TP 5579

STANDARDS RELATING TO DESIGN, CONSTRUCTION AND OPERATIONAL SAFETY OF DYNAMICALLY SUPPORTED CRAFT IN CANADA

VOLUME 1. - DESIGN, CONSTRUCTION, TESTING AND DOCUMENTATION OF AIR CUSHION VEHICLES

Ship Design and Construction Division,
Ship Safety Branch,
Canadian Coast Guard.

Ottawa
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Explanatory Note

This is the first in a series of volumes of Standards relating to the safety of Dynamically Supported Craft in Canada. It covers the requirements with which compliance is necessary in order to design, construct and develop Air Cushion Vehicles such that a level of safety at least equivalent to that of other forms of transport, commensurate with the Canadian environment, is achieved. Subsequent volumes will cover operational safety in service; crew qualifications and certification; maintenance personnel qualifications and certification, and in-service technical procedures, for Air Cushion Vehicles, Hydrofoils and other forms of Dynamically Supported Craft.

The Standards conform to the Code of Safety for Dynamically Supported Craft, adopted by the International Maritime Organization. They are substantially similar and equivalent to the requirements for safety certification of A.C.V's developed by authorities in other countries. However, compliance with these Standards does not necessarily imply that vehicles would be approved in other countries; neither should it be assumed that an A.C.V. manufactured and approved by another nation would be approved for operation in Canada without detailed investigation for compliance.

This volume has been developed in a progressive format, with Divisions devoted separately to Design, Operational Equipment, Construction, Tests, Technical Information, and Certification Documentation. Within each Division, Chapters are devoted to topics and sub-topics, with paragraph numbering related to each topic and sub-topic. This results in deliberate breaks in paragraph numbering, to provide space for any subsequent additions. Additionally, some Chapters are provided with Appendices containing guidance information of a non-mandatory nature; for ease of identification, there Appendices are printed on yellow paper.

REVISION 1

Comments on the original proposed Standard which were received during 1984, and further review, have resulted in a number of changes, primarily of a clarification nature, which have now been incorporated to provide REVISION 1. The high-lights of this revision are outlined below; for ease of identification, all changes have been under - or side - lined.

Application	-	Clarified and further information provided.
Definitions	-	"Certification Authority", "Payload", "Special Category Space" added.
106	-	Revised title.
107	-	Reworded to conform more closely with IMO Code.
108	-	Reworded to provide additional guidance.
206	-	Added to provide further guidance.
New 301	-	Totally revised to include new definitions of L and B.
Ch. 3	-	Numerous sections revised to refer to intact buoyancy.
New 304	-	Added for clarification.
306(new 307)	-	Reworded for clarification.
312	-	Reworded to conform more closely with IMO Code.
315, 317	-	"Stability" added.
App.2 to Ch. 3	-	Icing allowances revised.
410	-	Reworded for clarity.
New 411	-	Added to correct omission.

REVISION 1 (Cont'd)

463	-	Reworded for clarity.
App. to Ch. 4	-	Table of notation added.
New 515	-	Added for further guidance.
606	-	Reworded for completeness.
703	-	Reworded to provide further guidance.
New 705	-	Added for further guidance.
707 (new 708)	-	Reworded to provide further guidance.
708 (new 709)	-	Reworded.
711 (new 712)	-	Further guidance added.
724 (new 725)	-	Reworded to provide further guidance.
New 726, 730 thru' 732	-	Added for further guidance.
New 792	-	Added for further guidance.
New 917, 923 thru' 926	-	Added for further guidance.
939	-	Reworded to provide additional guidance.
940	-	Reworded to provide closer definition.
942	-	Reference to 1035 added.
944	-	Reworded for clarification.
958	-	Reworded for clarification.
1004	-	Reworded and expanded for clarification.
1005	-	Reworded to conform more closely to IMO Code.
1007	-	Reference to 1004 added.
1011	-	Means of indication added.
1016	-	Reference added.
1017	-	Reworded to include approval conditions.
1027	-	Authority added.
1030	-	Weight revised.
1032	-	Reworded.

REVISION 1 (Cont'd)

1053	-	Additional control required.
New 1056	-	Added for further guidance.
App. to Ch. 10	-	Para. A revised and expanded.
1115	-	Reference to 1003 added.
		Paragraph numbering after 1116 corrected.
1128	-	Reworded to conform more closely with IMO Code.
1165	-	Reworded for clarity.
1170 thru' 1198	-	Renumbered as Chapter 12, 1201 thru' 1228.
1178(1208)	-	Reworded for clarity.
1182(1212)	-	New (b) added.
1184(1214)	-	(c) revised.
1186(1216)	-	Reworded for clarity.
1187(1217)	-	(f) reworded, (g), (h), (i) added.
Ch. 12 thru' 15	-	Renumbered as Ch. 13 thru' 16.
1203(1303)	-	Additional wording.
1214(1314)	-	Additional guidance provided.
1219(1319)	-	Additional guidance provided.
1220(1320)	-	Closer definition provided.
1230(1330)	-	Reworded for clarity.
1231(1331)	-	(h) added.
1500(1600)	-	Reworded to conform more closely with IMO Code.
1508(1608)	-	Reworded for clarity.
4102	-	Reference to 792 added.
4202	-	(j) added.

CONTENTS - VOLUME 1

Part C - Operating Safety Trials - Prototype Vehicles and Equipment.

Part D - Operating Safety Trials - Production Vehicles.

Part E - Vehicles of other than Canadian Manufacture.

Division 5. Vehicle Technical Information.

Application

01. This Standard applies to all A.C.V's designed, constructed, registered and/or operated in Canada or in Canadian jurisdictional waters, which are subject to provisions of the Canada Shipping Act.

02. Exceptionally, designs or proposals for A.C.V's which are intended to :-

a) Accommodate less than 12, or more than 450 passengers, or carry any combination of persons, cargo, freight or equipment so that the total payload is less than 1 tonne or greater than 40 tonnes, and/or

b) Operate on voyages in the course of which they will be more than 100 nautical miles from a safe haven of refuge shall be considered to determine the extent to which this or additional standards should apply.

03. In determining the operational safety of an Air Cushion Vehicle voyage, the Safety Certificate issued in respect of any Air Cushion Vehicle may impose operating limitations based upon:-

a) The approved operational and environmental envelope of the vehicle;

b) The proximity of safe havens of refuge;

c) Availability of adequate and reliable weather forecasting;

d) Availability of communication facilities between the vehicle and it's base port and havens along the route;

e) Availability of search and rescue facilities;

f) Availability of adequate base maintenance and inspection facilities, and

g) Qualifications of crew members.

Application (cont.)

04. Subject to suitable appropriate agreements, it is intended that these standards should be applicable to Canadian Air Cushion Vehicles engaged on international voyages.

05. It is important, in applying these standards to a vehicle, that all appropriate sections be applied consistently in order to maintain the balanced contributions to safety which each section provides within the overall safety philosophy.

06. In addition to Section 01 above, these Standards will apply to A.C.V's designed to carry cargo or a mixture of passengers and cargo.

07. Where not specifically covered by this Standard, the application of other standards in general use should be made to design, construction, installation and inspection, such as :-

Construction

CSA S.244 - Welding of aluminium alloys

CSA W.47.2 - Aluminium welding qualification code

Fire Safety

Underwriter's Laboratory of Canada Standards S.102, S.102.2

Underwriter's Laboratory Inc. UL-723

National Fire Protection Association Test 255.

American Society for Testing Materials Test E.162.

Application (cont.)

Navigation and Communication Equipment

C.C.G. Collision Regulations.

C.C.G. Standards for Navigating Lights, Shapes, Sound Signals and Radar Reflectors.

C.C.G. Ship Station Radio Regulations.

C.C.G. Ship Station Technical Regulations.

Life Saving Equipment

C.C.G. Life-Saving Equipment Regulations.

C.C.G. Standard for Construction and Inspection of Inflated Lifejackets.

CGSB 65-GP-14M - Standard for Inherently Buoyant lifejackets.

Guidance upon the applicability of such codes and standards, and upon their equivalency with those of other countries can be provided by the Certification Authority

Definitions.

Short Title.

This volume may be cited as "Canadian A.C.V. Safety Certification Standard".

Interpretation.

In this Standard,:-

"Air Cushion Vehicle" ("A.C.V") is a craft whose weight, or a significant part of whose weight, can be supported, at rest or in motion, by a continuously generated flow of air dependent for it's effectiveness upon the proximity of the surface over which the vehicle operates.

"Approved" means approved by the Director General, Ship Safety Branch, Canadian Coast Guard or his delegate.

"Certification Authority" means Ship Design and Construction Approval Division, Ship Safety Branch, Canadian Coast Guard, Ottawa.

"Design (operating) (environmental) Envelope" is the combination of limiting values of operating or environmental parameters for which the vehicle is designed as declared in the Design Specification.

"Designated Fire Zone" means a space within the vehicle which by virtue of it's contents, constitutes a fire risk requiring dedicated fire safety measures. (A more specific definition is given in Chapter 10.)

"Designer" means the person or organization responsible for the accuracy of data and drawings submitted for approval in compliance with these Standards.

"Manufacturer" means the person or organization responsible for the standards and procedures adopted during construction of an A.C.V. in compliance with design information and with these Standards.

"Payload" means any combination of persons, cargo and equipment carried by an A.C.V., other than crew members, equipment and replenishible fluids necessary for the safety of the A.C.V. on the intended voyage.

"Primary Structure" means any structure, failure of which would impair safety of the vehicle when operating within it's design envelope.

"Special Category Space" means an enclosed space provided for the transport of motor vehicles with fuel in their tanks for their own propulsion, into and from which they may be driven, and to which passengers have controlled access.

"Submit", "Submission" means the provision of information as required by these Standards, to the Certification Authority.

"Surveyor" means a steamship inspector or inspector of dynamically supported craft appointed under the Canada Shipping Act.

Abbreviations.

In these Standards:-

C.C.G. means Canadian Coast Guard. More specifically, queries should initially be addressed to the Ship Safety Branch or Regional Ship Safety office.

C.G.S.B. means the Canadian General Standards Board.

General Standards relating to the Design, Construction and Operational Safety Certification of Air Cushion Vehicles (A.C.V's) in Canada.

101. Introduction.

These Standards define the requirements to be complied with in order than an A.C.V. to which they apply (See Sections 01 and 05) may be considered for certification in Canada.

A.C.V's which are designed and constructed in compliance with these Standards will be eligible for certification subject to either:-

a) Approval of design and supervision of construction and trials by surveyors, or

b) Approval of design by surveyors, and supervision of construction and trials by an approved organization (see 103 below).

Procedure (a) will normally be followed for all vehicles being designed or constructed in Canada for the first time, and for constructors who do not have an approved organization.

Procedure (b) may be followed by a constructor with an approved organization for series production vehicles essentially identical to a previously certified prototype.

102. Design and Construction Controls.

In making initial submissions relating to a proposed A.C.V. development, persons or organizations responsible for each of the design and construction aspects should be clearly identified, and an effective liaison should be established between them.

In companies which include an approved organization, that organization should be responsible for ensuring adequate design-construction liaison in order to maintain appropriate standards.

103. Approved Organizations.

Companies wishing to be considered for approval of vehicle series production under the supervision of their own organization will be required to submit a comprehensive plan for approval. This plan should include the names and qualifications of key design, construction and inspection personnel, and an outline of the procedures to be established to ensure compliance with these Standards.

104. General Standards.

Where appropriate, generally recognised methods and standards for design calculations, drawings, construction materials and processes, and for testing should be used and identified. While CGSB standards are preferred, other recognised standards may be used if they are appropriate and do not result in a lesser level of safety. Any submission which do not meet with this requirement may be rejected without further consideration until corrected.

105. Reciprocity.

Vehicles or vehicle designs which have been approved or certified by authorities of other Administration may receive Canadian approval insofar as the previous approval or certification is commensurate with these Standards. Full details of the previous approval or certification, and the standard to which it relates, will be required.

106. Responsibility.

It is the responsibility of the designer, constructor, owner or operator as appropriate to seek approval, certification or licensing required. All enquiries should be addressed to:-

Superintendent Special Ships,
Design and Construction Approval Division,
Ship Safety Branch,
Canadian Coast Guard,
Transport Canada,
Ottawa, Ontario K1A 0N7

107. Equivalencies.

It is the intent that all A.C.V's requiring certification approval shall comply as closely as practicable to all applicable requirements of this Standard. Where substitution of an alternative fitting, material or component, or an alternative means of compliance is proposed, substantiating evidence to show that the alternative is at least as effective in providing safety as that required by this Standard is to be submitted for consideration of approval.

108. Construction and Equipment Standards.

Specialized methods of construction and specialized items of equipment used in A.C.V's, but which are not exclusive to A.C.V's, shall comply with the requirements of applicable standards, codes or regulations and the appropriate approval procedures. Reference to such requirements is made in the text, and examples of such standards are given in Paragraph 07.

Chapter 2 - Design - General.

201. Design Specification.

The designer shall initially declare a Design Specification which will stipulate the maximum intended design conditions for operation of the vehicle in terms of:-

a) Maximum vehicle weight;

b) Vehicle maximum speed relative to the surface;

c) Maximum sea state and obstacle height;

d) Maximum wind speed;

e) Environmental temperature range.

Design calculations shall relate to these conditions where appropriate; equipment, components and installations shall be selected or designed for safe operation within these conditions, and due allowance shall be made where applicable for the effects of vehicle icing.

202. Design Calculations.

Design calculations required by these standards shall be performed using recognized methods, which should be identified if of special application, and all assumptions made shall be clearly stated.

203. Design Approvals.

Any approvals given for designs as complying with these standards will be based upon such data as is submitted; they should therefore be in sufficient detail to enable compliance to be readily assessed.

204. Design Units.

Drawings, calculations and data submitted shall be consistently in S.I. Units, except in respect of equipment or components designed and manufactured using alternative units.

205. Design Responsibility.

The person assuming responsibility for the vehicle design shall:-

a) Be responsible for the accuracy and completeness of all data and calculations submitted in respect of the vehicle structural design, and

b) Ensure that sufficient data are available in respect of main machinery components (see Chapter 7) upon which compliance with these standards can be assessed.

