Section 4

Electrical Installations

A. General

1. Scope

1.1 These construction rules apply to the craft's wiring systems up to an operating voltage of 50 V, whatever the class or type of craft.

GL reserve the right to permit deviations from these rules on an individual case basis, or to make special demands in the case of novel installations or equipment.

1.2 If the rated voltage of the installation is more than 50 V or parts of the electrical installation are operated at a voltage higher than 50 V, the current Rules for Classification and Construction, I – Ship Technology, Part 2 – Inland Waterway Vessels, Chapter 3, are to be applied as appropriate. As regards the shore connection for shoreside voltages exceeding 50 V, reference is made to F.6.

1.3 These rules apply to permanently installed electrical systems and equipment.

2. Rules and standards

Where specifications for electrical installations and equipment are not provided in these rules, the application of other rules and standards will be agreed if appropriate. Amongst these are (e.g.) the publications of the IEC, particularly all IEC-92 publications.

As well as the GL Rules, existing national rules and regulations are to be observed.

3. Principle requirements

3.1 Dimensioning of components

All parts shall be designed to meet the special operating stresses due to (e.g.) craft motion, heel, trim, vibration and be protected against moisture and corrosion.

3.2 Environmental conditions

Trouble-free operation of the electrical installation is to be ensured under:

– continuous heel of up to 15°

– short time heel of up to 30°

– short time longitudinal inclinations of up to 20°

– ambient temperature up to 45 °C

For pleasure craft intended to operate only in restricted areas, GL may permit deviating conditions.

B. Approval Documentation

The documentation listed below is to be submitted in triplicate for approval before construction starts:

1. Form F 145

Information about extent and type of the electrical installation on Form F 145 (the form can be obtained from GL).

2. General circuit diagram

A general circuit diagram of the electrical installations showing the basic systems for power generation, energy storage and distribution with output data for generators, storage batteries, users including their fuses and the associated cable types and cross sections.

Any non-standard symbols used are to be explained in a key.

All documents are to be indicated with the hull number and the name of the shipyard.

C. Protective Measures

1. General

1.1 Materials for electrical machinery, cables and other electrical components must be capable of withstanding humid air and sea water mist, sea water and oil vapour. They must not be hygroscopic; shall be hard to ignite and self-extinguishing.

For areas where sea air need not be taken into account, appliances designed to Industrial Standards may be used.

2. Protection against foreign bodies and water

2.1 The grade of protection of electrical components against foreign bodies and water shall be suitable for the location where they are installed.

2.2 In the compartments listed below, the minimum grade of protection considered for electrical components shall be:

–	machinery spaces, operating spaces:	IP 23
–	below deck, living spaces, cabins:	IP 20
–	enclosed steering position:	IP 23
–	open deck, open steering positions:	IP 55
–	appliances which may be flooded:	IP 56
–	ventilation fan shafts to the open deck:	IP 44
–	storage battery spaces; lockers; boxes:	IP 44

2.3 The grades of protection are to be ensured by the appliances directly or by appropriate constructional measures when installing them.

2.4 Regarding protective systems for appliances in spaces where an explosive atmosphere may build up, see 3.

3. Explosion protection

3.1 In enclosed or semi-enclosed spaces housing petrol engines or petrol containers, all electrical equipment shall be ignition protected (Explosion-group IIA, temperature class T 3) if their installation there cannot be avoided. This includes electric starters and generators; excluded are outboard motors in well-ventilated trunks.

3.1.1 If it is not possible to use fully ignition protected appliances, the machinery space is to be pre-ventilated using electric-motor driven ventilation fans. The fan output is to be such as to ensure at least a five times air exchange. Only after that the petrol engine may be started.

Preferably an interlock is to be provided between the fan motor and the petrol engine starter, which ensures that the latter can only be operated once the above-mentioned condition for the pre-ventilation of the machinery space has been fulfilled. Alternatively a plate shall be displayed in a clearly visible place, e.g. the engine control position, with the inscription:

ATTENTION! EXPLOSION HAZARD!

Before starting the engine, the machinery space is to be ventilated for at least ..... minutes!

The length of ventilation time to be inserted in the above text shall be calculated from the machinery space volume and the fan output.

