RUSSIAN MARITIME REGISTER OF SHIPPING

CIRCULAR LETTER **No. 315-22-1900c** dated 20.02.2023

Re:

amendments to the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, 2023, ND No. 2-020101-175-E with regard to the requirements for testing of electrical equipment with rated voltage 15 ─ 220 кV

Item(s) of supervision:

Electrical equipment with rated voltage 15 ─ 220 кV

Entry-into-force date:
01.03.2023

~~Cancels / amends / adds Circular Letter No.~~ ~~dated~~

Number of pages: 1+51

Appendices:

Appendix 1: information on amendments introduced by the Circular Letter

Appendix 2: text of amendments to Section 10, Part IV "Technical Supervision during Manufacture of Products"

Acting Director General Sergey A. Kulikov

Text of CL:

We hereby inform that the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships shall be amended as specified in the Appendices to the Circular Letter.

It is necessary to do the following:

1. Bring the content of the Circular Letter to the notice of the RS surveyors, interested organizations and persons in the area of the RS Branch Offices' activity.
2. Apply the provisions of this Circular Letter during review and approval of technical documentation for the ships contracted for construction or conversion on or after 01.03.2023, and where no contract for construction is available – in compliance with 5.10 of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, starting from 01.03.2023.

List of the amended and/or introduced paras/chapters/sections:

paras 10.1.2, 10.4.4, 10.4.6.2.1─10.4.6.2.3, 10.4.6.6.1, 10.4.6.10, 10.5.1.1, 10.7.2.6, 10.7.5.9 and 10.7.18─10.7.27; Tables 10.8.4-1 and 10.8.4-2

Person in charge: A.Yu. Bessonov 315 +7(812) 605-05-17

"Thesis" System No. 22-222628

Appendix 1 to Circular Letter
No. 315-22-1900c dated 20.02.2023

Information on amendments introduced by the Circular Letter (for inclusion in the Revision History to the RS Publication)

Nos.	Amended paras/chapters/ sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
1	Para 10.1.2	The requirements for testing equipment and cables of 15─220 kV have been introduced	315-22-1900c of 20.02.2023	01.03.2023
2	Para 10.4.4	The requirements for testing equipment and cables of 15─220 kV have been introduced	315-22-1900c of 20.02.2023	01.03.2023
3	Para 10.4.6.2.1	The requirements for testing equipment and cables of 15─220 kV have been introduced	315-22-1900c of 20.02.2023	01.03.2023
4	Para 10.4.6.2.2	New para 10.4.6.2.2 has been introduced with the requirements for testing transformer winding insulation for winding voltage 15–220 kV at the firm (manufacturer)	315-22-1900c of 20.02.2023	01.03.2023
5	Para 10.4.6.2.3	New para 10.4.6.2.3 has been introduced. Para 10.4.6.2.2 and references thereto has been renumbered 10.4.6.2.3	315-22-1900c of 20.02.2023	01.03.2023
6	Para 10.4.6.6.1	Requirements have been introduced to testing of equipment and cables 15─220 kV considering the requirements of IEC 60502- 2:2014 and IEC 60840:2017	315-22-1900c of 20.02.2023	01.03.2023
7	Para 10.4.6.10	New para 10.4.6.10 has been introduced containing the requirements for testing high voltage equipment in excess of 15 kV	315-22-1900c of 20.02.2023	01.03.2023
8	Para 10.5.1.1	Requirements for testing equipment and cables of 15─220 kV have been introduced	315-22-1900c of 20.02.2023	01.03.2023
9	Para 10.7.2.6	Paras 10.7.2.6 ─ 10.7.2.6.18.2 have been introduced containing the requirements for testing power transformers for the voltage of 15–220 kV	315-22-1900c of 20.02.2023	01.03.2023

Nos.	Amended paras/chapters/ sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
10	Para 10.7.5.9	New para 10.7.5.9 has been introduced containing the requirements for testing integrated switchgear (IS) of indoor installation, high-voltage sections of transformer substations (TS) of 15–35 kV	315-22-1900c of 20.02.2023	01.03.2023
11	Paras 10.7.18—10.7.27	New paras 10.7.18—10.7.27 have been introduced containing the requirements for testing of integrated metal sheathed gas-insulated switchgears (GIS)	315-22-1900c of 20.02.2023	01.03.2023
12	Table 10.8.4-1	Requirements for current limiting and shunting reactors have been introduced	315-22-1900c of 20.02.2023	01.03.2023
13	Table 10.8.4-2	Requirements for the equipment to be applied in 15—220 kV systems have been introduced	315-22-1900c of 20.02.2023	01.03.2023

Appendix 2 to Circular Letter
No. 315-22-1900c dated 20.02.2023

RULES FOR TECHNICAL SUPERVISION DURING CONSTRUCTION OF SHIPS AND MANUFACTURE OF MATERIALS AND PRODUCTS FOR SHIPS, 2023,

ND No. 2-020101-175-E

PART IV. TECHNICAL SUPERVISION DURING MANUFACTURE OF PRODUCTS

10 ELECTRICAL EQUIPMENT

1 **Para 10.1.2** is replaced by the text reading as follows:

"**10.1.2** The Section contains the basic provisions on surveying and testing at the firm (manufacturer) of product prototypes and products at steady production.

The technical instructions and test standards specified in 10.3 to 10.7 pertain equally to product prototypes and products at steady production.

The instructions relating to the scope of checks and tests during surveying products at steady production are given in 10.8.

General and special types of tests and checks of product prototypes and products at steady production are given in Tables 10.1.2-1 and 10.1.2-2.

General and special types of tests and checks of product prototypes and products at steady production of the equipment and cables 15─220 kV are given in Tables 10.1.2-3 and 10.1.2-4.

Table 10.1.2-1

General types of tests and checks of product prototypes and products at steady production of electrical equipment

Item No.	Products	Inspection and checks		Measurements of insulation resistance		Check of operability		Tests of electrical insulating strength		Tests for compliance with operational conditions (mechanical and environmental)		Tests of protective enclosures		Heat tests		Overcurrent tests		Check of radio interference level		Tests for resistance to electromagnetic interference (EMI)	
		P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
1	Electrical machines [1]	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+			
2	Transformers [2]	+	+	+	+	+	+	+	+	+		+	+	+		+	+				
3	Static converters	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+		+	
4	Accumulators	+	+	+	+			+	+	+		+									
5	Switchgear	+	+	+	+	+	+	+	+	+		+	+	+				+[3]		+	
16	Electrical apparatus (switching, protective, etc.)	+	+	+	+	+	+	+	+	+		+	+	+				+		+	
7	Capacitors and capacitor sets to raise a power factor	+	+	+	+			+	+	+		+									
8	Busducts	+	+	+	+			+	+	+		+	+	+		+					
9	Electrical measuring instruments	+	+	+	+	+	+	+	+	+		+	+	+				+		+	
10	Electric drives (as a set)	+	+	+	+	+	+	+	+	+		+						+		+	
11	Electrical equipment of electrically-started internal combustion engines	+	+	+	+	+	+	+	+	+		+		+				+		+	
12	Lightning fixtures, search lights and control gear of gas-discharge lamps	+	+	+[4]	+	+	+	+[4]	+	+		+	+	+[4]				+[5]		+	
13	Ship's control and monitoring, communication and alarm devices	+	+	+	+	+	+	+	+	+		+		+				+[6]		+	
14	Cable products	+	+	+	+	–	–	+	+	+		+		+							
15	Heating and cooking appliances	+	+	+	+	+	+	+	+	+		+									
16	Items and devices for installation, splicing and connection of cables and wires	+	+	(+)	(+)	(+)	(+)	(+)	(+)	(+)				(+)							

Symbols :
P = prototype;
S = production sample;
+ = test is needed;
(+) = test performance and the scope of tests depend on the particular product;
– = test is not needed.

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[1] For electric motors over 2 kW.
[2] For power transformers only.
[3] For navigation lights commutators.
[4] Excepting accumulator, portable, explosion-proof lighting fixtures.
[5] Excepting the lightening fixtures with incandescent lamps and with no ignition control devices.
[6] For engine telegraphs, sensors of rudder angle and blade angle indicators, tachometers, telephone switchboards and apparatus of light and sound alarm devices, switches.

Table 10.1.2-2

Special types of prototype testing and checks and product testing during steady-state production of electrical equipment

Item No.	Products	Torque overload tests		Stalling tests		Tests for immunity to shortcircuit		Overspeed tests		Check of commutator machines commutation		Check of operability at load loss and increase		Check of secondary voltage variation value		Tests for limiting commutation stability		Check for operate and release values		Check of manual interlocks operation		Check of manual drive and an indicator of commutation		Check of electromagnetic brakes operation		Check of minimal voltage protection		Check of track and limit switches operation		Heat stability tests		Check of on-load and no-load operation		Check of capacitors discharge time		Insulation breakdown tests		Tests for tightness of tanks, cans, monoblocks and other products		Check of automatic starting after voltage recovery		Measuring of loss-angle tangent		Check of protection and alarm systems		Check of mechanical and thermoplastic properties of cables	
		P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
1	Electrical machines	+[1]		+[2]		+[3]		+		+[4]																																		+	+		
2	Transformers [5]					+								+																								+[6]	+								
3	Static converters					+						+																																+	+		
4	Accumulators																												+[7]									+[8]	+								
5	Switchgear					+																							+																	
6	Electrical apparatus (switching, protective, etc.)					+[9]										+		+[10]		+	+	+[11]	+																								
7	Capacitors and capacitor sets to raise a power factor																												+					+	+			+	+			+	+				
8	Busducts					+																														+[12]				+[13]	+			+	+		
9	Electrical measuring instruments																																														

Item No.	Products	Torque overload tests		Stalling tests		Tests for immunity to shortcircuit		Overspeed tests		Check of commutator machines commutation		Check of operability at load loss and increase		Check of secondary voltage variation value		Tests for limiting commutation stability		Check for operate and release values		Check of manual interlocks operation		Check of manual drive and an indicator of commutation		Check of electromagnetic brakes operation		Check of minimal voltage protection		Check of track and limit switches operation		Heat stability tests		Check of on-load and no-load operation		Check of capacitors discharge time		Insulation breakdown tests		Tests for tightness of tanks, cans, monoblocks and other products		Check of automatic starting after voltage recovery		Measuring of loss-angle tangent		Check of protection and alarm systems		Check of mechanical and thermoplastic properties of cables	
		P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
10	Electric drives (as a set)			+[14]																+[15]	+	+	+	+	+	+		+	+			+	+																
11	Electrical equipment of electrically-started internal combustion engines																							+																							
12	Lighting fixtures and control gear of gas discharge lamps																													+				+[16]													
13	Ship’s control and monitoring, communication and alarm devices																																							+[17]	+					+	+[18]
14	Cable products																																			+											
15	Heating and cooking appliances																																														

Symbols – refer to Table 10.1.2-1.

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[1] For a.c. and d.c. electric motors.
[2] For propulsion motors, anchor and mooring machinery motors, and motors of the direct drive of the rudder and steering gear.
[3] For a.c. and d.c. generators.
[4] For d.c. generators and motors, control generators, phase-wound motors and other commutator machines.
[5] For power transformers and current transformers.
[6] For power transformers with dielectric liquid only.
[7] Tests for heat resistance of the acid battery mastic.
[8] Checking of acid battery monoblocks tightness.
[9] Applied to circuit breakers, switches, breakers, disconnectors, contactors, current relays and other relays connected in series in power circuits.
[10] For circuit breakers, starters, controllers, electromagnetic brakes, electrohydraulic pushers.
[11] For circuit breakers, switches, breakers, disconnectors, starters, field rheostat controllers.
[12] For insulators, busducts and other insulators.
[13] For steering machinery and watertight doors machinery.
[14] For anchor and mooring machinery and directly-driven steering machinery.
[15] For boat winches, lifts, watertight door drives.
[16] For lighting fixtures with gas-discharge lamps.
[17] Fuel-oil and luboil heaters if covered by 1.3.2.1, Part XI “Electrical Equipment” of the Rules for the Classification and Construction of Sea-Going Ships.
[18] Periodically and selectively by agreement with the Register.

Table 10.1.2-3

General types of tests and checks of product prototypes and products at steady production of electrical equipment 15– 220 kV

Item No.	Products	Inspection and checks		Measurements of insulation resistance		Check of operability		Tests of electrical insulating strength		Tests for compliance with operational conditions (mechanical and environmental)		Tests of protective enclosures		Heat tests		Overcurrent tests		Check of radio interference level		Tests for resistance to electromagnetic interference (EMI)	
		P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
1	Transformers[1]	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+			
2	Integrated switchgears 15–35 kV	+	+	+	+	+	+	+	+	+		+	+	+				+		+	
3	Integrated gas-insulated switchgears 35–220 kV	+	+	+	+	+	+	+	+	+		+	+	+		+		+		+	
4	Shielded current lead 15–35 kV	+	+	+	+	+	+	+	+	+		+	+	+		+					
5	Gas-insulated current lead 110–220 kV	+	+	+	+	+	+	+	+	+		+	+	+		+					

Item No.	Products	Inspection and checks		Measurements of insulation resistance		Check of operability		Tests of electrical insulating strength		Tests for compliance with operational conditions (mechanical and environmental)		Tests of protective enclosures		Heat tests		Overcurrent tests		Check of radio interference level		Tests for resistance to electromagnetic interference (EMI)	
		P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
6	Cast (solid) insulated current leads 15–35 kV	+	+	+	+	+	+	+	+	+		+	+	+							
7	Collecting busbars, rigid busbar (including insulators as a part of equipment)	+	+	+	+	+	+	+	+	+		+	+								
8	Dry current-limiting reactors	+	+	+	+	+	+	+	+	+		+	+	+		+	+				
9	Valve-type arresters, overvoltage limiters.	+	+	+	+	+	+	+	+	+		+	+								
10	Entries and bushings 110–220 kV	+	+	+	+	+	+	+	+	+		+	+								
11	Fuses, disconnecting fuses 15 ─ 35 kV	+	+	+	+	+	+	+	+	+		+	+								
12	Cable products	+	+	+	+	-	-	+	+	+		+		+							
13	Items and devices for installation, splicing and connection of cables and wires	+	+	(+)	(+)	+	+	+	+	+				(+)							

Symbols :
P = prototype;
S = production sample;
+ = test is needed;
(+) = test performance and the scope of tests depend on the particular product;
– = test is not needed.

[1]For power transformers only.

Table 10.1.2-4

Special types of tests and checks of product prototypes and products at steady production of electrical equipment 15–220 kV

Item No.	Products	Tests for immunity to shortcircuit		Check of secondary voltage variation value		Tests for limiting commutation stability		Check for operate and release values		Check of manual interlocks operation		Check of manual drive and an indicator of commutation		Heat stability tests		Insulation breakdown tests		Tests for tightness of tanks, cans, monoblocks and other products		Measuring of loss-angle tangent		Check of protection and alarm systems		Testing of cable insulation by excessive rectified voltage		Partial discharge level check	
		P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S	P	S
1	Transformers[1]	+		+														+[3]	+[3]	+	+	+	+			+[5]	+[5]
2	Integrated switchgears 15–35 kV	+				+[2]		+[2]		+[2]	+[2]	+[2]	+[2]	+		+						+	+				
3	Integrated gas-insulated switchgears 35–220 kV	+				+[2]		+[2]		+[2]	+[2]	+[2]	+[2]	+		+		+	+			+	+			+	+
4	Shielded current lead 15–35 kV	+												+		+										+	
5	Gas-insulated current lead 110–220 kV	+												+		+		+	+			+				+	
6	Cast (solid) insulated current leads 15–35 kV	+												+		+										+	
7	Collecting busbars, rigid busbar (including insulators as a part of equipment)	+																									
8	Dry current-limiting reactors	+												+								+					
9	Valve-type arresters, overvoltage limiters	+																									
10	35–220 kV entries and bushing insulators																			+[4]	+[4]					+	+
11	Fuses, disconnecting fuses 15–35 kV					+																					
12	Cable products															+				+	+			+	+		

Symbols :
P = prototype;
S = production sample;
+ = test is needed;
(+) = test performance and the scope of tests depend on the particular product;
– = test is not needed.