206. Data to be submitted.

Drawings, conforming to good drafting practices, shall be submitted as clear blue-prints in triplicate, and shall contain all necessary information to identify materials and components depicted for all structure, components, equipment and their installation as required in this Standard. All supporting data by way of calculations, specifications, test reports, etc., shall be submitted in single legible copies in either the English or French language.

Chapter 3 - Buoyancy, Sub-Division and Hydrostatic Stability.

301. Definition.

a) In considering the extent of damage to be assumed in Sections 310 and 311 and in subsequent calculations, the following definitions shall be used :-

"L" means the length, measured on the intact waterline when floating at maximum certified weight, between the forward and after extremities of the centre-line of structure within which spaces contributing to intact buoyancy are provided, and

"B" means the breadth, measured on the intact waterline when floating at maximum certified weight, of structure at mid-length of the damage under consideration, which contains spaces contributing to intact buoyancy.

b) "Watertight", with respect to a space, means a space which satisfactorily meets the test requirement of Section 3207 of this Standard.

302. Intact Buoyancy Provision.

All A.C.V's designed to operate over water shall be provided with buoyancy which, when intact, provides at least 100% reserve when floating in fresh water of density 1 000 kg/m^3 (62.5 lb/ft^3) at maximum certified weight. The designer shall declare all spaces for which buoyancy is claimed, and the amount of buoyancy claimed for each space.

303. Intact Buoyancy Distribution.

Spaces claimed for intact buoyancy shall be evenly distributed over the vehicle plan-form so far as is practical, and shall be below a datum watertight deck or structure from which passenger emergency evacuation into survival craft could be effected.

304. Eligibility for Intact Buoyancy.

Contributions to intact buoyancy shall be claimed only for:-

a) Spaces designed and provided exclusively for buoyancy;

b) Spaces designed to carry fuel or other liquids, only to the extent of buoyancy contribution when the spaces contain their designed quantity of liquid and the vehicle is floating at maximum certified weight.

c) Other spaces within the vehicle up to a level 76 mm. below the lowest point at which, when the vehicle is floating at maximum certified weight in still water, that water may enter the vehicle at any point.

No space above the level of the lowest opening through which progressive flooding may occur when the vehicle is prepared for emergency evacuation of passengers shall be claimed in calculating intact buoyancy. Volumes of any such spaces may be considered in calculations of damaged stability.

305. Buoyancy Media.

If buoyancy is provided by other than structural voids, the buoyancy media and their method of application shall be approved. (see Appendix 1 to this Chapter.)

306. Buoyancy Sub-division.

Air spaces designed to contribute to intact buoyancy shall be watertight, and shall be sub-divided to ensure that the provisions of Sections 312, 313 and 314 are complied with.

307. Watertight Integrity.

Any penetrations of boundaries of air spaces contributing to intact buoyancy shall be watertight; any piping or ducts passing through such spaces will require to be approved with specific reference to the possibility of flooding other compartments when considering the damage postulated in Sections 310 and 311, and the possibility of transfer of bilge water when bilge pumping.

308. Buoyancy Space Access.

All spaces designed to contribute to intact buoyancy shall be provided with ready access for internal inspection, and air spaces shall be provided with means of detecting and removing accumulated liquids. Where access for detection of liquids by visual means on a regular basis is not practical or appropriate, buoyancy air spaces shall be provided with flood alarms giving indication in the compartment from which the vehicle is normally manoeuvred.

309. Intact Stability.

The vehicle when floating in still water at maximum certified weight shall have positive stability, and shall not exceed an angle of 8° in any direction under any permitted loading condition.

310. Bottom Damage to be considered.

In determining the distribution and sub-division of buoyancy spaces, the designer shall assume the following bottom damage:-

a) Damage resulting in loss of watertight integrity over the least of the following lengths measured parallel to the centre-line:-

i) 0.1 L

ii) 3m. + 0.03 L

iii) 11 m.

b) Such damage shall be assumed to extend vertically the lesser of 0.02 B or 0.5 m.

c) The width of the damage shall be assumed to be the lesser of 0.2 B or 5.0 m.

d) The shape of the damage shall be assumed to be parallelepiped.

311. Side Damage to be considered.

In determining the distribution and sub-division of buoyancy spaces, the designer shall assume the following side damage:-

a) Damage resulting in loss of watertight integrity over the least of the following lengths anywhere around the vehicle periphery:-

i) 0.1 L

ii) 3m. + 0.03 L

iii) 11 m.

b) Such damage shall be assumed to extend vertically over the full depth of the buoyancy space which has been damaged.

c) Damage shall be assumed to penetrate horizontally for 0.2 B or 5.0 m., whichever is the less, provided that such penetration in from the outer rigid structural boundary of the vehicle is at least 12% of the buoyancy tank width at the station considered.

312. Stability in the Damaged Condition.

Following damage to the extent considered in either Section 310 or 311, the vehicle shall have sufficient buoyancy and positive stability to ensure that when floating in still water at maximum certified weight:-

a) The final waterline at any point is at least 76 mm. below the lowest point of any opening through which progressive flooding may occur, and

b) The final floating attitude does not exceed 8° in any direction with fuel, ballast and payload positioned for normal operational trim, but making due allowance for movements of fluids resulting from the damaged attitude, following initial angles of attitude of up to 16°, and

c) Passenger evacuation is not impeded by flooding.

313. The design should ensure that, in the worst environmental conditions for which certification is sought, the vehicle when floating following the assumed damage shall maintain a positive metacentric height.

314. The designer shall examine the buoyancy and stability provisions to determine any more severe effects which may result from lesser damage than that considered in Sections 310 and 311

315. Damaged Integrity.

The combined structural integrity and post-damage buoyancy and stability should ensure that, in the worst environmental conditions for which certification is sought, the vehicle will remain afloat, with minimal impairment of access to and operation of escape routes, survival craft and emergency equipment, for the lesser of 30 minutes or 3 times the demonstrated evacuation time plus 7 minutes.

316. Icing.

In all design considerations related to floating and cushion-borne roll stability, the designer shall take due account of icing. Icing allowances to be considered are provided in Appendix 2 of this chapter.

317. Design Substantiation.

Buoyancy and stability design calculations shall be prepared and submitted to demonstrate quantitative compliance with the intact and damaged buoyancy and stability requirements of this Chapter. Representative model testing may be required.

318. Sidewall Vehicles.

The design of underwater structure or appendages of sidewall A.C.V's shall include provisions to minimize damage and consequent reduction in buoyancy and stability resulting from collision with underwater or floating objects.

319. Passenger Loading.

For the purposes of stability calculations, it shall be assumed that each passenger has a mass of 75 kg., with a centre of gravity 300 mm. above the seat cushion when seated, or 1 m. above the deck when standing.

Asymmetric loading to provide the most unfavourable rolling moment in the damaged condition shall be assumed, with passengers standing and distributed at 4 persons per square metre.

Appendix to Chapter 3 - Buoyancy Media.

Low Density Plastics.

Low density plastic media are frequently proposed for use as buoyancy. While there is no objection to this in principle, there is a very wide variety of such media, and designers should be aware that not all such media are acceptable as buoyancy. In general, foam plastics formed from multi-part mixes and poured in place are very sensitive to environmental conditions when mixing and pouring, and to vibration under operating conditions. Structural voids and poor generation of a closed-cell foam may result from inadequate mixing or pouring conditions, and vibration may result in rapid deterioration of the foam structure. These foams cannot therefore be relied upon as buoyancy, and will NOT, in general, be approved.

Expanded polyethylene foam has been shown to have excellent long-term performance as a buoyancy medium, and other pre-formed expanded or foamed plastics will be considered provided that supporting specifications and tests results are submitted.

In selecting buoyancy media, designers should ensure, and submit data to show, that they are:-

a) Structurally stable under service conditions;

b) Impervious to water absorbtion, and

c) Fire-retardant or self-extinguishing.

Appendix 2 to Chapter 3.

Icing Allowance.

1. In vehicle designs intended for year-round operation in Canadian waters, at least the following icing allowance should be considered in all stability and buoyancy analyses.

a) 60 kg./m^2 on all exposed horizontal surfaces below a height equal to the maximum significant wave height in which the vehicle is designed to operate, measured from the cushion-borne waterline at maximum certified weight. NOTE - The hull structure within the cushion is "exposed".

b) 37 kg/m^2 on all surfaces other than vertical.

c) 30 kg per running metre of all guardrails, stanchions, antennae, rigging, etc., less than 6.1 m. above the normal floating waterline at maximum certified weight.

2. The above values have been derived based upon year-round operation of A.C.V's in Canadian waters. 60 kg/m^2 equates approximately to an ice thickness of 7 cms., which, as an average may be generally experienced. Ice accretion is naturally a function of local operating conditions, and seasonal or temporary operating restrictions may be imposed upon vehicles which cannot meet these allowances or when conditions are likely to cause them to be exceeded.

Chapter 4 - Dynamic Stability and Control.

401. Directional Stability

The vehicle design shall be such that within the design operating envelope, moments due to aerodynamic yaw are kept to a minimum and shall, as far as practical, be stabilizing. Changes of yaw moment should be smooth and continuous.

402. Cushion Stability and Lift System Performance.

Design of the cushion shall be such that any disturbance in roll or pitch when cushion-borne shall generate a restoring moment.

403. Design calculations of cushion-borne stability in pitch and roll shall be supplemented if required by representative model tests, and in any case by full scale experiment. (See Division 4 Part A)

404. In designs where air delivered for the cushion may also be used for other purposes, the lift system performance shall be evaluated under all conditions of air usage.

405. In designing the lift system as a whole, the designer shall fully consider the relationship between total air requirements and the fan characteristics, and establish that under normal operational conditions, fan operation will be stable. Such consideration shall also include an assessment of flexible structure instability and cushion system heave instability, and due provision shall be made to ensure that unstable operation will not occur within the vehicle design operating envelope.

406. Flexible Structures.

Designs of all flexible structure, including any inflated structure, shall be such that any deformation due to dynamic contact with the surface does not contribute a destabilizing moment to the vehicle. In particular, the designer should consider the moments generated by scooping or tuck-under of any part of the flexible structure when operating anywhere within the design operational envelope and at extreme angles of hydrodynamic yaw.

407. Design Features Influencing Capsizing.

Within the very broad spectrum of amphibious vehicle and cushion system designs and the range of environmental conditions in which they operate, it has been established that a large number of design parameters, some of which are inter-dependent, have an influence on capsizing. In order to assist and guide designers, a list of these which may not be exhaustive, is provided in the Appendix to this Chapter, including ranges of values which have been found to be in normal use.

408. Hydrodynamic Design.

The hull design shall be such that underside or superstructure contact with the surface when operating anywhere within the design operational envelope and at extreme angles of hydrodynamic yaw will not contribute a destabilizing moment to the vehicle in roll or pitch.

409. Underside surfaces of the hull periphery should present a stabilizing planing surface to the water; in some designs, an equivalent effect may be provided by appropriate peripheral skirt and support structure design.

410. Peripheral superstructure immediately above peripheral flexible structure shall be so shaped as to :-

a) minimize the possibility of trapping water, and

b) generate a restoring moment upon contact with the water at any expected angle of roll or pitch.

411. Any external structure which is subject to water accumulation shall be provided with adequate drainage, which may require to include non-return provisions, effective under all conditions of trim up to 8° in any direction.

450. Stabilizing Systems and Directional Control.

Definition:- A stabilization system is a system which, when active, is designed to supplement or augment the stability of vehicle motions in roll, pitch, yaw or heave, or any combination of such motions.

451. Where such a system is installed, it shall be selectable at the discretion of the crew member operating the vehicle, and controls shall be provided at the vehicle control station.

452. The system shall be designed so that, when not selected, or under fault conditions affecting the functional operation of the system, directional control and stability devices which it commands revert to and remain in neutral positions without affecting any other input commands to which the devices may be subject by the crew member at the vehicle controls.

453. Where stabilization systems are automatic in operation, provision shall be made at the control position for the system to be over-ridden, and for cancellation of the over-ride. Such systems shall also include provisions for automatic disengagement should their operation cause the vehicle to exceed prescribed safe operating limits, and such disengagement shall be indicated.

454. The parameters subject to the commands of any stabilization system, and the degree of command provided, shall be approved.

455. The dynamic effects of the stabilization system and of any modal failures, shall be demonstrated and safe operating limits established.

456. Directional Control.

The vehicle shall be provided with directional control surfaces or devices to enable safe and effective manoeuvring under all conditions within the design operating envelope.

457. As appropriate to the particular directional control device and it's input system, it shall be provided with either:-

a) Two independent means of controlling deflection, or

b) Means to centralize the device or neutralize it's effect, or

c) Design features such that failure of power input causes it to revert to and remain in a neutral position.

458. The design and installation of directional control devices shall ensure that deflection will not generate any adverse or destabilizing moment in roll or pitch at any point within the vehicle design operating envelope.

459. In designs incorporating multiple directional control surfaces or devices, consideration shall be given to the effectiveness of control with one surface or device failed or inoperative.

460. In complying with the requirements of 458 and 459, restrictions or limitations which may be established as the result of demonstration are to be approved and contained in the vehicle Operating Manual.

461. Where provision is made for directional control to be effected from positions other than the compartment from which the vehicle is manoeuvred, such positions shall be provided with 2-way communication with that station, and with means of determining the control device deflection.

462. Where directional control devices depend for their normal operation upon power, any failure of that power shall be indicated at the crew station, from which the vehicle is normally manoeuvred.

463. In vehicle designs incorporating only one directional control device (or group of devices which are controlled and operate as one), it shall be demonstrated that the vehicle may be safely handled and manoeuvred in the event of failure of the input control to the device or devices. Any precautionary actions, or restrictions or limitations to be observed shall be contained in the vehicle Operating Manual.

464. Directional control systems are to so arranged that failure of any one device or of it's input system will not render any other directional control devices inoperative.

465. Directional control devices depending for their effectiveness upon the generation of aerodynamic or hydrodynamic forces shall be of adequate strength, and be attached to the vehicle adequately such that these forces will be reacted without distortion of the device or of it's attachment.

466. Where directional control or vehicle stabilization is dependent upon one device which is itself dependent for it's efficient operation upon power, such power shall be provided from two independent circuits, in the event of electrical power being used, one circuit may be provided from the emergency power source, provided with short circuit protection and an overload alarm.

