



RULES FOR BUILDING AND CLASSING

**MOBILE OFFSHORE UNITS
2018**

**PART 6
RULES FOR EQUIPMENT AND MACHINERY CERTIFICATION**

(Updated July 2018 – see next page)

**American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862**

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Updates

July 2018 consolidation includes:

- January 2018 version plus Notice No. 1

Rule Change Notice (2018)

The effective date of each technical change since 1993 is shown in parenthesis at the end of the subsection/paragraph titles within the text of each Part. Unless a particular date and month are shown, the years in parentheses refer to the following effective dates:

(2000) and after	1 January 2000 (and subsequent years)	(1996)	9 May 1996
(1999)	12 May 1999	(1995)	15 May 1995
(1998)	13 May 1998	(1994)	9 May 1994
(1997)	19 May 1997	(1993)	11 May 1993

Listing by Effective Dates of Changes from the 2018 Rules

Notice No. 1 (effective on 1 July 2018) to the 2018 Rules, is summarized below.

EFFECTIVE DATE 1 July 2018 – shown as (1 July 2018)
(based on the contract date for new construction between builder and Owner)

<i>Part/Para. No.</i>	<i>Title/Subject</i>	<i>Status/Remarks</i>
6-1-1/3.9.1	Design Review	To provide a reference to the requirements for witnessing components for shipping and transferring equipment. (Incorporates Notice No. 1)
6-1-6/7.3.1	Hydrostatic Tests of Shell Valves	To standardize the test process for these type of valves. (Incorporates Notice No. 1)

Rules for Equipment and Machinery Certification

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PART

6

CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 1 General

1 Application

This Section contains general requirements to certify material for hull structure, equipment and machinery for hull outfitting, equipment and machinery for marine systems and propulsion system (for self-propelled units) at manufacturer's plant (unit certification), prior to onboard installation and testing in a mobile offshore unit at builder's yard. The subsequent Sections contain requirements to certify individual product types.

This Chapter does not cover requirements for optional ABS Class Notations such as **ACC** or **AMCC** or **ACCU** or **AMCCU** for automation systems, **CDS** for drilling systems or **DPS** for dynamic positioning systems.

ABS Rules and Guides effective at the time the contract is signed between the owner and builder for the construction of the mobile offshore unit is to be used for certification of manufacturer's products.

In addition to the requirements contained in this Chapter, the design requirements given in Parts 3, 4 and 5 and the survey and testing requirements during fabrication, onboard installation, testing after installation, and final trial given in Sections 7-1-1 through 7-1-8 may need to be considered during the certification of the manufacturer's product.

1.1 Marine and Propulsion Systems

Boilers, pressure vessels, heat exchangers, internal combustion engines, turbines, propulsion equipment, steering gear and other applicable equipment are to be in accordance with the requirements of the *ABS Rules for Building and Classing Marine Vessels (Marine Vessel Rules)*, except as modified herein.

3 Unit Certification

3.1 Basic Requirements

The Rules define, to varying degrees, the extent of evaluation required for products to be manufactured based on the level of criticality of each of those items. There are two basic evaluation constituents:

- i) Design review; prototype testing; and
- ii) Survey during construction and testing at the plant of manufacture

Where design review is required by the Rules, a letter will be issued by ABS upon satisfactory review of the plans to evidence the acceptance of the design. In addition to, or independent of, design review, ABS may require survey and testing of forgings, castings and component parts at the various manufacturers' plants, as well as survey and testing of the finished product. A report will be issued upon satisfactory completion of each survey to evidence acceptance of the product. Design review, survey and the issuance of reports constitute the unit certification of a product.

Where the product is accepted in accordance with Product Quality Assurance (PQA) assessment of ABS Type Approval Program, survey and testing of the product in presence of a Surveyor is not required. However, product's unit certification will be issued by the ABS office having jurisdiction over the manufacturer. For further details, see 1-1-A2/5.7 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

Based on the intended service and application, some products do not require certification because they are not directly related to the scope of classification or because normal practices for their construction within the industry are considered adequate. Such products may be accepted based on the manufacturers' documentation on design and quality, which guarantees product's acceptance for classification provided it is satisfactorily installed and tested onboard the unit.

In general, surveys during installation onboard the vessel and at trials are required for all items of machinery. This is not considered a part of the product certification process. For onboard installation and trials, refer to Part 7 of these Rules.

3.3 Specific Requirements

Sections 2 through 10 of this Chapter describe specific certification requirements for material, marine equipment and machinery used in following areas:

- i) Hull Structure and Outfitting (Section 6-1-2)
- ii) Prime Movers (Section 6-1-3)
- iii) Propulsion and Maneuvering Systems (Section 6-1-4)
- iv) Boilers, Pressure Vessels and Fired Equipment (Section 6-1-5)
- v) Pumps and Piping Systems (Section 6-1-6)
- vi) Electrical Systems and Control Equipment (Section 6-1-7)
- vii) Fire and Safety – Equipment and Systems (Section 6-1-8)
- viii) Jacking System – Self-Elevating Units (Section 6-1-9)
- ix) Anchoring System (Section 6-1-10)

3.5 Angles of Inclination

All equipment, machinery and their components intended for essential services, as defined in 4-1-1/3.5, are to be designed to operate under the inclinations as indicated for each of the conditions listed in 4-1-1/Table 1.

Note: The above requirements do not apply to jacking systems of self-elevating units. Jacking systems are to be operable at maximum angle of inclination stated in the manufacturer's specification.

3.7 Ambient Temperature

For units of unrestricted service, all equipment and machinery, and their components intended for essential services, as defined in 4-1-1/3.5, are to be designed to operate under the ambient temperatures as indicated for each of the conditions listed in 4-1-1/Table 2.

For units of restricted or special service, the ambient temperature appropriate to the special nature is to be considered.

3.9 Skid Mounted Equipment or Machinery

Where skid mounted equipment or machinery is required to be design reviewed and surveyed in accordance with subsequent Sections 6-1-3 through 6-1-10, the skid is also to be design reviewed and surveyed at manufacturer's facility if the skid mounted unit has either of the following:

- Center of gravity height is more than 1.5 m (5 ft) in dry condition, or
- Maximum operating weight is in excess of 10 MT (metric tons) or 22.05 Kips.

3.9.1 Design Review (1 July 2018)

Design of the skid mounted equipment and machinery, together with structural design calculations, is to be submitted to ABS for review.

Note: Containers and associated lifting sets used solely for shipping or transferring equipment to the unit are not subject to the requirements of this Section. The ABS Guide for the Certification of Offshore Containers may be applied for these items outside the scope of these Rules.

3.9.2 Survey

Surveyor's attendance is required to verify that the skid mounted equipment/machinery is in compliance with ABS reviewed design and structural design calculations, and to at least carry out the following:

- i)* Verify Material Test Report (MTR) of skid material.
- ii)* Visual examination of final weldments of skid structure.
- iii)* Witness load testing of the skid structure lifting lugs or pad-eyes. Load test of the skid is to be carried out at maximum static load the lifting lugs or pad eyes may be subjected to during the transportation or installation of the equipment/machinery onboard the unit.
- iv)* Witness surface Nondestructive Testing (NDT) of skid structure weldments of the lifting lugs/pad eyes, after completion of the skid structure load test. Magnetic Particle Inspection (MPI) is recommended for NDT.
- v)* Verify proper alignment of assembled equipment/machinery components.
- vi)* Verify proper mechanical and electrical connections.
- vii)* Witness leak/pressure test, as applicable.
- viii)* Witness Factory Acceptance Test (FAT) of the equipment/machinery on skid.

5 Design Review and Survey of Equipment and Machinery

5.1 Design Review

Plans and data required to be submitted for certification of specific equipment and machinery are described under subsequent Sections 6-1-3 through 6-1-10.

5.3 Survey

Certain equipment and machinery and/or associated components require Surveyor's attendance at the manufacturer's plant during fabrication and testing of the respective product. Satisfactorily completed survey of the product is to be reported upon, only if the required ABS design review of the product was completed without any outstanding engineering comment.

During fabrication of equipment, the attending Surveyor is to have access to manufacturers' facilities and assembly sites to witness fabrication and/or testing, as required by these Rules. The manufacturer is to contact the attending Surveyor to make necessary arrangements. If the attending Surveyor finds reason to recommend repairs or additional surveys, notice will be immediately given to the manufacturer's representative so that appropriate action may be taken.

Each manufacturer is required to have an effective quality system which is to be verified by the attending Surveyor. Unless the manufacturer holds an effective ABS Product Quality Assurance (PQA) Certificate, Surveyor's attendance is required, typically for the following purposes.

- i)* To confirm that the facilities to manufacture, fabricate or repair mechanical or electrical marine components have and maintain an effective Quality Control Program (QCP) effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applied to their product.
- ii)* To qualify or verify welder's qualifications to the extent deemed necessary by the attending Surveyor.
- iii)* To qualify or verify welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.
- iv)* To verify material certificates/documentation.
- v)* To survey fit-up prior to major weldments.
- vi)* To survey final weldments.

- vii) To witness, as far as deemed necessary, Non-Destructive Testing (NDT) of welds and to review records of NDT.
- viii) To verify dimensions are the same as shown on approved drawings.
- ix) To check dimensional tolerances and alignment of mating surfaces.
- x) To witness prototype testing of jacking gear system subject to such testing in accordance with these Rules.
- xi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.
- xii) To witness final testing and functional testing of subassemblies and completed units, as called for in the fabrication procedures.
- xiii) To carry out other surveys as agreed upon during prefabrication meeting, including the Factory Acceptance Test (FAT).

Surveys required for certification of specific equipment are described under subsequent Sections 6-1-2 through 6-1-10.

7 Prototype Testing

Where prototype testing is required by these Rules, Surveyor is to witness the prototype testing at the plant of manufacture, and report upon the test results. Results of the prototype testing endorsed by the Surveyor are to be submitted to respective Engineering office to supplement the completed design review or where type testing was done in lieu of design review. Subsequent testing of the product that has been already prototype tested may be carried out by the manufacturer and test results accepted based upon previously completed prototype testing of the product.

Subsequent Sections 6-1-2 through 6-1-10 describe products that may be required to be subjected to prototype testing.

9 Type Approval Program

The process of the ABS Type Approval program is explained in 1-1-4/9.7 and 1-1-A2 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*.

9.1 Application and Limitations

For reference purposes, applicable Tables in subsequent Sections contain examples of the limitations of the Program for marine equipment and machinery. Products that are not listed in the Tables may be considered for inclusion in the Type Approval Program on a case-by-case basis. The manufacturer is to contact the nearest ABS office for advice.

9.3 Structural Material

Structural material, including certain piping material used for structural support purposes (see Section 6-1-2 of these Rules), is required to be certified in accordance with these Rules by a Surveyor attending the ABS approved steel mill. Type Approval Program is not applicable to certification of structural material.

9.5 Mass Produced Machinery

Non-mass produced critical machinery, such as propulsion boilers, slow speed diesel engines, turbines, steering gears, and similar critical items are to be individually unit certified in accordance with the procedure described in 6-1-1/3.1. However, consideration will be given to granting Type Approval to such machinery in the category of Recognized Quality System (RQS).

The category of Product Quality Assurance (PQA) will not normally be available for all products, and such limitations are indicated in the respective Tables of subsequent Sections. In each instance where Type Approval is granted, in addition to quality assurance and quality control assessment of the manufacturing facilities, ABS will require some degree of product specific survey during manufacture.

9.7 Non-mass Produced Machinery

Non-mass produced critical machinery, such as propulsion boilers, slow speed diesel engines, turbines, steering gears, and similar critical items are to be individually unit certified in accordance with the procedure described in 6-1-1/3.1. However, consideration will be given to granting Type Approval to such machinery in the category of Recognized Quality System (RQS).

The category of Product Quality Assurance (PQA) will not normally be available for all products, and such limitations are indicated in the respective Tables of subsequent Sections. In each instance where Type Approval is granted, in addition to quality assurance and quality control assessment of the manufacturing facilities, ABS will require some degree of product specific survey during manufacture.

9.9 Design and Manufacturing Assessment (RQS and PQA)

The Tables in subsequent Sections contain the requirements for Type Approval of the listed components and equipment with regard to Product Design Assessment (Design Review and Prototype Testing) and Manufacturing Assessment (PQA option only). Manufacturing Assessment in the category of Recognized Quality System (RQS) may be carried out on any product and therefore, are not shown on the Tables.

9.11 Type Examination and/or Testing, and Prototype Testing

Any product requested to be Type Approved is to be subjected to type examination and testing in the presence of the Surveyor attending the manufacturer's plant for initial assessment. Therefore, the type exam or type testing of the initial product required by the Type Approval Program, as referenced in 1-1-4/9.7 and Appendix 1-1-A2 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, are not indicated under the applicable Tables contained in subsequent Sections.

Where prototype test is required as indicated in the applicable Tables of this Chapter, the type examination and/or testing of the initial product for Type Approval may be waived, provided the design or fabrication process of the product remain unchanged since it was prototype tested.

11 Manufacturer's Guarantee

All products manufactured for installation onboard a classed unit are expected to operate in a safe and appropriate manner, and guaranteed by the manufacturer to do so, as long as the recommended maintenance procedure of the product is adhered to by the owner/operator.

11.1 Manufacturer's Affidavit

Where a manufactured product does not require Surveyor attendance for unit certification, Surveyor's attendance is not requested by the client, or the product is not certified under the ABS Type Approval Program, manufacturer's guarantee for product's compliance with a recognized standard may be accepted by ABS, provided the product as installed onboard satisfy the classification requirements of the unit. Where requested by ABS, manufacturer's affidavit is to be submitted.

13 Asbestos

Installation of material, which contains asbestos, is prohibited.

PART

6

CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 2 Hull Structure and Outfitting

1 General

Materials used for hull construction and hull outfitting are covered in more detail in other relevant sections of the Rules identified below.

Where material other than steel is used, material suitability and test results per the International Code for Application of Fire Test Procedures (FTP Code) is to be acceptable to ABS.

3 Material for Hull Structure

Materials used for hull construction and hull outfitting are to be in accordance with Section 3-1-4 and Part 3, Chapter 2, as applicable.

5 Material for Foundation Structures

In general, major foundations include but not limited to the foundations for the following equipment or machinery:

- Pedestal cranes for loading/unloading of equipment and personnel.
- Anchoring or mooring system winches.
- Fairleads.

Material used for major foundation structures are to be in accordance with ABS approved drawings. In lieu of unit certification, manufacturer's Material Test Report (MTR) for materials used for major foundations and tested in accordance with the *ABS Rules for Materials and Welding (Part 2)*, or Section 3-1-4 as applicable, may be accepted by the Surveyor. The Material Test Report (MTR) of each member is to be available to the Surveyor before being installed onboard.

All major foundation structures affect classification of a unit and are required to be design reviewed in accordance with Sections 3-2-2, 3-2-3, 3-2-4 or 3-2-5, as applicable, and surveyed during fabrication and installation.

7 Helideck Structure

Certification of helideck structure is to be designed in accordance with 3-2-2/3 and certified in accordance with this Chapter.

7.1 Material for Helideck Structure

The helideck structure deck plating and its main support structural members fabricated out of steel or other acceptable material need not be produced by an ABS approved mill and certified by an ABS Surveyor. However, the selection of such structural materials is to be in accordance with Section 3-1-4, and the Material Test Report (MTR) of each member is to be available to the Surveyor before being installed onboard.

7.3 Unit Certification of Helideck Structure

If the helideck structure is fabricated within the builder's yard where the unit is being built, design and fabrication of the helideck structure is to be in accordance with 3-2-2/3, and built in presence of and to the satisfaction of the Surveyor. In such case, the helideck may be considered as part of the rig's construction.

If the helideck structure is fabricated away from the builder's yard where the unit is being built, design and fabrication of the helideck structure is to be in accordance with 3-2-2/3, and built in presence of and to the satisfaction of the Surveyor. In such case, the helideck is to be treated as a product to be unit certified.

9 Watertight Doors

Certification of watertight doors are to be designed, fabricated and tested in accordance with this Section.

9.1 General

Watertight doors are to be designed to withstand water pressure to a head up to the bulkhead deck or freeboard deck respectively. A prototype pressure test is to be conducted for each type and size of door to be installed on the unit at a test pressure corresponding to at least the head required for the intended location. The prototype test is to be carried out at the manufacturer's plant. The installation method and procedure for fitting the door on board is to correspond to that of the prototype test. Large doors or hatches of a design and size that would make pressure testing impracticable may be exempted from the prototype pressure test, provided that it is demonstrated by calculations that the doors or hatches maintain watertightness at the design pressure.

Watertight doors are to be of ample strength for the water pressure to which they may be subjected. Doorframes are to be carefully fitted to the bulkheads; where liners are required, the material is to be not readily injured by heat or by deterioration.

Reference is also made to 3-3-2/5.3 with regard to watertight integrity of the unit.

9.3 Sliding Watertight Doors

Sliding watertight doors are to be tested for operation at the manufacturer's plant. Watertightness of doors which become immersed by an equilibrium or intermediate waterplane at any stage of assumed flooding is to be confirmed by prototype hydrostatic testing at the manufacturer's plant. The head of water used for the test shall correspond at least to the head measured from the lower edge of the door opening, at the location in which the door is to be fitted in the vessel, to:

- i) The bulkhead deck or freeboard deck, as applicable, or
- ii) The most unfavorable damage waterplane, if that is greater

Fabrication, hydrostatic testing, and satisfactory operational testing are to be carried out at the manufacturer's plant in the presence of the Surveyor as indicated in 6-1-2/9.1 and a Survey report is to be issued.

Doors above freeboard or bulkhead deck, which are not immersed by an equilibrium or intermediate waterplane but become intermittently immersed at angles of heel in the required range of positive stability beyond the equilibrium position, are to be hose tested after installation onboard.

9.5 Dogged Watertight Doors

Non-sliding dogged watertight doors are to be certified. Dogged watertight doors are to be manufactured in accordance with ABS approved drawings and subjected to type testing.

Dogged watertight doors are to be subjected to a hydrostatic test as indicated in 6-1-2/9.1 at the manufacturer's plant.

Fabrication, hydrostatic testing and satisfactory operational testing of the doors during the prototype testing are to be witnessed by a Surveyor and reported upon. Dogged doors that have satisfactorily completed its type-testing may then be certified without unit certification, preferably under the ABS Type Approval Program.

11 Portable Modules

Certification of portable modules is required as indicated in 6-1-2/Table 1 and they are to be designed and fabricated in accordance with this Section.

11.1 General

In general, portable modules are used to support various functions onboard the unit. Portable modules are expected to be used throughout the duration needed in support of unit operations, as scheduled by the Owner/Operator.

Acceptance criteria for various types of portable modules located in special areas or stacked higher than two units are shown in 6-1-2/Table 1.

11.3 Definition of Modules

Types of portable modules referenced in 6-1-2/Table 1 are defined below.

11.3.1 Accommodation Modules

Modules used for services defined as “accommodations” according to the *ABS Guide for Portable Accommodation Modules*. These portable modules are used as:

- i) Sleeping Quarters
- ii) Hospital
- iii) Galley
- iv) Dining Room
- v) Office
- vi) Recreation Room, Gym, TV Room, Cinema, Lounge, Library, Prayer Room
- vii) Training Room

11.3.2 Certified Modules

Modules that require additional design review in according with the *ABS MOU Rules*, *ABS Marine Vessel Rules*, or the *MODU Code/SOLAS*, applicable to the vessel. These portable buildings are used as:

- i) Control Stations (as defined in the *ABS MOU Rules* and the *IMO MODU Code*)
- ii) Space for Essential Services (as defined in the *ABS MOU Rules* and the *IMO MODU Code*)
- iii) Machinery Space Category A (as defined in the *ABS MOU Rules* and the *IMO MODU Code*)
- iv) High Risk Service Spaces (such as spaces used for mud logging, well test labs, storage of flammable liquids, battery (>2 kW) rooms)
- v) Storage of equipment for classed drilling systems, if applicable
- vi) Other services covered under the *IMO MODU Code*

11.3.3 Industrial Modules

Modules that do not require additional design review but do require an onboard installation survey. These portable modules are used as:

- i) Space for Non-Essential Services such as MCC, switchgears, dedicated drilling equipment, if applicable
- ii) Laundry
- iii) Low Risk Service Spaces such as spaces used as workshops or storage of batteries <2 kW

- iv)* Communication equipment buildings
- v)* ROV vans
- vi)* Mud logging buildings without returns

11.3.4 Exempt Modules

Modules that do not require design review or an onboard survey. These portable modules are:

- i)* Unmodified container boxes
- ii)* Container boxes with modified doors only (without any piping or electrical equipment)
- iii)* Wireline units
- iv)* Pantries (dry storage only)
- v)* Refrigeration spaces

11.5 Container Box used as a Portable Industrial Module

Where a container box is used as a portable module, the container is to be confirmed as being certified to a recognized standard, and is to be properly secured to the deck.

11.5.1 Means of Securing Container Boxes

Ultimate responsibility regarding efficiency of securing container boxes to the unit's structure reside with the Owner.

Container boxes are to be sufficiently secured to deck to prevent any safety hazard to the unit or the personnel onboard the unit, at all times.

Means of securing a single container to deck other than welding may be accepted provided the attending Surveyor is satisfied with the arrangements.

Means of securing multiple container boxes require ABS design review as well as onboard verification by ABS Surveyor. The extent of ABS review will only be to confirm that the deck where the container box will be installed has sufficient structural strength to withstand static and dynamic loads stated by the owner.

TABLE 1
Requirements for Portable Modules

<i>Located/Stacked</i>	<i>Accommodation Modules</i>	<i>Certified Modules</i>	<i>Industrial Modules*</i>	<i>Exempt Modules</i>
Within 30 meters from the Rotary ⁽¹⁾	a,c,d	a,c,d	d,e	-
Not within 30 meters from the Rotary	a,c,d	a,c,d	d,e	-
In Protected Locations ⁽²⁾	a,c,d	a,c,d	d,e	-
In Hazardous Areas ⁽³⁾	Not Allowed	a,c,d	d,e	d
Stacked >2 high ⁽⁴⁾	a,c,d	a,c,d	b,d,e	-

Requirements:

- (a): Full design review to the *MOU Rules*
- (b): Structural design review to the *MOU Rules*
- (c): Survey at Fabricator’s Facility
- (d): Survey After Installation
- (e): If the capacity of an available spare breaker is exceeded, review of the electrical interface
- (*): The division is required to be of steel or an equivalent material, but it is not required to be of an “A” class standard. However, where a deck is penetrated for the passage of electrical cables, pipes and/or vent ducts, such penetrations are to be made tight to prevent passage of flames and/or smoke.

