

---

**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

**iTeh STANDARD**  
**PREVIEW**

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: EN IEC 60700-3:2021**

<https://standards.iteh.ai/catalog/standards/sist/ed227478-5db-4ccd-8f00-56533ca219db/osist-pren-iec-60700-3-2022>

**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**

**iTeh STANDARD  
PREVIEW  
(standards.iteh.ai)**

oSIST prEN IEC 60700-3:2022

<https://standards.iteh.ai/catalog/standards/sist/ed227478-f5db-4ccd-8f00-56533ca219db/osist-pren-iec-60700-3-2022>



## 22F/667/CDV

## COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER:

**IEC 60700-3 ED1**

DATE OF CIRCULATION:

**2021-12-17**

CLOSING DATE FOR VOTING:

**2022-03-11**

SUPERSEDES DOCUMENTS:

**22F/640/CD, 22F/659/CC**

<b>IEC SC 22F</b>	
SECRETARIAT: <b>Russian Federation</b>	SECRETARY: <b>Mr. Lev TRAVIN</b>
OF INTEREST TO THE FOLLOWING COMMITTEES: <b>TC 115</b>	PROPOSED HORIZONTAL STANDARD: <input type="checkbox"/> Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: <input type="checkbox"/> EMC <input type="checkbox"/> ENVIRONMENT <input type="checkbox"/> QUALITY ASSURANCE <input type="checkbox"/> SAFETY	
<input checked="" type="checkbox"/> SUBMITTED FOR CENELEC PARALLEL VOTING <input type="checkbox"/> NOT SUBMITTED FOR CENELEC PARALLEL VOTING	
<b>Attention IEC-CENELEC parallel voting</b> 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. The CENELEC members are invited to vote through the CENELEC online voting system.	
This document is still under study and subject to change. It should not be used for reference purposes. Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.	

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

**Copyright © 2021 International Electrotechnical Commission, IEC.** All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.

## CONTENTS

	Page
1 Foreword .....	- 7 -
2 1 Scope .....	- 7 -
3 2 Normative references .....	- 7 -
4 3 Symbols and abbreviations .....	- 7 -
5 3.1 Subscripts .....	- 7 -
6 3.2 Letter symbols .....	- 8 -
7 3.3 Abbreviations .....	- 9 -
8 4 Service conditions .....	- 9 -
9 4.1 General .....	- 9 -
10 4.2 Environmental conditions .....	- 9 -
11 4.2.1 Site altitude .....	- 9 -
12 4.2.2 Air temperature and humidity range in valve halls .....	- 9 -
13 4.2.3 Cleanness in valve halls .....	- 9 -
14 4.2.4 Seismic conditions .....	- 9 -
15 4.3 System conditions .....	- 9 -
16 4.3.1 General information of the system .....	- 9 -
17 4.3.2 AC system voltage .....	- 10 -
18 4.3.3 AC system frequency .....	- 10 -
19 4.3.4 DC system voltage .....	- 10 -
20 4.3.5 DC system current and overload requirements .....	- 10 -
21 4.3.6 Short circuit current requirements for thyristor valves .....	- 10 -
22 4.3.7 Insulation coordination design related to thyristor valves .....	- 10 -
23 4.4 Technical parameters for 6-pulse bridge design .....	- 11 -
24 4.4.1 General .....	- 11 -
25 4.4.2 Voltage parameters .....	- 11 -
26 4.4.3 Current parameters .....	- 11 -
27 4.4.4 Valve arrester parameters .....	- 12 -
28 4.4.5 Other system parameters .....	- 12 -
29 4.5 Other conditions .....	- 13 -
30 5 Ratings .....	- 13 -
31 5.1 Voltage and current ratings (limiting values) .....	- 13 -
32 5.1.1 Rated AC voltage across valve ( $U_{V0N}$ ) .....	- 13 -
33 5.1.2 Maximum steady state AC voltage across valve ( $U_{V0max}$ ) .....	- 13 -
34 5.1.3 Maximum temporary state AC voltage across valve ( $U_{V0maxT}$ ) .....	- 13 -
35 5.1.4 Minimum temporary state AC voltage across valve ( $U_{V0minT}$ ) .....	- 13 -
36 5.1.5 Valve repetitive peak off-state voltage ( $U_{VDRM}$ ) .....	- 13 -
37 5.1.6 Valve non-repetitive peak off-state voltage ( $U_{VDSM}$ ) .....	- 13 -
38 5.1.7 Valve repetitive peak reverse voltage ( $U_{VRRM}$ ) .....	- 14 -
39 5.1.8 Valve non-repetitive peak reverse voltage ( $U_{VRSM}$ ) .....	- 14 -
40 5.1.9 Valve switching impulse withstand voltage ( $SIWV_V$ ) .....	- 14 -
41 5.1.10 Valve lightning impulse withstand voltage ( $LIWV_V$ ) .....	- 14 -
42 5.1.11 Valve steep-front impulse withstand voltage ( $STIWV_V$ ) .....	- 14 -
43 5.1.12 Valve switching impulse protective firing voltage ( $SIPL_{PF}$ ) .....	- 14 -
44 5.1.13 Valve RMS current ( $I_{V(rms)}$ ) .....	- 14 -
45 5.1.14 Valve average current ( $I_{V(av)}$ ) .....	- 14 -
46 5.1.15 Valve one-loop fault current with re-applied forward voltage ( $I_{SC\alpha}$ ) .....	- 14 -
47 5.1.16 Valve multiple-loop fault current without re-applied forward voltage ( $I_{SC\beta}$ ) .....	- 15 -