Appendix to Chapter 4 -

Designs features influencing capsizing

This Appendix is based upon information contained in C.A.A. Paper 75017, and is included by kind permission of C.A.A.

Definitions

'Plough-in' - A rapid divergent pitching motion involving an increase in drag and reduction in pitch attitude.

'Tuck-under' - Deformation of the skirt, by local hydrodynamic drag forces pulling the skirt under the craft structure.

The combination of adverse design features, together with poor operating techniques and/or severe environmental conditions, is generally necessary for capsize. From extensive model research and studies of full-scale capsizes, it has been established that a capsize is usually associated with a plough-in and tuck-under during operating with an appreciable angle of hydrodynamic yaw. The vehicle speed in the direction of travel at which a capsize occurs is relatively low.

The investigations included extensive consideration of the contributions which vehicle design features make to vehicle motions in conditions favourable to a capsize. General guidelines, applicable to vehicles with peripheral skirt systems, have resulted for minimizing these contributions.

Designs features can be broadly classified into 3 groups:-

a) Independent structural and skirt geometric variables which can be selected by the designer with the objective of minimizing tuck-under;

b) Vehicle structure features which can be selected by the designer with the objective of resisting motions leading to a capsize, and

c) Vehicle stability characteristics, which are partially influenced by (a) and (b).

The principal parameters, and the range of values in general use are given for (a) and (b) in the tables overleaf. In respect of (c), the designer should establish that aerodynamic yaw moment derivatives with respect to both aerodynamic and hydrodynamic yaw angles exhibit no dangerous discontinuities and are stabilising. He should also establish that yaw control is always sufficient to overcome yawing moments.

The water surface immediately beneath the skirt of a vehicle near the point of capsize has an appreciable slope down into the cushion - in the order of 8 to 10 degrees. This, in conjunction with the roll angle associated with a near-capsize, produces a powerful destabilizing force should the lower structure impact the water. It is therefore essential that an effective hydrodynamic planing surface be provided around the lower periphery - chine angles of 25° or more are recommended. In some designs, there is no structure in this area, in which case space and skirt geometry should be such as to permit the skirt to deform to provide a planing surface.

The following tables are reproduced from the Civil Aviation Authority Paper 75017, and are primarily concerned with "bag and finger" skirt designs; the tables are a summary of the relevant text which includes discussion also of "Loop and segment" skirts; meaningful extrapolation out of context could be invalid, and designers requiring further data should contact the Civil Aviation Authority, whose permission to reproduce the extract is acknowledged. The following notation is used:-

b	Cushion Beam
c_{Δ}	Cushion loading = $\frac{w}{{}^{e}h^{g(S}c)^{3/2}}$
b.t.c	Buoyancy Tank Clearance
g	Acceleration due to gravity, 981 cm/sec^2, 32.2 ft/sec^2
h_g	Height of vehicle c.g. above mean water surface beneath vehicle
H_{SK}	Skirt depth, measured from bottom of vehicle hard structure
l_e	Effective cushion length, = S_c/b
p	Cross-sectional perimeter of bag
P_b	Bag pressure
P_c	Cushion pressure
W	Vehicle weight
X_H	Horizontal distance between outer and inner skirt hinge lines
Z_H	Vertical distance between outer and inner skirt hinge lines
${}^{e}h$	Density of water
$\varnothing$	Angle of roll

Design Factors Affecting Leading Sideskirt Tuck-under Boundary

Sectional Geometry Parameters	Comment	Current Practice
$\frac{Z_H}{X_H}$ = $\frac{\text{Hinge vert. spacing}}{\text{Hinge horiz. spacing}}$	High value favourable	0.15 to 1.0
$\frac{P}{X_H}$ = $\frac{\text{Bag perimeter}}{\text{Hinge horiz. spacing}}$	High value favourable at lower pressure ratios (P_B/P_C)	1.75 to 3.5
$\frac{b}{X_H}$ = $\frac{\text{Cushion beam}}{\text{Hinge horiz. spacing}}$	Low value favourable	5.0 to 7.5
Percentage finger depth	Low value favourable, in theory, but some minimum value (>20%) probably optimum in practice, due to better drag characteristics of finger than bag, even on purely beam-on considerations.	
Overall Skirt Geometry and Craft Parameters		
Compartmentation	Centre keel, with differential pressure in roll favourable, unless P_B/P_C for leading sideskirt becomes low and $Z_H/X_H$and or p/x_H are low.	
	Low value favourable	
	High value favourable	
$\frac{H_{SK}}{b}$ = $\frac{\text{Skirt Depth}}{\text{Cushion pressure}}$	High value favourable	0.10 to 0.20
C = Cushion loading	High value favourable	1.0 to 2.0
	Low value favourable, in conjunction with H_{SK}/b and C but only b/l_e is as powerful as these.	0.01 to 0.03
$\frac{\text{b.t.c.}}{H_{SK}}$ = $\frac{\text{Buoyancy tank clearance}}{\text{Skirt depth}}$		0.8 to 1.1
$\frac{b}{l_e}$ = $\frac{\text{Cushion beam}}{\text{Effective cushion length}}$	Low value favourable, but unlikely to be very different from model value, i.e. or order 0.01.	0.4 to 0.75
Wetting drag coefficient		

NOTE: the above statements and numerical ranges, which reflect design practice for several current craft, are provided for general guidance and not as design rules or limiting values. An overall configuration involves a compromise choice of all the factors, and may be satisfactory even if one or more factors are at the least favourable end of the range.

Design Factors Affecting Craft's Reverse against Capsizing

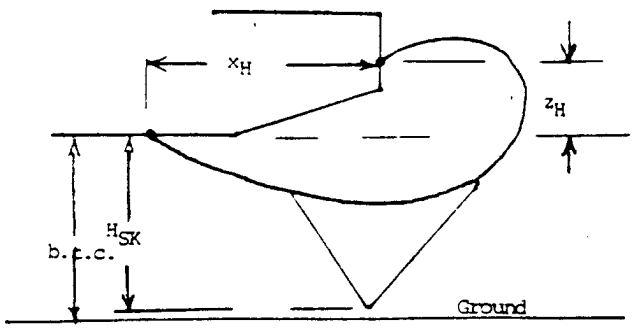
(up to Tuck-under Point)

Parameter	Comment	Current Practice
$7\varnothing(\Delta p/p_c)$ - ^{h}G $\varnothing p$ b = Differential pressure rate less CG CG height moment parameter	A high value is favourable in this context, but will be offset by an adverse adjustment to the tuck-under merit if hinge spacing and bag perimeter ratios are not good (unless intial pressure ratio is high).	-0.3 to 0.6
b.t.c. = Buoyancy tank clearance H_{SK} Skirt depth	The importance of this parameter is modified by the size of the drag moment parameter, but a high value is favourable.	0.8 to 1.1
$^{h}G/^{b}$ = CG height ratio $*C_{\Delta}$ Cushion loading parameter	Drag moment parameter. Low value favourable	10 to 25
P = Bag perimeter ^{x}H Horiz. hinge spacing	Affects beam increase. High value favourable.	1.75 to 3.5
P_B = Bag pressure P_C Cushion pressure	Affects bag pressure moment. High value favourable.	1.0 to 2.0
b = Cushion beam x_H Horiz. hinge spacing	Relates skirt contact moment to cushion beam dependent and other moments. Low value favourable.	5.0 to 7.5

NOTE: The above statements and numerical ranges, which reflect design practice for several current craft are provided for general guidance and not as design rules or limiting values. An overall configuration involves a compromise choice of all the factors and may be satisfactory even if one or more factors are at the least favourable end of the range.

* C_{Δ} = w/e $h^{g}(S_c)^{3/2}$;eh is mass density of water; S_c is cushion area

h_G is the height of vehicle c.g. above mean water surface beneath the craft.



Chapter 5 - Structural Strength

500. Definitions.

"Limit Load" is defined as the maximum load anticipated to be encountered, and is the load to be used in stress calculations.

"Primary Structure" is any structure, the failure of which will impair safety of the vehicle when operating within it's design envelope.

"Proof Factor of Safety" is the Proof Load divided by the Limit Load.

"Proof Load" is the maximum load which may be applied before consequential permanent deformation impairs safe operation.

"Ultimate Factor of Safety" is the Ultimate Load divided by the Limit Load.

"Ultimate Load" is the load under which primary structure will commence to fail.

501. Loading Cases to be considered.

In considering the strength and stiffness requirements of primary structure, the designer shall take account of the loads arising from:-

a) Dynamic responses to waves when operating in the Design Specification operating envelope with conditions giving rise to the most severe loadings. (N.B. This will not necessarily be at maximum weight in maximum waves - see Appendix to this Chapter.) See also Sections 550 et seq.

b) Impact loads resulting from total loss of lift power at any speed up to the maximum for which certification is sought;

c) Hogging and sagging when floating in trochoidal waves of 10:1 length to height ratio at maximum design weight;

d) The vehicle standing on, or being supported by, 75% of the designed support area at maximum design weight (amphibious vehicles) or at maximum designed lifting weight (non-amphibious vehicles);

e) Parking, picketting and mooring in winds of 148 km/hr. (80 knots);

f) The vehicle being towed;

g) Snow and ice;

h) Slinging and jacking.

502. Load Factors.

For structural loadings considered in Section 501 (a) thru' (d), the structure shall have minimum Proof and Ultimate Factors of Safety respectively of 1.0 and 1.5.

For structural loadings considered in Section 501 (e) thru' (g), the structure shall have minimum Proof and Ultimate Factors of Safety respectively of 1.33 and 2.0.

For slinging and jacking, the structure shall have minimum Proof and Ultimate Factors of Safety of 2.0 and 3.0 respectively.

503. Snow and Ice Loads.

In considering loadings for structural design purposes, it shall be assumed that the vehicle may experience:-

a) Accumulations of 73 kg/m^2 snow loading on all exposed horizontal surfaces when stationary;

b) Ice loads of 60 kg/m^2 on all exposed horizontal surfaces when operating, and ice accretion of 15 kg/m^2 on projected lateral surfaces above the water.

504. Towing, jacking and slinging loads.

In designing structure to accommodate towing, slinging and jacking, the designer shall clearly state any assumptions made, together with any resulting limitations of the vehicle or of the load and it's direction.

505. Deck Loading.

All decks designed for passenger movement and seating, and for carriage of cargo, shall be designed for local and distributed loads with minimum Proof and Ultimate Factors of Safety of 1.0 and 1.5 respectively. The maximum loadings and loading densities to which decks may be subject in service are to be declared.

506. Collision Accelerations.

Primary structure design shall take into account all combinations of inertia forces resulting from the following accelerations:-

4g downwards to 3g upwards

zero to 6g forwards

zero to 3g backwards

zero to 3g sideways

up to a resultant of 6g.

507. Primary structure and mountings for main machinery, equipment and seats shall be designed such that any failure arising from the accelerations quoted in Section 506 is constrained so far as is practical from causing injury to occupants or progressive damage to the vehicle.

508. Seats.

In designing seats and seat support structure and anchor points for seat belts or harnesses, it shall be assumed for the purposes of Section 506 that the combined weight of occupant and seat is 90 kg (200 lb.).

509. Cargo Restraints.

In designing structural provision for cargo restraint, the limiting values of applied loads and their direction shall be declared. Restraint shall be such that any cargo movement resulting from the accelerations quoted in Section 506 shall not cause injury to occupants in their normal seating; shall not cause damage to primary structure, and shall not adversely affect the safe operation of the vehicle.

510. Flexible Structure.

All flexible structure and it's attachments and fastenings shall have adequate strength to withstand anticipated loadings resulting from operation within the design operating envelope. In designing flexible structure intended to support and stabilize the vehicle in cushion-borne operation, the attachments shall be designed to withstand without failure any loads associated with lifting the vehicle from a floating condition in the water.

511. Fluctuating Loads.

All structure shall be designed so as to minimise fatigue or distortion damage arising from vibration, flutter or cyclic loadings.

512. Transmission Loads.

All components within systems transmitting power from engines to lift fans or propulsive devices shall be designed with Proof and Ultimate Factors of Safety of at least 1.0 and 1.5 respectively when considering the most adverse combination of torque, vibration, inertia and gyroscopic loads.

513. All transmission component mountings shall restrain components from breaking loose when subjected to the loadings quoted in Section 506.

514. Transmission components shall be designed to accept the stresses from torque variations by using the following torque values:-

a) Spark Ignition Engines.

4 x mean maximum torque for 2 cylinder engines) Firing 1
2 x mean maximum torque for 4 cylinder engines) cylinder
1.5 x mean maximum torque for engines with more) at a time
than 4 cylinders)

b) Compression Ignition Engines.

4 x mean maximum torque for 2 cylinder engines)Firing 1

3 x mean maximum torque for 4 cylinder engines)cylinder

2.25 x mean maximum torque for engines with more)at a time

than 4 cylinders)

c) Gas Turbine Engines.

1.33 x maximum operating torque.

515. It shall be the designer's responsibility to ensure that the output characteristics of any engine, in terms of power, speed and torque, and the vibratory characteristics of all components driven by it, and of their mountings, do not result in any resonant vibrations or fluctuations which would lead to premature component failure or structural damage, throughout the engine's operating envelope.

516. Design Calculations.

The designer shall submit calculations resulting from consideration of the loadings required by this Chapter to demonstrate compliance with safety factor requirements under the most adverse operating conditions within the design operating envelope. Calculations shall take due account of any effects upon material strength resulting from fabrication techniques, using normally recognized practices.

550. Hydrodynamic Loading.

In submitting design data for approval, the designer shall provide estimates of the weight and c.g. position of all major vehicle structural, machinery and equipment components, and of the vehicle and it's maximum design weight, together with the radius of gyration in pitch both at maximum design weight and at a representative minimum operating weight.

These data shall be used to prepare and submit for approval a structural analysis resulting from wave impacts giving rise to maximum accelerations. An acceptable development of the loadings to be considered is outlined in the Appendix to this Chapter.

551. The hull structural strength in bending shall be analysed for at least 3 wave impact cases:-

a) Symmetrical bow impact;

b) Impact at the c.g.;

c) Symmetrical stern impact.

