中 国 船 级 社

沿海小船建造规范

RULES FOR CONSTRUCTION OF COASTAL BOATS

2005

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北 京
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目　录

第 1 章　通　则

第 1 节　一般规定

1.1.1　适用范围

1.1.1.1　本规范适用于船长 20m 以下海上航行的入级船舶。本规范不适用于下列船舶：

（1）军船；

（2）木质船；

（3）非营业性①游艇；

（4）闪点小于 60℃的油船；

（5）运输危险品船（包括散化船、液化船）；

（6）潜水船舶或半潜水船舶；

（7）小水线面船；

（8）体育运动船；

（9）渔船。

1.1.1.2　适用本规范的小船，其航区营运限制规定如下：

（1）沿海航区营运限制：系指航行于距岸不超过 20n mile 的海域（中国台湾海峡及类似海域距岸不超过 10n mile），船舶满载并以其最大航速的 90％速度航行至庇护地②的时间：对客船不超过 4h，对货船不超过 8h。如上述某些水域的海况较为恶劣，则本社可视其情况对上述距离提出更严格的要求。如船旗国主管机关或其所在营运区的海岸主管机关对该水域有特定距离的规定时，则应根据该主管机关的规定执行。

（2）遮蔽航区营运限制：系指航行于沿海航区内，由海岸与岛屿、岛屿与岛屿围成的遮蔽条件较好、波浪较小的海域。在该海域内岛屿之间、岛屿与海岸之间距离不超过 10n mile；或在距岸不超过 10n mile 的海域（中国台湾海峡及类似海域距岸不超过 5n mile），船舶满载并以最大航速的 90％速度航行，航程时间：对客船不超过 2h，对货船不超过 4h，并限制在蒲氏风级不超过 6 级，目测波高不超过 2m 的海况下航行。

（3）平静水域营运限制：系指航行于距岸不超过 5n mile 的水域，船舶满载并以其最大航速的 90％速度航行，航程时间不超过 2h，并限制在蒲氏风级不超过 6 级，目测波高不超过 1m 的海况下航行。

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① 非营业性游艇系指用于非商业目的的游艇。

② 庇护地系指在船舶处于可能对其安全构成危险的情况下可提供庇护的任何天然或人工的遮蔽地区。

1.1.1.3　敞开艇仅限于在平静水域营运限制条件下营运。高速敞开艇载客不允许超过 12 人。

1.1.1.4　适用本规范的船舶，其材料可为钢质、铝合金或纤维增强塑料。船舶的材料与建造工艺应符合中国船级社（以下简称 CCS 或本社）《材料与焊接规范》的有关规定。

1.1.1.5　适用本规范的机动船舶系指以柴油、汽油或液化石油气（以下简称为 LPG）为燃料的发动机作为主动力的船舶。

1.1.1.6　现有船舶在修理、改装、改建后，至少应满足原先适用相应规范的要求，如重大修理、改装、改建，在合理和可行情况下，应满足本规范的要求。

1.1.1.7　船舶的稳性、消防、救生、通信等安全设备与环保要求应符合船旗国主管机关的有关要求。

1.1.1.8　本规范计算所得的板厚，如小数等于或小于 0.25mm 可予不计；大于 0.25mm 且小于 0.75mm 时，应进为 0.5mm，等于或大于 0.75mm 时，应进为 1.0mm。

1.1.2　定义

1.1.2.1　除另有规定外，本规范采用定义如下：

（1）　**总长** L_{oa}(m)：系指从船舶首柱最前缘量到尾封板或尾柱后缘的距离，不包括其他突出物。

（2）　**船长** L(m)：系指沿满载水线由首柱前缘量至舵柱后缘的长度；对无舵柱的船舶，由首柱前缘量至舵杆中心线的长度。船舶设计为倾斜龙骨时，其计量长度的水线应与设计水线平行。

（3）　**满载排水量**△ (t)：系指船上所有按规定配备的船员、设备、货物、备品、附件及索具等都装备齐全，并装满燃油、滑油、淡水、食品和供应品，额定乘员全部上船，船处于立即可以启航状态时所排开水的重量。

（4）　**满载吃水** d(m)：系指满载排水量静浮水面时，在船长 L 中点处由平板龙骨上缘（对纤维增强塑料船为龙骨下表面）量到满载水线的垂直距离。

（5）　**船宽** B(m)：系指在船舶的最宽处，由一舷的肋骨外缘量至另一舷的肋骨外缘之间的水平距离；对纤维增强塑料船为船体两侧外表面之间的最大宽度，不包括护舷材等突出物。

（6）　**型深** D(m)：系指在船长 L 中点处，沿舷侧由平板龙骨上缘量至上层连续甲板（甲板艇）横梁上缘或舷侧板顶端（敞开艇）的垂向距离；对纤维增强塑料船，由平板龙骨下表面量至上层连续甲板（甲板艇）上缘或舷侧板顶端（敞开艇）的垂向距离。

（7）　**干舷** F(m)：系指在船长 L 中点处，由满载水线量至干舷甲板（甲板艇）上缘或舷侧板顶端（敞开艇）的垂向距离。

（8）　**干舷甲板**：系指甲板艇上自首至尾的露天连续甲板。

（9）　**高速船**：系指其满载排水量时的最大航速 V 同时满足下列两式的船舶：

$$V \geqslant 3.7\nabla^{0.1667} \quad m/s$$

$$V \geqslant 10 \quad kn$$

式中：▽——满载排水量△对应的排水体积，m^3；

V——船舶满载排水量时以核定的最大持续推进功率在静水中航行能达到的航速。

（10）**最大航速**：系指船舶满载排水量时以核定的最大持续推进功率在静水中航行能达到的航速。

（11）**游艇**：系指用于娱乐、休闲或观光的营业性船舶。

（12）**甲板艇**：系指从首至尾具有风雨密的连续露天甲板的船舶。

（13）**敞开艇**：系指从首至尾不具有风雨密的连续露天甲板的船舶。

（14）**公务艇**：系指用于执行水上公务的工作艇，如巡逻艇、缉私艇、海监艇等。

（15）**客船**：系指乘客超过 12 人的船舶。

（16）**乘客**：系指除下列人员以外的每一个人。

① 船长、船员和在船上以任何职业从事或参与该船业务工作的人员；

② 1 周岁以下的儿童。

（17）**货船**：系指非客船的任何船舶。

1.1.3　等效与免除

1.1.3.1　对于具有新型结构和新型特性的任何船舶，如应用本规范的任何规定会严重妨碍这些船舶对其特性的应用或这些船舶的营运时，经 CCS 总部同意，可免除规范的任一要求。

1.1.3.2　船上安装的任何装置、材料、设备和器具可以代替 CCS 规范要求的装置、材料、设备和器具，条件是经试验和其他方法证明认定这些装置、材料、设备和器具至少与本规范要求具有同等效能。

1.1.3.3　若对规范要求的计算方法、评定标准、制造程序、材料、检验和试验方法，能提供相应的试验、理论依据、使用经验或有效的公认标准，经 CCS 总部同意，可以接受作为代替和等效方法。

1.1.4　规范解释

1.1.4.1　本规范的解释权属本社总部。

1.1.4.2　如对本规范的英文版本发生歧义，应以中文版为准。

1.1.5　法定检验

1.1.5.1　根据船旗国政府的授权，以及船东或设计单位或建造厂的申请或合同／协议，CCS 将承担部分或全部的船舶法定检验。

1.1.5.2　对拟申请 CCS 的入级船舶，同时 CCS 被授权进行法定检验时，CCS 将对船舶的入级与法定检验结合进行。

1.1.5.3　经 CCS 设计评审、建造中检验和建造后检验，确认入级部分已符合 CCS 入级规范的要求，并满足相应的法定要求，CCS 将签发相应的法定证书和 / 或报告。

1.1.5.4　由 CCS 进行入级与法定检验的船舶，如入级证书失效，则相关的法定证书也同时失效。

1.1.5.5　根据客户的申请或合同 / 协议，CCS 也可承担有关的法定检验。

1.1.5.6　经 CCS 设计评审、建造中检验和建造后检验，确认入级部分已符合 CCS 入级规范的要求，并满足相应的法定要求，CCS 将签发相应的符合证明和 / 或报告。

第 2 节　检验与证书

1.2.1　检验的类别

1.2.1.1　船舶的检验类别分为：

(1)　初次检验，包括：

① 新建船舶的建造检验；

② 现有船舶的初次检验（包括建造时不是由 CCS 按照本规范进行设计评审和检验，其后经 CCS 进行检验认为其符合本规范的规定）。

(2)　建造后检验，包括：

① 年度检验；

② 上排 / 坞内检验；

③ 特别检验；

④ 临时检验。

1.2.1.2　在本节所列各种检验项目中，可按各种船的具体情况进行适用项目的检验。

1.2.2　证书的签发

1.2.2.1　船舶经初次入级检验，认为其符合本规范的有关规定和其他要求时，将授予船级符号和相应附加标志，并签发船级证书。

1.2.2.2　船级证书的有效期对客船不超过 2 年，对高速船不超过 5 年，对货船不超过 5 年。

1.2.3　建造后检验的间隔期

1.2.3.1　已取得船级证书的船舶，应按规定的间隔期和本节 1.2.6 ～ 1.2.8 规定的内容进行建造后检验。

1.2.3.2　年度检验应于证书的每周年前、后 3 个月内进行。经检验合格，验船师在相应证书上签署，确认证书在规定期限内继续有效。

1.2.3.3　上排 / 坞内检验对于客船每 2 年进行 1 次，对高速船一般应每年 1 次，对货船 5 年内应不少于 2 次，最长间隔不大于 3 年，但其中 1 次应在特别检验时进行。经检验合格，验船师在相应证书上签署，确认证书在规定期限内继续有效。

1.2.3.4　特别检验的间隔期对客船不超过 2 年，对高速船不超过 5 年，对货船不超过 5 年。经检验合格，换发新的相应证书。如在特别检验到期日还未完成特别检验，经同意，可给予不超过 3 个月的展期。

1.2.3.5　特别检验可与年度检验、坞内检验结合进行。

1.2.3.6　船舶出现下列情况之一时，应申请临时检验。检验合格，由验船师在相应证书上签署，确认证书在规定期限内继续有效：

(1)　发生事故，影响船舶适航性时；

(2)　改变船舶证书所限定的用途或航区时；

(3)　证书失效时；

(4)　船舶所有人或经营人变更、船名变更或船籍港的变更时；

(5)　涉及船舶安全的修理或改装时。

1.2.3.7　船舶如未按证书规定的营运条件营运或未按规定作建造后检验，证书自行失效。

1.2.4　入级船舶的船级符号与附加标志

1.2.4.1 凡申请本社检验并经批准的船舶，由本社分别授予下列船级符号：

★ CSAD

<u>★</u> CSAD

入级符号含义如下：

★ — 表示船舶在建造时由 CCS 按照本规范进行设计评审和检验，且符合本规范的规定；

<u>★</u> — 表示船舶在建造时不是由 CCS 按照本规范进行设计评审和检验，其后经 CCS 进行检验认为其符合本规范的规定；

CSAD — 表示船舶的结构与设备完全符合本规范的规定，且适合于国内水域航行。

1.2.4.2　根据船的具体情况在船级符号后加注船舶类型附加标志和营运限制类别附加标志。

(1)　船舶类型附加标志见表 1.2.4.2（1）。

(2)　营运限制附加标志见表 1.2.4.2（2）。

船舶类型附加标志　　　　　　表 1.2.4.2（1）

船舶类型	附加标志
小型客船	Passenger Boat
小型货船	Cargo Boat
小型非机动船	Non-propulsion Boat

营运限制附加标志　　　　　　表 1.2.4.2（2）

营运限制	附加标志
沿海航区营运限制	Coastal Service Restriction
遮蔽航区营运限制	Sheltered Service Restriction
平静水域营运限制	Calm Water Service Restriction

1.2.4.3　符合本规范规定的高速船，本社将尚应在船舶类型附加标志后加注“HSC”。

1.2.4.4　符合本规范第 6 章规定的液化石油气动力船舶，本社将授予液化石油气动力附加标志 LPG。

1.2.5　初次检验

1.2.5.1　船舶建造前应按本节规定将图纸资料一式 3 份送本社审查。

1.2.5.2　批准的图纸仅在审图申请书上规定的建造艘数范围内有效。批准图纸的有效期限为 4 年。

1.2.5.3　应视情况将下列图纸资料提交本社批准：

*(1) 总布置图；

*(2) 基本结构图（包括主要横剖面结构、首尾结构、舱壁、甲板、上层建筑、典型结构节点图等）；

(3) 铺层设计图；

（4）外板展开图；

（5）焊接方式和规格；

(6) 主机座和齿轮箱座结构图；

(7) 船体建造原则工艺说明书；

*(8) 门、窗、盖的结构，安装和布置图；

(9) 舾装数计算书锚泊、系泊、栏杆、扶手和甲板防滑设施图；

(10) 舵结构图（包括舵叶、舵杆、舵承及其连接等结构）及其强度计算书；

*(11) 机器处所布置图；

*(12) 机器处所通风布置图；

*(13) 轴系布置图及螺旋桨图；

(14) 轴系强度及螺旋桨强度计算书；

(15) Z 形推进装置或舷内外机的尾机布置图；

*(16) 操舵系统图；

*(17) 管系布置图（包括主、辅机排气管系、燃油管系、消防水管系、舱底水管系）；

(18) 电力负荷计算书（包括蓄电池容量计算）；

*(19) 电力系统图，图中应标明：

① 电机、变压器、蓄电池组和电力电子设备的主要额定参数；

② 配电板的所有馈电线；

③ 电缆的型号、截面积和主要额定参数；

④ 断路器和熔断器的型号和主要额定参数。

(20) 配电板单线图；

*(21) 电力设备布置图（包括发电机、蓄电池组、配电板等设备的安装位置）；

(22) 照明系统图和布置图；

*(23) 船舶操作手册（仅适用于高速船、游艇，其编写内容见附录）。

1.2.5.4 应视情况将下列图纸资料提交本社备查：

*(1) 总说明书；

(2) 线型图；

(3) 重量重心计算书；

(4) 静水力曲线图；

*(5) 船体结构规范计算书；

(6) 吨位计算书；

*(7) 窗玻璃厚度计算书；

*(8) 全船设备明细表。

1.2.5.5 提交审查的图纸资料名称可不尽相同，但至少应包括上述图纸资料的内容。除 1.2.5.3 和 1.2.5.4 外，本社可以根据船的实际情况要求补充提交其他图纸资料。

1.2.5.6 现有船舶初次检验核查图纸资料可按 1.2.5.3 和 1.2.5.4 中带“*”者。

1.2.5.7 新建船舶船体检验项目如下：

(1) 确认船体结构所用材料、工艺、设备和装置等符合规范要求，并取得有关船用产品证书；

(2) 检查船体成型模具；

(3) 核查建造厂提交的船体板材（包括单板和夹层板）试样的力学性能试验报告；

(4) 船体装配的正确性、完整性及焊缝质量；

(5) 船体成型后的检验；

(6) 检查第1层上层建筑和驾驶室前壁上的外窗的安装质量（包括窗玻璃、窗框及壁板之间的连接）；

(7) 检查锚泊、系泊设备；

(8) 倾斜试验。

1.2.5.8　新建船舶轮机、电气检验项目如下：

(1) 确认必要机械设备的船用产品证书；

(2) 管系装船后的密性试验；

(3) 重要机械的安装和试验；

(4) 系统的安装和试验。

(5) 确认重要用途的电气设备的产品证书；

(6) 发电机、蓄电池、配电板的检验和试验；

(7) 电缆规格核查和安装检查；

(8) 内部通信设备的试验；

(9) 主机、辅机、操舵系统及控制、安全和报警系统的检验和试验；

(10) 照明系统检查。

1.2.5.9　根据“系泊和航行试验大纲”进行系泊试验和航行试验。

1.2.5.10　现有船舶的初次检验

(1) 现有船舶初次检验中的送审图纸资料可分别按本节1.2.5.6的规定。

(2) 检验项目可视船龄和船的实际状况确定，但至少按年度检验项目进行。对船龄5年以上的客船应按换证检验项目进行。

1.2.6　年度检验

1.2.6.1　船体检验项目如下：

(1) 对纤维增强塑料船，检查船体结构和上层建筑的外表，观察有无裂缝、发白、分层现象；

(2) 对金属船，检查船体外板、甲板、舱壁等腐蚀现象；

(3) 检查船体各种连接处有无松动、渗水现象；

(4) 检查高速船前窗窗框及玻璃连接的有效性；

(5) 检查汽油舷内外机的机舱自然进风口是否有效；

(6) 检查锚泊设备、舵设备的配置及其有效性；

1.2.6.2　轮机、电气检验项目如下：

(1) 对推进装置，重要用途的辅机作外部检查。必要时，对某项目可要求进行效用试验；

(2) 对机器处所进行总体检查 ；

(3) 检查主机遥控系统，Z 形推进装置的液压操作系统，并确认其处于良好的工作状态；

(4) 检查油柜、油箱及燃油系统是否完好，应无渗漏现象；

(5) 检查操舵装置和控制系统，应在工作状况下进行试验；

(6) 检查舱底水系统、主机冷却系统等重要管系的使用情况。

（7）内部通信设备的试验；

（8）对发电机、蓄电池组作外部检查，了解其使用情况；

(9) 电气设备和电缆应尽可能在工作状态下进行总体检查和试验；

(10) 对接地情况和避雷针的接地情况进行总体检查。

1.2.6.3　对高速船，其年检项目应与特别检验项目相同。

1.2.7　上排／坞内检验

1.2.7.1　上排／坞内检验项目如下：

(1) 检查水线以下船壳板有无裂缝、损伤及腐蚀程度；

(2) 检查舵、舵柱、舵承、Z 形推进装置、螺旋桨、螺旋桨轴及其轴承、喷水推进、海底阀箱及格栅的完好性；

(3) 检查船壳上的接地板是否完好。

1.2.8　特别检验

1.2.8.1　特别检验项目除应包括年度检验和上排／坞内检验项目外，还应检查下列项目：

(1) 发动机：检查气缸、气缸盖、阀、活塞、连杆、曲轴及所有轴承、机座、机架、冷却器、减振器、机带泵等零部件；

(2) 齿轮箱：检查大小齿轮、轴、轴承和离合器；

(3) Z 形推进装置：检查大、小齿轮、轴、轴承和密封装置；

(4) 推进机械应在工作状态下进行操纵试验，主机和 Z 推装置的遥控系统和液压操纵系统应处于良好工作状态；

(5) 抽出螺旋桨轴，检查轴、衬套、键、锥体和法兰圆角、尾管轴承和油封装置以及螺旋桨与轴锥体的配合情况；

(6) 喷水推进器：检查叶轮、轴、轴封、进出水通道导向喷嘴、反向装置和控制机构并测量叶轮和导管间隙；

（7）电气设备和电路的绝缘电阻测量；

（8）发电机、蓄电池和操舵电动机（如设有）应进行检验和在工作状态下进行运转试验；

（9）重要设备用电动机连同其控制设备应进行检查，并应尽可能在工作状态下进行运转试验；

（10）配电板（箱）应进行检验，确认其处于良好的工作状态。

1.2.8.2 本章 1.2.8.1 中 (2) ～ (4) 项目，可检查其维修保养记录作为替代。

1.2.8.3 船体层板不应有渗水现象和明显的发白、分层。

1.2.8.4 对金属船，在其第 2 个及以后特别检验时，应对船壳板可疑区域进行测厚检查。

第 2 章　船体结构

第 1 节 纤维增强塑料船

2.1.1　一般要求

2.1.1.1　本节规定适用于以纤维增强塑料为船体结构材料的船舶。

2.1.1.2　建造纤维增强塑料船的工厂需经本社认可。建造厂应对建造施工质量进行严格控制。

2.1.1.3　本节规定适用于单层板结构和夹层板结构的船舶 。对全垫升气垫船，其结构应满足本社《海上高速船入级与建造规范》的要求。

2.1.1.4　结构设计原则

(1) 船体结构的设计应使船舶能够承受整个正常营运期间可能遭遇的最大外力。

(2) 允许采用直接计算法设计船体结构，但结构计算书应经本社审查。

（3）平板龙骨的宽度 或帽型龙骨的围长应不小于 0.1B（B 为型宽），其厚度应不小于船底板厚度的 1.5 倍，且在整个船长范围内保持不变。

（4）对型深小于 0.9m 的小船，可不设舷侧纵骨，但应在舷侧采取折角、折边等措施，并校核艇体的总纵强度。

（5） 船底肋板、舷侧肋骨以及甲板横梁应布置在同一横剖面内，并牢固衔接，特殊情况应征得审图同意。

（6）船体肋骨或纵骨的间距 S 应不大于 500mm。对于纵骨架式船舶，实肋板间距应不大于 4 个肋位；对横骨架式船舶，实肋板间距应不大于 2 个肋位。

（7）龙骨间距及龙骨至舭部折角线或舭部圆弧中点的间距应不大于 2m。

（8）船体纵向构件应尽可能在全船范围内保持连续。

（9） 帽型剖面构件的腹板高度与厚度之比值不应超过 30，其面板宽度与厚度之比值不应超过 20；T 型剖面构件的腹板高度与厚度之比值不应超过 20，其面板宽度与厚度之比值不应超过 10；其他剖面型式构件另行考虑。

（10） 斜底船实肋板的腹板高度从纵中剖面向舷侧可逐渐减小，但对船长 6m 以上船离纵中剖面 3/8 船宽处的腹板高度应不小于在纵中剖面处腹板高度的 1/2。

（11）对于单机船的机舱或平底船，允许以主机基座纵桁或两道旁内龙骨（左右各 1 道）代替中内龙骨。该主机基座纵桁或旁内龙骨与中内龙骨均不应在舱壁处突然中断，应各自在舱壁背面处延伸，其延伸长度应不小于 2 个肋位。

（12）板的厚度应为不计胶衣及修整复合物或其他非增强材料时的厚度。

2.1.1.5　总强度

（1）对船长 L 为 15m 及以上，且 L/D 大于或等于 12 的高速船及纤维增强塑料船，需校核船体的总纵强度。

（2）计算总纵强度时，通常取船长 L 之半处的船中横剖面作为校核剖面。对干舷甲板边线（甲板艇）或舷侧顶板线（敞开艇）的船体中剖面模数 W 应不小于按下式计算所得之值：

$$W = f L^2 B_w (C_b + 0.7) \quad \text{cm}^3$$

式中：f—系数，f = 0.25L+24；

L— 船长，m；

B_W— 满载水线处的船宽，m；

C_b— 船舶在满载水线下的方形系数。

（3）中剖面对其中和轴的惯性矩 I 应不小于按下式计算所得之值：

$$I = 4.0WL \quad \text{cm}^4$$

式中：L— 船长，m；

W— 按本节 2.1.1.5(2) 计算的中剖面模数，cm^3。

（4）中剖面模数的计算：

① 所有在船中 0.4L 范围内连续的船体纵向构件均可计入船中剖面模数。但上述构件上的开孔面积应予以扣除；

② 船中 0.4L 范围内，长度超过 0.2L 的上层建筑一般可认为参与总纵强度。但如上述上层建筑的侧壁上有大量开孔，且开孔纵向孔径之和超过该建筑长度之半，则认为该建筑不参与总纵强度；

③ 对采用夹层结构作为部分船体构件的船舶，可引入"相当剖面模数 W_e"的概念。

船体梁总纵弯曲时，由若干夹层结构构件组成的船中相当剖面模数 W_e 应按下式计算：

$$W_e = \frac{\sum E_i I_i}{EY} \quad \text{cm}^3$$

式中：E— 计算点处材料的弹性模量，N/mm^2；

Y— 计算点至船中剖面中和轴的垂向距离，cm；

E_i、I_i— 分别为船中剖面的各个构件材料的弹性模量（N/mm^2）和各个构件对船中剖面中和轴的惯性矩（cm^4）。

（5）对双体船，还应校核两片体连接桥结构的总横强度和扭转强度。校核方法可参见本社《海上高速船入级与建造规范》的相应规定。

（6）计算总强度时的许用应力如下：

许用弯曲应力：[σ] = 0.30σ_{nu}, σ_{nu} 为层板的极限弯曲强度，N/mm²；

单板结构的许用剪切应力：[τ] = 0.25τ_u，τ_u 为层板的极限剪切强度，N/mm²；

夹层板结构的许用剪切应力：[τ] = 0.5τ_{cr}，τ_{cr} 为夹层板面板的临界剪切强度，N/mm²，τ_{cr} 取下列 2 式计算值中的小者：

$$\tau_{cr} = 0.3\left(E_f^{45^\circ} E_c G_c\right)^{1/3} \quad \text{N/mm}^2$$

$$\tau_{cr} = 0.4\gamma G_c \qquad \text{N/mm}^2$$

式中：$E_f^{45^\circ}$— 夹层板面板沿 45⁰ 方向的压缩弹性模量，如面板为正交布层板，$E_f^{45^\circ}$ 可取为 60%，N/mm²；

E_c— 芯材的压缩弹性模量，NN/mm²；

G_c— 芯材的剪切弹性模量，N/mm²；

γ— 两面板厚度中心线的距离与两面板的平均厚度之比，且 6 ≤ γ ≤ 14。

2.1.1.6　主机基座与机舱骨架

（1）　主机基座的结构应具有足够的强度和刚度。基座纵桁一般应在每个肋位处设置横隔板和横肘板，以确保有效支承。

（2）　为增加基座纵桁的抗压和抗弯刚度，可采用木材或铝合金型材作纵桁腹板的芯材，但该芯材应与表层纤维增强塑料以及船底板有效粘接。

（3）　机舱内的骨架应保持结构的连续性，避免应力集中。

（4）　机舱内，船底为横骨架式时，应在每个肋位设置实肋板；船底为纵骨架式时，可每隔一个肋位设置实肋板，实肋板的剖面模数应较本章 2.1.2.4 或 2.1.3.6 的规定值增加 10%，且实肋板与基座纵桁应有效连接。

（5）　机舱处的舷侧应设置强肋骨，强肋骨应设置在实肋板处，其间距应不大于 4 个肋位。机舱处肋骨和强肋骨的剖面模数应较本章 2.1.2.4 或 2.1.3.6 的规定值增加 10%。

2.1.1.7　尾封板

（1）　尾封板的厚度应不小于舷侧板厚度的 1.2 倍，其骨材要求与舷侧板的骨材要求相同。

（2）　尾封板的设计应确保由舷外机或尾推进装置引起的弯矩和推力传递至船体结构时不产生过度的应力。

（3）　通常，舷外机和尾推进装置的尾封板应是其芯材为胶合板或类似的刚性和合适材料的夹层板。尾封板的总厚度一般应不小于表 2.1.1.7（3）的要求。

尾封板总厚度　　　　　　　　表 2.1.1.7（3）

发动机功率 **kW**	尾封板总厚度 （舷外机）**mm**	尾封板总厚度 （尾推进装置）**mm**
18 至＜30	30	35
30 至＜60	35	40
60 至＜150	40	45
＞150	按具体情况作特别考虑	按具体情况作特别考虑

2.1.1.8　局部加强

（1）　对高速船受波浪拍击严重区域（一般距首 1/3 L 处的前后 0.15L 范围内），应在每个肋位处设置实肋板或采取其他的加强措施。

（2）　对尾轴架、舵柱及其附体等贯穿船体处的外板或锚泊、系泊、拖带的强力点部位的板应设预埋件并予以适当加强。

（3）　应尽量避免在外板上开口，如需开口，则开口角隅应为圆角。对大开口还应根据具体情况予以补偿。

（4）　上层建筑或甲板室侧壁上如开门、窗、孔，其角隅尽可能为圆角，若需用直角开口，则应进行足够的加强。

2.1.1.9　支柱

（1）　对钢质、铝质支柱可按照本社《海上高速船入级与建造规范》的有关规定。

（2）　其他材料的支柱应经本社认可。

2.1.1.10　带板有效宽度

（1）　本节规定的骨材剖面模数的要求值均为连带板的最小要求值。构件带板有效宽度 b_e 按下述规定选取：

①　带板为单层板时，取下列算得的小者：

$$b_e = s,\quad b_e = 23t + b_s \qquad \text{mm}$$

②　带板为夹层板：

如芯材为泡沫塑料、轻木等无效芯材时，取下列算得的小者：

$$b_e = s,\quad b_e = 11d \qquad \text{mm}$$

如芯材为胶合板等有效芯材时，取下列算得的小者：

$$b_e = s,\quad b_e = 35d \qquad \text{mm}$$

式中：s — 骨材间距，mm；

t — 带板的厚度，mm；

d — 带板的两面板厚度中心线的距离，mm；

b_s — 骨材的净宽度，mm。

（2） 骨材若采用松木、胶合板等有效材料作芯材时，其剖面模数的计算可计入芯材的影响，但在计算芯材的剖面积时，应乘以芯材的弯曲弹性模量与层板材料的弯曲弹性模量之比。

2.1.1.11 层板的铺层设计

（1） 船体的壳板和构件应根据不同用途选择合适的原材料配合和合理的铺层设计。

（2） 层板厚度变化应缓慢，过渡区的宽度至少为厚度差的 30 倍。

2.1.1.12 层板试件力学性能要求

（1） 以纤维增强的层板试件力学性能指标应符合本社《材料与焊接规范》的要求。

（2） 每层以玻璃纤维及其制品增强的层板厚度 t 可按下式求得：

$$t = \frac{W_G}{100\gamma_R G} + \frac{W_G}{1000\gamma_G} - \frac{W_G}{1000\gamma_R} \quad \text{mm}$$

式中：W_G — 单位面积玻璃毡或玻璃布的设计重量，g/m^2；

G — 层板的玻璃纤维含量（重量比），%；

γ_R — 经固化后的树脂比重，g/cm^3；

γ_G — 玻璃毡或玻璃布的比重，g/cm^3。

2.1.1.13 船体密性试验

(1) 船体完工后，应对主要舱室进行压水试验或冲水试验，以证实结构件的强度和／或密性。试验压力尽实际可能为该舱内构件在船舶破损时可能遭受的最大压力。

(2) 冲水试验时，出水口压力应不小于 0.2MPa，喷嘴离被试项目的距离应不大于 1.5m，喷嘴内径应不小于 12mm，水柱移动速度应不大于 0.1m/s。

2.1.2 高速船

2.1.2.1 船重心处的垂向加速度

(1) 船重心处的设计垂向加速度 α_{cg} 应由船东或设计部门提供，一般可取为重心处 1/100 最大加速度的平均值。设计部门还可自行调整，但对客船 α_{cg} 不应超过 1.3g；对游艇 α_{cg} 不应超过 2g；对公务艇等可根据船东或设计部门的需求，选择合理的 α_{cg} 值。

(2) 船重心处的设计垂向加速度 α_{cg} 与该船营运限制规定的有义波高 $H_{1/3}$ 和船在该波高下对应的航速 V_H 三者的关系如下：

$$\alpha_{cg} = \frac{1}{426}\left(\frac{V_E}{\sqrt{L}}\right)^{1.4}\left(\frac{H_{1/3}}{B_{WL}} + 0.07\right)(50-\beta)\left(\frac{L}{B_{WL}} - 2\right)\frac{B_{WL}^{\ 3}}{\Delta}g \quad \text{m/s}^2$$

式中：g — 重力加速度，取 9.81 m/s²；

V_H — 船在有义波高 $H_{1/3}$ 的波浪中航行的航速，kn；

$H_{1/3}$ — 有义波高，m，对沿海航区营运限制，取 $H_{1/3\max}$=4m；对遮蔽航区营运限制，取 $H_{1/3\max}$=2m；对平静水域营运限制，取 $H_{1/3\max}$=1m；

L — 船长，m；

B_{WL} — 水线宽，m，系指船静浮于水面时，沿满载水线量得的最大型宽。对于多体船，系指满载水线处各片体最大型宽之和；

β — 船体重心处横剖面的船底斜升角（°），见图 2.1.2.1（2），取 $\beta_{\max}=30°$，$\beta_{\min}=10°$；

Δ — 满载排水量，t；

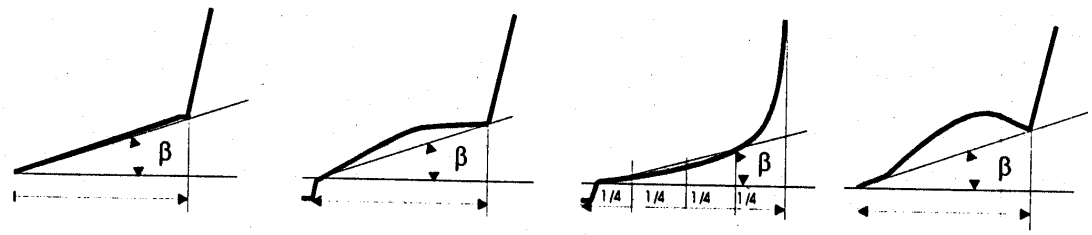


图 2.1.2.1（2）

（3） 将最终的 α_{cg} 取值代入上述（2）所列公式，推算出船在设计航区营运限制下的若干组 $H_{1/3} \sim V_H$ 的对应值，将其记录在操作手册中，并制成标牌固定展示在驾驶室内。

2.1.2.2 局部计算压力

（1） 船底波浪冲击压力 P_{sl} 按下式计算，且应不小于按本节 2.1.2.2（3）确定的对应位置处的舷侧压力：

$$P_{sl}=1.16K_{l1}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg}d \qquad \text{kN/m}^2$$

式中：K_{l1} — 纵向压力分布系数。船中前取 $K_{l1}=1$，尾端取 $K_{l1}=0.5$，尾端与船中之间用线性插值法求得；

A — 受力点计算面积，m²；

对板的计算面积取板格的承载面积，且 $A \ngtr 2.5S^2$；其中 S 为骨材间距，m；

对加强筋或桁材取 A = 承载宽度 × 跨距；

d — 吃水，m；

Δ — 满载排水量，t；

α_{cg} — 设计垂向加速度，m/s²，按本节 2.1.2.1 取值。

（2） 连接桥底的压力 P_{wd} 由下式确定，且应不小于按本节 2.1.2.2（3）确定的对应位置处水线以上舷侧压力：

$$P_{wd}=0.75K_{l2}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg} \qquad \text{kN/m}^2$$

式中：K_{L2} — 纵向压力分布系数。对双体船：船中前取 $K_{l2}=1.5$，尾端取 $K_{l2}=0.8$；对水面效应船：船中前取 $K_{l2}=0.8$，尾端取 $K_{l2}=0.5$；对水翼船：取 $K_{l2}=0.5$。上述分布系数位于尾端与船中之间用线性插值法求得；

Δ、A、α_{cg} — 同上述（1）。

（3） 舷侧波浪冲击压力 P_s 按下式计算：

$$P_s = 9.81h + 0.15P_{sl} \qquad \text{kN/m}^2$$

式中：h — 从舷侧板最低点到舷侧处干舷甲板上缘（甲板艇）或舷侧顶板上缘（敞开艇）的垂直距离，m；
P_{sl} — 该处船底的冲击压力，kN/m^2。

（4） 甲板计算压力 P_d 按下式计算：

露天甲板 $P_d = 0.25L+4.6$ kN/m^2
非露天甲板 $P_d = 0.1L+4.6$ kN/m^2
乘客甲板 $P_d = 4.5$ kN/m^2

对航行于遮蔽航区营运限制及平静水域营运限制的船舶，其露天甲板的计算压力可分别取上述值的 0.9 倍和 0.85 倍。

（5） 舱壁计算压力 P_h 按下式计算：

水密舱壁、防撞舱壁及其扶强材 $P_h = 10h$ kN/m^2
液体舱壁及其扶强材 $P_h = 10h_d+10$ kN/m^2

式中：h — 板的下缘或扶强材跨距的中点至上甲板的垂直距离，m；
h_d — 板的下缘或扶强材跨距的中点至液舱顶的垂直距离，m。

（6） 上层建筑和甲板室的计算压力 P 按下式计算：

前端壁及扶强材 $P = 5 + 0.3L$ kN/m^2
侧壁、尾端壁及扶强材 $P = 2.5 + 0.2L$ kN/m^2
顶板及扶强材 $P = 3$ kN/m^2

式中：L — 船长，m。

对航行于遮蔽航区营运限制及平静水域营运限制的船舶，其上层建筑前端壁及扶强材计算压力可分别取上述值的 0.9 倍和 0.85 倍。

2.1.2.3 层板结构尺寸

（1） 单层板的最小板厚 $t_{\min}$ 按下式计算：

$$t_{\min} = K_o\sqrt{L} \qquad \text{mm}$$

式中：K_o — 系数，由表 2.1.2.3（1）查取；
L — 船长，m。

系数 K_0 **表 2.1.2.3（1）**

	艇底外板 连接桥底板	舷侧板	甲板板	上层建筑、甲板室			舱壁	
				前端壁	侧后壁	顶板	水密舱	防撞舱、液舱
K_o	1.45	1.25	1.10	1.10	0.95	0.90	1.20	1.30

（2） 单层板的厚度 t 应不小于按下式计算所得之值：

$$t = 44.8 s\sqrt{\frac{P}{\sigma_{fnu}}} \quad \text{mm}$$

式中：σ_{fnu}— 层板的极限弯曲强度，N/mm²。

s— 骨材间距，m，通常指纵骨间距，对桁材或肋板为其承受面积的宽度；

P— 船体局部强度计算中，构件单位面积上承受正压力的设计值，按本节 2.1.2.2 计算。

（3） 夹层板面板的最小厚度（单面）$t_{\min}$ 按下式计算：

$t_{\min} = K_0\sqrt{L}$ mm，且不小于 2.0mm，外露面板①

$t_{\min} = K_0\sqrt{L} - 0.5$ mm，且不小于 1.5mm，被保护面板②

式中：K_0— 系数，由表 2.1.2.3（3）查取；

L— 船长，m。

系数 K_0 2.1.2.3（3）

	艇底外板 连接桥底板	舷侧板	甲板板	上层建筑、甲板室			舱壁	
				前端壁	侧后壁	顶板	水密舱	防撞舱、液舱
K_o	0.7	0.6	0.5	0.5	0.4	0.4	0.45	0.55

（4） 夹层板的总厚度 t 应不小于按下式计算所得之值：

$$t = \frac{1.428}{K}\left(1 + \frac{1}{\gamma}\right)\frac{Ps}{\tau_c} \quad \text{mm}$$