50	5.2	Delay and extinction angle ratings (limiting values).....	15 -
51	5.2.1	Rated firing delay angle ( $\alpha_N$ ) .....	15 -
52	5.2.2	Minimum allowable firing delay angle ( $\alpha_{\min}$ ) .....	15 -
53	5.2.3	Maximum allowable firing delay angle ( $\alpha_{\max}$ ) .....	15 -
54	5.2.4	Minimum temporary state firing delay angle ( $\alpha_{\min T}$ ) .....	15 -
55	5.2.5	Rated extinction angle ( $\gamma_N$ ) .....	15 -
56	5.2.6	Minimum allowable extinction angle ( $\gamma_{\min}$ ) .....	15 -
57	5.2.7	Maximum allowable extinction angle ( $\gamma_{\max}$ ) .....	15 -
58	5.2.8	Minimum temporary state extinction angle ( $\gamma_{\min T}$ ) .....	15 -
59	5.3	Insulation and test voltage levels (limiting values).....	15 -
60	5.3.1	Maximum DC voltage between valve terminals ( $U_{d(v)\max}$ ).....	15 -
61	5.3.2	Maximum DC voltage across multiple valve unit ( $U_{d(m)\max}$ ) .....	16 -
62	5.3.3	Maximum DC voltage across valve support ( $U_{d(vs)\max}$ ).....	16 -
63	5.3.4	Maximum AC voltage between valve terminals ( $U_{ac(v)\max}$ ).....	16 -
64	5.3.5	Maximum AC voltage across multiple valve unit ( $U_{ac(m)\max}$ ) .....	16 -
65	5.3.6	Maximum AC voltage across valve support ( $U_{ac(vs)\max}$ ).....	16 -
66	5.3.7	Maximum switching impulse voltage between valve terminals ( $U_{s(v)\max}$ ) ..	17 -
67	5.3.8	Maximum switching impulse voltage across multiple valve unit ( $U_{s(m)\max}$ ) ..	17 -
68	5.3.9	Maximum switching impulse voltage across valve support ( $U_{s(vs)\max}$ ) .....	17 -
69	5.3.10	Maximum lightning impulse voltage between valve terminals ( $U_{l(v)\max}$ ) ...	17 -
70	5.3.11	Maximum lightning impulse voltage across multiple valve unit ( $U_{l(m)\max}$ ) ..	17 -
71	5.3.12	Maximum lightning impulse voltage across valve support ( $U_{l(vs)\max}$ ) .....	17 -
72	5.3.13	Maximum steep-front impulse voltage between valve terminals ( $U_{st(v)\max}$ ) ..	18 -
73	5.3.14	Maximum steep-front impulse voltage across multiple valve unit ( $U_{st(m)\max}$ ) ..	18 -
74		-	
75	5.3.15	Maximum steep-front impulse voltage across valve support ( $U_{st(vs)\max}$ ) ..	18 -
76	6	Characteristics .....	18 -
77	6.1	General.....	18 -
78	6.2	Losses characteristics.....	18 -
79	6.2.1	General.....	18 -
80	6.2.2	Maximum load loss per valve at rated condition ( $P_{v0\max}$ ) .....	19 -
81	6.2.3	Maximum no-load loss per valve ( $P_{v0\max}$ ) .....	19 -
82	6.2.4	Maximum heat emission to valve hall ( $P_{E\max}$ ) .....	19 -
83	6.3	Protection characteristics .....	19 -
84	6.3.1	Valve lightning impulse protective firing voltage (LIPL <sub>PF</sub> ) .....	19 -
85	6.3.2	Valve steep-front impulse protective firing voltage (STIPL <sub>PF</sub> ) .....	19 -
86	6.3.3	Thyristor protective firing level ( $V_{PF}$ ) .....	19 -
87	6.3.4	Thyristor forward recovery protection level ( $V_{RP}$ ) .....	19 -
88	6.3.5	Thyristor forward du/dt protection level ( $du/dt_{PF}$ ) .....	19 -
89	6.3.6	Valve protective firing trip level ( $N_{tripPF}$ ) .....	19 -
90	6.3.7	Valve loss of redundancy trip level ( $N_{trip}$ ) .....	20 -
91	6.4	Temperature characteristics .....	20 -
92	6.4.1	Maximum cooling medium temperature at valve inlet ( $T_{(in)\max}$ ) .....	20 -
93	6.4.2	Maximum cooling medium temperature at valve outlet ( $T_{(out)\max}$ ) .....	20 -
94	6.4.3	Thyristor junction temperature at rated condition ( $T_{jN}$ ) .....	20 -
95	6.4.4	Maximum thyristor junction temperature ( $T_{j\max}$ ) .....	20 -
96	6.4.5	Storage temperature ( $T_{stg}$ ) .....	20 -
97	6.5	Reliability characteristics .....	20 -
98	6.5.1	General .....	20 -
99	6.5.2	Expected annual failure rate of thyristor level ( $\lambda_E$ ) .....	20 -