Notes:

- 1 Buildings located within 30 meters from the rotary will require compliance with additional fire protection requirements.
- 2 Refers to locations that are protected from waves and hazardous zones, as the *MOU Rules* will have additional requirements for other locations.
- 3 Refers to locations within or adjacent to the ABS-approved hazardous areas for the unit.
- 4 Refers to the stacking arrangements of the buildings, as all units if stacked over two high are subject to additional structural/access requirements regardless of service.

PART

6

CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 3 Prime Movers

1 General

Prime movers (diesel engines and their turbochargers, gas turbines, steam turbines) for which certification is required as indicated in 6-1-3/Table 1 are to be designed, constructed, tested, certified and installed in accordance with Part 4, Chapter 2 of the *Marine Vessel Rules* and this Chapter.

3 Internal Combustion Engines

3.1 Fuel Oil System

3.1.1 Injection Piping

All external high pressure fuel delivery lines between the high-pressure fuel pumps and fuel injectors are to be protected with a jacketed piping system capable of containing fuel from a high-pressure line failure. A jacketed pipe incorporates an outer pipe into which the high-pressure fuel pipe is placed, forming a permanent assembly. Metallic hose of an approved type may be accepted as the outer pipe, where outer piping flexibility is required for the manufacturing process of the permanent assembly. The jacketed piping system is to include means for collection of leakages and arrangements are to be provided for an alarm to be given of a fuel line failure.

3.1.2 Fuel Oil Return Piping

When the peak to peak pressure pulsation in the fuel oil return piping from the injectors exceeds 20 bar (20.5 kgf/cm², 285 psi), jacketing of the return pipes is also required.

3.1.3 Hot Surfaces

All surfaces with temperatures above 220°C, which may be impinged as a result of a fuel system failure, are to be properly insulated with non-combustible materials that are impervious to oil. Insulation material not impervious to oil is to be encased in sheet metal or an equivalent impervious sheath.

Oil fuel lines are to be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakages onto hot surfaces, into machinery air intakes, or other sources of ignition. The number of joints in such piping systems is to be kept to a minimum.

3.3 Turbines for Generators

Gas-turbine prime mover driving generators are to meet the applicable requirements in Section 4-2-3 of the *Marine Vessel Rules* and in addition are to comply with the following requirements.

3.3.1 Operating Governor

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining speed within the following limits. Special consideration will be given when an installation requires different characteristics.

3.3.1(a) *Transient Frequency Variations.* The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within $\pm 10\%$ of the rated frequency when:

- i) Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off:

In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the overspeed protective device fitted in addition to the governor, as required by 6-1-3/3.3.2, is not activated.

- ii) Running at no load and 50% of the full load of the generator is suddenly thrown on followed by the remaining 50% load after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within $\pm 1\%$ of the final steady state condition in no more than five seconds.

3.3.1(b) *Frequency Variations in Steady State.* The permanent frequency variation is to be within $\pm 5\%$ of the rated frequency at any load between no load and full load.

3.3.1(c) *Emergency Generator Prime Movers.* For gas turbines driving emergency generators, the requirements of 6-1-3/3.3.1(a) and 6-1-3/3.3.1(b) are to be met. However, for the purpose of 6-1-3/3.3.1(a)ii), where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used as the first applied load.

3.3.2 Overspeed Governor

In addition to the normal operating governor, an overspeed governor is to be fitted which will trip the turbine throttle when the rated speed is exceeded by more than 15%. Provision is to be made for hand tripping. See 6-1-7/5.13 for pressure-lubricated machines.

3.3.3 Power Output of Gas Turbines

To satisfy the requirements of 4-3-2/3.1, the required power output of gas turbine prime movers for drilling unit main service generator sets is to be based on the maximum expected inlet air temperature.

3.5 Diesel Engines for Generators

Diesel-engine prime movers are to meet the applicable requirements in Section 4-2-1 of the *Marine Vessel Rules* and, in addition, are to comply with the following requirements.

3.5.1 Operating Governor

An effective operating governor is to be fitted on prime movers driving main or emergency electric generators and is to be capable of automatically maintaining the speed within the following limits. Special consideration will be given when an installation requires different characteristics.

3.5.1(a) *Transient Frequency Variations.* The transient frequency variations in the electrical network, when running at the indicated loads below, are to be within $\pm 10\%$ of the rated frequency when:

- i) Running at full load (equal to rated output) of the generator and the maximum electrical step load is suddenly thrown off,

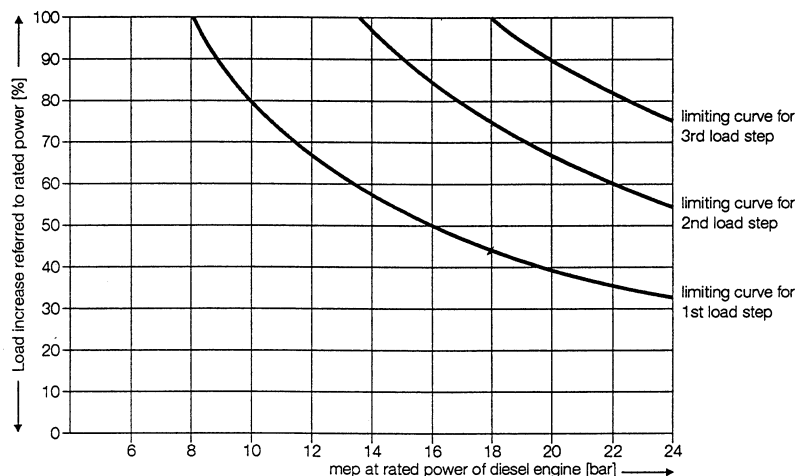
In the case when a step load equivalent to the rated output of a generator is thrown off, a transient frequency variation in excess of 10% of the rated frequency may be acceptable, provided the overspeed protective device, fitted in addition to the governor, as required by 6-1-3/3.5.2, is not activated.

- ii) Running at no load and 50% of the full load of the generator is suddenly thrown on followed by the remaining 50% load after an interval sufficient to restore the frequency to steady state.

In all instances, the frequency is to return to within $\pm 1\%$ of the final steady state condition in no more than five seconds.

- iii) Where the electrical power system is fitted with a power management system and sequential starting arrangements, the application of loads in multiple steps of less than 50% of rated load in 6-1-3/3.5.1(a)ii) above may be permitted, provided it is in accordance with 6-1-3/Figure 1. The details of the power management system and sequential starting arrangements are to be submitted and its satisfactory operation is to be demonstrated to the Surveyor.

FIGURE 1
Limiting Curves for Loading 4-stroke Diesel Engines
Step-by-step from No-load to Rated Power as Function
of the Brake Mean Effective Pressure



3.5.1(b) *Frequency Variations in Steady State.* The permanent frequency variation is to be within $\pm 5\%$ of the rated frequency at all loads between no load and full load.

3.5.1(c) *Emergency Generator Prime Movers.* For prime movers driving emergency generators, the requirements of 6-1-3/3.5.1(a) and 6-1-3/3.5.1(b) above are to be met. However, for the purpose of 6-1-3/3.5.1(a)ii), where the sum of all loads that can be automatically connected is larger than 50% of the full load of the emergency generator, the sum of these loads is to be used as the first applied load.

3.5.2 Overspeed Governor

In addition to the normal operating governor, each auxiliary diesel engine having a maximum continuous output of 220 kW and over is to be fitted with a separate overspeed device so adjusted that the speed cannot exceed the maximum rated speed by more than 15%. Provision is to be made for hand tripping. See 6-1-7/5.13 for pressure-lubricated machines.

3.7 Prime Movers for Propulsion Generators

In addition to 6-1-3/3.3 and 6-1-3/3.5, prime movers for propulsion generators are to comply with the following requirements:

3.7.1 Capability

The prime mover rated output are to have adequate overloading and build-up capacity for supplying the power which is necessary during transitional changes in operating conditions of the electrical equipment. When maneuvering from full propeller speed ahead to full propeller speed astern with the unit making full way ahead, the prime mover is to be capable of absorbing a proportion of the regenerated power without tripping due to overspeed.

3.7.2 Speed Control

Prime movers of any type are to be provided with a governor capable of maintaining the preset steady speed within a range not exceeding 5% of the rated full-load speed for load changes from full-load to no-load.

3.7.3 Manual Controls

Where the speed control of the propeller requires speed variation of the prime mover, the governor is to be provided with means for local manual control as well as for remote control. For turbines driving AC propulsion generators, where required by the system of control, the governor is to be provided with means for local hand control as well as remote adjustment from the control station.

3.7.4 Parallel Operation

In case of parallel operation of generators, the governing system is to permit stable operation to be maintained over the entire operational speed range of the prime movers.

3.7.5 Protection for Regenerated Power

Braking resistors or ballast consumers are to be provided to absorb excess amounts of regenerated energy and to reduce the speed of rotation of the propulsion motor. These braking resistors or ballast consumers are to be located external to the mechanical and electric rotating machines. Alternatively, the amount of regenerated power may be limited by the action of the control system.

3.9 References

3.9.1 Angles of Inclination

For requirements covering angles of inclination for design condition, refer to 6-1-1/3.5 and 4-1-1/Table 1.

3.9.2 Alarms and Safeguards for Emergency Diesel Engines

For requirements covering alarms and safeguards for emergency diesel engines, refer to 4-3-2/5.17.

3.9.3 Prime Mover driving Emergency Generator

For requirements covering emergency generator prime movers, refer to 4-3-2/5.5.2.

3.9.4 Engine Support Systems

For requirements covering support systems for internal combustion engines, refer to 4-2-5/7 (fuel oil system), 4-2-6/1 (lubricating oil system), 4-2-6/9 (starting-air system), 4-2-6/11 (cooling-water system) and 4-2-6/13 (exhaust system).

3.9.5 Internal Combustion Engines designed for Drilling Operations

For requirements covering internal combustion engines solely for drilling operations, refer to 8-2-1/7.

3.9.6 Internal Combustion Engines installed in Hazardous Areas

For requirements covering the installation of internal combustion engines in hazardous areas, refer to 4-3-6/11.

5 Survey and Certification

Where required, all material, type-testing and unit certification is to be carried out, in presence of and to the satisfaction of the Surveyor, at manufacturer's plant and reported upon before installation onboard. 6-1-3/Table 1 shows the extent of ABS unit certification services required for each type of prime mover and its associated equipment. Where a product does not require unit certification, Surveyor attendance is optional, and the product is to be designed and fabricated to satisfy a recognized industrial standard and the manufacturer's specification.

TABLE 1
Certification Details – Prime Movers

<i>Prime Movers</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Diesel engines with cylinder bore > 300 mm	5	6-1-1/1.1, 6-1-1/9.9
Diesel engines; steam turbines; gas turbines; ≥ 100 kW (135 hp), intended for essential services or required by optional class notation	4/5	6-1-3/1, 4-1-2/1
Diesel engines; steam turbines; gas turbines; < 100 kW (135 hp)	1	6-1-3/5, 4-1-2/1
Internal combustion engines used solely for Non-Essential Services	1	6-1-1/1.3, 4-1-2/3
Turbochargers for engines ≥ 100 kW (135 hp)	4/5	6-1-1/9.9, see MVR 4-2-2/1.1, 4-2-2/3
Turbochargers for engines < 100 kW (135 hp)	1	6-1-1/9.5, see MVR 4-2-2/1.1, 4-2-2/3
Governors for Prime Movers ≥ 100 kW (135 hp), intended for essential services	2	6-1-3/3.3–3.5

PART

6

CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 4 Propulsion and Maneuvering Systems

1 General

Propulsion and maneuvering machinery (propulsion shafts and its components, propulsion gears and clutches, propellers, propulsion and positioning thrusters and steering gears) for which certification is required as indicated in 6-1-4/Table 1 are to be designed, constructed, tested, certified and installed in accordance with Part 4, Chapter 3 of the *Marine Vessel Rules* and this Chapter.

3 Materials for Propulsion Equipment

Materials for the following equipment intended for main propulsion installation are to be tested in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*: thrust shafts, line shafts, propeller shafts, shafting for propulsion generators and motors, coupling bolts, and in the case of direct-connected turbine-driven propulsion generators, fan shrouds, centering and retaining rings.

Major castings or built-up parts such as frames, spiders and end shields are to be surface-inspected and the welding is to be in accordance with requirements of Chapter 4 of the above referenced Part 2.

5 Survey and Certification

Where required, all material, type-testing and unit certification is to be carried out, in presence of and to the satisfaction of the Surveyor, at manufacturer's plant and reported upon before installation onboard. 6-1-4/Table 1 shows the extent of ABS unit certification services required for propulsion and maneuvering machinery. Where a product does not require unit certification, Surveyor attendance is optional, and the product is to be designed and fabricated to satisfy a recognized industrial standard and the manufacturer's specification.

TABLE 1
Certification Details – Propulsion and Maneuvering Systems*

<i>Propulsion and Maneuvering Systems</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Propulsion Shafting		
Propulsion shafts, Couplings, coupling bolts	5	6-1-4/1, MVR 4-3-2/9
Cardan shafts	4/5	6-1-4/1, MVR 4-3-2/9
Coupling bolts constructed to a recognized standard	1	6-1-4/1, MVR 4-3-2/9
Gears and Clutches		
Gears and Clutches \geq 5590 kW (7500 hp)	5	6-1-4/1, MVR 4-3-1/9
Gears and clutches, \geq 100 kW (135 hp)	4/5	6-1-4/1, MVR 4-3-1/9
Gears and clutches, $<$ 100 kW (135 hp)	1	6-1-4/1, MVR 4-3-1/9
Propellers		
Propellers, fixed and controllable pitch	5	6-1-4/1, MVR 4-3-3/9
Propulsion thrusters	4/5	6-1-4/1, MVR 4-3-3/9
Steering		
Steering gears	5	6-1-4/1, MVR 4-3-4/19
Thrusters with optional notations (APS, AMS-NP, PAS, DPS notation)	4/5	6-1-4/1, MVR 4-3-5/1.1
Other thrusters	1	6-1-4/1

PART

6

CHAPTER 1 Marine Equipment and Machinery Certification

SECTION 5 Boilers, Pressure Vessels and Fired Equipment

1 General

Boilers, fired and unfired heaters, pressure vessels and heat exchangers for which certification is required as indicated in 6-1-5/Table 1 are to be designed, constructed, tested, certified and installed in accordance with Part 4, Chapter 4 of the *Marine Vessel Rules* and this Chapter.

All boilers, heaters, pressure vessels and heat exchangers within the scope of 6-1-5/1.1 are to be certified by ABS. Mass-produced pressure vessels, including seamless extruded cylinders and fluid power cylinders, may be certified by alternative means as described in 4-4-1/1.11 of the *Marine Vessel Rules*.

Pressure vessels used solely for drilling and industrial systems are to meet 8-2-1/5, except for the pressurized bulk storage tanks, such as bulk cement tank, which require compressed air for loading and discharging, are subject to the provisions of this section if the operating pressure and volume of the vessels exceed that indicated in 6-1-5/Table 2 item c.

1.1 Application

All pressure vessels for marine systems including boilers, fired and unfired heaters, pressure vessels and heat exchangers of the following categories are to be subjected to the provisions of this section:

- i) Boilers and steam generators with design pressure over 3.5 bar (3.6 kgf/cm², 50 psi).
- ii) Fired heaters for oil with design pressure over 1 bar (1 kgf/cm², 15 psi).
- iii) Independent pressure vessel tanks for the carriage of liquefied gases
- iv) Welded accumulators, regardless of their diameters
- v) Accumulators of extruded seamless construction are to be designed, manufactured and tested in accordance with a recognized standard for this type of pressure vessel subject to the provisions in 4-6-7/3.5.4 of the *Marine Vessel Rules*.
- vi) Other pressure vessels and heat exchangers of 150 mm (6 in.) diameter and over, having design pressure, temperature and volume as defined in 6-1-5/Table 2. Pressure vessels and heat exchangers under 150 mm (6 in.) in diameter are not required to comply with the provisions of this section. Acceptance of them will be based on manufacturer's guarantee of physical properties and suitability for the intended service, provided the installation is carried out to the satisfaction of the Surveyor.
- vii) Boilers and fired heaters not included above, fired inert gas generators and incinerators are subject to the provisions of 4-4-1/15 of the *Marine Vessel Rules* only.

1.3 Grouping of Boilers and Pressure Vessels

For purpose of specifying the degree of inspection and testing during the certification process, boilers and pressure vessels are categorized as in 6-1-5/Table 3.

3 Materials for Group I Boilers, Heaters, Pressure Vessels and Heat Exchangers

Materials for Group I boilers, heaters, pressure vessels and heat exchangers are to be tested in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*.

5 Survey and Certification

Where required, all material, type-testing and unit certification is to be carried out, in presence of and to the satisfaction of the Surveyor, at manufacturer's plant and reported upon before installation onboard. 6-1-5/Table 1 shows the extent of ABS unit certification services required for each boiler, heater, pressure vessel and heat exchanger. Where a product does not require unit certification, Surveyor attendance is optional, and the product is to be designed and fabricated to satisfy a recognized industrial standard and the manufacturer's specification.

TABLE 1
Certification Details – Boilers, Pressure Vessels and Fired Equipment*

<i>Boilers, Pressure Vessels and Fired Equipment</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Section 1: Group I		
Group I boilers and pressure vessels	5	6-1-5/1.3, 6-1-5/3, 6-1-5/5
Section 2: Group II		
Fired pressure vessels	4/5	6-1-5/1.3, 6-1-5/3, 6-1-5/5
Non-fired pressure vessels	4/5	6-1-5/1.3, 6-1-5/3, 6-1-5/5
Section 3: Inert Gas Generators & Incinerators		
Inert gas generators, incinerators	2	6-1-5/1.3, 6-1-5/3, 6-1-5/5

* Note: Reference Part 4, Chapter 4 of the *Marine Vessel Rules* and Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*.

TABLE 2
Pressure Vessels and Heat Exchangers*

	<i>Pressure</i>				<i>Temperature</i>			<i>Volume</i>	
	<i>bar</i>	<i>kgf/cm²</i>	<i>psi</i>		<i>°C</i>	<i>°F</i>		<i>m³</i>	<i>ft³</i>
a) Pressure vessels and heat exchangers for toxic and corrosive substances (see 4-1-1/3.9)	>1.0	>1.0	>15	–	all	all	–	all	all
b) Pressure vessels, heat exchangers and heaters other than a)	>6.9	>7	>100	–	all	all	–	all	all
c) Pressure vessels, heat exchangers and heaters other than a) and b)	>1.0	>1.0	>15	<i>and</i>	>149 ⁽¹⁾ >66 ⁽²⁾ >90 ⁽³⁾	>300 ⁽¹⁾ >150 ⁽²⁾ >200 ⁽³⁾	<i>and</i>	>0.14	> 5

Notes:

* Reference Part 4, Chapter 4 of the *Marine Vessel Rules* and Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*.

- 1 Applicable to steam, gas or vapor; and to liquids other than fuel oil, lubricating oil, hydraulic oil and thermal oil.
- 2 Applicable to fuel oil.
- 3 Applicable to lubricating oil, hydraulic oil and thermal oil.

TABLE 3
Grouping of Boilers, Pressure Vessels and Fired Equipment*

Grp	Type	Pressure				Temperature			Volume		Thickness		
		bar	kgf/cm ²	psi		°C	°F		m ³	ft ³	mm	in.	
I	a) Boilers and steam generators	>3.5	>3.6	>50	–	all	all	–	all	all	–	all	all
	b) Pressure vessels and heat exchangers, other than d) and e) ⁽⁶⁾	>41.4	>42.2	>600	or	>371 ⁽¹⁾ >204 ⁽²⁾	>700 ⁽¹⁾ >400 ⁽²⁾	and	all	all	or	>38	>1.5
	c) Fired heaters for oil	>41.4	>42.2	>600	–	all	all	–	all	all	–	all	all
	d) Liquefied gas pressure vessel cargo tanks ⁽⁶⁾	≥2.1	≥2.1	≥30	–	all	all	–	all	all	–	all	all
	e) Pressure vessels and heat exchangers for toxic or corrosive substances ⁽⁶⁾	>1.0	>1.0	>15	–	all	all	–	all	all	–	all	all
II	a) Fired heater for oil	≤41.4 and >1.0	≤42.2 and >1.0	≤600 and >15	–	all	all	–	all	all	–	all	all
	b) Pressure vessels and heat exchangers, other than Group I b) ⁽⁶⁾	≤41.4 and >6.9	≤42.2 and >7	≤600 and >100	and	≤371 ⁽¹⁾ ≤204 ⁽²⁾	≤700 ⁽¹⁾ ≤400 ⁽²⁾	and	all	all	and	≤38	≤1.5
	c) Pressure vessels and heat exchangers, other than Group II b) ⁽⁶⁾	≤6.9 and >1.0	≤7 and >1.0	≤100 and >15	and	>149 ⁽³⁾ >66 ⁽⁴⁾ >90 ⁽⁵⁾	>300 ⁽³⁾ >150 ⁽⁴⁾ >200 ⁽⁵⁾	and	>0.14	>5	and	≤38	≤1.5

Notes:

* Reference Part 4, Chapter 4 of the *Marine Vessel Rules* and Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*.

- 1 Steam, gas or vapor, other than toxic or corrosive substances.
- 2 Liquids, other than toxic and corrosive substances.
- 3 Steam, gas or vapor, and liquids excluding fuel oil, lubricating oil and thermal oil; other than toxic or corrosive substances.
- 4 Fuel oil.
- 5 Lubricating oil and thermal oil.
- 6 Internal diameter ≥ 150 mm (6 in.). Vessels with smaller diameter are outside the scope of this Section.

PART

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CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 6 Piping Systems

1 General

Materials used for piping system components, for which certification is required as indicated in this Section, are to be produced, tested, and certified in accordance with *ABS Rules for Materials and Welding (Part 2)*, as applicable and this Section.

Piping system components for which certification is required as indicated in 6-1-6/Tables 1 and 2 are to be designed, constructed, tested, certified and installed in accordance with Part 4, Chapter 2 and this Section.

