Annex F

Notes and Tables

A. Lightning Protection

1. Notes on the design of lightning protection installations on FRP recreational craft

1.1 General

A lightning strike in principle corresponds to a brief direct current shock whose strength may range from 10000 A to several 100000 A. Most discharges, about 80 %, are of current strengths below 60000 A.

The probability of lightning current strengths exceeding 250000 A is very low. However as the possibility of very high currents of around 200000 A occurring cannot be totally excluded, material used for lightning conductor systems shall be capable of withstanding the thermal and dynamic effects even of high lightning currents to guarantee the desired protection for people and objects. The following notes assume that the craft is afloat.

The notes apply only to so called "external lightning protection".

Overvoltage protection of (e.g.) electronic resources is not the subject of these notes.

2. Definitions

2.1 Lightning protection installation is the sum of arrangements for the external and internal protection of structural works against lightning.

2.2 External lightning protection is the sum of arrangements laid and existing on and below deck to trap the lightning current and deflect it into the water.

2.3 Internal lightning protection is measures against the high lightning overvoltages and the electromagnetic fields of lightning currents.

2.4 Earth: this always means the water or the metal surfaces arranged below waterline to discharge the lightning current into the water.

2.5 Earth connections are metal surfaces in the underwater part of the craft, such as earth plates, a metal ballast keel not laminated in, a metal centreboard, which

2.5.1 are connected to the trapping arrangement and

2.5.2 are suitable for discharging the lightning current into the water.

2.6 Trapping arrangement is the sum of the above deck metal components which can serve as points for the lightning to strike.

2.7 Protected zone is the space considered protected against lightning strike by a trapping arrangement.

2.8 Angle of protection is the angle to the vertical through any point of a trapping arrangement.

2.9 Discharge line is a metal connection between a trapping arrangement and an earth connection.

2.10 Potential equalisation is the unbroken linking of metal installations and electrical appliances to the lightning protection installation via leads, separating spark gaps or overvoltage protection equipment. It shall prevent the uncontrolled flashover of lightning from the discharge line to metal equipment in the craft.

2.11 Potential equalisation lead is an electrically conducting link serving to produce potential equalisation.

2.12 Separating spark gap for lightning protection installations is a spark gap for the galvanic separation of installation elements. When lightning strikes, the elements are temporarily electrically connected by triggering of the spark gap.

3. Protected zone

Trapping arrangements have the task of determining the point for lightning to strike, so as to prevent uncontrolled strikes elsewhere.

As both sailing and motor craft normally have a mast, the earthed masthead is most favourably used as the striking point for both crew and craft.

Below the masthead, a conical protected zone is formed whose tip is the earthed masthead. With a mast height up to 20 m above the waterline, the apex angle is about 45° to the vertical.

The mast height, particularly in the case of motor craft, is therefore to be chosen so that the craft, including the superstructures, is in the protected zone over its entire length. With earthed metal masts, or wooden masts with earthed head fittings, whose head is less than 20 m above the waterline, it is considered unlikely that lightning instead of striking the masthead will strike shrouds, stays or superstructure sideways.

4. Lightning protection installation

The lightning protection installation is to be understood as comprising everything above and below deck which serves the safe trapping and discharge of the lightning current.

A lightning protection installation must be installed complete; incomplete lightning protection installations may increase the danger to the persons on board under certain circumstances.

4.1 External lightning protection

4.1.1 Trapping arrangements

Masts of electrically non conducting material shall have a trapping device on the masthead, in the form of a metal rod at least 8 mm in diameter and projecting at least 300 mm above the mast.

Metal head fittings may be used as trapping arrangements if they enclose the mast all around and the material is at least 2 mm thick.

Metal masts do not need special trapping arrangements. Aerials, anemometers, etc. located on the masthead and whose operational requirements preclude direct earthing shall be linked to the masthead by separating spark gaps.

4.2 Discharge lines

Flexible copper leads of type NYY, NYAF, H07V-K or equivalent shall be provided as discharge lines.

The discharge lines running to the earth connection shall be as straight as possible. Sharp bends and tight bights of the conductor shall be avoided.