式中：γ— 两面板厚度中心线的距离与两面板的平均厚度之比，且 $6 \leqslant \gamma \leqslant 14$；

τ_c— 夹层板芯材的极限剪切强度，N/mm²；

K— 系数，对聚氨酯泡沫塑料芯材夹层板，

$K = 1.86 - 0.06\gamma$，且 $K \nless 1$；对聚氯乙烯泡沫塑 料芯材夹层板，

$K = 1.95 - 0.079\gamma$，且 $K \nless 1$；对胶合板芯材夹层板，K 取 1.0。

s、P —见本节 2.1.2.3（2）。

2.1.2.4 骨材

（1） 骨材的剖面模数 W 应不小于按下式计算所得之值：

$$W = K\frac{l^2 sP}{\sigma_{fnu}} \quad \text{cm}^3$$

① “外露面板”系指板的一个侧面持续受到液体的浸沉或可能受到局部机械磨损或冲击载荷。

② “被保护面板”系指板的一个侧面不承受上述载荷。

式中：σ_{fnu} — 层板的极限弯曲强度，N/mm^2；

K — 系数，由表 2.1.2.4（1）查取；

l — 骨材跨距，m，当骨材端部设置肘板时，跨距点可取在肘板长度之半处；当骨材端部不设置肘板时，跨距点取在骨材端部。对船体强骨材（如龙骨、实肋板、纵桁等），则与之相交的舱壁可作为该强骨材的端点。对甲板及上层建筑强骨材（如强横梁、纵桁等），则除舱壁外，与之相交的支柱点也可作为该强骨材的端点。各骨材的跨距选取同本节 2.1.3.6；

s 、P —见本节 2.1.2.3（2）。

系数 *K* 2.1.2.4（1）

	K	
	龙骨、纵桁、强肋骨、实肋板、强横梁	纵骨、肋板、肋骨、横梁、扶强材
船底 连接桥底	480	400
舷侧	480	400
甲板	480	400
上层建筑	_	400
水密舱壁	_	400
液体舱壁 防撞舱壁	_	480

（2） 对龙骨如按上述（1）计算剖面模数不切实际时，其剖面模数可另行考虑，但至少应同时满足下述条件：

① 对中内龙骨，其剖面模数应不小于该处实肋板剖面模数的 1.5 倍；对旁内龙骨，其剖面模数应不小于该处实肋板的剖面模数；

② 所有船舶均应校核船体总纵强度。

2.1.2.5 各构件剖面模数的要求值均为连带板的最小要求值。构件带板有效宽度 b_e 按下述规定选取：

（1） 带板为单层板时，取下列算得的小者：

$$b_e = S,\ b_e = 23t + b_s \quad \text{mm}$$

（2） 带板为夹层板：

① 如芯材为泡沫塑料、轻木等无效芯材时，取下列算得的小者：

$$b_e = S,\ b_e = 11d \quad \text{mm}$$

② 如芯材为胶合板等有效芯材时，取下列算得的小者：

$$b_e = S,\ b_e = 35d \quad \text{mm}$$

式中：t — 带板的总厚度，mm；

d — 带板的两面板厚度中心线的距离，mm；

S — 骨材间距，m；

b_s — 骨材的净宽度，mm。

2.1.2.6 骨材若采用松木、胶合板等有效材料作芯材时，其剖面模数的计算可计入芯材的影响，芯材的剖面积应乘以芯材的弯曲弹性模量与层板材料的弯曲弹性模量之比。

2.1.2.7　桁材的有效腹板面积

（1）　桁材的有效腹板面积 A_e 按下式计算：

A_e = 0.01$h_w t_w$　　　cm²　　端部无肘板

A_e = 0.01$h_w t_w$ + ΔA_e　cm²　　端部有肘板

式中：h_w— 计算剖面处减去开孔后的腹板有效高度，mm；

t_w— 纤维增强塑料腹板的总厚度，mm；

ΔA_e— 端部有肘板时的附加剪切面积，cm², 按肘板面板的水平倾角 θ 取值，见图 2.1.2.7（1）。

θ = 45° 时，ΔA_e = 0.9f_1; θ = 0° 时，ΔA_e = 0；θ 为中间值时，可用插入法求取 ΔA_e。f_1 为计算剖面处肘板面板的截面积，cm²。

（2）　按上述 2.1.2.7（1）计算所得的有效腹板面积 A_e 应不小于按下式计算所得之 $A_{e\min}$ 值：

$$A_{e\min} = \frac{25.5slP}{\tau_c} \quad \text{cm}^2$$

式中：τ_c— 夹层板的极限剪切强度，N/mm²;

s、P、l— 见本节 2.1.2.4（1）。

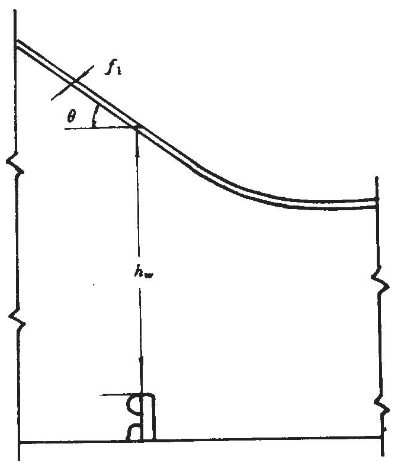


图 2.1.2.7（1）

2.1.3　非高速船

2.1.3.1　一般要求

（1）　船舶所有铺层设计其力学性能指标均应不低于本社《材料与焊接规范》的要求。本部分规定的船体结构尺寸是以玻璃纤维无捻粗纱正交布铺糊成型的标准铺层设计单层板的力学性能为基准。

（2）　对于其他铺层设计，若其单层板的强度与标准铺层设计层板的强度不一致时，本部分规定的船体构件尺寸可乘以下列规定的系数 K 进行修正：

① 对于厚度修正：$K=\sqrt{180/\sigma_{fnu}}$

式中：σ_{fnu}——层板的极限弯曲强度，N/mm^2 。

② 对于剖面模数修正：$K=180/\sigma_t$

式中：σ_t——层板的极限拉伸强度，N/mm^2 。

③ 对于极限弯曲强度和／或拉伸强度大于 400 N/mm^2 的层板，除修正外，还应对该层板船体的刚度进行校核。

（3） 层板的最小厚度 $t_{\min}$ 应满足本节 2.1.2.3 的有关要求。

（4） 船底板系指平板龙骨（或龙骨）至舭部上转角线之间的外板。

（5） 中内龙骨的腹板高度应不小于该处实肋板高度，其剖面模数应不小于该处实肋板剖面模数的 1.5 倍。

（6） 旁内龙骨的剖面模数应与该处实肋板的剖面模数相当。

（7） 机舱内中龙骨和旁龙骨的剖面模数应分别较上述（5）和（6）的规定值增加 10%。

2.1.3.2 外板

（1） 采用单层板的船底板厚度 t 应不小于按下式计算所得之值：

$$t=13.4s\sqrt{h} \quad \text{mm}$$

式中：s — 板格短边长度，m；

h — 从船底板最低处的下缘到舷侧处干舷甲板上缘的垂直距离，m。

（2） 对航行于平静水域营运限制的船舶，当吃水小于型深的 0.35 倍时，船底单层板的厚度可分别取按 2.1.3.2（1）计算所得之值的 0.9 倍。

（3） 采用单层板的舷侧板厚度 t 应不小于按下式计算所得之值：

$$t=12.4s\sqrt{h} \quad \text{mm}$$

式中：s — 同 2.1.3.2（1），m；

h — 从舷侧板最低点到舷侧处干舷甲板上缘的垂直距离，m。

（4） 采用单层板的舷侧板厚度可在船中部 0.4L 区域以外向首尾两端逐渐减薄，首尾端处的厚度可为船中部厚度的 0.85 倍。

（5） 若外板为夹层板，则夹层板的总厚度 t 应不小于按下式计算所得之值：

$$t=\frac{11hs}{\tau_c} \quad \text{mm}$$

式中：s — 板格短边长度，m；

h — 对船底板，见 2.1.3.2（1）；对舷侧板，见 2.1.3.2（3）；

τ_c — 芯材的抗剪强度，N/mm²。

(6) 用夹层板的首尾部分外板（尾封板除外）厚度应与船中部的外板厚度相同。

2.1.3.3　甲板

（1）　甲板计算压头 h 按下式选取：

露天甲板	h =0.02L + 0.46	m
非露天甲板	h =0.01L + 0.46	m
乘客甲板	h =0.45	m

对航行于遮蔽航区营运限制及平静水域营运限制的船舶，其露天甲板的计算压头可分别取上述值的 0.9 倍和 0.85 倍。

（2）　采用单层板的甲板在艇中部 0.4L 区域内的厚度 t 应不小于按下式计算所得之值：

$$t = 16.2s\sqrt{h} \quad \text{mm}$$

式中：s — 骨材间距，m；

h — 甲板计算压头，m；按本节 2.1.3.3（1）的有关高度选取。

（3）　采用单层板的露天甲板在艇中部 0.4L 区域以外的厚度可向船端部逐渐减薄，但其厚度应不小于船中部露天甲板厚度的 0.85 倍。

（4）　若甲板为夹层板，则甲板的总厚度 t 应不小于按下式计算所得之值：

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

式中：s — 板格短边长度，m；

h — 甲板计算压头，m；按 2.1.3.3（1）的有关规定选取；

τ_c — 芯材的抗剪强度，N/mm²。

2.1.3.4　舱壁板

（1）　采用单层板的舱壁板厚度 t 应不小于按下式计算所得之值：

$$t = 12.2s\sqrt{h} \quad \text{mm}$$

式中：s — 板格短边长度，m；

h — 计算压头，m；自舱壁板下缘量至舱顶的垂直距离。

（2）　若舱壁板为夹层板，则夹层板的总厚度 t 应不小于按下式计算所得之值：

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

式中：s— 板格短边长度，m；

h— 计算压头，m；自舱壁板下缘量至舱顶的垂直距离；

τ_c— 芯材的抗剪强度，N/mm^2。

（3） 计算防撞舱壁的构件尺寸时，其计算压头 h 应为其相应规定高度的 1.25 倍。

2.1.3.5 上层建筑和甲板室壁板

(1) 上层建筑或甲板室前端壁、侧壁和后壁的计算压头 h 应按下式计算：

前端壁	$h = 0.02L + 0.5$	m
侧壁和后端壁	$h = 0.02L + 0.25$	m
顶板	$h = 0.3$	m

(2) 对航行于遮蔽航区营运限制及平静水域营运限制的船舶，其上层建筑或甲板室前端壁的计算压头可分别取上述（1）值的 0.9 倍和 0.85 倍。

（3） 采用单层板的上层建筑壁板或甲板室围壁板的厚度 t 应不小于按下式计算所得之值：

$$t = 11.7s\sqrt{h} \quad \text{mm}$$

式中：s — 板格短边长度，m；

h— 计算压头，m；按上述（1）的有关规定选取。

（4） 上层建筑壁板或甲板室的壁板为夹层板时，夹层板的总厚度 t 应不小于按下式计算所得之值：

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

式中：s— 板格短边长度，m；

h— 计算压头，m；按上述（1）的有关规定选取；

τ_c— 芯材的抗剪强度，N/mm^2。

2.1.3.6 骨架

（1） 实肋板：

① 实肋板的剖面模数 W 应不小于按下式计算之值：

$$W = 15.4sDl^2 \quad \text{cm}^3$$

式中：s— 实肋板间距，m；

D— 型深，m；

l— 实肋板跨距，m；取实肋板面板与两舷侧交点之间的距离；若设有纵舱壁，则取纵舱壁与舷侧之间或纵舱壁之间的距离，取大者。

② 实肋板在纵中剖面的高度 H 应不小于按下式计算所得之值：

$$H = 62.5l \quad \text{mm}$$

式中：l — 见上述①。

（2） 船底纵骨的剖面模数 W 应不小于按下式计算所得之值：

$$W = 25.7shl^2 \quad \text{cm}^3$$

式中：s — 纵骨间距，m；

h — 计算压头，m；在纵骨跨距中点处自船底板下缘量至舷侧处干舷甲板上缘的垂直距离；

l — 纵骨跨距，m；实肋板之间或实肋板与舱壁之间的距离，取大者。

（3） 肋骨：

① 肋骨的剖面模数 W 应不小于按下式计算所得之值：

$$W = 24shl^2 \quad \text{cm}^3$$

式中：s — 肋骨间距，m；

l — 肋骨跨距，m；对船底肋骨，取龙骨之间或龙骨至舷侧之间的距离，取大者；对舷侧肋骨，取船底板上表面至甲板间的垂直距离；

h — 计算压头，m；对船底肋骨，取肋骨跨距中点处自船底板下缘量至舷侧处干舷甲板上缘的垂直距离；对舷侧肋骨，取肋骨跨距中点至干舷甲板边线的垂直距离。

② 强肋骨的剖面模数 W 应不小于按下式计算所得之值：

$$W = 22.6shl^2 \quad \text{cm}^3$$

式中：s — 强肋骨间距，m；

h — 计算压头，m；自强肋骨跨距中点至干舷甲板边线的距离；

l — 强肋骨的跨距，m。

（4） 舷侧纵骨的剖面模数 W 应不小于按下式计算所得之值：

$$W = 22.6shl^2 \quad \text{cm}^3$$

式中：s — 纵骨间距，m；

h — 计算压头，m；船中部舷侧处从纵骨至干舷甲板边线的距离；

l — 纵骨跨距，m；强肋骨之间或强肋骨与舱壁之间的距离，取大者。

（5） 甲板横梁

① 甲板横梁的剖面模数 W 应不小于按下式计算所得之值：

$$W = 19.6shl^2 \quad \text{cm}^3$$

式中：s — 横梁间距，m；

h — 甲板计算压头，m；按本节 2.1.3.3（1）的有关规定选取；

l — 横梁跨距，m；船侧与纵桁（纵舱壁）或纵桁与纵桁之间的距离，取大者。

② 强横梁的剖面模数 W 应不小于按下式计算所得之值：

$$W = 17.0shl^2 \quad cm^3$$

式中：s — 强横梁间距，m；
h — 甲板计算压头，m；按本节 2.1.3.3（1）的有关规定选取；
l — 强横梁跨距，m；船侧与船侧之间，船侧与支柱之间或支柱与支柱之间的距离，取较大者。

（6） 甲板纵骨的剖面模数 W 应不小于按下式计算所得之值：

$$W = 21.0shl^2 \quad cm^3$$

式中：s — 纵骨间距，m；
h — 甲板计算压头，m；按本节 2.1.3.3（1）的有关规定选取；
l — 纵骨跨距，m；强横梁之间或强横梁与舱壁之间的距离，取大者。

（7） 甲板纵桁：

① 甲板纵桁与龙骨应尽可能设置在同一平面内。

② 甲板纵桁的剖面模数 W 应不小于按下式计算所得之值：

$$W = 17.1bhl^2 \quad cm^3$$

式中：b — 甲板纵桁支承面积的平均宽度，m；
l — 纵桁跨距，m；支柱之间或支柱与舱壁之间的距离，取大者；
h — 甲板计算压头，m；按本节 2.1.3.3（1）的有关规定选取。

③ 甲板纵桁受有集中载荷时，其剖面模数 W 除应满足上述（2）要求之外，尚应增加按下式计算所得之值：

$$W = 0.102cPl \quad cm^3$$

式中：P — 集中载荷，KN；
l — 纵桁跨距，m, 同上述②；
c — 系数，按表 2.1.3.6（7）③选取；表中 a 为 P 的作用点至纵桁两支点间较远一点的距离，m。

系数 c **2.1.3.6（7）③**

a/l	0.94	0.90	0.85	0.80	0.75	0.70	0.60	0.50
c	3.56	8.32	14.06	18.22	21.39	22.77	23.73	24.75

（8） 舱壁扶强材的剖面模数 W 应不小于按下式计算所得之值：

$$W = Kshl^2 \quad cm^3$$

式中：s — 扶强材间距，m；

l — 扶强材跨距，m；

h — 计算压头，m；自扶强材跨距中点量到舱顶的垂直距离；

K — 系数，按下列情况选取：

扶强材两端用肘板连接，$K = 21.67$；

扶强材一端用肘板连接，$K = 28.87$；

扶强材两端削斜，$K = 34.61$。

（9） 上层建筑或甲板室的骨架

① 上层建筑或甲板室的甲板骨架尺寸应符合 2.1.3.6（5）至 2.1.3.6（7）的有关规定。

② 上层建筑或甲板室的围壁扶强材的剖面模数 W 应不小于按下式计算所得之值：

$$W = 20.3shl^2 \qquad cm^3$$

式中：s — 扶强材间距，m；

l — 扶强材跨距，m, 取扶强材的实际长度；

h — 计算压头，m；按本节 2.1.3.5（1）、（2）的有关规定选取。

第 2 节 钢质船

2.2.1 一般要求

2.2.1.1 本节规定适用于以钢为船体结构材料的船舶。对全垫升气垫船，其结构应满足本社《海上高速船入级与建造规范》的要求。

2.2.1.2 结构设计原则

（1） 船体结构的设计应能承受船舶在整个服役期间所遭遇的最大外力。

（2） 允许采用直接计算法设计船体结构，但结构计算书应经本社审查。

（3） 平板龙骨的宽度应不小于 600mm，其厚度应不小于该位置处船底板厚度加 1.2mm，且在整个船长范围内保持不变。

（4） 纵骨架式结构的纵向构件应保持连续或等效连续。

（5） 船体骨材的短边间距应不大于 500mm。对于纵骨架式船舶，实肋板间距应不大于 4 个肋位。

（6） 船体实肋板、强肋骨和甲板强横梁应布置在同一横剖面内。

（7） 计入总纵强度的船底纵桁的腹板应穿过水密横舱壁，或保持等效连续。

（8） 在机舱每个肋位均应设置实肋板，在推力轴承处须另行加强。

（9） 机舱内的主机座前后端须设置实肋板。

2.2.1.3 总强度

（1） 钢质高速船的总强度应满足本社《海上高速船入级与建造规范》的要求。

（2） 计算总强度时的许用应力如下：

许用弯曲应力：[σ] = 0.67σ_s
许用剪切应力：[τ] = 0.38σ_s
其中：σ_s — 材料屈服强度，N/mm^2；

2.2.1.4 局部加强

（1） 对高速船受波浪拍击严重区域（一般距首 1/3 L 处的前后 0.15L 范围内），应在每个肋位处设置实肋板。

（2） 尾封板的厚度应不小于舷侧板的厚度，但当尾封板上安置推进装置时，尾封板的厚度应不小于舷侧板厚度的 1.2 倍。对尾轴架、舵柱及其附体等贯穿船体处的外板或锚泊、系泊、拖带的强力点部位的板应予适当加强。

（3） 应尽量避免在外板上开口，如需开口，则开口角隅应为圆角。对大开口还应根据具体情况予以补偿。

（4）上层建筑或甲板室侧壁上如开门、窗、孔，其角隅应尽可能为圆角，若需用直角开口，则应进行足够的加强。

2.2.1.5 支柱

（1） 对钢质、铝质支柱可按照本社《海上高速船入级与建造规范》的有关规定。

（2） 其他材料的支柱应经本社认可。

2.2.1.6 船体密性试验

（1） 船体完工后，应进行密性试验。其要求与本章 2.1.1.13 相同。

（2） 如由于冲水试验可能造成机械、电气设备绝缘或舾装件的损坏而不可行时，则可用对焊缝的细致目视检查予以替代，但如认为必要时还应由类似于着色渗透试验或超声波测漏试验或等效试验加以支持。

2.2.2 高速船

2.2.2.1 船重心处的垂向加速度要求与本章 2.1.2.1 相同。

2.2.2.2 船底、船侧、甲板、上层建筑等处的局部计算压力要求与本章 2.1.2.2 相同。

2.2.2.3 板厚

（1） 最小板厚 t_{min} 按下式计算：

$$t_{min} = 1.1K_0\sqrt{L} \quad \text{mm}$$

式中：K_0— 系数，查表 2.2.2.3（1）；

L— 艇长，m。

对单体船、双体船和水面效应船的平板龙骨，其最小板厚应另加 2mm。

系数 K_0 表 2.2.2.3（1）

构件名称		K_0	
		单体船、双体船	水面效应船、水翼船
船底外板		0.80	0.60
连接桥底板		0.75	0.50
舷侧外板		0.70	0.45
甲板：露天 / 非露天		0.60/0.40	0.40/0.30
上层建筑	前端壁	0.60	0.40
	侧壁、后壁	0.45	0.30
	顶板	0.30	0.20
舱壁		0.50	0.35
舵及尾轴架等处底板		1.60	1.20
机座		0.90	0.90

（2） 船底组合型材（包括机座）应满足下列要求：

腹板：$t \geqslant \frac{h}{70}\sqrt{\frac{\sigma_s}{235}}$，其中 t 为腹板厚度，mm；h 为腹板高度，mm；σ_s 为材料屈服强度，N/mm²。

面板：$t \geqslant \frac{b}{15}\sqrt{\frac{\sigma_s}{235}}$，其中 t 为面板厚度，mm；b 为面板宽度，mm；σ_s 为材料屈服强度，N/mm²。

（3） 板厚度 t 应不小于按下式计算所得之值：

$$t = K_1 C_1 C_2 S\sqrt{\frac{P}{\sigma_s}} \quad \text{mm}$$

式中：K_1— 系数，查表 2.2.2.3（3）；

S— 骨材间距，m，通常指纵骨间距，对桁材或肋板为其承受面积的宽度；

C_1— 有曲率板的折减系数，$C_1 = 1-0.5S/r$，r 为板的曲率半径，m；

C_2— 板格短边与长边比的修正系数，$C_2 = (1.1-0.25S/l)^2$，l 为骨材跨距，m，当骨材端部不设置肘板时，跨距点取在骨材端部；当骨材端部设置肘板时，跨距点可取在肘板长度之半处。

P— 设计压力，按本章 2.1.2.2 要求计算所得值；

σ_S— 材料屈服强度，N/mm²。

系数 K_1　　　　　　　　　　表 2.2.2.3（3）

<table>
<tr><td colspan="2" rowspan="2">名　称</td><td colspan="3">K_1</td></tr>
<tr><td>首垂线 0.1L 处</td><td>船中 0.4L 处</td><td>尾垂线 0.1L</td></tr>
<tr><td>船底、连接桥底</td><td></td><td>21.5</td><td>25.0</td><td>21.5</td></tr>
<tr><td rowspan="3">舷侧</td><td>近船底</td><td>21.5</td><td>25.0</td><td>21.5</td></tr>
<tr><td>近中和轴</td><td>20.5</td><td>纵骨架式：20.5
横骨架式：21.5</td><td>20.5</td></tr>
<tr><td>近甲板</td><td>20.5</td><td>25.0</td><td>20.5</td></tr>
<tr><td colspan="2">甲板（包括上层建筑／甲板室顶板）</td><td>纵骨架式：20.5
横骨架式：21.5</td><td>25.0</td><td>纵骨架式：20.5
横骨架式：21.5</td></tr>
<tr><td colspan="2">上层建筑／甲板室围壁</td><td colspan="3">21.5</td></tr>
<tr><td rowspan="3">横舱壁</td><td>防撞舱壁</td><td colspan="3">21.5</td></tr>
<tr><td>水密舱壁</td><td colspan="3">19.0</td></tr>
<tr><td>液舱舱壁</td><td colspan="3">21.5</td></tr>
</table>

2.2.2.4　骨材

（1）　骨材剖面模数 W（包括带板）应不小于按下式计算所得之值：

$$W = K_2 \frac{\ell^2 SP}{\sigma_S} \qquad \text{cm}^3$$

式中：K_2— 系数，查表 2.2.2.4（1）；

ℓ、P、S、σ_S 同本节 2.2.2.3（3）。

系数 K_2　　　　　　　　　　表 2.2.2.4（1）

<table>
<tr><td colspan="2" rowspan="2">名　称</td><td colspan="3">次骨材</td><td>强骨材</td></tr>
<tr><td>纵骨</td><td>横梁、肋骨、肋板</td><td>扶强材</td><td>桁材、强肋骨、实肋板、强横梁</td></tr>
<tr><td colspan="2">船底、连接桥底</td><td>136</td><td>150</td><td></td><td>150</td></tr>
<tr><td colspan="2">舷侧</td><td>128</td><td>150</td><td></td><td>150</td></tr>
<tr><td colspan="2">甲板
（包括上层建筑／甲板室顶板）</td><td>甲板：200
顶板：128</td><td>150</td><td></td><td>150</td></tr>
<tr><td colspan="2">上层建筑／甲板室前、侧壁</td><td></td><td></td><td>150</td><td>150</td></tr>
<tr><td colspan="2">上层建筑／甲板室后壁</td><td></td><td></td><td>150</td><td>150</td></tr>
<tr><td rowspan="2">舱壁</td><td>防撞舱壁、液舱壁</td><td></td><td></td><td>150</td><td>150</td></tr>
<tr><td>水密舱壁</td><td></td><td></td><td>110</td><td>110</td></tr>
</table>

2.2.2.5　骨材剪切强度

（1）　纵骨端部的有效剪切面积 A_e 应不小于按下式计算所得之 $A_{e\,min}$ 值：

$$A_{e\,min} = 22.67 \frac{(\ell - S)SP}{\sigma_S} \qquad \text{cm}^2$$

A_e 按下式计算：

$$A_e = 0.01ht \quad \text{cm}^2$$

式中：h — 纵骨腹板高度，mm；

t — 纵骨腹板厚度，mm；

ℓ、S、P、σ_S— 同本节 2.2.2.3（3）。

（2） 桁材端部的有效剪切面积 A_e 应不小于按下式计算所得之 $A_{e\,min}$ 值：

$$A_{e\,min} = 13.5\frac{S\ell P}{\sigma_S} \quad \text{cm}^2$$

A_e 按下式计算：

$A_e = 0.01h_W t_W \quad \text{cm}^2$ 端部无肘板

$A_e = 0.01h_W t_W + \Delta A_e \quad \text{cm}^2$ 端部有肘板

式中：h_W — 计算剖面处减去开孔后的腹板实效高度，mm；

t_W — 腹板厚度，mm；

ℓ、S、P、σ_S— 同本节 2.2.2.3（3）；

ΔA_e— 端部有肘板时的附加剪切面积，按肘板面板的水平倾角 θ 取值，见本章图 2.1.2.5（1）。

$\theta = 45^0$ 时，$\Delta A_e = 0.9f_1$；$\theta = 0^0$ 时，$\Delta A_e = 0$；θ 为中间值时，可用插入法求取 ΔA_e。f_1 为计算剖面处肘板面板的截面积，cm²。

2.2.3 非高速船

2.2.3.1 一般要求

（1） 本部分规定适用于横骨架式的常规钢质小船。

（2） 按本部分规定计算所得的构件尺寸均为对沿海航区营运限制船舶的要求，对遮蔽航区营运限制及平静水域营运限制的船舶可按下述规定换算折减：

① 外板、强力甲板厚度允许较按本规定计算厚度减小 8%，但减小后的外板和强力甲板的最小厚度对 $L \geqslant 10$m 应不小于 4mm；对 $L < 10$m 应不小于 3.5mm。

② 船体骨架构件的剖面模数允许较按本规定计算的剖面模数减小 10%；但内底板、舱壁板以及实肋板、内龙骨、中桁材、旁桁材等的腹板厚度允许减少 0.5mm。

③ 上层建筑和甲板室的围壁板、甲板板允许较按本规定计算厚度减小 0.5mm，但最小厚度均不应小于 3.0mm。上层建筑和甲板室骨架构件的剖面模数允许减少 10%。

（3） 当本部分设计原则要求与本节 2.2.1.2 要求相冲突时，以本要求为准。

2.2.3.2 外板

（1） 船底板的厚度 t 应不小于按下两式计算所得之值：

$$t = 0.062s\ (L+170) \quad \text{mm}$$

$$t = 6.5s\sqrt{d} + 1 \quad \text{mm}$$

式中：s— 肋骨间距，m；

L— 船长，m；

d— 吃水，m。

（2） 舷侧板的厚度 t 应不小于按下两式计算所得之值：

$$t = 0.07s(L+115) \quad \text{mm}$$

$$t = 6s\sqrt{d} \quad \text{mm}$$

式中：s— 肋骨间距，m；

L— 船长，m；

d— 吃水，m。

（3） 强力甲板的厚度 t 应不小于按下式计算所得之值，且不小于 4mm：

$$t = 1.05s\sqrt{L+75} \quad \text{mm}$$

式中：s— 横梁间距，m；

L— 船长，m。

（4） 下层甲板的厚度 t 应不小于按下式计算所得之值，且不小于 4mm：

$$t = 10s \quad \text{mm}$$

式中：s— 横梁间距，m。

2.2.3.3 船体骨架

（1） 实肋板在中纵剖面处，腹板高度 h，厚度 t 及面板剖面积 A 应不小于按下式计算所得之值：

$$h = 42(B + d) - 70 \quad \text{mm}$$

$$t = 0.01h + 3 \quad \text{mm}$$

$$A = 4.8d - 3 \quad \text{cm}^2$$

式中：B — 船宽，m；

d — 吃水，m。

（2） 肋板的面板厚度应不小于其腹板厚度，面板宽度应不小于面板厚度的 10 倍，但亦不必大于 15 倍。

（3） 机舱内肋板腹板的厚度应不小于中内龙骨腹板的厚度。

（4） 中内龙骨的高度应与实肋板高度相同，其腹板厚度 t 和面板剖面积 A 应不小于按下式计算所得之值：

船中部 0.4L 区域内：$t = 0.06L + 6.2 \quad \text{mm}$

船端 0.075L 区域内：$t = 0.05L + 5.5 \quad \text{mm}$

$$A = 0.65L + 2 \quad \text{cm}^2$$

式中：L— 船长，m。

（5） 首尖舱内的中内龙骨可与肋板等高、等厚和具有相同的面板剖面积。

（6） 旁内龙骨的尺寸应与该处实肋板的尺寸相同。在机舱内，旁内龙骨腹板的厚度应不小于中内龙骨腹板的厚度。

（7） 旁内龙骨的间距应不大于 2.5m。

（8） 肋骨的标准间距 s_0 可按下式计算：

$$s_0 = 1.6L + 500 \quad \text{mm}$$

式中：L — 船长，m。

（9） 当肋骨的实际间距大于上述（8）计算值 100mm 时，船体外板和肋骨的尺寸应另行考虑。

（10） 肋骨的剖面模数 W 应不小于按下式计算所得之值：

$$W = Csdl^2 \quad \text{cm}^3$$

式中：s — 肋骨间距，m；

d — 吃水，m；

l — 肋骨跨距，m；

C— 系数，

$$C = \frac{2 + \frac{d}{D} \times 0.65}{1.45 - \frac{\sqrt{D}}{l}}$$

其中 D 为型深，m。

（11） 当舷侧设置纵桁支持肋骨时，按上述（10）计算的肋骨剖面模数可以减少一半。

（12） 机舱内应设置间距不大于 4 个肋距的强肋骨，强肋骨应从内底延伸到上甲板。其剖面模数 W 应不小于按下式计算所得之值：

$$W = 5shl^2 \quad \text{cm}^3$$

式中：s — 强肋骨间距，m；

l — 强肋骨跨距，m；

h — 强肋骨跨距中点至船中部上甲板边线的垂直距离，m。

（13） 舷侧纵桁的剖面模数 W 应不小于按下式计算所得之值：

$$W = 7.8bhl^2 \quad \text{cm}^3$$

式中：b — 舷侧纵桁支持宽度，m；

l — 舷侧纵桁跨距，m；

h — 舷侧纵桁跨距中点至船中部上甲板边线的垂直距离，m。

（14） 舷侧纵桁的剖面惯性矩 I 应不小于按下式计算所得之值：

$$I = 2.5Wl \quad cm^4$$

式中：W— 舷侧纵桁的剖面模数，cm^3；

l— 舷侧纵桁跨距，m。

（15） 对设置双层底的中桁材高度 h 应不小于按下式计算所得之值，且不小于 700mm：

$$h = 25B + 42d + 300 \quad mm$$

式中：B— 船宽，m；

d— 吃水，m。

（16） 中桁材的厚度应与所在部位平板龙骨的厚度相同，但应不小于相连实肋板的厚度。

（17） 旁桁材的厚度应与所在部位船底板的厚度相同，但应不小于相连实肋板的厚度。

（18） 在船中部 0.4L 区域内，内底板的厚度 t 应不小于按下式计算所得之值，且不小于 5mm：

$$t = 0.04L + 8s \quad mm$$

式中：L— 船长，m；

s— 肋骨间距，m。

（19） 机舱及燃油舱区域内的内底板厚度应不小于按上述（18）计算所得的内底板厚度加 1mm。

（20） 船端 0.075L 区域内的内底板厚度可为上述（18）计算所得值的 0.9 倍。

2.2.3.4 甲板骨架

（1） 露天强力甲板计算压头 h_0 应不小于按下式计算所得之值，且不小于 0.8m：

$$h_0 = 0.025L + 0.45 \quad m$$

式中：L— 船长，m。

（2） 其他甲板计算压头 h 按表 2.2.3.4（1）选取。

甲板计算压头 h 表 2.2.3.4（1）

甲板位置	甲板计算压头 h,m
1. 首垂线 0.15L 以前的露天强力甲板	1.2h_0
2. 露天甲板装载甲板货的区域	P + 0.3 或 h_0，取较大者
3. 上层建筑及甲板室区域内强力甲板用于居住及堆放杂物时，平台甲板、第一层甲板室甲板	0.8h_0
4. 上层建筑或第一层甲板室以上各层甲板	依次取 0.6h_0、0.4h_0、…，但不小于 0.45m

注：1. 表中 P 为载货甲板上货物重量的相当水柱高度（m）；

2. 液货舱甲板（平台）计算压头 h 应不小于至舱顶溢流管顶处的高度（m）。

（3） 甲板横梁的剖面模数 W 应不小于按下式计算所得之值：

$$W = 3.5C_1shl^2 + C_2Dd \quad \text{cm}^3$$

式中：s — 横梁间距，m；

l — 横梁跨距，m; 但取值不小于 2m；

h — 甲板计算压头，m；按本节表 2.2.3.4（1）、（2）选取；

D — 型深，m；

d — 吃水，m；

C_1 — 系数，对露天强力甲板 $C_1 = 0.0065L + 0.61$，其余甲板 $C_1 = 1$；

C_2 — 系数，对单甲板船的强力甲板 $C_2 = 0.8$，其余甲板 $C_2 = 0.5$。

（4） 甲板强横梁的剖面模数 W 应不小于按下式计算所得之值：

$$W = 5shl^2 \quad \text{cm}^3$$

式中：s — 强横梁间距，m；

l — 强横梁跨距，m；

h — 甲板计算压头，m；按本节表 2.2.3.4（1）、（2）选取。

（5） 甲板纵桁剖面模数 W 应不小于按下式计算所得之值：

$$W = 4.75bhl^2 \quad \text{cm}^3$$

式中：b — 甲板纵桁支承面积的平均宽度，m；

l — 甲板纵桁跨距，m；

h — 甲板计算压头，m；按本节表 2.2.3.4（1）、（2）选取。

（6） 甲板纵桁剖面惯性矩 I 应不小于按下式计算所得之值：

$$I = 2Wl \quad \text{cm}^4$$

式中：W — 甲板纵桁剖面模数，cm^3；

l — 甲板纵桁跨距，m。

2.2.3.5 舱壁

（1） 水密舱壁板的厚度 t 应不小于按下式计算所得之值，且不小于 4.5mm：

$$t = 4.2s\sqrt{h} \quad \text{mm}$$

式中：s — 扶强材间距，m；

h — 在舷侧处，有列板下缘量到舱壁甲板的垂直距离，m；但取值不小于 2.5m。

（2） 防撞舱壁板的厚度 t 应不小于按下式计算所得之值，且不小于 4.5mm：

$$t = 4.7s\sqrt{h} \quad \text{mm}$$

式中：s、h — 见上述（1）。

（3） 舱壁最下列板厚度应较计算所得值增大 0.5mm，污水沟及舱底污水井处应增大 1.5mm，尾轴管通过处舱壁板的厚度应增大 1 倍。

（4） 水密舱壁扶强材的剖面模数 W 应不小于按下式计算所得之值：

$$W = Cshl^2 \quad \text{cm}^3$$

式中：s — 扶强材间距，m；

h — 在舷侧处由扶强材跨距中点量到舱壁甲板的垂直距离，m；但取值不小于 2m；

l — 扶强材跨距，m；当设有桁材时，为扶强材末端与桁材之间或桁材与桁材之间的距离，取大者；

C — 系数，按下列情况选取：

$C = 6$ — 扶强材端部不连接或与无扶强的板直接连接；

$C = 3$ — 扶强材端部用肘板连接；扶强材端部直接同纵向构件搭接；扶强材端部同甲板或桁材腹板直接连接，但甲板或桁材另一边应具有与之连接且与该扶强材在同一直线上的至少为相同剖面的相邻构件。

（5） 防撞舱壁扶强材的剖面模数 W 应不小于按下式计算所得之值：

$$W = 1.25Cshl^2 \quad \text{cm}^3$$

式中：s、h、l、C — 见上述（4）。

2.2.3.6 上层建筑与甲板室

（1） 本条适用的甲板骨材或围壁扶强材的标准间距为 500mm。

（2） 上层建筑前端壁板厚度 t 应不小于按下式计算所得之值：

$$t = 0.025L+4 \quad \text{mm}, \ L \geqslant 10\text{m 时}$$

$$t = 0.025L+3.5 \quad \text{mm}, \ L < 10\text{m 时}$$

式中：L — 船长，m。

（3） 上层建筑后端壁的板厚可较上述（2）计算所得之值减小 0.5mm。

（4） 上层建筑端壁扶强材的剖面模数 W 应不小于按下式计算所得之值：

$$W = 3.5shl^2 \quad \text{cm}^3$$

式中：s — 扶强材间距，m；

l — 扶强材跨距，m；但取值不小于 2m；

h — 计算压头，m；按如下选取：

前端壁取 $0.132L(d/D)^{2.5}$，但不小于 $0.008L+2.5$ m；

后端壁取 $0.045L(d/D)^2$，但不小于 $0.004L+1.25$ m；

其中，L 为船长（m），d/D 为吃水型深比。$d/D < 0.7$ 时取 0.7，$d/D > 0.8$ 时取 0.8。

（5） 上层建筑舷侧板厚度应符合下述要求：

① 桥楼舷侧板厚度与船中部舷侧外板厚度相同；

② 首楼和尾楼舷侧板厚度 t 应不小于按下式计算所得之值：

$$t = 0.04L + 4 \quad \text{mm}, \quad L \geqslant 10\text{m 时}$$

$$t = 0.04L + 3.5 \quad \text{mm}, \quad L < 10\text{m 时}$$

式中：L — 船长，m。

（6） 上层建筑舷侧骨架应符合本节 2.2.3.3（10）的有关要求。

（7） 上层建筑甲板厚度 t 应不小于按下式计算所得之值：

$$t = 0.035L + 4 \quad \text{mm}, \quad L \geqslant 10\text{m 时}$$

$$t = 0.035L + 3.5 \quad \text{mm}, \quad L < 10\text{m 时}$$

式中：L —船长，m。

（8） 上层建筑甲板骨架应符合本节 2.2.3.4 的有关要求。

（9） 甲板室围壁板厚度 t 应不小于按下式计算所得之值：

$$t = 0.025L + 3.5 \quad \text{mm}$$

式中：L — 船长，m。

（10） 甲板室围壁扶强材剖面模数 W 应不小于按下式计算所得之值：

$$W = 3.5shl^2 \quad \text{cm}^3$$

式中：s、l — 见本节 2.2.3.6（4）；

h — 计算压头，m; 按如下选取：

甲板室前端壁取 $0.12L(d/D)^{2.5}$, 但不小于 $0.008L + 2.5$ m;