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[1] For power transformers only.
[2] Applied to breakers, switches, disconnectors being direct constituents of IS and/or GIS.
[3] For power transformers with liquid dielectric.
[4] For oil entries and bushing insulators.
[5] For power transformers of 110–220 kV voltage class.

“

2 **Para 10.4.4** is replaced by the text reading as follows:

"**10.4.4 Tests of insulation strength.**

10.4.4.1 The insulation strength of products, excepting single types specified in 10.4.6 where the time, voltage and frequency are specially stipulated, shall be tested during 1 min by the application of alternating voltage of the practically sinusoidal form with a frequency of 50 Hz at normal environmental conditions according to the following:

Voltage, in V

B Rated U_R	Test
Up to 65	$2U_H$ + 500
66–250	1500
251–500	2000
501–1000	$2U_H$ + 1000
1001–3600	10000
3601–7200	20000
7201–11000	28000
11001–15000	45000
15001–20000	55000
20001–24000	65000
24001–27000	70000
27001–35000	85000
35001–110000	200000
110001–150000	230000
150001–220000	325000

N o t e s: 1. The semiconductor elements of electrical devices that may be damaged during the tests may be disconnected under tests. During shutoff of the specified components the test voltage value shall be defined by the manufacturer with due regard to specifications of such elements.

2. The error in measuring the test voltage is not more than ±1,5 %.".

3 **Para 10.4.6.2.1** is replaced by the text reading as follows:

"**10.4.6.2.1** In testing of winding insulation for transformers rated at up to 1000 V at the firm (manufacturer), the windings shall withstand the test voltage of rms values given in Table 10.4.6.2.1- 1.

T a b l e 10.4.6.2.1-1

Transformers	Rated voltage of windings, in V	Test voltage, in kV
Power ones:		
three-phase rated at up to 6,3 kVA	Up to 50	1,0
single-phase rated at up to 4,0 kVA	51–250	1,5
	251–400	2,0
	401–660	2,5
	661–1000	3,0
three-phase rated over 6,3 kVA	127–1000	3,0
single-phase rated over 4,0 kVA	127–1000	3,0

In testing of winding insulation for transformers for 15—220 kV voltage at the firm (manufacturer), the windings shall withstand the test voltage of full and chopped lightning pulse, the actual values of which are given in Table 10.4.6.2.1-2.

Testing voltages of full and chopped lightning pulses shall represent standard voltage full and chopped lightning pulses, accordingly.

Full voltage lightning pulse (full lightning pulse) is the pulse characterized by the voltage rising to its maximum value in a time range of microsecond fractions to 20 μs followed by a less rapid voltage drop to zero.

Chopped voltage lightning pulse (chopped lightning pulse) is the pulse having a voltage decrease rate significantly greater than the voltage change rate at the time point immediately preceding the fall point.

Table 10.4.6.2.1-2

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage of internal and external insulation			
		lightning pulse		short-term (one minute) alternating voltage	
		full	chopped	dry	in the rain
		Power transformers, shunting reactors relative to ground and between phases (poles)[2]	Power transformers, shunting reactors relative to ground and between phases (poles)[2]	10. Power transformers, shunting reactors relative to ground and between phases (poles)[2]	Power transformers, shunting reactors relative to ground and between phases (poles)[2]
1	2	3	4	5	6
15–19	a	95	115	38	-
	b			45	
20–23	a	125	150	50	-
	b			55	
24–26	a	150	175	60	-
	b			65	
27–34	a	170	200	65	-
	b			70	
35–109	a	190	220	80	-
	b			85	
110–149	-	480	550	200	-
150–219	-	550	600	230/275[3]	-
220	-	750	835	325/395[3]	-

[1] Insulation level:
a – for electrical equipment with paper-oil and cast insulation, designed with the requirement of checking the insulation for the absence of partial discharges according to 4.10, for other electrical equipment – to be determined by agreement between the manufacturer and the user; insulation level
b – for electrical equipment designed without the requirement of checking the insulation for the absence of partial discharges.
[2] For electrical equipment of three-phase (three-pole) version.
[3] The denominator indicates values for the dry state test of transformers and shunt reactors between phases, the numerator indicates values relative to the ground.

The standardized test voltages of the high voltage (HV) winding insulation of power transformers of 110, 150 and 220 kV classes with incomplete neutral insulation allowing operation with neutral un-grounding are given in Table 10.4.6.2.1-3.

Table 10.4.6.2.1-3

Transformer voltage class, in kV	Short-time test voltage of mains frequency; actual value, in kV				Test voltage of full lightning pulse of internal and external neutral insulation and neutral entry; maximum value, in kV
	One-minute voltage of internal insulation		Voltage (at smooth rise) of external insulation		
	of neutral	neutral entry, tested separately	in dry state	in the rain	
			of neutral and neutral entry	neutral entry location category 1	
1	2	3	4	5	6
110–149	100	130	135	110	200
150–219	130	180	195	155	275
220	200	265	280	215	400

The following pulses shall be applied during testing: for the internal insulation of power transformers, reactors – negative polarity pulses; for the external insulation of power transformers and shunting reactors – positive polarity pulses; for external insulation between phases of power transformers – opposite polarity pulses with values on each of the two tested phases equal to half the standardized test voltage; the third phase shall be earthed.

The methods for insulation testing by lightning pulses and the test endurance criteria shall comply with the standards for the individual types of electrical equipment and shall be in accordance with IEC 60060-1:2010.

The following test procedures shall be used:

for the internal insulation of electrical equipment (except for gas-filled equipment) – three-impact method;

for the external insulation of electrical equipment and internal insulation of gas-filled electrical equipment – 15-impact method.

During the test (three-impact or 15-impact method) the standardized number of pulses of test voltage of each polarity (positive and negative) or only one polarity shall be applied in accordance with the instructions in the standard documentation for insulation resistance requirements (in accordance with IEC 60060-1:2010).

For the external insulation of power transformers, it is permissible to use the 50 % discharge voltage method instead of the 15-impact method, whereby the withstand voltage with a 90 % probability shall not be less than the appropriate test voltage.

Testing of the internal and external insulation of power transformers and reactors with lightning pulse voltages may be carried out simultaneously; the requirements for both internal and external insulation with respect to polarity, number of pulses and their maximum value, which shall be the highest of the two values standardized for internal and external insulation, with correction for atmospheric conditions during testing for the latter, shall be met.".

4 **New para 10.4.6.2.2** is introduced reading as follows:

"**10.4.6.2.2** In testing of winding insulation of transformers for the voltage of 15─220 kV at the firm (manufacturer), the windings shall withstand the test short-term alternating voltages of the mains frequency. The rms values of the standardized test voltages for the air gaps of electrical equipment of the voltage classes 15 to 220 kV are given in Table 10.4.6.2.2.

An aperiodic voltage pulse (aperiodic pulse) is a pulse the shape of which can be described by the sum of two exponential functions.

Test short-term alternating voltage of the mains frequency means sinusoidal voltage at a frequency of 50 Hz or (when testing power transformers and reactors with voltage induced in the transformer or reactor under test) of increased frequency, but not exceeding 400 Hz.

Test alternating one-minute voltage (one-minute test voltage) means test alternating voltage applied to the insulation for 1 minute or, in certain cases, a different time, but not exceeding 5 minutes.

Switching voltage pulse (switching pulse) – is a pulse characterized by a voltage rise to its maximum value within a period of 20 μs to several thousand microseconds and a subsequent decrease of the voltage value.

Variable voltage at smooth rise means variable voltage applied rising at a defined speed from zero to the overlap or to a defined value followed by a rapid fall to zero without delay.

Table 10.4.6.2.2

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage	
		variable at smooth rise	
		relative to ground	between phases
1	2	3	4
15–19	a,b	60	-
20–23	a,b	70	-
24–26	a,b	80	-
27–34	a,b	90	-
35–109	a,b	105	-
110–149	a,b	280	-
150–219	a,b	320	415
220	a,b	465	600
[1] The conditions for the application of the insulation levels are shown in Table 10.4.6.2.1-2.			

The test voltages for short-term mains frequency are given in Table 10.4.6.2.2:

a – the one-minute voltage applied to the insulation at the rated value for 1 minute or another time (5 minutes or less than 1 minute);

b – the smooth-rise voltage applied to the insulation without delay at the standardized value.

The methods for insulation testing by the short-time voltage of the mains frequency and the test endurance criteria shall comply with the standards for the individual types of electrical equipment and shall be in accordance with IEC 60060-1:2010.

The following test procedures shall be used:

for internal and external insulation in relation to the ground – a single application of a one-minute test voltage;

for the external insulation of power transformers and shunt reactors, the electrical strength of which is determined by the strength of the purely air gap, in relation to the ground and between the phases – three times application of the test voltage with a smooth rise.

It is permissible to use the full discharge method instead of the triple voltage method with a smooth rise; in this case the voltage withstand with 90 % probability shall not be less than the corresponding test voltage.

For the neutral winding insulation of power transformers and shunting reactors which do not allow neutral unearthed operation, a one-minute mains voltage test according to the method specified for the internal insulation is at the same time a test of their external insulation.".

5 Existing para **10.4.6.2.2** is replaced by para **10.4.6.2.3** reading as follows:

"**10.4.6.2.3** Interturn winding insulation of transformers is tested by applying twice the nominal high frequency voltage to the leads of one of the windings with the other windings open.

Test duration t, in min, shall be at least as determined by the formula:

$$t = 2f_{\text{н}}/f, \qquad (10.4.6.2.3)$$

where $f_{\text{н}}$ = rated frequency, in Hz;
f = increased frequency of test voltage equal to $.2f_{\text{н}}-2f_{\text{н}}$ (any value within these limits).

In all cases, the test duration shall be at least 15 s.".

6 **Para 10.4.6.6.1** is replaced by the text reading as follows:

"**10.4.6.6.1** Each insulated core of a finished cable shall withstand during 5 min without breakdown the application of an a.c. single-phase sinusoidal voltage having a frequency of] 50 (60) Hz or the d.c. voltage specified in Table 10.4.6.6.1. These test voltages for the finished cable apply both following the exposure of the products to water and without such exposure, both with and without immersion in water considering the requirements of IEC 60502- 2:2014 and IEC 60840:2017.

Table 10.4.6.6.1

Cables	Test voltage, in V	
	A.c. 50 (60) Hz current	D.c. current
Power cables for rated voltage, in V:		
250	1500	3000
750	2500	5000
1000	3000	-
3000	7000	-
6000	21000	-
8700	30500	-
12000	42000	-
18000	63000	-
45000–47000	65000	-
60000–69000	90000	-
110000–115000	160000	-
132000–138000	190000	-
150000–161000	218000	-
Alarm and communication cables for rated voltage 250 V	1500	3000
Notes: 1. The Table refers to cables having rubber, PVC and polyethylene insulation in a rubber or PVC sheath. 2. The test voltage for the cables of which the rated is ignored in the Table is stipulated by technical documentation in compliance with national and international standards. 3. The test voltage may be reduced by 25 per cent as compared with the one in the Table for cables with screened cores if these latter account for more than 50 % of all the cores.		

".

7 New para **10.4.6.10** is introduced reading as follows:

"**10.4.6.10** High voltage equipment over 15 kV.

10.4.6.10.1 The requirements for testing the insulation strength of power transformers for the rated voltage over 15 kV are specified in 10.4.6.2.2.

10.4.6.10.2 The requirements for testing the insulation strength of cable products for the rated voltage over 15 kV are specified in в 10.4.6.6.1.

10.4.6.10.3 Integrated switchgear (IS) 15─35 kV and shielded current leads:

.1 during testing at the firm (manufacturer) the external insulation, as well as insulation inside the IS enclosure, circuits of the IS primary connections shall withstand the voltages of full lightning pulses given in Table 10.4.6.10.3.1.

Table 10.4.6.10.3.1

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage of internal and external insulation				
		lightning pulse		short-term (one minute) alternating voltage		
		full		dry		in the rain
		IS with one pole break in relation to ground and between phases (poles)[2]	IS with two pole breaks in relation to ground and between phases (poles)[2]	IS with one pole break in relation to ground and between phases (poles)[2]	IS with two pole breaks in relation to ground and between phases (poles)[2]	IS in relation to the ground and between phases (poles)[2]
1	2	3	4	5	6	7
15–19	a	95	110	38	45	38
	b			55	63	
20–23	a	125	145	50	60	50
	b			65	75	
24–26	a	150	165	60	70	60
	b			75	90	
27–34	a	170	190	65	85	65
	b			80	95	
35	a	190	220	80	95	80
	b			95	120	

[1] Insulation level:
a – for electrical equipment with paper-oil and cast insulation, designed with the requirement of checking the insulation for the absence of partial discharges, for other electrical equipment – to be determined by agreement between the manufacturer and the user; insulation level;
b – for electrical equipment designed without the requirement of checking the insulation for the absence of partial discharges.
[2] For electrical equipment of three-phase (three-pole) version.

Test voltage shall be applied to:

to insulation in relation to the ground and between the poles in the operating and disconnected (control) positions of the withdrawable element;

to insulation between live and earthed parts when the withdrawable part is in repair position;

to insulation in relation to the ground and between the poles when disconnectors are switched on and off, connected to the primary circuits for the IS without withdrawable elements.

Note. Electrical equipment normally connected to the primary circuits of IS for which lightning pulse test voltages are lower than those specified in Table 10.4.6.10.3.1 shall be disconnected from the primary connection circuits during the testing according to this para. The test shall be repeated with all connected electrical equipment at the voltage permitted for all electrical equipment;

.2 external insulation inside the IS enclosure between the current-carrying parts of the same pole of the IS primary circuits in the disconnected (check) position of the withdrawable component with two discontinuities per pole shall withstand the full lightning pulse voltages specified in Table 10.4.6.10.3.1 (column 4).

IS without withdrawable elements shall withstand external insulation tests between the contacts of the same disconnector pole of the primary circuit breakers in the disconnector tripped position;

.3 requirements for IS insulation at short-time alternating voltages.

The primary circuit insulation of IS shall be able to withstand the one minute voltages specified in Table 10.4.6.10.3.1 (columns 5, 6 and 7).

Test voltage shall be applied to insulation in accordance with 10.4.6.10.3.1.

The external insulation inside the IS enclosure between the current-carrying parts of the same pole of the IS primary circuits in the disconnected (check) position of the withdrawable

component with two discontinuities per pole shall withstand in dry state the voltages specified in Table 10.4.6.10.3.1 (column 6).

The external insulation (outside the OPSG/outdoor packaged switchgear enclosure) of the OPSG primary circuits in relation to the ground shall withstand in the rain the voltages given in Table 10.4.6.10.3.1 (column 7);

.4 requirements for the insulation of shielded current leads.

Insulation of shielded current leads shall withstand:

voltages of full lightning pulses given in Table 10.4.6.10.3.1 (column 3);

one minute alternating voltages given in Table 10.4.6.10.3.1 (column 5).

10.4.6.10.4 Integrated gas-insulated switchgears (GIS) 110 ─ 220 kV.

10.4.6.10.4.1 Insulation of GIS main circuits.

.1 when tested at the firm (manufacturer), the insulation relative to GIS ground, as well as the insulation between the poles of the three-pole GIS, shall withstand the full lightning pulse test voltages in accordance with Table 10.4.6.10.4.1.5 (column 2);

.2 insulation of electromagnetic voltage transformers shall also be tested with the voltage of a chopped lightning pulse. Thus, the values of the test voltages of the chopped lightning pulse shall be equal to the values of the test voltages of full lightning pulse given in 10.4.6.10.4.1.1;

.3 insulation between the contacts of the same pole of switches and disconnectors shall withstand the test voltages of a full lightning pulse when the apparatus is switched off, according to Table 10.4.6.10.4.1.5 (columns 3 and 4);

.4 when tested at the firm (manufacturer), the insulation relative to GIS ground, as well as the insulation between the poles of the three-pole GIS, shall withstand test short-time (one minute) alternating voltages specified in Table 10.4.6.10.4.1.5 (column 5);

.5 insulation of the air – electronegative gas entry in GIS of voltage classes 72,5 to 220 kV in dry state, and for entries of location category 1, as well as in the rain, shall withstand test short-term (one-minute) alternating voltages according to Table 10.4.6.10.4.1.5 (column 5).

