.....	38
9	Optional tests on TCR and TSR valves.....	38
9.1	Overcurrent test .....	38
9.1.1	Overcurrent with subsequent blocking .....	38
9.1.2	Overcurrent without blocking.....	39
9.2	Positive voltage transient during recovery test .....	39
9.2.1	Objectives.....	39
9.2.2	Test values and waveshapes .....	39
9.2.3	Test procedures.....	40
9.3	Non-periodic firing test .....	40
9.3.1	Objectives.....	40
9.3.2	Test values and waveshapes .....	40
9.3.3	Test procedures.....	42
10	Optional tests on TSC valves .....	42
10.1	Positive voltage transient during recovery test .....	42
10.1.1	Test objective .....	42
10.1.2	Test values and waveshapes .....	42
10.1.3	Test procedures.....	42
10.2	Non-periodic firing test .....	43
10.2.1	Objectives.....	43
10.2.2	Test values and waveshapes .....	43
10.2.3	Test procedures.....	44
	Figure 1 – TSC branch .....	33

Figure 2 – One-loop overcurrent.....	34
Figure 3 – Two-loop overcurrent.....	35
Table 1 – List of tests.....	9
Table 2 – Number of thyristor levels permitted to fail during type tests .....	15

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### STATIC VAR COMPENSATORS (SVC) – TESTING OF THYRISTOR VALVES

#### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

#### **DISCLAIMER**

**This Consolidated version is not an official IEC Standard and has been prepared for user convenience. Only the current versions of the standard and its amendment(s) are to be considered the official documents.**

**This Consolidated version of IEC 61954 bears the edition number 2.2. It consists of the second edition (2011-04) [documents 22F/217/CDV and 22F/231A/RVC], its amendment 1 (2013-04) [documents 22F/274/CDV and 22F/287A/RVC] and its amendment 2 (2017-04) [documents 22F/409/CDV and 22F/418A/RVC]. The technical content is identical to the base edition and its amendments.**

**This Final version does not show where the technical content is modified by amendments 1 and 2. A separate Redline version with all changes highlighted is available in this publication.**

International Standard IEC 61954 has been prepared by subcommittee 22F: Power electronics for electrical transmission and distribution systems, of IEC technical committee 22: Power electronics.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Definitions of terms “thyristor level”, “valve section”, “valve base electronics” and “redundant thyristor levels” have been changed for clarification.
- b) Conditions of testing thyristor valve sections instead of a complete thyristor valve have been defined.
- c) The requirement has been added that if, following a type test, one thyristor level has become short-circuited, then the failed level shall be restored and this type test repeated.
- d) The time period of increasing the initial test voltage from 50 % to 100 % during type a.c. dielectric tests on TSC, TCR or TSR valves has been set equal to approximately 10 s.
- e) The duration of test voltage  $U_{ts2}$  during type a.c.-d.c. dielectric tests between TSC valve terminals and earth as well as the duration of test voltage  $U_{tvv2}$  during dielectric tests between TSC valves (for MVU only) has been changed from 30 min to 3 h.
- f) The reference on the number of pulses per minute of the periodic partial discharge recorded during a.c.-d.c. dielectric tests on TSC valves and exceeding the permissible level has been deleted.

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 "<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.

## STATIC VAR COMPENSATORS (SVC) – TESTING OF THYRISTOR VALVES

### 1 Scope

This International Standard defines type, production and optional tests on thyristor valves used in thyristor controlled reactors (TCR), thyristor switched reactors (TSR) and thyristor switched capacitors (TSC) forming part of static VAR compensators (SVC) for power system applications. The requirements of the standard apply both to single valve units (one phase) and to multiple valve units (several phases).

Clauses 4 to 7 detail the type tests, i.e. tests which are carried out to verify that the valve design meets the requirements specified. Clause 8 covers the production tests, i.e. tests which are carried out to verify proper manufacturing. Clauses 9 and 10 detail optional tests, i.e. tests additional to the type and production tests.

### 2 Normative references

The following referenced documents are indispensable for the application 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 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60071 (all parts), *Insulation co-ordination*

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*  
IEC 60071-1:2006/AMD1:2010

IEC 60270, *High-voltage test techniques – Partial discharge measurements*

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

### 3 Terms and definitions

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

#### 3.1

##### **thyristor level**

part of a thyristor valve comprising a thyristor, or thyristors connected in parallel or antiparallel, together with their immediate auxiliaries and reactor, if any

#### 3.2

##### **thyristor (series) string**

series connected thyristors forming one direction of a thyristor valve