The ohmic resistance between trapping arrangement and earth connection is not to exceed 0,02 Ohm.

4.2.1 Metal masts

Discharge lines shall be provided in the form of a main line from the mast foot plus secondary ones from all chain plates to which shrouds or stays are fastened.

Minimum cross sections:

– main line 25 mm^2

– secondary line 20 mm^2

Non-metallic masts:

With non-metallic masts, shrouds and stays have to be used as main discharge lines. The associated chain plates and any metal mast tracks for sail luffs shall be conductively linked to the earth connection.

Minimum cross sections:

– all discharge lines 16 mm^2

4.3 Earthing arrangements

The discharge lines are to be conductively connected, as close together as possible and in a place easily to be checked to:

– the bolts of a not laminated-in metal keel which are accessible from inside the craft or

– a copper, or equivalent metal plate at least 0,2 [m^2] in area. This plate shall be so located on the shell of the craft that it will remain below the surface of the water at all attitudes and movements of the craft that are to be expected.

To avoid damage to bearings, propeller shafting should not be used for discharging lightning current into the water.

The notes regarding the provision of cathodic protection for submerged metal parts are to be taken into account when arranging earth connections.

5. Internal lightning protection

If lightning strikes there is a risk of parts of the charge sparking-over to metal appliances in the vicinity of lightning protection arrangements.

To eliminate this risk all major metal parts on and below deck, such as bow and stern pulpits, stern tubes, steering gear, pipelines, metal wash basins and toilets, metal tanks plus the electric system (e.g. battery negative pole) are to be conductively linked to the earth connection of the lightning protection installation to provide potential equalisation. For this, copper conductors with a minimum cross section of 4 mm^2 shall be used.

If direct connection of certain appliances or equipment to the earthed lightning protection installation is not possible for operational reasons, arresters or closed separating spark gaps shall be inserted.

6. Joints

Standard commercial lightning conductor terminals or equivalent means are preferably to be used as connectors for the discharge lines.

Connecting devices as used for electrical installations are unsuitable because they will not withstand the dynamic and thermal stresses to be expected from a lightning strike.

Equally unsuitable are soft soldered joints, twist joints and ones with grub screws, plus joints connecting different materials which because of elemental interaction might lead to corrosion.

7. Setting-up a lightning protection installation

In view of the variety of possible versions, it is strongly recommended that the advice of an expert firm be sought when setting-up a lightning protection installation.

Table F.1 Anchors, anchor cables and lines of sailing craft and motorsailers

Equipment numeral Z [m³]	Deplacement D [t]	Weight of		Anchor cable		Towing line	
		1. anchor [3] [kg]	2. anchor [kg]	Length [4] [m]	Nominal thickness [1] [mm]	Length [m]	Nominal diameter [2] [mm]
—	up to 0,15	2,5	—	—	—	5 L_{WL}	12
—	at 0,20	3,0	—	—	—		12
—	at 0,30	3,5	—	—	—		12
—	at 0,40	4,5	—	—	—		12
—	at 0,50	5,0	—	—	—		12
—	at 0,60	5,5	—	—	—		14
—	at 0,75	6,5	—	—	—		14
—	at 1,00	7,5	—	—	—		14
—	at 1,50	8,7	—	—	—		14
up to 10	at 2,00	10,5	9,0	22,5	6,0		16
at 15	at 3,00	12,0	10,0	24,0	6,0		18
at 20	at 4,00	13,0	10,5	25,0	6,0		18
at 25	at 5,00	13,5	11,0	26,0	7,0		18
at 30	at 6,00	15,0	13,0	27,0	7,0		18
at 40	at 8,00	17,0	15,0	29,0	8,0		20
at 55	at 12,00	21,0	18,0	32,5	8,0		22
at 70	at 17,00	25,0	21,0	36,0	9,0		22
at 90	at 23,00	29,0	25,0	40,0	10,0	4,75 L_{WL}	22
at 110	at 29,00	34,5	29,0	43,0	10,0		24
at 130	at 36,00	40,0	34,0	47,0	11,0	4,5 L_{WL}	24
at 155	at 44,00	46,5	40,0	52,5	13,0		24
at 180	at 52,00	53,0	45,0	57,0	13,0		24
at 210	at 57,00	62,0	53,0	62,0	13,0		26
at 245	at 72,00	73,5	62,0	68,0	14,0		26
at 280	at 84,00	84,0	71,0	74,0	16,0	4,25 L_{WL}	26
at 300	at 100,00	95,0	81,0	78,0	16,0		26

Z Equipment numeral in accordance with Section 1, G.