Table 10.4.6.10.4.1.5

Voltage class	Test voltage, in kV					
	full lightning pulse			short-term (one minute) alternating voltage		
		between the contacts			between the contacts	
	in relation to the ground and between the poles	breakers	disconnectors	in relation to the ground and between the poles	breakers	disconnectors
1	2	3	4	5	6	7
72,5─99	325		375	140		160
100–122	450		520	185		210
123–149	550		630	230		265
150–219	750		860	325		375
220	950		1050	395		460

.6 insulation between the contacts of the same pole of switches and disconnectors shall withstand the test short-time (one minute) alternating voltages according to Table 10.4.6.10.4.1.5 (columns 6 and 7);

.7 insulation of GIS main circuits shall withstand testing by alternating voltage with partial discharge measurement. Partial discharge test shall be carried out by applying an alternating voltage to the insulation to be tested, the preliminary value of which for a duration of 10 s shall be equal to 1.05 $U_{\text{н.р}}$[1]. – for the equipment of 110 kV and over.

[1] *Uv.o* – the maximum operating voltage of electrical equipment – the maximum voltage of 50 Hz frequency, the application of which to the terminals of the different phases (poles) of the electrical equipment for an unlimited time period is permissible under its insulation operating conditions.

Then the voltage shall be reduced to a value of 1.1 without switching off $U_{H.P}/\sqrt{3}$ and maintained for at least 1 minute. The insulation is considered to have passed the test if the intensity of partial discharges at the voltage of 1,1 $U_{H.P}/\sqrt{3}$ does not exceed the value of 10^{-1} Kl;

.8 GIS bushing insulation shall comply with the requirements for thermal breakdown resistance and, for “air – electronegative gas” bushings in GIS of location category 1 – also with the leakage path length of the external insulation (for the bushing insulation requirements refer to 10.4.6.10.10).

10.4.6.10.4.2 Insulation of control circuits, auxiliary GIS circuits and secondary windings of measuring transformers:

.1 insulation of the secondary windings of voltage transformers shall withstand for 1 minute the test voltage of 3 kV at 50 Hz applied from an external source;

The insulation of the secondary windings of current transformers shall withstand for 1 minute the test voltage of 3 kV at 50 Hz applied from an external source.

The inter-sectional insulation of the primary and secondary winding sections intended for changing the ratio of current transformers shall withstand for 1 minute the test voltage of 3 kV at 50 Hz;

.2 insulation of the GIS control and auxiliary circuits with respect to earth shall withstand a short-term (one-minute) alternating voltage test for the electrical equipment of 220 kV and below, equal to 2 kV and applied alternately between:

live and earthed parts;

live parts of different circuits;

open contacts of the same circuit elements.

The test voltage exposure time shall be equal to 1 min.

N o t e . Testing of live parts of different circuits and open contacts of the same circuit elements may be omitted, provided that the electrical equipment manufacturer guarantees the required insulation quality.

.3 interturn insulation of solenoid windings in GIS control circuits (except those included in the secondary circuit of current transformers) shall withstand for 1 minute a short-term alternating voltage applied between the winding leads equal to 3,5 Uv – for a.c. windings and 2,5 Uv – for d.c. windings, where Uv is the rated voltage of auxiliary circuits and control circuits;

10.4.6.10.4.3 Types of tests and general instructions:

.1 GIS insulation shall be subjected to the above tests. Each GIS or each GIS cell, pole, separate module or transport unit consisting of one or more modules shall be tested;

.2 testing of the GIS insulation shall be carried out at the rated minimum operating density of electronegative gas. The rated value for the minimum operating density of electronegative gas is given in the type-specific electrical equipment standards (IEC 62271- 203:2011) as well as in the operating manual of the equipment;

.3 test voltages shall be adjusted to atmospheric conditions during the test only when testing the dielectric strength of the “air – electronegative gas” bushings;

.4 when testing the insulation of main circuits of GIS with full lightning pulse voltage, the 15-pulse method with positive and negative polarity pulses shall be applied;

.5 when testing the voltage transformers with the voltage of chopped lightning pulse, the three-pulse method shall be used, with pulses of positive and negative polarity applied;

.6 when testing the insulation of main circuits of GIS with switching pulse voltage, the 15 pulse method shall be applied with pulses of positive and negative polarity, except for the "air – electronegative gas" entry in the GIS of location category 1, which shall be tested in dry state with pulses of positive polarity, and in the rain with pulses of positive and negative polarity;

.7 when testing the insulation of main circuits, control circuits and auxiliary circuits of GIS and secondary windings of measuring transformers with short-term alternating voltages, the one-minute voltage method shall apply;

.8 testing by the alternating voltage test with partial discharge measurement according to 10.4.6.10.4.3.7. shall be carried out following the electrical strength test of the insulation by the lightning pulse, switching pulse and short-time alternating voltage.

10.4.6.10.5 Cast (solid) insulated current leads:

.1 when tested by the firm (manufacturer), electrical equipment or parts thereof with cast or compound-filled insulation shall withstand the test for the absence of partial discharges in gas inclusions in the insulation by application of alternating voltage.

The above test may be carried out by measuring the dissipation factor of the voltage varied to 120 % of the highest operating voltage for the electrical equipment of voltage classes 3 to 110 kV or 120 % of the highest operating voltage divided by √3 for the equipment of voltage classes 110 kV and over;

.2 partial discharge test shall be carried out by applying an alternating voltage to the insulation to be tested, the pretest value of which during 10 s to be equal to 1,3 $U_{o.v}$[1] for the equipment of voltage classes from 3 to 35 kV, 1,05 $U_{o.v.}$[1] – for the electrical equipment of 110 kV and over.

Then the voltage shall be reduced to a value of 1,1 without switching off $U_{H.P}/\sqrt{3}$ and held for at least 1 minute; the PD intensity, the permissible value of which is specified in the sections containing the requirements for specific types of electrical equipment, shall be measured;

.3 the method of testing in parts, as well as the voltage to be applied to those parts, shall be chosen by the manufacturer in accordance with the national standards for electrical equipment;

10.4.6.10.6 Gas-insulated current leads 110–220 kV:

.1 when tested at the firm (manufacturer), the standardized test voltages of the main circuits of the gas-insulated current leads shall comply with the data specified in Table 10.4.6.10.6.1;

Table 10.4.6.10.6.1

Voltage class	Test voltage, in kV			
	full lightning pulse		short-term (one minute) alternating voltage	
	in relation to the ground	between phases for GICL 3P	in relation to the ground	between phases for GICL 3P
110	450	450	230	230
150	650	650	300	300
220	900	900	440	440

Notes:
GICL – gas-insulated current lead;
GICL 3P – gas-insulated current lead with all three phases housed in the same enclosure.

For current leads with a common enclosure for all three phases, the test voltage is applied to each phase of the current lead or to two phases when the third phase is connected to the earthed enclosure in turn

.2 insulation of GICL control and auxiliary circuits in relation to the ground shall withstand a test short-term (one-minute) alternating voltage of 2,0 kV applied alternately between live and earthed parts, as well as between live parts of different circuits;

.3 partial discharge intensity in the GICL insulation shall not exceed the value of 10 – 11 Kl when an alternating voltage equal to $1{,}1Un.d./\sqrt{3}$ is applied;

.4 when an alternating voltage equal to of $1{,}1Uo.v./\sqrt{3}$, is applied to the external insulation of GISL terminations in the form of "air – electronegative gas" entries, the absence of a visible corona shall be recorded;

.5 electrical strength of the internal insulation of GICL "air – electronegative gas", "oil – electronegative gas", "cable – electronegative gas" and "electronegative

[1] *Uv.o* – the maximum operating voltage of electrical equipment – the maximum voltage of 50 Hz frequency, the application of which to the terminals of the different phases (poles) of the electrical equipment for an unlimited time period is permissible under its insulation operating conditions.

gas – electronegative gas" entries shall comply with the values of the rated test voltage in relation to the ground in accordance with 10.4.6.10.6.1.

10.4.6.10.7 Insulators to be tested separately (collecting busbars, rigid busbar).

.1 requirements to the insulator insulation at lightning pulse voltage. The external insulation of insulators shall withstand the full lightning pulse voltages specified for insulators and busbar supports, in Table 10.4.6.10.7.1;

Table 10.4.6.10.7.1

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage of internal and external insulation		
		lightning pulse	short-term (one minute) alternating voltage	
		full	dry	in the rain
		Insulator in relation to the ground and between phases (poles)[2]	Insulator in relation to the ground and between phases (poles)[2]	Insulator in relation to the ground and between phases (poles)[2]
1	2	3	4	5
15–19	a	95	38	38
	b		*55*	
20–23	a	125	50	50
	b		65	
24–26	a	150	60	60
	b		75	
27–34	a	170	65	65
	b		80	
35–109	a	190	80	80
	b		95	
110–149	-	450/550[3]	230	200
150–219	-	650	275	275
220	-	950	395	395

[1] Insulation level:

a – for electrical equipment with paper-oil and cast insulation, designed with the requirement of checking the insulation for the absence of partial discharges, for other electrical equipment – to be determined by agreement between the manufacturer and the user; insulation level;

b – for electrical equipment designed without the requirement of checking the insulation for the absence of partial discharges.

[2] For electrical equipment of three-phase (three-pole) version.

[3] The denominator indicates values for dry testing of non-oil insulators without checking the quality of insulation performance for the absence of partial discharges or by other additional methods, as well as busbar supports, the numerator indicates values for the remaining electrical equipment.

.2 requirements to insulator insulation at alternating voltage.

The internal insulation of insulators, including the insulation of apparatus bushings, shall withstand the one-minute voltages given in Table 10.4.6.10.4.5.1 (columns 4, 5).

The external insulation of insulators shall withstand in dry state, and for category 1 insulators also in the rain, the one-minute voltages specified for the insulators in Table 10.4.6.10.4.6.1 (columns 4, 5).

10.4.6.10.8 Dry current-limiting reactors.

.1 when testing of winding insulation of dry current limiting reactors for 15–220 kV voltage at the firm (manufacturer), the windings shall withstand the test voltage of full and chopped lightning pulse, the actual values of which are given in Table 10.4.6.2.1-2;

.2 each specimen of electrical equipment shall be subjected to an insulation test when leaving the manufacturer’s premises:

for internal insulation by one-minute alternating test voltage in accordance with 10.4.6.10.4.2.2;

for internal insulation filled with liquid or gaseous dielectric material with molded insulation elements of voltage classes 110 kV and above – by alternating voltage with the measurement of partial discharge characteristics.

N o t e s : 1. It is permitted not to separately test the products at steady production of insulation installed on reactors of voltage classes 15 to 35 kV, reinforced by the reactor manufacturer, but limit to the application of a test one-minute alternating voltage to the bushing of the reactor or apparatus during the testing.

2. It is permitted not to test products at steady production of the insulation of the assembled current-limiting dry-type reactors, but limit to testing of their insulators;

.3 internal insulation of the current-limiting reactor windings shall withstand, relative to ground and other windings, the one-minute test voltage applied from an external source as specified in Table 10.4.6.2.1-2. Parts of a split winding shall be considered as a separate winding each.

10.4.6.10.9 Valve-type arresters, overvoltage limiters.

.1 insulation of valve-type arresters and overvoltage limiters (hereinafter, overvoltage limiters or OVL) made of organic (polymer) materials shall be tracking-erosion-resistant;

.2 when tested by the firm (manufacturer), the insulation of the overvoltage limiter enclosure shall withstand lightning pulse, switching pulse, one-minute power frequency voltage in accordance with Table 10.4.6.10.9.2.

T a b l e 10.4.6.10.9.2

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage of internal and external insulation		
		lightning pulse	short-term (one minute) alternating voltage	
		full	dry	in the rain
		Surge arrester, OVL in relation to the ground and between phases (poles)[2]	Surge arrester, OVL in relation to the ground and between phases (poles)[2]	Insulator in relation to the ground and between phases (poles)[2]
1	2	3	4	5
15 ─ 19	a	95	38	38
	b		55	
20 ─ 23	a	125	50	50
	b		65	
24 ─ 26	a	150	60	60
	b		75	
27 ─ 34	a	170	65	65
	b		80	
35 ─ 109	a	190	80	80
	b		95	
110 ─ 149	-	450	230	200
150 ─ 219	-	650	300	275
220	-	900	440	395

[1] Insulation level

a – for electrical equipment with paper-oil and cast insulation, designed with the requirement of checking the insulation for the absence of partial discharges, for other electrical equipment – to be determined by agreement between the manufacturer and the user; insulation level;

b – for electrical equipment designed without the requirement of checking the insulation for the absence of partial discharges.

[2] For electrical equipment of three-phase (three-pole) version.

.3 lightning pulse voltage test shall be carried out for all types of limiters. The maximum value of the test pulse voltage shall not be less than the residual voltage at the limiter at rated discharge current multiplied by 1,3.

D i s c h a r g e v o l t a g e (OVL Udis) is the maximum voltage value at the limiter when a pulse current with a given amplitude and pulse shape is flowing through it.

R a t e d d i s c h a r g i n g c u r r e n t (OVL Ir) is the maximum (amplitude) value of 8/20 μs lightning current pulse used for OVL classification.

.4 switching pulse test shall be carried out on the external insulation of limiters with the rated discharge currents of 10000 and 20000 A and the maximum long-term permitted

operating voltage of 210 kV or higher. The test voltage shall be equal to the residual voltage at the highest value of switching current given in Table 10.4.6.10.9.4 multiplied by 1,25. The residual voltages of the limiter shall be specified by the manufacturer in the technical documents for the particular types of limiter at 30/60 μs, 8/20 μs and 1/10 μs current pulses with the maximum pulse values given in Table 10.4.6.10.9.4.

Table 10.4.6.10.9.4

Arrester class by capacity	Rated discharge current, in A	Maximum current values, A, at pulses, μs		
		30/60	8/20	1/10
1	5000	125, 250, 500	2500, 5000, 10000	5000
	10000	125, 250, 500	5000, 10000, 20000	10000
2	10000	250, 500, 1000	5000, 10000, 20000	10000
3	10000	500, 1000, 2000	5000, 10000, 20000	10000
4	10000	500, 1000, 2000	5000, 10000, 20000	10000
	20000	500, 1000, 2000	10000, 20000, 40000	20000
5	20000	500, 1000, 2000	10000, 20000, 40000	20000

.5 limiters with a rated discharge current of 5000 A as well as limiters with a rated discharge current of 10000 A and 20000 A, with a continuous permissible operating voltage of less than 210 kV, shall be subjected to the power frequency test (1 min).

The amplitude of the one-minute test voltage shall not be less than the value of:

the remaining voltage at the rated discharge current, multiplied by 0,88;

for limiters with a rated discharge current of 5000 A;

the residual voltage at the highest switching current according to Table 10.4.6.10.9.4 (depending on the capacity class and rated discharge current) multiplied by 1.06 – for limiters with the rated discharge current 10000 and 20000 A;

.6 testing of the OVL insulation enclosure shall be carried out by the 15-impact method. Under normal atmospheric conditions, the test voltage shall not be less than the residual voltage of the OVL at the rated discharge current multiplied by 1,3.

10.4.6.10.10 Entries, bushing insulators 110–220 kV;

.1 requirements to the insulation of entries and bushing insulators at lightning pulse voltage. During the testing at the firm (manufacturer) the external insulation of entries and bushing insulators with the voltage from 15 to 110 kV shall withstand the voltages of full lightning pulses given in Table 10.4.6.10.7.1.