100	6.6	Other characteristics .....	- 21 -
101	6.6.1	Valve on-state voltage ( $U_{V(on)}$ ) .....	- 21 -
102	6.6.2	Maximum steady state operating time at $\alpha=90^\circ$ ( $t_{90max}$ ) .....	- 21 -
103	6.6.3	Maximum temporary state operating time at $\alpha=90^\circ$ ( $t_{90maxT}$ ) .....	- 21 -
104	6.6.4	Maximum steady state commutation overshoot factor ( $k_c$ ) .....	- 21 -
105	6.6.5	Maximum temporary state commutation overshoot factor ( $k_{cT}$ ) .....	- 21 -
106	Figure 1-	Typical arrester arrangement for converter units with two 12-pulse bridges in	
107		series .....	- 22 -
108	Figure 2--	Operating voltage of valve and valve arrester in rectified mode .....	- 23 -
109	Figure 3 -	Thyristor valve voltage waveforms in different operation modes .....	- 23 -
110	Figure 4-	One loop valve short circuit current and voltage waveforms .....	- 24 -
111	Figure 5 -	Multiple loop valve short circuit current and voltage waveforms .....	- 24 -
112	Figure 6 -	Continuous operating voltages at various locations for a 12-pulse bridge in rectifier	
113		mode .....	- 25 -
114	Annex A	Input parameters for thyristor valve design .....	- 26 -
115	Annex B	Technical data sheet of thyristor valves .....	- 29 -
116	Bibliography	.....	- 33 -

# iTeh STANDARD PREVIEW (standards.iteh.ai)

oSIST prEN IEC 60700-3:2022

<https://standards.iteh.ai/catalog/standards/sist/ed227478-f5db-4ccd-8f00-56533ca219db/osist-pren-iec-60700-3-2022>

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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

### **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.

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

- 171 • reconfirmed,  
172 • withdrawn,  
173 • replaced by a revised edition, or  
174 • amended.