1 Nominal thickness of round bar steel chain in accordance with DIN 766, ISO 4565, EN 24565.

2 3-strand hawser-lay polyamide line in accordance with DIN 83330.

3 May be reduced by 25 % if the craft in question operates exclusively on inland waterways (Operating Category V) where strong currents and high seas can be excluded. A stock anchor of 1,33 times the weight may be used.

4 Applies for one anchor in each case.

Table F.2 Anchors, anchor chains and lines of motor craft

Equipment numeral Z [m^3]	Deplacement D [t]	Weight of 1. anchor [3] [kg]	Weight of 2. anchor [kg]	Anchor cable Length [4] [m]	Anchor cable Nominal thickness [1] [mm]	Towing line Length [m]	Towing line Nominal diameter [2] [mm]
—	up to 0,15	2,5	—	—	—		12
—	at 0,20	3,0	—	—	—		12
—	at 0,30	3,5	—	—	—		12
—	at 0,40	4,5	—	—	—		12
—	at 0,50	5,0	—	—	—		12
—	at 0,60	5,5	—	—	—		14
—	at 0,75	6,5	—	—	—		14
—	at 1,00	7,5	—	—	—		14
—	at 1,50	8,7	—	—	—	5 L_{WL}	14
up to 10	at 2,00	9,0	—	20,0	6,0		16
at 15	at 3,00	10,0	—	22,0	6,0		18
at 20	at 4,00	11,0	—	23,0	6,0		18
at 25	at 5,00	12,0	—	24,0	6,0		18
at 30	at 6,00	13,0	—	25,0	7,0		18
at 40	at 8,00	14,0	12,0	26,0	7,0		20
at 55	at 12,00	18,0	15,0	29,0	8,0		22
at 70	at 17,00	21,0	18,0	32,5	8,0		22
at 90	at 23,00	25,0	21,0	36,0	9,0	4,75 L_{WL}	22
at 110	at 29,00	29,0	25,0	38,5	10,0		24
at 130	at 36,00	34,5	29,0	42,0	10,0		24
at 155	at 44,00	40,0	34,0	47,0	11,0		24
at 180	at 52,00	46,0	39,0	51,0	13,0	4,5 L_{WL}	24
at 210	at 57,00	52,5	44,0	55,5	13,0		26
at 245	at 72,00	61,0	52,0	61,0	13,0		26
at 280	at 84,00	70,5	60,0	66,5	14,0	4,25 L_{WL}	26
at 300	at 100,00	79,5	67,5	70,0	16,0		26

Z Equipment numeral in accordance with Section 1, G.

[1] Nominal thickness of round bar steel chain in accordance with ISO 4565, EN 24565, DIN 766.

[2] 3-strand hawser-lay polyamide line in accordance with DIN 83330.

[3] May be reduced by 25 % if the craft in question operates exclusively on inland waterways (Operating Category V) where strong currents and high seas can be excluded. A stock anchor of 1,33 times the weight may be used.

[4] Applies for one anchor in each case.