The external insulation of entries and bushing insulators 110–220 kV shall withstand the full lightning pulse voltages specified in Table 10.4.6.10.10.1.

Table 10.4.6.10.10.1

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage of internal and external insulation		
		lightning pulse	short-term (one minute) alternating voltage	
		full	dry	in the rain
		Entry, bushing insulator in relation to the ground and between the phases (poles)[1]	Entry, bushing insulator in relation to the ground and between the phases (poles)[1]	Entry, bushing insulator in relation to the ground and between the phases (poles)[1]
1	2	3	4	5
110	-	450/550[2]	230	200
150	-	650	275	275
220	-	950	395	395
[1] For electrical equipment of three-phase (three-pole) version – also between the poles. [2] Values for bushings are given in the denominator; values for other insulators – in the numerator				

.2 it is permitted not to carry out testing under rain of the external insulation of electrical equipment with main active parts located in a metal enclosure and connected via separate

bushings when the test of the external insulation of the bushings in the rain was performed separately;

.3 each specimen of electrical equipment shall be subjected to an insulation test when leaving the manufacturer's premises:

for internal insulation of bushings of voltage classes 110 kV and above – by alternating voltage with the measurement of partial discharge characteristics.

N o t e s : 1. It is permitted not to separately test the insulation of bushings installed on transformers, reactors and apparatus of voltage classes 3 to 35 kV, reinforced by the transformer, reactor or apparatus manufacturer, as well as bushings assembled from parts on the electrical equipment tank, but limit to the application of a test one-minute alternating voltage to the bushing of the transformer, reactor or apparatus during the testing of products at steady production of the latter.

2. The scope of testing of porcelain bushing insulators specified in the standards for these insulators may omit the one-minute alternating voltage test, provided that another method of checking the manufacturing quality of the insulators is specified, as a substitute for the one-minute voltage test;

.4 external insulation of bushings intended for winding neutral terminals of HV power transformers of 110, 150 and 220 kV voltage classes with incomplete neutral insulation allowing operation with neutral un-grounding shall be tested with full lightning impulse voltages specified in Table 10.4.6.2.1-3 (column 6);

.5 requirements to insulator insulation at alternating voltage.

The internal insulation of insulators, including the insulation of apparatus entries, shall withstand the one-minute voltages given in Table 10.4.6.10.7.1 (columns 4 and 5).

The internal insulation of entries in power transformers and shunting reactors of voltage classes 110 kV and over shall withstand testing with continuous alternating voltage equal to 1,5 $U_{H.P}/\sqrt{3}$.

The voltage shall be smoothly raised to the rated value and then maintained for 0,5 h regardless of its frequency; the intensity of the partial discharges shall be measured.

The insulation is considered to have passed the test if the intensity of the partial discharges during the voltage exposure does not exceed the value of 10^{-11} Kl.

10.4.6.10.11 Fuses, disconnecting fuses:

.1 when tested by the firm (manufacturer), the external insulation of fuses, fuses-disconnectors (hereinafter, the fuses) shall withstand full lightning pulse voltages given in Table 10.4.6.10.11.1.

The methods for insulation testing by lightning pulses and the test endurance criteria shall comply with IEC 60060-1:1989 for the individual types of electrical equipment and are specified in Table 10.4.6.10.11.1.

The following test procedures shall be used:

for the internal insulation of electrical equipment – 3-impact method;

for the external insulation of electrical equipment – 15-impact method.

For external insulation between the contacts of the same poles of disconnectors and fuses with the cartridge removed, it is permissible to use the full discharge method instead of the 15-impact method, whereby the withstand voltage with a 90 per cent probability shall not be less than the appropriate test voltage.

Table 10.4.6.10.11.1

Electrical equipment voltage class, in kV	Insulation level[1]	Test voltage of internal and external insulation					
		lightning pulse		short-term (one minute) alternating voltage			
		full		dry		in the rain	
		Fuse in relation to the ground	Fuse between the contacts[2]	Fuse in relation to the ground	Fuse between the contacts[3,2]	Fuse in relation to the ground	Fuse between the contacts[2]
1	2	3	4	5	6	7	8
15 – 19	a	95	110	38	45	38	45
	b			55	63		
20–23	a	125	145	50	60	50	60
	b			65	75		
24 – 26	a	150	165	60	70	60	70
	b			75	90		
27 – 34	a	170	190	65	85	65	75
	b			80	95		
35 – 109	a	190	220	80	95	80	95
	b			95	120		
110 – 149	-	450	570	230		230	
150 – 219	-	650	790	300	315	300	315
220	-	900	1100	440	460	440	460

[1] Insulation level

a – for electrical equipment with paper-oil and cast insulation, designed with the requirement of checking the insulation for the absence of partial discharges, for other electrical equipment – to be determined by agreement between the manufacturer and the user; insulation level;

b – for electrical equipment designed without the requirement of checking the insulation for the absence of partial discharges.

[2] the insulation level between the contacts of the same fuse pole with cartridge but without fuse insert between the electrodes.

[3] the insulation level between the contacts of the same pole, fuses with the cartridge removed.

.2 testing of insulators, disconnectors, lightning pulse test voltages according to the method specified for external insulation is at the same time a test of the electrical strength of their internal insulation;

.3 external insulation of the fuses (fuse with a fuse holder with an undamaged fuse link) in relation to the ground and, for three-pole fuses, between adjacent poles, shall withstand full lightning pulse voltages specified in Table 10.4.6.10.11.1 (column 3). The external insulation of the fuses between the contacts of the same pole of the fuse with the cartridge removed shall withstand the voltages of full lightning pulses specified in Table 10.4.6.10.11.1 (column 4).

.4 requirements to insulation at one minute alternating voltage. Internal insulation of the fuses (fuse with a fuse holder with an undamaged fuse link) in relation to the ground and, for three-pole fuses – between adjacent poles, shall withstand the one minute voltage specified in Table 10.4.6.10.11.1 (column 5).

.5 external insulation of fuses in relation to the ground shall withstand in the dry state and, for category 1 fuses, also in the rain, the one-minute voltages specified in Table 10.4.6.10.11.1 (columns 5 and 7).

.6 external insulation of fuses between contacts of the same pole of the fuse with the cartridge removed shall withstand in dry state the one-minute voltage specified in Table 10.4.6.10.11.1 (column 6), and the insulation between contacts of the same pole of the fuse with the cartridge but without the fusible link between the electrodes in dry state and in the rain – the values specified in Table 10.4.6.10.11.1 (columns 6 and 8).".

8 **Para 10.5.1.1** is replaced by the text reading as follows:

"**10.5.1.1** The list of electrical equipment products subjected to various kinds of mechanical and environmental tests is given in Tables 10.5.1.1-1 and 10.5.1.1-2.

Table 10.5.1.1-1

Tests of equipment for compliance with operational conditions onboard a ship

Products	Mechanical tests				Environmental tests								tests of enclosure protection
	vibration tests	shock tests	resistance to motions	resistance to prolonged inclinations	heat stability	cold endurance	exposure to temperature changes	humidity resistance	resistance to hoarfrost and dew after thawing	resistance to salt mist	resistance to solar radiation	fungus resistance	
Electrical machines	+	+	(+)	+	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Transformers	+	+	(+)	(+)	+	+	–	+	–	(+)	–	(+)	(+)
Static converters	+	+	(+)	–	+	+	–	+	–	(+)	–	(+)	
Switch, protective and control apparatus	+	+	+	+	+	+	(+)	+	(+)	(+)	–	(+)	(+)
Electrical measuring instruments	+	+	(+)	+	+	+	–	+	–	(+)	+	(+)	+
Electrical switchboards and consoles	+	+	(+)	(+)	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Enclosures of switchgear, switchboards and consoles of electrical installations, monitoring and alarm	+	+	–	–	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Electrical drives	+	+	(+)	+	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Ship’s control and monitoring devices	+	+	(+)	+	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Internal communication and alarm devices and apparatus	+	+	+	(+)	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Electrical heating and cooking appliances	+	+	(+)	(+)	+	+	–	+	–	(+)	–	(+)	
Accumulators and accumulator batteries	+	+	+	+	+	+	–	–	–	(+)	–	(+)	–
Capacitors and capacitor sets to raise a power factor	+	+	(+)	(+)	+	+	–	+	–	(+)	–	(+)	(+)
Lighting fixtures	+	+	–	(+)	(+)	(+)	(+)	+	(+)	(+)	–	(+)	(+)
Wiring accessories	+	+	–	–	(+)	+	–	+	(+)	(+)	(+)	(+)	(+)
Cables and wires	(+)	(+)	–	–	+	+	–	+	–	(+)	(+)	(+)	–
Busducts	+	+	(+)	(+)	+	+	–	+	–	(+)	–	(+)	(+)

Symbols:
+ = products are subject to testing;
(+) = the test is not compulsory for some products of the given type or, in some cases, the products may be exempted from this test (refer to the provisions on this test performance and on testing the products of the given type);
– = the test is not needed.

Table 10.5.1.1-2

Tests of equipment 15–220 kV for compliance with operational conditions onboard a ship

Products	Mechanical tests				Environmental tests								
	vibration tests	shock tests	resistance to motions	resistance to prolonged inclinations	heat stability	cold endurance	exposure to temperature changes	humidity resistance	resistance to hoarfrost and dew after thawing	resistance to salt mist	resistance to solar radiation	fungus resistance	tests of enclosure protection
Transformers	+	+	(+)	(+)	+	+	-	+	-	(+)	-	(+)	(+)
Integrated switchgears 15–35 kV	+	+	-	-	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Integrated gas-insulated switchgears 35–220 kV	+	+	-	-	+	+	(+)	+	(+)	(+)	(+)	(+)	+
Shielded current lead 15–35 kV	+	+	+	(+)	+	+	-	+	-	(+)	(+)	(+)	(+)
Gas-insulated current lead 110–220 kV	+	+	+	(+)	+	+	-	+	-	(+)	(+)	(+)	+
Cast (solid) insulated current leads 15- 35 kV	+	+	+	(+)	+	+	-	+	-	(+)	(+)	(+)	(+)
Collecting busbars, rigid busbar (including insulators as a part of equipment)	+	+	+	(+)	+	+	-	+	(+)	(+)	(+)	(+)	-
Dry current-limiting reactors	+	+	+	+	+	+	-	+	-	(+)	(+)	(+)	(+)
Valve-type arresters, overvoltage limiters.	+	+	+	(+)	+	+	-	+	-	(+)	(+)	(+)	(+)
Entries, bushings 110 ─ 220 kV	+	+	+	+	+	+	-	+	(+)	(+)	(+)	(+)	+
Fuses, fuse disconnectors 15 ─ 35 kV	+	+	+	(+)	+	+	-	+	-	(+)	-	(+)	(+)
Cables and wires	(+)		-	(+)	+	+	-	+	-	(+)	(+)	(+)	-
Wiring accessories	+	+	-	-	(+)	+	-	+	(+)	(+)	(+)	(+)	(+)
Symbols: + – products are subject to testing; (+) = the test is not compulsory for some products of the given type or, in some cases, the products may be exempted from this test (refer to the provisions on this test performance and on testing the products of the given type); – = the test is not needed.													

".

9 New para **10.7.2.6** is introduced reading as follows:

"**10.7.2.6 Testing of power transformers of the voltage of 15 – 220 kV**.

The following tests shall be applied to power transformers with a voltage level between 15 and 220 kV, as specified in Table 10.7.2.6.".

Table 10.7.2.6

Item No.	Power transformers, voltage of 15 – 220 kV	Determination of transformer switching conditions	Chromatographic analysis of gases dissolved in oil	Evaluating the moisture content of entry solid insulation	Measurements of insulation resistance	Measurement of dissipation factor (tgδ) of winding insulation	Evaluation of paper winding insulation conditions	Testing of insulation with overvoltage at 50 Hz	Measurement of d.c. winding resistance	Checking current transformer ratio	Checking winding group of three-phase transformers and polarity of single-phase transformer leads	Paralleling of transformers	Measurement of idling losses	Measuring the short-circuit resistance (ZK) of the transformer	Evaluation of switching device status	Tank tightness test	Check of cooling devices, safety devices, gas relay, pressure switch, jet switch, oil protection against ambient air	Thermovision inspection of transformer status	Measurement of partial discharge characteristics
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	With oil insulation	+	+[1)]	+	+	+[2)]	+	+	+[1)]	+	+	+	+[3)]	+[4)]	+	+	+	+	+[1)]
2	With solid insulation (compound)	+	-	+	+	+[2)]	-	+	+[1)]	+	+	+	+[3)]	+[4)]	+	-	(+)	+	+[1)]

Symbols :
+ – products are subject to testing;
(+) = the test is not compulsory for some products of the given type or, in some cases, the products may be exempted from this test (refer to the provisions on this test performance and on testing the products of the given type);
– = the test is not needed.
[1)] To be carried out for transformers of voltage classes 35 kV and over
[2)] To be carried out for transformers of voltage classes 110 kV and over
[3)] To be carried out for transformer prototypes of 1000 kVA and over
[4)] To be carried out for transformer prototypes of 125 MVA and over

10.7.2.6.1 Determination of transformer switching conditions:

.1 monitoring at commissioning of new transformers and transformers that have undergone major repair or complete renovation with replacement of windings and insulation (first-time commissioning). Monitoring is carried out in accordance with the manufacturer's instructions;

.2 monitoring at commissioning of transformers that have undergone major repair in operating conditions (without replacement of windings and insulation).

10.7.2.6.2 Chromatographic analysis of gases dissolved in oil:

.1 the condition of transformer equipment shall be assessed by comparing the measured data with the limit values of gas concentration in oil, the rate of growth of gas concentration in oil, the ratios of diagnostic gas concentrations (gas pairs) and the graphical criterion taking into account operational factors and other applicable normative documents on the power transformer diagnosis;

.2 the following shall be monitored:

for voltage class 35 kV – unit transformers, auxiliary transformers and transformers with an average annual load of at least 50 % of the rated load (subject to an appropriate sampling method for the analysis of gases dissolved in oil);

for voltage classes 110 kV and over – all transformers.

.3 for shunting reactors, evaluation of the condition based on the analysis results of gases dissolved in the oil, according to the manufacturers' instructions;

.4 the analysis of gases dissolved in oil shall be carried out within the following time period:

transformers of 35 kV (unit transformers, auxiliary transformers and transformers with an average annual load of at least 50 % of the rated load) upon their commissioning – during the first 3 days, in 1 and 6 months after activation and then –at least once every 6 months;

all 35 kV transformers, irrespective of load, shall be monitored within the first 3 days after being put into operation;

all transformers 35 kV and over – before commissioning, prior to and after the completion of transformer major and remedial repairs and/or oil work;

transformers of 110 kV and over after being put into operation – within the first 3 days, in 10 days, 1, 3 and 6 months after being put into operation and further – at least once every 6 months. For transformers with a suspected defect, the periodicity of oil sampling is determined on a case-by-case basis, based on the composition and concentration of the gases and their build-up rate;

10.7.2.6.3 Evaluating the moisture content of solid insulation:

10.7.2.6.3.1 Tests are carried out for transformers with a voltage level of 110 kV and over. The permissible moisture content of solid insulation of newly commissioned and overhauled transformers shall not exceed 1 % and that of in-service transformers ─ not exceed 2 % by mass. For transformers with an expired service life, the moisture content of ─ 2 % is permissible, and for in-service transformers the moisture content of 4 % by mass is permissible.

10.7.2.6.3.2 Determination of the moisture content in solid insulation of transformers is carried out:

.1 before commissioning transformers and during major repair, where moisture presence indicators are detected by measurements and/or where the transformer core is exposed to air for at least 16 hours at the relative humidity up to 75 % and 8 hours at 75 % or more; for transformers of up to 35 kV voltage classes – for 16 hours at the relative humidity up to 75 % and 10 hours at the relative humidity up to 85 %;

.2 during a major repair which requires drying/flushing of the solid insulation;

The moisture content of solid insulation in transformers is determined by analyzing the moisture content of insulation samples in the tank as a priority;

Measurement of the moisture content of the solid insulation during operation may be omitted if the moisture content of the oil sampled from the transformer warmed up to 60 °C does not exceed 10 g/t;

The intervals for checking the water content of the solid insulation by calculation methods or other instrumental methods implemented without opening the transformer tank during

operation: for the first time ─ 12 years after commissioning and subsequently once in 4 ─ 6 years.

