

IEEE Guide for Test Procedures for HVDC Thyristor Valves

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Sponsored by
Task Force on Test Procedures for HVDC Thyristor Valves, DC Transmission
Subcommittee of the IEEE Transmission and Distribution Committee, and the
DC Converter Stations Subcommittee of the IEEE Substations Committee of the
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Task Force on Test Procedures for HVDC Thyristor Valves, the
DC Transmission Subcommittee of the IEEE Transmission and Distribution
Committee, and the DC Converter Stations Subcommittee
of the IEEE Substations Committee of the IEEE Power Engineering Society

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Abstract: IEEE Std 857-1990, *IEEE Guide for Test Procedures for HVDC Thyristor Valves*, contains information and recommendations for the type testing of thyristor valves for high-voltage, direct-current (HVDC) power transmission systems. These tests cover only the principal tests on the valves and do not include tests of auxiliary equipment associated with the valves.
Keywords: HVDC thyristor valves, HVDC power transmission systems, multiple-valve unit (MVU), thyristor-levels.

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Foreword

(This Foreword is not a part of IEEE Std 857-1990, IEEE Guide for Test Procedures for HVDC Thyristor Valves.)

This guide was prepared by the Task Force on Test Procedures for HVDC Thyristor Valves set up by the DC Transmission Subcommittee of the IEEE Transmission and Distribution Committee and the DC Converter Stations Subcommittee of the IEEE Substations Committee, both of the IEEE Power Engineering Society.

The purpose of this guide is to complement other IEEE Standards on high-voltage, direct-current (HVDC) power transmission systems and give guidance to the industry on how to treat the important subject of testing a thyristor valve that is a complex device. This guide contains information and recommendations for type testing of thyristor valves for HVDC power transmission systems. The tests in this guide cover only the principal tests on the valves. This guide is not intended to be a comprehensive guide on valve testing because it does not have within its scope other valve tests, i.e., development tests, production sample tests, routine tests, loss determination tests, commissioning tests, site tests.

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Contents

SECTION	PAGE
1. Scope.....	7
2. Purpose.....	7
3. References.....	7
4. Definitions	8
5. Classification of Tests.....	8
6. General Requirements	9
7. Criteria for Successful Type Testing.....	10
8. Test Program.....	12
9. Presentation of Test Results	20
10. Bibliography.....	21
FIGURE	
Valve Voltage Waveforms for Various Firing Angles.....	17
APPENDIX	
Redundancy.....	24

IEEE Guide for Test Procedures for HVDC Thyristor Valves

1. Scope

This guide contains information and recommendations for the type testing of thyristor valves for high-voltage direct-current (HVDC) power transmission systems. Other equipment tests, such as development tests, production sample tests, routine tests, tests for the determination of losses, commissioning tests, and site tests are not within the scope of this guide. Furthermore, the tests given here cover the principal tests on the valves only and do not include tests of auxiliary equipment associated with the valves, such as cooling system components.

This guide is designed to be general in its scope to allow for future developments in technology and economy of testing. It is also neutral regarding different designs of thyristor valves and availability of test facilities.

This guide applies to any type of thyristor valve used in converters for HVDC power transmission systems but does not apply to other types of semiconductor devices that might be used for HVDC transmission systems in the future.

2. Purpose

An HVDC thyristor valve consists of numerous, possibly hundreds, of interconnected electronic components, and various types of insulation and cooling facilities, which are arranged in an intricate structure to perform a specified function as a single device. Because it is a comparatively new device, valve designs are rapidly changing as improved technology becomes available. The complex nature of the valve combined with rapid design changes pose a difficult problem in defining tests to demonstrate the valve's capabilities.

It is recognized that thyristor valves are a special type of electrical apparatus for power systems, and that much of the industry is un-

familiar with their characteristics. Therefore, the purpose of this guide is to provide some guidance to the industry on how to treat the important subject of testing this complex device.