Table F.3 Notes regarding the selection of synthetic fibre ropes

1. Characteristic values and trade names

Material Letter symbol	**Polyamid PA**	**Polyester PES**	**Polypropylene PP**
Trade name	Perlon Nylon	Trevira	Poly
		Diolen	Polyprop
		Terylene	Hostalen
Density [kg/dm³]	1,14	1,38	0,19
Elongation at break [%]	35 – 50	20 – 40	20 – 40
Melting point [°C]	225 – 250	260	163 – 174
Light toughness	good	very good	good only if UV stabilised

2. Mechanical properties of 3-strand hawser-lay ropes

Polyamide ropes [1]		**Polyester ropes** [2]		**Polypropylene ropes** [3]	
Nominal diameter	**Minimum breaking** [4] **strength**	**Nominal diameter**	**Minimum breaking** [4] **strength**	**Nominal diameter**	**Minimum breaking** [4] **strength**
[mm]	**[kN]**	**[mm]**	**[kN]**	**[mm]**	**kN**
6	7,35	6	5,80	6	5,90
8	13,20	8	10,50	8	10,40
10	20,40	10	16,80	10	15,30
12	29,40	12	24,00	12	21,70
14	40,20	14	33,70	14	29,90
16	52,00	16	43,40	16	37,00
18	65,70	18	54,80	18	47,20
20	81,40	20	68,20	20	56,90
22	98,00	22	82,00	22	68,20
24	118,00	24	98,50	24	79,70
26	137,00	26	115,50	26	92,20

1 In accordance with DIN 83330.

2 In accordance with DIN 83331.

3 In accordance with DIN 83332.

4 The minimum breaking strength is reduced by the following operational influences.
- Splicing (approx. 10 %)
- Solar radiation
- Internal heating as a result of work
- External heating due to friction (hawsepipe, capstan drum, etc.)
- If lines are knotted, a 50 % loss of strength shall be taken into consideration.
- Polyamide rope tractive power reduces by 10 – 15 % when wet.

Care for synthetic fibre ropes calls for attention as follows:

Stowage below deck, once at sea (solar radiation).

Do not stow near heating appliances.

From time to time inspect ropes carefully for internal and external defects. In heavily stressed lines, the material can be broken down by internal friction (heat), which may also become evident by pulverisation between the strands. Polyamide ropes may harden.

Replace defective thimbles. Splice-in loose thimbles afresh and seize-in firmly.

1. Comments on Table F.4

Where determination of component dimensions gives figures other than whole or half millimetres, these may be rounded down up to 0,2/0,7 to whole or half millimetres; above 0,2/0,7 they shall be rounded up.

2. Section moduli

The section moduli of frames, girders, stiffeners and other components based on sections, determined in accordance with the dimensioning precepts of the Construction Rules apply to the sections in combination with the plate to which they are welded or rivetted. For selection of the section required, the Tables of section moduli that follow may be used without specially determining the effective width of plate. The section moduli may only be used in conjunction with the GL Construction Rules. The section moduli listed are based on the assumption that the thickness of the load supporting plate is $40 \cdot s$ (s = thickness of section web).

The section dimensions stated only apply to angles in accordance with DIN 1028 and 1029, bulb angle bar in accordance with DIN 1020 and bulb plate in accordance with DIN 1019, delivered from German steel works. If other sections, not standardised in Germany, are used GL is to be provided with precise dimensions and section moduli of these.

Table F.4 Section moduli with plate as flange

Section modulus [cm^3]	Sections with plate in [mm]			Bracket dimensions [mm]
5	— 40 x 20 x 4		— 50 x 5 — 60 x 4	
6	— 40 x 25 x 4		— 50 x 6 — 65 x 4	
7	— 50 x 30 x 3		— 60 x 5 — 50 x 7	
8	— 45 x 30 x 4		— 60 x 6	
9	— 50 x 30 x 4 — 45 x 30 x 5		— 80 x 4 — 65 x 6	
10	— 50 x 40 x 4		— 60 x 8	
11	— 50 x 30 x 5 — 60 x 30 x 4	— 60 x 4	— 80 x 5 — 65 x 7	
12		— 60 x 5	— 75 x 6	
13	— 50 x 40 x 5		— 65 x 8 — 90 x 5	
14	— 60 x 30 x 5	— 60 x 6	— 75 x 7	
15			— 80 x 7	
16	— 60 x 40 x 5		— 75 x 8	
17				
18				
19	— 60 x 30 x 7 — 60 x 40 x 6		— 75 x 9	
20		— 80 x 5	— 100 x 6	
21	— 60 x 50 x 5		— 75 x 10	
22	— 60 x 40 x 7			
23		— 80 x 6	— 90 x 8	
24				