Piping systems associated with steering gear systems are to be in accordance with Section 4-3-4 of the *Marine Vessel Rules*.

Piping systems, such as steam, exhaust and feed systems, associated with boilers are to be in accordance with the applicable requirements of Part 4, Chapters 4 and 6 of the *Marine Vessel Rules*.

Class I, II and III piping systems are defined in 4-2-1/Table 1.

3 Pipes

3.1 Manufacturer's Certification

For Class I and Class II piping systems, the manufacturer is to certify that the pipes comply with the standard to which is designed, fabricated and tested, and to report the results of tests so conducted.

For Class III piping systems, manufacturer's trademark, pressure/temperature rating and material identification, as applicable, temporarily marked on the pipe and verifiable against the manufacturer's catalog or similar documentation will suffice.

3.3 Identification

For all Class I, II and III piping systems, metallic pipes are to have a temporary identification for traceability during fabrication. Plastic pipes are to be permanently marked with identification as required in 7-1-3/13.5.

3.5 Plastic Piping

Manufacturing of plastic pipes is to be in accordance with 4-2-2/7.9. Where the manufacturer does not have a certified quality system in accordance with the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)* or ISO 9001 (or equivalent), tests required by these Rules will be carried out using samples from each batch of pipes being supplied for use aboard the unit, and in the presence of the Surveyor (see 4-2-2/7.9).

5 Piping Components other than Pipes

Piping components other than pipes are to be certified in accordance with 6-1-6/Table 1 and the following.

5.1 Pipe Fittings and Valves

5.1.1 Design Review

Design approval is a part of the ABS certification process and where indicated as 'required' in 6-1-6/Table 2, pipe fittings and valves are to meet an applicable recognized standard, or are to be design-approved by ABS. For the latter purpose, pipe fittings and valves are to be evaluated for their adequacy for the rated pressures and temperatures and, as applicable, type inspection and testing are to be conducted as part of the design evaluation process. See also 4-2-2/5.7, 4-2-2/7.5 and 6-1-6/3.5.

5.1.2 Manufacturer's Certification

Where indicated as 'required' in 6-1-6/Table 2, the manufacturer is to certify that the pipe fittings and valves with the standard to which the component is designed, fabricated and tested, and to report the results of tests so conducted. For Class III components, manufacturer's trademark, pressure/temperature rating and material identification, as applicable, stamped or cast on the component and verifiable against the manufacturer's catalog or similar documentation will suffice.

5.1.3 Identification

Pipe fittings and valves are to bear permanent identification, such as manufacturer's name or trademark, standard of compliance, material identity, pressure rating, etc., as required by the standard of compliance or the manufacturer's specification. Such markings may be cast or forged integral with, stamped on, or securely affixed by nameplate on the component, and are to serve as a permanent means of identification of the component throughout its service life.

5.1.4 Welded Non-Standard Valves and Fittings

Nonstandard steel valves and fittings fabricated by means of fusion welding are to comply also with the requirements of Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*. However, after a manufacturer's procedure in the fabrication of equipment of this kind has been demonstrated by tests to the satisfaction of a Surveyor to ABS, subsequent tests on the product need not be witnessed, but the manufacturer's guarantee that the Rules are complied with will be accepted as for other valves and fittings which conform to standards of the American National Standards Institute (ANSI) or other recognized standards.

5.1.5 Shell Valves

Shell valves are to be designed, constructed, and tested in accordance with 4-2-2/21.

5.1.7 Pipe Joints

Pipe joints and mechanical joints are to be designed, constructed and tested in accordance with 4-6-2/5.5 and 4-6-2/5.9 of the *Marine Vessel Rules*, respectively. See 4-2-1/11.11 and 4-2-1/11.13.

The installation of pipe joints and mechanical joints is to be in accordance with the manufacturer's assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be specified and supplied as necessary by the manufacturer. These special tools are to be kept onboard.

5.3 Flexible Hoses

Hoses for which design review and type-testing is required as indicated in 6-1-6/Table 1 are to be designed, constructed, and tested in accordance with 4-2-1/11.29.

5.5 Vent Heads and Pressure/Vacuum Valves

Vent heads for which design review and type-testing is required as indicated in 6-1-6/Table 1 are to be designed, constructed, and tested in accordance with 4-2-3/1.9.5.

When provided for the protection of crude oil tanks, pressure/vacuum valves are to be designed constructed and tested in accordance with IMO Resolution MSC/Circ. 677 and MSC/Circ. 450/Rev. 1.

5.7 Gauges, Detectors, and Transmitters

Gauges, detectors, and transmitters for which design review is required as indicated in 6-1-6/Table 1 are to be designed to withstand the design pressure of the system to which they are connected and the material is to be suitable for the type of fluid being measured.

5.9 Fluid Power Cylinders

Fluid power cylinders and systems, including valve actuators, for which design review is required as indicated in 6-1-6/Table 1 are to be designed in accordance with 4-2-2/19.

The physical and chemical characteristics of materials entering into the construction of hydraulic and pneumatic power cylinders are to be in accordance with the applicable requirements of Section 2-3-1 of the *ABS Rules for Materials and Welding (Part 2)* or such other appropriate material specification as may be approved in connection with a particular design.

Copies of certified mill test reports are to be made available to the Surveyor upon request.

Ordinary cast iron or similar materials (elongation less than 12%) are not to be used for cylinders which may be subjected to shock loading.

5.11 Pumps

Pumps are to be certified in accordance with 6-1-6/Table 1.

5.13 Nonstandard Components

Components not manufactured to a recognized national standard may be considered for acceptance based on manufacturers' specified pressure and temperature ratings and on presenting evidence, such as design calculations or type test data, that they are suitable for the intended purpose. For Classes I and II piping applications, drawings showing details of construction, materials, welding procedures, etc., as applicable, are to be submitted for such components, along with the basis for the pressure and temperature ratings. Nonstandard components are preferably to be Type Approved (see 1-1-A2/5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*).

7 Survey and Certification

Where required, all material, type-testing and unit certification is to be carried out, in presence of and to the satisfaction of the Surveyor, at manufacturer's plant and reported upon before installation onboard. 6-1-6/Table 1 shows the extent of services required for each pump, piping, and pipe component. Where a product does not require unit certification, Surveyor attendance is optional, and the product is to be designed and fabricated to satisfy a recognized industrial standard and the manufacturer's specification.

7.1 Survey and Certification of Pipes

Pipes intended for use in Class I and Class II piping systems are to be tested at the mill, in the presence of and to the satisfaction of the attending Surveyor, in accordance with the requirements of Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)* or such other appropriate material specification as may be approved in connection with a particular design (see 4-2-6/3.5).

The material surfaces will be examined by the Surveyor when specially requested by the purchaser. See also 4-6-7/3.5.1 of the *Marine Vessel Rules*.

The pipes are to be reasonably straight, free from defects, and have a workmanlike finish. At a minimum, the finished pipe is to be visually inspected at the same frequency as that required for the tension test specified in 2-3-12/Table 3 for the applicable grade. Welding repair to the pipe is not to be carried out without the purchaser's approval and is to be to the Surveyor's satisfaction.

Pipes intended for use in Class I and Class II piping systems are to be tested at the mill, in the presence of and to the satisfaction of the attending Surveyor or alternatively produced under an ABS certified Product Quality Assurance (PQA).

7.3 Survey and Certification of Piping Components other than Pipes

Where indicated in 6-1-6/Tables 1 and 2, the piping component is to be certified by ABS. This involves design approval of the component, as applicable, and testing in accordance with the standard of compliance at the manufacturer's plant.

7.3.1 Survey and Certification of Shell Valves (1 July 2018)

All valves intended for installation on the side shell at or below the deepest load waterline, including those at the sea chests, are to be hydrostatically tested in presence of and to the satisfaction of the attending Surveyor.

The valve housing of each valve is to be subjected to a pressure of not to be less than test pressure of 5 bar (5.1 kgf/cm², 72.5 psi). No leakage is permitted and holding time as follows:

- 15 seconds for sizes up to 50 mm (2 inch)
- 60 seconds for sizes 75 mm - 150 mm (2.5 inch - 6 inch)
- 120 seconds for sizes 200 mm - 300 mm (8 inch - 12 inch)
- 300 seconds for sizes 350 mm (14 inch) and larger

The valve assembly is to be subjected to a hydrostatic seat leakage test. The test is to be performed with closed valve with the other end open to atmosphere. The pressure is to be applied independently on each side. Test pressure is not to be less than 5 bar (5.1 kgf/cm², 72.5 psi). Holding time is 5 minutes for all sizes.

7.3.2 Survey and Certification of Pumps

Regardless of their capacity, the following pumps are required to be fabricated and tested in presence of and to the satisfaction of the attending Surveyor:

- Ballast pumps
- Bilge pumps
- Fire pumps, including emergency fire pumps
- Other fire fighting service pumps, such as, pumps for fixed water-based systems, or equivalent, local application fire-fighting systems, sprinkler systems, raw water pumps, booster pumps, etc.
- Hydraulic pumps for steering gear, anchor windlass and controllable pitch propellers, as applicable
- Fuel oil transfer pumps (for self-propelled units and dynamically positioned units only)
- Lubricating oil pumps (for self-propelled units and dynamically positioned units only)
- Fuel oil service pumps, booster pumps, etc. (for self-propelled units and for dynamically positioned units only with propulsion diesel engines with bores > 300 mm)
- Sea water and freshwater cooling pumps (for self-propelled units and for dynamically positioned units only with propulsion diesel engines with bores > 300 mm)

The pumps are to meet the hydrostatic and capacity test requirements in 6-1-6/7.3.2(a) and (b) and the tests are to be carried out at the manufacturer's plant in the presence of the Surveyor.

The capacity test will not be required nor will the hydrostatic test need to be witnessed by the Surveyor for individual pumps produced on a production line basis, provided the Surveyor is satisfied from periodic inspections and the manufacturer's quality assurance procedures that the pump capacities are acceptable and that hydrostatic testing is being performed.

7.3.2(a) Hydrostatic Tests. The pumps are to be hydrostatically tested to a pressure of at least $1.5P$, where P is the maximum working pressure of the pump. If it is desired to conduct the hydrostatic test on the suction side of the pump independently from the test on the discharge side, the test pressure on the suction side is to be at least $1.5P_s$, where P_s is the maximum pressure available from the system at the suction inlet. In all cases, the test pressure for both the suction and the discharge side is not to be less than 4 bar.

7.3.2(b) *Capacity Tests.* Pump capacities are to be checked with the pump operating at design conditions (rated speed and pressure head). For centrifugal pumps, the pump characteristic (head-capacity) design curve is to be verified to the satisfaction of the Surveyor. Capacity tests may be waived if previous satisfactory tests have been carried out on similar pumps.

7.3.2(c) *Relief Valve Capacity Test.* For positive displacement pumps with an integrated relief valve, the valve's setting and full flow capacity corresponding to the pump maximum rating is to be verified. The operational test for relief valve capacity may be waived if previous satisfactory tests have been carried out on similar pumps.

TABLE 1
Certification Details – Piping System Components

<i>Piping System Components</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Pipes – Steel; Class I	4/5	6-1-6/3.1
Pipes – Steel; Class II	4/5	6-1-6/3.1
Pipes – Steel; Class III	1	6-1-6/3.1
Pipes, pipe fittings and pipe joints Level I and II – Plastic	4/5	6-1-6/3.5 and 4-2-2/7.9, MVR 4-6-3/9, 4-2-2/7.5.6
Pipe fittings – Flanges, elbows, tees, expansion joints, etc., and valves; Classes I and II	2	6-1-6/5
Pipe fittings – Flanges, elbows, tees, expansion joints, etc., and valves; Class III	1	6-1-6/5.1.2
Pipe fittings – Mechanical joints	2	6-1-6/5.1.7
Fusion welded nonstandard valves and fittings	2	6-1-6/5.1.4
Shell valves ⁽¹⁾	5	6-1-6/5.1.5, 6-1-6/7.3.1
Flexible Hoses (not fire hoses)	2	6-1-6/5.3
Vent heads, pressure/vacuum valves	2	6-1-6/5.5
Gauges, detectors and transmitters	2	6-1-6/5.7
Fluid power cylinders and systems, including valve actuators	2	6-1-6/5.9
Pumps related to propulsion diesel engines (bore >300 mm) (11.8 in.) and gas turbines and gears – fuel, cooling water, lube oil services ⁽¹⁾	4/5	6-1-6/7.3.2
Pumps related to propulsion steam plant and gears – fuel oil, lube. Oil, condensate, main circulating, feed water services ⁽¹⁾	4/5	6-1-6/7.3.2
Hydraulic pumps of steering gears, controllable pitch propellers, anchor windlass ⁽¹⁾	4/5	6-1-6/7.3.2
Pumps for fire fighting, ballast and bilge ⁽¹⁾	4/5	6-1-6/7.3.2
Air compressors	1	

Note:

- 1 Design review is only required when applying for Type Approval Program.

TABLE 2
Piping Classes and Certification

<i>Piping Component</i>	<i>Class</i>	<i>Design Approval ⁽¹⁾</i>	<i>Manufacturer's Certification ⁽¹⁾</i>	<i>Identification ⁽¹⁾</i>	<i>Unit Certification</i>
Pipes	I, II	Not applicable ⁽³⁾	Required	Temporary ⁽³⁾	Required ⁽²⁾
	III	Not applicable ⁽³⁾	Required	Temporary ⁽³⁾	Not required ⁽³⁾
Pipe fittings	I, II	Required ^(4, 6)	Required	Permanent	Not required
	III	Not required ^(5, 6)	Required	Permanent	Not required
Valves	I, II	Required ⁽⁴⁾	Required	Permanent	Not required
	III	Not required ⁽⁵⁾	Required	Permanent	Not required

Notes:

- 1 See 6-1-6/3.1, 6-1-6/3.3, 6-1-6/5.1.1, 6-1-6/5.1.2 and 6-1-6/5.1.3.
- 2 Except hydraulic piping.
- 3 Except for plastic piping. See 6-1-6/3.5.
- 4 Where not in compliance with a recognized standard.
- 5 Documentary proof of pressure/temperature rating is required. See 6-1-6/5.13.
- 6 Design of flexible hoses and mechanical pipe joints is to be approved in each case. See 4-2-1/11.29 of these Rules and 4-6-2/5.9 of the *Marine Vessel Rules*, respectively.

PART

6

CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 7 Electrical Systems and Control Equipment

1 General

Electrical equipment and machinery for which certification is required as indicated in 6-1-7/Table 1 are to be designed, constructed, tested, certified and installed in accordance with this Chapter.

1.1 Insulation Material

For the purpose of these requirements, insulating material is designated as follows.

1.1.1 Class A Insulation

Materials or combinations of materials such as cotton, silk and paper when suitably impregnated or coated or when immersed in a dielectric liquid such as oil. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 105°C (221°F).

1.1.2 Class B Insulation

Materials or combinations of materials such as mica, glass fiber, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 130°C (266°F).

1.1.3 Class E Insulation

Materials or combinations of materials which, by experience or accepted tests, can be shown to be capable of operation at 120°C (248°F) (materials possessing a degree of thermal stability allowing them to be operated at a temperature 15°C (27°F) higher than Class A materials).

1.1.4 Class F Insulation

Materials or combinations of materials such as mica, glass fiber, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 155°C (311°F).

1.1.5 Class H Insulation

Materials or combinations of materials such as silicone elastomer, mica, glass fiber, etc., with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if, by experience or accepted tests, they can be shown to be capable of operation at 180°C (356°F).

1.1.6 Insulation for Temperature Above 180°C (356°F)

Materials or combinations of materials which by experience or accepted tests can be shown to be capable of satisfactory operation at temperature over 180°C (356°F) will also be considered. Supporting background experience or report of tests conducted in accordance with a recognized standard ascertaining their suitability for the intended application and temperature operation are to be submitted for review.

1.3 Accessibility

The design and arrangement of electrical apparatus is to provide accessibility to parts requiring inspection or adjustment. Refer to 7-1-5/7.13.3. Armature and field coils, rotors and revolving fields are to be removable and where air ducts are used, there are to be means of access.

3 Plans and Data to Be Submitted

3.1 Rotating Machines of 100 kW and Over

For rotating machines of 100 kW and over intended for essential services (primary and secondary) or for services related to additional optional notations requested for the unit, drawings showing the following particulars are to be submitted: assembly, seating arrangements, terminal arrangements, shafts, coupling, coupling bolts, stator and rotor details together with data for complete rating, class of insulation, designed ambient temperature, temperature rise, degree of protection for enclosures, weights and speeds for rotating parts. Plans to be submitted for generator prime movers are given in 4-2-4/1.5, 4-2-1/1.9 and 4-2-1/Appendix 1 of the *Marine Vessel Rules*, as applicable. See also 8-2-1/5 of these Rules.

3.3 Switchboards, Distribution Boards, Controllers, etc.

For switchboards, distribution boards, battery charger units, uninterruptible power system (UPS) units, motor control centers, and motor controllers intended for essential services (primary and secondary) or for services related to additional optional notations requested for the unit, drawings showing arrangements and details, front view, and installation arrangements are to be submitted for review together with data for protective device rating and setting, type of internal wiring, and size and rated current carrying capacity (together with short-circuit current data) of bus bars and internal wiring for power circuit. In addition, a schematic or logic diagram with a written description giving the sequence of events and system operating procedures for electrical power supply management on switchboards, and sequential or automatic changeover of the motors are also to be submitted for review. For equipment intended solely for drilling operations, see 8-2-1/5.

5 Rotating Machines

5.1 General

5.1.1 Applications

All rotating electrical machines of 100 kW and over intended for essential services (see 4-1-1/3.5) or for services related to additional optional notations requested for the unit, are to be designed, constructed and tested in accordance with the requirements of 6-1-7/5 and 6-1-7/19.

All other rotating electrical machines are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications. Manufacturer's tests for rotating electric machines less than 100 kW for essential services or for services related to additional optional notations requested for the unit, are to include at least the tests described in 6-1-7/Table 2 (Items 2 through 10 and Item 12), regardless of the standard of construction. The test certificates are to be made available when requested by the Surveyor. Acceptance of machines will be based on satisfactory performance test after installation. For rotating machines intended solely for drilling operations, see 8-2-1/5. Electric motors intended for installation into jacking gear systems must meet the requirements of 6-1-9/15.1 and 6-1-9/Table 2.

5.1.2 Certification on Basis of an Approved Quality Assurance Program

See 6-1-1/9.

5.1.3 References

5.1.3(a) Angles of Inclination. For the requirements covering angles of inclination for design condition, see 6-1-1/3.5 and 4-1-1/Table 1.

5.1.3(b) Insulation Material. For the requirements covering insulation material, see 6-1-7/1.1.

5.1.3(c) *Capacity of Generators.* For requirements covering main generator capacity, see 4-3-2/3.1.2 and 4-3-2/3.5. For requirements covering emergency generator capacity, see 4-3-2/5.3.

5.1.3(d) *Power Supply by Generators.* For requirements covering power supply by main or emergency generator, see 4-3-2/3.1 and 4-3-2/5.5.2, respectively.

5.1.3(e) *Protection for Generator Circuits.* For requirements covering protection for generator, see 4-3-2/9.3, 4-3-2/9.5 and 4-3-2/9.7.

5.1.3(f) *Protection for Motor Circuits.* For requirements covering protection for motor branch circuit, see 4-3-2/9.13.

5.1.3(g) *Installation.* For requirements covering installation, see 4-3-3/3.3 for generators and 4-3-3/3.5 for motors.

5.1.3(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.

5.3 Insulation Resistance Measurement

The resistance is to be measured before the commencement of the testing and after completion of the testing for all circuits. Circuits or groups of circuits of different voltages above earth are to be tested separately. This test is to be made with at least 500 volts DC, and the insulation resistance in megohms of the circuits while at their operating temperatures is to be normally at least equal to:

$$\frac{\text{Rated Voltage of the Machine}}{(\text{Rating in kVA} / 100) + 1000}$$

The minimum insulation resistance of the fields of machines separately excited with voltage less than the rated voltage of the machine is to be of the order of one-half to one megohm.

5.5 Overload and Overcurrent Capability

5.5.1 AC Generators

AC generators are to be capable of withstanding a current equal to 1.5 times the rated current for not less than 30 seconds. The test may be performed in conjunction with the short circuit testing, provided the electrical input energy to the machine is not less than that required for the above overload capability.

5.5.2 AC Motors

5.5.2(a) *Overcurrent Capacity.* Three-phase motors, except for commutator motors, having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV are to be capable of withstanding a current equal to 1.5 times the rated current for not less than two minutes. For three-phase and single phase motors having rated outputs above 315 kW, the overcurrent capacity is to be in accordance with the manufacturer's specification. The test may be performed at a reduced speed.

5.5.2(b) *Overload Capacity.* Three-phase induction motors are to be capable of withstanding for 15 seconds, without stalling or abrupt change in speed, an excess torque of 60% of their rated torque, the voltage and frequency being maintained at their rated values.

5.5.2(c) *Overload Capacity for Synchronous Motors.* Three-phase synchronous motors are to be capable of withstanding an excess torque, as specified below, for 15 seconds without falling out of synchronism, the excitation being maintained at the value corresponding to the rated load.

Synchronous (wound rotor) induction motors:	35% excess torque
Synchronous (cylindrical rotor) motors:	35% excess torque
Synchronous (salient pole) motors:	50% excess torque

When automatic excitation is used, the limit of torque values is to be the same as with the excitation equipment operating under normal conditions.

5.7 Dielectric Strength of Insulation

5.7.1 Application

The dielectric test voltage is to be successively applied between each electric circuit and all other electric circuits and metal parts earthed and for direct-current (DC) rotating machines between brush rings of opposite polarity. Interconnected polyphase windings are to be considered as one circuit. All windings, except that under test, are to be connected to earth.

5.7.2 Standard Voltage Test

The insulation of all rotating machines is to be tested with the parts completely assembled and not with the individual parts. The dielectric strength of the insulation is to be tested by the continuous application for 60 seconds of an alternating voltage having a frequency of 25 to 60 Hz and voltage in 6-1-7/Table 3. The requirements in 6-1-7/Table 3 apply to those machines other than high voltage systems covered by 6-1-7/19.19.

5.7.3 Direct Current Test

A standard voltage test using a direct current source equal to 1.7 times the required alternating-current voltage will be acceptable.