552. Combined torsional and bending strength of the hull structure shall be analysed by investigating an assymmetrical bow impact with conditions giving rise to the most severe loadings within the design operating envelope.

553. For design analysis purposes, the distributed pressure on the bottom skin plating may be assumed to be 44% of the peak impact pressure determined from paragraph 3 of the Appendix.

Appendix to Chapter 5

Hydrodynamic Loading structural analysis.

1. Vertical acceleration of vehicle c.g. in response to wave impact

The vertical acceleration of the c.g. may be obtained from:-

$$N_{w=} \frac{0.12.k_1.V.V_v}{w^{1/3}(1+x^2)^{2/3}}$$

Where N_w is the vertical acceleration of the c.g., in g

k_1 is a hull station weighting factor, reducing linearly from a value of 1.5 at the bow to a value of 1.0 at the station of the longitudinal c.g., thereafter remaining constant.

V is the vehicle velocity relative to the water

V_v is the vehicle vertical relative velocity, given by:-

$V_{v=}$ $\frac{2.26. .h}{\sqrt{l}}$ + 0.61 m/sec (2 ft/sec)

where h is wave height;

λ is wave length, and

$\frac{h}{\lambda}$ is 10

W is vehicle weight

x is the ratio of the length between the impact point considered and the c.g. to the radius of gyration in pitch.

It will be noted that the maximum value of N_w will not necessarily result from consideration of maximum values of W or of V.

2. Rigid Vehicle Response.

The complete response of the vehicle, assumed to be rigid, to a wave impact, shall be determined in order to provide a longitudinal spectrum of acceleration to be applied in performing the required structural analysis. The accelerations shall be determined by:-

$$a = \frac{N_w (1+{}^{L}1{}^{L}2)}{K^2}$$

Where:-

N_w is the c.g. vertical acceleration previously determined

a is the acceleration at the station considered

L_1 is the distance between the wave impact and the c.g.

L_2 is the distance between the station considered and the c.g.

K is the vehicle radius of gyration in pitch

Since the vehicle is rigid, the relationship of acceleration to longitudinal station is linear and only 2 values of L_2 need be considered; the full spectrum may be clearly presented graphically.

3. Local Impact Pressures.

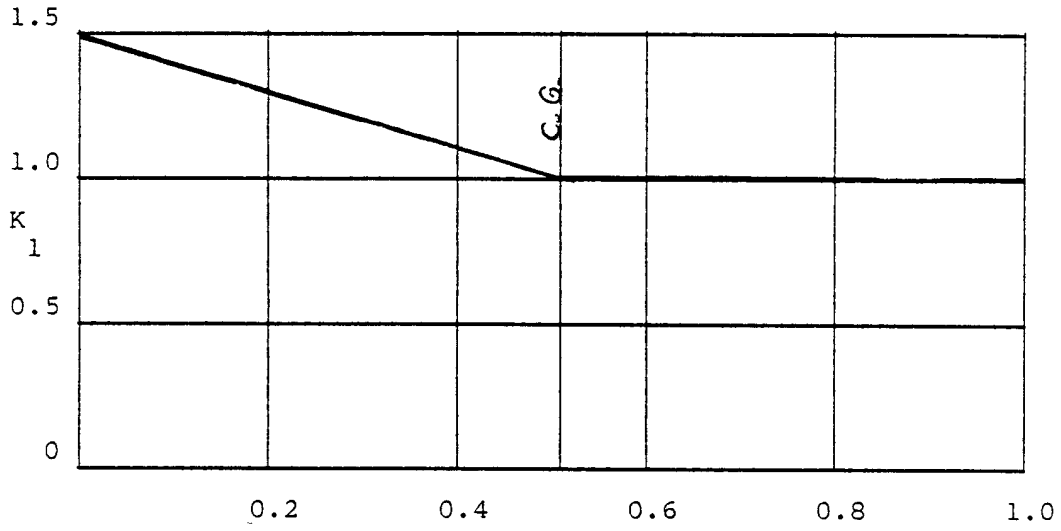
In designing hull structure underside plating, the designer shall take account of local pressures due to wave impacts, derived from:-

$P = 0.0162\ K_2\ V.V_v$ where

K_2 is a length-related weighting factor, varying linearly from a value of 2.0 at the bow to 1.0 at 22% of the hull length, thence continuing at 1.0.

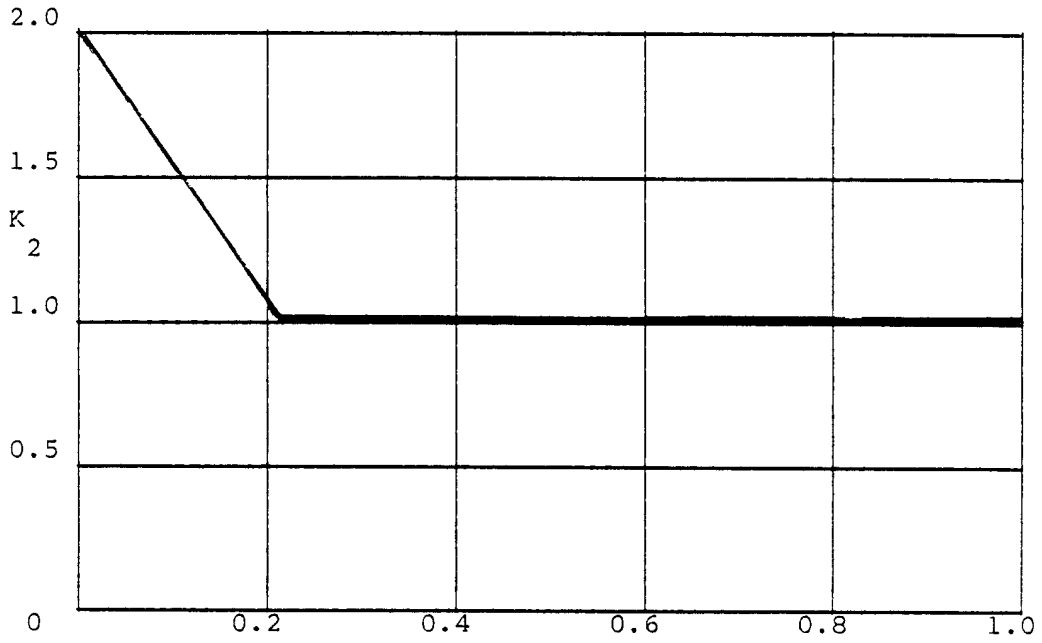
V, V_v are as in paragraph 1 above.

Figure 1.



Distance from bow
Bottom length

Figure 2.



Distance from bow
Bottom length

Chapter 6 - Materials

601. Rigid Structure

The designer shall select materials for rigid structure which are of appropriate strength and which have resistance to sea water corrosion and contamination by fluids used in operation of the vehicle. The hull should be of non-combustible material (but see 603).

602. In submitting data and drawings for approval, standard specification data for all material used in primary structure shall be provided.

603. Where glass-reinforced plastics or composite materials are used in the design, submitted data shall also include manufacturer's data relating to fire resistant properties of the material. The results of standard fire tests on representative samples may be required.

604. The design shall make due provision to prevent electrolytic corrosion due to dissimilar metal contact.

605. Flexible Structure

In submitting design data for approval, the designer shall include manufacturer's design and test data relating to the composition, weight and tear strength of any material used for flexible or inflated structure and components of the cushion system or buoyancy.

606. Flexible materials shall be selected with due consideration being given to service environmental conditions, and to the material's resistance to deterioration due to contamination from vehicle working fluids, and from exposure to ozone and ultra-violet radiation. Due regard shall also be paid to the material's resistance to fire.

607. Non-structural Materials

Any material used for insulation, decoration, covering or furnishing shall be of at least low flame spread standard. Where used in locations where they may become contaminated with flammable fluids, they shall be impervious to absorption of those fluids, and shall be self-extinguishing.

608. Manufacturer's data shall be provided for any foam materials used for buoyancy or for stabilizing movement of fluids in tanks.

609. Any foam material used for buoyancy shall be of closed-cell composition, and shall be structurally and chemically stable in service conditions; in addition, it shall not promote corrosion of surrounding structure, or generate corrosive or noxious vapours.

Chapter 7 - Main Machinery

701. Definition

Main machinery means all components used in the generation, transmission and conversion of power for lift and propulsion of the vehicle.

702. Main engines

Main engines shall be installed such that they are provided with adequate services to ensure that no operating limitations to which they may be subject shall be exceeded.

703. In submitting date for approval, the designer shall include all engine manufacturer's design and test data relating to weight, power-torque-speed characteristics, safety devices, any recommended limitations, and any special installation or operating requirements or instructions relating to the particular variant or model of the engine proposed. The information shall include details of any previous certification or approval issued in respect of the engine model or variant.

704. Any engine design proposed, which has not previously been used in an A.C.V. or essentially similar installation, or which requires modification affecting it's structural integrity oroperating characteristics will require the provision of additional data as appropriate. Applicable engine testing may be required.

705. In designing the engine and transmission installation, the designer shall ensure that the engine output characteristics in terms of power, torque, speed and vibration will not induce any resonant vibrations or fluctuations throughout the power transmission system which would lead to premature component failure or structural damage throughout the engine operating envelope.

706. All services provided to a main engine shall include adequate protection against contamination, erosion and icing of the engine and of air, fuel, coolants and lubricants supplied to it.

707. In designs employing multiple engines or engines containing coupled power-packs, arrangements shall be made to ensure that the failure of one engine or power-pack, or of services supplying the engine or power-pack, may be isolated to permit continued operation of remaining engines or power-packs.

708. All engines shall be provided with warning and protection devices which will activate in the event of approved limitations being exceeded. Such devices should include, where applicable, engine r.p.m., power, torque, oil temperature or pressure, coolant temperature, and exhaust gas temperature. Warnings shall be provided at any station from which the engine may be controlled; protection devices should not shut the engine down except where it is essential to avoid immediate hazard to safety of the vehicle and occupants. Any undesirable effects resulting from the operation of a protection device are to be declared.

709. Main engines containing high-energy rotors shall be designed and installed so as to minimise damage or injury in the event of a rotor or engine failure.

710. All main engines shall be installed within Designated Fire Zones; multiple engine installations may be approved within one Designated Fire Zone subject to satisfactory arrangements for fire containment and suppression. (See Chapter 10).

711. The design of all exhausts of hot or noxious fluids and gases shall ensure minimum risk of damage to structure or components and injury to personnel; no such fluids shall be exhausted into the cushion. Where exhausts penetrate any vehicle structure, adequate insulation or shielding shall be provided. No exhaust shall be positioned such that failure or leakage could adversely affect the normal operation of controls, and discharges shall be so sited that exhaust fluids cannot be re-ingested into the vehicle or cushion. Any exhaust, the lowest point of which discharges less than 76 mm. above the surface of the water when the vehicle is floating at maximum certified weight shall be provided with means to prevent the ingress of water. (See also 1070)

712. The designer shall ensure that all appropriate measures have been taken by the engine manufacturer, and in the engine installation design, to minimise the effects of salt ingestion by the engine on it's operation, and generally to protect the engine from corrosion.

713. The designer shall establish with the engine manufacturer that design of the engine installation and of services to the engine are satisfactory for operation of the engine within established limitations.

714. The engine installation shall be such as to minimize any adverse effect upon it's operation of the failure of any component driven by it.

715 All engines and their accessories shall be mounted and secured such that they shall not break loose under the acceleration loadings quoted in Section 506.

716. Engine and engine accessory mountings and couplings shall ensure that the effects of any engine vibrations upon vehicle structure or other components are minimised.

717. All engines shall be installed such that any excess fuel or oil supplied to them is contained and drained to a safe fire-resistant receptacle.

718. The designer shall submit a fault analysis to indicate the effect of all likely faults of main machinery components and controls upon vehicle operational safety.

719. All machinery spaces containing main machinery components shall be adequately ventilated to disperse any accumulations of toxic, noxious or inflammable vapours. Designated Fire Zones containing engines shall have additional ventilation arrangements (see Chapter 10).

720. Any machinery space which may be entered by crew members while the vehicle is operating shall be treated to reduce noise levels as far as practical, and shall be provided with 2-way communication with the crew station from which the vehicle is normally manoeuvred.

721. When Diesel engines are used as main machinery, fuel injector pipes shall either be double-walled or arranged so that, in the event of a leak or failure, the leaking fuel is contained and drained to a safe receptacle which is provided with a remote-reading level indicator displayed in the compartment from which the vehicle is normally manoeuvred.

722. Diesel engines with a cylinder diameter in excess of 200 mm. or a crankcase volume in excess of 0.6 cu.m. are to be fitted with adequate crankcase explosion relief valves oriented so as to minimise the risk of damage and of injury to personnel.

723. Any arrangements for compressed air systems for starting or controlling Diesel or other engines shall be submitted for approval, with particular reference to precautions against fire and explosion.

724. The engine installation shall ensure that adequate lubrication and cooling is provided to maintain the engine within recommended limits under all normal and emergency motions and attitudes of the vehicle. Lubrication and cooling systems shall include appropriate warnings in the event of failure.

725. Engines and components to which liquid systems are connected shall be so installed and arranged that any leakage from a liquid system will drain to a receptacle containing an automatic bilge alarm providing indication at the station from which the vehicleis normally manoeuvred.

726. Controls for all main engines and permanently installed Auxiliary Power Units shall be provided in the compartment from which the vehicle is normally manoeuvred such that power output may be varied and maintained within approved limits. At least two means of stopping engines, using controls connected directly to the engine, shall be provided; one shall be an emergency shut-down. Any undesirable effects resulting from operation of the emergency shut-down device shall be declared.

730. Starting Systems.

Installed sources of stored energy intended for use in starting main engines or auxiliary power units shall be of sufficient capacity to permit, without replenishment, 3 consecutive attempts to start any engine or auxiliary power unit to which it may be connected when following the engine or power unit manufacturer's recommended starting procedure.

731. Where starting of an engine or auxiliary power unit is dependent, in the absence of any other power source, upon such a source of stored energy, means shall be provided for replenishing the stored energy and maintaining it while the vehicle is in normal operation.

732. The starting system shall remain effective under conditions of failure of normal electrical power supply, and with the vehicle in any attitude as a result of damage considered in Chapter 3.

