Annex C

Excerpts from the Rules for Materials

A. General

1. Materials for the structural and equipment components dealt with in these Rules for Classification and Construction, I – Ship Technology, Part 3 – Special Craft, Chapter 3 – Yachts and Boats up to 24 m, shall comply with the latest version of the Rules for Classification and Construction, II – Materials and Welding, Part 1 and 2). Excerpts are given here.

The materials must satisfy the requirements which follow, and be tested in accordance with D. and approved. Materials whose properties differ from those in these rules may only be used with special permission.

2. Materials complying with national or international standards and manufacturers' requirements may be used if their properties are equivalent to those in these rules and GL approves their use.

3. GL reserve the right to extend the scope of testing, and to subject to it even materials or components for which testing is not specifically required in these rules.

4. By carrying out tests, GL does not provide any guarantee that a consignment which has only been checked by random sampling or workpieces tested in a prescribed place will comply in all parts with the GL rules and guidelines, or the delivery conditions.

Materials or components which during the subsequent processing turn out to be defective may be rejected even if they have passed an earlier test satisfactorily.

5. The maintenance of the dimensions, qualitative and other requirements of these Rules is the responsibility of the manufacturer. This applies even if GL carries out tests.

6. Each product shall be provided with a material schedule from which all data needed for identification of the material may be obtained, such as type of material, method of manufacture and maker's number, number, delivery form, dimensions, etc., and in which the manufacturer and/or supplier confirms that the material has as far as necessary been produced in accordance with an approved procedure and complies with the GL Rules.

7. Materials or components shall be so labelled that the surveyor can check their compliance with the material schedule.

B. Steels and Non-Ferrous Metals

1. Selection of material

1.1 Steel and non-ferrous metals recommended for use are those suitable for sea water without special corrosion protection. This includes stainless steels with a pitting resistance equivalent (W) exceeding 25 (W = % Cr + 3,3 % Mo) and some non-ferrous, copper and nickel based metals. These materials are sensitive to crevice corrosion and pitting and must not be coated without cathodic protection.

Ship steels, general purpose structural steel, aluminium alloys and most copper and nickel alloys must be provided with suitable corrosion protection. Maintenance of this protection is in the responsibility of the owner of the craft.

1.2 The materials used for welded structures shall be suitable for welding, and the welding fillers must match the base material in accordance with the manufacturer's instructions. In scantling determination, account shall be taken of the possibility that the mechanical properties of some materials are impaired by welding.

1.3 Combination of materials shall be chosen to minimise the potential difference, so that contact corrosion is avoided. The stated potential values are only for reference, as changes in environmental conditions, heat treatment, welding and deformation can change them. The rate of corrosion amongst other things depends on the surface conditions and the possible formation of a protective layer. Contact corrosion can be prevented by cathodic protection.

1.4 In the case of metallic structural components and equipment items, such as shaft brackets, rudder stocks of FRP hulls and wood in FRP craft crevice corrosion in particular must be prevented, i.e. the penetration of moisture into the gap between metal and FRP is to be prevented. The parts are to be assembled using permanently elastic sealant.

Table C.1: Ship steel and comparable structural steel (specification excerpts) [1]

Ship steel [1]			Comparable structural steel to EN 10025 or Steel-Iron Material leaflet 089-70			
Quality	**Minimum yield strength [N/mm²]**	**Tensile strength [N/mm²]**	**Steel type**	**Yield strength R_{eH} [N/mm²]**		**Tensile strength R_m**
				t ≤ 16 mm	**16 < t ≤ 40 mm**	**[N/mm²]**
GL–A GL–B	235	400 – 490	Fe 430 B Fe 360 B	275 235	265 225	410 – 540 340 – 470
GL–D			Fe 430 C Fe 360 C			
GL–E			(TT) StE 285 (TT) StE 255	285 [2] 255 [2]		390 – 510 360 – 480

[1] The various quality grades of ship steel within a strength group differ mainly by their specified toughness, see also GL Materials Rules. In general, 'A' quality steels are used for building yachts.

For welded components more than 30 mm thick subject to increased stress at low operating temperatures, tougher 'B', 'D' and 'E' quality steels are to be used as a safeguard against brittle fracture.