10.7.2.6.4 Measurements of insulation resistance.

10.7.2.6.4.1 Measurement of winding insulation resistance:

.1 winding insulation resistance is measured with a megohmmeter for 2500V;

.2 insulation resistance of each winding of newly commissioned and overhauled transformers, adjusted to the test temperature at which the initial values were determined, shall be at least 50 % of the values specified by the manufacturer. Where no manufacturer's values are available, with respect to the originally measured values. In any case, insulation resistance above 3000 MOhm at 20 °C is considered satisfactory and no comparison with initial data is necessary;

.3 for transformers of 15 to 35 kV inclusive and up to 10 MVA and arc suppression reactors, winding insulation resistance shall not be lower than the values shown in Table 10.7.2.6.4.1.3.

T a b l e 10.7.2.6.4.1.3

Insulation resistance value

Winding temperature, in °C	10	20	30	40	50	60	70
$R_{60''}$, MOhm	450	300	200	130	90	60	40

.4 insulation resistance of dry-type transformers with rated voltage of more than 15 kV at a winding temperature of 20 ─ 30 °C shall not be less than 500 MOhm;

.5 winding insulation resistance shall be measured at an insulation temperature not lower than:

10 °C ─ for transformers up to 150 kV inclusive;

20 °C ─ for 220 kV transformers;

.6 during operation, measurements of the insulation resistance of transformer windings are performed at least once every 4 years, as well as when the oil and/or dissolved gas test results are unsatisfactory and in the scope of a comprehensive diagnostic inspection;

10.7.2.6.4.2 Measurement of insulation resistance of available tension pins, bandages, yoke half-bandages and pressing rings relative to active steel and yoke beams, as well as yoke beams relative to active steel and electrostatic shields relative to the windings and magnetic conductor;

.1 the measurements shall be taken in case of examination of the active part of the transformer or via a special bushing on the transformer tank (if available). Megohmmeters for 1000 V are used;

.2 the measured values of insulation resistance of tension pins, bandages, yoke half-bandages and pressing rings relative to active steel and yoke beams, as well as yoke beams relative to active steel shall be at least 2 MOhm and the insulation resistance of the yoke beams at least 0,5 MOhm;

10.7.2.6.5 Measurement of the winding insulation dissipation factor ($tg\delta$) of 110 ─ 220 kV transformers;

.1 $tg\delta$ values of winding insulation of newly commissioned and overhauled transformers, adjusted to the test temperature at which the initial values were determined, taking into account the influence of oil $tg\delta$ shall not deviate from the values specified by the manufacturer in the negative direction by more than 50 %;

.2 the measured (at the insulation temperature 20 °C and over) $tg\delta$ values of winding insulation of newly commissioned and overhauled transformers not exceeding 1 % are considered satisfactory and no comparison with initial data is necessary;

.3 during commissioning and in operation $tg\delta$ of insulation shall be measured both according to the manufacturer's diagrams and in addition as per the insulation areas (e.g., HV - housing, LV – housing, HV – LV) by connecting the "screen" lead of the measuring bridge to free windings or tank. In operation, it is permissible to measure the insulation zones only;

.4 measurement of winding $tg\delta$ shall be carried out at an insulation temperature not lower than:

10 °C – for transformers up to and including 150 kV;

20 °C – for 220 kV transformers;

60 °C – for all transformers when evaluating the moisture content of the solid insulation by calculation;

.5 during the operation, measurements of tgδ value of transformer windings are performed at least once every 4 years, as well as when the oil and/or dissolved gas test results are unsatisfactory and in the scope of a comprehensive diagnostic inspection.

10.7.2.6.6 Evaluation of paper insulation winding;

10.7.2.6.6.1 Evaluation by the presence of furan compounds and the CO_2/CO ratio in oil;

.1 the content of furan derivatives in transformer oil, which limits the area of normal equipment condition, shall not exceed 0,0006 % by mass;

.2 when the CO_2/CO ratio exceeds 30 in conjunction with an oil moisture content of more than 30 g/t, this indicates that the lifetime of the paper winding insulation is completely expired (indicator of the limit state). If the content of furan derivatives and/or the CO_2/CO ratio reaches the above values, the paper insulation tests according to 10.7.2.6.6.2 shall be carried out;

.3 oil sampling for furan compounds shall be carried out prior to changing the silica gel in the adsorption and thermosyphon filters and oil treatment (degassing, regeneration, etc.), but not earlier than 6 months after changing.

10.7.2.6.6.2 Evaluation by the degree of polymerization.

.1 the degree of polymerisation of cellulose degradation, which affects the mechanical strength of the paper insulation, is assessed for transformers of 110 kV and over;

.2 solid insulation sampling is carried out when, according to indirect evaluation methods, there are reasonable grounds to expect significant deterioration of the solid insulation. An indirect evaluation of the solid insulation condition is carried out according to the following indicators:

the presence of furan derivatives, including furfural, in transformer oil;

the results of chromatographic analysis of furanic compounds dissolved in oil, CO and CO_2 gases as recommended in 10.7.2.6.2;

the results of oil physical-chemical analysis;

the results of insulation dielectric measurements (R60, tgδ).

.3 the resource of paper winding insulation is considered expired when the degree of polymerization of the paper drops to 250 units (limit value) or less. For essential 35 kV transformers, which have served their time as specified in the technical documentation (unit transformers, auxiliary transformers), evaluation of the paper insulation condition of windings by the degree of polymerization and determination of furan compounds is carried out during comprehensive diagnostic examinations;

10.7.2.6.7 Testing of insulation with overvoltage at 50 Hz;

.1 for major repair with complete replacement of windings and insulation, the overvoltage test together with the bushings is mandatory for all transformer types and classes. The value of the test voltage shall be taken equal to the voltage used by the manufacturer. In case of major repair with partial replacement of insulation or renovation of the transformer, the test voltage is assumed as 0,9 of the factory voltage;

.2 test voltage values are specified in Tables 10.7.2.6.7-1 and 10.7.2.6.7-2. Test duration – 60 s.

.3 imported transformers may only be tested with the voltages given in Tables 10.7.2.6.7-1 and 10.7.2.6.7-2 if they do not exceed the voltage values with which the transformer was tested by the manufacturer;

.4 the insulation test of the protective and instrumentation circuits installed on the transformer is performed on the fully assembled transformers. The insulation (relative to earthed parts and structures) of circuits with connected current transformers, gas and safety relays, oil detectors, shut-off valve and temperature sensors shall be tested with the disengaged connectors of the pressure gauge thermometers, the circuits of which are tested separately. Test voltage value – 1 kV. Test duration ─ 1 min. Test voltage value for testing manometer thermometers ─ 750 V. Test duration ─ 1 min.

Table 10.7.2.6.7-1

Test voltages of industrial frequency of electrical equipment of voltage classes up to 35 kV with normal and light insulation

Transformer voltage class, in kV	Test voltage					
	power transformers, shunting reactors and arc-suppression coils			apparatus, current and voltage transformers, current-limiting reactors, insulators, entries, communication condensers, shielded current leads, collecting busbars, IS		
					prototype at manufacture and at steady production	
	prototype at the manufacturer	prototype at manufacture	at steady production	prototype at the manufacturer	porcelain insulation	other types of insulation
15–19	45,0/37,0	40,5/33,3	38,3/31,5	55,0 (63,0)	55,0 (63,0)	49,5 (56,7)
20–34	55,0/50,0	49,5/45,0	46,8/42,5	65,0 (75,0)	65,0 (75,0)	58,5 (64,5)
35	85,0	76,5	72,3	95,0 (120,0)	95,0 (120,0)	85,5 (108,0)

Notes: 1 Test voltages indicated as a fraction apply to electrical equipment: numerator for normal insulated equipment, denominator for lightly insulated equipment (including dry-type transformers).

2. The test voltages for apparatus and IS apply both to their insulation against the ground and between the poles and to the gap between the contacts with one or two (figure in brackets) discontinuities per pole. Where the test equipment cannot provide a test voltage higher than 100 kV, it is permissible to carry out the test at the highest possible test voltage, but at least 100 kV.

3. When the prototype at the manufacturer was tested by the voltage different from that specified, the test voltages of the prototype at manufacture and at steady production shall be adjusted accordingly.

Table 10.7.2.6.7-2

Test voltages of industrial frequency of pressure-tight power transformers.

Transformer voltage class, in kV	Test voltage, in kV		
	prototype at the manufacturer	prototype at production	at steady production
15	38	34,2	32,3
20	50	45,0	42,5

10.7.2.6.8 Measurement of d.c. winding resistance:

.1 resistance of transformer windings to direct current shall be measured on all taps, unless otherwise specified in the transformer's certificate;

.2 measurements of the d.c. winding resistance of transformers during the inter-repair period are carried out in case of a comprehensive DIAGNOSTIC examination of the transformer, as well as where the presence of a defect is indicated by means of periodic monitoring carried out on the transformer in operation, such as oil dissolved gas analysis,

physical and chemical oil analysis, thermal inspection, examination and inspection of the on-load tap-changer (OLTC);

.3 for transformers with OLTC in-service measurements are carried out at the following intervals:

transformers of 110 kV and over – once every 4 years;

35 kV transformers – as decided by the technical superintendent;

.4 at least three complete switching cycles shall be performed prior to measuring the winding resistance of transformers equipped with load tap changers and a change-over switchgear without excitation;

.5 the winding resistance of three-phase transformers measured on the same taps of different phases at the same temperature shall not differ by more than 2 %;

.6 the winding resistance values of single-phase transformers after temperature recalculation shall not differ by more than 5 % from the initial values;

10.7.2.6.9 Checking current transformer ratio:

.1 the test is carried out at all positions of the tap changers.

The transformation ratio measured at commissioning of the transformer shall not differ by more than 2 % (unless otherwise stated in the manufacturer's documentation) from the values measured on the corresponding taps of other phases and from the initial values, and the ratio measured during a major repair shall not differ by more than 2 % from the transformation ratio calculated from the tapping voltages. During major repairs, the transformer ratio is checked when the transformer windings are replaced or repaired.

10.7.2.6.10 Checking winding group of three-phase transformers and polarity of single-phase transformer leads:

.1 the winding connection group and the polarity of the leads of the prototype and electrical equipment undergone a complete renovation or major repair is checked at production;

.2 the connection group shall comply with the specifications in the transformer certificate and the polarity of the terminals shall comply with the markings on the transformer cover;

.3 measurements are taken at commissioning, in operation – in case no firm documentation (nameplate) is available for the transformer and after major repair – in case of change in wiring diagram or replacement of windings.

10.7.2.6.11 Paralleling of transformers:

.1 prior to the first start-up of new or repaired equipment (if the transformer's external power connection scheme has been changed), it shall be phased.

10.7.2.6.12 Measurement of idling losses:

.1 measurements are made on prototype transformers of 1000 kVA or over at the voltage applied to the LV winding equal to that specified in the factory test report (certificate). Measurement of idling losses for transformers up to 1000 kVA shall be carried out following the major repair with complete or partial unstacking of magnetic conductor. For three-phase transformers, the idling losses are measured with single-phase excitation according to the manufacturer's schemes;

.2 at the production and during the major repair, for three-phase transformers, the ratio of losses in the different phases shall not deviate by more than 5 % from the ratios indicated in the factory test report (certificate). For single-phase transformers, the measured losses shall not exceed the initial (certified) values by more than 10 % on commissioning.

10.7.2.6.13 Measuring the short-circuit resistance (ZK) of the transformer:

.1 the short-circuit resistance is measured for transformers of 125 MVA and over;

.2 for transformers with on-load changer ZK shall be measured on the main and both outermost branches;

.3 ZK values of the transformer at steady production shall not exceed the values determined from the transformer fault voltage (Uf) on the main branch by more than 5 %;

.4 ZK values during the measurements at steady production and major repair shall not exceed the initial values by more than 3 per cent. For three-phase transformers, the difference in ZK values per phase on the main and outermost branches is additionally rated and shall not exceed 3 per cent;

.5 during operation, measurements of ZK are made after the transformer was exposed to a fault current exceeding 70 % of the design value used by the manufacturer, as well as in the scope of a comprehensive diagnostic examination.

10.7.2.6.14 Evaluation of switchgear status:

10.7.2.6.14.1 Switchgear with NLTC (no-load tap changer);

.1 in NLTC switchgear the condition of the following shall be checked:

contact element and gear;

spring contacts.

.2 for drum-type NLTCs, the force developed by the spring contacts shall be checked, and the value thereof shall be between 20─ 50N (2–5 kgf);

10.7.2.6.14.2 OLTC switchgear (on-load changing).

.1 the condition of the switchgear during commissioning and major repair of transformers is assessed in accordance with the manufacturer's instructions and the operating manual of the particular switchgear;

.2 current repair of OLTC gear shall be carried out together with the current repair of transformers at least once a year (unless otherwise stated in the manufacturer's documentation), and after the specific number of tap-change operations specified in the operating instructions of the OLTC manufacturer;

.3 oil in the OLTC contactor tank shall be tested for breakdown voltage following a specified number of tap-change operations as specified in the OLTC manufacturer's instructions, but at least once a year. Oil from the OLTC switchgear is tested for moisture content at the decision of the technical superintendent or in case of unsatisfactory breakdown voltage results. Oil in the OLTC contactor tank of OLTCs which are not automatically operated may be tested once every 2 years;

.4 if the values exceed the standard limits, oil shall be drained, cleaned or replaced. Oil sampling from the OLTC contactor tank for the analysis of oil-dissolved gases shall be carried out in case of unsatisfactory results of AVC of oil sampled from the transformer tank. The results are evaluated according to the OLTC manufacturer recommendations and the archived data of the technical diagnostics of the tap changer.

10.7.2.6.15 Tank tightness test;

.1 all transformer types, except for pressurized transformers and transformers without a surge tank, are subjected to testing;

.2 testing shall be carried out as follows:

for transformers up to and including 35 kV – by the hydraulic pressure of the oil column, the height of which above the level of the filled surge tank is 0,6 m, except for transformers with corrugated tanks and plate-type radiators, for which the height of the oil column is taken as 0,3 m;

for transformers with oil film protection – by creating an overpressure of 10 kPa inside the flexible enclosure;

for other transformers – by creating an overpressure of 10 kPa of nitrogen or dry air in the above-oil space of expansion tank;

.3 in all cases, the test duration shall be at least 3 h;

.4 during the test the oil temperature in the tank shall be:

at least 10 °C – for transformers up to and including 150 kV;

at least 20 °C – for 220 kV transformers;

.5 in-service tests are performed for transformers fitted with high voltage bushings of the pull-through type, the upper sealing unit of which is above the oil level in the transformer expansion tank, in case of unsatisfactory results of oil tests of the transformer tank for gas content;

.6 the transformer tank is considered to have passed the leakage test if no oil leakage or rated overpressure is detected outside the tank within the rated period of time.

10.7.2.6.16 Check of cooling devices, safety devices, gas relay, pressure switch, jet switch, oil protection against ambient air:

.1 the cooling devices are checked during commissioning, maintenance and service of the transformers and between repairs and major repairs in accordance with the operating

instructions for the cooling system included in the technical documentation of the manufacturer of the given transformer;

.2 check the safety and shut-off valve as well as the safety (exhaust) pipe during transformer commissioning and major repair in accordance with the manufacturer's instructions;

.3 check and test of the gas, pressure and jet relays in accordance with the operating instructions of the respective relays. It is prohibited to check the functionality of the gas relay installed on transformers with film protection by air blowing into it. The setting value of the gas relay shall be in accordance with the transformer's operating documentation. If there is no indication in the operating instructions, a setpoint corresponding to the maximum sensitivity that prevents the relay from tripping during start-up and shut-down of the electric cooling system pumps shall be accepted;

.4 the air dryer, the nitrogen and film oil protection systems, the thermosiphon filter and the adsorption filter shall be checked during commissioning, major repair and during operation in accordance with the manufacturer's documentation and national standards. The adsorbent to be loaded into the air dryer and transformer filters shall have a residual moisture content not exceeding 0,5 % by mass.