甲板室侧壁、后端壁取 $0.045L(d/D)^2$, 但不小于 $0.004L + 1.25$ m。

其中，$L, d/D$ 同本节 2.2.3.6（4）。

（11） 甲板室甲板的厚度 t 应不小于按下式计算所得之值：

$$t = 0.04L + 3 \quad \text{mm}$$

式中：L — 船长，m。

第 3 节　铝合金船

2.3.1　一般要求

2.3.1.1　本节规定适用于以铝合金为船体结构材料的船舶。对全垫升气垫船，其结构应满足本社《海上高速船入级与建造规范》的要求。

2.3.1.2　结构设计原则

铝合金船的结构设计原则与钢质船要求相同。

2.3.1.3　总强度

（1）　铝合金船的总强度应满足本社《海上高速船入级与建造规范》的有关要求。

（2）　计算总强度时的许用应力如下：

许用弯曲应力：$[\sigma] = 0.67\sigma_{sw}$

许用剪切应力：$[\tau] = 0.38\sigma_{sw}$

其中：σ_{sw} — 构件材料焊接后的屈服强度，N/mm²。取材料退火状态的屈服强度 $\sigma_{0.2}$。

2.3.1.4　其他

铝合金船的局部加强、支柱设置及船体密性试验要求等与钢质船相同。

2.3.2　垂向加速度

2.3.2.1　船舶重心处的垂向加速度要求与本章 2.1.2.1 相同。

2.3.3　局部计算压力

2.3.3.1　船底、船侧、甲板、上层建筑等处的局部计算压力要求与本章 2.1.2.2 相同。

2.3.4　板厚

2.3.4.1　最小板厚 t_{min} 按下式计算：

$$t_{min} = K_0\sqrt{L} \quad \text{mm}$$

式中：K_0— 系数，查表 2.2.2.3（1）；

L — 船长，m。

对单体船、双体船和水面效应船的平板龙骨，其最小板厚应另加 2mm。

2.3.4.2　船底组合型材（包括机座）应满足下列要求：

腹板：$t \geqslant \frac{h}{50}\sqrt{\frac{\sigma_{sw}}{125}}$

其中：t — 腹板厚度，mm；

h — 腹板高度，mm；

σ_{sw}— 材料焊接后的屈服强度，N/mm²（取退火状态）。

面板：$t \geqslant \frac{b}{12} \sqrt{\frac{\sigma_{sw}}{125}}$，

其中 t — 面板厚度，mm；

b — 面板宽度，mm；

σ_{sw} — 材料焊接后的屈服强度，N/mm^2（取退火状态）。

2.3.4.3　板厚度 t 应不小于按下式计算所得之值：

$$t = K\ C_1 C_2 S \sqrt{\frac{P}{\sigma_{SW}}} \qquad \text{mm}$$

式中：K — 系数，查表 2.3.4.3；

S — 骨材间距，m，通常指纵骨间距，对桁材或肋板为其承受面积的宽度；

C_1— 有曲率板的折减系数，$C_1 = 1-0.5S/r$，r 为板的曲率半径，m；

C_2— 板格短边与长边比的修正系数。如 $S/l < 0.5$, C_2=1.0，如 S/l=1.0, C_2= 0.92, 中间值可内插。其中 l 为骨材跨距，m，当骨材端部不设置肘板时，跨距点取在骨材端部；当骨材端部设置肘板时，跨距点可取在肘板长度之半处；

P — 设计压力，按本章 2.1.2.2 要求计算所得值；

σ_{Sw}— 材料焊接后屈服强度，N/mm^2。如采用带筋成型板，焊缝离板边较远，σ_{Sw} 可取为构件材料的屈服强度 σ_S。如为铆接结构，σ_{Sw} 则取 $0.9\sigma_s$。

系数 K　　　　表 2.3.4.3

名　称		板	次骨材			强骨材
			纵骨	横梁、肋骨、肋板	扶强材	桁材、强肋骨、实肋板、强横梁
船底、连接桥底		25.0	115	135		135
舷侧		25.8	130	150		150
甲板(包括上层建筑/甲板室顶板)		27.8	130	150		150
上层建筑/甲板室前壁		25.8			170	150
上层建筑/甲板室侧、后壁		25.8			150	150
舱壁	防撞舱壁、液舱壁	25.8			130	150
	水密舱壁	23.4			120	150

2.3.5　骨材

2.3.5.1　骨材剖面模数 W（包括带板）应不小于按下式计算所得之值：

$$W = \mathrm{K}\frac{\ell^2 SP}{\sigma_{SW}} \qquad \mathrm{cm}^3$$

式中：K — 系数，查表 2.3.4.3；

ℓ、P、S — 同本节 2.3.4.3。

σ_{SW}— 材料焊接后屈服强度，N/mm^2。应满足下列要求：

（1） 除舱壁扶强材外，所有部位纵骨屈服强度均采用材料焊接后屈服强度 σ_{SW};

（2） 除船底及水上平底结构外，所有部位桁材，强肋骨及强横梁均可采用材料的屈服强度 σ_S。

（3） 若为铆接结构，σ_{SW} 则取 0.9σ_S。

2.3.5.2　骨材的剪切强度

（1） 骨材的剪切强度要求与本章 2.2.2.5 相同。

第 4 节　门、窗、盖等设施

2.4.1　一般要求

2.4.1.1　上层建筑或甲板室的外门、露天甲板上的舱口应设有风雨密关闭装置，风雨密门和舱口盖应与周围结构的强度相当。

2.4.1.2　干舷甲板以下的舷侧部位，一般不应设置舷窗，如须设置，则舷窗应设带有铰链的内侧舷窗盖，其装置应能有效地关闭和保证水密。

2.4.1.3　防撞舱壁上不允许设置门，可允许设置用螺栓固定的水密人孔盖。水密舱壁上的门必须为水密门，且航行时保持关闭。

2.4.1.4　上层建筑和甲板室的外窗及其框架结构应能保证风雨密。窗玻璃、框架及与侧壁的连接应牢固、可靠，足以承受在其营运水域正常航行时可能遭遇的波浪冲击，且其连接结构应与周围结构的强度相当。

2.4.1.5　外窗玻璃应采用符合本社接受的相关标准的钢化安全玻璃、聚碳酸脂玻璃或层压玻璃，并向本社提交玻璃材料的力学性能指标。

2.4.1.6　门、窗、盖等设施的最低密性要求

（1） 设置在干舷甲板下舷侧的圆形舷窗应满足 1 级密性要求。

（2） 设置在露天各层甲板（包括上层建筑顶板）上的风雨密舱口盖，一般应满足 3 级密性要求。但对沿海航区营运限制的船舶上位于船中之前露天甲板上的风雨密舱口盖，应满足 2 级密性要求。

（3） 设置在干舷甲板以上的垂直面或稍有倾斜的垂直面上的露天的风雨密门和窗应满足 3 级密性要求。

2.4.1.7　密性试验方法见表 2.4.1.7。

门、窗、盖密性试验方法　　　　表 2.4.1.7

密性等级		1 级	2 级	3 级
装船①前的压力试验	水压 (MPa)	0.035	0.014	---
	压水时间（min）	3	3	---
	合格标准	试件不漏泄或不永久变形		---
装船后的冲水试验	冲水试验条件	对每一试件冲水持续时间应≥ 3min； 水柱流量≥ 10 *l*/min； 冲水软管的水压为 200kP； 喷嘴离试件距离≤ 2m； 水柱应对准试件周边每侧 0.05m 内区域冲。		
	合格标准（每一试件冲水后进水量）	≤ 0.05*l*		≤ 0.5*l*

注：①　压水试验应在专门的水箱中进行。

2.4.2　窗玻璃厚度要求

2.4.2.1　外窗玻璃的厚度 t 应不小于按下式计算所得的值：

$$t = \frac{b}{31.6}\sqrt{\frac{kcp}{\sigma_b}} \qquad \text{mm}$$

式中：b — 窗开口短边长度，mm；

p — 窗玻璃承受的载荷，kN/m²，可按本规范 2.1.2.2（6）（高速船）或 2.1.3.5 (1)～（2）（非高速船）取值；

c — 系数，查图 2.4.2.1；

σ_b— 窗玻璃材料的极限弯曲强度，MPa；

k — 安全系数，取 $k = 4.0$ 钢化安全玻璃；

取 $k = 3.5$ 聚碳酸脂。

若为夹层玻璃，则每层玻璃均应是钢化安全玻璃，玻璃层数至多不超过 3 层，且 3 层玻璃中任何 2 层的厚度差应不大于 2mm，层间塑料薄膜厚度不大于 0.76mm。层压玻璃的厚度 t 应不小于下式计算值：

对于 2 层的夹层玻璃　　$t = t_1 + t_2 = 1.2teq$

对于 3 层的夹层玻璃　　$t = t_1 + t_2 + t_3 = 1.5teq$

上式中：t_1、t_2、t_3 分别为各层玻璃厚度，mm；

teq 为按单层钢化安全玻璃厚度公式算得的相当厚度，mm。

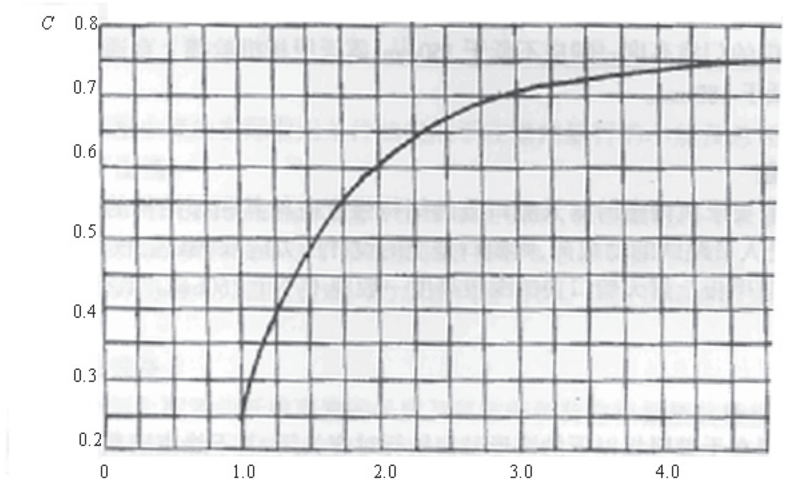
所取厚度 t 还应不小于下列最小值 t_{min}：

上层建筑或驾驶室前窗玻璃：　$t_{min} = 4$mm　　钢化安全玻璃；

$t_{min} = 5$mm　　聚碳酸脂；

上层建筑或甲板室的侧窗玻璃：$t_{min} = 3$mm　　钢化安全玻璃；

$t_{min} = 4$mm　　聚碳酸脂。



窗开口长宽比＝长边／短边

图 2.4.2.1

2.4.2.2　外窗玻璃若为聚碳酸脂玻璃，则玻璃嵌入窗框内的深度应不小于窗玻璃短边长度的 0.03 倍。

2.4.2.3　外窗玻璃可以采用粘接方式直接与壁板连接，如有必要应在窗玻璃的下缘处设置金属的水平构件支承玻璃重量。使用的粘接剂应具有抗紫外线、低温、高温和清洁用的化学剂的能力。粘接剂的长效粘接强度等性能指标以及施工要求、程序等文件应提交本社认可。

2.4.2.4　上述 2.4.2.3 的粘接方式还应满足下述要求：

（1）　玻璃的粘接宽度 d 应不小于按下式计算所得之值：

$$d = \frac{2.5 P_W b\, l}{\sigma_t (b + l)} \quad \text{mm}$$

式中：P_W = 0.0125（50+0.5v）^{2}　KN/m；

v — 最大静水航速，Kn；

b — 窗的短边长度，m；

l — 窗的长边长度，m；

σ_t — 粘接剂的最小拉伸强度，Mpa。

最小粘接宽度 d_{min} = 20b　mm。

（2）　粘接剂的厚度 t 应不小于按下式计算所得之值：

t = 5l　mm,　对钢化安全玻璃

t = 8l　mm,　对聚碳酸脂玻璃

最小粘接剂厚度 t_{min} = 6　mm。

（3）　粘接剂的拉伸强度应不低于 0.7Mpa，在延伸率为 12.5%时的拉伸强度应不低于 0.14Mpa。粘接剂扯断时的延伸率应大于 50%。

2.4.2.5　凡方窗的开口角隅应为圆角，避免在窗角处应力集中产生裂缝。

第 3 章　舾 装

第 1 节　舵设备

3.1.1　一般要求

3.1.1.1　本节适用于装有普通流线型舵或单板舵的小艇。

3.1.1.2　操舵装置应符合第 4 章的有关规定。

3.1.1.3　舵杆、舵叶、舵承的设计以及舵杆与舵叶的连接等一般应符合本社《钢质海船入级规范》的有关规定。对于高速艇的舵设备可满足本社《海上高速船入级与建造规范》的有关规定。

第 2 节　锚泊与系泊设备

3.2.1　一般要求

3.2.1.1　除另有规定外，所有机动船舶应设置锚和锚链。锚及其锚链应保持连接并置于随时可用的位置。

3.2.1.2　对锚的固定和锚链的存放应予以适宜布置。

3.2.1.3　首锚的锚链在船内端应采用有效的措施予以固定。

3.2.2　舾装数

3.2.2.1　舾装数 N 按下式计算：

$$N = \left[\Delta^{2/3} + 2(BH_c + \sum S_i \sin\theta_i) + 0.1A\right]k$$

式中：Δ — 满载排水量，t;

B — 船宽，m, 见 1.1.2.1（5）定义；

H_C — 从静浮满载水线至上甲板（甲板艇）或舷侧板顶端（敞开艇）的垂直距离，m;

S_i — 宽度超过 $B/4$ 的各层甲板室的前壁在横截面上的投影面积，m^2;

θ_i — 宽度超过 $B/4$ 的各层甲板室的前壁与水平面的夹角，°；

A — 满载水线以上的船体和宽度超过 $B/4$ 的各层甲板室的侧投影面积，m^2;

k — 系数，按营运限制取值：

沿海航区营运限制：$k = 1.5$

遮蔽航区营运限制：$k = 1.0$

平静水域营运限制：$k = 0.7$

对于无甲板室但有档风玻璃或者帆布蓬帐的艇，应考虑档风玻璃或帆布蓬的投影面积。

3.2.3 锚泊设备

3.2.3.1 通常应在船首配置一个大抓力锚，其重量应不小于根据算得的舾装数按表 3.2.3.1 查得之值。如配置非大抓力锚，则其重量应不小于按表 3.2.3.1 查得之值的 1.3 倍。

锚泊和系泊设备 表 3.2.3.1

舾装数N		首 锚	锚链直径		锚链或锚索		纤维系索	
超 过	不超过	大抓力锚重量(kg)	AM1(mm)	AM2(mm)	长度(m)	锚链或锚索的破断负荷(kN)	长 度(m)	破断负荷(kN)
—	5	12	8	8	75	29.4	2×22.5	25
5	10	12	8	8	75	29.4	2×22.5	25
10	15	14	8	8	75	29.4	2×25	25
15	20	20	8	8	80	29.4	2×25	30
20	25	25	8	8	84	29.4	2×25	30
25	30	31	8	8	87	29.4	2×35	30
30	35	37	8	8	90	29.4	2×40	32
35	40	43	8	8	93	29.4	2×40	32
40	50	51	8.5	8	97	29.4	2×40	32
50	70	67	9.5	8.5	105	38.3	3×40	34
70	90	90	11	9.5	113	50.8	3×50	37
90	110	112	12.5	11	121	63.3	3×55	39

3.2.3.2 如在船首配置 2 个锚，则每个锚的重量应不小于单锚重量的 0.7 倍。

3.2.3.3 根据船舶的实际营运条件如仅限于在港内航行的船舶及总长小于 8m 的船舶，经本社同意，可免于配锚。

3.2.3.3 可以采用锚链加锚索，也可全部采用锚索，但锚索应经本社认可。其总长度及锚链直径或锚索的破断负荷应不小于根据舾装数按表 3.2.3.1 查得之值。

3.2.3.4 对配备 30kg 及以上的锚的船舶应设置抛锚和起锚设备。允许使用人力锚绞盘或人力绞盘代替锚机，但应保证有效地收放锚。

3.2.4 系泊设备

3.2.4.1 船上配置的纤维系索的长度及其破断负荷应根据舾装数按表 3.2.3.1 查得，但此时舾装数计算公式中的系数 k，对于沿海航区营运限制和遮蔽航区营运限制的小船取 1，对于平静水域营运限制的小船取 0.85。系索直径应不小于 15mm，总长应不小于船长 4 倍。对于总长小于 8m 的船可根据具体情况另行考虑，但应经本社同意。

3.2.4.2 船舶的首、尾及两舷应设置适量的系柱或羊角。总长 L_{oa} 大于 6m 的船，船首、尾至少应分别装设 1 个系柱或羊角。

3.2.4.3 船舶的两舷应设有护舷橡胶及防碰垫等保护设施，避免在船舶停靠码头或平时系泊在码头边时舷侧与码头反复碰撞引起的船体损伤。

3.2.4.4 船舶应设有被拖带的装置并配备拖缆。拖缆长度应于锚链长度相同，其直径应不小于表 3.2.3.1 锚索直径的 0.85。

3.2.4.5 凡用以固定锚链、锚索、系索、拖索的设备（如带缆桩、羊角、拖柱）的安装处的船体结构应予以加强，使之能承受所受的拉力。

第 4 章 轮 机

第 1 节 一般规定

4.1.1 适用范围

4.1.1.1 小船的主推进装置、辅助机械装置、泵和管系的设计、制造、安装和试验均应符合本章的有关规定。

4.1.2 设计与安装

4.1.2.1 机械、燃油舱柜以及相关的管系和附件等的设计与构造应符合其拟定的用途，其安装和防护应使其在小船正常航行时对人员的危害降至最低，故应特别关注运动部件、热表面及其他危害之处。

4.1.3 环境条件

4.1.3.1 主推进机械和为小船推进和安全服务的辅助机械应设计成在下列状态可正常运转：

（1） 正浮状态；和

（2） 静态横倾不大于 15º；和

（3） 静态纵倾不大于 7.5º。

4.1.3.2 发动机的额定功率一般是指在绝对大气压 0.1MPa、环境温度 45℃、相对湿度 60％、海水温度 32℃的环境条件下，发动机所能发出的最大持续功率。

4.1.4 后退措施

4.1.4.1 小船应具有适当的后退能力，以确保在一切正常情况下能可靠地控制小船。

4.1.5 出入口

4.1.5.1 机舱至少应设有一个出入口。有人值班机舱的出入口应设有梯道，其布置应使操作人员出入方便，并应另设有一个应急出口。

4.1.6 通风

4.1.6.1 柴油机机舱应有足够的通风，以保证其中的机器在任何气候条件下全功率运转时机舱内有足够的空气，从而确保人员安全和机器的正常运转。

4.1.6.2 安装有汽油机和（或）汽油柜的舱室，其通风应符合本章第 3 节的规定。

4.1.7 材料

4.1.7.1 轴系材料应符合下列规定：

(1) 轴系应采用锻造的或轧制的碳钢、碳锰钢及经本社同意的其他材料制造；

(2) 对于最大直径不超过 80mm 的轴，可不必进行材料试验，但应向本社提交说明该材料性能的适用文件。

4.1.7.2 如采用塑料、热敏材料，则应经本社同意。

4.1.7.3 舷旁附件、通海接头等零、部件应采用钢、青铜或其他经本社认可的材料。

4.1.8 控制与仪表

4.1.8.1 客船应尽量设有一个控制中心，以便人员在正常或应急状态下均能有效地对船进行操纵和监控。控制中心至少还应设有下列功能的指示（或检测）仪表：

（1） 操纵小船的动力源；

（2） 主推进动力；

（3） 主灭火系统（如设有）；

（4） 机舱通风；

（5） 燃油泵和燃油速闭阀（如设有）；

（6） 舱底泵和舱底水水位。

4.1.9 产品

4.1.9.1 凡用于小船上的重要机器和设备，如发动机、齿轮箱、弹性联轴器、舱底泵、消防泵、螺旋桨、Z 型推进装置、喷水推进器等应具有认可的船用产品证书。其他产品应经本社同意后方可装船使用。

4.1.10 试验

4.1.10.1 轮机装置安装完毕后，应按本社同意的试验大纲进行系泊试验和航行试验。

第 2 节 发动机装置

4.2.1 一般要求

4.2.1.1 驱动推进装置每一台发动机应装有可靠的调速器和超速保护装置，并符合下列规定：

（1） 调速器应使其转速不超过额定转速的 115％；

（2） 超速保护装置应独立于调速器，并能防止发动机转速不超过额定转速的 120％。

4.2.1.2 驱动发电机的每一台发动机应有调速器和安全装置，并符合下列规定：

（1） 突然卸去或突然加上额定负荷时，其瞬时调速率和稳定调速率应分别不大于额定转速的 10％和 5%。突加额定负荷时，稳定时间（即转速恢复到波动率为 ±1％范围的时间）应不大于 5s；

（2） 发动机额定功率大于 220kW 时，应装设独立于调速器的超速保护装置，以防止发动机转速超过额定转速的 115％。

4.2.1.3 主机应设有应急停车装置。在驾驶室进行遥控的主机，则应在驾驶室设有应急停车装置。

4.2.1.4 在不补充能源的情况下，船上所设起动装置应能对主机从冷机连续起动不少于 6 次，对辅机的起动次数不少于 3 次。

4.2.1.5 发动机在船内的安装应使操作人员易于接近，以便于检查和维护。

4.2.1.6 发动机在船内的刚性安装应符合下列要求：

(1) 固定螺栓的螺母应有锁紧装置；

(2) 主机和齿轮箱的固定螺栓至少应各有 2 个紧配螺栓。

(3) 主机和齿轮箱应尽可能采用公共机座。

4.2.1.7 发动机海水冷却管系或循环系统的冷却水泵应连接不少于两个舷外海水吸口，吸口应尽可能分布在两舷；船长小于 10m 的小船，如能保证供水，可只设一个舷外海水吸口。

4.2.2 报警装置

4.2.2.1 主机应设有下列报警装置：

(1) 滑油低压报警装置；

(2) 冷却水高温报警装置。

在驾驶室遥控的主机应在驾驶室装设或延伸上述报警。

4.2.2.2 功率大于 35kW 的发电机原动机，应设有滑油低压报警装置。

4.2.3 舷外挂机的特殊要求

4.2.3.1 舷外挂机应用贯穿螺栓或等效设施可靠地固定在船的尾封板上。

4.2.3.2 安装舷外挂机的尾阱应有足够的尺寸，以便舷外挂机能根据运转工况的需要，左右、上下摆动。

4.2.3.3 舷外挂机的操纵电缆和燃油软管，如穿过船体结构应有效密封。

4.2.3.4 总功率小于 40kW 的舷外挂机，其转速和转向，可用单手柄操纵。总功率为 40kW 及以上的舷外挂机，应在船首设置手轮操纵台。

4.2.3.5　航速超过 20kn 的小船如操舵位置开敞，应在操舵位置附近设有一安全保护绳，如驾驶员失落于舷外时，该安全保护绳可关停舷外挂机。

第 3 节　汽油机和（或）汽油柜舱室

4.3.1　定义

4.3.1.1　开敞舱室：系指每 1m^3 净舱容至少具有 0.34m^2 直接开向大气的固定开孔面积的任何舱室。

4.3.2　一般要求

4.3.2.1　除开敞舱室外，装有汽油机和（或）汽油柜的舱室，应设有符合本节 4.3.3 要求的自然通风系统，装有汽油机的舱室还应设有符合本节 4.3.4 要求的动力通风系统。

4.3.2.2　装有汽油机和（或）汽油柜的舱室应与独立的客舱分隔，并能防止机舱的油气进入客舱。

4.3.2.3　凡装有汽油机和（或）汽油柜的舱室，其通风系统的进气或排气管道不应通向客舱。

4.3.2.4　除开敞舱室外，安装在汽油机或汽油柜的舱室以及与这些舱室相连通的其他舱室中的电气部件应为防点燃型的①。

4.3.2.5　安装在汽油机上的电气部件应符合第 5 章的有关规定。

4.3.2.6　便携式汽油箱或带有汽油燃料的设备应不放置在密闭的处所内，其放置处应设有快速系固装置，并能在应急情况下便于将其投弃，泄漏的汽油应直接排至舷外。

4.3.3　自然通风系统

4.3.3.1　自然通风的舱室应装设一个来自大气的进气孔或管道和一个通向大气的排气孔或管道。每一排气孔或管道开口均应从低于舱室高度的 1/3 处引出。每一进气孔或管道开口和每一排气孔或管道开口应处在正常舱底水积聚面之上。

4.3.3.2　只要舱室的尺寸允许，该舱室进气与排气管道开孔之间应至少隔开 600mm。

4.3.3.3　各进气孔或管道的合计面积，以及各排气孔或管道的合计面积应不小于按下式计算之值，且不小于 3000mm^2：

$$A = 3300\ln(V/0.14)$$

式中：A — 各开孔或管道的最小合计内横截面积，mm^2；

V — 舱室净容积，等于舱室总容积减去舱内固定安装之部件的体积，m^3；

ln— 自然对数。

① 参见 ISO 8846。

4.3.4　动力通风系统

4.3.4.1　每一动力通风舱室的抽风机或抽风机组的总排风量 Q 应不小于表 4.3.4.1 中所列的值。

总排风量 Q　　　　　表 4.3.4.1

净舱容 V m^3	总排风量 Q m^3/min
＜1	1.5
$1 \leqslant V \leqslant 3$	$1.5 \times V$
＞3	$1.5 \times V + 3$

4.3.4.2　抽风机应是不会产生火花的结构型式。

4.3.4.3　抽风机的每根进气管开口的位置应低于舱室高度的 1/3 处，且应在正常舱底水积聚面之上。

4.3.4.4　抽风机的排风口应尽量远离发动机排气管出口。

4.3.4.5　装有抽风机的汽油机舱室应在启动汽油发动机前 4 分钟开起抽风机。在小船营运期间（包括上、下客或临时停航），汽油机舱室应持续动力通风，不应关停抽风机。当抽风机因故关停时，应在机器处所和驾驶室发出声光报警信号。

第 4 节　轴系与推进器

4.4.1　轴的直径

4.4.1.1　轴采用锻钢或热轧圆钢制造，其抗拉强度对于锰钢和碳钢，应在 400 ～ 600N/mm² 范围内；对于合金钢，应不超过 800N/mm²。

4.4.1.2　轴的直径 d 应不小于按下式计算的值：

$$d = 100C\sqrt[3]{\frac{P}{n_e}\left(\frac{560}{\sigma_b + 160}\right)} \quad \text{mm}$$

式中：C — 系数，按下列规定取值：

C = 1.0 — 中间轴、传动轴；

C = 1.22 — 无键套合或法兰连接的螺旋桨轴、喷水推进器泵轴；

C = 1.26 — 键套合的螺旋桨轴。

P — 轴传递的额定功率，kW；

n_e — 轴传递 P 时的转速，r/min；

σ_b — 轴材料的抗拉强度，对于中间轴、传动轴，若 σ_b ＞ 800N/mm² 时，取 800N/mm²；对于螺旋桨轴、喷水推进器泵轴，若 σ_b ＞ 600N/mm² 时，取 600N/mm²。

轴的材料为不锈钢时，轴的直径 d 值可取上式计算值的 0.8 倍。

4.4.1.3　对于中空轴，若中孔直径 d_0 大于 $0.4d_a$ 时，轴直径应按下式进行修正：

$$d_c = d\sqrt[3]{\frac{1}{1-\left(\frac{d_o}{d_a}\right)^4}} \quad \text{mm}$$

式中：d_c— 修正后轴的直径；

d— 按本节 4.4.1.2 中公式计算的轴直径，mm；

d_a— 轴的实际直径，mm。

4.4.2 轴套（如设有）

4.4.2.1 螺旋桨轴在轴承挡处的铜套厚度 t 应不小于下式规定的值：

$$t = 0.015d + 3.8 \quad \text{mm}$$

式中：d— 螺旋桨轴在轴承挡处的直径，mm。

位于轴承挡之间的铜套厚度可适当减小，但不应小于 0.75t。

4.4.2.2 轴套应是整体铸造的，必要时可以允许轴套由几段组成，但须采用本社认可的方法将其焊成一体。

4.4.2.3 若两段轴套之间的轴使用玻璃钢或其他等效物包覆，则其包覆工艺及轴套衔接处的结构应能有效地防止海水浸入。

4.4.2.4 轴套套入到轴上前，应进行压力为 0.2MPa 的液压试验。

4.4.3 尾管及轴承

4.4.3.1 海水润滑的尾管后轴承的长度应不小于螺旋桨轴的规定直径的 4 倍。

4.4.3.2 油润滑的尾管后轴承的长度应不小于螺旋桨轴规定直径的 2 倍，且：

(1) 应装有认可型的油封装置；

(2) 应有冷却润滑油的措施。

4.4.3.3 对于本社已认可的有关新型轴承合成材料，其尾管后轴承长度经本社批准后可适当减小。

4.4.3.4 尾管在船上安装之前，应作压力为 0.2MPa 的液压试验。

4.4.4 联轴器

4.4.4.1 对于用键传递扭矩的联轴器，键材料的抗拉强度应不小于轴材料的抗拉强度，键受剪切的有效截面积应满足下式的规定：

$$BL \geqslant \frac{d^3}{2.6d_m} \quad \text{mm}^2$$

式中：B — 键的宽度，mm；

L — 键的有效长度，mm；

d — 由 4.4.1.2 确定的中间轴直径，mm；

d_m — 键中部处轴的直径，mm。

4.4.4.2 联轴器接合面处的紧配螺栓的直径 d_f 应不小于按下式计算的值：

$$d_f = 15.92\sqrt{\frac{P \times 10^6}{n_e D Z \sigma_b}} \quad \text{mm}$$

式中：P — 轴传递的额定功率，kW；

n_e — 轴传递 P 时的转速，r/min；

Z — 螺栓数；

D — 节圆直径，mm；

σ_b — 螺栓材料的抗拉强度，应不小于中间轴材料的抗拉强度，但不大于 1000 N/mm^2。

4.4.4.3 如采用普通螺栓连接时，则螺栓的螺纹根部直径 d_n 应不小于按下式计算的值：

$$d_n = 25\sqrt{\frac{P \times 10^6}{n_e D Z \sigma_b}} \quad \text{mm}$$

式中的符号 P、n_e、Z、D、σ_b 的含义与本节 4.4.4.2 相同。

4.4.5 螺旋桨

4.4.5.1 螺旋桨桨叶厚度及螺旋桨与桨轴的安装应符合本社《海上高速船入级与建造规范》的相关规定或经本社接受的标准。

4.4.6 Z 型推进装置

4.4.6.1 舵桨装置的输入轴、立轴及螺旋桨轴的直径应不小于按本节 4.4.1.2 公式所求之值。

4.4.6.2 舵桨装置的螺旋桨强度和安装要求应符合本节 4.4.5 的有关规定。

4.4.6.3 舵桨装置传动轴系的渐开线圆锥齿轮的设计和制造应符合本社接受的标准。

4.4.6.4 舵桨装置应有良好的润滑，其润滑油温度应不大于 70℃。

4.4.6.5 全回转或半回转舵桨装置应满足船舶从全速前进到后退操舵 180º 的时间不超过 20S。

4.4.6.6 回转装置动力设备如为电动或电动液压时，应设有备用动力设备或其他应急操纵措施，若小船设有两台或两台以上的 Z 型推进装置，则可免设备用动力设备。

4.4.6.7 回转装置的液压管系应符合第 8 节 4.8.1.7 的规定。

4.4.6.8 舵桨装置应在驾驶室和舵桨机室设有舵角指示器。

4.4.6.9　舵桨装置的上、下轮齿箱、转舵齿轮箱等部件制造完毕后应进行 0.2MPa 的液压试验，组装后应进行 0.1MPa 的密性试验。

4.4.6.10　液压管路应进行 1.5 倍设计压力的液压试验，装船后应连同附件进行 1.25 倍设计压力的密性试验。

4.4.7　喷水推进器

4.4.7.1　喷水推进器应能承受所有运转工况下的负荷。

4.4.7.2　喷水推进器泵轴的直径应符合本节 4.4.1.2 的有关规定。

4.4.7.3　喷水推进器的安装，包括轴系对中，应使推进系统在所有运转工况下安全工作。

4.4.7.4　喷水推进器的泵壳体应进行 1.5 倍设计压力的液压试验。

4.4.7.5　喷水推进器若采用油润滑轴承，其轴密封装置应为认可型，以防海水进入水泵的油润滑部件。

4.4.7.7　喷水推进器的方向控制装置应能在驾驶室内进行操纵。

4.4.7.8　应在驾驶室设有显示喷水泵转速和喷水推进器倒车头位置的指示装置。

第 5 节　燃油系统

4.5.1　一般要求

4.5.1.1　燃油系统的每一零部件应有足够强度，且它们的安装应使其能承受可能遇到的冲击和振动而不会发生任何漏泄。

4.5.1.2　燃油系统零部件的制造材料应具有抵抗所处环境腐蚀以及温度影响的能力。

4.5.2　燃油箱柜

4.5.2.1　燃油箱柜结构、布置等应符合下列规定：

(1)　燃油箱柜应紧固在牢固的基础上，且与舱壁或其他设备之间应留有一定空隙，以保证通风；

(2)　燃油箱柜安装前应进行水压试验，试验压头应达到至箱柜顶最高点以上 2.4m，水压试验时不允许出现漏泄现象。

(3)　燃油箱柜不得位于发动机、排气管、电气设备上方，并应尽可能远离蓄电池等；

(4)　燃油箱柜应设有足够流通面积的透气管，透气管应被引至不能进水也不会因油或油气溢出而造成危险的开敞处所。透气口应设有金属防火网；

(5)　燃油箱柜应装设测量管，允许用认可型液位指示器代替测量管；

(6) 置放燃油箱的处所应有有效的通风。

(7) 燃油舱柜不应布置在防撞舱壁之前。

4.5.2.2 柴油箱柜应有足够强度，其最小壁厚应不小于下列规定值：

奥氏体铬镍合金钢	1mm
制造后经外部热浸镀锌的低碳钢	1.5mm
含铜量不大于 0.1% 的铝合金	2mm
聚乙稀	5mm

对于采用其他材料制造的柴油箱柜，其材质和壁厚应经本社同意。

4.5.2.3 汽油箱还应符合下列规定：

(1) 汽油箱应有足够强度，其最小壁厚应不小于下列规定值：

奥氏体铬镍合金钢	1mm
含铜量不大于 0.1% 的铝合金	2mm

对于采用其他材料制造的汽油箱，其材质和壁厚应经本社同意；

(2) 汽油箱不得设置任何泄油管；

(3) 汽油箱的布置应避免阳光直照并设有防止汽油箱滑移的装置；

(4) 汽油箱的注油应采用经本社接受的方式进行。

4.5.3 燃油管路

4.5.3.1 燃油管路应适当予以夹紧和保护，以防损坏和不正常磨损。为防电化腐蚀作用，管路不可用不同金属的附件组合在一起。

4.5.3.2 燃油管路应采用无缝退火铜管、铜镍合金管或等效金属管制成。对柴油，可采用铝管。

4.5.3.3 燃油管路采用软管时，应选用耐火燃油软管[①]，并应使用防滑金属软管夹使其固定。舷外发动机的燃油软管可采用非耐火燃油软管[②]。

4.5.3.4 应尽可能在最靠近燃油箱柜处的燃油管路上设置截止阀。且该阀可在机舱外的适当位置进行关闭。

第 6 节 排气系统

4.6.1 一般要求

4.6.1.1 排气管应采用适当的绝热材料进行包裹，绝热层表面温度应不超过 60℃。应采取措施防止高温表面伤人。

① 参见 ISO7840；

② 参见 ISO8469。

4.6.1.2　排气管装有金属软管时，该软管应是认可型的，且应能承受其相应的工作高温。

4.6.1.3　水冷排气管的管材应耐腐蚀或适当增加壁厚。

4.6.1.4　排气管布置应使舷外水不会倒灌入发动机或舱内。位于水线上不足 300mm 处的排气口应设防回水装置，且应在排气管可能积水的最低处设放水旋塞。

第 7 节　舱底水设施

4.7.1　一般要求

4.7.1.1　小船应设置有效的舱底水排除系统。舱底水管系的布置应能排除任何非永久性储存液体的水密舱的舱底水，并应防止水从一个舱室流入另一个舱室。

4.7.1.2　对个别舱室，如通过计算或必要的验证，表明该船的安全不会因该舱室的排水而受影响，则可以免设排水装置。

4.7.1.3　为了保护舱底水管系，如认为必要，吸入管路应安装有效的滤器，滤器应便于拆装和清洗，且其流通面积应不小于其管路截面的 2 倍。

4.7.1.4　为了防止海水倒灌，如认为必要，舱底水吸口阀应是止回型的。

4.7.1.5　在所有的舱口和升降口关闭的情况下高速小船应能操作舱底水泵（移动式泵除外）。

4.7.1.6　舱底水的排放应满足主管机关的防污染要求。

4.7.2　舱底水泵

4.7.2.1　舱底泵一般应是自吸式的。

4.7.2.2　船长 L 小于或等于 12m 时，可以只设置一台手动舱底泵。船长大于 12m 的机动船和有辅助动力的非机动船，应至少设置一台动力泵和一台手动泵。船长大于 12m 的无辅助动力的非机动船建议设置 2 台手动舱底泵。敞开艇还应配备一只舀水勺或水桶。

4.7.2.3　动力驱动的舱底泵可兼作他用，但不可作为油泵。

4.7.2.4　对不用于船体破损后控制舱底进水量的舱底泵，则舱底泵的总排量应不小于表 4.7.2.4 的规定。

舱底泵的总排量　　　　**表 4.7.2.4**

船长 L(m)	舱底泵总排量 (m^3/h)
$L \leqslant 6$	0.6
$6 < L \leqslant 12$	1.0
$12 < L \leqslant 24$	2.0

4.7.3　排水口

4.7.3.1　所有舷外的排水口均应在易于到达处安装截止止回阀。一般位于水线 350mm 以上且航行中不会因小船横摇而可能导致进水的排水口，可免装此截止止回阀。

4.7.4　舱底水水位报警装置

4.7.4.1　设有推进机械的水密分隔舱室，或易于积聚舱底水而又不易发现的其他舱室(空舱除外)，应装设舱底水高位报警装置。

4.7.4.2　设有固定或移动舱底水吸口的任一干舱室，如其舱底水水位不易发现，也应装设舱底水高位报警装置。

4.7.4.3　在船的操纵处应设有舱底水高位的声光报警信号。

第 8 节　操舵装置

4.8.1　一般要求

4.8.1.1　操舵装置应能确保航行时对船的操纵是可靠的。

4.8.1.2　动力操纵的操舵装置一般应设应急操舵装置。

4.8.1.3　如果操舵装置具有两台及以上的动力设备，则可免设应急操舵装置。

4.8.1.4　舷外挂机或舷内外机的方向控制装置可免设应急操舵装置。

4.8.1.5　采用 Z 型推进装置，应符合本章第 4 节 4.4.6 的规定。

4.8.1.6　采用具有方向控制功能的喷水推进器，应符合本章第 4 节 4.4.7 的规定。

4.8.1.7　对于液压操舵系统还应符合下列规定：

(1)　系统组件材料应适应其工作介质；

(2)　液压管系中应设有滤器和溢流阀，溢油一般应回至油箱；

(3)　液压管系和液压油缸等设备应有放气装置；

(4)　管路和软管应避免受到热影响，软管应是认可型的；

(5)　每一液压系统的循环油箱应设低位报警，且能在机器处所和驾驶室发出声、光报警信号，但舷外机的操舵装置可以例外。

4.8.1.8　操舵的位置应使操舵的人员具有良好的航行了望视野。

第 5 章　电气装置

第 1 节 一般规定

5.1.1　一般要求

5.1.1.1　船上主要电气设备的设计、制造、试验和安装应符合本章的有关规定，或本社接受的其他相应标准的规定。电气设备和电缆按本社相关规定具有相应的船用产品证书。

