Excerpt from ABS Rules
Developed for Switchboard Manufacturers

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CONTENTS

Foreword

Purpose

This booklet is an excerpt from the ABS Rules. It has been created to support equipment manufacturers in identifying the appropriate ABS Rules for their products.

Application

Equipment manufacturers seeking to have their products approved for marine and offshore applications under ABS classification or certification will find this booklet a practical reference for determining which sections of the ABS Rules are applicable to their specific equipment types.

This excerpt does not replace or supersede the complete ABS Rules. Users are responsible for consulting the full text of the applicable Rules and ensuring compliance with the most current edition, including any published corrigenda and notices.

Additional Information

For questions regarding the applicability of specific Rules to your equipment. Please contact your local ABS office.

The ABS Rules are available in their complete form at American Bureau of Shipping (ABS) Eagle.org.

9 Switchboards, Distribution Boards, Controllers, etc.

9.1 General

9.1.1 Applications

Switchboards are to provide adequate control of the generation and distribution of electric power. The following equipment are to be constructed and tested in accordance with the following requirements to the satisfaction of the Surveyor.

9.1.1(a) Switchboards.

Switchboards for essential services or for services related to additional optional notations requested for the unit.

9.1.2(b) Emergency Switchboard.

For requirements covering emergency switchboard, see 4-3-2/5.9.

9.1.2(c) Circuit Breakers.

For requirements covering generator circuit breakers, see 6-1-7/13.1.

9.1.2(d) Feeder Protection.

For requirements covering feeder protection, see 4-3-2/9.3 to 4-3-2/9.17, 4-3-2/11.3, 4-3-2/13.1.4 and 4-3-2/13.3.3.

9.1.2(e) *Hull Return and Earthed Distribution System.*

For requirements covering hull return system and earthed distribution system, see 4-3-2/7.3 and 4-3-2/7.5, respectively.

9.1.2(f) Earthing.

For requirements covering earthing connections, see 4-3-3/7. For requirements covering earthing for main and emergency switchboards of three-wire dual-voltage DC systems, see 4-3-5/5.3.

9.1.2(g) Installation.

For requirements covering installation, see 4-3-3/3.9 for switchboard, 4-3-3/3.11 for distribution boards, and 4-3-3/3.13 for motor controllers and control centers.

9.1.2(h) Protection Enclosures and its Selection.

For requirements covering degree of the protection and the selection of equipment, see 4-3-1/15 and 4-3-3/3.1, respectively.

9.3 Insulation Resistance Measurement

The insulation resistance between current-carrying parts (connected together for the purpose of this test) and earth and between current-carrying parts of opposite polarity is to be measured at a DC voltage of not less than 500 volts before and after the dielectric strength tests. The insulation resistance measurement after the dielectric strength tests is to be carried out before components which have been disconnected for the dielectric tests are reconnected, and the insulation resistance is not to be less than 1 megohm.

9.5 Dielectric Strength of Insulation

The dielectric strength of the insulation is to be tested for 60 seconds by an alternating voltage applied in accordance with 6-1-7/19.23 TABLE 6 between:

i. All live parts and the interconnected exposed conductive parts, and
ii. Each phase and all other phases connected for this test to the interconnected exposed conductive parts of the unit

The test voltage at the moment of application is not to exceed 50% of the values given in 6-1-7/19.23 TABLE 6. It is to be increased steadily within a few seconds to the required test voltage and maintained for 60 seconds. Test voltage is to have a sinusoidal waveform and a frequency between 45 Hz and 60 Hz.

9.5.1 Production-line Apparatus

Standard apparatus produced in large quantities for which the standard test voltage is 2500 volts or less can be tested for one second with a test voltage 20% higher than the one-minute test voltage.

9.5.2 Devices with Low Insulation Strength

Certain devices such as potential transformers having inherently lower insulation strength are to be disconnected during the test.

9.7 Construction and Assembly

9.7.1 Enclosures and Assemblies

Enclosures and assemblies are to be constructed of steel or other suitable, incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electrical (magnetic) and thermal stresses likely to be encountered in service, and are to be protected against corrosion. No wood is to be used, except for hardwood for nonconducting hand rails. Insulating materials are to be flame-retardant and moisture-resistant. The supporting framework is to be of rigid construction.

9.7.2 Dead Front

The dead-front type is to be used. Live-front type is not acceptable, regardless of the voltage ratings.