10.7.2.6.17 Thermovision inspection of transformer status:

.1 thermovision inspection shall be carried out for transformers of 15 kV and over;

.2 transformer monitoring frequency:

15 ─ 35 kV – once in 3 years;

35 ─ 110 kV – once in 3 years;

110 ─ 220 kV – once in 2 years;

.3 for transformers and autotransformers in which the concentration of methane, ethane and ethylene dissolved in oil exceeds or approaches the limit values, a thermovision inspection shall be carried out every 3 ─ 6 months unless otherwise stipulated by the technical superintendent. It is advisable to carry out the IR test with the transformer under maximum load and additionally at no-load.

10.7.2.6.18 Measurement of partial discharge characteristics:

.1 winding insulation monitoring according to partial discharge (PD) characteristics applies to transformers of 110 and 220 kV voltage classes at the discretion of the technical superintendent;

.2 for transformers of voltage classes 35 kV, inspection of winding insulation according to partial discharge characteristics is carried out when electrical defects are detected on the basis of analysis of gases dissolved in oil. The list of transformers to be monitored for PD and the measuring systems to be used shall be determined by the technical superintendent.".

10 New **para 10.7.5.9** is introduced reading as follows:

"**10.7.5.9** Testing of integrated switchgear (IS) of indoor installation, high-voltage sections of transformer substations (TS) of 15–35 kV in addition to 10.7.5.1 ─ 10.7.5.8.

10.7.5.9.1 Measurement of insulation resistance:

.1 the following symbols for the inspection categories are used in these requirements:

P – on commissioning of new electrical equipment and electrical equipment undergone renovation or major repairs and refurbishment by a specialized repair shop;

K – in case of major repair at an electric power entity;

S – at medium repair;

T – during routine maintenance of electrical equipment;

M – between repairs;

.2 the insulation resistance of elements made of organic materials is measured with a megohmmeter at 2500 V. The insulation resistance shall not be lower than the values given in Table 10.7.5.9.1.2.

Table 10.7.5.9.1.2

The lowest permissible insulation resistance values for moving parts made of organic materials

Test type	Insulation resistance, MOhm, for the rated voltage, in kV	
	15–150	220
P	3000	5000
S	1000	3000

.3 measurement of the insulation resistance of the secondary circuits is carried out with a megohmmeter for voltage 500–1000 – V.

10.7.5.9.2 Testing with overvoltage at 50 Hz:

.1 overvoltage testing of primary cell circuits with the frequency of 50 Hz shall be carried out on the equipment up to 35 kV inclusive. Test voltage value is assumed in accordance with Table 10.4.6.10.1.

Duration of test voltage application – 1 min.

All withdrawable elements with breakers are placed in the operating position, the breakers are switched on; withdrawable elements with surge arresters, power and measuring transformers are rolled out to the check position. The overvoltage test is carried out before the power cables are connected.

10.7.5.9.3 Checking the alignment and degree of engagement of the movable contacts in the fixed ones.

.1 contact misalignment shall not exceed 4–5 mm. The vertical play of slats of the disconnecting contacts of the withdrawable trolley shall be within 8 – 14 mm.

The contact opening of the movable contacts shall be at least 15 mm, the stroke margin – at least 2 mm;

10.7.5.9.4 D.c. resistance measurement.

.1 plug contact resistance shall not exceed the values specified in Table 10.7.5.9.2.4.1.

Table 10.7.5.9. 4.1

Permissible d.c. resistance values of IS elements

Element to be measured[1]	Permissible resistance values
1. Primary circuit plug contacts	The permissible contact resistance values are given in the manufacturer's instructions. Where contact resistance values are not given in the manufacturer's instructions, they shall not exceed: for 400 A contacts – 75 microohm; for 630 A contacts – 60 microohm; for 1000 A contacts – 50 microohm; for 1600 A contacts – 40 microohm; for 2000 A contacts and over – 33 microohm
2. Ground connection of the withdrawable element to the body	Not more than 0,1 Ohm

Note. [1] Measurement is carried out when the IS design allows for it.

10.7.5.9.5 Busbar monitoring.

.1 the inspection of the busbar connections shall be carried out in accordance with the instructions of 10.7.22;

10.7.5.9.6 Mechanical tests.

.1 tests include 5 times rolling in and out of the withdrawable elements, checking the alignment of the main circuit disconnecting contacts, operation of the shutter mechanism, interlocks, locks;

10.7.5.9.7 Checking contacts and contact connections of apparatuses and live parts of cells.

.1 check is carried out where technically possible.".

11 New **paras 10.7.18–10.7.27** are introduced reading as follows:

"**10.7.18 Testing of integrated metal sheathed gas-insulated switchgears (GIS).**

10.7.18.1 Resistance measurement of the main current-carrying circuit.

.1 measurements shall be carried out in accordance with the measurement chart for the main circuit section resistance given by the manufacturer in the operating documentation for GIS.

The measured resistance shall not exceed the values specified in the manufacturer's documentation.

10.7.18.2 Insulation resistance measurement of the main current-carrying circuit.

.1 measurements are made with a 2500 V megohmmeter.

Insulation resistance shall not be lower than the values given in Table 10.7.5.9.2.

10.7.18.3 Testing of main circuit insulation strength.

.1 the insulation of GIS main circuits shall be subjected to high-voltage testing with alternating voltage following the installation or repair affecting the insulation of the main circuits. Testing shall be carried out at the rated electronegative gas (mixture) pressure. All newly commissioned or repaired cells are subject to testing. Tests are carried out with alternating-voltage power-frequency or resonant-type test apparatuses. Tests may be carried out with alternating voltages of up to 400 Hz. The value and procedure of applying the test voltage, the stages and the order of testing the cells are determined by a technical test programme drawn up based on the provisions of IEC 62271-203 and the requirements of GIS manufacturers. Sections not subjected to testing in these cases, separated from the part under test by a breaker or disconnector, shall be earthed;

.2 it is allowed to test the GIS assemblies upon completion of repair and recovery work with a lower test voltage, compared to the one-minute rated voltage, as agreed with the technical superintendent of the electric power engineering utility. The tests shall be accompanied by monitoring of the partial discharge level. Level monitoring may be carried out using available electrical, acoustic or high-frequency partial discharge measurement methods. The GIS is considered to have passed the test if no insulation breakdowns and no partial discharges other than the noise level are detected during the test. In case of a breakdown, the repaired GIS volume shall be retested with partial discharge monitoring.

10.7.18.4 Tightness tests.

.1 tests shall be carried out on GIS filled to rated pressure with the same gas and under the same conditions as those used in operation.

The allowable leakage flow of electronegative gas shall not exceed 0,5 per cent per year of the total electronegative gas mass.

The leakage test is carried out to ensure that the leakage gas flow rate F does not exceed the manufacturer's approved leakage gas flow rate Fp.

Table 10.7.18.4.1

The allowable leakage flow of electronegative gas

Ambient temperature, in °C	Allowable leakage flow, in Fp
+40 and +50	3 Fp
20 ±2	Fp
-5 / -10 / -15 / -25 / -30 / -40	3 Fp
-50	6 Fp
-60	10 Fp

.2 when checking for leaks with a leak detector probe, the seal points of detachable joints and welds and the seals of movable parts of earthing disconnectors and breakers shall be examined. Where appropriate (multiple small defects in welds, adverse weather conditions, etc.), it is permissible to localize the suspected area with an unsatisfactory gas tightness indicator with a covering material.

Monitoring shall be carried out using a leak detector with a sensitivity of at least 102 Pa cm^3/s. The test result is considered satisfactory if the output of the leak detector shows no leakage.

Monitoring can also be carried out with fixed continuous monitoring systems (sensors) or special thermovision cameras.

10.7.18.5 Checking the moisture content in electronegative gas.

.1 the moisture content of commercial electronegative gas and used electronegative gas intended for filling or refilling of GIS isolated compartments is subject to checking when no manufacturer's certificate is available. The mass fraction of water shall not exceed 0,0015 per cent (corresponding to a dew point of minus 40 °C at the atmospheric pressure) for electronegative gas manufactured in accordance with IEC 60480:2019. When the manufacturer of the gas-insulated switch has higher quality requirements for electronegative gas than those given in the specifications, the moisture content of such gas shall comply with these requirements;

.2 the moisture content of electronegative gas in the GIS compartment shall be measured prior to GIS being put into operation (following the initial filling or refilling of GIS with electronegative gas or gas mixture, where necessary). To prevent condensation, the highest permissible moisture content inside gas-insulated GIS compartments shall be such that the dew point is not higher than minus 5 ºC for measurements at plus 20 ºC and rated electronegative gas pressure. An appropriate correction shall be made for moisture content measurements made at other temperatures, unless a different moisture content value is provided by the GIS manufacturer;

.3 should the moisture content in the electronegative gas contained in the gas-insulated GIS compartment exceed the standard, the gas shall be pumped out, the compartment drained and refilled with electronegative gas. The gas discharged from the compartment can be recovered and used in accordance with the guidelines of the GIS manufacturers and the recommendations of IEC 60480:2019.

Moisture content in the electronegative gas intended for reuse shall comply with the requirements of IEC 60480:2019.

10.7.18.6 Checking the actuation of the electrical contact device of density monitoring instruments of electronegative gas (gas mixture).

.1 checking the actuation of the electrical contact device of density monitoring instruments of electronegative gas (gas mixture) shall be carried out for each contact group of the device when the pressure monitored by the appliance is artificially reduced to warning and alarm values. The specified values shall be determined from the test pressure gauge and further adjusted to a temperature of plus 20 °C. The values obtained this way shall comply with the standard specified in the GIS operating instructions.

10.7.18.7 Checking the pressure of filling GIS gas-insulated compartments with electronegative gas or gas mixture using a test gauge.

.1 checking the pressure of filling GIS gas-insulated compartments with electronegative gas or gas mixture shall be carried out using a test gauge of the accuracy class 0,6 or higher.

The measured pressure value adjusted to a temperature of plus 20 ºC shall be within the range specified by the manufacturer.

10.7.18.8 Checking the electromagnetic interlock operation.

.1 electromagnetic interlocking includes interlocking between high voltage apparatus within the GIS cubicle, interlocking against connected busbar earthing switches and interlocking against manual operation of high voltage (HV) apparatus. Interlocking circuits are assembled on the secondary contacts of HV apparatus in accordance with the diagrams provided by the GIS manufacturer. The check consists of enabling control by an individual apparatus when the interlock conditions are met, or denying control if the conditions are not met. The check shall be carried out for all GIS apparatus.

10.7.18.9 Mechanical integrity monitoring and testing.

.1 checking of characteristics (clearances in actuator assemblies, strokes of actuator components, spring compression, etc.) is performed to the extent and according to the standards specified in the GIS operating documentation.

10.7.18.10 Check of partial discharge absence.

.1 partial discharge absence shall be monitored by the decision of the technical superintendent of the facility where the electrical equipment is located.

10.7.19 Testing of integrated shielded current leads 15 – 35 kV.

10.7.19.1 Measurement of insulation resistance.

.1 measurements are made with a 2500 V megohmmeter.

The insulation resistance measured during commissioning of the current lead is used as a baseline for subsequent monitoring during major repair work on generators or IS.

10.7.19.2 Testing of current lead insulation with overvoltage at 50 Hz

.1 the test is carried out on equipment up to 35 kV inclusive.

The value of the test voltage with the windings of generators and power transformers disconnected is taken according to Table 10.4.6.2.2-1. For conductors with a screen common to all three phases, the test voltage is applied alternately to each phase of the conductor with the other phases connected to the earthed enclosure.

Duration of the test voltage application – 1 min.

10.7.19.3 Checking the quality of the busbar and screen connections.

.1 the quality of the busbar connections shall be checked in accordance with the manufacturer's instructions;

.2 the quality of the welded joints during installation of the conductors shall be checked in accordance with the aluminum welding instructions or, if an appropriate installation is available, by X-ray or gamma-ray inspection, or by the method recommended by the manufacturer.

The welded joints of the busbars and shields shall meet the following requirements:

no cracks, burns, unsealed pits or spotting exceeding 10 per cent of the weld length and more than 15 per cent of the welded metal thickness are allowed;

the total value of poor penetration, undercuts, gas pores, oxide and tungsten inclusions in welded aluminum and aluminum alloys bars and shields in each considered section shall not exceed 15 per cent of the welded metal thickness. In operation, the condition of the welded contact joints is determined by visual inspection.

10.7.19.4 Checking the artificial ventilation devices of the current lead.

.1 check is carried out in accordance with the manufacturer's instructions.

10.7.19.5 Check for short circuits in the generator voltage current leads.

.1 The check at commissioning and during major repair work is carried out according to Table 10.7.19.5.1

Table 10.7.19.5.1

Criteria for the absence of short circuits in the current leads

Current lead design	Assembly to be checked	Condition assessment criterion	Note
With continuous screens	Insulation of shields or current lead ducts from transformer and generator enclosure at: a continuous air gap (slot) between the current lead shields and the generator enclosure;	No metal shorts between the shields and the generator enclosure	At visual examination
	one-side insulation of shield seals or current lead ducts from transformer and generator enclosure;	Integrity of the insulating bushings, no contact of the shielding surfaces or ducts (at the insulating points) with the transformer and generator housings	At visual examination
	double-side insulation of shield seals or current lead ducts connected to transformer and generator enclosure	The insulation resistance of the removable screen or duct against the transformer and generator enclosure with the tie rods and earthing conductors removed shall be at least 10 kOhm	To be measured with a 500 – 1000 V megohmmeter

Current lead design	Assembly to be checked	Condition assessment criterion	Note
Sectioned	Insulation of rubber compensators of current lead shields from transformer and generator housings	The clearance between the bolts of adjacent rubber compensator pressure rings shall be at least 5 mm	At visual examination
	Insulation of rubber seals for removable and movable screens	The insulation resistance of the screen against the steel structures with the tie rods removed shall be at least 10 kOhm	To be measured with a 500 ─ 1000 V megohmmeter
All types with double-layer screen bed gaskets	Insulating gaskets for screen beds	The insulation resistance of the gaskets against the steel structure shall be at least 10 kOhm	1. To be measured with a 500 ─ 1000 V megohmmeter 2. The condition of bushings of the frame fixing bolts is checked by visual inspection
All types	Interphase rods of disconnectors and earthing switches	The rods shall have insulating bushings or other elements to prevent short-circuiting	At visual examination

10.7.19.6 Check gas analysis for hydrogen content from a current lead.

.1 during the analysis, the hydrogen content of the hydrogen nodes is checked. The hydrogen content of shielded current leads, line and neutral terminal enclosures shall be less than 1 per cent.

10.7.19.7 Thermovision inspection.

.1 heating of the contacts and contact connections of the current-carrying circuit is assessed during the inspection. Heat monitoring is carried out where technically possible.

10.7.19.8 Partial discharge monitoring.

.1 partial discharge shall be monitored by the decision of the technical superintendent of the facility with the specified electrical equipment.

10.7.20 Testing of gas-insulated current leads (GICL) 35─220 kV.

10.7.20.1 Measurement of main circuit insulation resistance.

.1 measurements are made with a 2500 V megohmmeter.

Insulation resistance shall not be lower the values given in Table 10.7.5.9.1.2.

10.7.20.2 Measurement of main circuit resistance.

.1 measurements shall be carried out in accordance with the measurement chart for the main circuit resistance given by the manufacturer in the operating documentation for the gas-insulated current leads.

The measured resistance shall not exceed the maximum values permissible during the acceptance test.