[2] Product thickness t ≤ 35 mm

Table C.2: Mechanical properties of austenitic stainless steels (specification excerpts)

Material No.	Designation according to DIN 17440	Tensile strength R_m [N/mm²]	Yield strength $R_{p0,2}$ [N/mm²]
1.4306	X2CrNi1911	450 – 700	215
1.4404	X2CrNiMo17132	450 – 700	235
1.4435	X2CrNiMo18143	450 – 700	235
1.4438	X2CrNiMo18164	500 – 700	235
1.4439	X3CrNiMoN17135	600 – 800	315
1.4541	X6CrNiTi1810	500 – 750	245
1.4462	X2CrNiMoN22	680 – 880	480
1.4571	X6CrNiMoTi17122	520 – 670	220
The materials listed are suitable for service under the influence of sea water or marine atmosphere			

Table C.3:

Material No.	Designation according to DIN 17440	Sweden SS	USA AISI / SAE
1.4306	X2CrNi1911	2333	340 L
1.4404	X2CrNiMo17132	2348	316 L
1.4435	X2CrNiMo18143	2353	316 L
1.4438	X2CrNiMo18164	2367	317 L
1.4439	X3CrNiMoN17135		
1.4541	X6CrNiTi1810	2337	321
1.4462	X2CrNiMoN225	2324	329
1.4571	X6CrNiMoTi17122	2350	316 Ti

Table C.4: Material condition and mechanical properties of sheet aluminium

Material designation according to		Condition	Thickness range [mm]		Tensile strength R_m min.	Yield point $R_{p0,2}$ min.	Elongation at fracture min.	Hardness HB 2,5/62,5
DIN 1725 Part 1	ISO R 209		over	up to	[N/mm²]	[N/mm²]	[%]	
Al Mg 3	AlMg3	cold rolled (¼ hard)		6,0	220	165	9	65
		hot rolled [1]	6,0	10,0	210	140	12	60
		hot rolled [1]	25,0	50,0	190	80	12	50
AlMg4,5Mn	AlMg4, 5Mn	soft	—	50,0	270	125	17	70
		hot rolled [1]	2,0	30,0	275	125	12	70
		heat treated (¼ hard)	2,0	40,0	310	205	10	85
AlMgSi1	AlSi1MgMn	cold age hardened	3,0	20,0	205	110	14	65
		heat treated	3,0	20,0	275	200	12	85
		heat treated	10,0	20,0	295	245	9	95

[1] Hot rolled may contain a lower cold working proportion

Table C.5: Mechanical properties of extruded aluminium sections suitable for sea water

Symbol [1]	**Material number** [1]	**Material condition**	**Wall thickness [mm]**	**Tensile strength R_m min. [N/mm²]**	**Yield strength $R_{p0,2}$ min. [N/mm²]**	**Elongation at break min. [%]**
3.3535.08	AlMg3F18	extruded	any	180	80	14
3.3547.08	AlMg4,5MnF27	extruded	any	270	140	12
3.3206.71	AlMgSi0,5F22	heat treated	any	215	160	12
3.2315.81	AlMgSi1,F28	heat treated	up to 10	275	200	12
3.2315.72	AlMgSi1,F31	heat treated	up to 20	310	260	8

[1] In accordance with DIN 1748, Part 1 or DIN 1746, Part 1.

Table C.6: Material designation

Type	**Ing. Leg. Register**	**ISO**	**D DIN**	**E UNE**	**F NF**	**GB BS**	**I UNI**	**S. SIS-MNC**
AlMgSi0,5	6060	AlMgSi	AlMgSi0,5	L–3442	6060	—	9006/1	144103
AlSi1MgMn	6082	AlSi1MgMn	AlMgSi1	L–3453	6082	6082	9006/4	144212
AlMg3	5754	AlMg3	AlMg3	L–3390	5754	—	—	—
AlMg4,5Mn	5083	AlMg4,5Mn0,7	AlMg4,5Mn	L–3321	5083	5083	9005/5	144140

Table C.7: Timber durability groups and characteristic values in accordance with DIN 68364

Wood type	Durability Group [1]	Bulk density [2]	Mean breaking strengths [3]			Young's modulus		Shear modulus	Transverse contraction
			Tension	Compression	Bending	E_L long.	E_T rad.	G_{LT} [3]	μ_{TL}
		[g/cm³]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	
Coniferous									
European spruce	4	0,47	80	40	68	10000	800	600	0,33
Fir	4	0,47	80	40	68	10000			
Pine	3 – 4	0,52	100	45	80	11000	1000		0,30
Oregon pine	3	0,54	100	50	80	12000	900	800	0,46
Larch	3	0,59	105	48	93	12000			
Spruce	4	0,47	85	35	65	9500	870	680	0,34
Deciduous									
Khaya-Mahogany	3	0,50	75	43	75	9500	1040	830	0,59
True-Mahogany	2	0,54	100	45	80	9500	990	770	0,44
Sapele-Mahogany	3	0,64	85	57	69	9800			
Sipo-Mahogany (Utile)	2	0,59	100	58	100	11000	1300	1140	0,53
Meranti, red	3	0,59	129	53	105	13000	1250		
Iroko	1 – 2	0,63	79	55	95	13000	1450	1080	0,59
Makore	1 – 2	0,66	85	53	103	11000	1390	1160	0,42
Oak	2	0,67	110	52	95	13000	1580	1150	
Beech	5	0,69	135	60	120	14000	2280	1640	0,52
Birch	5	0,65	137	60	120	14000	1130	1200	0,36
Ash	5	0,69	130	50	105	13000	1500	880	0,55
Teak	1	0,69	115	58	100	13000	1490	1040	0,55
Yang	3	0,76	140	70	125	16000	1850		

[1] Criterion for the durability group is the service life and the resistance of the wood against fungi and animal pests (but not the marine borer, teredo navalis) in contact with soil under central European conditions; the meanings are:

1 = high resistance
2 = resistance
3 = moderate resistance
4 = little resistance
5 = no resistance

[2] Bulk density in reference atmosphere standardised condition with 12 % moisture content in accordance with DIN 52183.