9.7.3 Mechanical Strength

All levers, handles, hand wheels, interlocks and their connecting links, shafts and bearings for the operation of switches and contactors are to be of such proportions that they are not broken or distorted by manual operation.

9.7.4 Mechanical Protection

The sides and the rear and, where necessary, the front of switchboards are to be suitably guarded. Exposed live parts having voltages to earth exceeding a voltage of 55 volts DC or 55 volts AC rms between conductors are not to be installed on the front of such switchboards. Unless the switchboard is installed on an electrically insulated floor, non-conducting mats or gratings are to be provided at the front and rear of the switchboard. Where the floor on which the switchboard is installed is of electrically insulated construction, the insulation level of the floor to the earth is to be at least 50 MΩ. A notice plate is to be posted at the entrance to the switchboard room or on the switchboard front panel to state that the floor in the room is of electrically insulated construction. Drip covers are to be provided over switchboards when subject to damage by leaks or falling objects.

9.9 Bus Bars, Wiring and Contacts

9.9.1 Design

Copper bar is to be used for main and generator bus in the switchboard. Other materials and combination of materials are subject to ABS technical assessment and approval. Generator bus bars are to be designed on a basis of maximum generator rating. All other bus bars and bus-bar connections are to be designed for at least 75% of the combined full-load rated currents of all apparatus they supply, except that when they supply one unit or any group of units in continuous operation, they are to be designed for full load.

9.9.2 Operating Temperature of Bus Bars

Bus bars are to be proportioned to avoid temperatures which affect the normal operation of electrical devices mounted on the board.

9.9.3 Short Circuit Rating

Circuit breakers and bus bars are to be mounted, braced and located so as to withstand the thermal effects and mechanical forces resulting from the maximum prospective short circuit current. Switchboard instruments, controls, etc., are to be located with respect to circuit breakers to minimize the thermal effects due to short circuit currents.

9.9.4 Internal Wiring

Instrument and control wiring is to be of the stranded type and is to have heat-resisting and flame-retarding insulation. Wiring from hinged panels is to be of the extra-flexible type.

9.9.5 Arrangement

9.9.5(a) Accessibility.

The arrangement of bus bars and wiring on the back is to be such that all lugs are readily accessible.

9.9.5(b) Locking of Connections.

All nuts and connections are to be fitted with locking devices to prevent loosening due to vibration. Bolted bus bar connections are to be suitably treated (e.g., silver plating) to avoid deterioration of electrical conductivity over time.

9.9.5(c) *Soldered Connections.*

Soldered connections are not to be used for connecting or terminating any wire or cable of nominal cross-sectional area of greater than 2.5 mm^2 (4,933 circ. mils). Soldered connections, where used, are to have a solder contact length at least 1.5 times the diameter of the conductor.

9.9.6 Clearances and Creepage Distances

9.9.6(a) General.

For bare busbars, the minimum clearances and creepage distances between live parts of different potential (i.e., between phases and between phase and the ground) are to be in accordance with 6-1-7/19.23 TABLE 7.

9.9.6(b) Alternative.

Alternatively, reduced creepage and clearance distances may be used provided:

i. The equipment is not installed in ‘Machinery Spaces of Category A’ or in areas affected by a Local Fixed Pressure
ii. Water-spraying or Local W= The minimum clearance distance is not to be less than 8 mm

iii. The minimum creepage distance is not to be less than 16 mm.
iv. The equipment complies with IEC 61439-1 and 61439-2
v. In applying IEC 61439-1 and 61439-2, the equipment is considered to be:
   - Of overvoltage Category III,
   - Installed in an environment of pollution degree 3,
   - Having insulating material of type IIIa, and
   - Installed in inhomogeneous field conditions
vi. The temperature dependent criteria in IEC 61439-1 and 61439-2 are derated to meet the ambient temperatures found on marine installations. Refer to 4-1-1/7.7 TABLE 2.
vii. The equipment is subject to an impulse voltage test with test voltage values shown in the Table below. Where intermediate values of rated operational voltage are used, the next higher rated impulse withstand test voltage is to be used. The impulse voltage test reports are to be submitted to ABS for review.