740. Fans.

The installation of any fans designed for lift or propulsion shall be designed to minimise loss of performance due to obstructions, provided that adequate provision is made to safeguard intakes from ingesting foreign objects and to minimise the risk of injury. The effects of intake icing shall be considered.

741. In submitting design data for approval, the designer shall include fan manufacturer's design and test data relating to structural integrity, pressure-flow characteristic, power absorption and maximum speed. Any manufacturer's recommended operating limitations and special installation instructions or requirements shall also be included.

742. Fan installations shall be designed so as to minimise the risk of damage to the vehicle or injury to occupants in the event of disintegration. Where this is not achieved by physical separation or position, appropriate energy-absorbing physical protection may be required.

743. Any fan design proposed which has not previously been used in an A.C.V. or an essentially similar installation, or which requires modification affecting it's structural integrity or operating characteristics, shall be subject to an overspeed test of 120% the maximum intended operating speed for at least 30 seconds. Where an existing fan design has been modified, details of the modifications shall be provided.

744. In designs incorporating the use of multiple lift fans, the installation shall include provision for preventing loss of lift air in the event of one lift system being inoperative.

745. Fans shall be so installed as to minimise damage due to contact with water.

746. The installation of fans shall make adequate provision to minimise the onset of corrosion and erosion.

Propellors

760. Propellors shall be installed so that the swept area of the propellor disc is totally within the planform boundary of the vehicle.

761. In submitting design data for approval, the designer shall include propellor manufacturer's design and test data relating to structural integrity, power absorption, thrust characteristics and maximum speed. Any manufacturer's recommended operating limitations and special installation instructions or requirements shall also be included.

762. The installation shall provide adequate safeguards against the ingestion of foreign objects and to minimise the risk of injury; the effects of icing shall be considered.

763. The installation shall be designed to provide as free inlet conditions as practical, and shall minimise the possibility of cyclic loading due to inlet turbulence.

764. Any propellor design proposed which has not previously been used in an A.C.V. or an essentially similar installation, or which requires modification affecting it's structural integrity or operating characteristics shall be subject to an overspeed test of 120% maximum intended operating speed for at least 30 seconds. Where an existing propellor design has been modified, details of the modification shall be provided.

765. Propellor manufacturers shall make adequate provision to minimise the effects of erosion of blades on structural integrity and performance.

766. The installation of propellors shall include measures to minimise the effects of corrosion, galvanic action or cavitation.

Transmissions

780. The designer shall provide data as appropriate from the manufacturer of any gearbox, belt, clutch or coupling, the integrity of which under the intended service conditions is essential for the safe operation of the main machinery. Such data should relate to structural integrity, power loadings and speeds, and should include any manufacturer's recommended operating limitations or special installation requirements or instructions.

781. Design calculations for all shafting shall be submitted; first order critical (whirling) speed shall be not less than 110% the shaft maximum designed operating speed.

782. All transmission components shall be provided with adequate safeguards to prevent injury to personnel when operating, and to prevent injury or damage in the event of a failure.

783. No transmission components shall be situated in, or pass through, compartments normally occupied by passengers or crew members.

784. Components, or assemblies of components, of transmission systems may be required to be subjected to an agreed test schedule.

785. Selection and installation of any clutch shall ensure that normal engagement does not induce abnormally high stresses in the system; the system should also provide safeguards against dangerously high stresses being generated by inadvertent operation of the clutch.

786. Transmission systems shall, to the maximum extent practicable, incorporate safeguards such that a single failure in the system will not result in progressive damage which may hazard the safety of the vehicle or it's occupants.

787. Any lubrication system upon which the transmission depends for it's safe operation shall be designed and installed to ensure operation within recommended limits, and shall incorporate a warning device displaying at the vehicle control position.

Machinery Installation Testing.

790. Any machinery testing required by previous sections of Chapter 7 - e.g. 704, 743, 764, 784 - shall relate to the individual integrity of the machinery component.

791. Additionally, testing shall be carried out of all machinerywhen installed in the vehicle. Such testing will be to an agreed schedule consistent with the configuration of the installation, specifically relating to demonstrating the structural integrity of the machinery in the designed installation under all conditions of the operating envelope of the machinery.

792. The test schedule referred to in 791 shall include tests to demonstrate, where applicable :-

a) Full and adequate control and governing of engine and power train components throughout the machinery operating envelope;

b) Adequate provision of cooling and ventilation media to ensure that approved limitations are not exceeded within the operational and environmental envelopes of the vehicle;

c) Freedom of all components of power trains when installed in the vehicle and operating at any point within the machinery approved limitations from any power surges, engine stalls and vibratory resonances likely to cause component or structural mounting failure;

d) Effectiveness of all warning and protection devices installed, including engine emergency shut-down.

Chapter 8 - Auxiliary Power Units

801. In designs incorporating the use of an auxiliary power unit, the designer shall submit manufacturer's data relating to design, power output, and control, together with any recommended operating limitations, and special installation instructions or requirements.

802. Mountings or stowages for auxiliary power units shall restrain the units from breaking loose under the acceleration loadings quoted in Section 506.

803. The installation or stowage of auxiliary power units shall provide adequate protection against corrosion, and against contamination of all working fluids supplied to the unit.

804. All services essential for the safe operation of the auxiliary power unit shall be independent of, or capable of isolation from, those services provided for main engine operation.

805. Auxiliary power units which are permanently installed shall be contained in a Designated Fire Zone. (See Chapter 10).

806. Installation of auxiliary power units shall be arranged to provide ready access for starting, controlling and operating the units under emergency or damage conditions within the vehicle's design environmental envelope.

807. Designated Fire Zones containing an engine of an auxiliary power unit shall be provided with forced ventilation arranged such that the engine may not be started until ventilation has been initiated.

808. Exhaust systems of auxiliary power units will be required to comply with the requirements of Section 711.

Chapter 9 - Fluid Systems

901. General

All components forming part of a system designed to contain fluid under pressure shall be designed with a safe working pressure of 1.5 times the maximum working pressure to which they will be subjected in service.

902. All components shall have Proof and Ultimate Factors respectively of at least 1.0 and 1.5 when installed and subjected to the acceleration loadings quoted in Section 506 combined with the design maximum operating pressure.

903. Pressure regulating or relief devices shall be provided to protect systems and components against excessive pressure build-up.

904. All systems shall include adequate protection against contamination; provision for foreign solid or liquid separation or filtration shall be made, at least to the standard prescribed by the manufacturer of any component to which the fluid is being supplied.

905. Provision shall be made to maintain the working temperatures of all fluids within component manufacturer's prescribed limits. Any associated coolers shall be designed and installed so as to ensure an uninterrupted flow of cooling medium at the required rate under all vehicle designed operational conditions.

906. The designer shall ensure that all materials used in a system are compatible with the contained fluid, and shall make provision to protect all system components from marine and electrolytic corrosion and from erosion.

907. All systems shall be provided with isolating devices to minimize the loss of working fluid and the effect of leaks on safe operation, in the event of a system failure.

908. In all systems, the possibility of syphoning should be considered and safeguards provided to prevent it.

909. In systems with volumetric capacity which varies in operation, consideration shall be given to fluid content requirements throughout the range of operation.

910. All systems installations shall be designed to incorporate protection against failure due to vibration and fatigue in service.

911. No components containing fluid under pressure shall pass through, or (other than portable fire extinguishers) be contained in, any compartment designed to accommodate passengers, or to which passengers may have access.

912. At any location where regular servicing operations may cause spillage of working fluids, adequate access or means for removal of spillage shall be provided.

913. Any working fluid drainage associated with normal service operation shall be channeled overboard or to drainage receptacles. (but see 924).

914. All fluid replenishment points shall be provided with positive securing caps, and notices defining the replenishment fluid.

915. Any system component with a normal operating surface temperature in excess of 60°C shall be guarded to prevent direct personal contact.

916. All systems should be designed with provision for the expulsion of trapped air, and such that they cannot cause air entrainment into the system.

917. Pipes and components containing fluids shall, so far as practical, be routed or positioned so as to minimise the possibility of vapour lock or syphoning action while systems and machinery are operating or after shut-down.

918. All components of pressurized systems containing flammable fluids which are mounted on, or contained within, the boundaries of a Designated Fire Zone shall be of fire resisting material.

919. All metallic pipes shall be electrically bonded to form a continuous electrical path, and shall be adequately grounded.

920. All systems shall include indication of fluid content level and where appropriate, of working fluid temperature and pressure. Indications shall be readily visible to a crew member at his normal duty station.

921. Adequate ventilation shall be provided where operation of components or maintenance and servicing operations may result in the accumulation of flammable liquids or vapours.

922. Pipes, valves, couplings and components carrying flammable fluids shall be constructed of steel; alternate materials will be subject to approval, consideration being given to the location, service and fluid working pressure. (See 944).

923. Where fluid other than fuel is used as a ballast or trim medium, the ballast or trim system is to be arranged so as to be isolated from other fluid systems in the vehicle.

924. Overboard Discharges.

No openings shall be provided which would permit the A.C.V. when normally operating to discharge liquids overboard, other than:

a) Bilge water;

b) Circulating water used for cooling machinery;

c) Potable water used for drinking or washing;

d) Air conditioning condensate and windscreen washer fluids.

925. Hull Openings.

Any openings as permitted by 924, or for cooling water intake or exhaust discharge, which at their lowest point are less than 76 mm. above the final floating waterline subsequent to the damage considered in Chapter 3 of this Standard shall be provided with an effective means of closure at the hull surface.

926. Approval of Pressurized Components.

Plans and data for approval of any component subject to pressure in normal operation shall be submitted unless the component has been constructed to the requirements of a recognized code, and in which :-

a) The working pressure is less than 103 kPa, or

b) The internal volume subject to pressure is less than 0.14 m^3 and the working pressure is less than 690 kPa, or

c) The internal volume subject to pressure is less than 0.04 m^3 or the internal diameter subject to pressure is less than 152 mm., with no limit on pressure.

930. Fuel Systems

Fuel tanks and fuel system components shall be so positioned as to minimize the risk of leaks due to vehicle damage.

931. Fuel tanks shall be so positioned that fuel contents and usage will either have negligible effect upon pitch and roll trim of the vehicle, or can be managed to provide pitch and roll trim corrections.

932. Fuel tanks shall be designed to minimize the effect of fuel sloshing on structure and on vehicle motion.

933. Where fuel tanks are integral with the vehicle structure, all joints shall be designed to be fuel tight under all service conditions; such tanks will be required to be subject to pressure testing. (See 3210).

934. Where fuel is stowed in flexible bladders contained within a structural space of the vehicle, installation of the bladder shall be such that there is minimal relative movement of the bladder under all service conditions and over the complete range of fuel contents. In submitting data for approval, manufacturer's design and test data for fuel bladders will be required.

935. All fuel tanks, and spaces containing fuel bladders, shall be vented to atmosphere through flame-proof anti-syphon vents. Vent piping for fuel tanks shall be sized such that fuel system components and fuel tanks are not subjected to pressures in excess of normal working pressure during refuelling operations.

936. Installation or stowage of portable tanks intended for fuel stowage, including those associated with auxiliary power units, shall be approved.

937. All fuel filling points shall be provided with a readily accessible bonding point.

938. All tanks designed for fuel storage shall be physically separated from Designated Fire Zones by as large a distance as practical (but see 943).

939. All pipes supplying fuel to an engine shall include a shut-off device capable of being operated from the station from which the vehicle is normally manoeuvred so as to prevent fuel from entering a Designated Fire Zone. Additionally, any pipe supplying fuel under gravity shall have a similar device installed as close as practical to the fuel storage tank to which it is connected.

940. All permanently installed fuel tanks feeding main engines or Auxiliary Power Units shall be equipped with an effective remote-reading contents indicating system with display in the compartment from which the vehicle is normally manoeuvred.

941. All fuel system components shall be separated from electrical components, hot surfaces, and intakes by as large a distance as practical.

942. Fuel tanks should be separated from passenger accommodation by as large a distance as practical; no component containing or carrying fuel or fuel vapour shall pass through, or require control or adjustment from, any compartment to which passengers have access, cargo space, or special category space. (See 1035).

943. Any permanently installed receptacles or tanks designed to contain fuel and which are situated in Designated Fire Zone shall be made of steel. Their installation arrangements shall be approved, and shall include adequate precautions to minimize the risk of rupture or explosion in the event of a fire in the Zone. Capacity in any event shall not exceed 300 litres.

944. All pipes, valves and couplings through which fuel or fuel vapour may pass shall be steel or equivalent material within Designated Fire Zones. Elsewhere, and subject to approval, other materials may be used; in such cases the components shall be readily accessible and visible for inspection.

945. Penetrations of watertight and fire-resistant boundaries by fuel pipes shall be by way of secured rigid fittings; penetrations of other structure shall provide adequate protection against chafing or other damage.

946. Fuel vent discharges shall be so sited as to minimize the risk of re-ingestion of fuel vapour into the vehicle or the cushion.

950. Bilge Systems

All spaces designed to contribute to intact buoyancy shall be provided with access and means for removing accumulated fluids.

951. Where this means of removal is designed as a permanently installed bilge pumping system, provision shall be made to prevent transfer of fluid from one buoyancy space to another through the system.

952. Bilge pumps connected, or capable of connection, to the bilge pumping system shall be capable of efficient operation under any vehicle attitudes resulting from damage considered under Sections 310 and 311.

953. Two pumps shall be available for removal of bilge water, one of which shall be dedicated to bilge pumping. Pumps may either be permanently connected to the bilge pumping system, or portable.

954. Any pump used for bilge pumping which has a rated output in excess of 1.5 tonnes per hour shall be power driven.

955. The output of each pump used for bilge pumping shall be not less than that given by:-

$$Q = 3.75\ (1+L/36)^2$$

Where Q is the rated pump output in tonnes hour, and

L is the floating waterline length of vehicle rigid structure in metres, at maximum certified weight.

956. In vehicles of less than 20 tonnes empty weight, the requirements of Section 955 may be relaxed, provided that the rated output of each pump is not less than 1 tonne per hour.

957. All bilge pump suctions shall be fitted with strainers, and shall not be of less than 25 mm. internal diameter.

958. Bilge pumping systems installed in marine sidewall A.C.V's shall be so arranged that bilge pumping of compartments may be automatically accomplished when the vehicle is unattended in the water.