5.1.1.2　船上的电气装置应能：

(1) 确保为保持船舶处于正常操纵状态所必需的所有电力辅助设备供电；

(2) 确保乘员和船舶的安全，免受电气事故的危害。

5.1.2　电气设备的设计、制造和安装

5.1.2.1　电气设备的设计、制造和安装应考虑安全和便于检修。

5.1.2.2　电气设备应能在表 5.1.2.2 的电压和频率偏离额定值的波动情况下可靠工作：

电压和频率波动　　　　表 5.1.2.2

设备	参数	稳态，%	瞬态	
			%	恢复时间，s
一般设备	电压	+6 ～ -10	±20	1.5
	频率	±5	±10	5
由蓄电池供电的设备： 充电期间接于蓄电池者 充电期间不接于蓄电池者	电压	 +30 ～ -25 +20 ～ -25	—	—

5.1.2.3　电气设备应能在下列环境条件下正常工作：

(1)　环境空气温度应符合表 5.1.2.3(1) 的规定；

环境空气温度　　　　表 5.1.2.3(1)

部位	温度
封闭处所内	0 ～ 40℃
温度超过 40℃和低于 0℃的处所内	按这些处所的温度
开敞甲板	－ 25 ～ 40℃

适用于电子设备的环境空气温度的上限为 55℃；

(2)　潮湿空气、盐雾、油雾和霉菌；

(3)　船舶正常营运中所产生的振动和冲击；

(4)　倾斜摇摆如表 5.1.2.3（4）所列。

倾斜和摇摆　　　　　　表 5.1.2.3（4）

设备组件	倾斜角 (°)[①]			
	横向		纵向	
	横倾	横摇	纵倾	纵摇
应急电气设备、开关设备、电气及电子设备	22.5	22.5	10	10
上列以外的设备、组件	15	22.5	5	7.5

注：①　可能同时发生横向和纵向倾斜。

5.1.2.4　电气设备应安装在远离易燃材料，通风良好，不可能积聚易燃气体的处所，且该处所不易遭受到机械损伤或水、油的损害。如必需安装在容易遭受到上述各种危险之处，则设备应具有适当的结构防护或加以封闭。

5.1.2.5　电气设备的外壳防护型式，应满足表 5.1.2.5 的规定。

外壳防护型式　　　　　　表 5.1.2.5

船上处所	防护等级
甲板下保护良好的舱室	IP20
舱顶遮蔽的甲板上	IP22
溅湿的甲板上	IP44
大量浸水的甲板上	IP56

5.1.3　接地

5.1.3.1　电气设备和电缆的带电部件以外的所有可接近的金属部件应可靠接地。

5.1.3.2　对于非金属船体，应设置金属接地板。金属接地板应以截面积不小于 0.1m²，厚度不小于 1mm 的铜或其他耐海水的金属（例如不锈钢）制成。如果非金属船的发动机或螺旋桨具有接地板的等效功能，可不要求另设接地板。

5.1.3.3　金属接地板应固定在水线以下，在船舶的任何航行情况下均能浸没在水中。对于双体船，应在每片船体上设置接地板。

5.1.3.4　中性导体应只在电源处接地，即在船舶上发电机、电力变压器的次级接地。岸电的中性点应通过岸电电缆接地，不应在船舶上接地。

5.1.3.5　应把直流等电位搭接导体（如设有）接地，以使杂散电流减至最小。

5.1.4　避雷

5.1.4.1　对于具有非金属桅的船舶，应设置避雷针。避雷针应至少高出桅 150mm。船舶的桅应具有适当的高度，以便避雷针能对船舶起到避雷作用。

5.1.4.2　避雷针应以截面积不小于 8mm² 的铜导体制成，并以 5.1.4.3 规定的互连导体与 5.1.3.3 规定的金属接地板作可靠的电气连接。对金属桅的船舶，金属桅可作避雷针用，如果金属桅顶安装有电气设备，则应设置专门的避雷针。

5.1.4.3　互连导体应满足下列要求：

(1) 互连导体应为截面积不小于 8mm² 铜导体；

(2) 铜线的任一股的截面积应不小于 0.71mm²，应至少有 19 股；

(3) 金属带或金属条的厚度应至少为 1mm。

第 2 节 电源与配电

5.2.1 电源的型式和配备

5.2.1.1 除 5.2.1.5 另有规定外，船舶上应至少设有两套电源，在任一套电源发生故障时，剩余电源的容量应能继续满足船舶正常航行情况下的需要。

5.2.1.2 电源可以采用下列几种形式：

(1) 由独立的原动机驱动的发电机；

(2) 由推进主机驱动的发电机；

(3) 蓄电池组。

5.2.1.3 对于操舵装置、为推进主机服务的各种辅机及保障船舶安全航行所必需的设备均为电力供电时，应至少设置一台与主机独立的发电机组。

5.2.1.4 对于正常航行不完全依靠电力的船舶，可设置主机轴带发电机和蓄电池组作为电源，轴带发电机的容量应能向船舶所需的所有电气设备供电，蓄电池组的容量应至少在与整个航程相适应的时间内，足以对维持船舶安全航行所必需的用电设备供电。

5.2.1.5 对于在遮蔽水域营运限制或平静水域营运限制航行的船舶，可设置两组蓄电池组作为电源，两组蓄电池组的总容量应能维持船舶正常航行所必需的设备供电。

5.2.1.6 对于非机动船，电源可根据需要设置。

5.2.2 蓄电池组

5.2.2.1 凡以蓄电池组作为电源的船舶，如果蓄电池组的额定容量有一合理的余量，而无需在航行期间充电，则船舶上可不配充电装置，但应设有岸电充电装置。另外，若能满足主机起动要求，也可作为主机的起动蓄电池组。

5.2.2.2 蓄电池组应安装在舱底水水位以上的干燥、通风的部位。蓄电池的安装方式应考虑到船舶的预定用途，限制其水平和垂直移动。对于已安装的蓄电池，当其经受相当于蓄电池重量之两倍的力时，其在任何方向上的移动幅度不应大于 ±10mm。

5.2.2.3 安装在船上的蓄电池应在倾斜 45° 时，其电解液不会漏泄。应设有在蓄电池处于正常工作位置时用于容纳任何溅出电解液的设施。

5.2.2.4　蓄电池的安装位置应能防止受到机械损伤。

5.2.2.5　蓄电池不应安装在燃油箱（柜）或燃油滤器的直接上方或直接下方。

5.2.2.6　安装在蓄电池顶部上方300mm之内的燃油系统的任一金属部件均应以介质材料予以绝缘。

5.2.2.7　蓄电池电缆接线端子不应藉助于弹性拉力作为其与蓄电池接线端子的机械连接。

5.2.2.8　酸性和碱性蓄电池不应安装在同一围蔽处所内。开关、熔断器和其他容易产生电弧的电气设备不应安装在蓄电池组处所内。

5.2.2.9　蓄电池组的安装位置应与船壳保持一定的距离。

5.2.2.10　充电功率[①]大于 2kW 的蓄电池组，应安放在专用舱室内或也可安放在开敞甲板上的箱或柜中。

5.2.2.11　装有透气型蓄电池组的室、箱或柜通风装置的排气量 Q 应不小于：

$$Q = 0.11In \quad m^3/h$$

式中：I — 产生气体期间的最大充电电流，但不小于充电设备能够输出的最大充电电流的 25%，A;

n — 蓄电池数量。

5.2.2.12　装有阀控密封型蓄电池的室、箱或柜的排气量可减少至 5.2.2.11 规定排气量的 25%。

5.2.3　配电系统

5.2.3.1　配电系统的最高电压不应超过 500V，可以采用下列配电系统：

(1)　直流

双线绝缘系统

负极接地的双线系统

(2)　交流

单相双线绝缘系统

单相一线接地的双线系统

三相三线绝缘系统

中性点接地的三相四线系统

三相四线绝缘系统

5.2.4　配电板（箱）

5.2.4.1　配电板（箱）应安装在干燥、容易接近和通风良好的位置。配电板（箱）的前面、即开关和熔断器的操作面应易于接近，而其后面，即接端子的连接线处应可接近。

5.2.4.2　对同时设有直流和交流电气系统的船舶，应在单独的配电箱上分别进行直流和交流配电，或者在具有隔离板或其他可靠设施将直流和交流部分相互清晰地分开的同一配电箱上进行配电。船上应具有用以标识电路、组件和导线的接线图。

① 充电功率系指蓄电池组的标称电压乘最大充电电流值。

5.2.4.3　配电板（箱）的前后均应铺有防滑和耐油的绝缘地毯或经绝缘处理的木格栅。电压为50V 以下者可除外。

5.2.5　插座

5.2.5.1　不同电压和／或不同频率配电系统中的插座，应使用不可互换的插头和插座连接。

5.2.5.2　安装在经受雨淋、喷水或溅水部位的插座，当其不使用时，应能被封闭在至少为 IP55 的外壳中。插入相应插头后的插座也应相应密封。

5.2.5.3　安装在经受注水或瞬时浸水区域的插座应在防护等级至少为 IP56 的外壳中，当其与电气插头一起使用时，也应满足这些要求。

5.2.5.4　为厨房区域装设的插座的位置应使得各器具的电线不应跨越厨房炉灶或洗涤盆上方或穿过通行区域而插入这些插座。

第 3 节　系统保护

5.3.1　系统保护

5.3.1.1　电气装置中应设置合适的保护电器，以能在发生包括短路在内的过电流故障时，对其进行保护。

5.3.1.2　每一独立电路均应设有可靠的短路保护和过载保护。

5.3.1.3　发电机应以断路器进行保护，对 50kW 以下的发电机可用一个多极开关加熔断器进行保护。

5.3.1.4　电动机负载的过电流保护装置的整定值应与被保护电路的需用负载特性相协调。

5.3.1.5　过电流保护装置的定额应不超过被保护导线的最大载流容量。

5.3.1.6　对于电力变压器，包括由两个或三个单相变压器组成而作为一个装置运行的变压器组，均应设有过电流保护。每一变压器均应由一个设在初级侧的，定额不大于变压器初级额定电流 125% 的单独过电流保护装置予以保护。

5.3.1.7　应有标明每一电路过载保护电器额定值或相应的整定值的耐久标志，该标志应设在保护电器所在位置。

5.3.1.8　蓄电池组（除起动蓄电池外）均应设有短路保护，其保护电器应尽可能靠近蓄电池组。

5.3.1.9　应在尽可能靠近蓄电池组的某一易于接近的部位，在接至供电系统的蓄电池或蓄电池组的正极导线上安装一个蓄电池分断开关，下列情况例外：

(1)　只具有发动机起动和航行灯电路的舷外机船舶；

(2)　具有保护存储器和保护装置的电子装置，例如舱底泵和报警器，如其已在尽实际可行的靠近蓄电池接线端子处以断路器或熔断器单独地予以保护；

(3)　发动机燃油柜（舱）通风机，如果已在电源处单独地设有熔断器。

5.3.2 动力设备

5.3.2.1 额定功率等于或大于 1kW 的电动机及所有重要用途的电动机，一般应由配电板的独立分路供电。

5.3.2.2 每台电动机均应设置有效的起动和停止装置，其位置一般应在电动机附近。

5.3.3 铝合金船舶

5.3.3.1 配电系统应与船体绝缘或设置阴极保护系统。

5.3.3.2 对于直流系统，蓄电池不应通过推进机械或相关的机械部件接地。发动机的起动蓄电池可通过发动机接地。

第 4 节 照 明

5.4.1 照明

5.4.1.1 船舶甲板以及供乘员出入、使用的处所应设有照明。

5.4.1.2 除主照明外，在乘员经常出入的处所，还需设置应急照明，应急照明应由蓄电池组供电。对于由两组蓄电池组作为电源的船舶，可不必设置应急照明。

5.4.1.3 对于沿海航区营运限制的船舶，应急照明时间为 6h；对于遮蔽航区营运限制或平静水域营运限制的船舶，应急供电时间为 3h。

5.4.1.4 在主照明失效的情况下，应急照明应自动起作用。

第 5 节 电 缆

5.5.1 一般要求

5.5.1.1 船舶上应采用船用成束滞燃型电缆或电线。电缆、电线的选择应根据敷设的环境条件、敷设方法、电流定额、工作定额、需用系数和允许电压降等因素来确定。

5.5.1.2 在机舱中的电缆或电线的导体绝缘工作温度应至少为 70℃，并为耐油型，或者以绝缘的导管或套筒予以防护，其载流量应减少至额定载流量的 0.75 倍。

5.5.1.3 在机舱之外的电缆或电线的导体绝缘工作温度应至少为 60℃。

5.5.2 敷设

5.5.2.1 电缆或电线的走线应尽可能平直和易于检修。

5.5.2.2 除非在导管或电缆槽中走线或由托板予以支承，否则无护套的单根导线的最大支承间距应为 250mm。

5.5.2.3　有护套的导线以及蓄电池导线的最大支承间距应为450mm，第一个支承距接线端子不得大于1m。但起动电动机的导线可例外。

5.5.2.4　单独安装的长度超过200mm的每一根导线都应至少具有1mm^{2}的截面积。多芯电缆的每一根导线应至少具有0.75mm^{2}的截面积，且其可以伸出该护套外的距离不超过800mm。

5.5.2.5　电气系统的每一电气导线均应具有识别方法，以标识出其在该系统中的功能。但对于与发动机成套的，由该发动机制造厂提供的导线除外。

5.5.2.6　导线的连接应在防风雨的位置或防护等级至少为IP55的外壳中进行。

5.5.2.7　载流导线应避免在舱底水区域或可能积聚水的其他区域的预期水位线以上走线。如果必须在舱底水区域走线，则应采取适当的防水措施。

5.5.2.8　接线端子的双头螺栓、螺母和垫圈用的金属应为耐蚀的，且应与导线的金属在电化腐蚀上相兼容。不应把铝和未镀覆的钢用作电路中的双头螺栓、螺母或垫圈。

5.5.2.9　所有的导线均应具有适当的接线端子，即不得把裸导线与接线柱连接，但对其端部的各绞线已在其与接线柱连接相接触的全长上通过锡焊做成刚性者，则可例外。对于标称截面积大于2.5mm^{2}所有导线的连接和接线端子，不应采用锡焊接。

5.5.2.10　不应采用绞扭接头导线螺母。

5.5.2.11　对于接线端子的裸露颈部，应采用绝缘的隔板或套管予以防护，以免无意短路，但对在保护导线系统中的接线端子则可例外。

5.5.2.12　导线的走线应避开可能损坏其绝缘的排气管或其他热源。除非设有一等效的隔热板，否则其与水冷却排气部件的最小间距为50mm；与干式排气部件的最小间距为250mm。

5.5.2.13　可能遭受物理损伤的导线应以护套、导管或其他等效设施予以保护。贯穿舱壁或结构件的导线应对由擦伤引起的绝缘损坏予以保护。

5.5.2.14　在同一接线螺柱上紧固的导线数不应多于4根。电缆或电线不应直接敷设在玻璃钢层板内。

第6节　船内安装汽油机的附加要求

5.6.1　一般要求

5.6.1.1　在外部或内部会产生电火花而可能点燃汽油和空气混合物的汽油机上安装的电气系统部件（诸如断路器、开关、电磁线圈、发电机、调压器和电动机），其设计和安装时应符合本社接受标准[①]规定的防点燃型设备的要求。

5.6.2　发动机电气系统和部件

① 参见ISO8846的规定，防爆电气设备可以代替防点燃型设备。

5.6.2.1　所有电气系统部件应尽可能高地安装于发动机上方。发动机起动电动机和点火配电器的位置可以在发动机制造商的设计基础上予以调节。

5.6.2.2　点火线圈和永磁发动机应安装或保护使水不会在高压头周围积聚。

5.6.2.3　如要求电气部件为防点燃型，且扎带或其他罩盖为防点燃外壳的一部分，则在此部件上应固定永久性警告标签，或在扎带或罩盖上设有适当文字或符号的永久性明显标志，标志上应指示出当发动机运行时扎带或罩盖应在其位置上。

5.6.2.4　点火分配器应符合下列规定：

(1)　在发动机起动和运行时使用的分配器，应为防点燃型。用于紧固分配器端头的设施应有足够的强度以防止在内部燃油和空气汽化混合物爆炸时分配器脱离其密封表面。在试验期间，高电压（2 次）点火导线应如发动机运行时安装的那样，以接线端子的罩盖置于所分配器端头的凸缘上；

(2)　所有进气口或排气口均应以有效的火焰阻止器隔板盖住或具有等效的防点燃能力的尺寸和长度；

(3)　接线端子罩盖应紧紧固定以在高压导线绝缘外面及分配器端头凸缘外面形成水密，并满足 5.6.2.5(1) 的要求。

5.6.2.5　高压（2 次）点火电缆组件应符合下列规定：

(1)　高压点火电缆组件应有罩盖和安装螺纹套管，以在高压导线绝缘外部、分配器端头凸缘外部及火花塞陶瓷绝缘子外部形成水密，使当此连接浸入以重量计为 3% 盐水溶液液面下 3 ～ 5cm 处 2h 后，以 50 ～ 60Hz，20kV 峰值电压 (14kV rms) 作用于导体时不致发生漏电。在高压导线的自由端与浸入盐水溶液之间应以每秒 500V 峰值 (355V rms) 的速率施加电压。

(2)　安装于高压点火电缆上的罩盖和螺纹套管，在 125℃ ±2℃温度下放置 40h 后，接着在室温条件下在火花塞和配电器端头凸缘上装、拆 10 次以使其挠曲后满足上述 (1) 的漏电试验要求；

(3)　安装于高压点火电缆上的罩盖和螺纹套管，当在室温中悬挂于满足 ISO 1817 的试验液 C 液面以上 25mm±5mm 的密封的玻璃容器内 30h 后，接着在火花塞和分配器端头凸缘上装、拆 10 次以使其挠曲后应满足上述 (1) 规定的漏电试验要求；

(4)　安装于高压点火电缆上的罩盖和螺纹套管在 125℃ ±2℃，符合 ISO 1817 要求的 3 号试验油中放置 40h，将它从试验油拿走，冷却至室温，抹去附着的试验油，在火花塞和分配器端头凸缘上装、拆 10 次后应满足上述 (1) 规定的漏电试验要求；

(5)　上述 (2) 至 (4) 规定的试验应在高压点火电缆组件的各分组上进行。

第 6 章　液化石油气（LPG）动力船舶的附加要求

第 1 节　一般规定

6.1.1　一般要求

6.1.1.1　本章适用于以液化石油气（以下简称为：LPG）为燃料的发动机作为主动力的船舶。

6.1.1.2　适用本章的船舶，禁止使用双燃料。

6.1.1.3　对舷外 LPG 挂机的特殊要求可按照本规范第 3 章的有关规定。

6.1.2　定义

6.1.2.1　本章规定有关定义如下：

（1）**液化石油气（LPG）**：系指在常温和大气压下呈气态，通过增压和降温可使之保持液态的轻质碳氢化合物的混合物，其基本成分为丙烷、丙烯、丁烷、丁烯。它也可由商用丁烷、商用丙烷或两者混合物构成。

（2）**气罐**：系指船上用于储存液化石油气（LPG）的专用钢瓶。

（3）**气罐处所**：系指船上用于存放气罐的固定处所。

（4）**围蔽处所**：系指由舱壁和甲板所围成的封闭处所，但可以有门窗。

（5）**半围蔽处所**：系指由于具有顶板、甲板等结构，以致其自然通风条件与在开敞甲板有显著的差异，且其布置使气体不会发生扩散的处所。

（6）**开敞处所**：系指开敞的甲板空间。

6.1.3　附加标志

6.1.3.1　凡批准入级的装有 LPG 动力的船舶，将在船级符号与船舶类别附加标志之间加注液化石油气附加标志 LPG。

6.1.4　初次检验

6.1.4.1　应补充下列图纸资料提交本社审查批准：

（1）LPG 机器处所、气罐存放处所布置图；

（2）LPG 供气系统图；

（3）LPG 机器所处、气罐存放处所通风布置图；

（4）LPG 探测、报警系统图；

（5）LPG 动力系统操作手册。

6.1.4.2　现有船舶初次检验时送审的图纸、资料可酌情减少。

6.1.4.3　新建船舶的建造检验尚应增加下列项目：

（1）　LPG 发动机的安装和试验；

（2）　LPG 供气系统的安装和试验；

（3）　LPG 机器处所、气罐存放处所通风系统的安装和试验；

（4）　LPG 遥控关闭装置的安装和试验；

（5）　检查 LPG 探头的安装位置、数量并进行 LPG 探测报警系统的试验；

（6）　防爆设备或防点燃设备的确认和安全检查。

6.1.4.4　现有船舶初次检验的项目可视船舶具体情况酌情减少，重点检验与 LPG 动力系统、通风、消防等有关项目。

6.1.5　营运检验

6.1.5.1　年度检验尚应增加下列项目：

(1)　对 LPG 机器处所、气罐存放处所进行总体检查，并确认处所内不存在失火和爆炸危险以及通风系统处于良好工作状态；

(2)　检查 LPG 主机遥控系统并确认处于良好的工作状态；

(3)　检查 LPG 供气系统，如发现管路，阀件有较严重腐蚀、漏气现象应及时处理；

(4)　检查 LPG 探测报警系统的工作情况；

(5)　对遥控关闭 LPG 供气总阀的机构进行试验；

(6)　检查防爆电气设备或防点燃电气设备的工作状态；

(7)　检查气罐存放处所和机舱的底板及有密闭要求的隔壁的密闭性是否良好。

6.1.5.2　特别检验尚应增加下列项目：

(1)　折开 LPG 发动机、检查气缸、活塞、连杆、曲轴及所有轴承等零部件；

(2)　LPG 主机在工作状态下进行操纵试验，主机遥控系统处于良好工作状态。

第 2 节　LPG 发动机

6.2.1　一般要求

6.2.1.1　LPG 发动机（以下简称发动机）的设计和制造应符合国家有关标准的规定。

6.2.1.2　发动机作为主机时，应装设可靠的调速器，使主机的转速不超过额定转速的 115%，当发动机作为发电机的原动机时，应装设调速器，其调速特性应符合本社《海上高速船入级与建造规范》第 4 章的有关规定。

6.2.1.3　发动机应设有应急停车装置，该装置可用关闭 LPG 供气总管上的燃料总阀来实现，且应能在驾驶室进行遥控。

6.2.1.4　发动机冷却水系统应设加热装置，以确保发动机在冬天的正常起动。

6.2.1.5　发动机的排气管系应符合下列要求：

（1）　排气管应采用适当的绝热材料包裹，以使表面温度不超过 220℃。

（2）　排气管出口处应装设火星熄灭装置或等效设施。排气管出口应尽可能远离机舱和气罐储存处所的排风口。

第 3 节　LPG 供气系统

6.3.1　气罐及其附件

6.3.1.1　气罐应安装在独立的气罐存放处所内且有牢固的固定设施，确保其在海上航行时不会翻倒，并便于拆卸和调换。气罐与固定座之间应有防撞击的橡胶或木质垫料。

6.3.1.2　气罐安装方向及位置应考虑气、液相接头元件以及液面指示器有效与可靠的工作。

6.3.1.3　气罐应尽可能远离热源，避免阳光直接照射。气罐专用舱室或气罐箱内的温度一般应不高于 45℃，在夏天高温时应采取适当的降温措施。

6.3.1.4　气罐限量充装阀应在 LPG 充装量达到 80% 气罐水容积时，自动终止充装。

6.3.1.5　气罐安全阀应能确保气罐压力不超过其设计压力。

6.3.1.6　密封保护盒应可靠地将气罐口及各附件密封，并设置能使泄漏气体排向舷外安全处所的通气管道。

6.3.1.7　气罐及其附件应符合有关国家标准①的规定，其产品应具有经有关主管部门认可的产品证书。

6.3.2　LPG 控制设备

6.3.2.1　每一 LPG 供气系统应设有一个蒸发调压器，该调压器应能为各个用气发动机提供合适的、固定的工作压力。LPG 经蒸发调压器以后的管路内的压力应不大于 0.005MPa。

6.3.2.2　每一气罐的出口处应设限流阀，当限流阀两端压力差为 0.35MPa 时，限流阀自动关闭。

6.3.2.3　在 LPG 供气总管上的蒸发调压器的进口处应装设自动截止阀，其在下列情况之一时，能自动切断 LPG 供给。

（1）点火开关未打开；

（2）发动机未运转；

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①　参见 GB17259。

(3) 抽风机未开。

6.3.2.4 对多气罐的LPG供气系统，每一气罐引出的供气支管上应设有截止阀，以供调换气罐时关闭用。

6.3.2.5 同时供应多台发动机的LPG供气系统，应在每台发动机的进气管上装设截止阀。

6.3.2.6 气罐应设有容量测量装置并采用压力传感器及气量显示器，以便能在驾驶室显示其即时容量。

6.3.3 LPG供气管系

6.3.3.1 对刚性供气管应采用硬质拉制铜管或拉制不锈钢管。对外径为12mm及以下的管路，其壁厚应不小于0.8mm，而对外径大于12mm的管路，其壁厚应不小于1.5mm。蒸发调压器以后的低压管路可采用认可型橡胶软管，不得采用塑料软管。

6.3.3.2 从气罐至蒸发调压器的高压供气管路应安装在围蔽或半围蔽的气罐处所内。如安装在开敞处所，应用保护构件将其固定和遮挡，以防踩压或碰撞。

6.3.3.3 LPG供气管路不得通过客舱、服务处所和控制站。

6.3.3.4 LPG发动机与任何固定安装的金属管路之间应使用认可型橡胶软管连接，以避免因振动所引起的故障。

6.3.3.5 供气管路中凡部分采用软管者，软管两头的接头应有双夹头，夹头应有一定的接触长度，且不允许采用弹簧夹头，夹头的设置应具有可达性。

6.3.3.6 LPG供气管系中有可能泄漏燃气的部分管路应与电器设备尽可能远离。

6.3.3.7 LPG供气管与舱壁或甲板之间不应直接接触，在与其他管路相交处应避免接触。

6.3.4 试验

6.3.4.1 液化石油气管系应进行液压试验和密性试验，试验压力按表6.3.4.1的要求。

试验压力 表6.3.4.1

LPG管系	试 验 压 力	
	液压试验（在车间）(MPa)	密性试验（装船后）(MPa)
气罐至调压器管路	3.3	2.2
调压器至发动机管路	0.2	0.1

6.3.4.2 液化石油气供气系统安装完毕后，应进行效用试验，不应有气体泄漏。6.3.4.1中所述的密性试验也可与效用试验一起进行。

第 4 节　布置与通风

6.4.1　布置

6.4.1.1　机舱和气罐存放处所应相互独立，且严禁与客舱混合布置。气罐存放处所应尽可能采用半围蔽方式布置在甲板以上通风良好处。气罐存放处所应能上锁，以防止非工作人员触摸和搬动。气罐存放处所不应设有通往其下方舱室的孔洞及梯道口。气罐及高压管路在甲板上距船舶外轮廓边缘的距离（不包括护舷材）应不小于 100mm。

6.4.1.2　机舱和气罐存放处所应设有独立的疏排水系统，并与其他舱室的疏排水系统分开。

6.4.1.3　机舱和气罐存放处所的底部结构应保持气密，且应尽可能设置平台。对设有加强骨材的底部，其布置应不妨碍可燃气体的排泄。

6.4.1.4　机舱、气罐存放处所与客舱间的舱壁，以及气罐存放处所与机舱间的舱壁应保证气密，且一般不应设置开口。如有必要的管路或电缆穿过，则应在该穿过处予以气密，并保证该处结构防火的完整性。

6.4.1.5　对于客舱内的门、窗均为非风雨密的敞开式船舶，其客舱底板上应设有疏水槽及污水阱。

6.4.2　通风

6.4.2.1　围蔽或半围蔽的机舱或气罐存放处所应装设足够容量的机械通风系统，其换气次数应分别不小于 30 次 /h 和 20 次 /h。且机舱机械通风应与主机实现起动 / 运行联锁，即当通风机开起至少 10min 后，发动机才能被起动；当通风机因故关停时，发动机应能自动停机且应符合下列要求：

(1)　对于围蔽的机舱和气罐处所，一般应采用机械抽风系统。抽风机的每根进风管的风口应位于舱室高度的 1/3 以下，且在舱底水积聚面之上。排风口应使舱内空气排向舷外，并尽量远离发动机排气管出口。排风口靠近水线时应设有防止水倒灌的装置。

(2)　如通风系统采用机械鼓风的形式，排风口的位置一般应位于舱室高度的 1/3 以下，且在舱底水积聚面之上。排风口应使舱内空气排向舷外并尽量远离发动机排气管出口。排风口靠近水线时应设有防止水倒灌的装置。

(3)　风机应是不会产生火花的结构型式。

6.4.2.2　上述 6.4.2.1 所述的机舱和气罐存放处所，一般还应设有自然通风，其上下进排风口应尽可能远离。排风口的位置一般应位于舱室高度的 1/3 以下，且在舱底水积聚面之上。排口一般为百叶窗的型式。

第 5 节　探测与报警系统

6.5.1　LPG 可燃气体探测器

6.5.1.1　LPG 可燃气体探测系统应经本社认可。

6.5.1.2　围蔽和半围蔽的气罐存放处所及围蔽的机舱应设置固定的 LPG 可燃气体探测器。

6.5.1.3　LPG 可燃气体探测器的设置应满足下列要求：

(1)　探头应设置在 LPG 可燃气体易于泄漏和积聚的位置；

(2)　当 LPG 可燃气体浓度达到爆炸下限的 30% 时，应能在驾驶室发出声、光报警；当 LPG 可燃气体浓度达到爆炸下限的 60% 时，应能自动关闭或从驾驶室遥控关闭 LPG 供气总阀。

6.5.1.4　每一船应至少配置 1 只便携式 LPG 可燃气体探测器，以方便船员随时取用检查。

第 6 节　结构防火与消防用品

6.6.1　结构防火

6.6.1.1　机舱、气罐存放处所与客舱之间，以及气罐存放处所与机舱之间的分隔舱壁的向火面应用具有阻燃性能的玻璃钢或等效材料制成。

6.6.1.2　容易失火以燃烧时散发出大量烟雾或有毒气体的涂料、绝缘材料不能用于机舱和气罐存放处所内。

6.6.1.3　机舱和气罐存存放放处所应设有“禁止吸烟”醒目标牌。

6.6.2　消防用品

6.6.2.1　机舱应按表 6.6.2.1 的规定配置灭火器。

机舱灭火器配置　　　　表 6.6.2.1

机舱总功率　P(kW)	灭火器配置
$P \leqslant 37.5$	1 个干粉灭火器，其单个容量不小于 2kg。
$37.5 < P \leqslant 150$	2 个干粉灭火器，其单个容量不小于 2kg。
$150 < P \leqslant 300$	2 个干粉灭火器，其单个容量不小于 3kg。
$300 < P \leqslant 450$	2 个干粉灭火器，其单个容量不小于 4kg。

6.6.2.2　气罐存放处所应至少配置 2 个干粉灭火器，其单个容量不小于 2kg。

第 7 节　其　他

6.7.1　气罐存放处所的电气设备

6.7.1.1　在气罐存放处所应尽量不安装电气设备，如确实需要，应安装能防止 LPG 可燃气体点燃的电气设备。如有必要，每条船舶可配备 1 只自带电池的手提式防爆灯，以供应急时用。

6.7.2　营运要求

6.7.2.1　船上应备有本规范规定的船舶证书以及 LPG 动力系统操作手册等有关资料。

6.7.2.2　应对船员进行 LPG 动力系统正常操作和管理的培训。

6.7.2.3　应对船员进行应急程序的培训，以处理 LPG 泄漏或火灾事故等紧急情况。

6.7.3　进入处所

6.7.3.1　船上人员进入可能有 LPG 积聚的舱室、留空处所或其他封闭处所时，应采取下列措施之一：

(1) 使用固定式或可携式 LPG 探测设备，确定上述处所的空气中没有危险浓度的 LPG 可燃气体；

(2) 人员配带呼吸器和其他必需的防护设备。

6.7.3.2　人员进入上述处所，不得带有任何潜在的着火源，除非经验证，已对该处所进行过除气且仍保持这种状态。

6.7.4　LPG 动力系统操作手册

6.7.4.1　船上应备有经批准的、可供船上人员随时使用的 LPG 动力系统操作手册，以作为正常情况和所预料的紧急情况下安全操作的指南。

6.7.4.2　操作手册至少应包括以下规定的内容。

6.7.4.3　LPG 发动机的起动操作程序应符合下列要求：

(1) 开启探测和报警系统，确认无 LPG 泄漏；如探头测得机舱（如有时）和气罐存放处所有 LPG 泄漏，则应立即检查，找出泄漏原因，排除泄漏；

(2) 开起机舱和气罐存放处所的通风机；

(3) 为防止误操作，通风机与发动机之间设有联锁装置，当通风机开起达 4min 以上时，发动机方可被起动；当通风机因故关停时，发动机能自动停机。

6.7.4.4　在船舶营运期间（包括上、下客或临时停航），围蔽或半围蔽的机舱和气罐存放处所均应持续机械通风，不得关闭风机。

6.7.4.5　船舶设置的固定式LPG可燃气体探头当测得泄漏的可燃气体浓度达到爆炸下限30%时，驾驶室发出声光报警；当泄漏的可燃气体浓度达到爆炸下限60%时，LPG供气总阀应自动关闭，如该阀不能自动关闭，则驾驶人员必须在驾驶室立即关闭供气总阀。

6.7.4.6　更换气罐

(1) LPG气罐充装后，应检查气罐及其附件是否有泄漏现象，若发现有损坏部位及泄漏，则气罐不得上船。

(2) 气罐上船安装后，检查气罐出液阀与快速接头的连接处，该处不应有泄漏现象。

6.7.4.7　其他要求

(1) 如发现LPG供气系统有泄漏，在未查明原因和修复以前，该设备不得使用，且应采取切断LPG气源和开起通风换气的措施，并严禁各种火种和电器设备的使用。

(2) 船上严禁倒放、留存、处理气罐内LPG的残液。

(3) 船舶停航期间，应将LPG发动机的所有供气阀关闭。

(4) 当船舶发生火灾时，应能迅速把气罐拆除并抛出船外，以保护船舶与乘客安全。

(5) 液化石油气设备的管理、维修和使用应指定专人负责。

附录：船舶操作手册编写要求

船舶操作手册至少应包括下列内容：

1. 船舶的简介：包括船的主尺度、航速、营运限制的类别、配备的机电设备、通信设备、信号设备、灭火设备、救生设备、主机功率、油水装载量、续航力、乘员定额、排污设备等。

2. 各个系统简介：包括推进系统、燃油系统、操舵系统、通风系统、舱底水系统、电力系统、消防系统等。

3. 安全使用要点：包括

(1) 在风浪中航行时的航速限制；

(2) 高速船高速航行时防止横稳性突降的主机转速限制；

(3) 高速船高速回转时主机转速的限制；

(4) 追越其他船舶时的航速限制；

(5) 装有汽油 /LPG 舷内外机或舷内机艇的安全使用要求，包括保持自然通风口通畅及机械通风等要求。

4. 脱险措施。

5. 日常维护和保养要求：包括主、付机的日常维护保养、灭火设备的定期检查、汽油机和汽油舱柜的通风设备的保养、检查。

CONTENTS

Chapter 1 GENERAL

Section 1 General Requirements

1.1.1 Application

1.1.1.1 The Rules applies to classed sea-going boats of less than 20 m in length, and does not apply to:

(1) boats of war;

(2) wooden boats;

(3) yachts not engaged in trade ①;

(4) oil tanker carrying oil having a flash point of less than 60℃ ;

(5) boats carrying dangerous goods (including bulk chemical carrier and liquefied gas carrier);

(6) submerged and semi-submerged boats;

(7) small water-plane area twin-hull boats;

(8) sports boats; and

(9) fishing boats.

1.1.1.2 The service restriction for boats applicable to the Rules is specified as follows:

(1) Coastal service restriction means the service in the sea area within 20 n miles off the shore (not exceeding 10 n miles in Taiwan Strait and similar waters), and a passenger boat does not proceed in the course of its voyage more than 4 h, or a cargo boat 8 h, at 90% of the maximum speed from a place of refuge ② when fully laden. Where the sea state of some service areas above-mentioned is heavier, more stringent requirements may be made by the Society to the distance above-mentioned, depending on the specific cases. When special provisions for the service area are stipulated by the Administration of the flag State or by the coastal Authority in charge of the service area, the provisions are to be observed.

(2) Sheltered water service restriction means the service in the sea area between the island and the shore and between islands with a distance of less than 10 n miles in between, which form a comparatively good sheltered condition with a little wave, or within 10 n miles off the shore (not exceeding 5 n miles in Taiwan Strait and similar waters), and a passenger boat does not proceed in the course of its voyage more than 2 h, or a cargo boat 4 h, at 90% of the maximum speed when fully laden, Beaufort wind scale not more than 6 scale, and the visual wave height not more than 2.0 m in sea state.

(3) Calm water service restriction means the calm water service within 5 n miles off the shore and a boat does not proceed in the course of its voyage more than 2 h at 90% of the maximum speed when fully laden, Beaufort wind scale not more than 6 scale, and visual wave height not more than 1.0 m in sea state.

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① Yacht not engaged in trade means the yacht not for commercial purposes.

② Place of refuge is any naturally or artificially sheltered area which may be used as a shelter by a boat under conditions likely to endanger its safety.

1.1.1.3 Operation of open boat is only limited in the condition of calm water service restriction. High speed open boat is not permitted to carry more than 12 passengers.

1.1.1.4 The materials for boats applicable to the Rules may be of steel, aluminum alloy or fabric reinforced plastics. The materials and construction technology of boats are to be in compliance with the relevant requirements of Rules for Materials and Welding by China Classification Society (hereinafter referred to as CCS or the Society).

1.1.1.5 Motor boats applicable to the Rules are those mainly driven by engines with diesel oil, petrol or liquefied petrol gas (hereinafter referred to as LPG) as fuel.

1.1.1.6 The existing boats after repair, alteration and modification are at least to be in compliance with the applicable requirements of the original corresponding rules. Where major repair, alternation and modification are made, such boats are to comply with the requirements of the Rules in so far as reasonable and practicable.

1.1.1.7 The stability, fire safety, life-saving appliances and communications, etc. of boats are to comply with the requirements of the flag State Administration relating to safety equipment and environmental protection.

1.1.1.8 Where the decimal part of the calculated plate thickness in the Rules is 0.25 mm or less, it may be neglected; where it is greater than 0.25 mm but less than 0.75 mm, it is to be taken as 0.5 mm; where it is 0.75 mm or more, a round number of 1.0 mm is to be taken.

1.1.2 Definitions

1.1.2.1 Unless expressly provided otherwise, for the purpose of the Rules:

(1) Overall length L_{oa} (m) means a distance from the fore end of stem to the aft edge of stern transom plating or sternpost, excluding any other protrusions.