Rated Operational Voltage *V*	*Rated Impulse Withstand Test Voltage* *kV*
50	0.8
100	1.5
150	2.5
300	4
600	6
1000	8

9.9.7 Terminals

Terminals or terminal rows for systems of different voltages are to be clearly separated from each other. The rated voltage is to be clearly indicated at least once for each group of terminals which have been separated from the terminals with other voltage ratings. Terminals with different voltage ratings, each not exceeding 50 V DC or 50 V AC may be grouped together. Each terminal is to have a nameplate indicating the circuit designation.

9.11 Control and Protective Devices

9.11.1 Circuit-disconnecting Devices

9.11.1(a) Systems Exceeding 50 Volts.

Distribution boards, chargers or controllers for distribution to motors, appliances, and lighting or other branch circuits are to be fitted with multipole circuit breakers or a multipole switch-fuse combination in each unearthed conductor.

9.11.1(b) Systems of 50 Volts and Less.

For distribution boards, chargers or controllers where voltage to earth or between poles does not exceed 50 volts DC or 50 volts AC rms, the fuses can be provided without switches.

9.11.1(c) *Disconnect Device.*

The rating of the disconnecting device is to be coordinated with the voltage and current requirements of the load. The disconnect device is to indicate by position of the handle, or otherwise, whether it is open or closed.

9.11.2 Arrangement of Equipment

9.11.2(a) *Air Circuit Breakers.*

Air circuit breaker contacts are to be kept at least 305 mm (12 in.) from the unit's structure unless insulation barriers are installed.

9.11.2(b) Voltage Regulators.

Voltage regulator elements are to be provided with enclosing cases to protect them from damage.

9.11.2(c) Equipment Operated in High Temperature.

Where rheostats or other devices that can operate at high temperatures are mounted on the switchboard, they are to be naturally ventilated and so located or isolated by barriers as to prevent excessive temperature of adjacent devices. When this cannot be accomplished, the rheostat or other device is to be mounted separately from the switchboard.

9.11.2(d) Accessibility to Fuses.

All fuses, except for instrument and control circuits, are to be mounted on or be accessible from the front of the switchboard.

9.11.2(e) *Protective Device for Instrumentation.*

All wiring on the boards for instrumentation is to be protected by fuses or current limiting devices. See 4-3-2/9.17.

9.11.2(f) *Wearing Parts.*

All wearing parts are to be accessible for inspection and readily renewable.

9.11.3 Markings

Identification plates are to be provided for each piece of apparatus to indicate clearly its service. Identification plates for feeders and branch circuits are to include the circuit designation and the rating of the fuse or circuit-breaker trip setting required by the circuit.

9.13 Switchboards

In addition to 6-1-7/9.1 to 6-1-7/9.11, as applicable, the switchboards for essential or emergency services are to comply with the following requirements.

9.13.1 Handrails

Insulated handrail or insulated handles are to be provided on the front of the switchboard. Similarly, where access to the rear is required, insulated handrail or insulated handles are also to be fitted on the rear of the switchboard.

9.13.2 Main Bus Bar Subdivision

Where the main source of electrical power is necessary for propulsion of the unit, the main bus bar is to be subdivided into at least two sections which are to be normally connected by circuit breaker or other approved means. As far as practicable, the connection of generating sets and any other duplicated equipment is to be equally divided between the sections.

If the arrangement is such that the main switchboard is divided into separate sections which are interconnected by cable, the cable is to be protected at each end against faults.

9.13.3 Equalizer Circuit for Direct-current (DC) Generators

9.13.3(a) Equalizer Main Circuit.

The current rating of the equalizer main circuit for direct-current (DC) generators is not to be less than half of the rated full-load current of the generator.

9.13.3(b) Equalizer Bus Bars.

The current rating of the equalizer bus bars is not to be less than half of the rated full-load current of the largest generator in the group.

9.13.4 Equipment and Instrumentation

Equipment and instrumentation are to be provided in accordance with 6-1-7/19.23 TABLE 8. They are to be suitable for starting, stopping, synchronizing and paralleling each generator set from the main switchboard. They can be mounted on the centralized control console, if the main switchboard is located in the centralized control station.

15 High Voltage Systems

15.1 General

15.1.1 Application

The following requirements in this Subsection are applicable to AC systems with nominal voltage (phase to phase) exceeding 1 kV. Unless stated otherwise, high voltage equipment and systems are to comply with the other parts in Section 6-1-7 for low voltage equipment and systems, as well.

15.3 Machinery and Equipment

15.3.2 Switchgear and Control-gear Assemblies

Switchgear and control gear assemblies are to be constructed according to the IEC Publication 62271-200 and the following additional requirements:

15.3.2(a) Mechanical Construction and Configuration.

