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CLASSIFICATION NOTES:

REQUIREMENTS FOR AMPHIBIOUS AIR CUSHION VEHICLES

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CLASSIFICATION NOTES

Requirements for Amphibious Air Cushion Vehicles

September 2025

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Section 1

General

1.1 Application

1.1.1 This Classification Note is applicable to “flexible skirt hovercraft”, i.e. air-cushion vehicles with a downwardly extending flexible structure used to contain or divide the air cushion. This type of air-cushion vehicle is amphibious. Amphibious Air Cushion Vehicles are referred to as ACVs in this document.

1.1.2 In general, this Classification Note is to be used in conjunction with the IRS Rule Books, such as:

- *IRS Rules and Regulations for the Construction and Classification of High-Speed Craft and Light Crafts* (hereinafter referred to as the "HSC & LC Rules"),

1.1.3 In cases where some aspect is not explicitly addressed in this Classification Note, the requirements specified in the HSC & LC Rules are to be applied.

1.1.4 ACVs complying with the requirements of this Classification Note will be assigned Class notation ‘**AACV**’. Other Class notations assigned to the ACV will be in accordance with the notations given in the HSC &LC Rules. Appropriate characters of class will be assigned to seagoing and inland ACVs depending on their area of operation.

1.1.5 IRS may consider requests for certification of compliance of new construction ACVs with these Classification Notes without assignment and maintenance of classification. In such cases, IRS may issue a certificate of compliance (valid for one year from the date of issue) with the applicable design and construction requirements of these Classification Notes, instead of a Class certificate. Such vessels would not be subjected to periodical surveys after construction.

1.1.6 IRS on a case-by-case basis, will accept compliance with alternative requirements (such as the UK MCA Hovercraft Code) in lieu of this document for ACVs under 24 m in length, carrying no more than 12 passengers (15 persons total) and restricted to routes that do not exceed 60 nautical miles from a safe haven.

1.1.7 ACVs will be assigned an operational envelope (Speed / Hs / all-up-weight). The envelope is to:

(a) be appended to the Classification Certificate;
(b) appear in the Operational Manual; and
(c) be displayed on the wheel-house console in chart or tabular form.

1.2 Definitions

1.2.1 In general, the following definitions apply to ACVs except where they are inappropriate or where specifically defined otherwise.

1.2.1.1 **Hard structure,** is the watertight hull envelope excluding any skirt systems.

1.2.1.2 **Maximum All-Up-Weight, *W* max** is the maximum weight at which the ACV has been assessed for normal operation, in kg.

1.2.1.3 **Minimum All-Up-Weight, *W*** min, is the minimum weight at which the ACV has been assessed for normal operation, in kg.

1.2.1.4 **Lifting Weight, *W*** L, is the maximum weight at which the ACV has been assessed for jacking and slinging, in kg.

1.2.1.5 **Length, *L,*** is the maximum length of the hard structure, excluding projections, in metres.

1.2.1.6 **Length overall, LOA,** is the maximum overall length of the ACV, in metres.

1.2.1.7 **Breadth, B,** is the maximum breadth of the hard structure excluding projections, in metres.

1.2.1.8 **Breadth overall, BOA,** is the maximum overall breadth of the ACV, in metres.

1.2.1.9 **Significant wave height (Hs)**, is the average height of the highest one-third of observed waves, in metres.

1.2.1.10 **Depth, *D,*** is the maximum depth of the hard structure, in metres.

1.2.1.11 **Draught, *T,*** is the off-cushion draught at the design waterline, in metres.

1.2.1.12 **LCG** is the longitudinal centre of gravity, in metres.

1.2.1.13 **Safe haven**, a harbour or anchorage protected from prevailing weather in which the craft can remain safely afloat.

1.2.1.14 **Maximum operational weight, Wop**, the greatest weight at which the ACV may trade on its specified route; Wmax ≥ Wop ≥ Wmin.

1.3 Documentation

1.3.1 Hull

1.3.1.1 The following plans and particulars are to be submitted, where applicable, for approval/information:

For Information (I)

a. General arrangement of ACV and principal particulars.
b. Weights and centres of gravity of the hull, consumables, stores and payload.

For Approval (A)

a. Load-carrying platforms and decks.
b. Main longitudinal girders and beams.
c. Main transverse and diagonal girders, frames and beams.
d. Watertight bulkheads and integral buoyancy tanks.
e. Integral fuel and water tanks.
f. Bottom and side shell plating.
g. Webs or other arrangements to resist impact loads.
h. Machinery foundations.
i. Duct openings and framing.
j. Side bodies.
k. Superstructure and deck-house.
l. Closing arrangements.
m. Air rudders and propeller ducts.
n. General arrangement and attachments of propeller ducts, pylons and air propellers.
o. Lift fan inlet and outlet arrangements.
p. General arrangement and attachments of skirts.
q. General arrangements and attachments of external fuel and water tanks.
r. Vehicle and cargo decks (including tie-down fittings).
s. Crane foundation.
t. Loading ramp.
u. Anchoring and mooring equipment.
v. Welding details.
w. Operational-envelope diagram showing allowable combinations of speed, significant wave height and all-up-weight;

x. Prototype-trial report (for first-of-class craft) including manoeuvring, endurance and emergency test results.

1.3.1.2 Scantlings of ACVs require special consideration and calculations are to be submitted in support of the main structural plans and data given in 1.3.1.1. The supporting calculations are generally to be contained in a report which is to include the following, where applicable:

a. Lists of plans used, including dates and versions.
b. Description of structural models, including all modelling assumptions.
c. Plots to demonstrate correct structural modelling and assigned properties.
d. Details of material properties used.
e. Details of all load cases.
f. Design criteria.
g. Buckling analysis.
h. Results showing compliance, or otherwise, with the design criteria.
i. Proposed amendments to structure where necessary, including revised assessment of stresses and buckling capacity.

1.3.1.3 Structural loads are to be calculated in accordance with Section 4. Alternatively, loads may be derived through direct calculations. All such calculations are to be submitted for review.