(2) Length L (m) means the length between the forward stem post and after rudder post along the full load waterline of a boat, or the length between the forward stem post and the center line of the rudder stock for a boat without rudderpost.

(3) Full-load displacement $\triangle$ (t) means the weight of sea water displaced by a boat under an immediate sailing condition with the required equipment, cargo stores, accessories, rigging, crew, etc., 100% of fuel oil, lubricating oil , fresh water, food, supplies and rated passengers onboard the boat.

(4) Full load draft d (m) means the vertical distance measured at the midpoint of length (L) from the top of the plate keel (or from the lower surface of keel for fabric reinforced plastics boat) to the full load waterline of a boat at full-load displacement in rest floatation.

(5) Breadth B (m) means the horizontal distance measured from the outside of the boat frame of one to that of other side; or the maximum breadth between two sides of external surfaces for fabric reinforced plastics boat, at the widest part of a boat, excluding protrusions, fenders, etc.

(6) Moulded depth D (m) means the vertical distance measured at the middle of the length L from the top of the plate keel to the top of the deck beam at side on the uppermost continuous deck (for decked boat) or to the top end of the shell side plating (for open boat). For fabric reinforced plastics boat, the vertical distance measured at the midpoint of length (L) from the lower surface of the plate keel to the top of the uppermost continuous deck (for decked boat) or to the top end of the shell side plating (for open boat).

(7) Freeboard F (m) means the vertical distance measured from the full load waterline to the top of freeboard deck (for decked boat) or to the top end of the shell side plating (for open boat).

(8) Freeboard deck means a continuous weather deck from bow to stern on decked boat.

(9) High speed boat means a boat capable of a maximum speed V meeting both the following formulae at its full-load displacement:

$$V \geqslant 3.7 \nabla^{0.1667} \quad \text{m/s}$$

$$V \geqslant 10 \quad \text{kn}$$

where: ∇— displacement corresponding to its full-load displacement, in m^3;
V— speed achieved at its maximum continuous propulsion power for which the boat is certified at its full-loaded displacement and in smooth water.

(10) Maximum speed is the speed achieved at the maximum continuous propulsion power for which the boat is certified at maximum operational weight and in smooth water.

(11) Yacht means a boat engaged in trade for public entertainment, leisure or touring.

(12) Decked boat means a small boat having a continuous weathertight deck from bow to stern.

(13) Open boat means a small boat not having a continuous weathertight deck from bow to stern.

(14) Public boat means a working boat intended for patrol, customs and police service, etc.

(15) Passenger boat means a boat carrying more than 12 passengers.

(16) A passenger is every person other than:

① the master and the members of the crew or other persons employed or engaged in any capacity on board a boat on the business of that boat; and

② a child under one year of age.

(17) Cargo boat means any boat other than passenger boat.

1.1.3 Equivalent and exemption

1.1.3.1 Any boat which embodies structure and features of a novel kind may be exempted from any requirement of the Rules if the application of which might seriously impede the incorporation of its features or its service, subject to agreement by the Headquarters of CCS.

1.1.3.2 Any fitting, material, appliance or apparatus, other than that required in CCS Rules, may be allowed to be fitted in a boat, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance or apparatus is at least as effective as that required in the Rules.

1.1.3.3 Equivalence or substitution to those methods of calculation, criteria of evaluation, manufacturing procedures, materials, survey and test requirements specified by the Rules may be accepted subject to agreement by the Headquarters of CCS, when relevant tests, theoretical basis or service experience are provided, or recognized effective standards are available.

1.1.4 Interpretations of the Rules

1.1.4.1 The right of interpretations on the Rules is to be left solely to the Headquarters of the Society.

1.1.4.2 In case of any different understanding to the English version of the Rules, the currently effective Chinese version of the Rules is to prevail.

1.1.5 Statutory surveys

1.1.5.1 CCS will undertake part or entire statutory surveys of boats under the authority of the Government of flag States and in accordance with the application or contracts/agreements from the boat owners or designers or shipyards.

1.1.5.2 For boats intended to be classed with CCS, CCS will carry out the classification survey in conjunction with the statutory survey when so authorized.

1.1.5.3 CCS will issue relevant statutory certificates and/or reports, upon completion of design review, surveys during construction and after construction, and the classification part is confirmed complying with the CCS requirements relating to classification and satisfying the corresponding statutory requirements.

1.1.5.4 For boats which the classification and statutory surveys are carried out by CCS, where the classification certificate is invalid, then the corresponding statutory certificate will be invalid simultaneously.

1.1.5.5 In accordance with the client's request or contracts/agreements, CCS may also undertake related statutory surveys.

1.1.5.6 CCS will issue relevant documents of compliance and/or reports, upon completion of design review, surveys during construction and after construction, and the classification part is confirmed complying with the CCS requirements relating to classification and satisfying the corresponding statutory requirements.

Section 2 Surveys and Certificates

1.2.1 Types of survey

1.2.1.1 The types of survey are divided into:

(1) Initial survey, including:

① construction survey for newbuildings;

② initial survey for existing boats (including those constructed not under the design review and supervision of CCS in accordance with the Rules, however subsequent survey carried out and considered to comply with the provisions of the Rules by CCS).

(2) Surveys after construction, including:

① annual survey;

② up-to-slipway/docking survey;

③ special survey;

④ occasional survey.

1.2.1.2 All surveys mentioned in this Section may be carried out as appropriate basing on each type of boat.

1.2.2 Issue of certificates

1.2.2.1 Where a boat is found in compliance with the relevant provisions of the Rules and other requirements after the initial classification survey, the character of classification and corresponding class notations will be assigned and the classification certificate will be issued.

1.2.2.2 The validity of classification certificates is not to exceed 2 years for passenger boat, 5 years for high speed boat and 5 years for cargo boat.

1.2.3 Interval of surveys after construction

1.2.3.1 The boat having the classification certificate is to be carried out surveys after construction in accordance with the specified interval and the requirements of 1.2.6 to 1.2.8 of this Section.

1.2.3.2 Annual surveys are to be carried out within 3 months before or after each anniversary date of the certificate. After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.2.3.3 Up-to-slipway/docking surveys are to be carried out once every two years for passenger boat, annually for high speed boat and a minimum of twice within a five-year period for cargo boat, the maximum interval between successive surveys is not to exceed 3 years, however one of the two surveys required in each five-year period is to coincide with the special survey. After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.2.3.4 The interval of special surveys is not to exceed 2 years for passenger boat, 5 years for high speed boat and 5 years for cargo boat. Corresponding certificate is to be renewed after a satisfactory survey. Where it is not able to complete the special survey by its due date, the boat may be granted an extension not exceeding 3 months subject to agreement.

1.2.3.5 The special survey may be carried out in conjunction with annual survey and docking survey.

1.2.3.6 An occasional survey is to be applied for in either of the following conditions:

(1) an accident to a boat which affects its seaworthiness;

(2) alteration of a boat's intended purpose or service area as restricted in its certificates;

(3) invalidity of a boat's statutory certificate;

(4) changes of a boat's owner or manager, and of a boat's name or port of registry;

(5) repairs or modification involved in the safety of a boat.

After a satisfactory survey, the Surveyor is to endorse the corresponding certificates to confirm the certificates are valid continuously within the specified period.

1.2.3.7 All the certificates will be invalid automatically where the boat is not operated in accordance with the service requirements stipulated by the certificates or is not carried out surveys after construction.

1.2.4 Characters of classification and class notations for classed boats

1.2.4.1 Boats applied for and classed with the Society is to be assigned with the following characters of classification as appropriate after approval:

★ CSAD
★ CSAD

Meaning of the characters of classification are to be as follows:

★ — indicating that the boat has been constructed under the design review and supervision of CCS in accordance with the Rules, and comply with the requirements of the Rules;
★ — indicating that the boat has not been constructed under the design review and supervision of CCS, however subsequent survey carried out and considered to comply with the provisions of the Rules by CCS;
CSAD — indicating that the boat's structure and equipment comply fully with the requirements of the Rules, and suitable for the service in domestic waters.

1.2.4.2 Boats classed with the Society will be assigned type notations and service restriction notations to be affixed to the character of classification, depending on the specific cases.

(1) Boat type notations are shown in Table 1.2.4.2(1).

(2) Service restriction notations are shown in Table 1.2.4.2(2).

Type notations **Table 1.2.4.2(1)**

Type of boat	Type notation
Passenger boat Cargo boat Non-propulsion boat	Passenger Boat Cargo Boat Non-propulsion Boat

Service restriction notations **Table 1.2.4.2(2)**

Service restriction	Service restriction notation
Coastal service restriction Sheltered water service restriction Calm water service restriction	Coastal Service Restriction Sheltered Water Service Restriction Calm Water Service Restriction

1.2.4.3 High speed boat complying with the Rules is to be affixed HSC to the type notation by the Society.

1.2.4.4 LPG power-driven boats complying with the requirements of Chapter 6 of the Rules will be assigned LPG Power-driven notation by the Society.

1.2.5 Initial survey

1.2.5.1 Before construction of a boat, plans and documents in triplicate as specified in this Section are to be submitted to the Society for approval.

1.2.5.2 The approved plans and documents are only effective in the designated scope of the construction numbers. The validity of the approved plans and documents is 4 years.

1.2.5.3 The following plans and documents are to be submitted to the Society for approval as appropriate:

*(1) General arrangement;

*(2) Construction profile (including main transverse sections, bow and stern construction, bulkheads, decks, superstructure, typical joints, etc.);

(3) Laminate design;

(4) Shell expansion;

(5) Welding methods and specifications

(6) Construction plan of main engine seating and gear box seating;

(7) Technology specifications of hull construction;

*(8) Structure, installation and arrangement of doors, windows and covers;

(9) Calculations of equipment number and arrangement of anchoring, mooring, handrails and deck skid-proof;

(10) Construction of rudder (including rudder blades, rudder stocks, rudder bearings and connections) and Calculations of rudder strength;

*(11) Arrangement of machinery spaces;

*(12) Ventilation arrangement in machinery spaces;

*(13) Shafting arrangement and propeller plan;

(14) Calculations of shafting and propeller strength;

(15) Arrangement of Z-type propelling unit or stern machinery of inboard/outboard engine;

*(16) Steering system;

*(17) Arrangement of piping (including main/auxiliary exhaust piping, fuel oil piping, fire piping and bilge piping);

(18) Electric loading calculations (including calculations of storage battery capacity);

*(19) Electric power system, marking:

① primary rated parameters of motors, transformers, storage batteries and power electric equipment;

② all the feeder lines on switchboard;

③ types, section areas and primary rated parameters of cables;

④ types and primary rated parameters of circuit breakers and fuses.

(20) Single line of switchboard;

*(21) Arrangement of electric power equipment (including installation position of motors, storage batteries, switchboards, etc.);

(22) Schematic diagrams and arrangement of lighting;

*(23) Boat's operation manual (only applicable for high speed boat and yacht, refer to Appendix).

1.2.5.4 The following plans and documents are to be submitted to the Society for information as appropriate:

*(1) General specification;

(2) Lines;

(3) Calculations of weight and gravity center;

(4) Hydrostatic curves;

*(5) Scantling calculations according to the Rules;

(6) Tonnage calculations;

*(7) Thickness calculations of window glass;

*(8) Particulars of all boat equipment.

1.2.5.5 The names of plans and documents to be submitted may not be all the same, however at least the contents of the above-mentioned plans and documents are to be included. In addition to 1.2.5.3 and 1.2.5.4, other plans and documents may be required to submit by the Society according to the practical cases.

1.2.5.6 The plans and documents of the existing boats for initial survey may be in accordance with the requirements marked with * in 1.2.5.3 and 1.2.5.4.

1.2.5.7 Hull surveys of newbuildings are as follows:

(1) to confirm material, technology, equipment and fittings used for hull structure complying with the rules requirements and holding the relevant marine product certificates;

(2) to examine hull forming die;

(3) to check test report of mechanical properties of hull plating specimens (including single plate and sandwich plate);

(4) to check correctness, completeness and welds quality of hull assembly;

(5) to examine after hull if formed;

(6) to examine installation quality of the windows of the first layer of superstructure and the front wall of bridge room (including connections between window glasses, frames and bulkheads and walls);

(7) to examine anchoring and mooring equipment;

(8) inclination test.

1.2.5.8 Machinery surveys and electrical surveys of newbuildings are as follows:

(1) to confirm marine products certificates of essential machinery equipment;

(2) tightness test of piping system after installation onboard;

(3) installation and test of essential machinery;

(4) installation and test of system;

(5) to confirm product certificates of electrical equipment in primary purposes;

(6) to examine and test the generators, storage batteries and switchboards;

(7) specification check and installation survey of cables;

(8) internal communication equipment test;

(9) survey and test of main/auxiliary engines, steering systems and control, safety and alarm systems;

(10) to examine lighting system.

1.2.5.9 Mooring trials and sea trials are to be made in accordance with the requirements for Programme of Mooring and Sea Trials.

1.2.5.10 Initial survey of existing boats

(1) Plans and documents to be submitted for initial survey of existing boats are to be in accordance with the requirements of 1.2.5.6 of this Section.

(2) The initial survey items may be determined depending on the boat's age and actual condition, but to be carried out at least in accordance with the annual survey items. For passenger boats over 5 years of age, surveys are to be carried out in accordance with the renewal survey items.

1.2.6 Annual survey

1.2.6.1 Hull surveys are as follows:

(1) to examine appearance of hull structure and superstructure whether it has cracks or turns to white or laminates for fabric reinforced plastics boat;

(2) to examine shell plating, deck and bulkheads whether they have any corrosion for metal boats;

(3) to examine any evidence of loosing or water leakage in way of connections of the hull;

(4) to examine effectiveness of fore window frame and glass connection for high speed boat;

(5) to examine whether natural vents of petrol internal/external engines are effective;

(6) to examine complement and effectiveness of mooring and rudder equipment.

1.2.6.2 Machinery surveys and electrical surveys are as follows:

(1) an external examination of propelling unit, auxiliary engine in primary purposes. If deemed necessary, an effectiveness test may be conducted for some item;

(2) a general examination of machinery spaces;

(3) to examine remote control system of main engines and hydraulic operating system of Z-type propelling units and to confirm they are in good order;

(4) to examine whether oil tanks and fuel oil system are in good order without leakage;

(5) to examine steering gears and control system and test to be carried out under working conditions;

(6) to examine operating condition of essential piping systems such as bilge system and main engine cooling system, etc.;

(7) internal communications test;

(8) an external examination of generators and storage batteries, and its operation;

(9) a general examination and test of electrical equipment and cables under working conditions as far as practicable;

(10) a general examination of earthing and lightning-rod earthing.

1.2.6.3 Annual survey items for high speed boat are to be same as special survey items.

1.2.7 Up-to slipway/docking survey

1.2.7.1 The up-to-slipway/docking survey items are as follows:

(1) to examine cracks, damages and corrosions of shell under waterline;

(2) to examine integrity of rudders, rudder stocks, rudder bearings, Z-type propelling units, propellers, screw shaft and bearings, water-jet unit, suction boxes, and gratings;

(3) to examine whether the earth plates of shell are in good order.

1.2.8 Special survey

1.2.8.1 In addition to annual survey and up-to-slipway/docking survey items, the special survey items are to include the following:

(1) for motors: to examine cylinders, cylinder heads, valves, pistons, connecting rods, crank shafts and all of the parts, i.e. bearings, engine foundations, chassises, coolers, shock dampers, engine-driven pumps;

(2) for gear boxes: to examine wheels, pinions, shafts, bearings and incorporated clutch arrangements;

(3) for Z-type propelling units: to examine wheels, pinions, shafts, bearings and sealing arrangements;

(4) maneuvering test is to be carried out on propelling working condition for the propulsion machinery, the remote control system and hydraulic operating system of main engines and Z-type propelling units are in good order;

(5) to withdraw screw shaft and examine shafts, liners, keys, shaft cones, fillets of flanges, stern tube bearings, oil sealing arrangement and the fit conditions of propellers and screw shaft cones;

(6) for jet propeller: to examine blades, shafts, shaft seals, guiding nozzles, reverse and control systems in way of ingress-egress shafts and measure clearance between blades and guide ducts;

(7) measurement of insulation resistance for electrical equipment and circuits;

(8) to examine generators, storage batteries and steering motor (if any), and a running test under working conditions;

(9) to examine stand-by motors together with controls for essential equipment, and a running test as far as practicable under working conditions;

(10) to examine switchboards (box), to confirm in good working order.

1.2.8.2 The items in 1.2.8.1(2) to (4) of this Chapter may be replaced by the examination of their maintenance records.

1.2.8.3 The plywood of hull is not to turn to white or laminates without any leakage.

1.2.8.4 For metal boats, thickness measurements on suspect areas of hull plating are to be carried out at the second and subsequent special surveys.

Chapter 2 HULL STRUCTURE

Section 1 Fabric Reinforced Plastics Boats

2.1.1 General requirements

2.1.1.1 This Section applies to boats whose hull structures are of FRP material.

2.1.1.2 The manufacturers of FRP boat are to be subject to approval by the Society and construction quality is to be controlled strictly by the manufacturers.

2.1.1.3 The requirements of this Section are applicable to boats with single plate and sandwich plate structures. For air-cushion vehicles, the structures are to comply with the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

2.1.1.4 Principle of structural design

(1) The hull structure is to be so designed that the boat can withstand the maximum external force that may be encountered throughout its whole period of normal operation.

(2) The hull structure may be designed by direct calculation, however the Structural Calculations are to be approved by the Society.

(3) The width of flat keel or girth of hood keel is not to be less than 0.1*B* (*B* being the molded breadth), the thickness is not to be less than 1.5 times that of the boat's bottom plating and is kept unchangeable within the whole length of boat.

(4) Shell side longitudinals of the boat with molded depth less than 0.9 m may not be fitted, however, hard chine hull form may be adopted and hull girder strength is to be checked.

(5) The bottom floors, side frames and deck transverses are to be arranged in the same transverse section and connected fixedly, special cases are to be subject to plan approval.

(6) The spacing (*S*) of boat's frames or longitudinals are not to be more than 500 mm. The spacing of plate floors for longitudinally framing boat is not to be more than 4 frame-spaces, and that for transversely framing boat is not to be more than 2 frame-spaces.

(7) The spacing of keels and spacing between keel and bilge chines or midpoints of bilge circular are not to be more than 2 m.

(8) The hull longitudinal components are to be kept continuous within the whole length of boat as far as possible.

(9) The ratio of web height and thickness of hood type sectional structural members is not to exceed 30, and that of the face plate width and thickness is not to exceed 20. The ratio of web height and thickness of T type sectional structural members is not to exceed 20, and that of the face plate width and thickness is not to exceed 10. Other sectional type members are to be specially considered.

(10) The web height of sloping bottom boat's plate floors may be reduced gradually from longitudinal centerplane to sides, however for boat of more than 6 m in length, the web height in way of 3/8 breadth from longitudinal centerplane is not to be less than 1/2 of that in way of longitudinal centerplane.

(11) For engine room of single-engine boat or flat bottom boat, the center keelson may be replaced by girder of main engine's foundation or two side keelsons (one at each side). The girder of main engine's foundation or side keelson and center keelson are not to be interrupted in way of any bulkhead and are to extend on the back of the bulkhead with the length not to be less than 2 frame-spaces.

(12) The plate thickness is to be such that is not taken the gel coat and repaired composite or other non-reinforced material into account.

2.1.1.5 Hull girder strength

(1) Hull girder strength is to be checked for high speed boat and fabric reinforced plastics boat of 15 m and over in length and L/D equal to or more than 12.

(2) The midsection at half of boat length (L) is in general to be taken as the checking section during calculation of hull girder strength. The amidship section modulus W of freeboard margin line (decked boat) or side top strake line (open deck boat) is not to be less than:

$$W = f L^2 B_w (C_b + 0.7) \quad \text{cm}^3$$

where: f —- factor, $f = 0.25\,L + 24$;
L —- length of boat, in m;
B_w —- breadth in way of full load waterline, in m;
C_b —- block coefficient under full load waterline.

(3) The moment of inertia (I) to neutral axis amidship section is not to be less than:

$$I = 4.0\,WL \qquad \text{cm}^4$$

where: L —- length of boat, in m;
W —- amidship section modulus calculated in accordance with the requirements of 2.1.1.5(2), in cm^3.

(4) Calculation of amidship section modulus

① All continuous longitudinal members within 0.4 L at amidship may be taken into account in the calculation of midsection modulus, however the sectional areas of openings on them are to be deducted from the midsection area.

② In general, a superstructure having a length greater than 0.2 L but within 0.4 L amidship may be taken into account in the hull girder strength. Where there are large amount openings on the side walls of above-mentioned superstructure and the sum of length of all openings on each side wall exceed half of the superstructure length, the superstructure is not to be considered to make contribution to the hull girder strength.

③ Where a boat adopted sandwich construction as parts of hull's members, the concept of equivalent section modulus (W_e) is to be introduced.

For the longitudinal bending of hull girder, the equivalent section modulus (W_e) of the middle transverse section composed by some of members made of sandwich construction is to be calculated as follows:

$$W_e = \frac{\Sigma E_i I_i}{EY} \qquad \text{cm}^3$$

where: E —- modulus of elasticity of material at the point calculated, in N/mm^2;
Y —- vertical distance from the point calculated to the neutral axis of the mid-boat section in cm;
E_i, I_i —- modulus of elasticity for each member's material composing of the midcraft section, in N/mm^2 and moment of inertia to the neutral axis of the midcraft section for each member, in cm^4, respectively.

(5) For catamarans, the transverse strength and the torsional strength of connecting structure of their twin hull are to be checked in accordance with the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

(6) Allowable stress for calculation of general strength are to be as follows:

$[\sigma] = 0.30\sigma_{nu}$ for allowable bending stress, where, σ_{nu} is the ultimate bending stress of the laminate, in N/mm²;

$[\tau] = 0.25\tau_u$, for allowable shearing stress of single skin panel, where τ_u is the ultimate shearing stress of the laminate, in N/mm²;

$[\tau] = 0.5\tau_{cr}$, for allowable shearing stress of sandwich panel, where τ_{cr} is the critical shearing stress of the skin laminate of the sandwich panel in N/mm², τ_{cr} is to be taken from the following formulas, whichever the smaller:

$$\tau_{cr} = 0.3\left(E_f^{45°} E_c G_c\right)^{1/3} \quad \text{N/mm}^2$$

$$\tau_{cr} = 0.4\gamma G_c \quad \text{N/mm}^2$$

where: $E_f^{45°}$ — compressing modulus of elasticity for the skin laminate of sandwich panel in 45° direction, in N/mm², $E_f^{45°}$ may be taken as 60%, where the skin laminate is biaxial laminate;
E_c — compressing modulus of elasticity of core material, in N/mm²;
G_c — shearing modulus of elasticity of core material, in N/mm²;
γ — ratio of the distance between centerlines of opposite skin laminates to the mean thickness of opposite laminates, $6 \leqslant \gamma \leqslant 14$.

2.1.1.6 Main engine's foundations and engine room's framings

(1) The structures of main engine's foundations are to have enough strength and rigidity. Transverse separating plates and transverse bracket plates are to be provided in each frame space for girders of foundations to ensure the effective supporting.

(2) In order to increase the compression and bending rigidity, timbers or aluminum alloy sections may be used as core materials of girder webs, however, the core materials are to be effectively bound with the surface of FRP and the bottom floor of boat.

(3) The frames in engine rooms are to be kept continuous to avoid stress concentration.

(4) In the engine room, plate floors are to be provided in each frame space as the boat's bottom is transversely framed and plate floors are to be provided alternative frame space as the boat's bottom is longitudinally framed. The sectional modulus of plate floors are to be increased 10% of the values stipulated in 2.1.2.4 or 2.1.3.6 of this Chapter, and the plate floors are to be effectively connected with foundation girders.

(5) Web frames are to be provided at sides in way of engine room and they are to be fitted in way of plate floors with spacing not to be more than 4 frame-spaces. The sectional moduli of frames and web frames are to be increased by 10% of the values stipulated in 2.1.2.4 or 2.1.3.6 of this Chapter.

2.1.1.7 Stern transom plating

(1) The thickness of stern transom plating is not to be less than 1.2 times that of shell side plating, the requirements for frames and stiffeners for stern transom plating are the same as those for shell side plating.

(2) The stern transom plating is to be so designed as to ensure that an excessive stress is not produced when bending moment and thrust caused by outboard motor or stern propelling unit are transmitted to hull structure.

(3) In general, the stern transom plating of a boat with the outboard motor or stern propelling unit is to be sandwich plate with core material such as plywood or similar rigid suitable material. The total thickness of the stern transom plating is not to be less than that as required in Table 2.1.1.7(3).

Total thickness of stern transom plating **Table 2.1.1.7(3)**

Power of engine P (kW)	Total thickness of stern transom plating (mm) (outboard motor)	Total thickness of stern transom plating (mm) (stern propelling unit)
$18 \leqslant P < 30$	30	35
$30 \leqslant P < 60$	35	40
$60 \leqslant P < 150$	40	45
$P > 150$	Specially considered as per specific case	Specially considered as per specific case

2.1.1.8 Local strengthening

(1) Plate floors are to be fitted in each frame space for the severe areas of high speed boat subject to wave panting (generally within the range of 0.15 L from 1/3 L of bow), or other measures are to be taken.

(2) The shell plating for penetration of propeller shaft bracket, rudder post and their attachments or the plates at the strong points for anchoring, mooring and towing are to be provided with embedded parts and suitably strengthened.

(3) Openings on the shell plating are to be avoided as far as possible. If it is needed, the opening corners are to be rounded, and compensation is to be made for large openings under certain cases.

(4) Where doors, windows and openings are provided in side walls of superstructures or deckhouses, the corners are to be rounded as far as practicable, and sufficient strengthening is to be made if right angle opening needs to be used.

2.1.1.9 Pillars

(1) For pillars of steel and aluminium alloy, reference may be made to the relevant requirements in Rules for Constructions and Classification of Sea-going High Speed Craft by the Society.

(2) Other materials used for pillars are to be subject to approval of the Society.

2.1.1.10 Effective breadth of attached plates

(1) The required values of section modulus of secondary members stipulated in this Section are the minimum ones for them with their attached plates. The effective breadth of attached plates of members b_e is to be taken as follows:

① Where the attached plates are of a single plate, the lesser of following is to be taken:

$$b_e = s,\ \ b_e = 23t + b_s \qquad \text{mm}$$

② Where the attached plates are of a sandwich plate:

For ineffective core such as cellular plastics, balsa wood, etc., the lesser of following is to be taken:

$$b_e = s,\ \ b_e = 11d \qquad \text{mm}$$

For effective core such as plywood, etc., the lesser of following is to be taken:

$$b_e = s,\ \ b_e = 35d \qquad \text{mm}$$

where: s — stiffener spacing, in mm;
t — thickness of attached plates, in mm;
d — distance between centerlines of opposite skin laminates of attached plate, in mm;
b_s — net breadth of secondary members, in mm.

(2) Where the effective material such as pine or plywood is employed as core of the member, the core affection is to be taken into account in calculating the section modulus. The sectional area of the core is to be reduced by the ratio of its bending modulus of elasticity to the bending modulus of elasticity of the member's laminate.

2.1.1.11 Design of laminated plate

(1) For shell plating and members suitable raw materials and reasonable lay up design are to be chosen in accordance with different purposes.

(2) The thickness change of laminated plate is to be gradual and the breadth of transition region is at least 30 times the thickness difference.

2.1.1.12 Mechanical properties of laminated plate specimen

(1) The mechanical properties of test specimen of FRP are to comply with the requirements of Rules for Welding and Materials by the Society.

(2) The thickness t of each laminated plate of glass fiber is to be taken as follows:

$$t = \frac{W_G}{100\gamma_R G} + \frac{W_G}{1000\gamma_G} - \frac{W_G}{1000\gamma_R} \quad \text{mm}$$

where: W_G — design weight of glass-fiber mat or glass-fiber cloth in a unit Area, in g/m^2;
G — content of glass fiber (weight ratio) of laminated plate, in %;
γ_R — specific gravity of resin after solidification , in g/cm^3;
γ_G — specific gravity of glass-fiber mat or glass-fiber cloth, in g/cm^3.

2.1.1.13 Tightness test of hull

(1) After the completion of hull, main compartments are to be subject to waterhead test or hose test for verifying the strength and/or tightness of the structural members. The test pressure is to be as practicable the pressure due to the maximum head of water which the structural elements might have to sustain in the event of damage to the boat.

(2) During hose test, the water pressure of nozzle is not to be less than 200 kPa, the nozzle is to be placed at a distance of not greater than 1.5 m from the tested object, the inner diameter is not to be less than 12 mm. The moving speed of water-jet is not to be greater than 0.1 m/s.

2.1.2 High Speed Boat

2.1.2.1 Vertical acceleration at gravity center of a boat

(1) The vertical acceleration at gravity center of a boat α_{cg} is to be provided with by the boat owner or the designer, normally an average value of the 1/100 maximum acceleration at gravity center of a boat may be taken. The designer may also make an adjustment itself, however α_{cg} is not to exceed 1.3 g for a passenger boat and 2 g for a yacht. For a public boat, a reasonable value α_{cg} may be selected according to the need of the boat owner or the designer.

(2) The relation among the designed vertical acceleration at gravity center of a boat α_{cg} and significant wave height $H_{1/3}$ specified in its service restriction and its speed V_H corresponding to the wave height is as follows:

$$\alpha_{cg} = \frac{1}{426}\left(\frac{V_E}{\sqrt{L}}\right)^{1.4}\left(\frac{H_{1/3}}{B_{WL}} + 0.07\right)(50-\beta)\left(\frac{L}{B_{WL}} - 2\right)\frac{B_{WL}^{\ 3}}{\Delta}g \quad \text{m/s}^2$$

where: g — acceleration of gravity, $g = 9.81$ m/s^2;
V_H — speed at sea with significant wave height $H_{1/3}$, in kn;
$H_{1/3}$ — significant wave height, in m, $H_{1/3} = 4$ m for coastal water service restriction, $H_{1/3} = 2$ m for sheltered water service restriction and $H_{1/3} = 1$ m for calm water service restriction;
L — length of boat, in m;
B_{WL} — width of waterline, in m, means the maximum moulded width measured along the full load waterline of a boat in rest floatation. For multi-hull boat, it means the sum of maximum moulded widths of each hull at full load waterline;
β — deadrise angle at LCG, in °, β_{max} = 3°, see Fig. 2.1.2.1(2);
$\triangle$ — full-loaded displacement, in t;

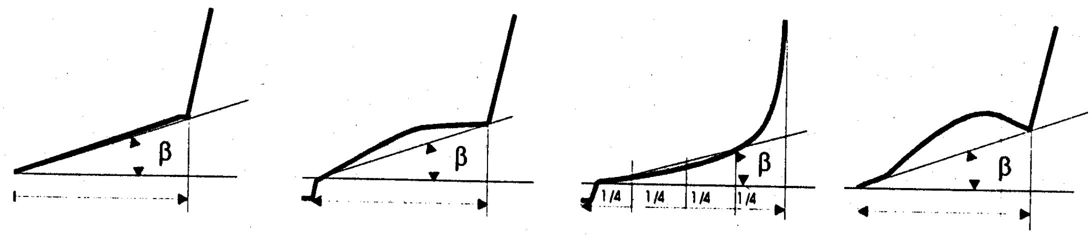

Fig. 2.1.2.1(2)

(3) The final α_{cg} value is to be put in (2) above to calculate group of corresponding values of $H_{1/3}$ to V_H specified in its design service restriction. The values are to be recorded in the boat's operation manual, and to be marked on a label to be fixed and displayed in the bridge room.

2.1.2.2 Local calculated pressure

(1) The wave slamming pressure on bottom P_{sl} is to be calculated by the following formula, and is not to be less than the slamming pressure P_s on side in way of corresponding position as determined by 2.1.2.2(3) of this Section:

$$P_{sl}=1.16K_{l1}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg}d \qquad \text{kN/m}^2$$

where: K_{l1} — longitudinal pressure distribution factor. $K_{l1} = 1$ for forward of amidship, $K_{l1} = 0.5$ for stern, the factor between amidship and stern is to be obtained by linear interpolation;
A — design load area for element considered, in m^2,
for plating, A is not to be taken greater than 2.5 S^2; where S is the spacing of the frames, in m;
for stiffener or girder, A is to be taken as the product: spacing × span;
d — draft, in m;
Δ — full load displacement, in t;
α_{cg} — design vertical acceleration, in m/s^2, to be taken in accordance with that in 2.1.2.1 of this Section.

(2) Deck pressure of connecting structure P_{wd} is to be determined by the following formula, and is not to be less than the pressure on side above the waterline in way of corresponding position as determined by 2.1.2.2(3) of this Section:

$$P_{wd}=0.75K_{l2}\left(\frac{\Delta}{A}\right)^{0.3}a_{cg} \qquad \text{kN/m}^2$$

where: K_{l2} — longitudinal pressure distribution factor. For catamarans, $K_{l2} = 1.5$ for forward of amidship, $K_{l2} = 0.8$ for stern; for surface effect craft, $K_{l2} = 0.8$ for forward of amidship, $K_{l2} = 0.5$ for stern; for hydrofoil craft, $K_{l2} = 0.5$. The above factors between amidship and stern is to be obtained by linear interpolation;
Δ, A, α_{cg} — the same as those in (1) above.

(3) Slamming pressure P_s on side is to be taken as:

$$P_s = 9.81h + 0.15P_{sl} \qquad \text{kN/m}^2$$

where: h — vertical distance between the lowest point of side plate and the upper edge of freeboard deck at sides (deck boat) or upper edge of top strake at sides (open boat), in m;

P_{sl} — slamming pressure on bottom in way, in kN/m^2.

(4) Pressure P_d on deck is to be taken as:

$P_d = 0.25L + 4.6$ kN/m^2, for exposed deck;
$P_d = 0.1L + 4.6$ kN/m^2, for unexposed deck;
$P_d = 4.5$ kN/m^2, for passenger accommodation deck.

For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure for exposed deck may be taken as 0.9 times and 0.85 times the above value respectively.

(5) Pressure P_h on bulkhead is to be taken as:

$P_h = 10\,h$ kN/m^2, for watertight bulkheads, collision bulkheads and their stiffeners;
$P_h = 10\,h_d + 10$ kN/m^2, for bulkheads and their stiffeners of liquid tanks.

where: h — vertical distance from the bottom edge of plate or midpoint of span of stiffener to the upper deck, in m;

h_d — vertical distance from the bottom edge of plate or midpoint of span of stiffener to the top of the liquid tank, in m.

(6) Pressure P on superstructure and deckhouse is to be taken as:

$P = 5 + 0.3\,L$ kN/m^2, for fore end bulkhead and its stiffeners;
$P = 2.5 + 0.2\,L$ kN/m^2, for side bulkheads, aft end bulkhead and their stiffeners;
$P = 3$ kN/m^2, for top plates and their stiffeners.

where: L — length of boat, in m.

For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure for fore bulkheads of superstructure and its stiffeners may be taken as 0.9 times and 0.85 times the above value respectively.

2.1.2.3 Scantling of laminated plates

(1) The minimum thickness t_{min} of single plate is to be taken as follows:

$$t_{\min} = K_0\sqrt{L} \quad \text{mm}$$

where: K_0 — coefficient, obtained from Table 2.1.2.3(1);

L — length of boat, in m.

Coefficient K_0 **Table 2.1.2.3(1)**

	Bottom, connecting structure	Side	Deck	Superstructure & deckhouse			Bulkhead	
				Front	Side, behind	Top	Watertight	Collision, liquid tank
K_0	1.45	1.25	1.10	1.10	0.95	0.90	1.20	1.30

(2) The thickness t of single plate is not to be less than the following:

$$t = 44.8 s \sqrt{\frac{P}{\sigma_{fnu}}} \quad \text{mm}$$

where: σ_{fnu} — ultimate bending stress of laminate, in N/mm²;

s — frame spacing, in m, in general means the longitudinal spacing, it is the breadth subjected to its area for girders or floors;

P — designed value subjected to positive pressure in member's unit area in the calculation of hull local strength, calculated in accordance with the requirements of 2.1.2.2 of this Section.

(3) The minimum thickness t_{min} of each skin laminate on structural sandwich plates is to be calculated as follows:

$t_{min} = K_0\sqrt{L}$ mm, and not less than 2.0 mm for exposed skin laminate ①

$t_{min} = K_0\sqrt{L} - 0.5$ mm, and not less than 1.5 mm for protected skin laminate ②

where: K_0 — coefficient, obtained from Table 2.1.2.3(3).

Coefficient K_0 **Table 2.1.2.3(3)**

	Bottom, connecting structure	Side	Deck	Superstructure & deckhouse			Bulkhead	
				Front	Side, behind	Top	Watertight	Collision, liquid tank
K_0	0.7	0.6	0.5	0.5	0.4	0.4	0.45	0.55

(4) The total thickness t of a structural sandwich plate is not to be less than:

$$t = \frac{1.428}{K}\left(1 + \frac{1}{\gamma}\right)\frac{Ps}{\tau_c} \quad \text{mm}$$

where: γ — ratio of the distance between centerlines of opposite skin laminates to the mean thickness of opposite skin laminates, $6 \leqslant \gamma \leqslant 14$;

τ_c — ultimate shear stress of sandwich core material, in N/mm²;

K — coefficient,

$K = 1.86 - 0.06\gamma$ and $K \nless 1$, for core of PU cellular plastic;

$K = 1.95 - 0.079\gamma$ and $K \nless 1$, for core of PVC cellular plastic;

$K = 1$ for core of plywood;

s,P — refer to 2.1.2.3(2) of this Section.

2.1.2.4 Stiffeners and frames

(1) The section modulus W of stiffeners and frames is not to be less than that obtained from the following:

$$W = K\frac{l^2 sP}{\sigma_{fnu}} \quad \text{cm}^3$$

① Exposed skin means the skin laminate subjected to liquid continuously or milling of machine or impacting load.

② Protected skin means the laminate not subjected to the above load.

where: σ_{fnu} — ultimate bending stress of laminate, in N/mm^2;

K — coefficient, obtained from Table 2.1.2.4(1);

l — span of stiffeners and frames, in m, where bracket is provided at the ends of stiffeners and frames, span point may be at half of the bracket length; where no bracket is provided at the ends of stiffeners and frames, span point may be at their ends. For hull stiffeners and frames (e.g. keels, plate floors and girders), the bulkhead connected may be taken as the end point of that stiffeners and frames. For stiffeners and frames of decks and superstructures, (e.g. web beams and girders), in addition to bulkhead, the pillar connected may be taken as the end point of that stiffeners and frames. For spans of stiffeners and frames, refer to 2.1.3.6 of this Section;

s, P — refer to 2.1.2.3(2) of this Section.

Coefficient *K* **Table 2.1.2.4(1)**

	K	
	Keel, girder, web frame, plate floor, web beam	Longitudinals, floor, frame, beam, stiffener
Bottom, connecting structure	480	400
Side	480	400
Deck	480	400
Superstructure	-	400
Watertight bulkhead	-	400
Liquid tank & collision bulkhead	-	480

(2) Where calculation of section modulus for keels as per (1) above is not practicable, such section modulus may be specially considered, but at least the following conditions are to be satisfied simultaneously:

① the section modulus for center keelson is not to be less than 1.5 times the section modulus for plate floor in way; the section modulus for side keelson is not to be less than that for plate floor in way; and

② hull girder strength is to be checked for all boats.