10.7.20.3 Tests of electrical insulating strength at 50 Hz.

.1 the insulation of the main circuits of gas-insulated current leads shall be subjected to high-voltage testing with alternating voltage following the installation or repair affecting the insulation of the main circuits. Testing shall be carried out at the rated electronegative gas (mixture) pressure. All newly commissioned or repaired cells are subject to testing. Tests are carried out with alternating-voltage power-frequency or resonant-type test apparatuses. Tests may be carried out with alternating voltages of up to 400 Hz. The value and procedure of applying the test voltage, the stages and the order of testing the cells are determined by a technical test programme drawn up based on the requirements of equipment manufacturers. Sections not subjected to testing in these cases, separated from the part under test by a breaker or disconnector, shall be earthed;

.2 it is allowed to test the current leads upon completion of repair and recovery work with a lower test voltage, compared to the one-minute rated voltage, as agreed with the

technical superintendent of the electric power engineering utility. The tests shall be accompanied by monitoring of the partial discharge level. Level monitoring may be carried out using available electrical, acoustic or high-frequency partial discharge measurement methods. The current lead is considered to have passed the test if no insulation breakdowns and no partial discharges other than the noise level are detected during the test. In the event of a breakdown, the repaired GICL volume shall be retested with partial discharge monitoring.

10.7.20.4 Checking the tightness of enclosures.

.1 tests shall be carried out on gas-insulated current leads filled to the rated pressure with the same gas and under the same conditions as those used in operation.

Checking is carried out using a leak detector with a sensitivity of at least 10^2 Pa cm^3 /s. The leak detector probe is used to inspect the joint seals and enclosure welds. The test result is considered satisfactory where no leak is indicated by the leak detector.

The allowable leakage flow of electronegative gas shall not exceed 1 % per year of the total electronegative gas mass.

The check can also be carried out with fixed continuous monitoring systems (sensors) or special thermovision cameras.

10.7.20.5 Checking the moisture content in electronegative gas.

.1 the moisture content of commercial electronegative gas and used electronegative gas intended for filling or refilling of GICL isolated compartments is subject to checking when no manufacturer's certificate is available. The mass fraction of water shall not exceed 0,0015 % (corresponding to a dew point of minus 40 °C at the atmospheric pressure) for electronegative gas manufactured in accordance with IEC 60480:2019. When the manufacturer of the gas-insulated switch has higher quality requirements for electronegative gas than those given in the specifications, the moisture content of such gas shall comply with these requirements;

.2 the moisture content of electronegative gas in the GIS compartment shall be measured prior to GIS being put into operation (following the initial filling or refilling of GIS with electronegative gas or gas mixture, where necessary). To prevent condensation, the highest permissible moisture content inside gas-insulated GIS compartments shall be such that the dew point is not higher than minus 5 ºC for measurements at plus 20 ºC and rated electronegative gas pressure. An appropriate correction shall be made for moisture content measurements made at other temperatures, unless a different moisture content value is provided by the GIS manufacturer.

Should the moisture content in the electronegative gas contained in the gas-insulated GIS compartment exceed the standard, the gas shall be pumped out, the compartment drained and refilled with electronegative gas. The gas discharged from the compartment can be recovered and used in accordance with the guidelines of the GIS manufacturers and the recommendations of IEC 60480:2019.

Moisture content in the electronegative gas intended for reuse shall comply with the requirements of IEC 60480:2019.

10.7.20.6 Checking the pressure of filling GICL gas-insulated compartments with a gas or gas mixture using a test gauge.

.1 checking the pressure of filling GICL gas-insulated compartments with a gas or gas mixture shall be carried out using a test gauge of the accuracy class 0,6 or higher.

The measured pressure value, adjusted to a temperature of plus 20 °C, shall be within the range specified by the manufacturer.

10.7.20.7 Monitoring of partial discharge absence.

.1 absence of partial discharge shall be monitored by the decision of the technical superintendent of the facility with the specified electrical equipment.

10.7.21 Testing of current leads with cast (solid) insulation for the voltage of 15– 35 kV.

10.7.21.1 General.

.1 testing shall be carried out within the extent specified in 10.7.19 ─ 10.7.19.3;

.2 partial discharge monitoring.

10.7.21.2 Partial discharge shall be monitored by the decision of the technical superintendent of the facility where the specified electrical equipment is located.

10.7.21.3 Thermovision inspection.

.1 thermovision inspection is carried out where technically possible.

10.7.22 Testing of collecting busbars and connecting bars, rigid busbars.

10.7.22.1 Measurement of insulation resistance of suspended and supported porcelain insulators.

.1 measurement shall be carried out with a megohmmeter for a voltage of 2500 V only when the ambient air temperature is positive.

When installing insulators, the insulation resistance is measured immediately before installing the insulators.

The resistance of each insulator or each element of a multiple-element insulator shall be at least 300 MOhm.

10.7.22.2 Testing of busbar insulation with overvoltage at 50 Hz

.1 the test is carried out on equipment up to 35 kV inclusive.

Test voltage value is assumed in accordance with Table 10.4.6.2.1-2.

.2 newly installed multi-element or suspended insulators shall be tested with increased voltage of 50 kV at 50 Hz applied to each insulator element.

Duration of test voltage application ─ 1 min.

10.7.22.3 Checking of condition of entries, supporting and bushing insulators.

.1 is carried out in accordance with the provisions of section 10.7.25 of this Section.

10.7.22.4 Thermovision inspection.

.1 thermovision inspection is carried out where technically possible.

10.7.23 Testing of current-limiting dry reactors.

10.7.23.1 Measurements of winding insulation resistance relative to hold-down bolts.

.1 measurement is carried out with a megohmmeter for voltages of 1000 ─ 2500 V. The value of the insulation resistance of newly commissioned reactors shall be at least 0,5 MOhm and at least 0,1 MOhm during operation.

10.7.23.2 Testing of reactor support insulators with overvoltage at 50 Hz.

.1 the test is carried out on equipment up to 35 kV inclusive.

Test voltage value is assumed in accordance with Table 10.4.6.2.1-2.

Testing of reactor support insulators with 50 Hz overvoltage can be carried out together with bus arrangement insulators.

Duration of test voltage application ─ 1 min.

10.7.24 Testing of valve-type arresters and overvoltage limiters (OVL).

10.7.24.1 General.

.1 Overvoltage limiters not listed in this section shall be tested in accordance with the manufacturer’s operating instructions.

10.7.24.2 Resistance measurement of arresters and overvoltage limiters.

.1 the measurement shall be carried out:

for arresters and OVL with the rated voltage below 3 kV – by a 1000 V megohmmeter;

for arresters and OVL with the rated voltage of 3 kV and over – by a 2500 V megohmmeter;

.2 resistance is measured before commissioning and at the start of scheduled maintenance of the equipment to which the protective devices are connected, but at least once every 6 years for arresters and OVL;

.3 the resistance of the RVP, RVO, GZ arrester types shall not be less than 1000 MOhm, and for RVN shall comply with the manufacturer’s requirements.

The resistance of the RVS-type arrester elements shall comply with the requirements of the manufacturer’s instructions. The resistance of the RVM, RVRD, RVMG, RVMK type arrester elements shall comply with the values given in Table 10.7.24.2.3.

The resistance of the capacity simulator shall be measured with a 1000 V megohmmeter. The value of the measured resistance shall not differ by more than 50 % from the manufacturer’s measurement results or previous measurements in operation;

Table 10.7.24.2.3

Resistance values of valve-type arresters

Type of arrester or element	Resistance, in MOhm		Permissible operating variations from the manufacturer's data or initial measurement data
	not less	not more	
RVM-15 RVM-20 RVM-35 (2-element)	600 1000 600	2000 10000 2000	±30 %
RVMG arrester element 110M 150M 220M	 400 400 400	 2500 2500 2500	±60 %

.4 the insulation resistance of the insulating bases of arresters with trip recorders shall be measured with a 1000–2500 V megohmmeter. The value of the measured insulation resistance shall not be less than 1 MOhm;

.5 the resistance of overvoltage limiters with the rated voltage of 3–35 kV shall comply with the manufacturer's instructions;

.6 the resistance of overvoltage limiters with the rated voltage of 110 kV or over shall not be less than 3000 MOhm (unless another value is specified in the manufacturer's instructions) and shall not differ by more than ±30 % from that given in the data sheet or obtained from previous measurements in operation;

.7 measurement of the conductive current of valve arresters at the rectified voltage;

.7.1 measurement shall be carried out for arresters with shunt resistors before commissioning, and in addition for arrester with magnetic arc quenching at least every 6 years. An unscheduled measurement of the conductivity current is carried out for a final assessment of the arrester condition where the megohmmeter measurement detects a change in resistance exceeding the value specified in 10.7.24.2.3.

The permissible conductivity currents of the valve arresters are given in Table 10.7.24.2.7.1.

Table 10.7.24.2.7.1

Permissible values of conductive current of valve arresters at the rectified voltage

Type of arrester or element	Test rectified voltage, in kV	Conductive current at arrester temperature 20 °C, in μA	
		not less	not more
PBC-15 PBC-20 PBC-33 PBC-35	16 20 32 32	200 200 450 200	340 340 620 340
PBM-15 PBM-20	18 28	500 500	70 700
PBЭ-25M PBMЭ-25	28 32	400 450	650 600
PBMГ-110M, 150M, 220M arrester element	30	1000	1350

Note. To adjust the conductive currents of the arresters to a temperature of plus 20 °C, a correction equal to 3 % for every 10 degrees of deviation shall be made (at the temperature above 20 °C the correction shall be negative).

.8 measurement of the conductive current of the overvoltage limiters.

.8.1 measurement of the conductive current of the overvoltage limiters shall be carried out:

Prior to commissioning:

for limiters of voltage classes 15–110 kV at the highest continuous permissible phase voltage;

for limiters of voltage class 150, 220[1] kV at 100 kV of 50 Hz frequency.

In operation:

for 35 kV overvoltage limiters once in 4 years;

for limiters of voltage class 110 kV and over, without disconnection from the network, once a year before the lightning season;

for limiters installed in the neutral conductor of a 110 kV transformer, when the transformer is taken out of service, but at least once every 6 years;

for limiters of voltage class 110 kV and over, when taken out of service for more than 1 month.

.8.2 the method of conductive current measurement, as well as the limiting values at which the limiter is taken out of service, are specified in the manufacturer's instructions.

.9 thermovision inspection of valve-type arresters and surge arresters;

.9.1 is carried out on valve-type arresters with shunt resistance and overvoltage limiters, where technically possible.

If the thermal inspection results are satisfactory, the check of the status of the valve dischargers and voltage limiters according to 10.7.24.2.2–10.7.24.2.4 may be omitted during the inter-repair tests;

.10 checking of arrester tightness;

.10.1 the tightness is checked in the event of the arrester major repair with its opening-up. Checking shall be carried out at vacuum of 300–400 mmHg. The pressure change with the valve closed shall not exceed 0,5 mmHg within 1 – 2 hours.

10.7.25 Testing of entries and bushing insulators.

10.7.25.1 General.

.1 testing of 35 – 750 kV bushings with RIP, RBP, RIN insulation is carried out according to the manufacturer's procedure. The rated parameters and test periods are as specified in the manufacturer's certificates and instructions.

10.7.25.2 Measurement of insulation resistance.

.1 measurement of the insulation resistance of the measuring capacitor PIN (C_2) with a 2500 V megohmmeter, and of the last insulation layers (C_3) with a 2500 V megohmmeter shall be carried out, unless otherwise instructed by the manufacturer.

The insulation resistance values shall be at least 1000 MOhm during commissioning and at least 500 MOhm during operation;

.2 measurement interval for entries of 110–220 kV – once every 4 years.

For entries with solid insulation, measurements of insulation resistance shall be made in accordance with the manufacturer's instructions.

Measurement of the insulation resistance of transformer entries shall be carried out in accordance with 10.7.2.6.7.

10.7.25.3 Measurement of tgδ and insulation capacity.

.1 the following measurement of tgδ and capacity shall be carried out:

of the base insulation of entries at 10 kV;

insulation of the measuring capacitor PIN (C_2) or (and) the terminal layers of the insulation (C_3) at 5 kV, unless the measurement of C_3 is prohibited by the manufacturer;

measurement of C_3 and $tg\delta_3$ for RIP insulation is not performed to prevent damage to the entry.

Limit values of tgδ are given in Table 10.7.25.3.1;

.2 the limit increase in the basic insulation capacitance is 5 per cent of the capacity measured at commissioning.

During operation, the following measurement intervals are set for the entries:

35 kV – when carrying out repair work on the breakers where they are installed;

110 – 220 kV – in 1 year after commissioning, then once every 4 years.

[1] For overvoltage limiters of 220 kV the conductive current may be measured at 75 kV of 50 Hz frequency.

Table 10.7.25.3.1

Limiting tgδ values of entries

Entry type and insulation area	Limit values of tgδ, in %, for entries with the rated voltage, in kV		
	35	110 ─ 150	220
Paper-oil insulation of entry: - base insulation (C1) and PIN capacitor insulation (C2); - terminal layers of insulation (C3).	-─ -	0,7/1,5 1,2/3,0	0,6/1,2 1,0/2,0
Solid entry insulation with oil filling*: - base insulation (C1).	1,0/1,5	1,0/1,5	─
Paper-bakelite mastic-filled input insulation: - base insulation (C1)	3,0/9,0	─	─
RIP – entry insulation[1] - base insulation (C1)	1/1,2	0,7/1,2	

[1] In accordance with the manufacturer's documentation.

1. The numerator indicates the insulation tgδ value at commissioning, the denominator – the insulation tgδ value during operation.

2. A decrease of Δtgδ (%) ≥ 0,3 in the tgδ of the base insulation of the sealed entry in comparison with the previous measurement is an indication for additional tests to determine the cause of the decrease in tgδ. For solid insulation, the limit value of $tg\delta_1$ shall not be lower than 0,25 per cent, and in case of a sharp increase of $tg\delta_1$ by more than 0,2 per cent in one year, the manufacturer's advice is necessary.

3. The tgδ values adjusted to a temperature of 20 °C are standardized. The adjustment shall be made in accordance with the instructions for the entry operation.

4. "-" sign indicates no limit value.

10.7.25.4 Testing with overvoltage at 50 Hz.

.1 the test is carried out on equipment up to 35 kV inclusive.

The test voltage value for bushing insulators and entries tested separately or upon installation on equipment, is assumed according to Table 10.4.6.10.7.1;

.2 testing of entries installed on power transformers is carried out together with testing of the windings of these transformers. Test voltage value is assumed in accordance with Table 10.4.6.10.7.1.

Duration of test voltage application – 1 min.

10.7.25.5 Overpressure test.

.1 the overpressure test is carried out on untight oil-filled entries of 110 kV and over, with an overpressure of 0,1 MPa for the purpose of checking the seals.

The test duration is 30 min. A pressure drop of max. 5 kPa during the test period is permissible.

10.7.25.6 Testing of oil from the entries.

.1 when commissioning the entries, oil shall be tested in accordance with the relevant requirements;

.2 determination of the physical and chemical characteristics of oil from unsealed entries is performed:

for 110 ─ 220 kV entries ─ once in 4 years;

.3 the necessity for chromatographic analysis of oil-dissolved gases (DGA) shall be determined by the technical superintendent of the electrical power entity based on the aggregate results of the entry tests. Evaluation of the results ─ in accordance with the manufacturer's recommendations and the archived data of the bushing state technical diagnostics.

10.7.25.7 Gauge testing.

.1 for sealed entries, check the pressure gauge means its replacing with a calibrated pressure gauge. The replacement shall be carried out within the interval between checks.

10.7.25.8 Monitoring of insulation under operating voltage.

.1 it is advisable to monitor the insulation of entries under operating voltage at all capacitor-type entries of 110 ─ 220 kV with paper-oil insulation, installed on transformers with the rated voltage of 110 kV and higher, installed on the essential facilities.