1.3.2 Machinery

1.3.2.1 Steering System

1.3.2.1.1 Details of the primary and secondary means of steering the ACV are to be submitted for approval. The submission is to include following:

(a) A plan showing arrangement(s) for the control of the air rudders and/or other means of steering the ACV, including skirt shift.

(b) Design calculations for the steering system, showing maximum mechanical loadings of the linkages, fastenings and power units, including securing arrangements.

(c) Where additional thrusters (e.g. bow thrusters) are used for essential steering purposes, full details are to be submitted.

1.3.2.2 Air propellers and lift fans

1.3.2.2.1 Arrangement and detailed plans, including particulars of materials, of propellers and lift fan assemblies. Details of service intervals, maintenance requirements and service suppliers. The following plans/documentation are to be submitted for review:

(a) The methods and procedures for construction, testing and balancing of propellers and lift fans.

(b) Schematic of propeller pitch control system .

(c) The manufacturer is to issue a Certificate for Air Propellers for each propeller stating the agreed International/ National Standard to which the propeller was designed, manufactured and tested. Documentation is to be provided that verifies the propeller performance in accordance with the agreed Standard.

Section 2

Surveys

2.1 General

2.1.1 All ACVs classed with IRS are to be subjected to periodical surveys for the purpose of maintenance of Class generally in accordance with requirements specified in this section. In general, the requirements specified for intermediate and special surveys are in addition to that of Annual surveys.

2.2 Annual Surveys

2.2.1 The ACV is to be slung or jacked up to permit a thorough inspection of all underside parts, fittings and attachments.

2.2.2 Panelling, floor coverings etc. need not be removed during annual surveys, unless they are of portable type or unless the Surveyor has reason to suspect they may conceal significant damage.

2.2.3 The Surveyor is to be satisfied regarding the condition of the following items:
(a) Bottom and side plating, any external stiffeners, and side walls or skirts, including flexible keels, if any.
(b) Weather doors, ventilators, windows and emergency or other hatches.
(c) Weather decks, houses, etc.
(d) Machinery casings and seats.
(e) Anchoring and mooring equipment when required by the Rules.
(f) Fire equipment including fire detection, alarm systems and means of escape ,
(g) Where applicable, passenger seat foundations and cargo tie down points.
(h) Skirt attachment and operating mechanisms.
(i) Air propeller shroud structures.
(j) Side body attachments and supports (if fitted).
(k) Operation of ramps, and their closing and locking arrangements.
(l) The structural attachment and retention arrangements for external fuel tanks (if fitted).

2.2.4 The Surveyor is to be satisfied regarding the condition of the following items:
(a) Fuel tanks and associated fuel system with pumps, filters, etc.
(b) Lubricating oil tanks and associated lubricating system with coolers, pumps, filters, etc.
(c) The bilge pumping system.
(d) Machinery alarm arrangements.
(e) The electrical machinery, the switchgear and other electrical equipment are to be generally examined under operating conditions so far as practicable. The satisfactory operation of the emergency source of power, including the automatic controls as fitted, is to be verified.
(f) Hydraulic, electrical and pneumatic control systems, including steering, are to be examined under operating conditions.
(g) Engine starting arrangements.
(h) All drive belts, associated running surfaces and tension adjustment (where fitted).
(i) Air propellers, including (where fitted) hub assemblies, servos and actuating equipment of controllable pitch propellers.
(j) The overall operation of the machinery including propulsion and lift machinery. A machinery proving trial of short duration is to demonstrate to the Surveyor the satisfactory operation of the machinery.

2.3 Intermediate Surveys

2.3.1 Preparation

2.3.1.1 Sufficient amount of panelling, floor covering, insulation and paint etc. is to be removed to enable the Surveyor to satisfy that all major structural items are in a satisfactory condition.

2. 3.2 Examination and testing

2.3.2.1 Representative integral tanks and buoyancy spaces are to be examined as necessary, to ensure that they continue to be in a satisfactory condition.

2.3.2.3 Tanks or buoyancy spaces may require to be tested at the discretion of the Surveyor, to ensure that they continue to be tight.

2.4 Special Surveys

2.4.1 Hull

2.4.1.1 All integral tanks and buoyancy spaces are to be examined and tested to ensure that they continue to be tight and in a satisfactory condition.

2.4.1.2 All other hull compartments are to be examined.

2.4.1.3 The anchoring and mooring equipment, when required by the Rules, is to be examined to ensure its efficiency, accessibility and readiness for use. Anchor cables and mooring lines are to be ranged for examination.

2.4.2 Machinery

2.4.2.1 The main and essential auxiliary machinery is to be generally examined with particular attention given to safety devices, fastening arrangements and resilient mountings. A limited opening up, e.g. removal of inspection covers, should be undertaken in order that the Surveyor can confirm the satisfactory condition of these items.

2.4.2.2 Lubricating oil analysis may be required, where not carried out as a regular monitoring procedure.

2.4.2.3 Items that have not been overhauled as part of the approved planned maintenance scheme since installation, commissioning or since the previous Special Survey may require to be opened up for examination.

2.4.2.4 The insulation resistance of the electrical equipment and connections is to be tested.

Section 3

Materials of Construction

3.1 Materials, components, equipment and machinery

3.1.1 The materials used in the construction of ACVs or in the repair of ACVs already classed, are to be of good quality and free from defects and are to be tested in accordance with Chapter 3 of the HSC & LC Rules.

3.1.2 When the construction material is steel, the same is to be manufactured by an approved process at works recognized by IRS. Alternatively, for other materials, tests to the satisfaction of IRS will be required to be carried out. Chapter 1, Cl. 3.8 of the HSC & LC Rules, may also be referred.