2.1.2.5 The required values of section modulus of secondary members are the minimum ones for them with their attached plates. The effective breadth of attached plates of members b_e is to be taken as follows:

(1) Where the attached plates are of a single plate, the lesser of following is to be taken:

$$b_e = S,\ \ b_e = 23t + b_s \qquad \text{mm}$$

(2) Where the attached plates are of a sandwich plate:

① For ineffective core such as cellular plastics, balsa wood, etc., the lesser of following is to be taken:

$$b_e = S,\ \ b_e = 11d \qquad \text{mm}$$

② For effective core such as plywood, etc., the lesser of following is to be take:

$$b_e = S,\ \ b_e = 35d \qquad \text{mm}$$

where: t — thickness of attached plates, in mm;

d — distance between centerlines of opposite skin laminates of attached plate, in mm;

S — stiffener spacing, in mm;

b_s — net breadth of secondary members, in mm.

2.1.2.6 Where the effective material such as pine or plywood is employed as core of the member, the core affection is to be taken into account in calculating the section modulus. The sectional area of the core is to be reduced by the ratio of its bending modulus of elasticity to the bending modulus of elasticity of the member's laminate.

2.1.2.7 Effective web plate area of girders

(1) The effective web plate area of girders A_e is to be calculated as follows:

$A_e = 0.01\ h_w t_w$ cm^2, for no bracket at ends of girder

$A_e = 0.01\ h_w t_w + \Delta A_e$ cm^2 , for bracket at ends of girder

where: h_w — effective girder height after deduction of cutouts in the cross section considered, in mm;
t_w — total thickness of FRP web plate, in mm;
ΔA_e — additional shear area for girder with bracket at end, in cm^2, obtained in accordance with the horizontal angle of the bracket's face plate, refer to Fig. 2.1.2.7(1).
$\Delta A_e = 0.91 f_1$, where $\theta = 45°$,
$\Delta A_e = 0$, where $\theta = 0°$,

The value ΔA_e may be obtained by linear interpolation where $\theta = 0 \sim 45°$, f_1 is area of the bracket's face plate in the cross section considered, in cm^2.

(2) The effective web plate area A_e calculated in accordance with the requirements of 2.1.2.7(1) above is not to be less than $A_{e\,min}$ as follows:

$$A_{e\,\min} = \frac{25.5slP}{\tau_c} \quad \text{cm}^2$$

where: τ_c — limited shear stress of sandwich plate, in N/mm^2;
s, P, l — refer to 2.1.2.4(1) of this Section.

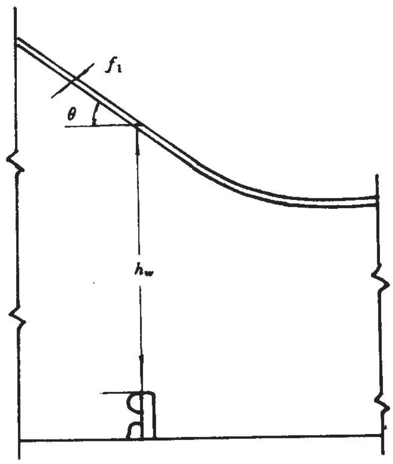

Fig. 2.1.2.7(1)

2.1.3 Non-high speed boat

2.1.3.1 General requirements

(1) The mechanical properties of all laminates designed for boat are not to be less than that as required by Rules for Welding and Materials by the Society. The specified hull structural scantlings are based on the mechanical properties of the standard laminating single skin plate moulded by lay-out with glass fiber biaxial woven rovings.

(2) For other laminating design, where the single skin plate strength is not in conformity with the strength of standard laminating single skin plate, the hull structural scantlings specified may be corrected by multiplying the following coefficient K:

① $K = \sqrt{180/\sigma_{fnu}}$, for thickness correction

where: σ_{fnu} — the ultimate bending stress of the laminate, in N/mm^2.

② $K = 180/\sigma_t$, for section modulus correction, in N/mm^2.

where: σ_t — the ultimate tensile stress of the laminate, in N/mm^2.

③ For laminate with its ultimate bending stress and/or tensile stress more than 400 N/mm^2, in addition to correction, a rigidity of that laminate hull is to be checked.

(3) The minimum thickness t_{min} of laminates is to comply with the relevant requirements of 2.1.2.3 of Section 2.

(4) The bottom plating means the shell plating between flat keel (or keel) and upper corner turning line at bilge.

(5) The web height of center keelsons is not to be less than the height of plate floors and the section modulus is not to be less than 1.5 times that of plate floors in way.

(6) The section modulus of side keelsons is to be equivalent to those of plate floors in way.

(7) The section modulus of center keelsons and side keelsons in engine rooms are to be increased by 10% of the values stipulated in (5) and (6) above respectively.

2.1.3.2 Shell plating

(1) The thickness t of single plate used as bottom plating is not to be less than:

$$t = 13.4 s\sqrt{h} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — vertical distance between the lower edge of the lowest place of bottom plating and the upper edge of freeboard deck at boat's sides, in m.

(2) For boats navigating in calm water service restriction, where the draught is less than 0.35 times moulded depth, the thickness of bottom single plate is to be 0.9 times the values obtained from 2.1.3.2(1) respectively.

(3) The thickness t of single plate used as side plating is not to be less than:

$$t = 12.4 s\sqrt{h} \quad \text{mm}$$

where: s — refer to 2.1.3.2(1), in m;
h — vertical distance between the lowest point of side plate and the upper edge of freeboard deck at boat's sides, in m.

(4) The thickness of single plate used as side plating may be reduced gradually from 0.4 L amidship to fore and aft ends, the thickness at fore and aft ends may be 0.85 times that at amidship.

(5) Where the shell plating is a sandwich plate, the total thickness of sandwich plate t is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — refer to 2.1.3.2(1) for bottom plating, refer to 2.1.3.2(1) for side plate;
τ_c — shear strength of core material, in N/mm^2.

(6) The thickness of sandwich plate used as shell plating of fore and aft parts (except stern transom plating) is to be same as that at amidship.

2.1.3.3 Deck

(1) The calculated pressure head on deck (h) is obtained from:

h = 0.02 L + 0.46 m , for expose deck
h = 0.01 L + 0.46 m, for non-exposed deck
h =- 0.45 m , for passenger deck

For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure head on exposed deck may be taken as 0.9 times and 0.85 times the above value respectively.

(2) The thickness t of single plate used as deck within 0.4 L amidship is not to be less than:

$$t = 16.2\,s\sqrt{h} \quad \text{mm}$$

where: s — spacing of stiffeners and frames, in m;
h — calculated pressure head on deck, in m; obtained in accordance with the relevant height in 2.1.3.3(1) of this Section.

(3) The thickness of single plate used as exposed deck may be reduced gradually from 0.4 L amidship to ends of boat, however, the thickness is not to be less than 0.85 times that of exposed deck at amidship.

(4) Where the deck is a sandwich plate, the total thickness t of deck is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head on deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
τ_c — shear strength of core material, in N/mm^2.

2.1.3.4 Bulkhead plating

(1) The thickness t of single plate used as bulkhead plating is not to be less than:

$$t = 12.2\,s\sqrt{h} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head, in m; vertical distance measured from lower edge of bulkhead plating to tank top.

(2) Where the bulkhead is a sandwich plate, the total thickness t of the plate is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head, in m; vertical distance measured from lower edge of bulkhead plating to tank top;
τ_c — shear strength of core material, in N/mm^2.

(3) In calculation of scantling of collision bulkhead, the calculated pressure head h is to be 1.25 times of the corresponding specified height.

2.1.3.5 Wall plating of superstructure and deckhouse

(1) The calculated pressure head h of fore end walls, side walls and aft walls of superstructures or deckhouses are to be as follows:

$h = 0.02L + 0.5$ m, for fore end wall;
$h = 0.02L + 0.25$ m, for side and aft end wall;
$h = 0.3$ m, for top plate.

(2) For boats navigating in sheltered water service restriction and calm water service restriction, the calculated pressure head of fore wall of superstructure or deckhouse may be taken as 0.9 times and 0.85 times above value in (1) respectively.

(3) The thickness t of single plate used as wall plating of superstructure or deckhouse is not to be less than:

$$t = 11.7\, s\sqrt{h} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head, in m; obtained in accordance with the relevant requirements of (1) above.

(4) Where the wall plating of superstructure or deckhouse is a sandwich plate, the total thickness of sandwich plate is not to be less than:

$$t = \frac{11hs}{\tau_c} \quad \text{mm}$$

where: s — length of short side of plate field, in m;
h — calculated pressure head on deck, in m; obtained in accordance with the relevant requirements of (1) above;
τ_c — shear strength of core material, in N/mm^2.

2.1.3.6 Framing

(1) Plate floors

① The section modulus W of plate floor is not to be less than:

$$W = 15.4\, sDl^2 \quad \text{cm}^3$$

where: s — spacing of plate floor, in m;
D — moulded depth, in m;
l — span of plate floor, in m; it is the distance between the surface plate of plate floor and the intersection point of sides; if longitudinal bulkhead is provided, it is the distance between longitudinal bulkhead and sides or the distance between longitudinal bulkheads, whichever is the greater.

② The height H of plate floor in longitudinal centerplane is no to be less than:

$$H = 62.5\ l \qquad \text{mm}$$

where: l — refer to (1) above.

(2) The section modulus W of longitudinals at boat's bottom is not to be less than:

$$W = 25.7\ shl^2 \qquad \text{cm}^3$$

where: s — spacing of longitudinals, in m;
h — calculated pressure head, in m; the vertical distance measured from lower edge of bottom plating to upper edge of freeboard at sides in the midspan of longitudinal;
l — span of longitudinal, in m; the distance between plate floors or the distance between plate floor and bulkhead, whichever is greater.

(3) Frames

① The section modulus W of frames is not to be less than:

$$W = 24\ shl^2 \qquad \text{cm}^3$$

where: s — frame spacing, in m;
l — frame span, in m; for bottom frame, it is the distance between keels or the distance between keel and side, whichever is the greater; for side frame, it is the vertical distance between upper surface of bottom plating and deck;
h — calculated pressure head, in m; for bottom frame, the vertical distance measured from the lower edge of bottom plating to the upper edge of freeboard deck at sides in the midpoint of frame span, for side frame, the vertical distance between the mid point of frame span and the freeboard deck margin line.

② The section modulus W of web frame is not to be less than:

$$W = 22.6\ shl^2 \qquad \text{cm}^3$$

where: s — web frame spacing, in m;
h — calculated pressure head, in m; the distance between the midpoint of web frame span and the freeboard deck margin line;
l — web frame span, in m; molded depth for single bottom boat, molded depth minus double bottom height for double bottom boat.

(4) The Section modulus W of side longitudinal is not to be less than:

$$W = 22.6\ shl^2 \qquad \text{cm}^3$$

where: s — longitudinal spacing, in m;
h — calculated pressure head, in m; the distance between longitudinal and freeboard deck margin line in way of amidship sides;
l — longitudinal span in m; the distance between web frames or the distance between web frame and bulkhead, whichever is the greater.

(5) Deck beam

① The section modulus W of deck beam is not to be less than:

$$W = 19.6\ shl^2 \qquad \text{cm}^3$$

where: s — beam spacing, in m;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
l — beam span, in m; the distance between side and girder (longitudinal bulkhead) or the distance between girders, whichever is the greater.

② The section modulus W of web beam is not to be less than:

$$W = 17.0shl^2 \qquad \text{cm}^3$$

where: s — beam spacing, in m;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
l — web beam span, in m; the distance between sides, the distance between side and pillar or the distance between pillars, whichever is the greater.

(6) The section modulus W of deck longitudinal is not to be less than:

$$W = 21.0\, shl^2 \qquad \text{cm}^3$$

where: s — longitudinal spacing, in m;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section;
l — longitudinal span, in m; the distance between web beams or the distance between web beam and bulkhead, whichever is the greater.

(7) Deck girder

① The deck girder and keel are to be arranged in the same plane as far as possible.

② The section modulus W of deck girder is not to be less than:

$$W = 17.1bhl^2 \qquad \text{cm}^3$$

where: b — mean breadth of deck area supported by deck girder, in m;
l — girder span, in m; the distance between pillars or the distance between pillar and bulkhead, whichever is the greater;
h — calculated pressure head of deck, in m; obtained in accordance with the relevant requirements of 2.1.3.3(1) of this Section.

③ Where deck girder is subjected to concentrated load, in addition to meeting the requirements of (2) above, W is to be added as follows:

$$W = 0.102\, cPl \qquad \text{cm}^3$$

where: p — concentrated load, in kN;
l — girder span, in m, as the same as ② above;
c — coefficient, obtained from Table 2.1.3.6(7) ③; where a is the distance between the action point P and the further fulcrum of girder, in m.

Coefficient *c* **Table 2.1.3.6(7) ③**

a/l	0.94	0.90	0.85	0.80	0.75	0.70	0.60	0.50
c	3.56	8.32	14.06	18.22	21.39	22.77	23.73	24.75

(8) The section modulus W of bulkhead stiffener is not to be less than:

$$W = Kshl^2 \qquad \text{cm}^3$$

where: s — stiffener spacing, in m;
l — stiffener span, in m;
h — calculated pressure head, in m; the vertical distance measured from the midpoint of stiffener span to the top of tank;
K — coefficient, obtained in the following cases:

$K = 21.67$ for stiffener with two ends connected with bracket;
$K = 28.87$ for stiffener with one end connected with bracket;
$K = 34.61$ for stiffener with two stiffener scarfing.

(9) Framing of superstructure or deckhouse

① The scantling of framing for superstructure or deckhouse is to comply with the relevant requirements of 2.1.3.6(5) to 2.1.3.6(7).

② The section modulus W of trunk stiffener of superstructure or deckhouse is not to be less than:

$$W = 20.3shl^2 \qquad \text{cm}^3$$

where: s — stiffener spacing, in m;
l — stiffener span, in m, the practical length of stiffener;
h — calculated pressure head, in m; obtained in accordance with the relevant requirements of 2.1.3.5(1) and (2) of this Section.

Section 2 Steel Boats

2.2.1 General requirements

2.2.1.1 This Section applies to boats whose hull structures are of steel material. For air-cushion vehicles, the structures are to comply with the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

2.2.1.2 Principle of structural design

(1) The hull structure is to be so designed that the boat can withstand the maximum external force that may be encountered throughout its whole period of service life.

(2) The hull structure may be designed by direct calculation, however the Structural Calculations are to be approved by the Society.

(3) The width of flat keel is not to be less than 600 mm, the thickness of that is not to be less than 1.2 mm plus the thickness of bottom plating is kept unchangeable within the whole length of boat.

(4) Longitudinal members of longitudinal framings are to be continuous or equivalently continuous.

(5) Spacing of short side of hull frames is not to be more than 500 mm. For longitudinal framing boats, spacing of plate floors is not to be more than 4 frame-spaces.

(6) The plate floors, web frames and deck transverses are to be arranged in a same section.

(7) Web plates of bottom longitudinal girders taken into account in hull girder strength are to be continuous in way of the transverse watertight bulkheads, or to be equivalently continuous.

(8) The plate floors are to be fitted on each frame in the engine room, additional strengthening is to be provided in way of the thrust bearing.

(9) The plate floors are to be fitted on both ends of a main engine in the engine room.

2.2.1.3 Hull girder strength

(1) Hull girder strength of steel high speed boat is to meet the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

(2) Allowable stress for calculation of general strength is to be taken as follows:

$[\sigma] = 0.67\sigma_s$ for allowable bending stress;
$[\tau] = 0.38\sigma_s$ for allowable shearing stress

where: σ_s — yield stress of material, in N/mm^2.

2.2.1.4 Local strengthening

(1) Plate floors are to be fitted in each frame space for the severe areas of high speed boat subject to wave panting (generally within the range of 0.15 *L* from 1/3 *L* of bow).

(2) The thickness of stern transom plating is not to be less than that of shell side plating, however where propelling unit is fitted on the stern transom plating, the thickness of stern transom plating is not to be less than 1.2 times that of shell side plating. The shell plating for penetration of propeller shaft bracket, rudder post and their attachments or the plates at the strong points for anchoring, mooring and towing are suitably strengthened.

(3) Openings on the shell plating are to be avoided as far as possible. If it is needed, the opening corners are to be rounded, and compensation is to be made for large openings under certain cases.

(4) Where doors, windows and openings are provided in side walls of superstructures or deckhouses, the corners are to be rounded as far as practicable, and sufficient strengthening is to be made if right angle opening needs to be used.

2.2.1.5 Pillars

(1) For pillars of steel and aluminium alloy, reference may be made to the relevant requirements in Rules for Constructions and Classification of Sea-going High Speed Craft by the Society.

(2) Other materials used for pillars are to be subject to approval of the Society.

2.2.1.6 Tightness test of hull

(1) After the completion of hull, tightness test is to be carried out as required by 2.1.1.13 of this Chapter.

(2) Where a hose test is not practicable because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where deemed necessary by means such as a dye penetrant test or an ultrasonic leak test or an equivalent test.

2.2.2 High speed boat

2.2.2.1 The requirements for vertical acceleration at gravity center of a boat are to be same as in 2.1.2.1 of this Chapter.

2.2.2.2 The requirements for local calculated pressure in way of the bottom, side, deck and superstructure are to be same as in 2.1.2.2 of this chapter.

2.2.2.3 Thickness of plating

(1) The minimum thickness t_{min} of plating is to be taken as follows:

$$t_{min} = 1.1K_0\sqrt{L} \quad \text{mm}$$

where: K_0 — coefficient, to be obtained from Table 2.2.2.3(1);
L — length of boat, in m.

The minimum thickness of plate keel for monohull, catamarans and SES is to be increased by 2 mm over the above value.

Coefficient K_0 **Table 2.2.2.3(1)**

Item		K_0	
		MONO, CAT	SES, FOIL
Bottom plating		0.80	0.60
Connecting structure bottom		0.75	0.50
Side plating		0.70	0.45
Deck: exposed/unexposed		0.60/0.40	0.40/0.30
Superstructure	Front	0.60	0.40
	Side, behind	0.45	0.30
	Top	0.30	0.20
Bulkhead		0.50	0.35
Bottom in way of rudder shaft brackets, etc.		1.60	1.20
Main engine foundations		0.90	0.90

(2) Built-up sections of bottom, including engine seating, is to comply with the following requirements:

$$t \geqslant \frac{h}{70}\sqrt{\frac{\sigma_s}{235}} \quad \text{for web}$$

where: t — web thickness, in mm;
h — web depth, in mm;
σ_s — yield stress of material, in N/mm^2.

$$t \geqslant \frac{b}{15}\sqrt{\frac{\sigma_s}{235}} \quad \text{for face plate}$$

where: t — plate thickness, in mm;
b — plate width, in mm;
σ_s — yield stress of material, in N/mm^2.

(3) The thickness t of plating is to be taken not less than that from the following:

$$t = K_1 C_1 C_2 S\sqrt{\frac{P}{\sigma_S}} \quad \text{mm}$$

where: K_1 — coefficient, to be obtained from Table 2.2.2.3(3);
S — spacing of frames, in m, normally for longitudinal frame spacing, and width subjected to the area for girders or floors;
C_1 — reduction factor for curved plates; $C_1 = 1\text{-}0.5S/r$, where: r is radius of curvature, in m;
C_2 — correction factor for aspect ratio of plate field; $C_2 = (1.1\text{-}0.25S/l)^2$, where: l is span of stiffeners and frames, in m. Where no bracket is provided at the ends of stiffeners and frames, span point may be at their ends; where bracket is provided at the ends of stiffeners and frames, span point may be at half of the bracket length;.
P — design pressure, to be taken as required by 2.1.2.2 of this Chapter;
σ_s — yield stress of material, in N/mm^2.

Coefficient K_1 **Table 2.2.2.3(3)**

Item		K_1		
		Within 0.1*L* from F.P.	Within 0.4*L* at amidship	Within 0.1*L* from A.P.
Bottom, connecting structure bottom		21.5	25.0	21.5
Side	Near bottom	21.5	25.0	21.5
	Near neutral axis	20.5	20.5 for longitudinally framing 21.5 for transversely framing	20.5
	Near deck	20.5	25.0	20.5
Deck, including superstructure/deckhouse top		20.5 for longitudinally framing 21.5 for transversely framing	25.0	20.5 for longitudinally framing 21.5 for transversely framing
Superstructure/deckhouse wall		21.5		
Bulkhead	Collision	21.5		
	Watertight	19.0		
	Liquid tank	21.5		

2.2.2.4 Stiffeners and frames

(1) The section modulus *W* including attached plating of stiffeners and frames is not to be less than:

$$W = K_2 \frac{\ell^2 SP}{\sigma_S} \quad \text{cm}^3$$

where: K_2 — coefficient, to be obtained from Table 2.2.2.4(1);
ℓ、P、S、σ_S — same as in 2.2.2.3(3) of this Section.

Coefficient K_2 **Table 2.2.2.4(1)**

Item		Secondary members			Primary members
		Longitudinal member	Beam, frames, floors	stiffeners	Girders, web frames, plate floors, web beams
Bottom, connecting structure bottom		136	150		150
Side		128	150		150
Deck, including superstructure/deckhouse top		Deck: 200 Top: 128	150		150
Superstructure/deckhouse front and side walls				150	150
Superstructure/deckhouse rear walls				150	150
Bulkhead	Collision and liquid tank			150	150
	Watertight			110	110

2.2.2.5 Shearing strength for longitudinals and girders

(1) The effective shear area A_e at end of longitudinals is not to be less than A_{emin} obtained from the following formula:

$$A_{emin} = 22.67 \frac{(\ell - S)SP}{\sigma_S} \quad \text{cm}^2$$

The shear area A_e is to be calculated as follows:

$$A_e = 0.01ht \quad cm^2$$

where: h — web depth of longitudinals, in mm;
t — web thickness of longitudinals, in mm;
ℓ、P、S、σ_S — same as in 2.2.2.3(3) of this Section.

(2) The effective shear area A_e at end of girders is not to be less than A_{emin} obtained from the following formula:

$$A_{e\,min} = 13.5\frac{S\ell P}{\sigma_S} \quad cm^2$$

The shear area A_e is to be calculated as follows:

$A_e = 0.01h_W t_W$ cm^2, for no brackets at ends of girder;

$A_e = 0.01h_W t_W + \Delta A_e$ cm^2, for brackets at ends of girder

where: h_W — net girder height after deduction of cutouts in the cross section considered, in mm;
t_W — web thickness, in mm;
ℓ、P、S、σ_S — same as in 2.2.2.3(3) of this Section.
ΔA_e — additional shear area at end of girder with bracket, obtained according to the horizontal angle θ of the bracket's face plate, see Fig. 2.1.2.7(1) of this Chapter.

$\Delta A_e = 0.9f_1$ where $\theta = 45°$; $\Delta A_e = 0$ where $\theta = 0°$; ΔA_e may be obtained by linear interpolation where $\theta =$ 0~45°; f_1 is area of the bracket's face plate in the cross section considered, in cm^2.

2.2.3 Non-high speed boat

2.2.3.1 General requirements

(1) The requirements of 2.2.3 are applicable to conventional steel boats with transverse framing.

(2) Scantlings obtained from the requirements of 2.2.3 are required for boats in the coastal service restriction. Scantlings of boats in the sheltered water service and calm water service restrictions may be reduced by calculation in accordance with the following requirements:

① The thickness of shell plating and strength deck may be reduced by 8% of the calculated thickness as specified, but the minimum thickness of the reduced shell plating and strength deck is not to be less than 4 mm for $L \geqslant 10$ m, and that is not to be less than 3.5 mm for $L < 10$ m.

② The section modulus of hull framing may be reduced by 10% of the calculated section modulus as specified, but the thickness of inner bottom plating and bulkhead plateing, and the web thickness of plate floors, keelson, center girder, side girder, etc. may be reduced by 0.5 mm.

③ The thickness of boundary bulkheads, deck plating of superstructures and deckhouses may be reduced by 0.5 mm of the calculated thickness as specified, but the minimum thickness is not to be less than 3.0 mm. The section modulus of framing of superstructures and deckhouses may be reduced by 10%.

(3) Where the requirements for design principle is not in conformity with that for in 2.2.1.2 of this Section, the former is to prevail.

2.2.3.2 Shell Plating

(1) The thickness t of bottom plating is not to be less than that obtained from the following formulae:

$$t = 0.062s\,(L + 170) \quad \text{mm}$$

$$t = 6.5s\sqrt{d} + 1 \quad \text{mm}$$

where: s — frame spacing, in m;
L — length of boat, in m;
d — draft, in m.

(2) The thickness t of the side plating is not to be less than that obtained form the following formulae:

$$t = 0.07s(L + 115) \quad \text{mm}$$

$$t = 6s\sqrt{d} \quad \text{mm}$$

where: s — frame spacing, in m;
L — length of boat, in m;
d — draft, in m.

(3) The thickness t of strength deck is to be less than that obtained from the following formula, and not less than 4 mm:

$$t = 1.05\text{s}\sqrt{L + 75} \quad \text{mm}$$

where: s — beam spacing, in m;
L — length of boat, in m.

(4) The thickness t of the lower deck is not to be less than that obtained from the following formula, and not less than 4 mm:

$$t = 10s \quad \text{mm}$$

where: s — beam spacing, in m.

2.2.3.3 Hull Framing

(1) The height h, thickness t of web plates and sectional area A of face plates of plate floors at center longitudinal section are not to be less than those obtained from the following formulae respectively:

$$h = 42\,(B + d) - 70 \quad \text{mm}$$
$$t = 0.01h + 3 \quad \text{mm}$$
$$A = 4.8d - 3 \quad \text{cm}^2$$

where: B — breadth of boat, in m;
d — draft, in m.

(2) The face plate thickness of the floor is not to be less than that of web plates, and the breadth of face plates is not to be less than 10 times the thickness of face plates, but need not be more than 15 times.

(3) The web plate thickness of floors in engine rooms is not to be less than that of the web plate of center keelson.

(4) The height of center keelson is to be equal to that of the plate floor. The thickness t of web plates and sectional area A of face plates are not to be less than those obtained from the following formulae respectively:

$t = 0.06L + 6.2$ mm, within 0.4 L amidships;
$t = 0.05\,L + 5.5$ mm, within $0.075L$ at ends;
$A = 0.65d + 2$ cm^2

where: L — length of boat, in m.

(5) The center keelson in forepeak may have the same height, thickness and face plate sectional area as that of the floor respectively.

(6) The scantling of side keelsons is to be the same as that of the plate floors in way. In engine room, the web plate thickness of the side keelsons is not to be less than that of the center keelson.

(7) The spacing of the side keelsons is not to be more than 2.5 m.

(8) The standard spacing s_o of frames is to be calculated as follows:

$$s_o = 1.6\,L + 500 \quad \text{mm}$$

where: L — length of boat, in m.

(9) Where the actual spacing of frames is more than 100 mm of the calculated value in (8) above, shell plating and frames are to be specially considered.

(10) The section modulus W of frames is not to be less than that obtained from the following formula:

$$W = Csdl^2 \quad \text{cm}^3$$

where: s — frame spacing, in m;
d — draft, in m;
l — frame span, in m;
C — coefficient

$$C = \frac{2 + \dfrac{d}{D} \times 0.65}{1.45 - \dfrac{\sqrt{D}}{l}}$$

where: D is the moulded depth, in m.

(11) Where side stringers are fitted to support the frames, the section modulus of frames calculated in (10) above may be reduced by half.

(12) Web frames are to be fitted in engine room with spacing not more than that of 4 frame-spaces, and are to extend from the inner bottom to upper deck. The section modulus W is not to be less than that obtained from the following formula:

$$W = 5shl^2 \quad \text{cm}^3$$

where: s — spacing of web frames, in m;
l — span of web frames, in m;
h — vertical distance, in m, measured from the mid-point of web frame span to upper deck at side amidships.

(13) The section modulus W of side stringers is not to be less than that obtained form the following formula:

$$W = 7.8bhl^2 \quad \text{cm}^3$$

where: b — supporting breadth of side stringers, in m;
l — span of side stringers, in m;
h — vertical distance in m, measured from the mid-point of side stringer span to upper deck at side amidships.

(14) The moment of inertia I of the side stringers is not to be less than that obtained from the following formula:

$$I = 2.5Wl \quad \text{cm}^4$$

where: W — section modulus of side stringers, in cm^3;
l — span of side stringers, in m.

(15) The height h of the central girder provided for double bottom is not to be less than that obtained from the following formula, and not less than 700 mm:

$$h = 25B + 42d + 300 \quad \text{mm}$$

where: B — breadth of boat, in m;
d — draft, in m.

(16) The thickness of the central girder is to be the same as that of the flat keel in way, but not less than that of plate floors connected.

(17) The thickness of side girders is to be the same as that of the bottom plating in way, but not less than that of plate floors connected.

(18) Within 0.4 L amidships, the thickness t of the inner bottom plating is not to be less than that obtained from the following formula, and not less than 5 mm:

$$t = 0.04\,L + 8\,s \quad \text{mm}$$

where: L — length of boat, in m;
s — spacing of frames, in m.

(19) The thickness of the inner bottom plating in the engine room and fuel oil tanks are not to be less than that of inner bottom plating increased by 1 mm in accordance with (18) above.

(20) The thickness of the inner bottom plating within 0.075 L of the ends may be 0.9 times that obtained from the calculation in (18) above.

2.2.3.4 Deck framing

(1) The design heads h_o of the weather strength deck are not to be less than that obtained from the following formula, and not less than 0.8 m:

$$h_o = 0.025L + 0.45 \quad \text{m}$$

where: L — length of boat, in m.

(2) The design heads h of other decks are to be selected from Table 2.2.3.4(2).

Design heads of decks **Table 2.2.3.4(2)**

Deck position	Design heads of decks h, m
1. Forecastle deck and weather strength deck forward of 0.15 L from F.P.	$1.2h_o$
2. Deck cargo area of weather deck	$P + 0.3$ or h_o, whichever is greater
3. Strength deck of the superstructure and deckhouse area used for accommodation and stacking sundries, platform deck, deck of the first tier deckhouse	$0.8h_o$
4. Each layer of deck above the superstructure deck or the first tier deckhouse	Taking, in turn, $0.6h_o$, $0.4h_o$…, but not less than 0.45 m

Notes: 1. P in Table is the equivalent height (m) of the water head of cargo weight on cargo decks;
2. Design heads h of decks (platforms) of cargo tanks are not to be less than the height (in m) to the top of overflow pipe of the tank top.

(3) The section modulus W of deck beams is not to be less than that obtained from the following formula:

$$W = 3.5C_1shl^2 + C_2Dd \quad \text{cm}^3$$

where: s — spacing of beams, in m;
l — span of beams, in m, but not less than 2 m;
h — design heads of decks, in m, selected from Table 2.2.3.4(2) of this Section;
D — moulded depth, in m;
d — draft, in m;
C_1 — coefficient,
$C_1 = 0.0065L + 0.61$ for weather strength deck;
$C_1 = 1$ for other decks;
C_2 — coefficient,

$C_2 = 0.8$ for strength deck of boat with single deck;
$C_2 = 0.5$ for other decks.

(4) The section modulus W of deck transverses is not to be less than that obtained from the following formula:

$$W = 5shl^2 \quad \text{cm}^3$$

where: s — spacing of deck transverses, in m;
l — span of deck transverse, in m;
h — design heads of deck, in m, selected from Table 2.2.3.4(2) of this Section.

(5) The section modulus W of deck girders is not to be less than that obtained from the following formula:

$$W = 4.75bhl^2 \quad \text{cm}^3$$

where: b — mean breadth, in m, of deck area supported by the deck girders;
l — span of deck girders, in m;
h — design head of deck, in m, selected from Table 2.2.3.4(2) of this Section.

(6) The moment of inertia I of deck girders is not to be less than that obtained from the following formula:

$$I = 2Wl \quad \text{cm}^4$$

where: W — section modulus of deck girders, in cm^3;
l — span of deck girders, in m.

2.2.3.5 Bulkhead

(1) The thickness t of watertight bulkhead plating is not to be less than that obtained from the following formula, and not less than 4.5 mm:

$$t = 4.2s\sqrt{h} \quad \text{mm}$$

where: s — spacing of stiffeners, in m;
h — vertical distance, in m, measured from the lower edge of the plate in a strake to the bulkhead deck at side, but not to be taken as less than 2.5 m.

(2) The thickness t of collision bulkhead plating is not to be less than that obtained from the following formula:

$$t = 4.7s\sqrt{h} \quad \text{mm}$$

where: s, h — see (1) above.

(3) The thickness of plating for the lowest strake of bulkheads is to be increased by 0.5 mm, and be increased by 1.5 mm in way of the bilge well. The thickness of bulkhead plating in way of the stern tube is to be doubled.

(4) The section modulus W of watertight bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = Cshl^2 \quad \text{cm}^3$$

where: s — spacing of stiffeners, in m;
h — vertical distance, measured from the mid-point of stiffener span to the bulkhead deck at side, in m, but not to be taken as less than 2 m;
l — span of stiffeners, in m, where girders are fitted, it is the distance between the end of stiffener and the girder or between the girders, whichever is the greater;
C — coefficient, to be taken as follows:

$C = 6$ for stiffeners unattached at both ends, or directly attached to unstiffened plating;
$C = 3$ for stiffeners bracketed at ends, stiffeners directly lap-connected to longitudinal members at ends, stiffeners directly connected to deck plating or girder web at ends, provided that on the other side of the deck or girder, an adjacent member is provided with the same section as and in line with the said stiffener.

(5) The section modulus W of collision bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = 1.25Cshl^2 \quad \text{cm}^3$$

where: s, h, l, C — see (4) above.

2.2.3.6 Superstructures and deckhouses

(1) The standard spacing of deck frames or boundary stiffeners, to which this Section is applicable, is 500 mm.

(2) The thickness t of fore end bulkheads of superstructures is not to be less than that obtained from the following formulae:

$t = 0.025L + 4$ mm, for $L \geqslant 10$m;
$t = 0.025L + 3.5$ mm, for $L < 10$ m

where: L — length of boat, in m.

(3) The thickness of aft end bulkheads of superstructures is to be reduced by 0.5 mm of that obtained from the calculation in (2) above.

(4) The section modulus W of end bulkhead stiffeners of superstructures is not to be less than that obtained from the following formula:

$$W = 3.5shl^2 \quad \text{cm}^3$$

where: s — spacing of stiffeners, in m;
l — span of stiffener, in m, but not to be taken as less than 2 m;
h — design heads, in m, to be selected as follows:
for fore end bulkheads, to be taken as $0.132L\,(d/D)^{2.5}$, but not to be less than $0.008L + 2.5$ m;
for aft end bulkheads, to be taken as $0.045L\,(d/D)^{2}$, but not to be less than $0.004L + 1.25$ m;
where: L — length of boat, in m;
d/D — the ratio of draft to moulded depth:
0.7 for $d/D < 0.7$;
0.8 for $d/D > 0.8$.

(5) The thickness of side plating of superstructures is to comply with the following requirements:

① The thickness of side plating of bridges is to be equal to that of side plating amidship.

② The thickness t of side plating of forecastle and poop is not to be less than that obtained from the following formulae:

$t = 0.04L + 4$ mm, for $L \geqslant 10$ m;
$t = 0.04L + 3.5$ mm, for $L < 10$ m

where: L — length of boat, in m.

(6) The side framing of superstructures is to comply with the relevant requirements of 2.2.3.3(10) of this Section.

(7) The thickness t of decks of superstructures is not to be less than that obtained from the following formulae:

$t = 0.035L + 4$ mm, for $L \geqslant 10$ m;
$t = 0.035L + 3.5$ mm, for $L < 10$ m

where: L — length of boat, in m.

(8) The deck framing of superstructures is to comply with the relevant requirements of 2.2.3.4 of this Section.

(9) The thickness t of boundary bulkheads of deckhouses is not to be less than that obtained from the following formula:

$$t = 0.025\, L + 3.5 \quad \text{mm}$$

where: L — length of boat, in m.

(10) The section modulus W of the stiffeners of the deckhouse boundary bulkheads is not to be less than that obtained from the following formula:

$$W = 3.5shl^2 \quad \text{cm}^3$$

where: s, l — see 2.2.3.6(4) of this Section;
h — design heads, in m, to be selected as follows:
for fore end bulkheads of deckhouses, to be taken as $0.12L(d/D)^{2.5}$, but not to be less than $0.008L + 2.5$ m;
for side bulkheads and aft end bulkheads of deckhouses, to be taken as $0.045L(d/D)^2$, but not to be less than $0.004L + 1.25$ m;
where: L, d/D are the same as those in 2.2.3.6(4) of this Section.

(11) The thickness t of the deckhouse decks is not to be less than that obtained from the following formula:

$$t = 0.04L + 3 \quad \text{mm}$$

where: L — length of boat, in m.

Section 3 Aluminum Boats

2.3.1 General requirements

2.3.1.1 This Section applies to boats whose hull structures are of aluminum material. For air-cushion vehicles, the structures are to comply with the requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

2.3.1.2 Principle of structural design

(1) The principle of structural design is same as to that of steel boats.

2.3.1.3 Hull girder strength

(1) Hull girder strength of aluminum boats is to meet the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

(2) Allowable stress for calculation of general strength is to be taken as follows:

$[\sigma] = 0.67\sigma_{sw}$ for allowable bending stress;

$[\tau] = 0.38\sigma_{sw}$ for allowable shearing stress

where: σ_{sw} — yield stress after welding of member's material, in N/mm^2, to be taken as $\sigma_{0.2}$ in the annealed condition of material.

2.3.1.4 Others

The local strengthening, pillar arrangement and hull tightness testing requirements for aluminum boats are same as to that for steel boats.

2.3.2 Vertical acceleration

2.3.2.1 The requirements for vertical acceleration at gravity center of a boat are same as to that for in 2.1.2.1 of this Chapter.

2.3.3 Local calculated pressure

2.3.3.1 The requirements for local calculated pressure of bottom, side, deck and superstructure are same as to that for in 2.1.2.2 of this Chapter.

2.3.4 Plate thickness

2.3.4.1 The minimum thickness t_{min} of plating is to be taken as follows:

$$t_{min} = K_0\sqrt{L} \quad \text{mm}$$

where: K_0 — coefficient, to be obtained from Table 2.2.2.3(1);
L — length of boat, in m.

The minimum thickness of plate keel for monohull, catamarans and SES is to be increased by 2 mm over the above value.

2.3.4.2 Built-up sections of bottom, including engine seating, is to comply with the following requirements:

$$t \geqslant \frac{h}{50}\sqrt{\frac{\sigma_{sw}}{125}} \quad \text{for web}$$

where: t — web thickness, in mm;
h — web depth, in mm;
σ_{sw} — yield stress after welding of member's material, in N/mm^2, to be taken in the annealed condition of material.

$$t \geqslant \frac{b}{12}\sqrt{\frac{\sigma_{sw}}{125}} \quad \text{for face plate}$$

where: t — plate thickness, in mm;

b — plate width, in mm;

σ_{sw} — yield stress after welding of member's material, in N/mm^2, to be taken in the annealed condition of material.