In installations where pre-ventilation is obligatory, it shall be ensured that after a short interruption (possibly reversing) the propulsion engines of the craft can be started again without delay.

3.1.2 If the ventilation fans described under 3.1.1 above are installed in the machinery space, they must be ignition protected. Fans whose electric motor is not ignition protected shall be fitted outside the machinery space and outside the ventilation duct.

3.2 Electrical components must not be fitted in stowage spaces for gas cylinders for heating and cooking.

4. Protection against lightning

It is recommended that a lightning protection system be fitted.

For notes regarding design and construction see Annex F.

D. Electrical Machinery

1. General

1.1 All motors and generators must meet a standard accepted by GL, provided no special data are contained in the rules that follow.

1.2 Terminals must be located in an easily accessible position and dimensioned in accordance with the cross-section of the cable to be connected. The terminals are to be clearly identified.

1.3 Each generator and motor is to have a manufacturer's name- and capacity plate fitted which contains all important operating data as well as the manufacturing number.

E. Storage Batteries

1. General

1.1 These rules apply to permanently installed storage batteries.

1.2 Storage batteries shall be so made that they retain their rated capacity up to an inclination of 22,5° and leakage of electrolyte is prevented up to 40° of inclination (50° in the case of sailing yachts). Cells without covers are not permitted.

1.3 Storage battery ratings are to be shown on a rating plate.

2. Location

2.1 Storage batteries are to be so located that escaping gases or electrolyte can neither endanger persons nor damage equipment.

2.2 Storage batteries must not be located where they are exposed to unacceptably high, or also low, temperatures, spray or other influences which might impair their ability to function or reduce their service life. The minimum protective grade to be provided is IP 12.

2.3 When locating the storage batteries, the output of the associated chargers is to be taken into account. The charging capacity of the batteries is to be calculated from the charger maximum current and the battery rated voltage.

Depending on operating mode, service and utilisation of the storage battery to be charged and the nature of the charging process (charger characteristic), following agreement with GL, the maximum current may be deviated from as the basis for calculation of the charging capacity.

If several storage batteries are assembled in one place, the sum of their charging capacities is to be used as the basis.

2.4 Storage batteries with a charging capacity of up to 2 kW may be located below deck, open in a well-ventilated locker or housing.

2.5 Storage batteries with a charging capacity of more than 2 kW, if located below deck, are to be housed in an enclosed locker/housing or compartment, with ventilation supply and -extraction to the open deck (see also 4.4.).

2.6 Storage batteries shall be safeguarded against slipping. Straps or supports must not impair ventilation.

3. Equipment in battery compartments

3.1 Lights, ventilation fan motors and space heaters in battery compartments shall be ignition protected. The following minimum requirements are to be met:

– Explosion Group II C

– Temperature Class T 1

3.2 The internal walls of battery compartments, boxes and lockers including all supports, troughs, containers and racks shall be protected against the damaging effect of the electrolyte, should an escape of electrolyte be possible.

4. Ventilation

4.1 All battery compartments, lockers and boxes must be so constructed and ventilated that any build-up of ignitable gas mixtures is prevented.

4.2 The ventilation supply and exhaust openings are to be so arranged that there is a flow of fresh air over the entire battery.

4.3 Fittings impeding the free passage of air, such as flame arrestors and Davy screens must not be installed in battery compartment air supply and exhaust ducts.

4.4 If batteries are operated exclusively in parallel or switch-selected with the supply system, battery compartments, containers or lockers may be naturally ventilated provided the charging capacity does not exceed:

– 3 kW in the case of lead-acid batteries

– 2 kW in the case of nickel-cadmium batteries

even under boost charging conditions.

If that charging capacity is exceeded, forced ventilation is to be provided.

4.5 The minimum volume of air to be extracted is

$$Q = 0{,}11 \cdot I \cdot n$$

Q = the volume of air extracted in [m^3/h]

I = strength of current according to charger characteristic, but at least 1/4 of the maximum current of the charging system or of the charging current reduced in accordance with 2.3.

n = number of cells in the battery.

4.6 In case of natural ventilation, the conditions of 4.5. are considered being met if ducts are rated as set out below, where an air velocity of 0,5 m/sec is used as a basis.