Table F.4 Section moduli with plate as flange

Section modulus [cm^3]	Sections with plate in [mm]			Bracket dimensions [mm]
25	— 75 x 50 x 5	— 80 x 7		— 100 x 6,5
26			— 90 x 9	
27	— 75 x 55 x 5		— 100 x 8	
28				
29	— 80 x 40 x 6 — 65 x 50 x 7		— 90 x 10	
30				
31			— 100 x 9	— 110 x 6,5
32			— 110 x 8	
33			— 90 x 11	
34		— 100 x 6		
35	— 75 x 50 x 7		— 100 x 10	
36	— 65 x 50 x 9		— 90 x 12	
37	— 75 x 55 x 7 — 80 x 40 x 8		— 110 x 9	— 120 x 6,5
38		— 100 x 7	— 120 x 8	
39	— 80 x 65 x 6		— 100 x 11	
40				
41				
42		— 100 x 8	— 100 x 10	— 130 x 6,5
43	— 90 x 60 x 6			
44	— 75 x 50 x 9		— 120 x 9	

B. Example

1. Form F 146

Plans and Technical Data for Yachts and Small Craft

Germanischer Lloyd

Page: 1

To ensure compliance with the Rules the following drawings and documents are to be submitted in triplicate showing the arrangement and the scantlings of structural members

Project: _____

Distribution 1.: _____

2.: _____

3.: _____

Journal No.: _____

Hull

- ☐ Midship section, other sections and bulkheads
- ☐ Longitudinal section, shell
- ☐ Deck, superstructures and cabins
- ☐ Fuel and water tanks where integral with hull
- ☐ Machinery seatings
- ☐ Rudder blade with stock, trunk and bearings
- ☐ Propeller brackets
- ☐ Laminate construction [1]
- ☐ Material specification
- ☐ Welded connections
- ☐ Closures, details at GL-form F 434 [2]
- ☐ Anchoring equipment
- ☐ Sailplan with details on standing rigging

  Drawings showing mast and main boom cross-sections, including details on section moduli and moments of inertia, materials, mast fittings, eye plates (including fittings for total fore and aft stays), terminals, turnbuckles, shackles, as far as serving for connection of standing rigging; details of hydraulic equipment, righting lever curve, displacement).
- ☐ Stability calculation or stability tests for vessels **L** < 10 m, inclining test for vessels **L** ≥ 10 m, tests of the turning-circle angle of heel for motor vessels **L** ≥ 10 m.
- ☐ Cooking appliances with open flame, materials, arrangement sketch
- ☐ General arrangement (for information only) one fold
- ☐ Lines plan (for information only), one fold

Plans and Technical Data for Yachts and Small Craft

Germanischer Lloyd

Page: 2

Machinery and Electrical Installations [3]

- ☐ Arrangement of propulsion plant
- ☐ Propeller shaft and sterntube
- ☐ Type, capacity and installation drawing of transverse thruster
- ☐ Plumbing installation and fuel systems
- ☐ Fuel and water tanks
- ☐ Type and drawing of anchor windlass [4]
- ☐ Type and drawing of steering gear scheme of hydraulic system
- ☐ Engine exhaust system
- ☐ Electrical installation on form F 145
- ☐ Basic-circuit diagram of the electrical installation with indication of fuse rating currents and switch gear

Other particulars to be submitted:

Remarks:

Additional information, however, may be required to define the structure and arrangements to the necessary detail. Where the hull scantlings are being determined by direct calculation rather than extracted from the published Rules, the calculations are to be submitted. The drawings must contain details on the main scantlings of the yacht, full details on its structure, equipment, scantlings of the hull structural elements and their materials.

Footnotes:

1 For FRP hulls the following materials are to be specified: Gelcoat, resin, fibre reinforcement materials, core materials of sandwich components and plywood of structural elements. Laminating process to be indicated.

2 It is advisable to have the closing condition examined at as early a state of construction as possible.

3 For motor yachts in service range I and II the rules for machinery installations of seagoing ships are applicable.

4 Required for anchor weights exceeding 50 kg.