175

176

177

178

179

180

181

182

183

## iTeh STANDARD PREVIEW (standards.iteh.ai)

[oSIST prEN IEC 60700-3:2022](https://standards.iteh.ai/catalog/standards/sist/ed227478-f5db-4ccd-8f00-56533ca219db/osist-pren-iec-60700-3-2022)

<https://standards.iteh.ai/catalog/standards/sist/ed227478-f5db-4ccd-8f00-56533ca219db/osist-pren-iec-60700-3-2022>



# 184 THYRISTOR VALVES FOR HIGH VOLTAGE DIRECT CURRENT (HVDC)

## 185 POWER TRANSMISSION –

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

#### 188 1 Scope

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

#### 194 2 Normative references

195 The following referenced documents are indispensable for the application of this document. For dated  
196 references, only the edition cited applies. For undated references, the latest edition of the referenced  
197 document (including any amendments) applies.

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

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

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

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

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

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

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

#### 210 3 Symbols and abbreviations

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

##### 214 3.1 Subscripts

215	0 (zero)	at no load
216	i	ideal
217	N	nominal or rated value
218	d	direct current or voltage
219	ac	alternating current or voltage
220	r	resistive or overvoltage
221	x	inductive
222	u	undervoltage
223	j	thyristor junction

224	v	valve or valve side of converter transformer
225	m	multiple valve (unit)
226	vs	valve support
227	s	switching impulse or stray
228	l	lightning impulse
229	st	steep-front impulse
230	PF	protective firing
231	RP	recovery protection
232	T	temporary
233	S	short term
234	SC	short circuit
235	max	maximum
236	min	minimum
237	rms	root mean square
238	av	average
239	ar	arrester
240	DRM	off-state repetitive maximum value
241	DSM	off-state non-repetitive maximum value
242	RRM	reverse repetitive maximum value
243	RSM	reverse non-repetitive maximum value
244	<b>3.2 Letter symbols</b>	
245	$\alpha$	(trigger/firing) delay angle
246	$\gamma$	extinction angle
247	$\mu$	(commutation) overlap angle
248	$X_t$	commutation circuit reactance, including leakage reactance of converter transformer and other
249		reactance in the commutation circuit which influence commutation process
250	$P_{cu}$	on-load losses of converter transformer and DC smoothing reactor when a six-pulse bridge is
251		operating at rated load
252	$R_{th}$	equivalent resistance of the voltage drop of the thyristor valve
253	$f_N$	rated AC system frequency
254	$t_p$	valve conduction interval
255	$t_G$	valve hold-off interval
256	$k_{df}$	uneven voltage distribution factor, defined as the maximum deviation of the peak voltages of
257		thyristor levels in a valve under the specified type of impulses, representing the degree of
258		uneven voltage distribution due to tolerances of the voltage divider components, stray
259		capacitances and differences in recovery charge of thyristors

ITeh STANDARD  
PREVIEW  
(standards.iteh.ai)

oSIST prEN IEC 60700-3:2022

<https://standards.iteh.ai/catalog/standards/sist/ed227478-511-4-018/00-56533-m210-05/osist-pren-iec-60700-3-2022>

2022

### 260 3.3 Abbreviations

- 261 MVU multiple valve (unit)
- 262 SIPL switching impulse protective level
- 263 LIPL lightning impulse protective level
- 264 STIPL steep-front impulse protective level

## 265 4 Service conditions

### 266 4.1 General

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

### 274 4.2 Environmental conditions

#### 275 4.2.1 Site altitude

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

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

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

#### 283 4.2.2 Air temperature and humidity range in valve halls

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

#### 288 4.2.3 Cleanness in valve halls

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

#### 293 4.2.4 Seismic conditions

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

### 298 4.3 System conditions

#### 299 4.3.1 General information of the system

300 This part shall include at least the following information:

- 301 a) the purpose of the project, and
- 302 b) rated power, and
- 303 c) direction of power flow, and
- 304 d) converter configuration, including a simple one-line diagram, and

- 305 e) converter operating modes such as monopolar, bipolar, parallel or multi-terminal, and  
 306 f) interface information.

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

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

### 315 4.3.2 AC system voltage

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

### 321 4.3.3 AC system frequency

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

### 324 4.3.4 DC system voltage

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

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

### 330 4.3.5 DC system current and overload requirements

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

### 333 4.3.6 Short circuit current requirements for thyristor valves

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

### 341 4.3.7 Insulation coordination design related to thyristor valves

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

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

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

- 350 a) withstand voltages across a valve, and  
 351 b) withstand voltages between the upper 12-pulse bridge DC bus and earth, and  
 352 c) withstand voltages between the upper 12-pulse bridge mid-point DC bus and earth, and