3.2 Selection of Skirt Material for Air Cushion Vehicles (For Guidance Purposes Only)

3.2.1 The selection of skirt material for an Air Cushion Vehicle (ACV) should be guided by the requirement to maintain structural integrity, airtightness, and operational performance over the intended service life of the craft. The principal material characteristics to be considered include:

- Tensile strength – to resist the stresses induced by cushion pressure, skirt tension, and transient loads.
- Tearing strength – to limit the propagation of accidental cuts or punctures.
- Resistance to delamination – to ensure coating and substrate remain bonded under repeated flexing and environmental exposure.
- Flexibility with ageing resistance – to allow repeated bending without cracking, even after prolonged service.
- Low-temperature performance – particularly for craft operating in ice or cold climates, where material embrittlement must be avoided.

It is noted that tensile and tearing strengths do not necessarily vary in proportion to fabric weight; both should be independently verified when selecting materials.

In practice, skirt assemblies are generally fabricated from elastomer-coated fabrics, where the textile substrate (often a synthetic fibre such as nylon or polyester) provides structural reinforcement, and the elastomer coating (such as neoprene, polyurethane, or nitrile blends) provides air retention, environmental protection, and abrasion resistance. The balance between fabric weight, coating thickness, and flexibility is determined by the craft's operational profile:

- Craft operating from abrasive environments, such as sandy beaches or gravel bars, benefit from heavier or thicker coatings for improved wear resistance.
- High-speed or military ACVs, where weight saving and seakeeping are critical, may use lighter coatings to reduce skirt mass and improve dynamic response.

Operational factors contributing to skirt wear such as abrasion from suspended particles, hydrodynamic drag, skirt slamming, water scooping, and plough-in events should be considered in determining the most suitable material. Reference data from design studies comparing fabric weights, coating types, and service performance, can assist in achieving an optimum compromise between durability and operational efficiency.

Verification of selected skirt materials should be carried out using testing programmes that reflect actual service conditions. These should include cyclic flexing endurance, impact and puncture resistance, coating adhesion, and abrasion testing under both wet and dry conditions. While laboratory-scale tests are valuable for initial screening, full-scale or near full-scale trials under simulated operational loading provide the most reliable indication of expected service life.

Section 4

Design Loads

4.1 Design accelerations

4.1.1. General

4.1.1.1 Following requirements are to be applied in lieu of the requirements in Chapter 4, Section 2 of the HSC & LC Rules.

4.1.2 Vertical accelerations

4.1.2.1 The ACV may be subject to a wave impact at any point along its length, for example, at the bow, stern or LCG. The rigid body acceleration is to be calculated for a series of impact locations along the length to give an envelope of design values. The maximum acceleration may not always occur at the maximum speed and/or wave height and therefore a range of speeds and wave heights is to be investigated to determine the design values. The vertical acceleration at the LCG, 'a_{cg}', for the location to be examined for wave impact in terms of g is given by:

$$a_{cg} = \frac{1.0108 \times K_1 \times V \times V_v}{\sqrt[3]{W} \times (1 + X^2)^{2/3}}$$

Where,

a_{cg} is not to be taken less than 0.5

K_1 is loading coefficient value as given in figure 4.1.1.1

V = speed of ACV at wave height H in m/s

$V_v = \frac{1.24 \times \pi \times H}{\sqrt{\lambda}} + 0.61$ m/s

λ = wave length, in meters

H = wave height, in meters
=λ/10, for λ≤ 36.9
=0.607√λ, for λ > 36.9

X =d/r

d= distance from the LCG of the ACV to the location of the wave impact considered, in meters.

r = radius of gyration in pitch of the ACV, in meters = $\sqrt{\frac{I_m}{W}}$

I_m= mass moment of inertia about the LCG, in kg/m^2 = $\sum_{i=0}^{n} W_i X_i^2$

W_i = weight at station 'i'
X_i= distance of station 'i' from LCG
W = W_{min} or W_{max}, in kg
n = number of stations

4.1.2.2 The acceleration, a_{xi} any given station 'i' along the hull in terms of g may then be taken as:

$$a_{xi} = a_{cg}\left(1 + \frac{d \times l_a}{r^2}\right)$$

Where,
d as defined in 4.1.2.1
l_a= distance of the considered station from the LCG, in meters
r= radius of gyration in pitch of the ACV, in meters.

4.1.2.3 For a wave impact occurring at the LCG, the vertical acceleration is constant along the length of the ACV. Wave impacts occurring away from the LCG will give rise to angular accelerations.

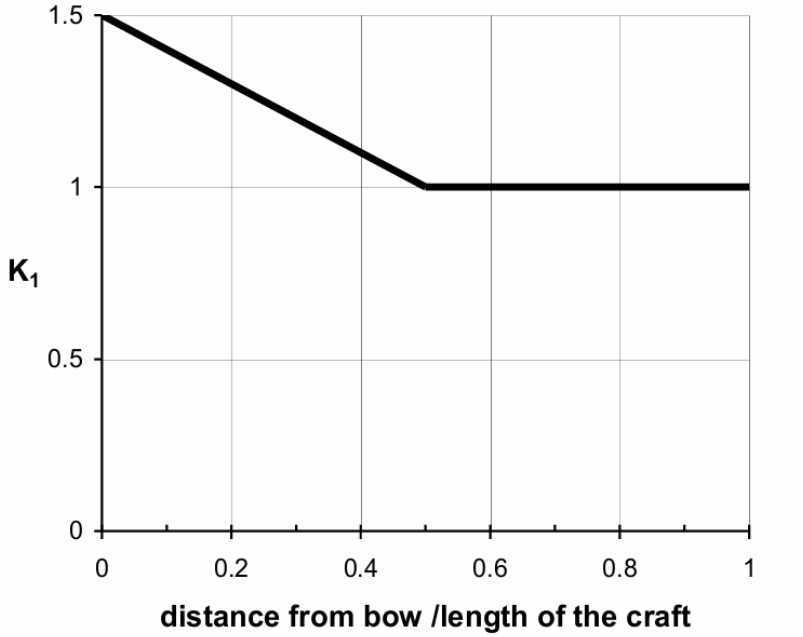

Figure 4.1.1.1: Loading coefficient value

4.2 Local loads

4.2.1 General

4.2.1.1 Unless otherwise specified, following requirements are to be applied in lieu of the requirements in Chapter 4, Section 3 of the HSC & LC Rules.