2.3.4.3 The thickness t of plating is to be taken not less than that from the following:

$$t = K\ C_1 C_2 S\sqrt{\frac{P}{\sigma_{SW}}} \quad \text{mm}$$

where: K_1 — coefficient, to be obtained from Table 2.3.4.3;

S — spacing of frames, in m, normally for longitudinal frame spacing, and width subjected to the area for girders or floors;

C_1 — reduction factor for curved plates; $C_1 = 1\text{-}0.5S/r$, where: r is radius of curvature, in m;

C_2 — correction factor for aspect ratio of plate field. $C_2 = 1.0$ for $S/l < 0.5$, $C_2 = 0.92$ for $S/l = 1.0$, may be obtained by linear interpolation, where: l is span of stiffeners and frames, in m. Where no bracket is provided at the ends of stiffeners and frames, span point may be at their ends; where bracket is provided at the ends of stiffeners and frames, span point may be at half of the bracket length;.

P — design pressure, to be taken as required by 2.1.2.2 of this Chapter;

σ_{sw} — yield stress after welding of material, in N/mm^2. Where the stiffened plates formed by extruding area used and the welded joint of the plates are far away from the edge of the plates, σ_{Sw} in the formula may be taken as the yield stress of material σ_S. Where riveting structure is used, σ_{Sw} is to be taken as $0.9\sigma_S$.

Coefficient *K* **Table 2.3.4.3**

Item		Plating	Secondary members			Primary members
			Longitudinal member	Beam, frames, floors	stiffeners	Girders, web frames, plate floors, web beams
Bottom, connecting structure bottom		25.0	115	135		135
Side		25.8	130	150		150
Deck, including superstructure/deckhouse top		27.8	130	150		150
Superstructure/deckhouse front walls		25.8			170	150
Superstructure/deckhouse side and rear walls		25.8			150	150
Bulkhead	Collision and liquid tank	25.8			130	150
	Watertight	23.4			120	150

2.3.5 Stiffeners and frames

2.3.5.1 The section modulus W including attached plating of stiffeners and frames is not to be less than:

$$W = \mathrm{K}\frac{\ell^2 SP}{\sigma_{SW}} \quad \text{cm}^3$$

where: K — coefficient, to be obtained from Table 2.3.4.3;

ℓ, P, S — same as in 2.3.4.3 of this Section.

σ_{SW} — yield stress after welding of material, in N/mm^2. The following requirements are to be complied with:

(1) the yield stress σ_{SW} after welding is to be taken for all longitudinals except for bulkhead stiffeners;

(2) the yield stress σ_S of the material may be taken as in the above formula for all girders, web frames and web beams, except for bottom and flat bottom above water;

(3) $\sigma_{SW} = 0.9\sigma_S$ for riveting structure.

2.3.5.2 Shearing strength for longitudinals and girders

(1) The requirements for the shearing strength for longitudinals and girders are same as in 2.2.2.5 of this Chapter.

Section 4 Doors, Windows and Covers

2.4.1 General requirements

2.4.1.1 The external doors of superstructures or deckhouses, and the hatches on open decks are to be provided with weathertight closing devices. The structural strength of weathertight doors and hatch covers is to be equivalent to that of adjacent bulkheads.

2.4.1.2 In general, side scuttles are not to be provided in way of sides under freeboard deck. Where it is necessary to provide circular side scuttles, watertight closing device is to be provided to secure watertightness.

2.4.1.3 No door is to be provided on collision bulkhead but watertight man-hole cover with bolts may be allowed. The door in watertight transverse bulkhead is to be of watertight type and is to be kept closed during navigation.

2.4.1.4 The external windows and their frames of superstructure or deckhouse are to be capable of ensuring weathertightness. The connection between window and frame and the connection between frame and wall plating are to be firm and reliable, and capable of sustaining wave slamming as the boat is navigating normally in its service restriction. The structural strength is to be equivalent to that of adjacent structure.

2.4.1.5 The external windows are to be adopted of toughened glass or polycarbonate glass or laminated glass in compliance with the relevant standards accepted by the Society, and the mechanical properties of glass materials are to be submitted to the Society.

2.4.1.6 Minimum tightness requirements for doors, windows and covers

(1) The circular side scuttles provided below freeboard deck are to comply with the tightness requirements for Class I.

(2) In general, the weathertight hatch covers provided above each open deck (including top plate of superstructure) are to comply with the tightness requirements for Class III. The weathertight hatch covers on open deck forward the amidship onboard a boat navigating in coastal service restriction are to comply with the tightness requirements for Class II.

(3) The open weathertight doors and windows provided in vertical plane or vertical plane with slight inclination above the freeboard deck are to comply with the tightness requirements for Class III.

2.4.1.7 For the tightness testing methods, refer to Table 2.4.1.7.

Tightness testing methods for doors, windows and covers Table 2.4.1.7

Tightness class		I	II	III
Pressure test before installation ①	Water pressure (MPa)	0.035	0.014	---
	Time (min)	3	3	---
	Qualified standard	Specimen with no leakage or permanent deformation		---
Hose test after installation	Conditions of hose test	Continuous hose time for each specimen ⩾ 3 min; Flow rate of water column ⩾ 10 *l* /min; Pressure of hose = 200 kP; Distance between nozzle and specimen ⩽ 2m; Water jet to each side of specimen ⩽ 0.05 m		
	Qualified standard (volume of water ingress after hose test for each specimen)	⩽ 0.05 *l*		⩽ 0.5 *l*

Note: ① Pressure test is to be carried out in a designated tank.

2.4.2 Requirements for thickness of window glass

2.4.2.1 The thickness *t* of window glass is not to be less than:

$$t = \frac{b}{31.6}\sqrt{\frac{kcp}{\sigma_b}} \quad \text{mm}$$

where: b — short side length of window opening, in mm;
p — lateral pressure, in kN/mm², to be taken according to 2.1.2.2(6) for high speed boat or 2.1.3.5(1) to (2) for non-high speed boat;
c — coefficient, obtained from Fig. 2.4.2.1;
σ_b — ultimate bending stress of glass, in MPa;
k — safety factor,
k = 4.0, for toughened safe glass;
k = 3.5 for polycarbonate glass.

Each glass is to be of toughened safe glass in case of sandwich glass, the maximum glass layers are to be of three, and the thickness error for any two layers of them is not to be more than 2 mm, the thickness of plastic membranes in between is not to be more than 0.76 mm.

The thickness *t* of sandwich glass is not to be less than:

$t = t_1 + t_2 = 1.2teq$, for two-layer sandwich glass;
$t = t_1 + t_2 + t_3 = 1.5teq$, for three-layer sandwich glass

where: t_1, t_2, t_3 — thickness of each glass, in mm;
teq — equivalent thickness as calculated from single layer toughened safe glass, in mm.

In addition, the thickness *t* to be taken is not to be less than the following minimum values t_{min}:
front window glass of superstructure or bridge room:
t_{min} = 4 mm, for toughened safe glass;
t_{min} = 5 mm, for polycarbonate glass;

side window glass of superstructure or deckhouse:
t_{min} = 3 mm, for toughened safe glass;
t_{min} = 4 mm, for polycarbonate glass.

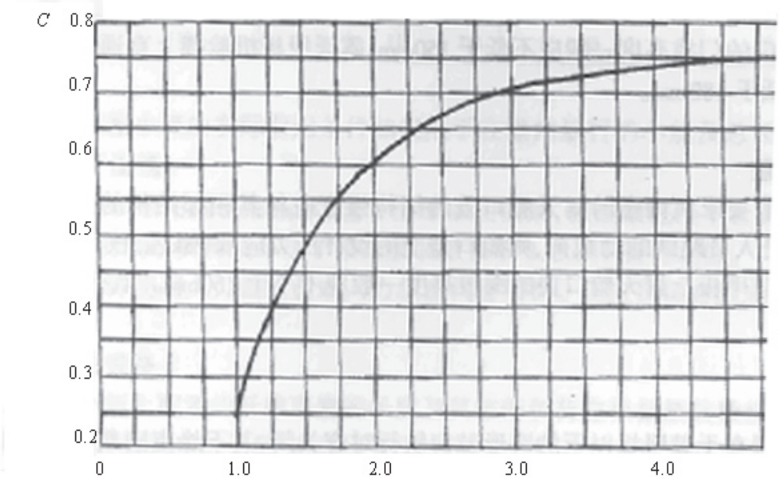

Fig. 2.4.2.1 Window aspect ratio = Long side length/ Short side length

2.4.2.2 Where the window glass is of polycarbonate glass, depth of glass inserted in the frame of window is not to be less than 0.03 times the length of short side of the window glass.

2.4.2.3 The window glass may be connected directly to wall plating by means of adhering. Where necessary, metal horizontal members are to be provided at the lower edge of window glass to support the glass weight. The adhesive adopted is to be capable of resisting ultraviolet light, low and high temperature and chemical cleaning agent. The properties of adhesive such as long-life adhering strength and its working requirements and procedure documents are to be submitted to the Society for approval.

2.4.2.4 In addition, the adhering methods as mentioned in 2.4.2.3 above are to comply with the following requirements:

(1) The adhering width d is not to be less than:

$$d = \frac{2.5 P_W b l}{\sigma_t (b + l)} \quad \text{mm}$$

where: $P_W = 0.0125(50 + 0.5v)^2$ KN/m;
v — maximum speed in calm water, in Kn;
b — short side length of window, in mm;
l — long side length of window, in mm;
σ_t — minimum tensile stress of adhesive, in MPa.

The minimum adhering width is $d_{min} = 20b$ mm.

(2) The thickness t of adhesive is not to be less than:

$t = 5l$ mm, for toughened safe glass;
$t = 8l$ mm, for polycarbonate glass.

The minimum adhering thickness is $t_{min} = 6$ mm.

(3) The tensile stress of adhesive is not to be less than 0.7 MPa, the tensile stress is not to be less than 0.14 MPa when the elongation is 12.5%, and the elongation is to be more than 50% when the adhesive is broken.

2.4.2.5 The opening of rectangular windows is to be of rounded corner type in order to avoid cracks caused by the stresses concentrated in the corners.

Chapter 3 OUTFITTING

Section 1 Rudders

3.1.1 General requirements

3.1.1.1 The requirements of this Section apply to boat with spade rudders or single-plate rudders.

3.1.1.2 The steering gears are to comply with the relevant requirements of Chapter 4.

3.1.1.3 In general, the design of rudder stocks, blades, rudder bearings and the connection between rudder stocks and blades are to comply with the relevant requirements of Rules for Classification of Sea-going Steel Ships by the Society. The rudders for high speed boat may comply with the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

Section 2 Anchoring and Mooring Equipment

3.2.1 General requirements

3.2.1.1 Unless specified otherwise, all motor boats are to be provided with anchors and chains. The anchors and chains are to be kept connected and to be arranged available for use at any time.

3.2.1.2 Securing of anchors and storage of chains are to be suitably arranged.

3.2.1.3 Effective measures are to be taken in board for securing bower chains.

3.2.2 Equipment number

3.2.2.1 The equipment number N is to be calculated by the following formula:

$$N = \left[\Delta^{2/3} + 2\left(BH_c + \sum S_i \sin\theta_i\right) + 0.1A \right] k$$

where: Δ — full-loaded displacement, in t;

B — breadth of boat, in m, see definition in 1.1.2.1(5);

H_c — vertical distance from full load waterline of a boat in rest floatation to upper deck (for decked boat) or top end of side plate (for open boat), in m;

S_i — projection area of front bulkhead of each tier of deckhouse whose breadth exceeds $B/4$ to section, in m²;

θ_i — angle between the horizontal level and the front bulkhead of each tier of deckhouse whose breadth exceeds $b/4$, in °;

A — area in profile view of the hull above the full load waterline and the houses whose breadth exceeds $B/4$, in m²;

k — coefficient, to be taken according to the service restriction:

$k = 1.5$, for coastal service restriction;

$k = 1.0$, for sheltered water service restriction;

$k = 0.70$, for calm water service restriction.

For boat with no deckhouse but windscreen or awning, the projection area of windscreen or awning is to be taken into account for calculation of the equipment number.

3.2.3 Anchoring equipment

3.2.3.1 An anchor with high holding power is normally to be arranged at the bow. The weight of it is not to be less than that obtained from Table 3.2.3.1 based on the equipment number. Where it is not a high holding power anchor, the weight is not to be less than 1.3 times that obtained from Table 3.2.3.1.

Anchoring and mooring equipment **Table 3.2.3.1**

Equipment number		Bow anchor	Diameter of chain		Chain or cable		Fiber ropes for mooring	
Exceeding	Not exceeding	Weight of H.H.P anchor (kg)	AM1 (mm)	AM2 (mm)	Length (m)	Breaking strength (kN)	Length (m)	Breaking strength (kN)
-	5	12	8	8	75	29.4	2×22.5	25
5	10	12	8	8	75	29.4	2×22.5	25
10	15	14	8	8	75	29.4	2×25	25
15	20	20	8	8	80	29.4	2×25	30
20	25	25	8	8	84	29.4	2×25	30
25	30	31	8	8	87	29.4	2×35	30
30	35	37	8	8	90	29.4	2×40	32
35	40	43	8	8	93	29.4	2×40	32
40	50	51	8.5	8	97	29.4	2×40	32
50	70	67	9.5	8.5	105	38.3	3×40	34
70	90	90	11	9.5	113	50.8	3×50	37
90	110	112	12.5	11	121	63.3	3×55	39

3.2.3.2 Where two anchors are provided at the bow, the weight of each anchor is not to be less than 0.7 times that of a single anchor.

3.2.3.3 The anchor may be exempted, subject to agreement of the Society, according to the practical service restriction, e.g. a boat having an overall length less than 8 m and only operating in harbors.

3.2.3.4 The anchor chain and cable may be used, or cable may be used in total length, however, the cable is to be approved by the Society. The overall length and diameter of anchor chain or breaking strength of cable are not to be less than that obtained from Table 3.2.3.1 based on the equipment number.

3.2.3.5 Boats equipped with anchors 30 kg and more in weight are to be provided with anchoring equipment. Hand anchor capstan or hand capstan may be allowed for substituting for windlass, provided that it can effectively handle chain cables.

3.2.4 Mooring equipment

3.2.4.1 The length and breaking strength of fiber ropes for mooring provided onboard are to be obtained from Table 3.2.3.1 based on the equipment number. However, the coefficient k in the formula for calculating the equipment number is: $k = 1$ for coastal service restriction and sheltered water service restriction, $k = 0.85$ for calm water service restriction. The diameter of ropes is not to be less than 15 mm and the overall length is not to be less than 4 times the length of boat. For fiber ropes in the boat having an overall length less than 8 m, special consideration may be given under certain cases subject to agreement of the Society.

3.2.4.2 Suitable number of bitt or cleat is to be fitted respectively on stem, stern and both sides onboard. For boats having an overall length more than 6 m, at least one bitt or cleat is to be fitted respectively on stem or stern.

3.2.4.3 Protective measures, i.e. fender rubber and collision mat are to be provided in both sides onboard in order to prevent hull damage caused by repeated collision between side and wharf when the boat is calling at ports or daily mooring at wharfs.

3.2.4.4 Towed equipment is to be provided and tow ropes to be equipped. The length of tow ropes is to be same as that of anchor chains, with diameter not to be less than 0.85 times that of cables in Table 3.2.3.1.

3.2.4.5 The hull structure in way of the installation places where the equipment (bitt bollard, cleat and towing post) for securing chains, cables, ropes, towing ropes is to be strengthened and capable of bearing the pulling force.

Chapter 4 MACHINERY INSTALLATIONS

Section 1 General Requirements

4.1.1 Application

4.1.1.1 The design, manufacture, installation and testing of main propulsion device, auxiliary machinery, pump and piping system for boats are to comply with the relevant requirements of this Chapter.

4.1.2 Design and installation

4.1.2.1 Design and construction of machinery, fuel oil tanks and associated piping and fittings are to comply with their intended purposes, and are to be so installed and protected as to minimize the hazards to persons when the boat is in normal navigation. Therefore, particular attention is to be paid to moving parts, thermal surfaces and other hazards.

4.1.3 Ambient conditions

4.1.3.1 Main propelling machinery and auxiliary machinery essential to boat's propulsion and safety are to be so designed as to ensure normal operation under the following conditions:

(1) boat's upright; and

(2) static heal not more than 15°; and

(3) static trim not more than 7.5°.

4.1.3.2 In general, the rated power of engine means the maximum continuous power for the engine under the ambient conditions of 0.1 MPa absolute atmosphere, 45℃ ambient temperature, 60% relative humidity and 32℃ sea water temperature.

4.1.4 Means of going astern

4.1.4.1 Suitable power for going astern is to be provided to secure proper control of the boat in all normal circumstances.

4.1.5 Doorways

4.1.5.1 At least one doorway is to be provided in engine room. Stairways are to be provided in doorways of the engine room requiring to be manned and to be easily accessible for operators. An emergency exit is to be additionally provided.

4.1.6 Ventilation

4.1.6.1 Diesel oil engine room is to be adequately ventilated so as to ensure that an adequate supply of air is maintained to the engine room when the engines are operated at full power under any weather conditions for the safety of personnel and normal operation of engines.

4.1.6.2 The ventilation in compartments installed petrol engine and/or petrol tank is to comply with the requirements of Section 3 in this Chapter.

4.1.7 Material

4.1.7.1 The requirements for material of shafting are to comply with the following:

(1) The shafting is to be made of forged or rolled carbon steel, carbon-manganese steel or other material subject to agreement of the Society.

(2) Material test may not be carried out for the shaft having the maximum diameter less than 80 mm, but suitable documents to prove the properties of such material are to be submitted to the Society.

4.1.7.2 Plastic or heat-sensitive material, if used, is to be subject to agreement of the Society.

4.1.7.3 Parts and components, such as side fittings, sea connection, etc. are to be made of steel, bronze or other material approved by the Society.

4.1.8 Control and instrument

4.1.8.1 Passenger boats are to be provided with a control center as far as practicable, so that the personnel can effectively maneuver and control the boat in either normal or emergency condition. In addition, the control center is to be provided at least with instrument having the following indicating (or testing) functions:

(1) power source for maneuver the boat;

(2) main propulsion power;

(3) main fire-extinguishing system, if any;

(4) engine room ventilation;

(5) fuel pump and quick-closing value, if any;

(6) bilge pump and bilge water level.

4.1.9 Products

4.1.9.1 All of the primary machines and equipment onboard, such as engines, gear boxes, elastic couplings, bilge pumps, fire pumps, propellers, Z-type propelling units, water-jet unit, etc. are to have marine product certificates issued by the Society. Other products may be installed onboard only after agreed by the Society.

4.1.10 Testing

4.1.10.1 The mooring trials and sea trials, after completion of installation of machinery, are to be carried out according to the test programmes approved by the Society.

Section 2 Engines

4.2.1 General requirements

4.2.1.1 Each engine driving propelling machinery is to be provided with reliable governors and overspeed protective devices, which are to comply with the following requirements:

(1) Governors are to prevent the engine from exceeding 115% of its rated speed.

(2) Overspeed protective devices are to be independent of governors, and to prevent the engine from exceeding 120% of its rated speed.

4.2.1.2 Each engine driving generators is to be provided with reliable governors and safety devices, which are to comply with the following requirements:

(1) When sudden rated load drops or sudden rated load accelerates, the rate of instantaneous and steady regulating speed is not to be more than 10% and 5% of the rated speed respectively. When sudden rated load accelerates, the steady time (i.e. the time of returning to the range with pulsating rate being ±1%) is not to be more than 5 s.

(2) When rated power of engine is more than 220 kW, overspeed protective devices independent of governors are to be provided to prevent the engine from exceeding 115% of its rated speed.

4.2.1.3 Main engines are to be provided with emergency stopping devices. For main engine remotely controlled in bridge room, the emergency stopping device is to be provided in the bridge room.

4.2.1.4 The total capacity of the starting arrangements is to be sufficient to provide, without replenishment, not less than six consecutive starts of the main engine in cold condition and not less than three consecutive starts of the auxiliary engine in cold condition.

4.2.1.5 The engines are to be so installed inside the boat as to be easily accessible and be maintained and inspected conveniently by operators.

4.2.1.6 The rigid installation of engines inboard is to comply with the following requirements:

(1) The nuts for securing bolts are to be provided with locking devices.

(2) The securing bolts of main engine and gear box are to be provided with at least two fitting bolts respectively.

(3) The main engine and gear box are to use a common foundation as far as practicable.

4.2.1.7 Not less than two sea inlets are to be connected with the cooling water pump of sea-water cooling piping system or circulating system and to be fitted on both sides of boat as far as practicable. For a boat of less than 10 m in length, one sea inlet may be fitted only if the water supply can be ensured.

4.2.2 Alarm device

4.2.2.1 Main engines are to be provided with the following alarm devices:

(1) low-pressure alarm device for lubricating oil;

(2) high-temperature alarm device for cooling water.

For main engine remotely controlled in bridge room, the above alarms are to be provided or extended in the bridge room

4.2.2.2 For prime motor of generator with power more than 35 kW, low-pressure alarm device for lubricating oil is to be provided.

4.2.3 Special requirements for outboard engine

4.2.3.1 The outboard engines are to be reliably fixed on the stern transom plating by through bolts or equivalent means.

4.2.3.2 The installation trunk of outboard engine is to have sufficient dimension so that the outboard engine can be moved around according to the operating conditions.

4.2.3.3 The openings for operational cable and fuel hose of outboard engine are to be effectively sealed if penetrating hull structure.

4.2.3.4 For outboard engine with total power less than 40 kW, the speed and direction can be operated by single handle. For outboard engine with total power of 40 kW and above, handwheel console is to be provided in stem.

4.2.3.5 Where the steering position is open onboard a boat with the speed exceeding 20 kn, a safety rope is to be provided near the steering position. Where the navigating officer falls outside, the safety rope can stop the outboard engine.

Section 3 Petrol Engine and/or Petrol Tank Compartments

4.3.1 Definitions

4.3.1.1 Open compartment means a compartment or space having at least 0.34 m^2 of permanent open area directly exposed to the atmosphere for each cubic meter of net compartment volume.

4.3.2 General requirements

4.3.2.1 Except open compartments, natural ventilation system is to be provided in petrol engine and petrol tank compartments in accordance with the requirements of 4.3.3 of this Section. Powered ventilation system is to be provided in petrol engine compartments in accordance with the requirements of 4.3.4 of this Section.

4.3.2.2 Compartments containing petrol engines and/or petrol tanks are to be separated from the independent passenger's cabins to prevent the petrol gas from entering the passenger's cabins.

4.3.2.3 For compartments containing petrol engines and/or petrol tanks, neither supply nor exhaust ducts are to open into a passenger's cabin.

4.3.2.4 Except open compartments, all electrical components installed in compartments containing petrol engines and/or petrol tanks and in other compartments connecting to such compartments are to be of ignition-protected type. [①]

4.3.2.5 The electrical components installed on the petrol engines are to comply with the relevant requirements of Chapter 5.

4.3.2.6 Portable petrol tank or equipment with petrol fuel is not to be arranged in enclosed spaces, they are to be arranged in a place provided with quick-securing devices and to be ready for jettison in an emergency. The leaked petrol is to be able to be drained directly outboard.

4.3.3 Natural ventilation system

4.3.3.1 A supply opening or duct from the atmosphere and an exhaust opening or duct to the atmosphere are to be provided in natural ventilated compartments. Each exhaust opening or duct is to originate in the lower 1/3 of the compartment. Each supply opening or duct and each exhaust opening or duct in compartment are to be above the normal level of accumulated bilge water.

4.3.3.2 Compartment air intake and exhaust duct openings are to be separated by at least 600 mm with compartment dimension permitting.

4.3.3.3 The combined area of supply openings or ducts, and the combined area of exhaust openings or ducts are to have a minimum internal cross-sectional area calculated as follows, and not less than 3000 mm^2:

$$A = 3300 \ln (V/0.14)$$

where: A — the minimum combined internal cross-sectional area of the openings or ducts, in mm^2;
V — the net compartment volume equal to the total compartment volume minus the volume of permanently installed components in it, in m^3;
ln — natural logarithm.

① Refer to ISO 8846.

4.3.4 Powered ventilation system

4.3.4.1 The total airflow capacity Q of each exhaust blower or combination of blowers in compartment is not to be less than that in Table 4.3.4.1.

Total airflow capacity Q Table 4.3.4.1

Net volume of compartment (m^3)	Total airflow capacity Q (m^3/min)
< 1	1.5
$1 \leqslant V \leqslant 3$	$1.5 \times V$
> 3	$1.5 \times V + 3$

4.3.4.2 The blower is to be of non-spark type.

4.3.4.3 Each intake duct for an exhaust blower is to be in the lower 1/3 of the compartment and above the normal level of accumulated bilge water.

4.3.4.4 The exhaust outlet of blower is to be as far apart as possible from the outlet of exhaust pipe for engine.

4.3.4.5 The suction blower fitted in the petrol engine compartment is to be operated 4 min before starting of engine. During the service period of boat (including embarkation, disembarkation or laid-up), continuous powered ventilation is to be kept in petrol engine compartment and the blower is not to be stopped. When it stops due to any reasons, visual and audible alarms are to be given in the machinery space and bridge.

Section 4 Shafting and Propulsor

4.4.1 Diameter of shaft

4.4.1.1 The shaft is to be made of forged steel or hot-rolled steel. The tensile strength is to be within the range of 400 to 600 N/mm^2 for manganese steel and carbon steel, and not exceeding 800 N/mm^2 for alloy steel.

4.4.1.2 The diameter of shaft d is not to be less than:

$$d = 100C\sqrt[3]{\frac{P}{n_e}\left(\frac{560}{\sigma_b + 160}\right)} \quad \text{mm}$$

where: C — coefficient, to be taken as follows:
C = 1.0, for intermediate shaft, transmission shaft;
C = 1.22, for screwshaft with keyless propeller shrunk on or attached by means of a flange and pump shaft of water-jet unit;
C = 1.26, for screwshaft carrying a keyed propeller shrunk.
P — rated power transmitted by the shaft, in kW;
n_e — speed of the shaft at P, in r/min;
σ_b — tensile strength of the shaft materials, in N/mm^2. For intermediate and driving shafts, if $\sigma_b > 800$ N/mm^2, to be taken as 800 N/mm^2; for screwshaft and pump shaft of water-jet unit, if $\sigma_b > 600$ N/mm^2, to be taken as 600 N/mm^2.

If the shaft material is stainless steel, the shaft diameter d is to be equal to 0.8 times the value obtained from the formula above.

4.4.1.3 Where the shafts have central holes with a diameter $d_o > 0.4\, d_a$, the diameter of the shafts is to be modified by the following formula:

$$d_c = d\sqrt[3]{\frac{1}{1-\left(\frac{d_o}{d_a}\right)^4}} \quad \text{mm}$$

where: d_c — diameter of shaft after modification, in mm;
d — diameter of shaft determined by the formula in 4.4.1.2 of this section, in mm;
d_a — actual diameter of the shaft, in mm.

4.4.2 Shaft liners (if fitted)

4.4.2.1 The thickness t of bronze shaft liners shrunk on screwshafts, in way of bushes, is not to be less than:

$$t = 0.015d + 3.8 \quad \text{mm}$$

where: t — diameter of screwshaft in way of bushes, in mm.

The thickness of a continuous liner between the bushes may be somewhat reduced, but is not to be less than 0.75 t.

4.4.2.2 Continuous liner is generally to be cast in one piece. Where necessary, it may consist of two or more pieces, but these are to be welded by the methods approved by the Society.

4.4.2.3 Where the portion of the shaft between any two lengths of the liner is protected with fiber reinforced plastic or other equivalent materials, the protection at the junction of the liner ends is to be of such a construction as to prevent the shaft from water ingress.

4.4.2.4 Before liner is fitted on the shaft, hydraulic testing with 0.2 MPa pressure is to be made.

4.4.3 Stern tube and bearings

4.4.3.1 The length of sea water lubricated after bearing of stern tube is not to be less than 4 times the stipulated diameter of screwshaft.

4.4.3.2 The length of oil lubricated after bearing of stern tube is not to be less than 2 times the stipulated diameter of screwshaft, and:

(1) an approved oil sealing gland is to be provided;

(2) means for cooling lubrication oil are to be provided.

4.4.3.3 For new types of composed materials approved by the Society, the length of after bearing of stern tube is to be suitably reduced subject to agreement of the Society.

4.4.3.4 Stern tubes are to be subjected to hydraulic testing with a pressure of 0.2 MPa before being fitted onboard.

4.4.4 Coupling

4.4.4.1 For couplings which are transmitted torque by keys, the tensile strength of the key material is not to be less than that of the shaft material, the effective sectional area of the key in shear is to be determined by the following formula:

$$BL \geqslant \frac{d^3}{2.6d_m} \quad \text{mm}^2$$

where: B — breadth of key, in mm;
L — effective length of key, in mm;
d — diameter of intermediate shaft determined by 4.4.1.2, in mm;
d_m — diameter of shaft at mid-length of the key, in mm.

4.4.4.2 The diameter d_f of fitting bolts at the jointing faces of couplings is not to be less than:

$$d_f = 15.92\sqrt{\frac{P \times 10^6}{n_e D Z \sigma_b}} \quad \text{mm}$$

where: P — rated power transmitted by shaft, in kW;
n_e — speed of the shaft at P, in r/min;
Z — number of bolts;
D — diameter of pitch circle of bolts, in mm;
σ_b — tensile strength of bolt material, in N/mm^2. It is not to be less than that of the intermediate shaft material but not greater than 1000 N/mm^2.

4.4.4.3 Where general bolts are used, the diameter d_n at the root of thread of bolts is not to be less than:

$$d_n = 25\sqrt{\frac{P \times 10^6}{n_e D Z \sigma_b}} \quad \text{mm}$$

where: the symbols P, n_e, D, Z, σ_b are same as defined in 4.4.4.2 of this Section.

4.4.5 Propeller

4.4.5.1 The blade thickness of propeller and the installation of propeller to screwshaft are to comply with the relevant requirements of Rules for Construction and Classification of Sea-going High Speed Craft or the standards accepted by the Society.

4.4.6 Z-type propelling unit

4.4.6.1 The diameters of input shaft, vertical spindle and screwshaft for steering and propulsion system are not to be less than those obtained from 4.4.1.2 in this Section.

4.4.6.2 The strength and installation requirements for propeller of such system are to be in compliance with the relevant requirements of 4.4.5 of this Section.

4.4.6.3 The design and manufacture of involute conic gear for transmitting shafting of such system are to comply with the standards accepted by the Society.

4.4.6.4 Such system is to be well lubricated with a temperature of lubricating oil not more than 70℃ .

4.4.6.5 The rotatable steering and propulsion system is to comply with the requirements, i.e. the period of the boat's steering of 180° from full ahead to full astern does not exceed 20 s.

4.4.6.6 Where the power unit of rotatable system is electro-dynamic or electro-hydraulic, stand-by power unit or other emergency operating means are to be provided. Power unit can be exempted if the boat is provided with two or more Z-type propelling units.

4.4.6.7 The hydraulic piping for rotatable system is to comply with the requirements of 4.8.1.7 of Section 8.

4.4.6.8 Rudder indicators for steering and propulsion system are to be provided in bridge room and steering gear room.

4.4.6.9 After completion of manufacture, the parts and components of the system, such as upper gear box, lower gear box and rotatable gear box are to be subject to a hydraulic test at 0.2 MPa and after assembly, they are to be subject to a tightness test at 0.1 MPa.

4.4.6.10 Hydraulic testing is to be carried out for hydraulic piping with 1.5 times the design pressure, after installation onboard, the hydraulic piping together with its accessories are to be subject to a tightness test at 1.25 times the design pressure.

4.4.7 Water-jet unit

4.4.7.1 The water-jet units are to be capable of sustaining loads under all possible working conditions.

4.4.7.2 The diameter of pump shafts of the water-jet units is to comply with the relevant requirements of 4.4.1.2 of this Section.

4.4.7.3 The installation of a water-jet unit, including shafting alignment, is to give safety performance of propulsion system under all working conditions.

4.4.7.4 The pump case of water-jet unit is to be subject to a hydraulic test at 1.5 times the design pressure.

4.4.7.5 Where lubricating oil bearing is used for water-jet unit, the shaft sealing device is to be of approval type in order to prevent water from ingress to oil lubricated parts of the pump.

4.4.7.7 Directional control device for water-jet unit is to be capable of operating in the bridge room.

4.4.7.8 Indicators are to be provided in the bridge room to show speed of water-jet pumps and the water-jet asterning position.

Section 5 Fuel Oil System

4.5.1 General requirements

4.5.1.1 Each part of fuel oil system is to have a sufficient strength and to be so installed as to be capable of bearing impact and vibration which will possibly take place and not to cause any leakage.

4.5.1.2 The material of parts of fuel oil system is to be capable of resisting environment corrosion and temperature affect.

4.5.2 Fuel oil tanks

4.5.2.1 The structure and arrangement of fuel oil tanks are to comply with the following:

(1) The fuel oil tanks are to be tightly fixed on the foundation and certain spaces between fuel oil tanks and bulkheads or other equipment are to be kept as to ensure free ventilation.

(2) Hydraulic pressure testing is to be carried out before fuel oil tank is installed, the test head is to reach 2.4 m above the top of the tank, and leakage is not to be allowed.

(3) The fuel oil tanks are not to be positioned above engines, exhaust pipes and electrical installations, and apart from accumulator batteries, etc. as far as possible.

(4) Vent pipes with sufficient flow area are to be provided for fuel oil tanks and they are led to open spaces where neither flooding nor danger caused by leakage of oil or oil gases. Flame-proof gauze diaphragm is to be provided for opening of vent pipe.

(5) Sounding pipes are to be provided for fuel oil tanks, and the approved liquid level indicator is allowed to substitute for sounding pipe.

(6) The space where fuel oil tank is located is to be effectively ventilated.

(7) Fuel oil tanks are not to be arranged forward of collision bulkheads.

4.5.2.2 The diesel oil tank is to have enough strength and the minimum wall thickness is not to be less than the following:

Austenite chrome nickel steel	1 mm
Low carbon steel subjected to external hot dipping zinc after manufacture	1.5 mm
Aluminum alloy with the content of copper not more than 0.1%	2 mm
Polyethylene	5 mm

For diesel oil tanks made of other materials, the material quality and wall thickness are to be subject to agreement of the Society.

4.5.2.3 The petrol tank is to comply with the following:

(1) The petrol tank is to have sufficient strength and the minimum wall thickness is not to be less than:

Austenite chrome nickel steel	1 mm
Aluminum alloy with the content of copper not more than 0.1%	2 mm

For petrol tanks made of other materials, the material quality and wall thickness are to be subject to agreement of the Society.

(2) No oil draining pipes are allowed to be provided for petrol tanks.

(3) Petrol tanks are to be so arranged as to avoid direct sunlight, and means for prevention of shifting of petrol tank is to be provided.

(4) Filling of petrol tanks is to be carried out by an method approved by the Society.

4.5.3 Fuel oil pipeline

4.5.3.1 The pipeline is to be suitably fastened and protected to prevent from damage and abnormal wearing. Pipeline is not to be combined with the attachment made of different metal material in order to avoid electric erosion.

4.5.3.2 The pipeline is to be made of seamless annealed copper, copper-nickel alloy or other equivalent alloy. For diesel oil, aluminum pipeline may be used.

4.5.3.3 Where hose is used for pipeline, the fire-proof type hose[①] is to be adopted. Non-fireproof hoses[②] may be used for outboard engine.

4.5.3.4 Stop valve is to be provided on the fuel oil pipeline as near as possible to the oil tank. The valve can be closed at an appropriate position outside the engine room.

Section 6 Exhaust System

4.6.1 General requirements

4.6.1.1 Exhaust pipe is to be bound with suitable insulation material, the surface temperature of insulation is not to exceed 60℃ . Means is to be taken to prevent the high temperature surface from injuring persons.

① Refer to ISO 7840.
② Refer to ISO 8469.

4.6.1.2 If metal hose is fitted on exhaust pipes, the hose is to be of an approved type and capable of bearing its corresponding work temperature.

4..6.1.3 The material of water-cooling exhaust pipes is to be of an anti-corrosion type, otherwise the thickness is to be suitably increased.

4.6.1.4 The exhaust pipes are to be so arranged that the outboard water can not flood into the engine. Anti-back-water device is to be provided for the discharge positioned at less than 300 mm above waterline, and draining cock is to be provided in the lowest place of exhaust pipes where water may easily accumulate.

Section 7 Bilge Pumping System

4.7.1 General requirements

4.7.1.1 Effective bilge pumping system is to be provided in each boat. The system is to be so arranged as to drain water effectively from any watertight compartment other than that intended for permanently storing liquid and prevent water flowing from one compartment to another.

4.7.1.2 For individual compartment, the drainage may be exempted provided that the safety of the boat is not affected by drainage of this compartment through calculation or necessary demonstration.

4.7.1.3 Where deemed necessary, the bilge suction pipes are to be fitted with effective strum boxes for the purpose of protecting bilge water piping. The strum boxes are to be easily removed and replaced for cleaning and the combined area of a box is not to be less than twice the sectional area of the bilge suction pipe.

4.7.1.4 Where deemed necessary, bilge suction valves are to be of non-return type for the purpose of preventing water flowing coracle.

4.7.1.5 When all hatches are closed, bilge pumps, other than portable pumps, are to be capable of being operated for high speed boat.

4.7.1.6 Discharge of bilge water is to satisfy the pollution prevention requirements of the Administration.

4.7.2 Bilge pump

4.7.2.1 In general, the bilge pump is to be of self-priming type.

4.7.2.2 A hand bilge pump is to be provided for a boat of less than or equal to 12 m in length. At least one power bilge pump and one hand bilge pump are to be provided for a motor boat or a non-propulsion boat with auxiliary power of more than 12 m in length. Two hand bilge pumps are recommended to be provided for a non-propulsion boat without auxiliary power of more than 12 m in length. Open deck boat is to be additionally provided with a bailer or a bucket.

4.7.2.3 The bilge pump driven by power may be used for other purposes, but is not to be used as an oil pump.

4.7.2.4 For bilge pump not used to control the flooding quantity at bilge after the boat is damaged, the total displacement of bilge pump is not to be less than the requirements of Table 4.7.2.4.

Total displacement of bilge pump **Table 4.7.2.4**

Length of boat L (m)	Total displacement of bilge pump (m^3/h)
$L \leqslant 6$	0.6
$6 < L \leqslant 12$	1.0
$12 < L \leqslant 24$	2.0

4.7.3 Discharges

4.7.3.1 Screw-down non-return valve is to be fitted in an accessible place for all the discharges draining to the outboard. In general, the said valve may be exempted for the discharge located at a place 350 mm above the waterline and no water flooding will take place due to boat's rolling in navigation.

4.7.4 Bilge water level alarms

4.7.4.1 A watertight compartment fitted with propelling machinery, or any other compartment (except void space) where bilge water may easily accumulate but not be found easily, is to be provided with a bilge alarm of high water level.

4.7.4.2 Any one dry compartment fitted with fixed or portable bilge water suction, where bilge water level is not found easily, are also to be provided with bilge water high level alarms.

4.7.4.3 Visual and audible alarms for bilge water high level are to be provided at the maneuvering position of the boat.

Section 8 Steering Gear

4.8.1 General requirements

4.8.1.1 The steering gear is to ensure the reliable maneuvering for the boat in navigation.

4.8.1.2 Power steering gears are generally to be provided with an emergency steering gear.

4.8.1.3 Where a steering gear comprises two or more power units, the emergency steering gear may be exempted.

4.8.1.4 Emergency steering gear may be exempted for directional control device of outboard engine or internal/external engine.

