# SLOVENSKI STANDARD
# oSIST prEN IEC 60700-3:2022

**01-februar-2022**

**Tiristorski ventili (elektronke) za visokonapetostni enosmerni prenos (HVDC) električne energije - 3. del: Bistvene lastnosti (mejne vrednosti) in karakteristike**

Thyristor valves for high voltage direct current (HVDC) power transmission - Part 3: Essential ratings (limiting values) and characteristics



Valves à thyristors pour le transport d'énergie en courant continu à haute tension (CCHT) - Partie 3: Valeurs assignées (valeurs limites) et caractéristiques essentielles

**Ta slovenski standard je istoveten z: prEN IEC 60700-3:2021**



**ICS:**

| | | |
|---|---|---|
| 29.200 | Usmerniki. Pretvorniki. Stabilizirano električno napajanje | Rectifiers. Convertors. Stabilized power supply |
| 31.080.20 | Tiristorji | Thyristors |

**oSIST prEN IEC 60700-3:2022** **en,fr,de**

# 22F/667/CDV

COMMITTEE DRAFT FOR VOTE (CDV)

| | |
|---|---|
| PROJECT NUMBER:<br>**IEC 60700-3 ED1** | |
| DATE OF CIRCULATION:<br>**2021-12-17** | CLOSING DATE FOR VOTING:<br>**2022-03-11** |
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|---|---|
| IEC **SC 22F** | |
| SECRETARIAT:<br>**Russian Federation** | SECRETARY:<br>**Mr. Lev TRAVIN** |
| OF INTEREST TO THE FOLLOWING COMMITTEES:<br>**TC 115** | PROPOSED HORIZONTAL STANDARD:<br>☐<br>Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary. |
| FUNCTIONS CONCERNED:<br>☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY | |
| ☒ SUBMITTED FOR CENELEC PARALLEL VOTING<br>**Attention IEC-CENELEC parallel voting**<br>The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting.<br>The CENELEC members are invited to vote through the CENELEC online voting system. | ☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING |

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TITLE:

**Thyristor valves for high voltage direct current (HVDC) power transmission - Part 3: Essential ratings (limiting values) and characteristics**

PROPOSED STABILITY DATE: **2027**

NOTE FROM TC/SC OFFICERS:

As the plenary meeting of SC 22F was cancelled in 2020 due to COVID-19 pandemic (see 22F/591/INF), comments of National Committees on 22F/590/CD containing in document 22F/605/CC were considered by SC 22F Chair, secretary, convenor and members of SC 22F/WG 35.
The agreed decision supported by the National Committee of Sweden has been taken that SC 22F/WG 35 is to develop the current second CD by July 2021. The second CD (22F/640/CD) was prepared by SC 22F/WG 35 (convenor Mr. Yantao LOU, CN).
Compilation of comments 22F/659/CC on document 22F/640/CD was considered by the secretary of SC 22F, the Chair of SC 22F, Convenor and members of SC22F/WG35. The Chair of SC 22F made decision (supported by the secretary of SC 22F) to prepare a CDV by putting agreed changes into 22F/640/CD by 2021-12

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# THYRISTOR VALVES FOR HIGH VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION –

## Part 3: Essential ratings (limiting values) and characteristics

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International Standard IEC 60700-3 ED1 has been prepared 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 International Standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 22F/XX/FDIS | 22F/XX/RVD |

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.

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.

# THYRISTOR VALVES FOR HIGH VOLTAGE DIRECT CURRENT (HVDC) POWER TRANSMISSION –

# Part 3: Essential ratings (limiting values) and characteristics

## 1 Scope

This part of IEC 60700 specifies the service conditions, the definitions of essential ratings and characteristics of thyristor valves utilized in line commutated converters with three-phase bridge connections to realize the conversion from AC to DC and vice versa for high voltage direct current (HVDC) power transmission applications. It is applicable for air insulated, liquid cooled and indoor thyristor valves.