4.2.2 Impact loads on the bottom and side shell

4.2.2.1 The peak pressure, P_p in kN/m^2 at any point along the length of the bottom structure is given by:

$$P_p = 0.35 \times K_2 \times V_v \times V$$

Where
K_2 = Pressure wave impact factor as given in figure 4.2.1.1
V, Vv as defined in 4.1.2.1

4.2.2.2 The distributed pressure, P_d in kN/m^2 along the length of the bottom structure is taken as:

$$P_d = 0.44 \times P_p$$

4.2.2.3 The peak pressure, P_p, is generally to be applied to plating and secondary stiffeners. The distributed pressure, P_d, is generally to be applied to primary frames, girders and large unstiffened panels of plating, and over an impact area, A_{wi}, m^2, taken as:

$$A_{wi} = \frac{F_{wi}}{P_d}$$

Where

F_{wi}, as defined in 4.3.2.2

4.2.2.4 Both the peak pressure and distributed pressure are to be applied to the bottom structure to the transverse extent of the outermost chine. Above this point both pressures may be reduced linearly to pressure, P_g in kN/m^2 at the gunwale.

$$P_g = K_3\,(5 + 0.01L)\big(1 + 0.5a_{cg}\big) + 3$$

Where
$K_3 = 2(x/L) - 0.5$, for $x/L > 0.75$
$= 1$, for $x/L \leq 0.75$
x = distance from aft end to the point at which K_3 is required, in meters
L is defined in 1.2.1.5
a_{cg} is defined in 4.1.2.1 for the longitudinal centre of gravity impact case and is not to be taken less than 1

Figure 4.2.1.1: Pressure wave impact factor

4.2.3 Floating loads

4.2.3.1 In addition to the loads given in 4.2.2, local loads acting on the bottom and side shell when the ACV is off-cushion and floating whilst underway at the maximum towing speed, will be specially considered in accordance with Chapter 4, Section 3 of the HSC & LC Rules.

4.2.4 Deck loads

4.2.4.1 Local loads acting on the decks are to be specially considered in accordance with Chapter 4, Section 3 and together with Chapter 6 and Chapter 7 of HSC & LC Rules, to determine the scantlings of steel, aluminium alloy and composite craft.

4.2.5 Machinery loads

4.2.5.1 Machinery foundation reactions resulting from collision accelerations, torque and dynamic loads are to be provided by the designer.

4.2.5.2 The loads mentioned in 4.2.5.1 are to be used additionally to assess the attachment of the resilient mounts where fitted.

4.2.6 Slinging and jacking loads

4.2.6.1 Supporting structures, such as lifting posts and struts, are to be designed to withstand the slinging and jacking loads at each lifting point. The supporting structures are to have adequate buckling capacity to withstand the concentrated loads. Allowance is to be made for the inclination of any lifting wires which may give rise to longitudinal, transverse and vertical loads.

4.2.7 Collision loads

4.2.7.1 The following requirements are to be applied in lieu of Chapter 12, Section 1.15 of the HSC & LC Rules

4.2.7.2 The strength of supporting structure and attachments of masses greater than 50 kg are to be able to withstand design accelerations without fracturing. Force magnitudes and directions are to be taken as follows:

- 6g forward direction.
- 3g after direction.
- 3g transverse direction.
- 3g vertical upward direction.
- 4g vertical downward direction.

The vertical acceleration cases include the self-weight component.

4.2.8 Superstructure and deckhouses

4.2.8.1 Design loads for superstructures and deckhouses are specified in Chapter 4, Section 3.5.3 of the HSC & LC Rules. Loads are to be determined assuming that the ACV is off-cushion and floating whilst underway at the maximum towing speed.

4.2.8.2 Design loads for machinery casings may be taken as that for superstructure and deckhouses in the same position.

4.2.8.3 As an alternative to 4.2.8.1 and 4.2.8.2, the designer may submit design loads for consideration. These loads may include but are not limited to the following:

.1 Concentrated loads due to equipment;

.2 Personnel loads;

.3 Snow and ice loads;

.4 Wind loads;

.5 Marine environmental loads.

4.2.9 Vehicles and deck cargo

4.2.9.1 For wheel loading resulting from the proposed stowage or operation of vehicles refer to the requirements in Part 3, Chapter 11, Section 5 of the HSC & LC Rules.

4.2.9.2 Details of the deck loading resulting from the proposed stowage of cargo are to be provided by the designer and shown on the submitted plans. The loads for which the cargo decks have been approved are to be included in the ACV's documentation and also clearly displayed on the deck.

4.2.9.2.1 The cargo deck pressure is to be taken as:

$$P_{CDP} = P_{cd}(1 + a_{xi}) \text{ kN/m}^2$$

Where
P_{cd} is the pressure exerted by the cargo on deck specified by the designer
a_{xi} is as given in 4.1.2.2

4.2.9.3 Supporting members which are subjected to local compressive and/or shear loads are to have adequate buckling strength.

4.2.9.4 Details of the vehicle and cargo tie-down arrangements are to be provided. The Safe Working Load (SWL) of the vehicle and cargo tie downs are to be used to determine the strength of the tie-down attachment to the deck and the supporting structure. When considering the loads, all expected directions of operation are to be taken into account.

4.2.9.5 For concentrated loads, local reinforcement to distribute the load is to be fitted as necessary.

4.2.9.6 Loading doors and ramps are to be designed to withstand wave impact loads and are to be fitted so as to ensure tightness consistent with operational conditions.

4.2.9.7 Ramps are to be designed to withstand concentrated loads due to vehicle and other cargo operations.

4.3 Global loads

4.3.1 General

4.3.1.1 Following requirements are to be applied in lieu of the requirements in Chapter 4, Section 4 of the HSC & LC Rules.

4.3.2 Wave impact load while airborne on waves

4.3.2.1 Rigid-body equilibrium during a single wave impact

.1 When an air-cushion vehicle (ACV) passes over a wave crest, it is to be assumed to experience a transient, downward-acting global impact force arising from the rapid variation of cushion pressure together with any simultaneous impact of green seas on the craft structure.