3. References

This guide shall be used in conjunction with the following publications:

- [1] IEC 71-1 (1976), Insulation co-ordination Part 1: Terms, definitions, principles and rules.¹
- [2] IEC 71-2 (1976), Insulation co-ordination Part 2: Application guide.
- [3] IEC 146 (1973), Semiconductor convertors.
- [4] IEC 633 (1978), Terminology for high-voltage direct current transmission.
- [5] IEC 700 (1981), Testing of semi-conductor valves for high voltage d.c. power transmission.
- [6] IEEE Std 4-1978, Techniques for High Voltage Testing (ANSI).²
- [7] IEEE Std 100-1988, IEEE Standard Dictionary of Electrical and Electronics Terms.
- [8] IEEE Std 223-1966, Definitions of Terms for Thyristors.*

¹IEC Standards are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, USA.

²IEEE Standards are available from the Sales Department, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA.

*This standard has been withdrawn. Archival copies are available through the IEEE Standards Department, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[9] IEEE Std 289-1968, Letter Symbols for Quantities Associated with Thyristors.*

[10] IEEE Std 332-1972, Techniques for Switching Impulse Testing (ANSI).*

4. Definitions

Definitions given in this guide apply specifically to the testing of HVDC thyristor valves.

4.1 failure of thyristor-level. A thyristor-level is deemed to have failed if it becomes short circuited or in any other way has degraded to the extent to make it functionally inoperative.

4.2 multiple-valve unit (MVU). A single structure comprising more than one valve. (See IEC 633 (1978) [4].³)

4.3 redundancy factor. The ratio of the total number of series thyristor-levels in the valve to the same number minus the total number of redundant series thyristor-levels in the valve. (See IEC 700 (1981) [5].)

The redundancy factor, f_r , is defined by:

$$f_r = \frac{N_t}{(N_t - N_r)}$$

where:

N_t = Total number of series thyristor-levels in the valve.

N_r = Total number of redundant series thyristor-levels in the valve.

4.4 redundant thyristor-levels. The maximum number of levels in the series string of thyristors in a valve that may be short circuited externally or internally during service without affecting the safe operation of the valve, and which, if and when exceeded, would require shut down of the valve within a reasonable time to replace the failed thyristors or acceptance of increased risk of failure of the valve. (See the appendix of this guide.)

*This standard has been withdrawn. Archival copies are available through the IEEE Standards Department, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

³The numbers in brackets correspond to those in Section 3.

4.5 single-valve unit. A single structure comprising only one valve. (See IEC 633 (1978) [4].)

4.6 test withstand voltage. The maximum value of a test voltage at which a new valve, with unimpaired integrity, does not show any disruptive discharge, nor suffer excessive component failure, when subjected to a specified number of applications of the test voltage, under specified conditions. IEC 700 (1981) [5] defines test withstand voltage as the *peak value of a nonrepetitive test voltage*.

4.7 thyristor-level. A single thyristor, or thyristors if the valve has parallel connected thyristors, and the associated components for control, voltage grading, protection and monitoring which constitute a single voltage level within the valve.

4.8 valve. A converter arm in a three-phase, six-pulse bridge converter connection. (See IEC 633 (1978) [4].)

4.9 valve base. That assembly which mechanically supports, and electrically insulates the valves from ground.

NOTE: A part of a valve that is clearly identifiable in a discrete form to be a valve base may not exist in all designs of valves.

A valve base could be a separate platform insulated from ground by post-type insulators which carries a live-tank valve unit, or a steel framework insulated from ground by post-type insulators on which the various modules of a multiple valve unit are mounted, or a raised platform of insulating material which is integral to the valve structure and forms the base.

4.10 valve module. The smallest assembly, comprising a number of thyristors and their immediate auxiliaries for firing and protection, voltage dividing components, and distributed valve reactors, from which the valve is built up and which exhibits the same electrical properties as the complete valve but can withstand only a portion of the full voltage blocking capability of the valve. (See IEC 700 (1981) [5].)

5. Classification of Tests

The type tests described in this guide are