959. Functioning of any bilge pump operating automatically shall be indicated at the crew station from which the vehicle is normally manoeuvred.

Chapter 10 - Fire Safety.

Application.

1001. The requirements of this Chapter define the minimum fire safety standards to be applied to A.C.V's in which fuel with a flash point, as determined by an approved closed cup method, in excess of 38°C is used. The use of fuels with lower flash points may require additional provisions.

Definitions.

1002. a) Designated Fire Zone - any space containing machinery using fuel, or any space where electrical equipment is operating in close proximity to fuel system components or in an atmosphere potentially capable of promoting combustion or explosion, is defined as a Designated Fire Zone.

b) Incombustible - a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to 750°C, as determined by an acceptable test method, is defined as incombustible. All other materials are regarded as combustible.

c) Standard Fire Test - a test in which representative specimens of structure, which should be of not less than 4.65 sq.m. in area, are exposed in a test furnace to temperatures approximating to the following time-temperature relationship:-

After 5 minutes - 538°C.

After 10 minutes - 704°C.

After 30 minutes - 843°C.

After 60 minutes - 927°C.

d) Low Flame Spread - a material which, when subjected to an appropriate approved test, adequately restricts the spread of flame. Such a test as Test No. Ul-723 of the Underwriters Laboratories Inc. (U.S.A.) and conforming to Underwriters Laboratories of Canada Standard S.102, would be acceptable. When so tested, the flame spread rating shall not exceed 20.

Structure

1003. The hull of the vehicle should be constructed of incombustible material. Where such material is not used, it shall be treated or protected by means which shall be specifically approved subject to satisfactory results of representative fire testing.

1004. Divisions forming boundaries between a Designated Fire Zone and other enclosed spaces within the vehicle shall be of incombustible material, or shall be insulated in the Designated Fire Zone such that they will prevent the passage of smoke and flame without collapse for the greater of 30 minutes or 3 times the demonstrated evacuation time of the total complement into survival craft plus 7 minutes. Other boundaries shall be of similar fabrication to the maximum extent possible, and shall as a minimum be capable of preventing the passage of smoke, flame and gas from the Designated Fire Zone for sufficient time to contain, in the required concentration and for the required time, two successive discharges of fixed or portable fire extinguishers provided for protection of the Zone.

1005. Divisions designed to comply with Section 1004 and which are not constructed of steel shall be insulated so that during the first 30 minutes of the standard fire test, the core temperature does not exceed 200°C above ambient. All divisions shall be insulated such that the temperature of the surface on the remote side after 30 minutes of the standard fire test does not exceed 139° C above ambient; at locations where persons may come into contact with the remote surface, the surface temperature shall not exceed 70°C after 30 minutes of the standard fire test. Insulation shall not give off toxic vapours.

1006. All equipment, components, pipes and cables within, or attached to the inside surfaces of boundaries of, Designated Fire Zones shall be of incombustible material; electrical equipment shall additionally be designed and constructed so as to prevent the generation of sparks or flashes.

1007. No penetration of a boundary of a Designated Fire Zone shall reduce the fire integrity of that boundary. Where penetrations are essential to provide access to the atmosphere for the normal operation of equipment within the Zone, such penetrations shall be provided with fire resistant closings which may be remotely operated and which comply with the requirements of Section 1004.

1008. All material within a Designated Fire Zone, and elsewhere in the vehicle where it may become contaminated with flammable fluids, shall be impermeable to such fluids.

1009. All furnishings, insulation, trim, flooring and facing materials shall be of at least low flame-spread rating, or be treated to have an equivalent rating.

1010. Structural fire protection as appropriate to the vehicle layout may be required for compartments other than Designated Fire Zones, from which the vehicle may be controlled.

Fire Detection.

1011. All Designated Fire Zones shall be provided with remote-indicating detection equipment providing indication at the crew station from which the vehicle is normally manoeuvred. The arrangement and type of detection equipment shall provide the most effective indication of a potential fire hazard in the Zone being protected, and the equipment installed in a Designated Fire Zone shall not be associated with similar equipment installed in other Designated Fire Zones or other spaces. Indication shall be both visual and audio.

1012. All detection systems shall be re-settable after they have provided a hazard indication, and shall incorporate a test facility to indicate system integrity and serviceability at the station from which the vehicle is normally manoeuvred.

1013. All fire detection systems shall be capable of efficient operation in the event of total failure of electrical power generation, and they shall be permanently connected to a source of electrical power at all times that such power is available to or in the vehicle.

1014. Fire detection systems shall be intalled to withstand the acceleration loadings quoted in Section 506 without affecting their efficient operation.

Fire Suppression.

1015. All Designated Fire Zones shall be provided with remotely controlled fire suppression systems, with controls provided at least at the crew station from which the vehicle is normally manoeuvred. The type, quantity and distribution of fire extinguishant, and the arrangement of controls, shall be approved. In submitting data for approval, the designer shall include all appropriate calculations. A fire extinguishant discharge and retention test may be required.

1016. No fire extinguishant storage container shall be installed in a Designated Fire Zone; installation arrangements shall ensure that the storage containers are maintained within approved limits of environmental conditions appropriate to the extinguishant, as determined by the National Fire Protection Agency Standard Codes.

1017. All fire extinguishant storage containers shall, for extinguishers manufactured in Canada, bear the approval label of Underwriter's Laboratory of Canada; extinguishers manufactured in the United Kingdom or United States shall be approved for marine use by the British Department of Trade and Industry or by the United States Coast Guard respectively. They shall be installed so that the quantity contained may be readily determined.

1018. In spaces designed for passengers accommodation, and in crew compartments, approved portable fire extinguishers shall be provided in readily visible and accessible stowages clearly marked; the quantity, type and distribution shall be approved, based upon the vehicle layout and the space to be protected.

1019. All fire extinguishant containers shall be stowed such that, when subject to the acceleration loadings quoted in Section 506, they will be retained and the loading will not affect their efficient operation.

1020. In vehicles where boundaries of Designated Fire Zones contain openings, the fire extinguishing system shall be arranged so that extinguishant cannot be discharged until all such openings are closed.

1021. Designated Fire Zones containing an engine or part of an engine used for vehicle lift or propulsion shall be provided with means of discharging a second fire extinguisher. Where this extinguisher is provided primarily for the protection of another space, it's alternate selection shall require a distinctive action. Where practical, use of a portable extinguisher may be approved for the second discharge, in which case a suitable fire-resistant frangible closure in the fire-resistant boundary shall be provided.

1022. Electrical circuits associated with activating the discharge of fire extinguishant shall have a test facility provided, operable at the crew station from which the vehicle is normally manoeuvred.

1023. All electrical circuits associated with activating the discharge of fire extinguishant shall be capable of efficient operation in the event of total failure of electrical power generation, and they shall be permanently connected to an electrical source of power at all times that such power is available to or in the vehicle.

1024. All indicators, test facilities and controls associated with fire detection and fire suppression systems shall be provided at a station or stations at which crew members other than the operator of navigational radar are stationed in their normal duties. In vehicle designs where machinery in Designated Fire Zones may be operated from local controls, fire suppression system controls shall be positioned immediately adjacent to the exit from the Zone, on the external face of the fire-resistant boundary. Such controls shall include all those necessary to ensure efficient operation of the fire extinguishant discharge system.

1025. Any multiple installation of fire extinguishant controls in compliance with Section 1024 shall be so arranged that the controls at all stations are effective at all times.

Supplementary Fire Safety Measures.

1026. Where the designer proposes to use materials containing chemical treatments or mechanical applications of materials intended to improve the fire suppression or extinguishing properties of the material, he shall submit all relevant data and test results from the manufacturer of the protective treatment. Upon review of these data, additional testing may be required. No treatment or application which depends for it's effectiveness upon the emission of noxious or toxic vapours will be considered for use in a compartment which may be occupied when the vehicle is in normal operation.

Fixed Fire Extinguishant Media.

1027. Where gaseous media in the form of either carbon dioxide or a halogenated hydrocarbon are used, quantities shall be provided such that the following concentrations result from a single discharge into the space being protected:-

Carbon Dioxide	-	30% of gross volume being protected.
Halon 1211	-	5 to 5.5% of net volume of space being protected.
Halon 1301	-	5 to 7% of net volume of space being protected.
Halon 2402	-	to be provided on a mass per unit volume basis, between 0.20 kg/m^3 and 0.30 kg/m^3 net volume.

For the purposes of determining quantities required, volumes of media shall be calculated as follows:-

Carbon Dioxide	-	0.56 m^3/kg.
Halon 1211	-	0.14 m^3/kg.
Halon 1301	-	0.16 m^3/kg.

Additional guidance data relating to the design of fire suppression systems should be sought from the appropriate standard of the National Fire Protection Agency (NFPA).

1028. Systems shall be arranged so that discharges shall be substantially complete:-

For carbon dioxide - 85% of gas discharged within 2 minutes.

For halogenated hydrocarbons - liquid phase discharge complete within 20 seconds.

1029. Where other media are proposed for fixed fire extinguishing installations, full supporting data are to be provided by the designer, indicating that protection equivalent to that provided by Sections 1027 and 1028 will result.

Portable Fire Extinguishers.

1030. Portable fire extinguishers when fully charged shall have a total weight of not more than 23 kg.

1031. Fire extinguishers containing water shall not be provided in spaces containing electrical equipment or components operating at voltages in excess of 55 volts.

1032. Fire extinguishers containing dry powder chemicals shall not be provided in compartments containing switchboards, open electrical connections or electronic equipment.

Doors and Exits.

1033. Doors between passenger accommodation and spaces in the vehicle to which the crew may have access which are not required to be either fire-resistant or watertight shall be designed and installed so as to minimise the passage of smoke and vapours when closed.

1034. Doors and personnel accesses in fire-resistant boundaries shall be hinged to open outwards from Designated Fire Zones to which they provide access, and shall have effective means of opening and of securing to preserve fire-resistant integrity, operable from both outside and inside the space.

Special Category Spaces.

1035. A special category space is an enclosed space provided for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which they may be driven and to which passengers have controlled access.

1036. Special category spaces shall be provided either with a fixed fire extinguishing system or with adequate semi-portable fire extinguishers, subject to a minimum of two such extinguishers being provided.

1037. The design and installation of all fire safety provisions made for the protection of special category spaces, including alarms and controls and such provisions, shall be determined and approved taking into consideration the volume and arrangement of the space.

1038. Where the discharge of fixed fire extinguishant media may result in significant accumulation of liquids in the space, adequate arrangements for drainage shall be provided.

1039. All electrical equipment installed in a special category space shall be certified safe for operation in explosive vapour/air mixtures, and all electrical cables shall be contained in protective conduits. No electrical equipment shall be installed less than 0.45 m. above the deck of the space.

1040. All doors and exits for passengers and crew members giving access to or from the special category space shall be provided with effective means of securing in the closed position, operable from both inside and outside the space.

1041. Each special category space shall be provided with two-way communication with the crew station from which the vehicle is normally manoeuvred; the arrangement of such communication shall be approved.

Fire Safety Ventilation

1050. Effective forced ventilation shall be provided for all spaces in which flammable fluids or vapours may accumulate. Where such spaces contain machinery or equipment which may be potential sources of ignition, the design shall provide adequate forced ventilation, or means thereof, to ensure that the space is adequately vented prior to start-up of machinery or equipment.

1051. All ventilation discharges shall be overboard and sited to prevent as far as practical the re-ingestion of vapour into the vehicle or cushion.

1052. Ventilation openings in the boundaries of Designated Fire Zones shall be kept to a minimum consistent with safe operation, and shall be provided with externally operated effective and secure fire-resistant closings. Provision to the maximum extent practical shall be made for their remote operation such that the discharge of fire extinguishant is inhibited until closings are in place.

1053. All ventilation fans controls should be from outside the space they serve, and additionally from inside where the space may be occupied; failure of electrical power to ventilation fans shall be indicated at the crew station from which the vehicle is normally manoeuvred.

1054. Any ventilation duct or trunking passing through a Designated Fire Zone boundary shall, within the Designated Fire Zone, be either:-

a) Constructed and insulated to the same standard as the boundary, or

b) Provided with effective closures at the fire resistant boundary having identical fire resistant properties as the boundary.

1055. Special category spaces shall be provided with ventilation giving a minimum of 10 complete changes of air per hour; indication of failure of power to any fan providing this ventilation shall be provided at the crew station from which the vehicle is normally manoeuvred.

1056. In spaces where flammable liquids or vapours may accumulate and where ventilation is provided by electrical means, all components of the electrical ventilation system within the space shall be of a type certified safe for operation in the particular atmosphere, i.e. "explosion proof", "intrinsically safe", "increased safety".

Materials - Fire Safety.

1060. No materials used in the construction, furnishing or decoration of any spaces normally accessible to passengers or crew members performing their duties when an A.C.V. is operating shall emit toxic smoke or vapours when exposed to temperatures in excess of 60°C.

1061. The use of materials which do emit toxic smoke or vapours when heated above 60°C is to be minimised so far as is practicable and shall be restricted to spaces remote and sealed from spaces to which passengers and crew members have access during normal vehicle operation.

1062. Material manufacturer's or fabricator's data, which may include reports of tests by competent agencies, relating to flammability and emissions resulting from exposure to heat, may be required for any material or material treatment used in the fabrication, furnishings and finishings of a vehicle.

1063. All materials used for thermal and acoustic insulation shall, to the maximum extent practicable, be non-combustible, and shall not give off toxic fumes or vapours when heated in excess of 60°C.

1064. Low density foam materials used for buoyancy shall be non-combustible or self-extinguishing, and their installation shall be shielded to the maximum extent practicable from potential sources of ignition, and from possible contamination by flammable fluids.

Hot exhausts - Fire Protection.

1070. Where any duct or pipe carrying the exhaust gases of engines, galley equipment or other components, passes through or runs along any vehicle structure, bulkhead or plating, the duct or pipe and the structural component are to be adequately separated and shielded with non-combustible material and thermal insulation. When penetrating, the duct or pipe is to be adequately supported to maintain separation; all exhaust runs should be kept as short as practical, supported to prevent distortion, and provided with such expansion measures as may be required to minimise stresses due to thermal expansion. All outlets carrying noxious or toxic fumes, or gases with temperature in excess of 40°C shall have adjacent warning notices.