For live entries, monitoring in accordance with 10.7.25.1, 10.7.25.2 (except of measurement of insulation resistance and tgδ of area C3) and 10.7.25.5 in operation may only be carried out if the test results according to 10.7.25.7 are unsatisfactory.

Parameters to be monitored: change of dissipation factor (Δtgδ) and capacitance (ΔC/C) of the base insulation. The change in the values of the parameters to be monitored is defined as the difference between the results of regular measurements and those taken at the manufacturer's release;

.2 where the tgδ value differs from the manufacturer's data by 0,3 per cent and more, perform measurements at Utrest = 10 kV. Should the difference be observed, perform DGA. The limit value of the increase in insulation capacitance is 5 per cent of the value measured when the live monitoring system is put into operation. Periodicity of inspection of live entries is 2 times a year. One of the measurements can also be taken at sub-zero temperatures.

T a b l e 10.7.25.8

Limiting values of |Δtgδ| and ΔY/Y

Voltage class, in kV	Limiting values of parameters, in, %, | Δtgδ | and ΔY/Y	
	at periodical monitoring	at continuous monitoring
110 ─ 220	2,0	3,0

N o t e . A decrease of Δtgδ (%) ≥ 0,3 in tgδ of the base insulation of the sealed entry in comparison with the previous measurement is an indication for additional tests to determine the cause of the decrease in tgδ.

10.7.25.9 Checking the insulation integrity.

.1 if chipping and cracking of porcelain, cracks in reinforcement joints are detected, vibroacoustic examination of the damaged entries and bushings shall be carried out by decision of the technical superintendent of the electric power entity.

10.7.25.10 Thermovision inspection.

.1 thermovision inspection of entries where technically possible.

10.7.25.11 Partial discharge monitoring.

.1 measurement of partial discharge levels on entries and bushings at the voltage of 110 kV and over shall be carried out by decision of the technical superintendent of the electric power entity.

10.7.25.12 Comprehensive diagnostic examination.

.1 comprehensive diagnostic examination (CDE) of the of generator circuit breaker bushings, all circuit breakers and power transformers of 110 kV and above shall be carried out during the CDE of the said power equipment.

Comprehensive diagnostic examination of entries shall be carried out to the extent of the tests and measurements of this section.

10.7.26 Testing of fuses, fuse disconnectors with voltage of 15─35 kV.

10.7.26.1 Testing of reference insulation with overvoltage at 50 Hz.

.1 the test is carried out on equipment up to 35 kV inclusive.

The value of the test voltage of the fuse, fuse disconnector base insulation is taken according to Table 10.4.6.18.1.

Duration of test voltage application ─ 1 min.

10.7.26.2 Checking the integrity of the fuse insert.

.1 to be checked:

using an ohmmeter ─ the integrity of the fusible link;

visually ─ the calibration on the cartridge.

10.7.26.3 Measurement of the d.c. resistance of the fuse-disconnector cartridge.

.1 the measured resistance value shall correspond to the nominal current value of the cartridge calibration.

10.7.26.4 Measurement of contact pressure in the fuse disconnector receptacle contacts.

.1 the measured value of the contact pressure shall correspond to the manufacturer's specifications.

10.7.26.5 Check the condition of the arc-suppression part of the fuse disconnector cartridge.

.1 check the internal diameter of the arc-suppression part of the fuse disconnector cartridge. The measured value of the internal diameter of the arc-suppression section of the cartridge shall be in accordance with the manufacturer's specifications.

10.7.26.6 Checking the operation of the fuse disconnector.

.1 5 cycles of fuse disconnector on and off operations are performed.

Each operation shall be successful at a single attempt.

10.7.26.7 Thermovision inspection.

.1 is carried out where technically possible.

10.7.27 Testing of power cable lines with voltages from 15 to 220 kV.

For power cable lines (CL) of 15 to 220 kV, the following tests shall be carried out to confirm the quality and proper installation of CL and to determine the technical characteristics of CLs:

A.c. voltage, sinusoidal waveform and frequency ─ in the range of 20 ─ 300 Hz, test voltage level according to Table 10.7.27.7.1.3, or rated operating line voltage for 24 hours without load;

determination of cable core integrity and phasing of cable cores and cable shields is carried out in operation after assembly, installation of sleeves or disconnection of cable cores has been completed;

determination of cable core resistance;

determination of the electrical operating capacity of cables;

measurement of current distribution over single-core cables and shields;

checking the earthing device (measuring the earthing resistance);

testing of cable sheaths with d.c. voltage;

measurement of partial discharge characteristics;

thermovision inspection of terminations and cable entries in GIS (for 35 ─ 220 kV cable lines);

measurement of the dissipation factor;

checking the integrity of the fibre optic cables (at the customer's request, this check can also be carried out immediately after laying the construction cable lengths, before installation of the couplings and termination sleeves).

Electrical tests of cable lines after laying are carried out upon completion of the cable installation.

10.7.27.1 Testing of cable insulation by excessive rectified voltage.

.1 for plastic-insulated cables up to 3 ─ 35 kV the duration of the full test voltage application is 10 min and at steady production ─ 5 min.

.2 for cables of 35 ─ 220 kV the duration of the full test voltage is 15 minutes.

.3 the permissible leakage currents depending on the test voltage and the permissible values of the asymmetry coefficient for measuring the fault current are given in Table 10.7.27.1.3.

The absolute value of the leakage current is not a rejection indicator.

Cables with satisfactory insulation must have stable fault currents. The fault current shall decrease when the test is carried out. If the fault current does not decrease, or when it increases or the current is unstable, carry out the test until the defect is detected, but not longer than 15 minutes.

Table 10.7.27.1.3

Fault currents and asymmetry coefficients for power cables

Cable of voltage, in kV	Test voltage, in kV	Permissible fault current values, in mA	Permissible values of asymmetry coefficients (I_{MAX}/I_{MIN})
20–34	100	1,5	10
35–109	175	2,5	10
110–149	285	not standardized	not standardized
150–219	347	not standardized	not standardized
220	510	not standardized	not standardized

.4 it is permissible, in agreement with the cable manufacturer, to carry out an a.c. voltage test at 50 Hz instead of a rectified voltage test for cables of 110–220 kV voltage level. In this case the tests shall be carried out with the voltage (1,00–1,73) ·Unom, and test duration time shall be agreed with the manufacturer.

10.7.27.2 Determination of cable core integrity and phasing of cable lines.

.1 the testing shall be carried out following completion of the installation, reassembly of the couplings or disconnection of the cable cores;

10.7.27.3 Determination of cable core resistance.

.1 tests are carried out for lines of 20 kV and over. Resistance of cable cores to direct current, corrected to a specific value (per 1 mm^2 of cross-section, 1 m of length, at 20 °C), shall not exceed 0,01793 Ohm for copper core and 0,0294 Ohm for aluminum core. The measured resistance (corrected to specific value) may deviate from the specified values by no more than 5 %.

10.7.27.4 Determination of the electrical operating capacity of cables.

.1 determination is carried out for lines of 20 kV and over. Cross-linked polyethylene (CLP) cables are not subject to this test. The measured capacity corrected to a specific value (per 1 m of length) shall not differ from the factory test values by more than 5 per cent.

10.7.27.5 Measurement of current distribution over single-core cables.

.1 current distribution irregularity in the conductive cores and sheaths (shields) of the cables shall not exceed 10 per cent. Monitoring is performed when 2 or more cables are connected in parallel in the same phase.

10.7.27.6 Checking the earthing device.

.1 for 15– 220 kV lines, the transient earthing resistance of cable terminals and terminations are measured in relation to the armour (shield) of the CL and the earth connection of the electrical installation to which the cable line is connected. Transient resistance is measured (if the contact connection is in good condition, resistance does not exceed 0,05 Ohm).

.2 in operation, the transient earth resistance is measured during the major repair of the earthing devices, and the integrity of the metal bonding between the earthing switches of cable lines of voltage 110 kV and over and the transformer neutral is measured once every 3 years. Check is carried out by tapping the joints with a hammer and examination for breaks and other defects.

10.7.27.7 Testing of 110–220 kV CLP insulated cables with increased a.c. voltage.

.1 testing shall be carried out in accordance with IEC 60840:2017 and IEC 62067:2011.

.2 20–300 Hz overvoltage tests are carried out with a resonant high-voltage test equipment. Duration of test voltage application – 60 min.

Table 10.7.27.7.1

Value of test alterating voltage for 35 – 220 kV CLs with CLP insulation

Voltage class, in kV	Test voltage level, in kV	
	commissioning	in operation
35 – 47 (IEC 60840:2017)	52 kV	52 kV irrespective of the service life
47,1– 69(IEC 60840:2017)	72 kV	72 kV irrespective of the service life
69,1–115 (IEC 60840:2017)	128 kV	128 kV irrespective of the service life
115,1–138 (IEC 60840:2017)	152 kV	132 kV irrespective of the service life
138,1–161 (IEC 60840:2017)	174 kV	150 kV irrespective of the service life
161,1–220 (IEC 62067:2011)	180 kV	180 for cables with a service life of up to 5 years; 152 for cables with a service life over 5 years

10.7.27.8 Monitoring the condition of couplings by means of measurement and localization of partial discharges.

.1 the examination is carried out on plastic-insulated CLs of 110 kV and over at commissioning, then at the decision of the technical superintendent of the electric power entity, depending on the results of the last PD measurements and thermovision inspection.

10.7.27.9 Thermovision inspection.

.1 during the operation, thermovision inspection is carried out:

on CLs 35 kV and below – at least once every 3 years together with the electrical equipment of the switchgear (provided that a television inspection of the CLs under load can be carried out);

on 110–220 kV CLs – at least once every 2 years together with the electrical equipment of the switchgear;

.2 unscheduled thermovision inspection of CLs is carried out when signs of a developing defect are detected by other means of inspection (PD, tgδ, current in the shield earthing, etc.). The sheath temperature of cables on which a temperature monitoring system is fitted shall be monitored at shift takeover by the attending operating personnel every shift. At sites without permanent attending staff – at least once a month.".

12 **Table 10.8.4-1** is replaced by the following:

"Table 10.8.4-1

Products	Tests and checks in accordance with 10.8.2 and 10.8.3	Test at increased speed[1]	Measurements of collector runout (of slip rings), check of axial displacement of a rotor (armature)	Test of interturn insulation strength	Check in operation at nominal parameters and short- time current overload	Check of interlocks, protection and alarm operation	Other specific checks
Electrical machines[2]	+[3,4]	+[5]	+[6]	+	+[7]	+	+[8]
Electromagnetic couplings	+[3,4]	+	+[6]	+	+	-	-
Transformers, current-limiting and shunting reactors	+	-	-	+	+[7]	+	+[9]
Static converters	+	-	-	+[10]	+	+[11]	+[12]

[1] Performed prior to insulation testing.
[2] Synchronous and d.c. generators, induction and d.c. motors, converters, rotary amplifiers.
[3] If necessary (as a rule, for large products), with measurements of air gaps, with a check of documents on balancing, testing a water cooling system for tightness and strength.
[4] With mass production of machines rated up to 5 kW, insulation strength may be tested during 1 s at a voltage equal to 1,2 times the full normalized test voltage.
[5] Excepting cage induction motors.
[6] Applies to large products. With propulsion plant motors and couplings, the runout of a shaft end shall also be measured.
[7] For a.c. machines and transformers, the check may be replaced by an open-circuit and short-circuit tests.
[8] Check of commutator machines switching at the rated load and short-time current overload, the check of limits of voltage setting variation for generators with a static field system, the check of electric heating of the machine, the measurement of voltage between the insulated bearing base and foundation, as well as between shaft ends of such machines.
[9] With nonflammable liquid-filled transformers, the tank test for tightness and the test of a dielectric sample taken from the tank.
[10] Applies to converter transformers lacking such a test.
[11] Check of overload and short-circuit protection in operation.
[12] Check of operation at load loss and increase, the check of control apparatus and filter operation.

".

13 **Table 10.8.4-2** is replaced by the following:

"Table 10.8.4-2

Products	Tests and checks in accordance with 10.8.2 and 10.8.3	Check of operation of drives and indicators of switching positions	Check of interlocks operation	Check of adjustment and operation of elements (releases, integrated relays, etc.)	Check of electrical resistance value	Operational test	Other specific checks
Circuit breakers	+	+	+	+	-	-	-
Breakers, switches, disconnectors, push-button and limit switches	+	-	-	-	+[1]	-	-
Fuses, disconnecting fuses	+	-	-	-	+[1]	-	+[2]
Contactors, contact relays	+	-	-	-	-	-	+[3]
Starters, controllers	+	-	+	+	-	+	-
Rheostats	+	+	-	+	+	-	-
Resistors in boxes	+	-	-	-	+	-	-
Magnetic amplifiers, apparatus, blocks and modules with contactless elements	+	-	-	-	-	+	-
Reactors, chokes	+	-	-	-	+[4]	-	-
Generator protection devices	+	-	+	+	-	+	-
Electrical measuring (switchboard) instruments	+	-	-	-	-	+[5]	+[6]
Electrical switchboards and consoles	+	+	-	-	-	+[7]	-
Integrated switchgears up to 35 kV	+	+	+	-	+	+[7]	+[8]
Integrated gas-insulated switchgears 35 ─ 220 kV	+	+	+	-	+	+[7]	+[9]
OVL, valve-type arresters	+	-	-	-	-	-	+[10]
Insulators, entries	+	-	-	-	-	-	+[11]
Internal communication and alarm devices and apparatus	+	-	-	-	-	+	-

Products	Tests and checks in accordance with 10.8.2 and 10.8.3	Check of operation of drives and indicators of switching positions	Check of interlocks operation	Check of adjustment and operation of elements (releases, integrated relays, etc.)	Check of electrical resistance value	Operational test	Other specific checks
Ship's control and monitoring devices[12]	+	-	-	-	-	+	+[13]
Electrical heating and cooking appliances	+	-	-	-	-	-	+[14]
Lighting fixtures	+	-	-	-	-	-	-
Busducts	+	+	-	-	-	-	-
Shielded current leads, with cast insulation	+	+	-	-	-	-	+[15]
Gas-insulated current leads	+	+	-	-	+	-	+[16]

[1] Applies to fuse-links, performed periodically by sampling.
[2] Test for the maximum non-fusing current and minimum fusing current. Performed periodically by sampling.
[3] Check of contact gaps, follows-up and pressure. Check of actuation parameters.
[4] Measured inductive impedance.
[5] Performed with instruments inclined. Periodical sampling inspection of operation at ambient air temperatures above 25 °C; at mechanical actions (in a reduced scope as compared with prototype tests): at the limiting permissible deviations of voltage and frequency from rated values.
[6] Determination of a basic error and variation.
[7] Applies to control, monitoring and alarm circuits.
[8] Monitoring the integrity of enclosures, checking the moisture content in electronegative gas, checking the pressure of filling gas-insulated compartments with a gas or gas mixture using a test gauge.
[9] Measurement of conductive current, leakage test.
[10] Measurement of insulation capacity, overpressure test, oil test from entries in the appropriate types of equipment.
[11] Checking the alignment and degree of engagement of the movable contacts in the fixed ones, check of collecting busbars, contacts.
[12] Sensors (tachogenerators) and indicators of tachometers of propeller shafts shall be additionally tested as electrical machines and electrical measuring instruments respectively.
[13] Check of accuracy of indicator readings.
[14] Test of fuel oil and luboil heaters for tightness and strength (or check of documents if such tests are carried out in production), as well as of products operating under steam pressure, or potentially being pressurized with steam, if these are subject to the requirements of 1.3.2.1, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships. Check of operation of protection against abnormal operating modes (an elevated temperature, the drop of a liquid level, etc.).
[15] Check of artificial ventilation devices, check of the absence of short circuits in the generator voltage current leads, control gas analysis for hydrogen content in the relevant equipment.
[16] Tightness test, check of moisture content in electronegative gas, acting test of electrical contact device of gas (gas mixture) density monitoring, check of filling pressure of gas-insulated compartments with gas or gas mixture with a control manometer, check and tests of mechanical integrity testing.

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