5.9 Temperature Ratings

5.9.1 Temperature Rises

5.9.1(a) Continuous Duty Machines. After the machine has been run continuously under a rated load until steady temperature condition has been reached, the temperature rises are not to exceed those given in 6-1-7/Table 4.

5.9.1(b) Short-time Duty Machines. After the machine has been run at a rated load during the rated time, followed by a rest and de-energized period of sufficient duration to re-establish the machine temperatures within 2°C (3.6°F) of the coolant, the temperature rises are not to exceed those given in 6-1-7/Table 4. At the beginning of the temperature measurement, the temperature of the machine is to be within 5°C (8°F) of the temperature of the coolant.

5.9.1(c) Periodic Duty Machines. The machine has been run at a rated load for the designed load cycle to be applied and continued until obtaining the practically identical temperature cycle. At the middle of the period causing the greatest heating in the last cycle of the operation, the temperature rises are not to exceed those given in 6-1-7/Table 4.

5.9.1(d) Non-periodic Duty Machines. After the machine has been run continuously or intermittently under the designed variations of the load and speed within the permissible operating range until reaching the steady temperature condition, the temperature rises are not to exceed those given in 6-1-7/Table 4.

5.9.1(e) Insulation Material Above 180°C (356°F). Temperature rises for insulation materials above 180°C (356°F) are to be defined during the approval process of these materials in accordance with 6-1-7/1.1.6.

5.9.2 Ambient Temperature

These final temperatures are based on an ambient temperature of 50°C (122°F), for machines located within boiler and engine rooms in accordance with 4-3-1/17. Where provision is made for ensuring the ambient temperature of the space being maintained at 40°C (104°F) or less, as by air cooling or by locating the machine outside of the boiler and engine rooms, the temperature rises of the windings may be 5°C (9°F) higher. The ambient temperature is to be taken in at least two places within 1.83 m (6 ft) of the machine under test and by thermometers having their bulbs immersed in oil contained in an open cup.

5.11 Construction and Assembly

5.11.1 Enclosure, Frame and Pedestals

Magnet frames and pedestals may be separate but are to be secured to a common foundation.

5.11.2 Shafts and Couplings

Rotating shaft, hollow shaft and coupling flange with bolts are to comply with 4-2-4/5.3, 4-3-2/5.3 and 4-3-5/5.7.3 of the *Marine Vessel Rules*. Plans to be submitted are given in 4-2-4/1.5 and 4-2-1/1.9 of the *Marine Vessel Rules*.

5.11.3 Circulating Currents

Means are to be provided to prevent circulating currents from passing between the journals and the bearings where the design and arrangement of the machine is such that damaging current may be expected. Where such protection is required, a warning plate is to be provided in a visible place cautioning against the removal of such protection.

5.11.4 Rotating Exciters

Rotating exciters are to conform to all applicable requirements for generators.

5.11.5 Insulation of Windings

Armature and field coils are to be treated to resist oil and water.

5.11.6 Protection Against Cooling Water

Where water cooling is used, the cooler is to be so arranged to avoid entry of water into the machine, whether through leakage or from condensation in the heat exchanger.

5.11.7 Moisture-Condensation Prevention

Where steam-heating coils are installed for this purpose, there are to be no pipe joints inside of the casings. See item 7 in 6-1-7/Table 8 for space heater pilot lamp for alternating-current generators.

All generators, and each propulsion motor are to be provided with a means to prevent moisture condensation in the machine when idle.

Motors, rated 50 kW and over, used for essential services and located in damp spaces or exposed to weather are to be provided with a means to prevent moisture condensation in the machine when idle.

5.11.8 Terminal Arrangements

Terminals are to be provided at an accessible position and protected against mechanical damage and accidental contact for earthing, short-circuit or touching. Terminal leads are to be secured to the frame and the designation of each terminal lead are to be clearly marked. The ends of terminal leads are to be fitted with connectors. Cable glands or similar are to be provided where cable penetrations may compromise the protection property of terminal enclosures.

5.11.9 Nameplates

Nameplates of corrosion-resistant material are to be provided in an accessible position of the machine and are to indicate at least the information as listed in 6-1-7/Table 5.

5.13 Lubrication

Rotating machines are to have continuous lubrication at all running speeds and all normal working bearing temperatures, with the unit's inclinations specified in 4-1-1/7.1. Unless otherwise approved, where forced lubrication is employed, the machines are to be provided with means to shut down their prime movers automatically upon failure of the lubricating system. Each self-lubricating sleeve bearing is to be fitted with an inspection lid and means for visual indication of oil level or an oil gauge. Refer to 4-3-3/3.3 for lubrication of generators in ship-type units.

5.15 Operating and Overspeed Governors for Generator Prime Movers

Gas turbines and diesel engines used as prime movers for main and emergency generators are to comply with the requirements specified in 6-1-3/3.3 and 6-1-3/3.5, respectively.

5.17 Alternating-Current (AC) Generators

5.17.1 Control and Excitation of Generators

Excitation current for generators is to be provided by attached rotating exciters or by static exciters deriving their source of power from the machine being excited.

5.17.2 Voltage Regulation

5.17.2(a) Voltage Regulators. A separate regulator is to be supplied for each AC generator. When it is intended that two or more generators will be operated in parallel, reactive-droop compensating means are to be provided to divide the reactive power properly between the generators.

5.17.2(b) Variation from Rated Voltage – Steady Conditions. Each AC generator for unit main service driven by its prime mover having governor characteristics complying with 6-1-3/3.3.1 or 6-1-3/3.5.1 is to be provided with an excitation system capable of maintaining the voltage under steady conditions within plus or minus 2.5% of the rated voltage for all loads between zero and rated load at rated power factor. These limits may be increased to plus or minus 3.5% for emergency sets.

5.17.2(c) Variation from Rated Voltage – Transient Conditions. Momentary voltage variations are to be within the range of minus 15% to plus 20% of the rated voltage, and the voltage is to be restored to within plus or minus 3% of the rated voltage in not more than 1.5 seconds when:

- A load equal to the starting current of the largest motor or a group of motors, but in any case, at least 60% of the rated current of the generator, and power factor of 0.4 lagging or less, is suddenly thrown on with the generator running at no load; and
- A load equal to the above is suddenly thrown off.

Subject to ABS approval, such voltage regulation during transient conditions may be calculated values based on the previous type test records, and need not to be tested during factory testing of a generator.

Consideration can be given to performing the test required by 6-1-7/Table 2, Item 4 according to precise information concerning the maximum values of the sudden loads instead of the values indicated above, provided precise information is available. The precise information concerning the maximum values of the sudden loads is to be based on the power management system arrangements and starting arrangements provided for the electrical system.

5.17.2(d) Short Circuit Conditions. Under steady-state short-circuit conditions, the generator together with its excitation system is to be capable of maintaining a steady-state short-circuit current of not less than three times its rated full load current for a period of two seconds or of such magnitude and duration as required to properly actuate the associated electrical protective devices. In order to provide sufficient information for determining the discrimination settings in the distribution system where the generator is going to be used, the generator manufacturer is to provide documentation showing the transient behavior of the short circuit current upon a sudden short-circuit occurring when excited, and running at nominal speed. The influence of the automatic voltage regulator is to be taken into account, and the setting parameters for the voltage regulator are to be noted together with the decrement curve. Such a decrement curve is to be available when the setting of the distribution system's short-circuit protection is calculated. The decrement curve need not be based on physical testing. The manufacturer's simulation model for the generator and the voltage regulator may be used where this has been validated through the previous type test on the same model.

5.17.3 Parallel Operation

For AC generating sets operating in parallel, the following requirements are to be complied with. See also 4-3-2/9.5.2 for protection of AC generators in parallel operation.

5.17.3(a) Reactive Load Sharing. The reactive loads of the individual generating sets are not to differ from their proportionate share of the combined reactive load by more than 10% of the rated reactive output of the largest generator, or 25% of the rated reactive output of the smallest generator, whichever is the less.

5.17.3(b) *Load Sharing.* For any load between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 15% of the rated output in kilowatt of the largest generator or 25% of the rated output in kilowatt of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate output with each generator carrying its proportionate share.

5.17.3(c) *Facilities for Load Adjustment.* Facilities are to be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5% of the aggregate output at normal frequency.

5.19 Direct-Current (DC) Generators

5.19.1 Control and Excitation of Generators

5.19.1(a) *Field Regulations.* Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately. This equipment is to be capable of adjusting the voltage of the DC generator to within 0.5% of the rated voltage at all loads between no-load and full-load.

5.19.1(b) *Polarity of Series Windings.* The series windings of each generator for two wire DC system are to be connected to the negative terminal of each machine.

5.19.1(c) *Equalizer Connections.* See 6-1-7/9.13.3.

5.19.2 Voltage Regulation

5.19.2(a) *Shunt or Stabilized Shunt-wound Generator.* When the voltage has been set at full-load to its rated value, the removal of the load is not to cause a permanent increase of the voltage greater than 15% of the rated voltage. When the voltage has been set either at full-load or at no-load, the voltage obtained at any value of the load is not to exceed the no-load voltage.

5.19.2(b) *Compound-wound Generator.* Compound-wound generators are to be so designed in relation to the governing characteristics of prime mover that with the generator at full-load operating temperature and starting at 20% load with voltage within 1% of rated voltage, it gives at full-load a voltage within 1.5% of rated voltage. The average of ascending and descending voltage regulation curves between 20% load and full-load is not to vary more than 3% from rated voltage.

5.19.2(c) *Automatic Voltage Regulators.* Unit main service generators which are of the shunt type are to be provided with automatic voltage regulators. However, if the load fluctuation does not interfere with the operation of essential auxiliaries, shunt-wound generators without voltage regulators or stabilized shunt-wound machines may be used. An automatic voltage regulator will not be required for the unit main service generators of approximately flat-compounded type. Automatic voltage regulators are to be provided for all service generators driven by variable speed engines used also for propulsion purposes, whether these generators are of the shunt, stabilized shunt or compound-wound type.

5.19.3 Parallel Operation

For DC generating sets operating in parallel, the following requirements are to be complied with. See also 4-3-2/9.7.2 for protection of DC generators in parallel operation.

5.19.3(a) *Stability.* The generating sets are to be stable in operation at all loads from no-load to full-load.

5.19.3(b) *Load Sharing.* For any load between 20% and 100% of the sum of the rated output (aggregate output) of all generators, the load on any generator is not to differ more than 12% of the rated output in kilowatt of the largest generator or 25% of the rated output in kilowatt of the individual generator in question, whichever is the less, from its proportionate share of the combined load for any steady state condition. The starting point for the determination of the foregoing load-distribution requirements is to be at 75% of the aggregate output with each generator carrying its proportionate share.

5.19.3(c) *Tripping of Circuit Breaker.* DC generators which operate in parallel are to be provided with a switch which will trip the generator circuit breaker upon functioning of the overspeed device.

7 Accumulator Batteries

7.1 General

7.1.1 Application

All accumulator batteries for engine starting, essential or emergency services are to be constructed and installed in accordance with the following requirements. Accumulator batteries for services other than the above are to be constructed and equipped in accordance with good commercial practice. All accumulator batteries will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

7.1.2 Sealed Type Batteries

Where arrangements are made for releasing gas through a relief valve following an overcharge condition, calculations demonstrating compliance with the criteria in 4-3-3/3.7.3 under the expected rate of hydrogen generation are to be submitted together with the details of installation and mechanical ventilation arrangements.

7.3 Construction and Assembly

7.3.1 Cells and Filling Plugs

The cells are to be so constructed as to prevent spilling of electrolyte due to an inclination of 40 degrees from normal. The filling plugs are to be so constructed as to prevent spilling of electrolyte due to the unit's movements, such as rolling and pitching.

7.3.2 Crates and Trays

The cells are to be grouped in crates or trays of rigid construction equipped with handles to facilitate handling. For protection from corrosion, see 4-3-3/3.7.4. The mass of crates or trays are not to exceed 100 kg (220.5 lb).

7.3.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of each crate or tray and are to indicate at least the information as listed in 6-1-7/Table 5.

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.

9.1.1(b) Motor Controllers. Motor Controllers of 100 kW and over intended for essential services or for services related to additional optional notations requested for the unit.

9.1.1(c) Motor Control Centers. Motor control centers with aggregate loads of 100 kW or more intended for essential services or for services related to additional optional notations requested for the unit.

9.1.1(d) Battery Charger Units and Uninterruptible Power System (UPS) Units. Battery charger units of 25 kW and over and uninterruptible power system (UPS) units of 50 kVA and over intended for essential services, services related to additional optional notations requested for the unit, emergency source of power or transitional source of power.

9.1.1(e) Distribution Boards. Distribution boards associated with the charging or discharging of the battery system or uninterruptible power system (UPS) in 6-1-7/9.1.1(d).

Switchboard, distribution board, battery charger units, uninterruptible power system (UPS) units, motor control centers and motor controllers not covered by the above paragraph are to be constructed and equipped in accordance with good commercial practice, and will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

9.1.2 References

9.1.2(a) *Angles of Inclination.* For the requirements covering angles of inclination for design condition, see 6-1-1/3.5 and 4-1-1/Table 1.

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/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/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 may 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 will not be 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 will be specially considered. 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 temperature which will 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 so as 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 mm² (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 bus bars, 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/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 Water-spraying or Local Water-mist Fire Extinguishing System.
- ii) The minimum clearance distance shall not be less than 8 mm
- iii) The minimum creepage distance shall not 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/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.

<i>Rated Operational Voltage</i> V	<i>Rated Impulse Withstand Test Voltage</i> 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 may 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 may 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/Table 8. They are to be suitable for starting, stopping, synchronizing and paralleling each generator set from the main switchboard. They may be mounted on the centralized control console, if the main switchboard is located in the centralized control station.

9.15 Motor Controllers and Control Centers

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

9.15.1 Enclosures and Assemblies

The following materials are acceptable for the enclosures.

- Cast metal, other than die-cast metal, at least 3 mm ($\frac{1}{8}$ in.) thick at every point.
- Nonmetallic materials which have ample strength, are noncombustible and nonabsorptive, (e.g., laminated phenolic material).
- Sheet metal of adequate strength.

Motor control centers are to be constructed so that they are secured to a solid foundation, be self-supported or be braced to the bulkhead.

9.15.2 Disconnect Switches and Circuit Breakers

Means are to be provided for the disconnection of the full load from all live poles of supply of every motor at 0.5 kW or above and its controlgear. Where the controlgear is mounted on or adjacent to a main or auxiliary distribution switchboard, a disconnecting switch in the switchboard may be used for this purpose. Otherwise, a disconnecting switch within the controlgear enclosure or a separate enclosed disconnecting switch is to be provided. Disconnect switches and circuit breakers are to be operated without opening the enclosures in which they are installed.

9.15.3 Auto-starters

Alternating-current (AC) motor manual auto-starters with self-contained auto-transformers are to be provided with switches of the quick-make-and-break type, and the starter is to be arranged so that it will be impossible to throw to the running position without having first thrown to the starting position. Switches are to be preferably of the contactor or air-break-type.

9.17 Battery Systems and Uninterruptible Power Systems (UPS)

In addition to 6-1-7/9.1 to 6-1-7/9.11, as applicable, equipment for essential, emergency, and transitional sources of power services is to comply with the following requirements. Such equipment would include:

- Battery charging and discharging units of 25 kW and over and the associated distribution boards.
- Uninterruptible power supply (UPS) units of 50 kVA and over and the associated distribution boards.

9.17.1 Definitions

Uninterruptible Power System (UPS) – A combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure.

Off-line UPS unit – A UPS unit where under normal operation the output load is powered from the bypass line (raw mains) and only transferred to the inverter if the bypass supply fails or goes outside preset limits. This transition will invariably result in a brief (typically 2 to 10 ms) break in the load supply.

Line interactive UPS unit – An off-line UPS unit where the bypass line switch to stored energy power when the input power goes outside the preset voltage and frequency limits.

On-line UPS unit – A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the supply input failing or going outside preset limits.

DC UPS unit – A UPS unit where the output is in DC (direct current).

9.17.2 Battery Charging Rate

Except when a different charging rate is necessary and is specified for a particular application, the charging facilities are to be such that the completely discharged battery can be recharged to 80% capacity in not more than 10 hours. See also 4-3-4/3.7.3.

9.17.3 Discharge Protection

An acceptable means, such as reverse current protection, is to be provided for preventing a failed component in the battery charger unit or uninterruptible power system (UPS) unit from discharging the battery.

9.17.4 Design and Construction

9.17.4(a) Construction. Battery charger units and uninterruptible power system (UPS) units are to be constructed in accordance with the IEC 62040 Series, or an acceptable and relevant national or international standard.

9.17.4(b) Operation. The operation of the UPS is not to depend upon external services.

9.17.4(c) Type. The type of UPS unit employed, whether off-line, line interactive or on-line, is to be appropriate to the power supply requirements of the connected load equipment.

9.17.4(d) Continuity of Supply. An external bypass is to be provided to account for a failure within the uninterruptible power system (UPS). For battery charger units and DC UPS units, see 4-3-2/7.1.6(c).

9.17.4(e) Monitoring and Alarming. The battery charger unit or uninterruptible power system (UPS) unit is to be monitored and audible and visual alarm is to be given in a normally attended location for the following:

- Power supply failure (voltage and frequency) to the connected load;
- Earth fault,
- Operation of battery protective device,
- When the battery is being discharged, and
- When the bypass is in operation for on-line UPS units. When changeover occurs, for battery charger units and DC UPS units required to comply with 4-3-2/7.1.6(c).

11 Transformers

11.1 General

11.1.1 Applications

All transformers which serve for essential or emergency electrical supply are to be constructed, tested, and installed in accordance with the following requirements. Transformers other than the above services, auto-transformers for starting motors or isolation transformers are to be constructed and equipped in accordance with good commercial practice. All transformers are to be of the dry and air cooled type. The use of liquid immersed type transformers will be subject to special consideration. Transformers other than for essential or emergency services will be accepted, subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

11.1.2 References

11.1.2(a) Power Supply Arrangement. For requirements covering arrangement of power supply through transformers to unit main service systems, see 4-3-2/7.1.6.

11.1.2(b) Protection. For requirements covering protection of transformers, see 4-3-2/9.15.

11.1.2(c) Protection Enclosures and its Selection. For requirements covering selection of the protection enclosures for location conditions, see 4-3-3/3.1.1.

11.1.3 Forced Cooling Arrangement (Air or Liquid)

Where forced cooling medium is used to preclude the transformer from exceeding temperatures outside of its rated range, monitoring and alarm means are to be provided and arranged so that an alarm activates when pre-set temperature conditions are exceeded. Manual or automatic arrangements are to be made to reduce the transformer load to a level corresponding to the cooling available.

11.1.4 Rating

Transformers are to be continuously rated based on the maximum expected ambient temperature to which they are subjected, but not less than 45°C (113°F). Temperature rises in accordance with alternative transformer construction standards may also be considered. Also, refer to 4-3-1/17.1 for electrical equipment installed spaces considered to have lower ambient temperatures and in environmentally controlled spaces.

11.3 Temperature Rise

The maximum temperature rise of the transformer insulated windings, based on an ambient temperature of 45°C (113°F), is not to exceed that in 6-1-7/Table 9.

11.5 Construction and Assembly

11.5.1 Windings

All transformer windings are to be treated to resist moisture, sea atmosphere and oil vapors.

11.5.2 Terminals

Terminals are to be provided in an accessible position. The circuit designation is to be clearly marked on each terminal connection. The terminals are to be so spaced or shielded that they cannot be accidentally earthed, short-circuited or touched.

11.5.3 Nameplate

Nameplates of corrosion-resistant material are to be provided in an accessible position of the transformer and are to indicate at least the information as listed in 6-1-7/Table 5.

11.5.4 Prevention of the Accumulation of Moisture

Transformers of 10 kVA/phase and over are to be provided with effective means to prevent accumulation of moisture and condensation within the transformer enclosure where the transformer is disconnected from the switchboard during standby (cold standby). Where it is arranged that the transformer is retained in an energized condition throughout a period of standby (hot standby), the exciting current to the primary winding may be considered as a means to meet the above purpose. In case of hot standby, a warning plate is to be posted at or near the disconnecting device for the primary side feeder to the transformer.

12 Semiconductor Converters for Adjustable Speed Motor Drives

12.1 Application

All semiconductor converters that are used to control motor drives having a rated power of 100 kW (135 hp) and over intended for essential services (see definition in 4-1-1/3.5) or for services indicated in 4-8-3/Table 7 of the *Marine Vessel Rules* are to be designed, constructed and tested in accordance with the requirements of 6-1-7/12.

Manufacturer's tests for semiconductor converters that are used to control motor drives having a rated power less than 100 kW (135 hp) for essential services (see definition in 4-1-1/3.5) or for services indicated in 4-8-3/Table 7 of the *Marine Vessel Rules* are to include at least the tests described in 6-1-7/12.7. All other semiconductor converters used to control motor drives are to be designed, constructed and tested in accordance with established industrial practices and manufacturer's specifications.

The required tests may be carried out at the manufacturer facility whose certificates of tests will be acceptable and are to be submitted upon request to ABS. All semiconductor converters will only be accepted subject to a satisfactory performance test conducted to the satisfaction of the attending Surveyor after installation.

12.3 Standards of Compliance

The design of semi-conductor converters for adjustable speed motor drives, unless otherwise contradicted by ABS Rules, shall be in compliance with the requirements of IEC Publication 61800-5-1:2007 (titled 'Adjustable speed electrical power drive systems : Safety Requirements – Electrical, thermal and energy') and 60146-1-1:2009 (titled 'Semiconductor converters – General requirements and line commutated converters – Specification of basic requirements'). For convenience, the following requirements are listed.

12.5 Design, Construction and Assembly Requirements

12.5.1 Rating

Semiconductor converters are to be rated for continuous load conditions and if required by the application, are to have specified overload capabilities.

The operation of the semiconductor converter equipment, including any associated transformers, reactors, capacitors and filter circuits, shall not cause harmonic distortion and voltage and frequency variations in excess of the values mentioned in 4-3-2/7.9 and 4-3-1/9, respectively.

The semiconductor converter circuits shall be able to withstand voltage and current transients that the system may be subject to for certain applications.

The semiconductor converters are to be suitable for environmental conditions found in marine installations such as those mentioned in 4-1-1/Table 1 and 4-1-1/Table 2.