.2 For global analysis the ACV weight is to be represented by point loads located at longitudinal stations.

- Not fewer than ten stations are to be used; where the overall hard-structure length *L* exceeds 30 m, at least twenty stations are required.
- Each station weight *Wi* represents the mass between the mid-points of adjacent stations, and the algebraic sum of the *Wi* values is to equal the design all-up weight.

.3 The rigid-body vertical acceleration at the longitudinal centre of gravity for the impact location considered, *acg*, is to be obtained from 4.1.2 and is not to be taken as less than 0.5 g.

.4 The vertical acceleration at any other station *i* is to be taken from 4.1.2.2.

.5 The upward inertia load at each station is to be modelled as a point load Q_i acting at the station's longitudinal position.

$$Q_i = W_i a_{xi}$$

.6 The algebraic sum of the station loads, $\sum Q_i$ is to be balanced by a single downward point load Fw applied at the assumed impact location. Force- and moment-equilibrium conditions about the longitudinal reference axis are both to be satisfied:

$$\sum Q_i + F_w = 0$$
$$\sum Q_i x_i + F_w x_w = 0$$

where,

xi and xw are measured from the longitudinal centre of gravity.

.7 Impact locations to be examined are to include, as a minimum, the bow, the LCG and the stern. Additional locations are to be assessed whenever the calculated vertical-acceleration envelope exhibits local maxima that are not captured by these three positions.

.8 Both the station inertia loads and the balancing wave-impact force are to be applied as point loads in structural calculations, and the wave-impact force is to be entered with a negative sign (downward) so that the resulting shear-force and bending-moment distributions follow the conventional sign convention.

.9 Because the cushion pressure and craft weight are assumed to remain in mutual equilibrium at the instant of impact, the static component of gravitational acceleration need not be applied separately in this load case.

4.3.2.2 Design magnitude of the balancing wave impact force

.1 the design value of Fw is to be taken as

$F_w = \frac{a_{cg} \times W \times g}{1000}$ kN

Where

a_{cg} and W is defined in 4.2.1.1

g is the acceleration due to gravity (9.81 m/sec^2)]

4.3.3 Floating loads

4.3.3.1 Wave-supported global load cases

.1 The longitudinal strength of the ACV is to be verified for regular trochoidal waves whose length and height are likely to generate the highest global shear forces and bending moments.

.2 As a minimum, two wave positions are to be examined:
- Hogging – wave crest located at or near the longitudinal centre of gravity (LCG).
- Sagging – wave trough located at or near the LCG.

.3 The investigation is to cover a spectrum of wave lengths, λ, typically from 0.6 L to 1.5 L, where *L* is the overall hard-structure length, unless more restrictive limits can be justified analytically or by model tests.

.4 At every wave position:
- Vertical support reactions are to be applied only at stations that are intersected by the instantaneous wave profile; stations that lie wholly above the free surface are to be considered unsupported.
- The local reaction at an immersed station shall be the algebraic sum of cushion thrust and any hydrostatic pressure acting on immersed structure or skirt.
- Downward (negative) reactions are not to be applied at un-immersed stations.

.5 The point-load set derived in .4 is to be used to obtain longitudinal shear-force and bending-moment envelopes for strength assessment.

.6 For the load cases defined above the wave-height-to-wave-length ratio, H / λ, is to be taken as defined in 4.1.2.1.

4.3.4 Slinging and Jacking loads

4.3.4.1 Global longitudinal and transverse strength is to be investigated for slinging and jacking loads. Allowance is to be made for any variation of the center of gravity.

4.3.4.2 The maximum lifting weight and weight distributions are to be stated in the Operating Manual.

4.3.5 Parking loads

4.3.5.1 Global longitudinal and transverse strength is to be investigated for parking loads.

4.3.5.2 The craft is to be designed to support the maximum all-up weight on three-quarters of the supports and other assumed worst cases depending on the positions of the landing pads and skids.

Section 5

Stability, Subdivision, Watertight and Weathertight Integrity

5.1 Stability

5.1.1 In the absence of any alternative criteria specified by the flag Administration, stability is to be in compliance with Chapter 5 of the HSC & LC Rules.

5.2 Subdivision

5.2.1 The ACV is to have an intact buoyancy reserve of at least 100 per cent at the maximum operational weight.

5.2.2 In general, the hull is to be adequately subdivided by longitudinal girders and transverse primary members. Individual spaces which are required to contribute to buoyancy are to be designed as watertight structures. For structural design purposes, the head [m] is to be measured vertically, as follows:

- Plating - the distance from a point one third of the height of the plate above its lower edge to the top skin.
- Stiffening - the distance from the mid-span of stiffener to the top skin.

5.2.3 Tests are to be carried out to check the tightness and integrity of individual buoyancy spaces. Testing requirements are to be agreed with the attending Surveyor.

5.2.4 Suitable access to the buoyancy spaces is to be provided for facilitating inspection to the satisfaction of the attending Surveyor.

5.3 Watertight and Weathertight integrity

5.3.1 Watertight closing appliances (such as doors and hatches) are to prevent the passage of water through the structure in any direction under the head of water likely to occur in the intact or damaged condition. Such appliances are to comply with the requirements of Ch 5, Sec.6 of the HSC & LC Rules, where practicable.

5.3.2 Weathertight closing appliances (such as windows, doors and hatches) are to prevent water penetration into the ACV in any wind and wave conditions expected during the service of the ACV. Such appliances are to comply with the requirements of Ch. 5, Sec 5 of the HSC & LC Rules, where practicable.

5.3.3 De-watering arrangements (where provided) for enclosed wells are to be to the satisfaction of the attending Surveyor.

Section 6

Structure

6.1 Global Strength

6.1.1 Following requirements are to be applied in lieu of the requirements in Chapter 6, Section 2 of the HSC & LC Rules.