[3] In the radial plane.

C. Wood and Timber Products

Timber products for structural members shall meet the following requirements.

Wood and timber products that shall be integral with FRP laminate as load bearing components or be embedded as local reinforcement are subject to individual testing (swelling, shrinkage and durability).

1. Solid wood

1.1 Only timber in durability groups 1, 2 or 3 of Table C.7 may be used for primary structural members and load bearing components of the hull.

1.2 The timbers to be used must be long fibred and of best quality (free from sap, shakes, harmful knots and other defects).

1.3 For components not exposed to water or weather, and without demands on their strength, timber of lower durability may be used.

1.4 Wooden structures must be so designed that the direction of principal stress is also that of maximum mechanical strength of the wood.

1.5 The timber used is to be radially cut(quarter sawn), the angle of the annular rings to the lower cut edge to be not less than 45°.

1.6 When choosing timber, the fact that swelling and shrinkage differ in different directions must be taken into account to prevent components becoming loose and leaks developing at seams or butts.

1.7 Timber differing from that specified in Table C.7 may be used if it can demonstrate equivalent durability.

2. Plywood

2.1 Only GL approved marine plywood (exterior ply) may be used for primary structural members of the hull exposed to atmospheric influence without protection, e.g. decks,.

In accordance with GL test specifications for marine plywood, the following varieties of timber shall be used:

Teak	Tectona grandis
Makoré	Dumoria hekelii
Douka	Dumoria africana
Sipo-Mahogany (Utile)	Entandrophragma utile
Sapele Mahogany	Entandrophragma cylindricum
Oak	Quercus sp.
True Mahogany	Switenia Mahagonimacrophylla
Khaya-Mahogany	Khaja ivorensis
Okumé (Gabun)	Aucoumea Klaineana

2.2 For load bearing internal structural members of FRP hulls, plywood made from timber varieties other than those listed in 2.1 may be used provided it is bonded in accordance with DIN 68705-BFU 100. Timber not in durability groups 1, 2 or 3 according to DIN 68364 shall be bonded according to DIN 68705-BFU 100 G.

Timber in bilges and other wet areas must be permanently protected against moisture.

The mechanical properties and safety factors to be taken into account for scantling determination of internally used plywood shall be agreed with GL.

D. Testing Materials

1. The stipulated tests are carried out on application by the manufacturer of the material; they must be carried out in the manufacturer's premises before delivery. They may be carried out under GL supervision at the manufacurer's or by a test institute recognised by GL (e.g. an official materials testing house).

2. GL may require follow-up tests on the consignment, under its supervision, if the material verification provided for the materials or components is inadequate or they cannot be properly identified.

3. The tests are based on Table C.8.

Table C.8 Scope of materials tests

Type of material	Scope of tests	Type of certificate
Polyester, cold curing	GL-Form F 510	GL material test certificate [1]
Epoxy resin systems, cold curing	GL-Form F 511	
Woven Roving	GL-Form F 516	
Spray roving	GL-Form F 517	
Chopped strand mat	GL-Form F 518	
Woven fabric	GL-Form F 519	
Non woven fabric	GL-Form F 520	
Rigid expanded plastics and other core materials for sandwich construction	GL-Form F 515 [2]	
Ferrous Materials Non-Ferrous Metals	[3]	Acceptance test certificate B to DIN EN 10204-3.1 B
Plywood (exterior ply)	according to GL test rules for Non-metallic materials / Wood, latest version	GL material test certificate [1]
Plywood (interior ply)	[4]	Workshop test certificate DIN EN 10204-2.3

[1] These certificates are issued if tests under GL supervision have proven that the material meets all requirements of these Rules. It is up to the manufacturers of the materials to apply to GL Head Office for approval of their products.

[2] Tests to be agreed with GL Head Office.

[3] Is determined together with approval of the technical construction documentation, taking account of the type of material and its purpose.

[4] Test scope is based on DIN 68705. Tests are to be carried out by an officially approved material test establishment as part of external supervision.

Test standards:

BFU 100: weatherproof bonding for durability-groups I, II or III timber in accordance with DIN 68464.

BFU 100 G: weatherproof bonding with an agent to resist xylophagous fungi added during panel manufacture, for timber not in durability-groups I, II or III in accordance with DIN 68364