4.8.1.5 The Z-type propelling unit is to comply with the requirements of 4.4.6 of Section 4 in this Chapter.

4.8.1.6 The water-jet unit with directional control function is to comply with the requirements of 4.4.7 of Section 4 in this Chapter.

4.8.1.7 For hydraulic steering system, the following requirements are also to be complied with:

(1) Material of system components is to be suitable for its working medium.

(2) Oil filter and overflow valve are to be fitted in hydraulic piping system, in general, oil spill is to be back to tanks.

(3) Gas-releasing arrangement is to be provided for hydraulic piping system and hydraulic oil cylinder.

(4) Hoses or pipelines are to avoid heat influence and the hose is to be of an approval type.

(5) Low level alarms are to be provided for the circulating oil box of each hydraulic system and to give visual and audible alarms in machinery spaces and bridge room, however, steering gear for outboard engine may be exceptional.

4.8.1.8 The steering position is to have a good visibility of navigation for the steering persons.

Chapter 5 ELECTRICAL INSTALLATIONS

Section 1 General Requirements

5.1.1 General requirements

5.1.1.1 The design, manufacture, test and installation of main electrical installations onboard are to comply with the relevant requirements of this Chapter, or to meet other corresponding standards accepted by the Society. Electrical equipment and cables are to have appropriate certificates of marine products as required by the Society.

5.1.1.2 Electrical installations onboard are to ensure:

(1) that they are capable of giving power supply to all electrical auxiliary services necessary for maintaining the boat in normal operation;

(2) the safety of passengers, crew and the boat from electrical hazards.

5.1.2 Design, manufacture and installation of electrical equipment

5.1.2.1 Electrical equipment are to be so designed, manufactured and installed as to ensure safe operation and to be easy for inspection and repair.

5.1.2.2 Electrical equipment are to be operated satisfactorily under the voltage and frequency fluctuations as given in Table 5.1.2.2.

Voltage and frequency fluctuation **Table 5.1.2.2**

Equipment	Parameter	Steady-state (%)	Transient	
			%	Maximum recovery time (s)
General equipment	Voltage	+6 to -10	± 20	1.5
	Frequency	± 5	± 10	5
Equipment supplied by accumulator batteries: Connected to batteries during charging Not connected to batteries during charging	Voltage	+ 30 to - 25 + 20 to - 25	—	—

5.1.2.3 All electrical equipment are to be operated satisfactorily under the following environmental conditions:

(1) The ambient air temperatures are as given in Table 5.1.2.3(1).

Ambient air temperatures **Table 5.1.2.3(1)**

Location	Temperature
In enclosed spaces	0℃ to 40℃
In spaces subject to temperatures exceeding 40℃ and below 0℃	According to specific local condition
On open deck	- 25℃ to 40℃

The upper limit of ambient air temperature for the electronic installations is 55℃ .

(2) Moisture, sea air, oil vapour and mould.

(3) Vibration and shock likely to arise under normal service of boat.

(4) The inclination of boat from the normal position is as given in Table 5.1.2.3(4).

Inclination **Table 5.1.2.3(4)**

Equipment components	Angle of inclination			
	Athwartships		Fore-and-aft	
	Static	Dyn	Static	Dyn
Emergency electrical equipment, switchgear, electrical and electronic equipment	22.5	22.5	10	10
Electrical equipment excluding stated above	15	22.5	5	7.5

5.1.2.4 The electrical equipment are to be arranged apart from inflammable material and with effective ventilation and in the places where no inflammable gas may concentrate and where they are not easily subjected to mechanical damage or oil and water corrosion. Where they are fitted in the above mentioned various hazardous places, suitable structural protection or enclosure is to be provided for such equipment.

5.1.2.5 The type of protective casing selected for electrical equipment is to meet the requirements in Table 5.1.2.5.

Protective casing **Table 5.1.2.5**

Location onboard	Grade of protection
Compartments with well protection below deck	IP20
On the tank top sheltered deck	IP22
On the splashed deck	IP44
On the immersed deck	IP56

5.1.3 Earthing

5.1.3.1 Exposed metal parts of electrical equipment and cables which are not intended to be live are to be earthed reliably.

5.1.3.2 Non-metal structure boat is to be provided with an earthing bedplate, which is to be made of copper with not less than 0.1 m^2 in cross sectional area and a thickness not less than 1 mm or other sea water corrosion-resisting metal, such as stainless steel. Where engines or propellers of the non-metal structure boat have an equivalent function of the earthing bedplate, such earthing bedplate is not required.

5.1.3.3 The metal earthing bedplate is to be fixed below the waterline, and is to be immersed in water in any navigation conditions of the boat. For a twin-hull boat, earthing bedplate is to be provided on each hull.

5.1.3.4 The neutral conductor is only to be earthed in way of power source, i.e. the secondary earthing for generator, power transformer onboard. The neutral point of shore power supply is to be earthed by cable of shore power supply and not on the boat.

5.1.3.5 The direct current isopotential lapped conductor (if any) is to be connected to the earth of boat in order to minimize the stray current to the least.

5.1.4 Lightning arresting

5.1.4.1 Lightning rod is to be provided for a boat with non-metal mast and it is to be at least 150 mm higher than the mast. The mast is to have a suitable height in order that lightning rod can function for the boat.

5.1.4.2 Lightning rod is to be made of copper rod with the cross sectional area not less than 8 mm^2 and is to be connected effectively to and in good electrical contact by the metal earthing bedplate as required in 5.1.3.3 and the connecting conductor as required in 5.1.4.3. Special lightning rod is to be provided for the electrical equipment fitted on metal top. For a boat with metal mast, the mast is to be regarded as lightning rod.

5.1.4.3 The connecting conductor is to meet the following requirements:

(1) The connecting conductor is to be a copper conductor with the cross sectional area not less than 8 mm^2.

(2) The cross sectional area of any strand of copper wire is not to be less than 0.71 mm^2 and the insulated copper line is to have at least 19 strands.

(3) The thickness of metal strap or metal strip is to be at least of 1 mm.

Section 2 Source of Electrical Power and Distribution

5.2.1 Type and provision of electrical power source

5.2.1.1 Unless otherwise stated in 5.2.1.5, at least two sources of electrical power are to be provided onboard, in the event of any one electrical power source in failure, the capacity of remainder will still supply those services necessary to provide in normal operational conditions.

5.2.1.2 The sources of electrical power may be either:

(1) generators driven by main independent prime movers;

(2) generators driven by main propulsion engine; or

(3) accumulator batteries.

5.2.1.3 Where the steering gears, various auxiliary machines serving for main propulsion engine and the necessary equipment to ensure the safety navigation of boats are powered by electricity, at least one generating set is to be provided independent from the main engine.

5.2.1.4 For boats navigating without electrical power, main engine shaft driven generator and accumulator batteries may be provided as the source of electrical power. The capacity of shaft driven generator is to supply the power to all the necessary electrical equipment onboard and the capacity of accumulator batteries is at least to be capable of supplying electrical power to the electrical equipment to maintain the safety navigation of boats within a period corresponding to the whole voyage.

5.2.1.5 For boats navigating in sheltered water service restriction or calm water service restriction, two sets of accumulator batteries can be provided as the source of electrical power and the total capacity of two sets of accumulator batteries is to be capable of power supplying for the equipment to maintain the safety navigation of boats.

5.2.1.6 For a non-propulsion boat, source of electrical power may be provided as necessary.

5.2.2 Accumulator batteries

5.2.2.1 For a boat using accumulator batteries as electrical source, if the accumulator batteries have such as reasonable surplus of rated capacity and charging during navigation is not necessary, shore charging device instead of charging device onboard is to be provided. In addition, if the accumulator batteries meet with the requirements for engine starting, they may be used for starting the main engine.

5.2.2.2 Accumulator batteries are to be permanently installed in a dry, ventilated location above the anticipated bilge-water level. Batteries are to be installed in a manner to restrict their movement horizontally and vertically considering the intended use of the boat. A battery, as installed, is not to move more than ±10 mm in any direction when exposed to a force corresponding to twice the battery weight.

5.2.2.3 Accumulator batteries installed onboard are to be capable of inclination of up to 45° without leakage of electrolyte. Means are to be provided for containment of any spilled electrolyte in way of the normal working position of batteries.

5.2.2.4 Accumulator batteries are to be so installed that mechanical damage can be prevented.

5.2.2.5 Accumulator batteries are not to be installed directly above or below a fuel tank or fuel filter.

5.2.2.6 Any metallic component of the fuel system within 300 mm above the battery top, as installed, are to be electrically insulated.

5.2.2.7 Battery cable terminals are not to depend on spring tension for mechanical connection to them.

5.2.2.8 The acid accumulator batteries are to be placed in different enclosed space apart from that for the alkaline accumulator batteries. The switch, fuse and other electrical appliances which are easily to cause electrical arc are not to be fitted in the space where accumulator batteries are placed.

5.2.2.9 The installation position of accumulator batteries is to be separated from the boat's shell with a certain distance.

5.2.2.10 Batteries connected to a charging device having a power[①] greater than 2 kW are to be installed in a room assigned to the batteries only, or may be located in a box or a locker if the batteries are installed on exposed decks.

5.2.2.11 The quantity of air removed Q of the gas-permeability battery rooms, boxes or lockers is not to be less than:

$$Q = 0.11\, In \qquad m^3/h$$

where: I — the maximum charging current during the production of gas, but not less than 25% of the maximum charging current output by the charger, in A;
n — number of battery cells.

5.2.2.12 The quantity of air removed of the valve-regulated sealed battery rooms, boxes or lockers may be reduced to 25% of that required in 5.2.2.11.

5.2.3 Distribution system

5.2.3.1 Where the maximum voltage of distribution system does not exceed 500 V, the following distribution systems may be used:

(1) D.C.
two wire insulated system
two wire system with negative pole earthed

(2) A.C.
single phase two wire insulated system
single phase two wire system with one pole earthed
three phase three wire insulated system
three phase four wire system with neutral point earthed
three phase four wire insulated system

5.2.4 Switchboards (boxes)

5.2.4.1 The switchboards (boxes) are to be installed in a dry, readily accessible and well-ventilated position. The front side of switchboards (boxes), i.e. the operation panel of switches and fuses is to be readily accessible and the back side of switchboard, i.e. the place for connecting lines of terminals is to be accessible.

5.2.4.2 Boats equipped with both D.C. and A.C. electrical systems are to have their distribution from either separate panel boards or from a common one with a partition or other positive means provided clearly to separate the A.C. and D.C. sections from each other, and be clearly identified. Wiring diagrams to identify circuits, components and conductors are to be included with the boat.

① The charging power means the nominal voltage of accumulator batteries multiples the value of maximum charging current.

5.2.4.3 Skid-proof and oil-resisting insulated carpet or insulated wood granting are to be provided in the front of and behind the switchboard (box), with the exception for the voltage less than 50 V.

5.2.5 Sockets

5.2.5.1 Sockets and matching plugs used on A.C. systems are not to be interchangeable with those used in the D.C. systems onboard.

5.2.5.2 Sockets installed in locations subject to rain, spray or splash are to be able to en enclosed in IP55 enclosures as a minimum, when not in use. Sockets mated with the appropriate plug are to be also remained sealed.

5.2.5.3 Sockets installed in areas subject to flooding or momentary submersion are to be in IP56 enclosures as a minimum, also meeting these requirements when in use with electrical plugs.

5.2.5.4 Sockets provided for the galley area are to be located so that appliance cords may be plugged in without crossing above a galley stove or sink or across a traffic area.

Section 3 Protection

5.3.1 Protection

5.3.1.1 Electrical installations are to be protected against accidental over-current, including short-circuit by appropriate devices.

5.3.1.2 Each independent circuit is to be provided with a reliable short-circuit current and overload protective device.

5.3.1.3 Generators are to be protected by means of circuit breakers, for a generator with the power of less than 50 kW, a multi-pole switch and fuse may be used for protection.

5.3.1.4 Over-current protection devices for motor loads are to have a predetermined value of current flow consistent with demand load characteristics of the protected circuit.

5.3.1.5 The rating of the over-current protection device is not to exceed the maximum current-carrying capacity of the conductor being protected.

5.3.1.6 For power transformer, including a bank of two or three single-phase transformers operating as a unit. Each transformer is to be protected by an individual over-current device on the primary side, rated at not more than 125% of the rated primary current of the transformer.

5.3.1.7 The rated or corresponding setting value of the overload protection appliance for each circuit are to be permanently indicated at the location of the protection appliance.

5.3.1.8 Accumulator batteries, other than engine starting batteries, are to be protected against short-circuit with electrical appliances positioned as near as possible to the accumulator batteries.

5.3.1.9 A section switch for accumulator battery is to be provided in a certain accessible position of accumulator batteries as near as practicable, i.e. in way of positive of power supplying system, with exception of:

(1) boats only having outboard motor starting and navigation light circuit;

(2) electronic equipment having protective storage and protecting devices, i.e. bilge pump and alarm, if breakers or fuses are to be protected independently in way of the connecting line terminals of battery as near as possible;

(3) ventilator of fuel oil tank for motor, if fuses are provided independently in way of the electrical source.

5.3.2 Power equipment

5.3.2.1 Motors rated at 1 kW or above and motors required for essential services are to be supplied from distribution boards by separate final sub-circuits.

5.3.2.2 Every electrical motor is to be provided with efficient means of starting and stopping which are, in general, placed near the motor concerned.

5.3.3 Aluminum boats

5.3.3.1 Distribution systems are to be insulated with hull or provided with cathodic protection system.

5.3.3.2 For D.C. system, accumulator batteries are not to be earthed through propelling machinery or associated machinery components. The starting accumulator batteries of engine may be earthed through the engine.

Section 4 Lighting

5.4.1 Lighting

5.4.1.1 Lighting is to be provided for decks and for those parts normally accessible to and used by passengers and crew onboard.

5.4.1.2 In addition to main lighting, emergency lighting is to be provided for spaces where passengers and crew are normally accessible. The emergency lighting is to be supplied from accumulator batteries. For a boat using two sets of accumulator batteries as electrical source, emergency lighting is not necessary.

5.4.1.3 For boats of coastal service restriction, a period of time of emergency lighting is 6 h; for boats of sheltered water service restriction or of calm water service restriction, a period of time of emergency power supply is 3 h.

5.4.1.4 The emergency lighting is to be automatically operable in case the main lighting fails.

Section 5 Cables

5.5.1 General requirements

5.5.1.1 Marine flame retarding cables or wires are to be used onboard. Cables or wires selected are to be determined according to the environmental conditions of the location, laying methods, rated current, duty, diversity factor, permissible voltage drop, etc.

5.5.1.2 Conductor insulation temperature rating of cables or wires in engine room is to be oil-resistant at 70℃ minimum, or protected by insulating conduit or sleeving, and the current-carrying capacity is to be reduced to 0.75 times of the rated capacity.

5.5.1.3 The insulation temperature rating of cables or wires outside the engine room is to be at least 60℃ .

5.5.2 Cable runs

5.5.2.1 Cables or wire runs are to be straight and accessible for inspection and repair as far as possible.

5.5.2.2 Conductors that are not sheathed are to be supported throughout their length in conduits, cable trunking, or trays or by individual supports at maximum intervals of 250 mm.

5.5.2.3 Sheathed conductors and battery conductors to the battery disconnect switch are to be supported at maximum intervals of 450 mm, with the first support not more than 1 m from the terminal. Sheathed outboard-motor starter conductors constitute an exception.

5.5.2.4 Each conductor longer than 200 mm installed separately is to have an area of at least 1 mm^2. Each conductor in a multi-conductor sheath is to have an area of at least 0.75 mm^2 and may extend out of the sheath a distance not to exceeding 800 mm.

5.5.2.5 Each electrical conductor that is part of the electrical system is to have a means to identify its function in the system, except for conductors integral with engines as supplied by their manufacturers.

5.5.2.6 Conductor connections are to be in locations protected from the weather or in IP55 enclosures as a minimum.

5.5.2.7 Current-carrying conductors are to be routed above foreseeable levels of bilge water and other areas where water may accumulate. If conductors must be routed in the bilge area, suitable water-proof means are to be taken.

5.5.2.8 Metals used for terminal studs, nuts and washers are to be corrosion-resistant and galvanically compatible with the conductor and terminal. Aluminum and unplated steel are not to be used for studs, nuts or washer in electrical circuits.

5.5.2.9 All conductors are to have suitable terminals installed, i.e. no bare wires to stud connections unless end strands are made rigid by soldering over the length of their contact with the terminal post connection. Soldered connections are not to be used for connecting or terminating any conductor of nominal cross-sectional area greater than 2.5 mm^2.

5.5.2.10 Twist-on connectors (wire nuts) are not to be used.

5.5.2.11 Exposed shanks of terminals are to be protected against accidental shorting by insulating barriers or sleeves, except those in the protective conductor system.

5.5.2.12 Conductors are to be routed away from exhaust pipes and other heat sources which can damage the insulation. The minimum clearance is 50 mm from water-cooled exhaust components and 250 mm from dry exhaust components, unless an equivalent thermal barrier is provided.

5.5.2.13 Conductors which may be exposed to physical damage are to be protected by sheaths, conduits or other equivalent means. Conductors passing through bulkheads or structural members are to be protected against insulation damage by chafing.

5.5.2.14 No more than four conductors is to be secured to one terminal stud. Cable or wire runs are not to be in the laminating plate in FRP.

Section 6 Additional Requirements for Inboard-mounted Petrol Engine

5.6.1 General requirements

5.6.1.1 Engine-mounted electrical system components which, as designed and installed, can create an electrical arc externally or internally which is capable of igniting a petrol and air mixture, such as circuit breakers, switches, solenoids, alternators, generators, voltage regulators and electric motors, are to be ignition-protected in accordance with the standards① accepted by the Society.

5.6.2 Engine electrical systems and components

① Refer to ISO8846.

5.6.2.1 All electrical system components are to be mounted as high as practical on the engine. The engine-cranking motor and ignition distributor position may be as controlled by the basic engine manufacturer's design.

5.6.2.2 Ignition coils and magnetos are to be mounted or protected so that water will not accumulate around the high voltage cap.

5.6.2.3 If an electrical component is required to be ignition-protected and bands or other covers form part of the ignition-protection enclosure, a permanent warning tag is to be affixed to the component, or the band or cover is to be permanently and visibly marked, with appropriate language or symbols, indicating that the band or cover must be in place when the engine is operating.

5.6.2.4 Ignition distributors are to comply with the following requirements:

(1) The distributor, when operating during engine cranking and operation is to be of strength to resist lifting of the cap off the sealing surface in the event of an internal explosion of fuel and air vapour mixture. During test, high-tension (secondary) ignition wiring is to be in place on all distributor cap towers with terminal covering boots as installed during engine operation.

(2) All inlets or outlets are to be covered by effective flame-arrester screens or are to be of a size and length providing equivalent ignition-protection capability.

(3) Terminal covering boots are to be a close fitting to effect a water-tight seal on the outside of high-tension wire insulation and on the outside of the distributor cap tower when in place and meeting the requirements of 5.6.2.5(1).

5.6.2.5 The high-tension (secondary) ignition cable assemblies are to comply with the following requirements:

(1) The high-tension ignition cable assemblies are to have boots and nipples installed which form a water-tight seal with the outside of the high-tension wire insulation, the outside of the distributor cap terminal towers and the outside of the spark-plug ceramic insulator, such that leakage of electrical current will not occur when the connection is submerged for 2 h at 3 cm to 5 cm below the surface of a grounded 3% salt and water solution by weight, with an applied voltage of 20 kV peak (14 kV rms) 50 Hz to 60 Hz applied to the conductor. The voltage is to be applied at a rate of 500 V peak (355 V rms) per second between the free end of the high-tension lead and the grounded salt water solution.

(2) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning at 125℃ ±2℃ for 40 h and subsequent flexing by installation and removal, at room temperature, 10 times on the spark plug and distributor cap tower.

(3) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning for 30 h in a sealed glass container at room temperature when suspended 25 mm±5 mm above test liquid C in accordance with ISO 1817, and subsequent flexing by installation and removal 10 times from the spark plug and distributor cap tower.

(4) Boots and nipples installed on high-tension ignition cables are to meet the dielectric leakage test requirements of (1) after conditioning for 40 h in test oil No.3 in accordance with ISO 1817 maintained at 125℃ ±2℃ .
Remove from oil; cool to room temperature; remove excess oil. Flex boots and nipples by installing and removing 10 times from the spark plug and distributor cap tower.

(5) Tests as per (2) to (4) above are to be conducted on separate groups of high-tension ignition cable assemblies.

Chapter 6 ADDITIONAL REQUIREMENTS FOR LPG POWER-DRIVEN BOATS

Section 1 General Requirements

6.1.1 General requirements

6.1.1.1 This Chapter applies to boats with LPG engine as their main power.

6.1.1.2 For boats applicable to this Chapter, the use of dual fuel is prohibited.

6.1.1.3 Special requirements for outboard LPG engines may be referred to in Chapter 3 of the Rules.

6.1.2 Definitions

6.1.2.1 For the purpose of this Chapter, the relevant definitions are as follows:

(1) LPG means mixture of light hydrocarbon which is in a gaseous state under normal temperature and atmospheric pressure and may be kept in a liquid state by pressurization and cool-down, the basic composed are propane, propylene, butane and butylenes. It may also be composed of commercial butane or commercial propane or the mixture of both.

(2) Gas tank means a special steel cylinder for storage of LPG.

(3) Gas tank space means a fixed space for storage of gas tanks.

(4) Enclosed space means a space enclosed by bulkheads and decks but may have windows and doors.

(5) Semi-enclosed space means a space having structures such as top plating, deck so that its natural ventilation condition is different from that on open deck and it is so arranged that gases can not diffuse.

(6) Open space means an open deck space.

6.1.3 Notations

6.1.3.1 For the classed boats installed with LPG power, the notation LPG will be inserted between characters of classification and class notation.

6.1.4 Initial Survey

6.1.4.1 The following plans and documents are to be submitted to the Society for approval:

(1) Arrangement of LPG machinery space and gas tank space;

(2) LPG supply system;

(3) Ventilation of LPG machinery space and gas tank space;

(4) LPG detection and alarm system;

(5) Operation Manual of LPG Power System.

6.1.4.2 The required plans and documents for initial survey of existing boats may be reduced to submit to the Society for approval in accordance with the boat's conditions.

6.1.4.3 The following items for construction survey of newbuildings are required in addition:

(1) installation and test of LPG engine;

(2) installation and test of LPG supply system;

(3) installation and test of ventilation system in LPG machinery space and gas tank space;

(4) installation and test of LPG remote-control closing devices;

(5) examination of installation position and number of LPG probes and test of LPG detection and alarm system;

(6) confirmation and safety inspection of explosion-proof equipment or ignition-protection equipment.

6.1.4.4 The items of initial survey for existing boats may be reduced in accordance with the boat's conditions, but special attention is to be made to the relevant items of LPG power system, ventilation and fire protection.

6.1.5 Survey for Boats in Service

6.1.5.1 The following items for annual survey are required in addition:

(1) overall examination of LPG machinery space and gas tank space to confirm that no fire and explosion risks exist in the spaces and the ventilation system is in a good working condition;

(2) to examine remote-control system of LPG main engine and confirm that it is in a good working condition;

(3) to examine LPG supply system, where substantial corrosion or leakage of the pipelines and valves is found, repair is made in time;

(4) to examine working conditions of LPG detection and alarm system;

(5) to test the mechanism which remotely closes the LPG supply manifold valve;

(6) to examine working conditions of explosion-proof or ignition-proof electrical equipment;

(7) to examine the bottom plating of gas tank space and engine room and the bulkheads required tightness to ascertain whether their tightness is good.

6.1.5.2 The following items for special survey are required in addition:

(1) to dismantle LPG engine and examine the cylinder, piston, connecting rod, crankshaft, bearing, etc.;

(2) maneuvering test under working conditions of LPG main engine and the remote-control system of main engine is in a good working condition.

Section 2 LPG Engine

6.2.1 General requirements

6.2.1.1 The design and manufacture of LPG engine (hereinafter called the engine) are to comply with the relevant requirements of GB.

6.2.1.2 Where the engine is used as a main engine, reliable governors are to be provided to prevent the engine from exceeding 115% of its rated speed. Governors are to be provided for prime motors where used as generators and their performances are to be in compliance with the relevant requirements of Chapter 4 of Rules for Construction and Classification of Sea-going High Speed Craft by the Society.

6.2.1.3 Engines are to be provided with emergency shut-down devices which may cut-off the fuel manifold on LPG supply main and it may be remotely controlled in the bridge room.

6.2.1.4 Heating installation is to be provided in cooling water system of engine in order to ensure that the engine can be normally started in winter.

6.2.1.5 The exhaust piping of engine is to comply with the following requirements:

(1) Suitable insulation is to be used for exhaust pipe to prevent the surface temperature from exceeding 220℃ .

(2) Spark arrester or equivalent means is to be provided in the outlet of exhaust pipe which is as far as possible apart from those for ventilation of engine room and gas tank space.

Section 3 LPG Supply System

6.3.1 Gas Tanks and Accessories

6.3.1.1 The gas tanks are to be installed in an independent gas tank space with permanent fixing means to ensure they can not fall during the sea voyages and can be easily dismantled and exchanged. The collision rubber or wood packing is to be provided between gas tank and fixed seating.

6.3.1.2 Effective and reliable working of gaseous and liquid phase joint elements and liquidometer are to be taken into consideration for the installation direction and location of gas tanks.

6.3.1.3 Gas tanks are as far as possible apart from heat sources to avoid direct sunlight. In general, the temperature of gas tank special holds or gas tank compartments is not to be more than 45 ℃ , and suitable cooling means is to be provided in summer.

6.3.1.4 The metering valve of gas tank is to automatically stop charging when the LPG charging capacity achieves 80% volume of gas tank.

6.3.1.5 The safety valve of gas tank is to ensure the pressure not exceeding its design pressure.

6.3.1.6 The sealed protective box is to seal the opening of gas tank and its accessories reliably and vent pipe is to be provided to lead the leakage gases to safe spaces outboard.

6.3.1.7 The gas tanks and accessories are to comply with the relevant requirements of GB[①], the products are to have the approved certificates of the authorities concerned.

6.3.2 LPG Control Equipment

6.3.2.1 Each LPG supply system is to be provided with an evaporation pressure regulator, which is to be capable of supplying suitable and rated working pressure for each gas-driven engine. The pressure within the pipelines after LPG passes through the evaporation pressure regulator is not to be more than 0.005 MPa.

6.3.2.2 Each outlet of gas tank is to be provided with flow-limiting valve which is automatically closed when the pressure deficiency between two ends of the valve is 0.35 MPa.

6.3.2.3 Automatic stop valve is to be provided in way of inlet of evaporation pressure regulator for LPG supply pipe main, and it can automatically cut off LPG supply in the following cases:

(1) ignition switch is not on;

(2) engine is not operated;

① Refer to GB17259.

(3) exhaust blower is not operated.

6.3.2.4 For the LPG supply system with more than one gas tank, stop valve is to be provided in supply pipe branch of each gas tank for use when gas tanks are exchanged.

6.3.2.5 For supply system simultaneously supplying for more than one engine, stop valve is to be provided in way of inlet pipe of each engine.

6.3.2.6 The gas tank is to be provided with capacity measuring means, pressure sensor and capacity indicator so as to show its present capacity in the bridge room.

6.3.3 LPG Supply Piping

6.3.3.1 The rigid drawn copper tube or drawn stainless tube is to be used for rigid supply pipe. For the pipelines with outer diameter of 12 mm and below, the thickness is not to be less than 0.8 mm, for those more than 12 mm, the thickness is not to be less than 1.5 mm. The approved rubber hose may be to use for low pressure pipelines after the evaporation pressure regulator, however, plastic hose is not to be used.

6.3.3.2 The high pressure supply pipelines from gas tank to evaporation pressure regulator are to be installed within enclosed or semi-closed gas tank spaces. Where it is installed in an open space, protective members are to be used for fixing and sheltering so as to prevent from stepping on or collision.

6.3.3.3 LPG supply pipelines are not to penetrate passenger cabins, service spaces and control stations.

6.3.3.4 The approved rubber hoses are to be used for connection between LPG engine and any permanently installed metal pipelines so as to avoid failure caused by vibration.

6.3.3.5 Where hose is used partially in supply pipeline, double clamps are used for the joint at both ends of hose and the clamps are to have a certain contacting length, no pinch-cock clamps are permitted to use and the clamps are to be so fitted as to be accessible.

6.3.3.6 The partial pipelines which gas may possibly leak in LPG supply pipelines are to be apart from electrical equipment as far as possible.

6.3.3.7 The LPG supply pipe is not to contact directly with bulkhead or deck and avoid contacting in way of the intersection of other pipelines.

6.3.4 Test

6.3.4.1 Hydraulic and tightness tests are to be carried out for LPG piping, the test pressure is in accordance with the requirements of Table 6.3.4.1.

Test pressure **Table 6.3.4.1**

LPG piping	Test pressure	
	Hydraulic test (in workshop) (MPa)	Tightness test (onboard) (MPa)
Pipeline from gas tank to pressure regulator	3.3	2.2
Pipeline from pressure regulator to engine	0.2	0.1

6.3.4.2 Effectiveness test is to be carried out after the installation of LPG supply system and no gas leakage exists. The tightness test mentioned in 3.4.1 may also be carried out together with effectiveness test.

Section 4 Arrangement and Ventilation

6.4.1 Arrangement

6.4.1.1 Engine room and gas tank space are to be independent from each other and it is prohibited to arrange them with passenger cabins. The gas tank space is to be as far as possible arranged in a place with good ventilation above deck by a semi-enclosed way. The gas tank space is to be capable of being locked to prevent persons other than the staff from touching and removing. No holes and stairway openings leading to the holds below are permitted to provide in the gas tank spaces. The distance from the gas tank and high pressure pipeline on deck to the outline edge of the boat (excluding fenders) is not to be less than 100 mm.

6.4.1.2 The engine rooms and gas tank spaces are to be provided with independent drainage systems and the drainage systems are to be separated from those in other compartments.

6.4.1.3 The bottom structures of engine rooms and gas tank spaces are to keep gastight and platforms are to be provided as far as possible. For bottoms with strengthening stiffeners, the arrangement is not to impair the drainage of combustible gases.

6.4.1.4 The bulkheads between engine room, gas tank space and passenger cabins and the bulkheads between gas tank space and engine room are to keep gastight, and in general, openings are not to be provided. Where it is necessary for the pipelines or cables are to penetrate the bulkheads, airtight is to be kept in way of the penetration and structural fire integrity is to be ensured.

6.4.1.5 For open yacht with windows and doors of non-weathertight type in passenger cabins, drainage groove and bilge well are to be provided in the bottom plating of passenger cabins.

6.4.2 Ventilation

6.4.2.1 Mechanical ventilation system having sufficient capacity is to be provided in enclosed or semi-enclosed engine rooms or gas tank spaces with the air charge ratio not less than 30 times/h and 20 times/h respectively. The mechanical ventilation in engine room is to be realized by interlocking start/operation with the main engine, i.e. after the blower is operated at least 4 min, the engine is started, where the blower is stopped caused by some reasons, the engine can be automatically stopped and the following requirements are to be complied with:

(1) In general, mechanical ventilation system is to be used in enclosed engine room and gas tank space. Each intake duct for an exhaust blower is to be under 1/3 height of the compartment and above the normal level of accumulated bilge water. The exhaust outlet is to be so arranged as to discharge the air in compartments to outboard and as far apart from the outlet of exhaust pipe for engine as possible. Where the exhaust outlet is near waterline, means to prevent water flooding is to be provided.

(2) Where mechanical blast is used for ventilation system, in general, the exhaust outlet is to be under 1/3 height of compartment and above the normal level of accumulated bilge water. The exhaust outlet is to be so arranged as to discharge the air in compartments to outboard and as far apart from the outlet of exhaust pipe for engine as possible. Where the exhaust outlet is near waterline, means to prevent water flooding is to be provided.

(3) The blower is to be of the non-spark type.

6.4.2.2 In general, natural ventilation is also to be provided in the engine room and gas tank space mentioned in 6.4.2.1 above. The inlet is to be as far apart from the outlet as possible. The exhaust outlet is to be under 1/3 height of compartment and above the normal level of accumulated bilge water. The exhaust outlet is generally of shutter type.

Section 5 Detection and Alarm System

6.5.1 LPG combustible fume detector

6.5.1.1 The LPG combustible fume detection system is to be subject to approval by the Society.

6.5.1.2 Fixed LPG combustible fume detector are to be provided in enclosed and semi-enclosed gas tank spaces and enclosed engine room.

6.5.1.3 LPG combustible fume detectors are to be so arranged to meet the following requirements:

(1) Probes are to be provided in a position where LPG combustible fume leaks and accumulates easily.

(2) Where the concentration of LPG combustible achieves 30% lower limit of explosion, visual and audible alarm is to be given in the bridge, where it achieves 60% lower limit of explosion, manifold on LPG supply main may be automatically cut-off or remotely cut-off in the bridge.

6.5.1.4 Each shipping company is to provide at least one portable LPG combustible fume detector in watch-keeping room on wharf, which is available for use by crew.

Section 6 Structural Fire Protection and Fire Extinguishing Apparatus

6.6.1 Structural fire protection

6.6.1.1 The side of separating bulkheads facing fire hazard zone between engine room, gas tank space and passenger cabin and between gas tank space and engine room is to be made of FRP having flame-retardant performance or equivalent materials.

6.6.1.2 Coating and insulation which may set easily fire and emit large amount of smoke or noxious gases during burning can not be used in engine room and gas tank space.

6.6.1.3 Prominent "No Smoking" signs are to be posted in engine room and gas tank spaces.

6.6.2 Provision of fire extinguishers

6.6.2.1 Engine room is to be provided with fire extinguishers as required in Table 6.6.2.1.

Provision of fire extinguishers in engine room Table 6.6.2.1

Total power in engine room *P* (kW)	Provision of fire extinguishers
$P \leqslant 37.5$	One dry powder fire extinguisher with a capacity not less than 2 kg
$37.5 < P \leqslant 150$	Two dry powder fire extinguisher with a capacity not less than 2 kg each
$150 < P \leqslant 300$	Two dry powder fire extinguisher with a capacity not less than 3 kg each
$300 < P \leqslant 450$	Two dry powder fire extinguisher with a capacity not less than 4 kg each

6.6.2.2 At lest two dry powder fire extinguishers with a capacity not less than 2 kg each are to be provided in a gas tank space.

Section 7 Miscellaneous

6.7.1 Electrical equipment in gas tank space

6.7.1.1 Electrical equipment is not to be installed in gas tank space as far as possible. Where it is needed, electrical equipment preventing LPG combustible fume from igniting is to be provided. Where it is necessary, one portable explosion-proof light with batteries is to be provided in emergency use onboard the boat.

6.7.2 Operation Requirements

6.7.2.1 Boat's certificate and/or operation manual of LPG power-driven system, etc. required in the Rules are to be provided onboard the boat.

6.7.2.2 The crew is to be trained for normal operation and management of LPG power-driven system.

6.7.2.3 The crew is to be trained for emergency procedures in order to deal with the emergency cases such as LPG leakage or fire.

6.7.3 Accessing spaces

6.7.3.1 When the crew accesses a compartment, void space or other enclosed spaces where LPG is likely to accumulate, one of the following means is to be taken:

(1) fixed or portable LPG detecting device is to be used to confirm that no dangerous concentration of LPG combustible fume exists in the air of the above-mentioned spaces;

(2) respirators and other necessary protective equipment are to be provided for personnel.

6.7.3.2 Where personnel access the above-mentioned spaces, any potential fire source can not be brought in, unless it is verified that free gas is carried out for the space and it is still kept in such a condition.

6.7.4 Operation Manual of LPG Power-Driven System

6.7.4.1 Operation Manual of LPG Power-driven system approved by the Society is to be readily available onboard, and it is used as safe operation guidance in normal conditions and in emergency.

6.7.4.2 The Operation Manual is to contain at least the following.

6.7.4.3 The starting procedures of LPG engine is to comply with the following requirements:

(1) to switch on detection and alarm system to confirm no LPG leakage, where LPG leakage is detected in engine room (sometimes) and gas tank space by the probe, examination is to be made immediately to find the leakage reason and handle with it;

(2) to switch on blowers in engine room and gas tank space;

(3) in order to prevent mal-operation, interlocking device is to be provided between blower and engine. After the blower is operated more than 4 min, the engine can be started, where the blower is stopped caused by some reasons, the engine can be automatically stopped.

6.7.4.4 During the boat's service period (including embarkation, disembarkation or temporary laid-up), mechanical ventilation is to be kept in the enclosed or semi-enclosed engine room and gas tank spaces and blower can not be stopped.

6.7.4.5 Fixed LPG combustible fume probe is to be provided onboard the boat. Where the concentration of LPG combustible fume achieves 30% lower limit of explosion, visual and audible alarm is to be given in the bridge, where it achieves 60% lower limit of explosion, manifold on LPG supply main may be automatically cut-off, if it fails, the navigating officer must cut-off the LPG supply main immediately in the bridge.

6.7.4.6 Changing of gas tanks

(1) After recharged, the gas tank and its accessories are to be examined whether it leaks or not, if found damage and leakage, the gas tank can not be onboard.

(2) After it is installed onboard, the connection between outlet valve and quick connection of gas tank is to be examined, leakage is not to be found there.

6.7.4.7 Other requirements

(1) Where it is found the LPG supply system leaks, it can not be used before the cause is determined and repair is made, means are to be taken to cut off LPG supply source, start the blower, various fire sources are prohibited and electrical equipment is not to be used.

(2) It is prohibited to discharge, store or deal with the LPG residual liquid in gas tanks onboard.

(3) All supply valves of LPG engine are to be closed during boat's laid-up.

(4) Where fire takes place onboard, the gas tanks are to be dismantled and thrown outboard quickly to protect the safety of boat and passengers.

(5) Special-assigned persons are to be responsible for the management, maintenance and service of LPG equipment.

Appendix: Requirements for preparation of boat's operation manual

A boat's operation manual is to include at least the following:

1. Brief introduction of boat, including boat's main scantlings, speed, category of service restriction, equipped machinery and electrical installations, communication equipment, signal equipment, fire-extinguishing apparatus, life-saving appliances, main engine power, oil/water capacity, endurance, complement, sewage equipment, etc.

2. Brief introduction of each system, including propulsion system, fuel oil system, steering system, ventilation system, bilge water system, electrical power system, fire-protection system, etc.

3. Key points for safe operation, including:

(1) speed limitation during navigating in wind waves;

(2) main engine speed limitation for preventing sudden drop of transverse stability during navigation with high speed;

(3) limitation of main engine speed when high speed boat in top speed turn;

(4) speed limitation in overtaking other boats;

(5) requirements for safe use of inboard and outboard engines or inboard engine boat with petrol/LPG, including requirements for maintaining natural air vents to be clear and for mechanical ventilation, etc.

4. Escape measures.

5. Requirements for routine maintenance, including main and auxiliary engines maintenance, regular inspections for fire-extinguishing apparatus, maintenance and inspections for ventilation equipment of petrol engine and petrol tank compartments.