6.1.2 The effective sectional area of continuous longitudinal and transverse strength members, after deduction of openings, is to be used for the calculation of the section modulus.

6.1.3 In general, superstructures or deckhouses will not be accepted as contributing to the global longitudinal or transverse strength of the ACV. However, where it is proposed to include substantial continuous stiffening members, special consideration will be given to their inclusion.

6.1.4 The contribution of riveted components will be specially considered.

6.1.5 Structural members which contribute to the overall hull girder strength are to be carefully aligned so as to avoid discontinuities resulting in abrupt variations of stresses and are to be kept clear of any form of opening which may affect their structural performance.

6.1.6 For all structural members that contribute to the hull girder strength, buckling strength is to be adequate to withstand in-plane compressive, bending and shear loads. Generally, the shear loads are assumed to be carried through vertical divisions.

6.1.7 Safety Factors for Global Strength Assessment

6.1.7.1 All calculated stresses resulting from global load cases shall be multiplied by applicable safety factors, and the resulting values are not to exceed the specified minimum yield strength (R_{eH}) of the material.

6.1.7.2 Specific Load Cases

(a) Wave-Impact Global Load Case:
- Bending stress safety factor: 1.50
- Shear stress safety factor: 2.1
- Von Mises equivalent stress safety factor: 1.43

(b) Floating Global Load Case:
- Bending stress safety factor: 1.50
- Shear stress safety factor: 2.1
- Von Mises equivalent stress safety factor: 1.43

(c) Slinging and Jacking Global Load Case:
- Bending stress safety factor: 2.00
- Shear stress safety factor: 2.1
- Von Mises equivalent stress safety factor: 1.89

(d) Parking Global Load Case:
- Bending stress safety factor: 2.00
- Shear stress safety factor: 2.1
- Von Mises equivalent stress safety factor: 1.89

6.1.7.3 Where local stress concentrations or unusual structural arrangements exist, IRS may require additional analyses. Such measures are to reflect the severity of loading and structural criticality.

6.2 Local strength

6.2.1 Following requirements are to be applied in lieu of the requirements in Chapter 6, Section 3, 4 & 5 of the HSC & LC Rules.

6.2.2 When applying the loads given in this section 4 above, strength models based on simple plate bending, beam theory, or other recognised methods will generally be acceptable.

6.2.3 Where longitudinal and transverse stiffeners form grillage structures providing mutual support, or where the structural arrangement is complex, finite element or alternative methods may have to be used and are to be agreed with IRS prior to submission.

6.2.4 Consideration is to be given to assumptions regarding end fixity and load application as appropriate for the selected method.

6.2.5 Laterally loaded thin skins designed to support the design pressure by membrane action with associated large deflections will be specially considered.

6.2.6 Structural geometry is to be arranged and detailed to ensure a smooth transfer of loads throughout the structure. Concentrated or point loads are to be transmitted into the supporting structure by stiff supporting members. In no case are concentrated or point loads to land on unsupported plating.

6.2.7 The longitudinal girders forming the machinery foundations are to extend as far forward and aft as practicable and be adequately supported by transverse primary structure.

6.2.8 Integration of lift fans and associated supporting structure will be specially considered.

6.2.9 In areas where fluctuating pressure (panting) occurs e.g. fan bays, inlets, volutes etc. design details will be specially considered.

6.2.10 Openings in the structure are to be suitably framed and have well-rounded corners to minimise stress concentrations

6.2.11 Safety factors for local-strength assessment

6.2.11.1The calculated local stresses for structural components are to be multiplied by the appropriate safety factors S_f provided below. The resulting stress values is not to exceed the specified minimum yield strength R_{eH} of the material. For collision loads only, the ultimate tensile strength Rm to be used as the reference strength.

(a) Bottom and side structure:
- Plating: Bending Sf=1.5
- Stiffening: Bending Sf=1.50; Shear Sf=2.56
- Machinery foundations: Bending Sf=1.82; Shear Sf=3.13; Equivalent (von Mises) Sf=1.33

(b) Deck structure:
- Plating: Bending Sf=1.33
- Stiffening: Bending Sf=1.54; Shear Sf=2.63

(c) Superstructure and deck-house:
- Plating and stiffening: Bending Sf=1.33; Shear Sf=2.33

(d) Bulkheads:
- Watertight bulkhead plating: Bending Sf=1.00
- Watertight bulkhead stiffening: Bending Sf=1.05; Shear Sf=1.82; Equivalent Sf=1.00
- Watertight doors and hatches: Bending Sf=1.21; Shear Sf=2.08; Equivalent Sf=1.21
- Supporting structure for doors/hatches: Bending Sf=1.25; Shear Sf=2.17

(e) Slinging and jacking:
- Supporting structure: Bending Sf=2 ; Shear Sf=3.45
- Eyeplates (lifting eyes): Bending Sf=4

(f) Hull appendages:
- Skirt attachments: Bending Sf=2
- Side bodies: Bending Sf=1.5; Shear Sf=2.56
- Landing pads and skids: Bending Sf=1.5; Shear Sf=2.56

(g) Special features:
- Vehicle decks and ramps: Bending Sf=2; Shear Sf=3.45; Equivalent Sf=1.33
- Supporting structure and tie-down fittings: Bending Sf=1.5; Shear Sf=2.56; Equivalent Sf=1.16
- Crane foundations: Bending Sf=1.43; Shear Sf=2.5; Equivalent Sf=1.33

(h) Anchoring and mooring equipment:
- Equipment attachments and fittings: Bending Sf=1.11; Shear Sf=1.92
- Equipment supporting structure: Bending Sf=1; Shear Sf=1.72

(i) Structures and attachments subject to collision loads (use Rm):
- Equipment attachments and Supporting structure : Bending Sf=1.11; Shear Sf=1.92

6.3 Superstructures and deckhouses

6.3.1 All openings are to be substantially framed and have well-rounded corners. Arrangements are to be made to minimise the effects of discontinuities.

6.3.2 Special attention is to be given to the connection of the superstructure and deckhouse to the deck in order to provide an adequate load distribution and avoid stress concentrations.