12.5.2 Enclosures

Enclosures and assemblies are to be constructed of steel or other suitable incombustible, moisture-resistant materials and reinforced as necessary to withstand the mechanical, electro-magnetic and thermal stresses which may be encountered under both normal and fault conditions.

Enclosures are to be of the closed type. The degree of protection of the enclosure is to be in accordance with 4-3-3/Table 1. For HV converters, the enclosure is to satisfy the requirements in 4-3-5/Table 1.

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

12.5.3 Nameplate Data

A nameplate made of corrosion resistant material is to be provided on the semi-conductor assembly and is to indicate at least the following:

- i)* Manufacturer's name and identification reference/equipment serial number
- ii)* Number of input and output phases
- iii)* Rated input voltage and current
- iv)* Rated output voltage and current
- v)* Rated input and output frequency, if any
- vi)* Range of output frequency
- vii)* Maximum permissible prospective symmetrical rms short-circuit current of the power source
- viii)* Cooling methods
- ix)* Degree of protection

12.5.4 Warning Labels

Appropriate warning labels informing the user of the dangers with working with the different parts of the converter assembly is to be placed at all appropriate places of the assembly.

12.5.5 Hand Rails

Insulated handrails or insulated handles are to be provided for each front panel of the assembly. Where access to the rear is also required, insulated handrails or insulated handles are to be fitted to the rear of the assembly as well.

12.5.6 Accessibility

All components of the semiconductor converter assembly are to be mounted in such a manner that they can be removed from the assembly for repair or replacement without having to dismantle the complete unit.

12.5.7 Capacitor Discharge

Capacitors within a semiconductor converter assembly shall be discharged to a voltage less than 60 V, or to a residual charge less than 50 μC , within 5 seconds after the removal of power. If this requirement cannot be met, appropriate warning labels shall be placed on the assembly.

12.5.8 Cooling Arrangements

Design of cooling systems is to be based on an ambient air temperature of 45°C (113°F) indicated in 4-1-1/Table 2.

Semiconductor converter assemblies are to be installed away from sources of radiant energy in locations where the circulation of air is not restricted to and from the assembly and where the temperature of the inlet air to air-cooled converters will not exceed that for which the converter has been designed.

Where arrangements for forced cooling have been provided, the equipment is, unless otherwise specifically required, to be designed such that power cannot be applied to, or retained on, the semiconductor circuits, unless effective cooling is maintained. Other effective means of protection against equipment over-temperature such as reduction in the driven load may also be acceptable.

Semiconductor assemblies with forced cooling are to be provided with a means of monitoring the temperature of the cooling medium. Over-temperature of the cooling medium is to be alarmed locally and at a continuously manned location and the equipment shutdown when temperature exceeds the manufacturer specified value.

Semiconductor assemblies with liquid cooling are to be provided with a means to detect leakage. In case of leakage, an audible and visible alarm is to be initiated locally and remotely at a continuously manned location. Means to contain any leakage are to be provided so that the liquid does not cause a failure of the semiconductor assembly or any other electrical equipment located near the converter. Where the cooling liquid is required to be non-conducting, the conductivity of the cooling liquid is to be monitored and an alarm given both locally and remotely in a continuously manned location if the conductivity exceeds the manufacturer specified value.

In case of failure of the cooling system, an alarm is to be given both locally and remotely at a continuously manned location and the output current is to be reduced automatically.

Cooling liquids which are in contact with live unearthed parts of the assembly are to be non-conductive and non-flammable.

12.5.9 Emergency Stop

When required, semiconductor converter assemblies shall be provided with an emergency stop function. The emergency stop circuit is to be hard-wired and independent of any control system signal.

12.5.10 Electrical Protection

12.5.10(a) Overvoltage Protection. Means are to be provided to prevent excessive overvoltage in a supply system to which semiconductor converters are connected and to prevent the application of voltages in excess of the rating of semiconductor devices.

12.5.10(b) Overcurrent Protection. Arrangements are to be made so that the permissible current of semiconductor converters or semiconductor devices associated with the semiconductor converter cannot be exceeded during operation.

12.5.10(c) Short Circuit Protection. Semiconductor converters and the associated semiconductor devices are to be protected against short circuit.

12.5.10(d) Filter Circuits. Filter circuits are to be protected against overvoltage, overcurrent and short circuit.

12.5.10(e) Alarms. Visual and audible alarms are to be provided at the control station in the event of operation of the protection system.

12.5.11 Clearance and Creepage Distances

Clearance and creepage distances used in standard production (COTS) semiconductor converter assemblies are to be in accordance with IEC 61800-5-1 and suitable for overvoltage category III, pollution degree 3 and insulating material group IIIa. The relevant values are reproduced in the Table below for convenience.

<i>System Voltage (V)</i>	<i>Minimum Clearance Distance (mm)</i>
≤50	0.8
100	0.8
150	1.5
300	3.0
600	5.5
1000	8.0
3600	25
7200	60
12000	90
15000	120

Note: Interpolation is permitted.

<i>Working Voltage (rms) (V)</i>	<i>Minimum Creepage Distance (mm)</i>
50	1.9
100	2.2
125	2.4
160	2.5
200	3.2
250	4.0
320	5.0
400	6.3
500	8.0
630	10.0
800	12.5
1000	16
1250	20
1600	25
2000	32
2500	40
3200	50
4000	63
5000	80
6300	100
8000	125
10000	160

Note: Interpolation is permitted.

12.5.12 Protection and Monitoring Requirements

Semiconductor assemblies, as a minimum, shall have alarm functions for the following parameters:

- i) Overcurrent
- ii) Overload
- iii) Overvoltage
- iv) Ground fault
- v) Loss of cooling
- vi) Increase in resistivity of cooling medium (for liquid cooled converters)
- vii) Over-temperature
- viii) Loss of communication to process control
- ix) Loss of motor speed feedback

If harmonic filters are used in conjunction with semiconductor converter assemblies, refer to 4-3-2/9.19 for additional protection requirements.

For vessels with electric propulsion, refer to 4-9-6/Table 4A of the *Marine Vessel Rules*.

12.5.13 Load-sharing

When semiconductor converters have multiple parallel/series circuits, load sharing between the multiple circuits is to be distributed uniformly, as far as practicable.

12.5.14 EMC Emission Requirements

If requested by the customer, EM immunity and EM emissions testing of the semiconductor assembly shall be done as an optional test in accordance with IEC 61800-3 (titled 'Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods').

Note: Radiated and conducted emissions/immunity does not depend on the equipment alone but also on the interaction between the semiconductor converter assembly and the rest of the power system. There shall be communication between the manufacturer and the customer as to what installation guidelines may need to be followed to satisfy the different EM emission/immunity requirements, such as cable routing, types of interconnect cables used, cable shielding, etc.

12.5.15 Harmonic Filter Requirements

If harmonic filter circuits are used in association with semiconductor converter assemblies to reduce the harmonics and transients in the system, they are to comply with the requirements in 4-3-2/9.19.

12.5.16 Performance

The converter control system shall be able to control the motor by speed ramp, torque or power, as per customer specification.

Upon loss of the reference signal, the converter shall either decelerate the driven motor to minimum speed/torque/power or down to standstill as per customer specification for the required application.

When, during normal operation, the motor is decelerated to standstill, it shall be possible to de-energize the motor by blocking the control signals to the power semiconductors, while leaving the converter input circuit energized.

When automatic restart is specified, the converter shall be capable of catching an already spinning motor.

12.7 Inspection and Testing

Semiconductor assemblies for motor drives shall undergo Type tests, Routine tests and Optional tests, if any specifically required by the Owner, at manufacturer's production facility as per the Table below. The Type tests, Routine tests and Optional tests shall be conducted in the presence of and witnessed by an ABS Surveyor. Type tests shall be carried out on one prototype of a converter or the first of a batch of identical converters. Routine tests shall be carried out on each assembly. A summary of the required type tests and routine tests are given in the Table below:

No.	Tests (see 6-1-7/12.7)	Type Test	Routine Test	ABS Reference	IEC Test Reference
1	Visual inspection	x	x	6-1-7/12.7.1	61800-5-1/5.2.1
2	Insulation test (AC or DC voltage test)	x	x	6-1-7/12.7.2	61800-5-1/5.2.3.2
3	Insulation resistance test	x	x	6-1-7/12.7.4	60146-1-1/7.2.3.1
4	Impulse voltage test	x		6-1-7/12.7.3	61800-5-1/5.2.3.1
5	Cooling system test	x	x	6-1-7/12.7.5	61800-5-1/5.2.4.5
6	Breakdown of components test	x		6-1-7/12.7.6	61800-5-1/5.2.3.6.4
7	Light load and functional test	x	x	6-1-7/12.7.7	60146-1-1/7.3.1
8	Rated current test	x		6-1-7/12.7.8	60146-1-1/7.3.2
9	Temperature rise test	x		6-1-7/12.7.9	61800-5-1/5.2.3.8
10	Capacitor discharge test	x		6-1-7/12.7.10	61800-5-1/5.2.3.7

12.7.1 Visual Inspection

Semiconductor assemblies are subject to visual inspection for the following aspects:

- i) Verify enclosure integrity, alignment of different cabinets in the assembly as per system drawings.
- ii) Verify if nameplate is present as per 6-1-7/12.5.3.
- iii) Check if adequate and visible warning and safety labels are present.
- iv) General hardware and electrical point-to-point wire check.
- v) Verify correct routing and connections of fiber optic cables and ethernet cables.
- vi) Verify correct connection of grounding wires on the assembly.
- vii) Point-to-point inspection of cooling system, if applicable. For drive assemblies with liquid cooling, verification of proper installation of piping and hoses, correct orientation of flow restrictors and related coolant liquid monitoring instrumentation.
- viii) Door interlocks, if any

12.7.2 Insulation Test (AC or DC Voltage Test)

Semiconductor assemblies shall be subject to insulation tests to ensure adequate dielectric strength of insulation of its components and to verify that clearance distances have not been compromised during manufacturing operations. The insulation test is to be performed with the appropriate AC or DC voltage (equal to the peak value of the specified AC rms voltage) mentioned in Table 21/ Table 22/ Table 23 of IEC 61800-5-1(2007). The AC test voltage is to be voltage of sinusoidal wave form and a frequency of 50 Hz/60 Hz. The duration of the test is to be at least 5 sec for the Type Test and 1 sec for the Routine Test. All main power, control power and logic circuits have to be subject to the Insulation test.

12.7.3 Impulse Voltage Test

Semiconductor assemblies shall be subject to an Impulse voltage test to simulate the impact of impulse transient over voltages generated in the mains supply or those caused by switching of equipment. The impulse voltage test is to be done as per 5.2.3.1 of IEC 61800-5-1(2007). For purposes of selection of test voltages, the semiconductor assembly shall be treated as belonging to overvoltage category III.

Impulse voltage tests shall be done as a routine test on assemblies that do not satisfy the clearance and creepage distance requirements of 6-1-7/12.5.11.

12.7.4 Insulation Resistance Test

One minute after the insulation test, insulation resistance shall be measured by applying a direct voltage of at least 500 V.

12.7.5 Cooling System Test

Semiconductor assemblies shall be subject to cooling system tests that test for failure of the cooling system and the associated response of the semiconductor assembly to these cooling system failures as per 5.2.4.5 of IEC 61800-5-1 (2007).

In addition, for liquid cooled semiconductor assemblies, the cooling piping system shall be subject to a coolant leak pressure test. The cooling system piping shall be hydrostatically tested to 1.5 times the design pressure for a period of 30 minutes. The pressure relief mechanism shall also be checked for proper calibration and operation. The cooling system shall be verified as having no leakage by monitoring the pressure and by visual inspection.

The instrumentation critical to the operation of the cooling system such as valve positions, programming of level switch sensors, flow sensors, pressure sensors, temperature sensors, pressure relief valve operation, coolant conductivity sensor, etc., shall be checked to ensure correct calibration and functionality.

12.7.6 Breakdown of Components Test

Components which have been identified by circuit analysis could result in a thermal or electric shock hazard are to be subject to a breakdown test as per 5.2.3.6.4 of IEC 61800-5-1.

12.7.7 Light Load and Functional Test

Semiconductor assemblies shall be subject to a light load and functional test to ensure that all parts of the electrical circuit and the cooling system work properly together and that the assembly meets the required proof of performance as per customer requirements. The main things to be checked include, but are not limited to:

- i)* Verify that the control equipment, auxiliaries, protection equipment and main circuit are operating properly together.
- ii)* Check power supplies to different power and control circuits of the assembly and associated communication control interfaces.
- iii)* Check pre-charge circuit settings.
- iv)* Verify the various software parameters.
- v)* Check for voltage/current sharing in the semiconductor devices used in the arms of the converter.
- vi)* Testing of the converter for scenarios like, but not limited to, emergency trip of the assembly, input fault protection, loss of cooling, local and remote control operation, etc.
- vii)* Testing of the converter for any specific customer defined scenario like output power ramp-down on loss of input power, ability of the converter to catch a spinning motor after recovering from a trip or from automatic restart, etc.

12.7.8 Rated Current Test

The test is carried out to verify that the equipment will operate satisfactorily at rated current. The DC terminals shall be short-circuited directly or with a reactor and an alternating voltage of sufficient value, to cause at least the rated continuous direct current to flow, shall be connected to the AC terminals of the converter and operation of the assembly shall be checked.

12.7.9 Temperature Rise Test

The test is carried out to verify that parts and accessible surfaces of the semiconductor assembly do not exceed temperature limits specified below and the manufacturer's temperature limits of safety-relevant parts. The temperature rise test is to be conducted at worst-case conditions of rated power and rated output current.

<i>Materials and Components</i>	<i>Thermometer Method (°C)</i>	<i>Resistance Method (°C)</i>
Rubber/Thermoplastic-insulated conductors	55	-
User terminals	Note 1	-
Copper bus bars and connecting straps	120	-
Winding Insulation		
Class A	95	105
Class E	100	115
Class B	105	125
Class F	115	135
Class H	135	155
Class N	175	195
Phenolic composition	145	-
Bare resistor material	395	-
Capacitor	Note 2	-
Power switching semiconductors	Note 2	-
Printed wiring boards (PWB's)	Note 2	-
Liquid cooling medium	Note 2	-

Notes:

- 1 Maximum terminal temperature shall not exceed 15°C more than the insulation temperature rating of the conductor or cable specified by the manufacturer.
- 2 Maximum temperature shall be as specified by the manufacturer.

12.7.10 Capacitor Discharge Test

Verification of the capacitor discharge time as required in 6-1-7/12.7.7 is required to be done by a test and/or by calculation.

12.9 Integration Requirements

12.9.1 Integration

In cases where the semiconductor converters are integrated into larger assemblies that have other components (i.e., transformers, reactors, motors, etc.), the individual tests of the other components shall be done in accordance with relevant portions of the ABS Rules.

Installation requirements such as earthing of equipment, selection of cable and acceptable cable lengths, etc., should be as per manufacturer installation guidelines.

12.9.2 Reactors and Transformers for Semiconductor Converters

12.9.2(a) Voltage Regulation. Means to regulate transformer output voltage are to be provided to take care of increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

12.9.2(b) High Temperature Alarm. Interphase reactors and transformers used with the semiconductor converters for main and auxiliary propulsion systems are to be provided with a high temperature alarm at the switchboard or the propulsion control station. The setting value of the alarm is to be determined by their specific insulation class and is not to exceed the temperature corresponding to the limit listed in 6-1-7/Table 9.

12.9.3 Critical Speeds

The semiconductor converter supplier, the driven equipment supplier and the Owner should come to an agreement on the calculations of the resulting critical lateral speeds of the whole mechanical string with special attention being paid to the following:

- i) Take into account the influence of the stiffness of the bearing arrangement and the foundation.
- ii) Avoid any continuous running with insufficient damping close to lateral critical speeds ($\pm 20\%$).

13 Other Electric and Electronics Devices

13.1 Circuit Breakers

13.1.1 General

Circuit breakers are to be constructed and tested to comply with IEC Publication 60947-2 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. Circuit breakers of the thermal type are to be calibrated for an ambient-air temperature as provided in 4-3-1/17.

Note: Where thermal-type breakers are mounted within enclosures, it is pointed out that the temperature within the enclosure may exceed the designated ambient-air temperature.

13.1.2 Mechanical Property

Arc-rupturing and main contacts of all open frame circuit breakers are to be self-cleaning.

13.1.3 Isolation

The electrical system is to be arranged so that portions may be isolated to remove circuit breakers while maintaining services necessary for propulsion and safety of the unit, or circuit breakers are to be mounted or arranged in such a manner that the breaker may be removed from the front without disconnecting the copper or cable connections or without de-energizing the supply to the breaker.

13.3 Fuses

Fuses are to be constructed and tested to comply with IEC Publication 60269 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. All components of the fuse are to be resistant to heat, mechanical stresses and corrosive influences which may occur in normal use.

13.5 Semiconductor Converters

13.5.1 General

The requirements in this subsection are applicable to static converters for essential and emergency services using semiconductor rectifying elements such as diodes, reverse blocking triodes, thyristors, etc. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS. All semiconductor converters will be accepted subject to a satisfactory performance test conducted after installation to the satisfaction of the Surveyor.

13.5.2 Cooling Arrangements

Semiconductor converters are preferably to be of a dry and air cooled type. Where semiconductor converters are of a liquid-immersed type, a liquid over-temperature alarm and gas overpressure protection devices are to be provided. If provision is made for breathing, a dehydrator is to be provided. Where arrangement for the forced cooling is provided, the circuit is to be designed that power cannot be applied to, or retained, on converter stacks unless effective cooling is maintained.

13.5.3 Accessibility

Semiconductor converter stacks or semiconductor components are to be mounted in such a manner that they can be removed from equipment without dismantling the complete unit.

13.5.4 Nameplate

A nameplate or identification is to be provided on the semiconductor converter and is to indicate at least the information as listed in 6-1-7/Table 5.

13.7 Cable Junction Boxes

13.7.1 General

The design and construction of the junction boxes are to be in compliance with 6-1-7/13.7.2 or other recognized standard. The tests may be carried out by the manufacturer whose certificate of tests will be acceptable and is to be submitted upon request from ABS.

13.7.2 Design and Construction

Live parts are to be mounted on durable flame-retardant, moisture-resistant material of permanently high dielectric strength and high resistance. The live parts are to be so arranged by suitable spacing or shielding with flame-retardant insulating material that short-circuit cannot readily occur between conductors of different polarity or between conductors and earthed metal. Junction boxes are to be made of flame-retardant material and are to be clearly identified, defining their function and voltage.

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

15.3.1 Rotating Machines

15.3.1(a) Protection. Refer to 4-3-5/Table 1 for ingress protection (IP) requirements.

15.3.1(b) Windings. Generator stator windings are to have all phase ends brought out for the installation of the differential protection.

15.3.1(c) Temperature Detectors. Rotating machines are to be provided with temperature detectors in their stator windings to actuate a visual and audible alarm in a normally attended position whenever the temperature exceeds the permissible limit. If embedded temperature detectors are used, means are to be provided to protect the circuit against over-voltage.

15.3.1(d) Space Heater. Effective means are to be provided to prevent the accumulation of moisture and condensation within the machines when they are idle.

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, an adequate number of earthing and short circuiting facilities is 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 could flow if arc protection techniques are adopted
 - The distance, from the location of the arc flash, at which the arc flash energy would be 1.2 calories per cm² 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.

15.3.3 Transformers

15.3.3(a) *Application.* Provisions of 6-1-7/15.3.3 are applicable to power transformers for essential services. See also 6-1-7/11. Items 6-1-7/15.3.3(c) and 6-1-7/15.3.3(d) are applicable to transformers of the dry type only. These requirements are not applicable to transformers intended for the following services:

- Instrument transformers.
- Transformers for static converters.
- Starting transformers.

Dry type transformers are to comply with the applicable Parts of the IEC Publication 60076-11. Liquid filled transformers are to comply with the applicable Parts of the IEC 60076 Series. Oil immersed transformers are to be provided with the following alarms and protections:

- Liquid level (Low) – alarm
- Liquid temperature (High) – alarm
- Liquid level (Low) – trip or load reduction
- Liquid temperature (High) – trip or load reduction
- Gas pressure relay (High) – trip

15.3.3(b) *Plans.* In addition to the details required in 6-1-7/11, the applicable standard of construction and the rated withstanding voltage of the insulation are also to be submitted for review.

15.3.3(c) *Enclosure.* Transformers are to have a degree of protection of at least IP23. However, when installed in spaces accessible to unqualified personnel, the degree of protection is to be increased to IP4X, where “X” is dependent on the liquid condition in the location in which the equipment is to be installed (see 4-3-1/Table 3). For transformers not contained in enclosures, the degree of protection is to be in accordance with 4-3-3/Table 1.

15.3.3(d) *Space Heater.* Effective means to prevent accumulation of moisture and condensation within the transformers (when de-energized) is to be provided.

17 Electric Propulsion System

17.1 General

17.1.1 Temperature Rating

When generators, motors or slip-couplings for electric propulsion are fitted with an integral fan and will be operated at speeds below the rated speed with full-load torque, full-load current, or full-load excitation, temperature rise limits according to 6-1-7/Table 4 are not to be exceeded.

17.1.2 Protection Against Moisture Condensation

6-1-7/5.11.7 is applicable for rotating machines and converters, regardless of the weight of the machines.

17.1.3 Accessibility

For purposes of inspection and repair, provision is to be made for access to the stator and rotor coils, and for the withdrawal and replacement of field coils. Adequate access is to be provided to permit resurfacing of commutators and slip-rings, as well as the renewal and bedding of brushes.

17.3 Machinery and Equipment

17.3.1 Rotating Machines for Propulsion

The following requirements are applicable to propulsion generators and propulsion motors.

17.3.1(a) Ventilation and Protection. Electric rotating machines for propulsion are to be enclosed ventilated or be provided with substantial wire or mesh screen to prevent personnel injury or entrance of foreign matter. Dampers are to be provided in ventilating air ducts, except when recirculating systems are used.

17.3.1(b) Fire-extinguishing Systems. Electric rotating machines for propulsion which are enclosed or in which the air gap is not directly exposed are to be fitted with fire-extinguishing systems suitable for fires in electrical equipment. This will not be required where it can be established that the machinery insulation is self-extinguishing.