Switchgear is to be of metal-enclosed type in accordance with IEC Publication 62271-200 or of the insulation-enclosed type in accordance with IEC Publication 62271-201.

15.3.2(b) Clearance and Creepage Distances.

For clearance and creepage distances, see 4-3-5/1.1.3.

15.3.2(c) Locking Facilities.

Withdrawable circuit breakers and switches are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers, switches and fixed disconnectors is to be possible. Withdrawable circuit breakers, when in the service position, are to have no relative motion between fixed and moving parts.

15.3.2(d) Shutters.

The fixed contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawn= position, the live contacts of the bus bars are automatically covered. Shutters are to be clearly marked for= incoming and outgoing circuits. This may be achieved with the use of colors or labels.

15.3.2(e) Earthing and Short-circuiting Facilities.

For maintenance purposes, earthing and short circuiting facilities are to be provided to enable equipment and= cables to be earthed or short-circuited to earth before being worked upon.

15.3.2(f) Arc Flash and Associated Installation Requirements

i. Internal Arc Classification (IAC). Switchgear and control gear assemblies are to be Internal Arc Classified (IAC). Where switchgear and control gear are accessible by authorized personnel only accessibility Type A is sufficient (IEC 62271-200; Annex AA; AA 2.2). Accessibility Type B is required if accessible by non-authorized personnel. Installation and location of the switchgear and control gear is to correspond with its internal arc classification and classified sides (F, L and R).
ii. Calculations, in accordance with the applicable parts of Standard IEEE 1584 or other recognized standard, are to be made to establish:
    - The maximum current that can flow in the case of an arc fault
    - The maximum time and current that can flow if arc protection techniques are adopted
    - The distance, from the location of the arc flash, at which the arc flash energy is 1.2 calories per cm^2 if the enclosure is open
iii. In addition to the marking required by the equipment design standard, arc flash data consistent with the Design Operating Philosophy and the required PPE is also to be indicated at each location where work on the HV equipment could be conducted.

19.5 Switchboards

Factory testing schedule required for switchboards intended for main power, emergency power and propulsion system are indicated with an "X" mark in 6-1-7/19.23 TABLE 6. Requirements for compliance are further referenced in 6-1-7/9.1 through 6-1-7/9.13, 6-1-7/19.23 TABLE 7, and 6-1-7/19.23 TABLE 8.

Construction and assembly of switchboards are to be verified in compliance with 6-1-7/9.7.

All switchboards intended for main power, emergency power and propulsion system are to be examined and tested in presence of and to the satisfaction of the Surveyor. Examination and testing of other boards may be carried out without a Surveyor’s presence but the manufacturer’s test certificate is to be available to the Surveyor attending construction of the drilling unit at shipyard.

TABLE 6
Factory Testing Schedule for Switchboards, Chargers, Motor Control Centers, and Controllers [See 6-1-7/19.5, 6-1-7/19.7 and 6-1-7/19.9]

1	Insulation resistance measurements in accordance with 6-1-7/9.3.
2	Dielectric strength test in accordance with 6-1-7/9.5 and the Table below.
3	Protective device tripping test, such as overcurrent tripping, emergency tripping, preferential tripping,
4	etc. Inspection of the assembly, including inspection of wiring and, if necessary, electrical operation test.

Standard Test Voltage for Dielectric Strength Test

Rated Insulation Voltage	*Dielectric Test Voltage AC rms*
Up to and including 12 V	250 V
over 12 V to 60 V inclusive	500 V
over 60 V to 300 V inclusive	2000 V
over 300 V to 690 V inclusive	2500 V
over 690 V to 800 V inclusive	3000 V
over 800 V to 1000 V inclusive	3500 V
over 1000 V to 1500 V inclusive*	3500 V
Note: *For Direct-current (DC) only	

TABLE 7
Clearance and Creepage Distance for Switchboards, Distribution Boards, Chargers, Motor Control Centers and Controllers (1) [See 6-1-7/9.9.6]

Rated insulation voltage (V)	*Minimum clearances mm (in.)*	*Minimum creepage distances mm (in.)*
Up to 250	15 ($^{19}/_{32}$)	20 ($^{25}/_{32}$)
From 251 to 690	20 ($^{25}/_{32}$)	25 (1)
Above 690	25 (1)	35 ($1^{3}/_{8}$)

Notes:

1 The values in this table apply to clearances and creepage distances between live parts as well as between live parts

2 and exposed conductive parts, including earthing.
For 1 kV to 15 kV systems, see 4-3-5/1.1.3.