6.3.3 Where pillars are fitted to support the span of stiffening members, they are to comply with the requirements of Chapter 6, Section 5 and Chapter 7, Section 9 of the HSC & LC Rules.

6.3.4 Seating Construction

6.3.4.1 Seats and their attachments to the deck are to be certified in accordance with the HSC 2000 Code - Resolution MSC.97 (73) Annex 10 - Criteria for testing and evaluation of seats (as may be amended).

Section 7

Hull Appendages, Air Propeller Supports and Ducts Arrangements

7.1 Hull Appendages

7.1.1 Skirt and Skirt Attachment

7.1.1.1 The design and scantlings of the skirt are outside the scope of Classification; however, designers are to submit their proposals in respect of the hull attachment detail. The strength of the hull attachment is to be based on the breaking load of the straps, ties, cords or cables to which it is attached. The following supporting information is to be submitted:

(a) cushion pressure,

(b) calculations demonstrating that the effect of damage to the flexible membrane and/or the retaining section arising from high-speed impact, grounding, fouling, etc. will not compromise the structural and watertight integrity of the craft.

7.1.1.2 Suitable supporting structure is to be provided in way of hull attachments for skirts

7.1.1.3 The skirt is to be securely attached around its periphery and is to be suitably reinforced by the use of backing plates.

7.1.1.4 Where the skirt is retained by bolting, the retaining bars are to be as long as practicable with a fastener spacing of not more than 50 [mm].

7.1.1.5 Where the design of the skirt is such that the flexible edge is retained by the use of a pre-formed channel, only the bolted hull connection of the preform to the hull structure is considered.

7.1.2 Air Propeller Ducts

7.1.2.1 The duct is to have adequate stiffness to maintain a clearance between the propeller tips and the inner surface during the most adverse operational conditions. Duct strength, stiffness, hull foundation, and factors of safety will be specially considered based on the operational loads, e.g. thrust and inertia.

7.1.2.2 The hull supporting structure and attachments of the ducts will also be considered for collision loads.

7.1.3 Supports for Air Propellers

7.1.3.1 Strength of air propeller supports or pylons, hull foundations and factors of safety will be specially considered based on the operational loads, e.g. propeller gyroscopic thrust and inertia.

7.1.3.2 The hull supporting structure and attachments of the air propeller supports or pylons will also be considered for collision loads.

7.1.4 Landing pads and Skids

7.1.4.1 ACVs are to be fitted with landing pads or skids to facilitate parking. The ACV is to be designed to support the maximum all-up weight on three-quarters of the supports. The landing pads or skids are to be integrated and aligned with the hull supporting structure which is to be additionally stiffened where necessary.

Section 8

Anchoring and Mooring Equipment

8.1 General

8.1.1 Equipment requirements are to be as required for mono-hull craft in Chapter 9 of the HSC & LC Rules.

8.2 Equipment Number

8.2.1 Fenders, tail fins, air propellers, ducts and flexible skirts need not be included in the calculation of the Equipment Number.

8.3 Arrangements

8.3.1 ACVs are to carry a single anchor that is easily accessible and ready for immediate use. Adequate storage is to be provided for the anchor cable, along with suitable means for its recovery (manual retrieval may be acceptable). The cable's bitter end is to be securely fastened to a strong point on the ACV.

8.3.2 Arrangements are to be in place to ensure that the anchor does not snag or cause damage to the skirt during launching or retrieval

8.3.3 The craft is to have suitable arrangements (in way of anchor and cable) as to protect the structure from being damaged during normal operation.

8.3.4 The design and installation of anchoring equipment, towing bitts, mooring bollards, fairleads, cleats, and eyebolts is to be capable of withstanding the breaking strength of the anchor cable, mooring lines, or towlines. The assumed breaking loads and any directional limitations are to be clearly indicated on the submitted plans.

8.3.5 The supporting structure for the equipment is to be capable of withstanding loads up to 1.2 times the breaking strength of the anchor cable, mooring lines, or towlines. It should have sufficient resistance to buckling and allow for effective load distribution.

8.3.6 The Operational Manual is to specify the maximum allowable towing speed for the ACV.

Section 9

Fire Safety

9.1 General

9.1.1 Fire safety arrangements are to be provided in accordance with the HSC & LC Rules except where modified by this section.

9.2 Insulation

9.2.1 Thermal or acoustic insulation installed within the machinery space is to be made of non-combustible materials. Such insulation is to be considered non-combustible if it meets the criteria specified in the FTP Code, Annex 1, Part 1.

9.2.2 Insulation is to be protected against impregnation by flammable vapours or liquids. Where insulation is cut, the edges are to be sealed(e.g., with non-combustible tape) to prevent such impregnation. Where insulation is susceptible to damage, it is to be appropriately protected.

9.3 Fire detection

9.3.1 Fire detection system is to be installed in accordance with the FSS Code, Chapter 9.

9.3.2 The fire detectors are to be suitable for the identified hazards and are to provide an audible warning that can be heard both in the affected space and at the control position when the ACV is in operation.

9.4 Fire-extinguishing for ACVs with enclosed interior spaces

9.4.1 A sufficient number of portable fire-extinguishers are to be provided in enclosed interior spaces to ensure that at least one extinguisher is to be readily accessible within each compartment.

9.4.2 Portable fire-extinguishers are to be positioned in locations that allow for immediate and easy access when needed.

9.4.3 Portable fire-extinguishers intended for use in a space are to be stowed near the entrance to that space. At least one portable fire-extinguisher is to be located within reach of the main steering position of the ACV.

9.4.4 In areas where cooking appliances are present, a portable fire-extinguisher suitable for the specific energy source used is to be installed in a location that allows quick access during a fire emergency.

9.4.5 Where a fire risk is associated with cooking activities, a fire blanket complying with a recognised standard is to be located in close proximity to the cooking area.