Appendix to Chapter 10

A. Fire Extinguishant Media.

Generally accepted fire extinguishant media are:-

Liquid	-	water, foam.
Gaseous	-	carbon dioxide, halogenated hydrocarbons (BCF, BCM, Halons)
Solid	-	dry chemical powder.

No liquid medium will generally be permitted in spaces where the extinguishant may contact electrical equipment; exceptionally, liquid extinguishant may be permitted if there is no possibility of it coming into contact with electrical equipment operating at voltages of 55 volts or more.

Gaseous media will not generally be permitted in any space which may contain occupants when the vehicle is in operation. When designing fixed fire suppression systems, it is highly desirable to consult with fire safety specialists; the effectiveness, in particular of halogenated hydrocarbons, is sensitive to the rapidity with which the required concentration can be achieved.

Delays may not only reduce the effectiveness, but can also lead to decomposition of the extinguishant to produce highly toxic products.

Dry chemical powder extinguishants, unless specially formulated, promote corrosion particularly of electrical contacts, leading to delayed electrical equipment failures. Due to their nature, they may permeate widely and are difficult to completely clean up; their use near electrical or electronic equipment is therefore not generally permitted. A further problem with dry chemical extinguishant is the tendency to "cake" under dynamic conditions, which may severely restrict it's effective discharge when required.

B. Material Treatment to Improve Fire Resistance.

Glass reinforced plastics may attain satisfactory fire resistant properties by one of two methods - the resin may be specially formulated to provide fire-resistant properties, or additives may be mixed with the resin. Designers should consult with resin manufacturers to determine how fire resistance is provided, and should ensure that provision of fire resistance is maintained over the life expectancy of the hull or structure considered, and that structural strength of the final material is not adversely affected by the fire resistant treatment.

The use of intumescent paints or treatments, which rely for the provision of fire protection on the release of fire-suppressant vapours in the presence of heat, will only be permitted in spaces normally unattended during vehicle operation. Where they are permitted, full instructions relating to the maintenance of the treatment are to be provided in vehicle servicing and maintenance manuals.

Chapter 11 - Compartment Design.

1100. Passenger Accommodation.

All cabins or compartments in which passengers are accommodated, or to which they have access, shall be provided with adequate room for free movement in the event of an emergency.

1101. Provision shall be made to circulate a temperature-controlled supply of air to all spaces to which passengers have access. Air circulation for accommodation spaces shall provide a minimum of 4.7 1/sec. per person, or 3 complete volume changes per hour, whichever is greater. Air circulation for toilet spaces shall be at least the greater of 10 complete volume changes per hour, or 16.5 1/sec.

1102. All spaces to which passengers have access shall be provided with lighting at all times; under emergency conditions and in the event of normal electrical power supply failure, lighting shall be automatically provided to illuminate evacuation paths, all exits, and toilet spaces.

1103. No electrical equipment, rotating assemblies or equipment containing high pressure or high temperature fluids shall be located in, or pass through, spaces to which passengers have access, unless adequate provision is made to protect passengers from injury.

1104. No components or equipment requiring attention of crew members when performing their normal duties in operating the vehicle shall be located in a space accessible to passengers in such a manner that passengers may impede those crew members in performing their duties.

1105. All spaces to which passengers have access shall be provided with a public address system and visual means to notify them to remain seated or return to their seats.

1106. Handholds, which may be horizontal or vertical bars, or seatbacks, shall be provided in all areas of passenger movement at a convenient height; horizontal spacing shall not exceed 1.25 m. in any direction.

1107. The material of windows shall not break into dangerous fragments if fractured; the positioning of windows shall pay due regard to the external structure and equipment.

1108. Passenger Seats.

Each passenger for which the A.C.V. is certified shall be provided with a seat designed and secured such that the risk of injury to the occupant, in emergency conditions, is minimal. Seats and seat mountings shall be capable of withstanding the acceleration loadings of Section 506 without collapsing.

1109. Any seat which may be folded shall have positive means of securing it in both the stowed and deployed positions. When in the stowed position, it shall not hinder movement nor impede access to any exit.

1110. No seating shall be arranged such that an occupant normally seated will significantly obstruct movement of other persons.

1111. The exterior surface of seats shall be resilient, and the seat design shall contain no sharp unprotected edges, corners or protrusions which may cause injury or damage.

1112. Where seats are used to provide, or are designed for, stowage of lifejackets, such stowage shall afford the maximum possible protection to the lifejacket, which shall be secure but readily accessible.

1113. Passenger Exits.

Each separate compartment designed for passenger accommodation shall be provided with a minimum of two exits. At least one exit shall be used for normal access to and from the compartment, and at least one other exit shall be provided for use in emergency conditions. The number of exits shall be related to their position and size and to the number of occupants for which the compartment was designed, and shall be approved.

1114. All doors used for exits shall be hinged to open outwards and may also be capable of being jettisonned. Doors shall be provided with effective means of securing them in both the open and closed positions. Means of opening, closing and securing shall be simple and obvious, with appropriate instructions as necessary, and shall be operable from both inside and outside the vehicle. The opening and securing operations shall not require undue physical effort such as may impede rapid egress. In securing the door in the open position, the designer shall consider loads associated with winds of up to 100 km./hr.

1115. All doors shall be provided with seals such that, when closed they are effectively water-tight as established by testing in accordance with Section 4003(a) of this Standard.

1116. All exits shall have unobstructed access from both inside and outside the vehicle. Normal exits shall have sufficient space on both sides to provide for passenger assistance by a crew member. All exits shall have sufficient space on the outside of the vehicle to permit safe and ready access to liferaft boarding stations in the event of an emergency.

1117. Emergency exits shall be capable of being opened from both inside and outside the vehicle, and any necessary instructions shall be prominently displayed, together with the location of the exit, immediately adjacent on both sides.

1118. Normal Exit Dimensions.

Normal exits shall provide a clear unobstructed width of not less than 0.76 m.; the height of the opening top from immediately adjacent floor level shall be not less than 1.75 m.

1119. The sill height shall not be more than 0.2 m. above the adjacent floor level on one side; if adjacent floor levels differ on either side of the door, such difference shall not exceed
0.3 m.

1120. Emergency Exit Dimensions.

Any exit designed for use in emergency conditions shall provide a clear unobstructed width of not less than 0.66 m.

1121. The vertical dimension of the opening will depend upon the height of the bottom above immediately adjacent horizontal surfaces inside the vehicle, but shall in no case be less than 0.66 m.

1122. Evacuation Paths.

Passenger accommodation shall provide at least two unobstructed evacuation paths for each passenger. Each path shall be not less than 0.51 m. in width up to a height of 0.66 m., and not less than 0.66 m. in width above that height. Paths shall be at least 1.5 m. in height before the exit is reached.

1123. All exits, stairways and doorways in evacuation paths shall be provided with secure and appropriate handholds or handrails, and non-slip walking surfaces.

1124. Any part of an evacuation path external to the vehicle accommodation, leading to, or forming part of, liferaft boarding stations shall provide a smooth, level and secure foothold, and shall be provided with handrails at an appropriate height.

1125. Evacuation paths shall, so far as practicable, ensure that passengers avoid, and are not required to assemble close to, Designated Fire Zones.

1126. Crew Access to Passenger Accommodation.

In designs where passenger accommodation is not normally attended by crew members, internal access to it, having the same dimensions as required by section 1122 shall be provided for a crew member from his normal duty station.

1127. Cabin Attendants.

In passenger accommodation spaces designed to seat 25 or more passengers, provision shall be made to seat in addition, one or more crew member cabin attendants. The number of such attendants will be related to the vehicle layout, it's accommodation and passenger exits, and arrangements for evacuation.

1128. Lifejacket Stowage.

The designer shall make provision in each passenger accommodation space for the stowage of at least one lifejacket for each person for whom seating is provided in that space. Additionally, provision is to be made for stowage, immediately accessible to a crew member, for:

a) A number of lifejackets suitable for children, not less than 10% of the number of passengers for whom seats are provided, and

b) A number of standard lifejackets, not less than 5% of the total number of persons on board for which the vehicle is certified.

1129. If lifejacket stowage is not immediately accessible to each passenger, the stowage is to be clearly and visibly placarded and provided with illumination under all normal and emergency electrical supply conditions.

1130. Signs and Markings.

All passenger accommodation spaces shall be clearly marked with signs in both official languages and/or pictorial displays showing:-

a) The location of lifejackets and emergency equipment;

b) The location of all exits;

c) Any special instructions necessary to explain the operation of an exit; these are to be immediately adjacent to the exit, both inside and outside the vehicle.

1131. Evacuation Plan.

The designer shall, at an early stage in the vehicle design, establish and submit the proposed plan and procedure for evacuating the vehicle of it's full complement of passengers and crew.

1140. Baggage and Special Category Spaces.

No controls, emergency equipment, electrical equipment, high temperature components, or pipelines or tanks containing flammable or pressurized fluid shall be located in spaces designed to carry baggage or cargo, unless they are adequately protected from damage and do not require access for operation of the vehicle.

1141. All baggage, cargo and special category spaces and areas shall be provided with means whereby contents may be secured and restrained from movement when subjected to the accelerations quoted in Section 506.

1142. All baggage, cargo and special category spaces shall be clearly and visibly marked with pertinent deck loading limitations and any restraint instructions necessary for compliance with Section 1141 above.

1143. The closures of all exterior openings of baggage, cargo or special category spaces shall be provided with positive means of securing in the closed position, and such means shall provide an effective watertight seal.

1144. In vehicles designed for the external carriage of cargo, due consideration shall be given to the proximity of cargo areas to lift fan intakes, propulsive devices and directional control devices. External cargo areas shall be arranged such that they do not impede access to or from any vehicle exit or to the deployment of, and evacuation into, survival craft.

1150. Crew Compartments.

Compartments designed for the use of crew members operating or navigating the vehicle or monitoring vehicle systems shall be laid out to minimise fatigue and workload for members in performing their duties.

1151. Each crew member shall be provided with an adjustable seat equipped with positive locking and a safety restraint such that the occupant may perform his duties from one adjusted and locked position.

1152. Seats and their mountings shall be capable of withstanding the acceleration loadings quoted in Section 506 without collapse.

1153. Positions from which the vehicle may be manoeuvred or navigated shall be provided with a clear undistorted view through transparencies which will not break into dangerous fragments if fractured. The field of view from the position from which the vehicle is normally manoeuvred shall extend horizontally for a minimum of 210°, provided always that vision is provided, generally continuous, forward from at least 30° abaft the starboard beam. (See also Sections 1163 to 1166).

1154. Provision shall be made to maintain clear vision through a horizontal sector of not less than 60° on either side of the bow, from the position from which the vehicle is normally manoeuvred, under all external and internal environmental conditions for which approval is sought. Vision clearance devices shall not damage or distort the transparencies.

1155. Each crew member in a crew compartment shall be provided with a supply of fresh air with adjustable outlets. Fresh air supply should be provided at the greater of:- a minimum of 4.7 1/sec per crew member, or at least 3 complete changes of compartment volume per hour. Air supply and temperature control should enable air temperature to be maintained within the range 18 - 25°C, paying due regard to the environmental conditions for which approval is sought. Air ventilation shall not cause distracting air currents.

1156. All crew members whose place of duty is in a crew compartment shall have access to their work station without passing through passenger accommodation.

1157. All crew compartments shall be provided with at least one normal and one emergency exit conforming to the requirements of Sections 1114 to 1122.

1158. Instrument panels and transparencies shall be so positioned that seated crew members performing their normal duties have no reflections or glare impairing the internal or external vision required under all external and internal lighting conditions encountered when operating.

1159. All controls, displays and indicators essential for the safe operation of the vehicle and it's systems shall be provided with illumination under all normal and emergency electrical supply conditions, and the level of such illumination shall be controllable.

1160. Provision shall be made at each crew member station for the stowage of a lifejacket.

1161. Stowage shall be provided in the compartment from which the vehicle is normally manoeuvred for a signalling lantern; distress flares; a portable fire extinguisher; a portable 2-way radiocommunication set for use with a life-raft, and for navigational equipment.

1162. In designs where windows may be opened, due protection shall be provided to minimize the effects of spray on equipment in the compartment.

1163. Visibility Augmentation.

In designs where visibility from the crew station from which the vehicle is normally manoeuvred requires augmentation for close manoeuvring, the arrangements and installation of augmentation devices shall be approved.

1164. Augmentation devices shall be so positioned that a clear uninterrupted view of the sector required is presented at the main vehicle manoeuvring station; associated controls operating in the natural sense should be provided adjacent to the display.

1165. Augmentation devices shall include provision to minimise the effect of misting and icing upon efficient operation.

1166. Power supplies upon which an augmentation device depends for it's effective operation shall be provided from at least two independent sources.

1167. Exceptions.

In smaller vehicles or vehicles whose design makes full compliance with Sections 1153 thru' 1157 above impracticable, the designer shall submit alternative proposals for consideration of approval.

Chapter 12 - Control Stations, Monitoring and Alarms.

1201. Crew Stations and Control Layout.

At all stations from which the vehicle or it's systems are normally controlled or monitored, appropriate display of information, indicators, and controls shall be provided within ready reach and vision of the crew member when seated at his station.

1202. Controls and switches shall be designed and spaced paying due regard to the requirement for any simultaneous operation, and to the possibility of the crew member wearing thermal protective clothing.

1203. All crew members when at their normal duty station shall be provided with effective means of two-way communication. Additionally, the station from which the vehicle is normally manoeuvred shall be provided with control of a public broadcast system transmitting to all passenger accommodation spaces.

1204. At least one crew station shall be provided with means of illuminating warning signs in passenger accommodation spaces.

1205. The station from which the vehicle is normally manoeuvred shall be provided with means of two-way communication with any other station in the vehicle from which vehicle manoeuvring may be effected or directed, and with any station from which the vehicle main machinery may be controlled.

1206. Adequate controls and indicators shall be provided to enable crew members at their normal duty stations to monitor and manage:-

a) Fuel transfer and feed systems;
b) Ballast systems;
c) Permanently installed bilge pumping systems;

d) Permanently installed auxiliary power units;

e) Electrical power generation and distribution under normal and emergency conditions and under conditions of failure of normal electrical power supply.