17.3.1(c) Air Coolers. Air cooling systems for propulsion generators are to be in accordance with 4-6-5/7.7.1 and 4-6-5/7.5 of the *Marine Vessel Rules*. Water-air heat exchangers of rotating propulsion machines for single systems (single generator and single motor), as specified in 4-3-5/3.5.1(b), are to have double wall tubes and be fitted with a leak detector feature to monitor for any water leakage. A visual and audible alarm is to be provided at a normally manned location to indicate such water leakage.

17.3.1(d) Temperature Sensors. Stator windings of AC machines and interpole windings of DC machines, rated above 500 kW, are to be provided with temperature sensors.

17.3.1(e) Generator Excitation. Excitation current for propulsion generators may be derived from attached rotating exciters, static exciters, excitation motor-generator sets or special purpose generating units. Power for these exciters may be derived from the machine being excited or from any unit main service, emergency or special purpose generating units.

17.3.1(f) Propulsion Motors. Propulsion motors are to be designed to be capable of withstanding the mechanical and thermal effects of a short-circuit at its terminals.

17.3.2 Direct-current (DC) Propulsion Motors

17.3.2(a) Rotors. The rotors of DC propulsion motors are to be capable of withstanding overspeeding up to the limit reached in accordance with the characteristics of the overspeed protection device at its normal operational setting.

17.3.2(b) Overspeed Protection. An overspeed protection device is to be provided to prevent excessive overspeeding of the propulsion motors due to light loads, loss of propeller, etc.

17.3.3 Electric Couplings

17.3.3(a) General. Couplings are to be enclosed ventilated or be provided with wire or mesh screen to prevent personnel injury or the entrance of foreign material. All windings are to be specially treated to resist moisture, oil and salt air.

17.3.3(b) Accessibility for Repairs. The coupling is to be designed to permit removal as a unit without moving the engine. See also 6-1-7/17.1.3.

17.3.3(c) Temperature Rating. The limits of temperature rise are to be the same as for alternating-current generators given in 6-1-7/Table 4, except that when a squirrel-cage element is used, the temperature of this element may reach such values as are not injurious. Depending upon the cooling arrangements, the maximum temperature rise may occur at other than full-load rating so that heat runs will require special consideration. For this purpose, when an integral fan is fitted, the coupling temperatures are not to exceed the limits in 6-1-7/Table 4 when operated continuously at 70% of full-load rpm, full excitation and rated torque. Temperature rises for insulation materials above 180°C (356°F) will be considered in accordance with 6-1-7/1.1.6.

17.3.3(d) Excitation. Excitation is to be provided as required for propulsion generators. See 6-1-7/5.17.1, 6-1-7/5.19.1 and 6-1-7/17.3.1(e).

17.3.3(e) Control Equipment. Electric-coupling control equipment is to be combined with the prime mover speed and reversing control and is to include a two-pole disconnect switch, short-circuit protection only, ammeter for reading coupling current, discharge resistor and interlocking to prevent energizing the coupling when the prime mover control levers are in an inappropriate position.

17.3.3(f) Nameplates. Nameplates of corrosion-resistant material are to be provided in an accessible position of the electric coupling and are to contain the following typical details:

- Manufacturer's name, serial number and frame designation
- Rated output and type of rating
- Ambient temperature range
- Rated voltage, speed and temperature rise
- Rated exciter voltage and current

17.3.4 Semiconductor Converters for Propulsion

Semiconductor converters are to comply with the requirements in 6-1-7/12.

17.3.5 Reactors and Transformers for Semiconductor Converters

17.3.5(a) General. Interphase reactors and transformers used with semiconductor converters are to conform with the requirements of 6-1-7/11.1.1, 6-1-7/11.1.2(c), 6-1-7/11.3, 6-1-7/11.5.1 and 6-1-7/11.5.2, and the following.

17.3.5(b) Voltage Regulation. Means to regulate transformer output voltage are to be provided to take care of the increase in converter forward resistance and, in addition, to obtain the necessary performance characteristics of the converter unit in which the transformer is used.

17.3.5(c) High Temperature Alarm. See 6-1-7/12.9.2(b).

17.3.6 Propulsion Cables

17.3.6(a) Conductors. The conductors of cables external to the components of the propulsion plant, other than cables and interconnecting wiring for computers, data loggers or other automation equipment requiring currents of very small value, are to consist of not less than seven strands and have a cross-sectional area of not less than 1.5 mm² (2,960 circ. mils).

17.3.6(b) Insulation Materials. Ethylene-propylene rubber, cross-linked polyethylene, or silicone rubber insulated cables are to be used for propulsion power cables, except that polyvinyl chloride insulated cables may be used where the normal ambient temperature will not exceed 50°C (122°F).

17.3.6(c) *Braided Metallic Armor and Impervious Metallic Sheaths.* Propulsion cables need not have braided metallic armor nor impervious metallic sheaths. Where metallic sheaths are provided, they are not to be used with single alternating current cables.

17.3.6(d) *Inner Wiring.* The insulation of internal wiring in main control gear, including switchboard wiring, shall be of flame-retardant quality.

19 Survey and Certification

Where required, type-testing and unit certification is to be carried out, in presence of and to the satisfaction of the Surveyor, at manufacturer's plant and reported upon before installation onboard. The extent of services required for each electrical cable, equipment, and machinery are indicated in 6-1-7/Table 1. Where a product does not require unit certification, Surveyor attendance is optional, and the product is to be designed and fabricated to satisfy a recognized industrial standard and the manufacturer's specification.

For the purpose of 6-1-7/19, the reference to essential services means essential services as defined in 4-1-1/3.5 and services related to additional optional notations requested for the unit.

Following paragraphs define the requirements for survey and certification of products manufactured in presence of a Surveyor.

19.1 Generators and Motors ≥ 100 kW (135 hp) intended for Essential Services

Factory testing schedule required for generators and motors of 100 kW (135 hp) and over intended for essential services are indicated with an "X" mark in 6-1-7/Table 2. Requirements for compliance are further referenced in 6-1-7/5.1 through 6-1-7/5.19, 6-1-7/Table 3 and 6-1-7/Table 4.

Construction and assembly of rotating machines are to be verified in compliance with 6-1-7/5.11 and their nameplates are to indicate at least the information as listed in 6-1-7/Table 5.

All generators and motors ≥ 100 kW (135 hp) intended for essential services are to be examined and tested in presence of and to the satisfaction of the Surveyor. Examination and testing of other generators and motors 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 unit at shipyard.

19.3 Propulsion Generators and Motors

Requirements for survey and certification of propulsion generators and motors, regardless of their power, are same as generators and motors ≥ 100 kW (135 hp) intended for essential services, as indicated in 6-1-7/19.1.

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/Table 6. Requirements for compliance are further referenced in 6-1-7/9.1 through 6-1-7/9.13, 6-1-7/Table 7, and 6-1-7/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 unit at shipyard.

19.7 Motor Controllers and Control Centers intended for Essential Services ≥ 100 kW (135 hp)

Factory testing schedule required for motor controllers and control centers intended for essential services ≥ 100 kW (135 hp) are indicated with an "X" mark in 6-1-7/Table 6. Requirements for compliance are further referenced in 6-1-7/9.1 through 6-1-7/9.11, 6-1-7/9.15, and 6-1-7/Table 7.

Construction, enclosures and assembly of motor controllers and control centers are to be verified in compliance with 6-1-7/9.15.

All motor control centers with aggregate loads ≥ 100 kW intended for essential services are to be examined and tested in the presence of and to the satisfaction of the Surveyor. Examination and testing of other motor control centers 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 unit at shipyard.

19.9 Battery Charging Units ≥ 25 kW, UPS units ≥ 50 kVA, and Associated Distribution Boards, for Essential, Emergency or Transitional Source of Power

Factory testing schedule required for battery charging units ≥ 25 kW, UPS units ≥ 50 kVA, and associated distribution boards, for essential, emergency or transitional source of power are indicated with an "X" mark in 6-1-7/Table 6. Requirements for compliance are further referenced in 6-1-7/9.1 through 6-1-7/9.11, 6-1-7/9.17.

Construction, enclosures and assembly of motor controllers and control centers are to be verified in compliance with 6-1-7/9.15 and their nameplates are to indicate at least the information as listed in 6-1-7/Table 5.

Appropriate testing is to be carried out to demonstrate that the battery charger units and uninterruptible power system (UPS) units are suitable for the intended environment. This is expected to include as a minimum the following tests:

- i) Functionality, including operation of alarms;
- ii) Temperature rise;
- iii) Ventilation rate; and
- iv) Battery capacity.

Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.

All battery charging units ≥ 25 kW, UPS units ≥ 50 kVA, and associated distribution boards, for essential, emergency or transitional source of power are to be tested in presence of and to the satisfaction of the Surveyor. Testing of all other battery charging units, UPS units, and associated distribution 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 unit at shipyard.

19.11 Power Transformers ≥ 100 kVA and Converters for High Voltage Systems over 1 kV, for Essential or Emergency Source of Power

Factory testing schedule required for power transformers ≥ 100 kVA and converters for high voltage systems over 1 kV, for essential or emergency source of power are indicated with an "X" mark in 6-1-7/Table 6. Requirements for compliance are further referenced in 6-1-7/9.3 through 6-1-7/9.11, 6-1-7/11.

Construction and assembly of power transformers ≥ 100 kVA and converters for high voltage systems over 1 kV are to be verified in compliance with 6-1-7/11.5 and their nameplates are to indicate at least the information as listed in 6-1-7/Table 5.

All power transformers ≥ 100 kVA and converters for high voltage systems over 1 kV, for essential or emergency source of power are to be tested in presence of and to the satisfaction of the Surveyor. Testing of all other transformers and converters 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 unit at shipyard.

For single-phase transformers rated 1 kVA and above or three-phase transformers rated 5 kVA and above intended for essential or emergency services, the following tests are to be carried out by the transformer's manufacturer in accordance with a recognized standard:

- i) Measurement of winding resistance, voltage ratio, impedance voltage, short circuit impedance, insulation resistance, load loss, no load loss and excitation current, phase relation and polarity;
- ii) Dielectric strength; and
- iii) Temperature rise (required for one transformer of each size and type). See 6-1-7/11.3.

19.13 Semiconductor Converters for Propulsion (only for Self-Propelled Units)

Semiconductor converters for propulsion systems are to be tested to the type test requirements of the relevant standard.

If the standard is the IEC 60146 Series, then type tests are to include the following:

- i) Insulation test;
- ii) Light load and function test;
- iii) Rated current test;
- iv) Power loss;
- v) Temperature rise test; and
- vi) Checking the auxiliary devices, properties of the control equipment and protective devices.

Duplicate units of previously tested semiconductor converters are to be tested to the routine test requirements of the relevant standard.

If the standard is the IEC 60146 Series, then the routine tests are to include the following:

- i) Insulation test;
- ii) Light load and function test; and
- iii) Checking the auxiliary devices, properties of the control equipment and protective devices.

19.15 Propulsion Cables other than Internal Wiring in Control Gears and Switchboards (only for Self-Propelled Units)

All propulsion cables other than internal wiring in control gears and switchboards are to be subjected to dielectric and insulation tests.

19.17 Controls for Electric Propulsion Equipment (only for Self-Propelled Units)

Controls for electric propulsion equipment are to be inspected when finished and dielectric strength tests and insulation resistance measurements made on the various circuits in the presence of the Surveyor, preferably at the plant of manufacture. The satisfactory tripping and operation of all relays, contactors and the various safety devices are also to be demonstrated.

19.19 High Voltage (HV) Systems – Rotating Machinery

Each design of HV generator and motor is to be assessed by testing in accordance with the “type tests” schedule indicated in 6-1-7/Table 2. Each subsequent production unit of an accepted design is to be tested in accordance with the “routine tests” schedule also indicated in 6-1-7/Table 2.

19.19.1 Inter-turn Insulation Test

In addition to the tests normally required for rotating machinery, a high frequency, high voltage test, in accordance with IEC Publication 60034-15, is to be carried out on the individual coils in order to demonstrate a satisfactory withstand level of the inter-turn insulation to steep fronted switching surges.

19.19.2 Insulation Resistance

Immediately after the high voltage test the insulation resistance is to be measured using a direct current insulation test meter between:

- i) All current carrying parts connected together and earth
- ii) All current carrying parts of different polarity or phase where both the ends of each polarity or phase are individually accessible.

The minimum values of test voltage and corresponding insulation resistance are given in the table below. The insulation resistance is to be measured close to the operating temperature. If this is not possible then an approved method of calculation is to be used.

<i>Rated Voltage U_n (V)</i>	<i>Minimum Test Voltage (V)</i>	<i>Minimum Insulation Resistance (MΩ)</i>
1000 < U _n ≤ 7200	1000	U _n /1000 + 1
7200 < U _n ≤ 15000	5000	U _n /1000 + 1

19.21 High Voltage (HV) Systems – Switchgear and Control-Gear Assemblies

A power frequency voltage test is to be carried out on high voltage switchgear and control-gear assemblies with test voltages shown in Table below. The test procedure is to be in accordance with IEC Publication 62271-200.

<i>Rated Voltage (kV)</i>	<i>Rated Power Frequency Withstand Voltage (kV)</i>
3.6	10
7.2	20
12	28
15	38

Where intermediate values of switchgear rated voltages are used, the next higher power frequency withstand test voltage is to be used.

19.23 High Voltage (HV) Systems – Transformers

Three-phase transformers or three-phase bank transformers of 100 kVA and above are to be tested in accordance with the standard applicable to the transformer. Specific requirements are applicable for the following tests:

- i) In the dielectric strength test, the short duration power frequency withstand voltage to be applied is to follow the standard applicable to the transformer but not less than the estimated voltage transient generated within the system. If the short duration power frequency withstand voltage is not specified in the applicable standard, IEC 60076-3 is to be referred to. For the voltage transient, see 4-3-5/1.7.2(c).
- ii) The induced over-voltage withstand test (layer test) is also to be carried out in accordance with the standard applicable to the transformers in the presence of the Surveyor. This test is intended to verify the power-frequency withstand strength along the winding under test and between its phase (strength between turns and between layers in the windings). If the induced over-voltage withstand test is not specified in the applicable standard, IEC 60076-3 is to be referred to.

In addition to the requirements in 6-1-7/Table 5, the following information is also to be indicated on the nameplate:

- Applicable standard; and
- Short duration power frequency withstand voltage for verification of insulation level of each winding.

Testing of all other transformers 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 unit at shipyard.

TABLE 1
Certification Details – Electrical Systems and Control Equipment

<i>Electrical Systems and Control Equipment</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Generators and motors \geq 100 kW (135 hp) intended for essential services	4/5	6-1-7/5, 6-1-7/19.1 (See Note 1)
Generators and motors $<$ 100 kW (135 hp) intended for essential services	1	6-1-7/5.1.1 (See Note 1)
Other Generators and motors intended for non-essential services	1	6-1-7/19, 6-1-7/19.1
Propulsion generators and motors	5	6-1-7/17, 6-1-7/19.3
Switchboards (propulsion, main and emergency)	5	6-1-7/19.5
Other Electrical Boards	2	6-1-7/19.5
Motor controllers \geq 100 kW (135 hp) intended for essential services	4/5	6-1-7/19.7
Motor control centers with aggregate load \geq 100 kW (135 hp) intended for essential services	5	6-1-7/9.15
Battery charging units \geq 25 kW, UPS units \geq 50 kVA and associated distribution boards, for essential, emergency or transitional source of power	4/5	6-1-7/19.9
Other battery charging units, UPS units, and associated distribution boards	1	6-1-7/19.9
Power transformers \geq 100 kVA and converters for high voltage systems exceeding 1 kV, for essential or emergency source of power	5	6-1-7/19.11
Power transformers $<$ 100 kVA and converters for low voltage systems of 1 kV and below, for essential or emergency source of power	2	6-1-7/19.11
Semiconductor converters that are used to control motor drives having a rated power of 100 kW (135 hp) and over intended for essential services	4/5	6-1-7/12.7
Semiconductor converters for propulsion (only for self-propelled units)	2	6-1-7/19.13
Cables	1	6-1-7/19.15
Propulsion cables other than internal wiring in control gears and switchboards (only for self-propelled units)	5	6-1-7/19.17
Circuit breakers and fuses	1	6-1-7/13.1, 6-1-7/13.3
Certified equipment (for installation in hazardous areas)	2	4-3-3/9
Controls, monitoring and safety system devices, including computers, programmable logic controllers, etc., intended for automation systems	2	4-3-4/5
Complete assembly or subassembly units intended for automation systems	2	4-3-4/5
Controls for electric propulsion equipment	5	6-1-7/19.17
HV rotating machinery	4/5	6-1-7/19.19
HV switchgear and control-gear assemblies	4/5	6-1-7/19.21
HV three-phase transformers or three-phase bank transformers \geq 100 kVA	5	6-1-7/19.23ii)
All non-essential services HV transformers	1	6-1-7/19.23

Note:

- 1 For jacking gear motors, refer to 6-1-9/Table 2, "Certification Details – Jacking and Associated Systems".

TABLE 2
Factory Testing Schedule for Generators and
Motors ≥ 100 kW (135 hp) [See 6-1-7/19.1 and 6-1-7/19.3]

Tests	AC Generators		AC Motors		DC Machines	
	Type Test ⁽¹⁾	Routine Test ⁽²⁾	Type Test ⁽¹⁾	Routine Test ⁽²⁾	Type Test ⁽¹⁾	Routine Test ⁽²⁾
1. Visual inspection	X	X	X	X	X	X
2. Insulation resistance measurement	X	X	X	X	X	X
3. Winding resistance measurement.	X	X	X	X	X	X
4. Verification of voltage regulation system.	X	X ⁽³⁾	–	–	–	–
5. Rated load test and temperature rise measurement.	X	–	X	–	X	–
6. Overload/over-current test.	X	X ⁽⁴⁾	X	X ⁽⁴⁾	X	X ⁽⁴⁾
7. Verification of steady short circuit condition. ⁽⁵⁾	X	–	–	–	–	–
8. Over-speed test.	X	X	X ⁽⁶⁾	X ⁽⁶⁾	X ⁽⁶⁾	X ⁽⁶⁾
9. Dielectric strength test.	X	X	X	X	X	X
10. Running balance test. ⁽⁷⁾	X	X	X	X	X	X
11. Verification of degree of protection.	X	–	X	–	X	–
12. Bearing check after test.	X	X	X	X	X	X
13. Air gap measurement.	X	X	–	–	X	X
14. Commutation check.	–	–	–	–	X	–

Notes:

- 1 Type tests apply to prototype machines or to at least the first of a batch of machines.
- 2 Machines to be routine tested are to have reference to the machine of the same type that has passed a type test. Reports of routine tested machines are to contain manufacturers' serial numbers of the type tested machines and the test results.
- 3 Only functional test of voltage regulator system.
- 4 Applicable only to generators and motors ≥ 100 kW (135 hp) for essential services.
- 5 Verification at steady short circuit condition applies to synchronous generators only.
- 6 Where so specified and agreed upon between purchaser and manufacturer. Not required for squirrel cage motors.
- 7 Static balance (machine rated 500 rpm or less) or dynamic balance (over 500 rpm) will be accepted in lieu of the specified test on machines to be close-coupled to engines and supplied without shaft and/or bearings, or with incomplete set of bearings.

TABLE 3
Dielectric Strength Test for Rotating Machines [See 6-1-7/5.7]

Item	Machine or Part	Test Voltage (AC rms)
1	Insulated windings of rotated machines having rated output less than 1 kVA, and of rated voltage less than 100 V with the exception of those in items 4 to 8.	500 V + twice the rated voltage.
2	Insulated windings of rotating machines having rated output less than 10,000 kVA with the exception of those in items 1 and 4 to 8 (See Note 2).	1,000 V + twice the rated voltage with minimum of 1,500 V (See Note 1).
3	Insulated windings of rotating machines having rated output 10,000 kVA or more, and of rated voltage (see Note 1) up to 24,000 V with the exception of those in items 4 to 8 (see Note 2).	1,000 V + twice the rated voltage.
4	Separately-excited field windings of DC machines.	1,000 V + twice the maximum rated circuit voltage with minimum of 1,500 V (See Note 1).
5	Field windings of synchronous generators and synchronous motors.	
	a) Field windings of synchronous generators	Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V.
	b) When the machine is intended to be started with the field winding short-circuited or connected across a resistance of value less than ten times the resistance of winding.	Ten times the rated excitation voltage with a minimum of 1,500 V and a maximum of 3,500 V.
	c) When the machine will be started either with: – the field winding connected across resistance or more than ten times the field winding resistance, or – the field windings on open circuit or without a field dividing switch.	1,000 V + twice the maximum value of the voltage with a minimum of 1,500 V – between the terminals of the field winding, or – between the terminals of any section for a sectionalized field winding, which will be occurred under the specified starting conditions (see Note 3).
6	Secondary (usually rotor) windings of induction motors or synchronous induction motors if not permanently short-circuited (e.g., if intended for rheostatic starting)	
	a) For non-reversing motors or motors reversible from standstill only.	1,000 V + twice the open-circuit standstill voltage as measured between slip-rings or secondary terminals with rated voltage applied to the primary windings.
	b) For motors to be reversed or braked by reversing the primary supply while the motor is running.	1,000 V + four times the open-circuit standstill secondary voltage as defined in item 6.a. above.
7	Exciters (except as listed below) <i>Exception 1</i> —Exciters of synchronous motors (including synchronous induction motors) if connected to earth or disconnected from the field winding during starting <i>Exception 2</i> —Separately excited field windings of exciters (see Item 4 above).	As for windings to which they are connected. 1,000 V + twice the rated exciter voltage with a minimum of 1,500 V.
8	Assembled group of machines and apparatus.	A repetition of the tests in items 1 to 7 above is to be avoided if possible. But, if a test on an assembled group of several pieces of new apparatus, each one is made, the test voltage to be applied to such assembled group is to be 80% of the lowest test voltage appropriate for any part of the group (see Note 4).

Notes:

- 1 For two-phase windings having one terminal in common, the rated voltage for the purpose of calculating the test voltage is to be taken as 1.4 times the voltage of each separate phase.
- 2 High-voltage tests on machines having graded insulation is to be subject to special consideration.
- 3 The voltage, which is occurred between the terminals of field windings or sections thereof under the specified starting conditions, may be measured at any convenient reduced supply voltage. The voltage so measured is to be increased in the ratio of the specified starting supply voltage to the test supply voltage.
- 4 For windings of one or more machines connected together electrically, the voltage to be considered is the maximum voltage that occurs in relation to earth.