TABLE 8
Equipment and Instrumentation for Switchboard [See 6-1-7/9.13.4]

Instrumentation and Equipment		*Alternating-current (AC) Switchboard*	*Direct-current (DC) Switchboard*
1.	Pilot Lamp	A pilot lamp for each generator connected between generator and circuit breaker. See Note 3.	A pilot lamp for each generator connected between generator and circuit breaker.
2.	Generator Disconnect	A generator switch or disconnecting links in series with the generator circuit breaker which is to disconnect completely all leads of the generator and the circuit breaker from the buses, except the earth lead. See Note 1.	A generator switch, or disconnecting links, in series with the circuit breaker which will open positive, negative, neutral and equalizer leads, except that for 3-wire generators, equalizer poles may be provided on the circuit breaker. For 3-wire generators, the circuit breakers are to protect against a short circuit on the equalizer buses. See Note 1.
3.	Field Rheostat	A field rheostat for each generator and each exciter. See Note 2.	A field rheostat for each generator. See Note 2.
4.	Insulation Monitor and Alarm	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. See Note 3 and 5.	A means for continuously monitoring the electrical insulation level to earth, and an audible or visual alarm for abnormally low insulation values. For 3-wire generators, see 4-3-5/5.3. See Note 3.
5.	Ammeter	An ammeter for each generator with a selector switch to read the current of each phase. See Note 3.	An ammeter for each 2-wire generator. For each 3-wire generator, an ammeter for each positive and negative lead and a center-zero ammeter in the earth connection at the generator switchboard. Ammeters are to be so located in the circuit as to indicate total generator current.

Instrumentation and Equipment		*Alternating-current (AC) Switchboard*	*Direct-current (DC) Switchboard*
6.	Voltmeter	A voltmeter for each generator, with a selector switch to each phase of the generator and to one phase of the bus. See Note 3.	A voltmeter for each generator with voltmeter switch for connecting the voltmeter to indicate generator voltage and bus voltage. For each 3-wire generator, a voltmeter with voltmeter switch for connecting the voltmeter to indicate generator voltage, positive to negative, positive to neutral, and neutral to negative. Where permanent provisions for shore connections are fitted, one voltmeter switch to provide also for reading shore-connection voltage, positive to negative.
7.	Space Heater Pilot Lamp	Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator.	Where electric heaters are provided for generators, a heater pilot lamp is to be fitted for each generator.
8.	Synchroscope or Lamps	A synchroscope or synchronizing lamps with selector switch for paralleling in any combination. See Note 3.	Not applicable.
9.	Prime mover Speed Control	Control for prime mover speed for paralleling. See Note 3.	Not applicable.
10.	Wattmeter	Where generators are arranged for parallel operation, an indicating wattmeter is to be fitted for each generator. See Note 3.	Not applicable.
11.	Frequency Meter	A frequency meter with selector switch to connect to any generator. See Note 3.	Not applicable.
12.	Field Switch	A double-pole field switch with discharge clips and resistor for each generator. See Note 2.	Not applicable.
13.	Voltage Regulator	A voltage regulator. See Note 3.	Not applicable.
14.	Stator Winding Temperature Indicator	For alternating current propulsion generator above 500 kW, a stator winding temperature indicator is to be fitted for each generator control panel. See Notes 3 and 4.	For direct current propulsion generator above 500 kW, an interpole winding temperature indicator is to be fitted for each generator control panel. See Notes 3 and 4.

Notes:

1 The switch or links may be omitted when draw-out or plug-in mounted generator breakers are furnished.

2 For generators with variable voltage exciters or rotary amplifier exciters, each controlled by voltage-regulator unit acting on the exciter field, the field switch, the discharge resistor and generator field rheostat may be omitted.

3 Where units have centralized control systems in accordance with Part 4, Chapter 9 of the ABS *Marine Vessel Rules* and the generators can be paralleled from the centralized control station, and the switchboard is located in the centralized control station, this equipment may be mounted on the control console. See 6-1-7/9.13.4.

4 For high voltage systems, see also 6-1-7/15.3.1(c).

5 For high voltage systems, see 4-3-5/1.3.5.