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

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

IEC 60071-5, *Insulation co-ordination - Part 5: Procedures for high-voltage direct current (HVDC) converter stations*

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

IEC 60700-2, *Thyristor valves for high voltage direct current (HVDC) power transmission - Part 2: Terminology*

IEC TR 60919-1, *Performance of high-voltage direct current (HVDC) systems with line-commutated converters - Part 1: Steady-state conditions*

IEC 61803, *Determination of power losses in high-voltage direct current (HVDC) converter stations with line-commutated converters*



## 3 Symbols and abbreviations

The list covers only the most frequently used symbols and abbreviations related to this document. For a more complete list of symbols and abbreviations refer to the standards listed in the normative references.

### 3.1 Subscripts

| | |
|---|---|
| 0 (zero) | at no load |
| i | ideal |
| N | nominal or rated value |
| d | direct current or voltage |
| ac | alternating current or voltage |
| r | resistive or overvoltage |
| x | inductive |
| u | undervoltage |
| j | thyristor junction |

| | |
|---|---|
| v | valve or valve side of converter transformer |
| m | multiple valve (unit) |
| vs | valve support |
| s | switching impulse or stray |
| l | lightning impulse |
| st | steep-front impulse |
| PF | protective firing |
| RP | recovery protection |
| T | temporary |
| S | short term |
| SC | short circuit |
| max | maximum |
| min | minimum |
| rms | root mean square |
| av | average |
| ar | arrester |
| DRM | off-state repetitive maximum value |
| DSM | off-state non-repetitive maximum value |
| RRM | reverse repetitive maximum value |
| RSM | reverse non-repetitive maximum value |



### 3.2 Letter symbols

| | |
|---|---|
| $\alpha$ | (trigger/firing) delay angle |
| $\gamma$ | extinction angle |
| $\mu$ | (commutation) overlap angle |
| $X_t$ | commutation circuit reactance, including leakage reactance of converter transformer and other reactance in the commutation circuit which influence commutation process |
| $P_{cu}$ | on-load losses of converter transformer and DC smoothing reactor when a six-pulse bridge is operating at rated load |
| $R_{th}$ | equivalent resistance of the voltage drop of the thyristor valve |
| $f_N$ | rated AC system frequency |
| $t_p$ | valve conduction interval |
| $t_G$ | valve hold-off interval |
| $k_{df}$ | uneven voltage distribution factor, defined as the maximum deviation of the peak voltages of thyristor levels in a valve under the specified type of impulses, representing the degree of uneven voltage distribution due to tolerances of the voltage divider components, stray capacitances and differences in recovery charge of thyristors |

### 3.3 Abbreviations

MVU multiple valve (unit)

SIPL switching impulse protective level

LIPL lightning impulse protective level

STIPL steep-front impulse protective level

## 4 Service conditions

### 4.1 General

Thyristor valves shall be able to operate continuously and reliably under the specified service conditions throughout their entire service life except for maintenances. Such conditions are essential to define the ratings and characteristics of the thyristor valves, and mainly include the environmental conditions of valve halls under which thyristor valves will be required to operate, system conditions directly related to the design and operation of thyristor valves, main technical parameters of 6-pulse bridges required by the system design, and any other conditions provided by the purchaser. Some of these conditions may not be applicable depending on the HVDC system design.

### 4.2 Environmental conditions

#### 4.2.1 Site altitude

The altitude of the HVDC substation above sea-level shall be provided for insulation design of thyristor valves.



For external insulation (as defined in clause 3.1.3 of IEC 60700-1), the insulation level of thyristor valves under standardized reference atmospheric conditions shall be determined in accordance with clause 4.2 of IEC 60700-1.

For internal insulation (as defined in clause 3.1.3 of IEC 60700-1), clause 8.2 of IEC 60700-1 shall be referred to.

#### 4.2.2 Air temperature and humidity range in valve halls



The maximum temperature and minimum relative humidity inside valve halls shall be considered in the atmospheric correction according to clause 4.2 of IEC 60700-1. In addition, the air temperature and the relative humidity in the valve hall shall be considered to prevent condensation on any surface of components within the valve hall.