TABLE 4
Limits of Temperature Rise for Air-Cooled Rotating Machines
[See 6-1-7/5.9.1]

Ambient Temperature = 45°C

Item No.	Part of Machine	Temperature Measuring Method	Limit of Temperature Rise, °C for Class of Insulation				
			A	E	B	F	H
1	a) AC windings of machines having rated output of 5,000 kW (or kVA) or more	Resistance	55	—	75	95	120
		Embedded temp. detector	60	—	80	100	125
	b) AC windings of machines having rated output above 200 kW (or kVA) but less than 5,000 kW (or kVA)	Resistance	55	70	75	100	120
		Embedded temp. detector.	60	—	85	105	125
	c) AC windings of machines having rated outputs of 200 kW (or kVA) or less ⁽¹⁾	Resistance	55	70	75	100	120
		Thermometer	45	60	65	80	100
2	Windings of armatures having commutators	Resistance	55	70	75	100	120
		Thermometer	45	60	65	80	100
3	Field windings of AC and DC machines having DC excitation, other than those in item 4	Resistance	55	70	75	100	120
		Thermometer	45	60	65	80	100
4	a) Field winding of synchronous machines with cylindrical rotors having DC excitation winding embedded in slots, except synchronous induction motors	Resistance	—	—	85	105	130
		Thermometer	45	60	65	80	100
	b) Stationary field windings of AC machines having more than one layer	Resistance	55	70	75	100	120
		Embedded temp. detector.	—	—	85	105	130
		Thermometer	55	70	75	95	120
	c) Low resistance field winding of AC and DC machines and compensating windings of DC machines having more than one layer	Resistance	55	70	75	95	120
		Thermometer	60	75	85	105	130
	d) Single-layer windings of AC and DC machines with exposed bare or varnished metal surfaces and single layer compensating windings of DC machines ⁽²⁾	Resistance	60	75	85	105	130
		Thermometer	60	75	85	105	130
	5	Permanently short-circuited windings					
6	Magnetic cores and all structural components, whether or not in direct contact with insulation (excluding bearings)	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it.					
7	Commutators, slip-rings and their brushes and brushing	The temperature rise of any parts is not to be detrimental to the insulating of that part or to any other part adjacent to it. Additionally, the temperature is not to exceed that at which the combination of brush grade and commutator/slip-ring materials can handle the current over the entire operating range.					

Notes:

- 1 With application of the superposition test method to windings of machines rated 200 kW (or kVA) or less with insulation classes A, E, B or F, the limits of temperature rise given for the resistance method may be increased by 5°C.
- 2 Also includes multiple layer windings provided that the under layers are each in contact with the circulating coolant.

TABLE 5
Nameplates

<p>a. Rotating Machines [See 6-1-7/5.11.9]</p> <p>The manufacturer's name The manufacturer's serial number (or identification mark) The year of manufacture Type of Machine (Generator or motor, etc.) Degree of protection enclosures (by IP code) Class of rating or duty type The rated output The rated voltage The rated current and type of current (AC or DC) The rated speed (r.p.m.) or speed range The class of insulation or permissible temperature rise The ambient temperature</p> <p>Number of phase (for AC machines) The rated frequency (for AC machines) Power factor (for AC machines) Type of winding (for DC machines)</p> <p>Exciter voltage (for synchronous machines or DC machines with separate excitation) Exciter current at rating (for synchronous machines or DC machines with separate excitation) Open-circuit voltage between slip-rings and the slip-ring current for rated conditions (for wounded-rotor induction machines)</p>	<p>b. Accumulator Battery [See 6-1-7/7.3.3]</p> <p>The manufacturer's name The type designation The rated voltage The ampere-hour rating at a specific rate of discharge The specific gravity of the electrolyte (in the case of a lead-acid battery, the specific gravity when the battery is fully charged).</p> <p>c. Transformer [See 6-1-7/11.5.3]</p> <p>The manufacturer's name The manufacturer's serial number (or identification mark) The year of manufacture The number of phases The rated power The rated frequency The rated voltage in primary and secondary sides The rated current in primary and secondary sides The class of insulation or permissible temperature rise The ambient temperature</p> <p>d. Semiconductor Converter [See 6-1-7/13.5.4]</p> <p>The manufacturer's name The identification number of the equipment</p>
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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, etc.
- 4 Inspection of the assembly, including inspection of wiring and, if necessary, electrical operation test.

Standard Test Voltage for Dielectric Strength Test

<i>Rated Insulation Voltage</i>	<i>Dielectric Test Voltage AC rms</i>
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]

<i>Rated insulation voltage (V)</i>	<i>Minimum clearances mm (in.)</i>	<i>Minimum creepage distances mm (in.)</i>
Up to 250	15 (¹⁹ / ₃₂)	20 (²⁵ / ₃₂)
From 251 to 690	20 (²⁵ / ₃₂)	25 (1)
Above 690 ⁽²⁾	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 and exposed conductive parts, including earthing.
- 2 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]

<i>Instrumentation and Equipment</i>		<i>Alternating-current (AC) Switchboard</i>	<i>Direct-current (DC) Switchboard</i>
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.
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.

TABLE 9
Temperature Rise for Transformers* [See 6-1-7/11.3]

<i>Insulation Class</i>	<i>Average Winding-Temperature Rise Limits at Rated Current, °C (°F)</i>
A (105)	55 (99)
E (120)	70 (126)
B (130)	75 (135)
F (155)	95 (171)
H (180)	120 (216)
200	130 (234)
220	145 (261)

* Note: Temperature rises are based on an ambient temperature of 45°C (113°F). See 6-1-7/11.3.

PART

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CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 8 Fire and Safety – Equipment and Systems

1 General

Safety equipment and systems for which certification is required as indicated in 6-1-8/Table 1 are to be designed, constructed, tested, certified and installed in accordance with this Chapter.

3 Fire Doors

Fire doors are to be type tested in compliance with the *International Code for Application of Fire Test Procedures (Resolution MSC.61(67)) (FTP Code)*. In general, watertight, weathertight or gas-tight doors are not acceptable for use as a fire door, except when specially permitted. See 5-1-1/3.17.

The manufacturer is to certify that the door complies with a standard to which the door is designed, fabricated and tested, and to report the results of tests conducted for compliance with the FTP Code for the fire rating required.

All fire doors are to bear a permanent marking to indicate manufacturer's name, door model number and the fire rating it is approved for.

5 Fire-Rated Windows

Fire-rated windows, for use in 'B' and 'A' class boundaries are to be tested in compliance with the *FTP Code*. All fire rated windows are to be shatter resistant.

The manufacturer is to certify that the window complies with a standard to which the window is designed, fabricated and tested, and to report the results of tests conducted for compliance with the FTP Code for the fire rating required.

All fire-rated windows are to bear a permanent marking to indicate manufacturer's name/symbol, window model number and the fire rating it is approved for.

7 Gas-Tight Doors

Gas-tight doors are not required to be certified by ABS at manufacturer's facility. These doors will be accepted by the Surveyor after satisfactory installation and testing onboard the vessel. In general, watertight, weathertight or fire doors are not acceptable for use as a gas-tight door, except when specially considered.

Design review for manufacturing and testing of a gas-tight door is not required.

9 Fire and Gas Detection Systems

In general, the system components and associated visual and audible alarms are not required to be certified individually. However, the main and auxiliary alarm and control panels of the detection system are required to be certified in accordance with 6-1-8/Table 1.

Main and auxiliary alarm and control panels of the fire and gas detection systems are to be design-approved by ABS.

The manufacturer is to certify that the system components and individual alarms complies with a recognized standard to which the system is designed, fabricated and tested, and to report the results of tests so conducted.

All main and auxiliary control panels are to bear a permanent marking to indicate manufacturer’s name, and the model number of the panel.

11 Fire Pumps

Main and emergency fire pumps as well as other pumps used for fixed fire-extinguishing systems are to be certified in accordance with the 6-1-8/Table 1 and the following. For further details, refer to 6-1-6/7.3.2 of these Rules.

Design review for manufacturing and fire extinguishing pumps is not required.

The manufacturer is to certify that the fire pump complies with a recognized standard to which the pump is designed, fabricated and tested, and to report the results of tests so conducted.

All pumps used for fire extinguishing are to be bear a permanent marking to indicate manufacturer’s name, the model number of the pump, and its capacity.

13 Survey and Certification

Where required, type-testing and unit certification is to be carried out, in presence of and to the satisfaction of the Surveyor, at manufacturer’s plant and reported upon before installation onboard. 6-1-8/Table 1 shows the extent of services required for each fire and safety equipment. Where a product does not require unit certification, Surveyor attendance is optional, and the product is to be designed and fabricated to satisfy a recognized industrial standard and the manufacturer’s specification.

TABLE 1
Certification Details – Safety Equipment and Systems

<i>Safety Equipment and Systems</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Fire doors ⁽¹⁾	3	6-1-8/3
Fire-rated windows ⁽¹⁾	3	6-1-8/5
Fire and gas detection system alarm and control panels	2	6-1-8/9
Main and emergency fire pumps, other pumps used for fixed fire-extinguishing systems (see 6-1-6/7.3.2)	4/5	6-1-6/7.3.2
Fixed fire extinguishing system components	2	6-1-8/13
Clean agent fire extinguishing system components	2	6-1-8/9
Helicopter deck DIFFS components	2	5-2-3/9.3
Fireman’s outfit ⁽¹⁾	3	6-1-8/13
Fire hoses ⁽¹⁾	3	6-1-8/13
Portable and semi-portable fire extinguishers ⁽¹⁾	3	6-1-8/13

Note:

- 1 Type approval by flag Administration is acceptable in lieu of ABS Tier requirements.

PART

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CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 9 Jacking and Associated Systems

1 General

Jacking systems are used to elevate and lower the hull of self-elevating units in the elevated condition and to raise and lower the legs in the afloat condition.

The hull of the unit is maintained stationary in the elevated condition by means of a holding mechanism. The same mechanism is used to maintain the legs stationary in the afloat condition.

The jacking system and holding mechanism on self-elevating units are to be designed and constructed with sufficient redundancy so that upon failure of any one component, the system will prevent an uncontrolled descent of the unit. This is to be accomplished either by continuing to jack to a safe position or holding in place. Approved procedures are to be provided to allow emergency raising or lowering of the unit after failure in the case the unit is holding in an unsafe position.

Jacking systems are to be considered as machinery to provide the vertical movement of the legs as well as structural elements transmitting the loads between hull and legs, as applicable to the particular system design.

3 Definitions

The following definitions apply for the purpose of this Section.

3.1 Jacking System

A mechanical system used for raising the hull of a self-elevating unit above the surface of the sea by simultaneously applying a downward force on the movable legs of the unit. The same system is used for lowering the hull from the elevated condition in a controlled manner and for raising and lowering the legs relative to the hull in the afloat condition. The most commonly used jacking systems are the rack and pinion type and the yoke and pin type.

3.3 Holding Mechanism

A mechanism used for maintaining the hull of a self-elevating unit stationary in the elevated condition and/or maintaining the legs of the unit stationary in the afloat condition. The holding mechanism may be either the jacking system in a static position or a separate fixation system or a combination of both.

3.5 Rack and Pinion Jacking System

A jacking system using climbing pinions, most commonly driven by electric or hydraulic motors through a jacking gearbox, to engage with racks attached to the legs of the unit in order to raise or lower the hull in relation to the legs in the elevated condition or to raise or lower the legs in relation to the hull in the afloat condition.

3.7 Yoke and Pin Jacking System

A jacking system using yokes with pins, both operated by hydraulic cylinders, to engage with holes on the legs of the unit in order to raise or lower the hull in relation to the legs in the elevated condition or to raise or lower the legs in relation to the hull in the afloat condition.

3.9 Fixation System

A holding mechanism, independent from the jacking system, using a device attached to the hull to engage a counterpart device in the legs in order to establish a rigid connection between the hull and the legs of the unit.

3.11 Specified Service Temperature

Minimum atmospheric temperature identified for the unit (see 3-1-1/25 and 3-1-2/1) and documented in the unit's Operating Manual as per 1-2-5/1 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*

3.13 Jacking Unit Rated Capacity

Vertical effective force delivered to the leg by the jacking system per jacking unit when raising or lowering the hull. Effective force is inclusive of all frictional effects directly related to the jacking unit including leg interfaces such as a rack and pinion mesh.

3.15 Lifting Capacity per Leg

Vertical force per leg by the combination of jacking units attached to the leg, including the leg guide friction effect.

5 Plans and Data to be Submitted

The following plans and data are generally to be submitted:

- i) A description of the jacking system, holding mechanism and associated systems
- ii) Failure Modes and Effects Analysis (FMEA)
- iii) Design plans showing the following arrangements and details, as applicable:
 - Jacking system, including mechanical and hydraulic components such as rack and pinion, bearings, reduction gears, brakes, hydraulic power units, hydraulic cylinders, etc.
 - Fixation system
 - Jackcase (fixed or floating frame)
 - Electric system diagrams
 - Jacking motor and brake specifications and operating characteristics
 - Electric and/or hydraulic controls
 - Monitoring and alarm systems
 - Lubrication methods
 - Heating arrangements for low temperature operation
- iv) Material specifications
- v) Design calculations, including strength, fatigue, buckling, rigidity and critical speed (resonance) analyses, as applicable to the particular system
- vi) Specified service temperature
- vii) Limits of alignment/misalignment between rack and pinions
- viii) Motor Information:
 - Design documentation
 - Confirmation of application to jacking service
 - Shaft design documentation (including materials) for brake arrangements subjecting shaft to normal and/or storm holding loads while brake is engaged

- ix) Brake documentation:
 - Design documentation including brake static and dynamic capacities, and basis for establishing these values
 - Confirmation of application to jacking service
 - Any necessary conditions for attaining specified holding capacities
- x) Specifications and documentation of computer-based control systems
- xi) Technical limitations which may apply for emergency raising or lowering of the unit (such as loads, inclination, etc.)
- xii) Nondestructive examination details and procedure for components along the direct load path including locations of inspection, types of inspection, and acceptance/rejection criteria

7 Failure Modes and Effects Analysis (FMEA)

A failure modes and effects analysis (FMEA) is to be carried out on the jacking system and holding mechanism with the purpose of demonstrating that a single failure of any component will not cause an uncontrolled descent of the unit. The FMEA methodology has to ensure that any predictable failure mode relevant to the purpose of the FMEA has been considered and is to be sufficiently detailed to cover all systems associated with the jacking and holding operations. The FMEA is to be submitted for review and is to include but not be limited to the following information:

- A description of all the systems associated with the jacking and holding operations of the unit and a functional block diagram showing their interaction with each other. Such systems would include the jacking systems, the fixation systems, jackcase, electrical power distribution system, hydraulic power system, control systems (including programmable systems and their physical components such as programmable logic controllers, network hubs, cards, buses, cabling, encoders, and interfaces/displays), monitoring and alarm systems, etc. and their subcomponents.
- All significant failure modes relevant to the purpose of the FMEA
- Each predictable cause associated with each failure mode
- The method of detecting that the failure has occurred
- The effect of the failure upon the rest of the system's ability to jack the unit, including time effects (i.e., if necessary time is available for manual intervention)
- An analysis of possible common failure mode

Where parts of the system are identified as non-redundant and where redundancy is not possible, these parts are to be further studied with consideration given to their reliability and mechanical protection. The results of this further study are to be submitted for review.

9 Material

The material specifications for the components of the jacking system, holding mechanism and associated systems, including structural load carrying components (such as rack and jackcase for rack and pinion units or jacking pins and yoke for hydraulically actuated units), torque transmitting parts (such as climbing pinion, gears, pinions, planet carriers, pins, shafts, torque supports, couplings, coupling bolts, shafts, torque flanges and brakes of rack and pinion units), fixation system components and hydraulic components (such as hydraulic cylinders and actuators), as applicable to the particular system design, will be subject to approval and are to be submitted by the designer. These specifications are to include as a minimum, chemical composition, yield strength, ultimate tensile strength, percent elongation and reduction of area, and hardness for gears and coupling teeth, and where required, impact values.

Load bearing/torque transmitting components in the direct load path are to be constructed of steel, with elongation and reduction in area properties in accordance with Chapter 3 of the *ABS Rules for Materials and Welding (Part 2)*. Subject to agreement, high strength case hardened gears made to recognized standards may have a minimum elongation value of 8%. Other acceptable ductile materials can be applied provided they have a specified elongation of not less than 12%. Other materials suitable for the intended purpose may be specially considered.

Note: Materials for bushing, shim plates and other components under compressive loads only need not be ductile.

Materials for the load-bearing components of the fixation system in the direct load path are in general to comply with 3-1-4/5.5 and 3-1-4/5.7, as applicable. However for fixation systems that are not of welded construction, or are constructed from forgings or castings, the minimum required Charpy values for steel load-bearing components are to be in accordance with 6-1-9/Table 1.

Material manufacturers are to be ABS approved in accordance with Chapters 1 to 3 of the *ABS Rules for Materials and Welding (Part 2)*. The approval scope is to include all heat treatment facilities used by the manufacturer in the production of jacking components. For initial new production processes of the following direct load path components: jacking pins, pinions, planet carriers, gears, shafts, torque plates, torque couplings and torque transmitting jack casing, each manufacturer is to submit a production process plan to ABS prior to commencing production. This can be done in the format of a manufacturing inspection procedure (MIP), and/or an inspection and testing procedure (ITP). The manufacturers are to demonstrate to the satisfaction of the attending Surveyor, by first article testing, that actual products meet the mechanical properties required by the design. This is to be done by sacrificing a sample product or extracting a sample from an actual product.

To establish correct tempering temperatures, heat treatment sensitivity studies are to be carried out to demonstrate the tempering range where tensile, ductility and toughness are optimized. Data from the sensitivity studies is to be submitted to ABS. Alternatively, supporting data of existing heat treatment processes with satisfactory mechanical test results can be submitted in lieu of sensitivity studies.

Chemistry additions, forging and casting processes, and heat treatment practices are to be controlled, to avoid detrimental microstructures and precipitates that may degrade the mechanical properties of the material.

9.1 Toughness

The following toughness requirements refer to the core material after all thermal treatments.

For rack and pinion units, steel for the rack and rack attachments and the frame which attaches to the hull structure is to meet the toughness requirements for primary application (see 3-1-4/5.3.2) at the specified service temperature in accordance with 3-1-4/5.5 and 3-1-4/5.7, as applicable to the steel grade. Steel for the frame which will be used in cases of floating jacking systems is to meet the toughness criteria for secondary application (see 3-1-4/5.3.3) at the specified service temperature.

For systems actuated by hydraulic cylinders, steel for jacking pins and yoke is to meet the toughness criteria for primary application (see 3-1-4/5.3.2) at the specified service temperature in accordance with 3-1-4/5.5 and 3-1-4/5.7, as applicable to the steel grade.

Steel for torque transmitting parts for rack and pinion units is to meet the Charpy V-Notch (CVN) impact requirements specified in 6-1-9/Table 1. Charpy tests on forgings can be taken in the transverse or longitudinal direction. The longitudinal and transverse forging directions are to be determined by the forge and recorded in supporting documentation.

Materials other than steel are to exhibit fracture toughness which is satisfactory for the intended application, as evidenced by previous satisfactory service experience or appropriate toughness tests.

TABLE 1
Charpy V-Notch (CVN) Impact Requirements for Steel Materials

Application	Charpy V-Notch (CVN) Minimum Average Values at Specified Service Temperature (SST)								
	Forgings Longitudinal CVN Test			Forgings Tangential CVN Test			Castings		
	J	kgf-m	ft-lbf	J	kgf-m	ft-lbf	J	kgf-m	ft-lbf
Climbing Pinion and Planetary Carriers	27	2.8	20	20	2.0	15	20	2.0	15
Low Speed Gears and Pinions ⁽¹⁾	20	2.0	15	15	1.5	11	15	1.5	11
Fixation System ⁽³⁾	34	3.5	25	24	2.4	17	24	2.4	17
Other ⁽²⁾	SST of -20°C (-4°F) and above Not Required								
	SST below -20°C (-4°F) Subject to Special Consideration								

Notes:

- 1 As defined in 6-1-9/11, mesh rate MR < 100 Teeth/Minute
- 2 Torque transmitting/load bearing components in the load path (other than climbing pinion, planetary carriers and low speed gears and pinions), such as high speed pinions and gears, planetary ring gears, torque supports, shafts, pins, couplings and coupling bolts.
- 3 Forging requirement applies for un-welded plate.

11 Strength Analysis

11.1 Conditions to be Analyzed

Strength calculations of the jacking system and holding mechanism are to be submitted in accordance with 6-1-9/5. Strength calculations are to consider at least the maximum loads of the following loading conditions, as applicable to the unit:

- Normal raising of hull
- Normal holding of hull
- Normal lowering of hull
- Pre-load raising
- Pre-load holding
- Pre-load lowering
- Normal raising of legs
- Normal holding of legs
- Normal lowering of legs
- Severe storm holding (elevated or afloat)

Maximum rated loads associated with the normal jacking, pre-load jacking and normal holding conditions may be considered as static loadings only, where the static loads include operational gravity loadings and weight of the unit, with the unit afloat or resting on the sea bed in calm water. Maximum rated loads associated with severe storm conditions (elevated or afloat) and pre-load holding condition are to be considered as combined loadings, where the applicable static loads are combined with relevant environmental loadings, including acceleration and heeling forces.

When establishing the loads imposed on a jacking system during lifting operations for the purpose of providing loading guidance in the operations manual required in Section 1-2-5 of the *ABS Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*, friction losses are to be considered as defined in 3-2-3/9.

11.3 Strength

11.3.1 Individual Stresses

For the purpose of strength calculation of the jacking system and for designing mechanical components (including pins), the stress is not to exceed $F_y/F.S.$ where:

F_y = specified minimum yield point or yield strength, as defined in Chapter 1 of the *ABS Rules for Materials and Welding (Part 2)*

$F.S.$ = factor of safety

For static loadings, as defined above:

= 1.67 for axial or bending stress

= 2.50 for shear stress

For combined loadings, as defined above:

= 1.25 for axial or bending stress

= 1.88 for shear stress

except that gear reducers are to comply with a recognized standard such as American Gear Manufacturers Association (AGMA) standards or ISO. Gear rating calculations and justification of the applied gear design coefficients in accordance with the applicable design standard are to be submitted to ABS for review.