The slope of the ducts must not exceed 45° to the vertical.

4.7 For forced ventilation, a suction fan is to be used preferably. The fan motors shall either be ignition protected (see 3.1.) and electrolyte-proof, or be located outside the area of danger (preferred solution).

The fan impellers shall be of a material which does not create sparks if it touches the casing, and which does not conduct any static charges.

The ventilation systems shall be independent of those of other compartments.

4.8 Where battery charging and switching-on of the ventilation fan are automatic when charging starts, continued ventilation is to be ensured for at least one hour after charging has ended.

Table 4.1 Cross-section of extraction air ducts

Charging capacity P [Watts]	Cross section of extraction air ducts [cm²]	
	Lead batt.	Ni-cad batt.
P < 1000	80	120
1000 ≤ P ≤ 1500	120	180
1500 < P ≤ 2000	160	240
2000 < P ≤ 3000	240	Forced ventilation
P > 3000	Forced ventilation	

4.9 Where sealed-cell batteries with internal oxygen consumption are used exclusively, the outgoing air duct cross sections may be reduced by half.

5. Miscellaneous

5.1 Charging devices have to be provided which are able to charge the batteries within 10 hours up to 80 % of the battery capacity.

5.2 Storage batteries are to be protected against discharge by reverse current by suitable means in the charging system, and against short circuits by fuses nearby. The fuses must however not be fitted in the battery container or compartment itself. Regarding battery switches see F.3.

5.3 Installation of the appropriate measuring instruments for indicating battery voltage and charging and discharging current is recommended.

The functioning of generators is to be monitored.

5.4 The battery capacity must be designed to be sufficient to supply important users (e.g. navigation lights) for at least 8 hours without a boosting charge.

5.5 Where IC engines are fitted which cannot be started manually, provision of separate batteries for starting and for general use is recommended.

F. Distribution Systems

1. General

1.1 Only those systems are permitted in which all operationally current-carrying conductors are laid insulated. Hull-return systems are only allowed for locally restricted installations, e.g. the electrical equipment of IC engines.

1.1.1 If it is intended to earth the on-board mains, the negative pole of the power supply is to be earthed centrally and open to checking.

Possible earths are the metal hull of the craft, a metal ballast keel not laminated-in or an earthing plate located submerged.

In this context, notes regarding the corrosion protection required for metal components located on the submerged part of the hull (Section 1, F.) are to be observed.

1.1.2 The standardised voltages 12 and 24 V are preferably to be used for the general on-board mains.

2. Switchboards and switchgear

2.1 Switchboards and switchgear locations are to be easily accessible.

2.2 Switchboard housings are to be made of metal or of a hard-to-ignite and self extinguishing material.

3. Fuses and switches

3.1 A main switch for disconnecting the on-board mains batteries is to be provided close to these. The length of cable between batteries and main switch shall be as short as possible.

3.2 Each generator shall be provided with short-circuit and overload protection.

Deviations are permissible for small installations, comprising of a dynamo and associated governor.

3.3 Fuses acting as overload and short-circuit protection are to be provided in the main switchboard or the distribution boards on the positive pole for each consuming device or user group and in pleasure craft with metal hulls in each non-earthed conductor. Provision of a switch to disconnect the mains is recommended for every user outlet protected by fuses. Fuses are to have an enclosed fuse link.

For non-fused battery outlets, e.g. starter cables, see 4.7.

3.4 Operationally important users are to be individually fused in principle, and if necessary individually switched.

3.5 Position lights and other lights significant for navigation shall be fused and able to be switched independently from other users, at least as a separate group.

4. Cables, lines and laying them

4.1 Cables and insulated lines shall be of a GL-approved make. Examples of such are:

a) cables and lines according to IEC-92 or DIN 89150 and made in accordance with the standards and rules quoted in these.

b) VDE- and DIN types of lines, e.g.:

- HO7 RN-F in accordance with DIN 57282 VDE 0282
- HO5 VV-F in accordance with DIN 57281 VDE 0281
- HO7 V-K in accordance with DIN 57281 VDE 0281
- YSLY or NYSLY
- YSLYCY or NYSLYCYÖ

The conductors in the cables must be of electrolytic copper and multi or fine stranded.