#### 4.2.3 Cleanness in valve halls

The cleanness in valve halls (e.g. equivalent salt deposit density on the surface of insulators and insulating materials) shall be provided for determination of creepage distances of thyristor valves. Dust and pollution in valve halls shall be kept as low as possible to avoid un-economical increase of creepage distances of thyristor valves.

#### 4.2.4 Seismic conditions

Thyristor valves shall have the ability to withstand seismic stresses and to maintain their function without failure during and after an earthquake of any specified intensity that may occur at the location of the HVDC substation. Maximum expected horizontal and vertical acceleration along with the frequency range of oscillations shall be provided.

### 4.3 System conditions

#### 4.3.1 General information of the system

This part shall include at least the following information：

a) the purpose of the project, and

b) rated power, and

c) direction of power flow, and

d) converter configuration, including a simple one-line diagram, and

e) converter operating modes such as monopolar, bipolar, parallel or multi-terminal, and

f) interface information.

NOTE1 For long distance HVDC transmission systems, the most commonly used converter unit configuration is one 12 pulse group per pole or two 12 pulse groups in series connection or parallel connection per pole. Each valve group is composed of two series connected 6 pulse bridges that are supplied from three single-phase three-winding transformers or six single-phase two-winding transformers. For more details on converter unit configuration refer to IEC 60919-1.

NOTE2 The interfaces between the thyristor valves and other components of the system have to be coordinated, including the location and dimensions of points of attachment on the floor of the valve hall or to the roof, dimensions of cable ducts for fiber optic cable, the location and dimensions of the connecting flange for cooling water pipes, and the interfaces to valve hall buswork.

#### 4.3.2 AC system voltage

The steady state and temporary state AC system voltage ranges shall be specified, including the maximum and minimum steady state voltages under rated operating condition, as well as the maximum and minimum temporary state voltages along with their durations during AC system faults and during the recovery period immediately following fault clearing. The temporary state AC system voltage range will directly affect the voltage ratings of thyristor valves.

#### 4.3.3 AC system frequency

The rated frequency, steady state frequency variation range, temporary state frequency variation range, as well as temporary state extreme frequency variation range shall be specified.

#### 4.3.4 DC system voltage



The rated DC voltage, and the maximum and minimum DC voltages in continuous operation considering control and measurement errors and manufacturing tolerance shall be specified.

If thyristor valves are required to operate continuously with reduced DC voltages, the DC system voltages, along with the operating parameters of the thyristor valves, i.e. valve side winding voltages and firing delay angles under these operating conditions, shall also be provided.

#### 4.3.5 DC system current and overload requirements



The rated DC current and minimum DC currents in continuous operation, as well as the required short term overload and temporary overload DC currents along with their durations shall be specified.

#### 4.3.6 Short circuit current requirements for thyristor valves

For converter units, short circuits can be caused by breakdown of external or internal insulation, i.e. flashover or puncture of insulators, or by inadvertent operation of switches, or from other causes. Usually the most severe fault is a short circuit of the thyristor valve operating in rectifier mode with minimum delay angle and maximum AC system voltage. The maximum peak values of one-loop and multiple-loop short circuit currents, along with their durations and the maximum peak values of re-applied forward voltages and reverse recovery voltages that the thyristor valves are required to withstand, shall be specified.

#### 4.3.7 Insulation coordination design related to thyristor valves

The required overvoltage withstand capability of thyristor valves, as well as the protective levels (residual voltages and coordination currents for specified types of overvoltage) of valve arresters, shall be specified, according to the insulation coordination design of the system.

A typical arrangement for the arresters directly related to the thyristor valves of a station consisting of two series connected 12-pulse converters per pole is shown in Figure 1. It should be noted that some of the arresters may be eliminated depending upon the specific design.

For thyristor valve design and test, the required withstand voltages for switching and lightning impulses of the valves between the locations, as shown in Figure 1, shall be specified, including:

a) withstand voltages across a valve, and

b) withstand voltages between the upper 12-pulse bridge DC bus and earth, and

c) withstand voltages between the upper 12-pulse bridge mid-point DC bus and earth, and