9.5 Fire-extinguisher capacities for ACVs with enclosed interior spaces

9.5.1 ACVs are to be equipped with no fewer than two multi-purpose portable fire-extinguishers, certified to a recognised standard. These extinguishers are to have a minimum fire rating of 13A/113B, or may be substituted with smaller units provided they collectively achieve an equivalent rating.

9.6 Furnishing materials for ACVs with enclosed interior spaces

9.6.1 Upholstery composites, comprising fabric combined with any backing or padding materials, used throughout the ACV, including on open decks, are to be approved in accordance with the IMO FTP Code, Annex 1, Part 8, or an equivalent standard.

9.6.2 Organic foams used in upholstered furniture and mattresses are to be of the combustion-modified type.

9.6.3 Suspended textile materials, such as curtains and drapes, are to be certified in accordance with the IMO FTP Code, Annex 1, Part 7, or an equivalent standard.

Section 10

Piping Systems

10.1 General

10.1.1 The requirements in Chapter 11 of the HSC & LC Rules are to be applied, except where modified by this Section.

10.1.2 All piping systems and their associated fittings which are subject to internal pressure are to be appropriately tested, including a pressure test, before being put into service for the first time.

10.1.3 Fuel piping is to be routed outside accommodation and cargo spaces. Within engine spaces, all piping and equipment carrying flammable fluids are to be manufactured with non-heat sensitive materials.

10.1.4 Where the surface temperature of engine exhaust pipes and silencer may exceed 220°C, they are to be either water cooled or efficiently lagged to reduce the fire risk and prevent heat-related damage. If the lagging material covering the exhaust piping system, including flanges, is oil-absorbing or may permit penetration of oil, the lagging is to be encased in sheet metal or an equivalent protective covering. In locations where the Surveyor is satisfied that oil impingement could not occur, the lagging need not be encased.

10.1.5 Materials used in piping systems are to be compatible with the type of fuel conveyed, with due regard given to fire hazards. The use of non-metallic piping may be permitted in specific systems, provided that the structural integrity of the hull, watertight decks and bulkheads is maintained.

10.1.6 For ACVs with no sea-water connections, where it can be demonstrated that the buoyancy of the ACV in the flooded condition can be achieved without the need for dewatering, a bilge system complying with the requirements of Chapter 11 of the HSC & LC Rules need not be fitted.

Section 11

Transmission, Steering and Propulsion System

11.1 Transmission Systems

11.1.1 Shafts transmitting torque to propulsion and lift fans are to be adequately supported. Drive-belt pulley shafts are to be sized and supported so as to absorb lateral bending forces and minimise shaft deflection under all operating loads and speeds.

11.1.2 Appropriate measures are to be implemented to isolate the engine crankshaft from lateral forces arising from the transmission arrangement.

11.1.3 Effective means are to be provided to accommodate and absorb axial thrust generated by lift fans and air propellers.

11.1.4 Rolling element bearings are to be sealed against the ingress of water, dirt, dust, and airborne contaminants.

11.1.5 Where drive belts are used for power transmission the following requirements are applicable:

a. belts providing positive traction are to be selected;

b. belt tensioning devices are to be provided with effective securing and locking arrangements;

c. belt alignment is to be maintained within the tolerances specified by the belt manufacturer.

11.1.6 Drive arrangements for propellers and lift fans positioned outside of the enclosed machinery space are to be protected against damage from foreign objects, airborne sand, grit or similar particles.

11.1.7 Suitable guards are to be fitted around all exposed drive arrangements to prevent accidental contact during operation.

11.2 Steering Systems

11.2.1 The requirements in this Section are to be applied in addition to those specified in Chapter 8, Section 5 of the HSC & LC Rules.

11.2.2 Directional control of the ACV is to remain effective in the event of a single failure occurring within the primary directional control system.

11.2.3 An alternative independent means of steering the ACV is to be provided, designed to ensure effective steering capability in the event of a failure of the primary system. The effectiveness of the alternative system is to be demonstrated during trials.

11.2.4 If air rudders are used for steering, their design is to ensure that no secondary damage occurs, and that the ACV remains controllable, in the event of loss of the actuating system, or mechanical failure in the linkage mechanisms.

11.2.5 Air rudder scantlings, hull foundations and factors of safety will be specially considered based on the operational side forces.

11.3 Air Propellers and Lift Fans

11.3.1 General

11.3.1.1 The requirements of this Section apply to air propellers and lift fans which form part of the lift and/or propulsion system of ACVs.

11.3.1.2 This sub-section is to be read in conjunction with General Requirements for Machinery in Chapter 12, Section 1 of the HSC & LC Rules.

11.3.1.3 A fan or propeller can be type approved when it has been shown to meet the requirements of this Section while operating within the conditions defined in the Manufacturer's/ Designer's Declaration of design and performance.

11.3.2 Functional requirements

11.3.2.1 The design and installation of fans and propellers together with their accessories are to be such that –

a) they fulfill the function for which they are installed and reduce to an acceptable minimum the hazards to occupants or third parties in failure conditions;

b) they are capable of functioning satisfactorily without unacceptable damage when operated in the likely prevailing conditions of icing, spray, sand, aggregate, salt etc. Due regard is to be paid to effects of corrosion, electrolytic action between different metals, erosion or cavitation which may result from operation in the environments to which they are subjected. Materials particularly susceptible to the marine environment are to be avoided;

c) ingestion of debris or foreign matter is minimised;

d) where necessary, inspection and removal of debris can be carried out safely in service.

11.3.2.2 For multi-propeller ACVs, the ACV is to be capable of maintaining steerage, with one air propeller or lift fan out of action. Propulsion systems comprising single essential components will be specially considered.

11.3.2.3 The failure of one air propeller or lift fan, or its control system, is not to render any other air propeller or lift fan inoperative.

11.3.4 Design and testing requirements

11.3.4.1 Air propellers and lift fans are to be designed, constructed, and tested in accordance with a national or international standard, (such as the European Aviation Safety Agency (EASA) Certification Specifications for Propellers (CS-P) or 14 CFR Part 35 of the Federal Aviation Administration (FAA)), accepted by IRS or the Administration.

End of Classification Notes