4.2 Cables and lines must not be loaded and fused above the values given in Table 4.2.

In the case of lengthier cable runs, permissible voltage-drops are to be taken into account.

Permanently installed power cables shall have a minimum cross sectional area of 1,5 mm^2; control cables of 0,75 mm^2.

Table 4.2 Conductor cross-sectional area, allowable continuous current and stranding

Cross-sectional area mm^2	Maximum current, in amperes, for single conductors at insulation temperature ratings						Minimum number of strands	
	60 °C	70 °C	85 °C to 90 °C	105 °C	125 °C	200 °C	Type 1 [1]	Type 2 [1]
0,75	8	10	12	16	20	25	16	—
1	12	14	18	20	25	35	16	—
1,5	16	18	21	25	30	40	19	26
2,5	20	25	30	35	40	45	19	41
4	30	35	40	45	50	55	19	65
6	40	45	50	60	70	75	19	105
10	60	65	70	90	100	120	19	168
16	80	90	100	130	150	170	37	266
25	110	120	140	170	185	200	49	420
35	140	160	185	210	225	240	127	665
50	180	210	230	270	300	325	127	1 064
70	220	265	285	330	360	375	127	1 323
95	260	310	330	390	410	430	259	1 666
120	300	360	400	450	480	520	418	2 107
150	350	380	430	475	520	560	418	2 107

[1] Conductors with at least type 1 stranding shall be used for general craft wiring. Conductors with type 2 stranding shall be used for any wiring where frequent flexing is involved in use.

4.3 Cable cross sections for the electric starters of IC engines are to be dimensioned in accordance with the data furnished by the engine manufacturer.

Table 4.2 gives allowable continuous current ratings in amperes determined for 30 °C ambient temperature.

For conductors in engine rooms (60 °C ambient), the maximum current rating in Table 4.2 shall be derated by the factor below:

Table 4.3

Temperature rating of conductor insulation °C	**Multiply maximum current by**
70	0,75
85 to 90	0,82
105	0,86
125	0,89
200	1

4.4 The voltage drop between power source and consuming device must not exceed 7 %; for navigation lights 5 % respectively.

4.5 Cables and lines are to be so laid and fastened that the movements of the craft cannot cause them to shift, and that they are not exposed to unacceptable ambient temperatures.

They are to be laid at a safe distance from exhaust ducts and other sources of heat.

4.6 Non-fused cables, e.g. battery cables, are to be laid safe from short circuits, i.e. they must be laid in such a way that the possibility of a short circuit can be excluded even if the insulation should fail.

4.7 Multi-core cables or lines are preferably to be used.

4.8 Cables and lines must be hard-to-ignite and self-extinguishing.

5. Cable accessories and installation material

5.1 Cable and line connections shall, in principle, be made by using terminals with core protection, or via screwed connections by means of crimped lugs. Soldered connections must not be used.

5.2 Cable feed-throughs passing decks and watertight bulkheads shall have stuffing boxes or be sealed by means of a GL-approved pourable sealing compound.

6. Shore connection

6.1 Shore connection voltage ≤ 50 V

On-board mains voltage ≤ 50 V

The connection on board is to be made via a plug and socket. Protection shall be in accordance with C.2. but at least IP 23.

An information plate is to be fitted with data on permissible supply voltages, frequencies, current type and amperage.

The shore connection is to have overload and short circuit protection. There must be an indication whether the connection is live.

6.2 Shore connection voltage > 50 V

On-board mains voltage ≤ 50 V

Additionally to 6.1, a galvanic separation is to be fitted between shore and on-board mains, and the plug and socket shall have an earthing contact.

6.2.1 If individual users are fed at voltages exceeding 50 V via the shore connection, an earth-leakage circuit breaker shall be provided between the on-board plug and socket and the downstream users. The fault earth-leakage circuit breaker shall switch off the entire system if a rated fault current $I_{\Delta n} \leq 30$ mA is reached.

G. Spares

1. Spares

It is recommended that the following spares be taken on board:

1 set of electric bulbs for navigation lights

1 set of fuses unless all appliances are protected by automatic cut-outs.