Alternative design methods for low speed gears with a mesh rate MR less than 100 teeth/minute (where $MR = RPM \times \text{Number of teeth}$) may be specially considered, subject to the submission of adequate evidence to validate the design method, such as first principles calculations, experimental data and satisfactory operation experience for the intended application. The alternative design methods are to take into account all the various degradation factors, such as dynamic factor, non-uniform load distribution or misalignment.

11.3.2 Von Mises Approach

When recognized standards are not applicable, structural and mechanical components may be designed according to the von Mises equivalent stress criterion. Except for components under compressive loads only, the equivalent stress is not to exceed $F_y/F.S.$ where:

F_y as defined in 6-1-9/11.3.1

$F.S.$ = 1.43 for static loading, as defined in 6-1-9/11.3.1

= 1.11 for combined loading, as defined in 6-1-9/11.3.1

11.3.3 Fixation System

The scantlings of the load-bearing components of the fixation system in the direct load path are to be determined on the basis of the allowable stresses specified in 6-1-9/11.3.1 or 6-1-9/11.3.2.

11.5 Buckling

As applicable to the design, the buckling strength of structures is to be verified according to the latest version of the *ABS Guide for Buckling and Ultimate Strength Assessment for Offshore Structures*, or other recognized standard acceptable to ABS.

11.7 Fatigue

Fatigue damage of jacking system components due to cyclic loading is to be considered. A fatigue analysis is to be performed using an appropriate loading spectrum. The fatigue analysis is to be based on recognized fatigue assessment methodologies such as those shown in the latest editions of AGMA and ISO gear standards or the Miner's Rule for cumulative fatigue. For gears, both tooth surface contact and tooth root bending fatigue strength are to be considered. The calculated fatigue life is to be at least the design life of the unit, but not less than 20 years. Safety factors against maximum fatigue life in hours or cycles are to be as follows:

1. Tooth root bending: $F.S. = 1.5$ for cumulative fatigue due to all lifting and lowering operations and all other applicable cyclic loads
2. Tooth surface contact: $F.S. = 1.0$ for cumulative fatigue due to all lifting and lowering operations and all other applicable cyclic loads

In the calculation of the tooth surface contact fatigue, the magnitude/effect of non-uniform face load distribution is to be considered. Inspectable low speed, through hardened pinions and gears may not need to comply with the above safety factor for tooth surface contact fatigue, subject to past satisfactory experience with material and design for this purpose.

Jacking system design may be accepted based on full life-cycle fatigue load test results in lieu of theoretical fatigue calculations. Acceptability of test results is to be governed by the type and the extent of the testing. When testing for fatigue, the jacking system or parts are to be subject to all the applicable maximum cyclic loading conditions and each applicable load level is to be multiplied with relevant safety factors. The safety factors applied in case of full life-cycle fatigue load test will be specially considered.

Note: Full-life cycle fatigue load test does not exclude the required mandatory prototype test.

Where applicable, critical speed (resonance) analysis of rotating components is to be submitted to demonstrate that there are no harmful vibrations at operating speeds. Test results in lieu of theoretical analysis may be considered.

11.9 Alignment

For rack and pinion systems, the alignment between the rack and pinion is to be maintained within specified limits throughout the life of the rig. Documentation in this regard is to be submitted to ABS.

13 Mechanical Components

In addition to the strength requirements for mechanical components in accordance with 6-1-9/11, the following requirements are to be complied with:

13.1 Bearings

Bearings are to be designed for the operational static and dynamic loads in accordance with applicable recognized standards such as the latest editions of ISO 76 and ISO 281. Design calculations are to be submitted for bearings not covered by recognized standards. Adequate bearing lubrication is to be provided. Manufacturer's documentation is to be submitted to confirm the suitability of the bearings for operation at the specified service temperature of the unit.

13.3 Brakes

Brakes are to be designed to engage automatically in the event of failure of power supply to the motor (fail-safe type). The brake holding capacity is to be at least equal to 120% of the maximum required brake torque associated with the maximum rated load applied to the climbing pinion from all loading conditions specified in 6-1-9/11. Brake static capacity is to be applied in holding conditions, and dynamic capacity (i.e., ability to stop motion) is to be applied for raising and lowering conditions.

The brake manufacturer is to submit documentation identifying the static and dynamic capacities of the brakes, the basis upon which these capacities have been established (e.g., by testing), and statement confirming that the brakes are intended for jacking gear service. Dynamic capacity is to be established based on the operational speed of the motor and may reflect regenerative braking if provided.

Any conditions on attaining the stated holding capacity are to be specified by the manufacturer, and are to be included in maintenance manuals or marked on the data plate attached to the brake housing or casing. Examples include clearance range (air gap, minimum and maximum), brake run-in procedures, maximum ambient or operating temperature, minimum number of springs to be maintained in the brake, or maximum number of stops in a given time period.

13.5 Flexible Shock Pads

Jackcase shock pads are to be designed for the maximum severe storm loads and suitable for operation at the specified service temperature of the unit. Shock pads are to be suitably protected against adverse effects of the marine and working environment which may lead to degradation. Manufacturer's technical specification or similar documentation is to be submitted to verify the suitability of the shock pads for the intended service.

15 Electrical Power System

15.1 Electric Motor Drive

Jacking gear motor installations are to be in accordance with Part 4, Chapter 3, Section 6-1-7, 6-1-9/Table 2, and the requirements below. Design documentation is to be submitted for all motors, with particular attention paid to brake arrangements where the motor shaft is subject to the normal and/or storm holding loads. Where the shaft is subject to such loads, design review and material testing of the motor shaft are to be carried out in accordance with 6-1-9/9 under the applicable loads.

The capacity of the electric motor shall be sufficient for lifting requirements such as the following:

- Lifting the platform with uneven load (but within approved tolerances) for a specific duration;
- Lifting in preload, if specified, with a specific duration.

The friction between legs and guides, as well as the efficiency of the gear transmissions, is to be considered. See 6-1-9/11.1.

Group motor installations will be permitted as follows:

- On each leg, two or more motors of any power may be connected to a single branch circuit.
- The branch circuit is to be provided with short circuit protection set at not greater than ten times the sum of the full load currents of the motors.

A visual and audible alarm is to be provided at the jacking control station to indicate an overload condition in any of the jacking motors.

The motor manufacturer is to confirm that motors are intended for jacking gear service and are rated for operation over the required range of input voltage, current, frequency, and other parameters, as applicable. Limitations on the motor such as maximum number of starts per hour or the minimum time between starts of the electric motors are also to be specified.

15.3 Hydraulic Motor Drive

Hydraulically driven motors used for elevating and lowering the unit are to be designed based on applicable pressure vessel and piping standards for pressure retaining components, allowable stress for torque components, and recognized standards for seals. As an alternative to design review, mass produced motors may be accepted on the basis of specification review and a prototype test to 150% of the rated load, subject to agreement on design standards and manufacturing process.

Where an integral brake is not provided, the arrangement is subject to review and testing of the motor shaft if it is subject to normal and storm holding loads, as indicated in 6-1-9/15.1 for electric motors.

17 Hydraulic System

The hydraulic system for jacking units and holding mechanisms is to be in accordance with 4-2-6/3. Design of hydraulic cylinders and actuators, including materials, is to be in accordance with 4-2-2/19. Hydraulic cylinders are to be considered both as pressure containing and load bearing units.

Sufficient redundancy of the hydraulic power unit or units servicing the jacking systems is to be provided to maintain continuous jacking operation in the event of a single failure in the hydraulic power system.

19 Control, Monitoring and Alarm System

Operation of the jacking system and holding mechanism is to be possible from a central jacking control station, except that the operation of a fixation system is to be from a local control station in visual proximity to the system at each leg chord. The central jacking control station is to be provided with the following alarms and indications, as applicable to the particular system design:

- i) Audible and visual alarms for:
 - Motor overload, over temperature, or overvoltage for each motor
 - Unit out-of-level (elevated condition)
 - Significant differences in the currents or torque in the motors on one rack
 - Rack phase differential, where applicable to the design
 - Brake fault or overheating
- ii) Indication of:
 - Availability of power
 - Current or torque in each motor (during raising and lowering operations)
 - Brake release status
 - Hydraulic pressure
 - Air pressure
 - Pin position
 - Position of yoke
 - Inclination of the unit, in two horizontal, perpendicular axes (elevated condition)

Upon failure of the jacking system controls in the central control station, emergency controls to operate the jacking system are to be available.

An emergency stop is to be provided at the central jacking control station and at each jack house. Emergency stop circuits are to be independent from the jacking control circuits. In the event that the design incorporates an interlock system between jacking operations and a rack fixation system engagement, an override of the interlock is to be provided to prevent jacking system from being locked-out in case of a failure of sensing device for fixation system disengagement. A communication system as defined in 4-3-2/15.5.4 is to be provided.

Procedures and/or arrangements for confirming engagement and full disengagement status of fixation system are to be verified by attending Surveyor. The procedures are to be incorporated into the Operating Manual as specified in 1-1-5/1.17 of these Rules.

Arrangements are to be provided for detecting and correcting rack phase differential, where applicable to the design.

19.1 Programmable Electronic System (PES)

Where the jacking system uses Programmable Electronic Systems as defined in 4-3-4/5 for control and/or monitoring of jacking operations, such systems are to comply with Section 4-9-3 of the *Marine Vessel Rules*. Category I or II is to be assigned based on the functionality and criticality of the Programmable Electronic control Systems. If a Programmable Electronic System is only used for monitoring and indication, Category I can be assigned. If control logic operates part or all of the functions of the system, Category II may be assigned depending on the FMEA findings.

Programmable Electronic jacking control Systems are not considered “integrated” systems for the purposes of applying 4-9-3/5.3 of the *Marine Vessel Rules*.

Basic and application software for control systems are to reboot into a proven safe jacking system holding mode.

21 Low Temperature Operation

Jacking systems, holding mechanisms and associated systems intended for operation at a specified service temperature below -20°C (-4°F) will be subject to special consideration.

23 Jacking Systems of Novel Design

Jacking systems other than rack and pinion type or yoke and pin type will be subject to special consideration. Compliance with Section 6-1-9 is required, as applicable. The suitability of the novel features will be considered on the basis of first principles, applicable recognized standards and experimental test results, depending on the particular characteristics of the jacking system and type of unit.

25 Survey and Certification

All jacking or other elevating systems for Self Elevating Units are required to be certified by the attending Surveyor before installation and onboard testing.

25.1 Inspection and Material Testing

All jacking systems, holding mechanisms and associated systems are to be constructed and installed to the satisfaction of the Surveyor in accordance with approved plans.

Welded construction is to be in compliance with the applicable requirements of 3-2-6, 7-1-2/9 and 7-1-2/11 of these Rules and Chapter 4 of the *ABS Rules for Materials and Welding (Part 2)*. Material tests for the components of the jacking systems, holding mechanisms and associated systems are to be carried out in accordance with 6-1-9/9 of these Rules and Chapters 1 to 3 of the above referenced Part 2. All material testing as indicated in 6-1-9/Table 1 is to be witnessed by the attending Surveyor.

Gears of the climbing pinion gear train are to be examined at the plant of the manufacturer by an approved crack detection procedure and such an examination is to be witnessed by the Surveyor. For direct load path components, the locations of inspection, types of inspection and acceptance/rejection criteria are to be clearly indicated in the documentation.

25.1.1 Heat Treatment

All test specimens are to be representative of the components in the jacking system and in accordance with Chapter 3 of the above referenced Part 2. Representative specimens are to be of the same material grade, from the same heat and heat treatment batch, and are to be of sufficient size and mass to represent the heat transfer experienced in the components themselves during the complete heat treatment cycle.

Components and test material are to be heat treated together in the same furnace, and quenched in the same bath/tank (for Q & T components).

25.1.2 Surface Hardening

Where it is intended to surface harden climbing pinion teeth, full details of the proposed procedure and specification are to be submitted for approval. The manufacturer and heat treater will be required to demonstrate by test that the proposed procedure gives a uniform surface layer of the required hardness and depth and that it does not impair the soundness and properties of the steel. Test specimens are to be representative of the climbing pinions, and be in accordance with Chapter 3 of the above referenced Part 2. Representative specimens are to be of the same material grade, from the same heat and heat treatment batch, and are to be of sufficient size and mass to represent the heat transfer experienced in the pinions themselves during the complete heat treatment cycle, including the surface hardening cycle.

For other surface hardened gearing, recognized national or international standards are to be applied.

25.3 Prototype Test

A prototype test is to be performed on one unit of a newly designed rack and pinion system as part of the design approval procedure. The prototype testing and examination is to be carried out in the presence of, and to the satisfaction of, the Surveyor.

The prototype test procedure is to be submitted for review and as a minimum is to include the following:

- i) It is to be confirmed that the prototype has been manufactured to similar processes and materials, and according to the approved material specification, as that applied for the production units.
- ii) Prior to the prototype test, all pinions and gears of the climbing pinion gear train are to be examined using an approved crack detection procedure. (ABS material certificates as per 6-1-9/25.1 are to be provided for the prototype unit.)
- iii) The prototype test is to be carried out at 150% of the maximum normal holding capacity rating of the unit. As a minimum, the test is to be carried out for one complete revolution of the climbing pinion.
- iv) Subsequent to the prototype test, the unit is to be disassembled and examined. All pinions and gears of the climbing pinion gear train are to be examined using an approved crack detection procedure.

25.5 Replacement Jacking Equipment for Units in Operation

The following requirements apply to all jacking components, rack fixation systems, and associated equipment.

25.5.1 Design

Replacement components may be fabricated using original designs that were accepted in accordance with the same or earlier Rules.

Replacement components may be fabricated in accordance with designs approved to Rules more recent than the unit's contract date.

25.5.2 Material and Heat Treatment

Material manufacturers are to be ABS approved in accordance with Chapters 1 to 3 of the ABS *Rules for Materials and Welding (Part 2)*.

The approval scope is to include all heat treatment facilities used by the manufacturer in the production of jacking components.

Replacement components may be fabricated using original material specifications, or to specifications accepted by ABS engineering department.

25.5.3 Fabrication and Testing

Components are to be fabricated to the satisfaction of the attending Surveyor in accordance with the following requirements:

i) Inspection and material testing is to be conducted in accordance with 6-1-9/25.1.

Testing is to include the following items:

a) Physical/mechanical properties

- Yield strength
- Ultimate tensile strength
- Percent elongation
- Reduction of area
- Charpy impacts
 - Are to be taken in location specified by 6-1-9/9.1.
 - Values are to be in accordance with the design.
- Hardness values

b) Nondestructive testing (NDE) requirements

25.5.4 Installation

Certification conducted for components using this section will only be valid for use on units with a contract date the same as or previous to the elevating system's design approval date.

25.5.5 Recondition of Existing Equipment

Existing equipment removed from a unit Classed with ABS may be reconditioned and used as replacement equipment on a unit with the same Rule requirements.

All existing components that are reconditioned or repaired by welding are to have the testing listed above conducted were applicable.

Weld procedures are to be qualified by using actual components and tested in accordance with the complete list above.

TABLE 2
Certification Details – Jacking and Associated Systems

<i>Jacking and Associated Systems</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Material of load carrying components, such as; rack and jack-case for rack and pinion units, and jacking pins and yoke for hydraulic actuated units	5	6-1-9/9
Material of torque transmitting parts, such as climbing pinion, gears, pinions, planet carriers, pins, shafts, torque supports, couplings, coupling bolts, shafts, torque flanges and brakes of rack and pinion units, Jacking Gear Motor Shafts (regardless of motor KW) when integral to braking or load path and brakes of rack and pinion units	5	6-1-9/15.1, 6-1-9/9, 6-1-9/9.1, 6-1-9 Table 1
Material of holding mechanism (e.g., fixation system) components	5	6-1-9/9
Mechanical components, such as bearings, brakes and flexible shock pads	1	6-1-9/13
Electric motors >100 kW (135 hp)	5	6-1-7/19.1 and 6-1-9/15.1
Electric motors <100 kW (135 hp)	3	6-1-9/15
Hydraulic jacking motors	4	6-1-9/15
Hydraulic system components for jacking unit and holding mechanism, including hydraulic cylinders and actuators	5	6-1-9/17
System control, monitoring and alarms	5	6-1-9/19
Fixation system	5	6-1-9/25
Completed jacking system	5	6-1-9/25

PART

6

CHAPTER 1 Material, Marine Equipment and Machinery Certification

SECTION 10 Mooring Systems and Equipment

1 General

This Section applies to mobile offshore units that are classed with the **Ⓔ**, **Ⓜ** or **Ⓟ** symbol and also self-propelled units that are required to have temporary mooring equipment in Section 3-4-1 that have no symbol.

Additional requirements for mobile offshore units that are classed with the optional **Ⓜ** or **Ⓟ** symbols are located in Appendix 7-1-A1.

Design, construction and installation of all windlasses used for anchoring (temporary mooring) are to be carried out in accordance with 4-1-1/5 and Section 4-5-1 of the *Marine Vessel Rules*.

3 Temporary Mooring Equipment

All anchoring equipment required for temporary mooring is to be fabricated and tested in presence of and to the satisfaction of the attending Surveyor, and certified in accordance with 6-1-10/Table 1.

For non-propelled units fitted with an anchoring (temporary mooring) equipment, if the optional symbol **Ⓔ** is requested, equipment is to be fabricated and tested in presence of and to the satisfaction of the attending Surveyor, and certified in accordance with 6-1-10/Table 1.

When a vessel is required to have Temporary Mooring Equipment in Section 3-4-1, but is not required to have **Ⓔ**, it is to be tested in the presence of a Surveyor in accordance with the specifications of the Owner and in the presence of a Surveyor in accordance with 6-1-10/5 and 6-1-10/Table 1.

3.1 Inspection and Material Testing

All equipment is to be constructed and installed to the satisfaction of the Surveyor in accordance with approved plans. All material testing is to be witnessed by the attending Surveyor.

Welded construction is to be in compliance with the applicable requirements of Section 3-2-6, 7-1-2/9 and 7-1-2/11 of these Rules and Chapter 2 of the *ABS Rules for Materials and Welding (Part 2)*. Material tests for the components of the anchoring system are to be carried out in accordance with Chapters 1 to 3 of the above referenced Part 2.

All equipment is to be examined at the plant of the manufacturer by an approved crack detection procedure and such an examination is to be witnessed by the Surveyor. Acceptance of components manufactured at a plant which is under an ABS approved quality assurance program will be subject to special consideration.

3.3 Prototype Testing of Anchor Windlass

A prototype test is to be performed on one unit of a newly designed anchor windlass in lieu of the design approval procedure. The prototype testing and examination is to be carried out in the presence of, and to the satisfaction of, the Surveyor.

3.5 Certification of Anchoring System Equipment

Anchoring system equipment such as anchors, anchor chains or wires, anchor chain accessories such as shackles or links, and anchor wire-rope accessories such as sockets or links, are to be manufactured and tested in the presence of and to the satisfaction of the Surveyor.

Material, dimension and weight of all equipment is to satisfy the design criteria of the anchoring system that is to be approved by ABS for compliance with the symbol **ⓔ**.

5 Survey and Certification of Position Mooring Equipment **Ⓜ**

All equipment is to be constructed in accordance with the owner’s specification. All material testing is to be witnessed by the attending Surveyor. See 6-1-10/Table 2.

Testing of equipment at the manufacturer’s facility is to be in accordance with the following standards:

- Chain and accessories *ABS Guide for the Certification of Offshore Mooring Chain*
- Anchors *Section 2-2-1 of the ABS Rules for Materials and Welding (Part 2)*
- Fiber Ropes *ABS Guidance Notes on the Application of Fiber Ropes for Offshore Mooring*
- Wire Rope *API Spec 9A and API RP 9B*

The chain, connecting links, and accessories are to be in accordance with the requirements for “R” grade chain as specified in the *ABS Guide for the Certification of Offshore Mooring Chain*.

7 Survey and Certification of Position Mooring Systems **Ⓟ**

Mooring systems for units with the symbol **Ⓟ** are to be constructed and tested in the presence of a Surveyor in accordance with the drawings reviewed by ABS.

Winches, windlasses, fairleads, stoppers, etc., are to be surveyed at the plant of the manufacturer and certified by ABS. Welding is to be in accordance with *ABS Rules for Materials and Welding (Part 2)*.

All equipment including anchors, chains, wires, and accessories are to be constructed in accordance with the drawings reviewed by ABS. All material testing is to be witnessed by the attending Surveyor. See 6-1-10/Table 3.

Fabrication and testing of the equipment is to be in accordance with the following standards:

- Chain and accessories *ABS Guide for the Certification of Offshore Mooring Chain*
- Anchors *Section 2-2-1 of the ABS Rules for Materials and Welding (Part 2)*
- Fiber Ropes *ABS Guidance Notes on the Application of Fiber Ropes for Offshore Mooring*
- Wire Rope *API Spec 9A and API RP 9B*

TABLE 1
Certification Details – Temporary Mooring Equipment With or Without **ⓔ Symbol**

<i>Anchoring System for ⓔ Symbol</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Anchor windlass	5	6-1-10/3.1, 6-1-10/3.3
Anchors	5	6-1-10/3.1, 6-1-10/3.3
Anchor chains/wire-ropes	5	6-1-10/3.1, 6-1-10/3.3
Anchor chain accessories (Shackles/Links)	5	6-1-10/3.1, 6-1-10/3.3
Anchor wire-rope accessories (Sockets/Links)	5	6-1-10/3.1, 6-1-10/3.3

TABLE 2
Certification Details – Position Mooring Equipment for Ⓜ Symbol

<i>Component Required for Ⓜ Symbol</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Anchor windlass	5	6-1-10/5
Anchors	5	6-1-10/5
Anchor chains/wire ropes/fiber ropes	5	6-1-10/5
Anchor chain accessories (shackles/links)	5	6-1-10/5
Anchor rope accessories (sockets/links)	5	6-1-10/5

* Drawing Approval by ABS is not required, fabrication is to be to Owner's specifications.

TABLE 3
Certification Details – Position Mooring System for Ⓟ Symbol

<i>Component Required for Ⓟ Symbol</i>	<i>ABS Approval Tier</i>	<i>Rule Reference</i>
Anchor windlass	5	6-1-10/7
Anchors	5	6-1-10/7
Anchor chains/wire ropes/fiber ropes	5	6-1-10/7
Anchor chain accessories (shackles/links)	5	6-1-10/7
Anchor rope accessories (sockets/links)	5	6-1-10/7