1207. Provision shall be made in the compartment from which the vehicle is normally manoeuvred for the fitment and operation of radio-communication and navigation equipment commensurate with the class of vehicle and the possible service upon which it may be engaged.

1208. At least one compass shall be provided at the crew station from which the vehicle is normally manoeuvred, installed in such a fashion to minimise errors due to parallax. If a compass depends for it's operation upon an electrical power supply, a magnetic compass shall also be provided. (See also Chapter 14). All compasses shall be capable of adjustment to minimise installation errors and deviation.

1209. Information Display.

Any operating parameters of the vehicle, it's machinery or systems, the values of which are required to be maintained within prescribed limits to ensure safe operation of the vehicle, machinery or system, shall be displayed to crew members in the compartment from which the vehicle is normally manoeuvred; the safe operating limits of each parameter shall be clearly marked on each instrument or display.

1210. Information shall also be displayed to crew members in the compartment from which the vehicle is normally manoeuvred, relating to the contents and disposition of any usable or movable fluid such as fuel or ballast, and to the contents of all tanks containing fluids upon which safe operation of the vehicle, it's machinery or systems may depend.

1211. Information shall also be displayed to crew members in the compartment from which the vehicle is normally manoeuvred, relating to bilge contents above a pre-determined level; to functioning of automatically activated bilge pumps; to functioning of permanently installed auxiliary power units, and to generation and distribution of electrical power from all permanently installed sources.

1212. The crew station from which the vehicle is normally manoeuvred shall be provided with a continuous display of at least the following information:-

a) R.P.M. of all main engines;

b) R.P.M. of all propulsion devices or lift fans, if not mechanically connected to the output shaft of a main engine;

c) Temperatures and pressures of all main engine systems as appropriate to the engine type;

d) Transmission parameters as appropriate to the transmission;

e) Pitch or thrust of a controllable-pitch propellors;

f) Deflection of directional control devices;

g) Vehicle heading;

h) Warnings - see Sections 1215 thru' 1219.

All gauges and displays shall have scale capacities of at least 120% of the normal maximum value of the parameter monitored.

1213. Where the display of information which is essential to the safe operation of the vehicle depends upon the supply of electrical power, the display shall be provided with power from two independent sources arranged such that, in the event of failure of the normal source, uninterrupted supply is available from the alternate source.

1214. Controls.

The loads and ranges of movement of controls provided for manoeuvring the vehicle shall be such as to minimize fatigue of crew members. Control levers, wheels, pedals, etc., shall move readily and smoothly when subjected to loads not exceeding:-

a) Foot operated :- 30 kg.

b) Stick type :- 25 kg. fore and aft
15 kg. lateral or vertical

c) Wheel type :- 25 kg. fore and aft
10 kg. tangential at the rim.

Loads to maintain controls in a steady position shall not exceed 50% of the above values.

Emergency and Failure Warnings and Indications.

1215. Indications or warnings of any unsafe condition or event shall be provided at the crew station from which the vehicle is normally manoeuvred. Indications shall be visual, and may be supplemented by audio means; they shall automatically reset on resumption of normal conditions, and any audio warning shall be capable of being muted.

1216. Mandatory Warnings.

Mandatory warnings indicate conditions or events requiring immediate corrective action to recover from an unsafe situation. Such warnings shall be given by red lights placed prominently in full view of the crew member's normal range of vision when seated and operating the vehicle; they shall be provided for at least the following:-

a) Activation of fire detection system - the warning light is to be distinctive from all other warnings, and is to be supplemented by an audible alarm.

b) Total loss of electrical power supply.

c) Overspeed of main engines.

d) Thermal runaway of any permanently installed nickel-cadmium battery.

1217. Discretionary Warnings.

Discretionary warnings indicate conditions or events requiring action to be taken to prevent degradation to an unsafe condition. Such warnings shall be given by amber lights or other clear visual means, and shall be provided for at least the following:-

a) Exceeding of any limiting value of vehicle, machinery or system parameter, other than engine overspeed;

b) Failure of normal power supply to powered directional control devices.

c) Operation of any automatic bilging pump.

d) Failure of compass system.

e) Extinction of side, masthead or stern navigation light bulbs.

f) Low level of contents of each permanently installed fuel tank or group of fuel tanks with common levelling connection

g) Low level of contents of any fluid reservoir, the contents of which are essential for the normal operation of the vehicle or the system served.

h) Failure of electrical supply from any power-driven source of electrical power supply permanently installed and normally connected to the electrical power distribution system.

i) Failure of operation of any ventilation fan installed for ventilating spaces where inflammable gases or vapours may accumulate.

1218. Emergency Controls.

Controls shall be provided at the crew station from which the vehicle is normally manoeuvred to:-

a) Activate fixed fire extinguishing systems.

b) Close ventilation openings and stop ventilation machinery servicing each Designated Fire Zone, if not incorporated in (a).

c) Shut off fuel supplies to all machinery or equipment installed in Designated Fire Zones.

d) Disconnect all electrical power sources from normal electrical power distribution system.

e) Stop any main engine or permanently installed auxiliary power unit.

1219. Emergency controls shall be prominent, distinctive, and guarded against inadvertent operation. They shall be readily accessible to the crew member when seated, and adjacent to their warning light.

1220. Warnings and Emergency Controls - Power Supplies.

All electrical circuits associated with activating a warning shall be capable of being tested to establish correct functioning of the warning.

Electrical circuits associated with fire detection and fire extinguishing equipment shall be provided with electrical power at all times that a source of electrical power is installed in or connected to the vehicle.

All electrical circuits associated with warnings and emergency controls shall be provided with electrical power from two independent sources, with automatic change-over should the normal supply fail.

1221. Secondary Control Stations.

Should provision be made for any control function associated with starting, stopping or controlling main engines to be effected at any station other than the crew position from which the vehicle is normally manoeuvred, such station(s) shall be provided with effective 2-way communication with the crew compartment containing the normal manoeuvring station.

1222. Except where provided specifically for use under emergency or fault conditions, any permanently installed controls at secondary control stations shall be arranged so that they can only be made effective by a positive and distinctive action at the crew station from which the vehicle is normally manoeuvred, and shall be capable of being over-ridden from that station. When such remote controls are activated, an indication is to be provided at the primary control position, associated with the appropriate control.

1223. Secondary control stations provided for main machinery control shall be provided with all necessary controls to perform operations with the same effectiveness as that resulting from control at the primary control position.

1224. Secondary control stations provided for operating directional control devices shall be provided with means to control vehicle direction with an effectiveness which shall be demonstrated to be acceptable.

1225. Any power supplies upon which controls provided at secondary control stations depend for their effectiveness shall be provided from two or more independent sources.

1226. Position of Controls and Switches.

Controls and switches shall be positioned relative to their importance and frequency of use; wherever practicable, the use of vertical fore-and-aft panels close to the crew member and above shoulder level when seated should be avoided.

1227. Access to and from crew member's seats shall not be impeded by the positioning of controls.

1228. Warning System Faults and Failures.

All warning systems provided in compliance with Section 1216 shall incorporate test facilities and also a distinctive indication of fault conditions or failure of the alarm system itself.

Appendix to Chapter 12

Instrument and Control Panel Layout.

Each vehicle design will naturally have it's own requirements for instrumentation and controls, but the layout should be logical, functional, and guided by common principles.

Instruments relating to one component or system should be grouped together - e.g., all instruments relating to one engine might be in a single vertical row.

Instrumentation for each component or system should be physically separate from others - e.g., a multi-engined vehicle might have vertical rows of engine instruments in logical sequence, but separated from instruments for hydraulic systems, which again would be separate from fuel system instruments, etc.

Where appropriate, such as in a fuel system with multiple connections and controls, presentation may be best laid out with controls and indicators in a functional diagrammatic form.

Manoeuvring control indicators and operational/navigation instruments should be grouped but separate from each other and from other instrumentation.

Emergency indicators and controls may be either grouped together, or positioned in association with their component or system instruments.

Accessibility and visibility should be strictly related to the frequency of required monitoring, function and contribution to safety.

All switches, controls and movement areas should be so sized and spaced that wearing of protective clothing - gloves, boots, jackets, etc., - will not impede effective operation.

Chapter 13 - Electrical Systems.

1301. In submitting design data for approval, the designer shall include:-

a) Diagrams of all A.C. and D.C. power generation;

b) Diagrams of all A.C. and D.C. power distribution, and

c) An electrical load analysis.

Data should clearly indicate the electrical ratings of all components and equipment, and the specifications of all wiring.

1302. Except where necessary for performing it's normal duty, no electrical equipment shall be installed:-

a) Adjacent to any system piping or component containing flammable fluid;

b) In spaces provided for passenger accommodation;

c) Less than 10 cms. above the floating waterline at the maximum certified weight;

d) Within a Designated Fire Zone, or where flammable vapours may accumulate.

1303. Any electrical equipment installed in a Designated Fire Zone, a space where flammable fluids or vapours may accumulate, or directly adjacent to components containing flammable fluids shall be:-

a) Of a type certified safe for operation in the particular application, i.e., "explosion proof", "intrinsically safe", "increased safety";

b) Fire resistant; and

c) Installed and connected in such a manner that the fire integrity of Designated Fire Zone is not impaired.

1304. Power Generation.

Electrical systems shall have at least two independent sources of power available for connection arranged such that, in the event of failure of power from one source, uninterrupted power is available to maintain services essential for the safe operation of the vehicle.

1305. The design of the electrical generator installation shall ensure that no generator will, under normal service load conditions, be connected to a load in excess of 80% of it's maximum rated capacity.

1306. Where storage batteries are used as a source of permanently installed power, arrangements shall be made for them to be charged from the vehicle power generating system and from an external source. Arrangements shall be made to prevent reversed polarity of charging circuits, and also to prevent battery discharge through the charging circuit should battery voltage exceed that of the charging source.

1307. The power generation system shall include adequate control of generators, with automatic voltage regulation and protection against overload in parallel operation of generators.

1308. Each generator shall, in addition to normal protection devices, be provided with means of isolation from the distribution system; this isolator shall be immediately accessible from the crew station from which the vehicle is normally manoeuvred.

1309. The power generation system shall be arranged such that no failure or malfunction of one power source shall impair the efficient supply of power from any other connected source.

1310. General service power generation shall not exceed 250 volts; exceptionally, where higher voltages may be required, additional safety requirements may need to be considered.

1311. Generator Prime Movers.

Prime movers powering generating equipment shall be provided such that their continuous power rating is at least equivalent to the full rated load of the generator.

1312. Generator prime movers shall be provided with efficient automatic speed control such that, in the event of the full electrical load being removed, speed shall be limited to at least 5% less than the authorised overspeed trip setting.

1313. Controls and displays for starting, stopping and monitoring generator prime movers shall be provided in the compartment from which the vehicle is normally manoeuvred, and shall include an emergency stop control.

1314. Normal Power Distribution.

Vehicle electrical services shall be provided through at least one normal bus-bar. Where more than one bus-bar and more than one generator are provided for normal distribution, control and protection devices shall be provided to prevent over-loading of bus-bars and generators. Wiring shall normally be two - or three - wire insulated systems (but see 1319). Bus-bars and their connections shall be copper, all connections being tinned or silver-surfaced to inhibit corrosion and reduce resistance; the use of aluminium bus-bars shall be specifically submitted for approval.

1315. All services shall be supplied through circuit protection devices; the current ratings shall be clearly shown on the device itself or immediately adjacent to it.

1316. Circuits associated with services essential for safe operation of the vehicle shall be protected with circuit-breakers readily available to a crew member at his normal duty station.

1317. All circuit protection devices associated with power distribution shall be readily accessible when the vehicle is in normal operation.

1318. Where circuit protection devices are connected in series, they shall be graded so that fault or overload conditions shall cause the device nearest the fault, and on the supply side, to operate first.

1319. Hull (ground) returns may be exceptionally approved for circuits operating at voltages not exceeding 55 volts where appropriate precautions are taken; these should include :-

a) Consideration of galvanic corrosion under normal operation;

b) Consideration of the ability of the grounding points to accept fault currents without danger to the hull, and without fire risk.

Hull returns may be used for the starters of main engines and prime movers.

1320. All switches and circuit-breakers installed in circuits operating at 55 volts or more shall be double pole, both poles operating simultaneously.

1321. All circuits and sub-circuits shall be provided with means of connection and disconnection from the distribution system. For equipment required by section 1331 to be connected to an emergency source of power, direct connection to the emergency power source may be permitted.

1322. Means shall also be provided to ensure that all sources of installed electrical power may be disconnected from the distribution system(s), and such means shall be provided in the
compartment from which the vehicle is normally manoeuvred.

1323. In marine sidewall vehicles, approved arrangements shall be made to provide electrical power for bilge pumping when electrical power is disconnected from the general distribution system(s).

1324. Where 3-phase supplies are used, an alarm shall be provided in the compartment from which the vehicle is normally manoeuvred to indicate in the event of failure of any one phase.

1325. Instrumentation and indication shall be provided in the compartment from which the vehicle is normally manoeuvred to at least inform crew members of the electrical load of each generator or power source, of any failure of primary power generation or distribution, and of the charge or discharge current of all installed batteries.

1326. In power distribution systems with no connection to ground or hull, provision shall be made to monitor insulation resistance.

1327. Attention is drawn to the requirement of Section 466.

Emergency Electrical Power.

1330. All vehicles shall be provided with an emergency source of electrical power; the power source and it's distribution system shall be independent of, and physically separated from, the electrical power sources and distribution systems provided for normal operation to the maximum extent practicable. Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency source of power may be used exceptionally and for short periods to supply non-emergency circuits.

1331. Power from the emergency source shall be capable of being connected, within not more than 20 seconds of failure of normal power supply, with sufficient capacity to supply simultaneously:-

a) Emergency lighting for 2 hours; (see 1332)

b) Main navigation lights for 2 hours;

c) Internal communication and public broadcast for 2 hours; (see 1333)

d) One radio receiver and transmitter for 4 hours; (see 1333)

e) Fire detection and fire extinguishing activation for 2 hours;

f) Essential instruments, equipment and controls for main propulsion and directional control for 4 hours;

g) Not Under Command lights for 12 hours; and

h) Any electrically powered whistle or bell, for 4 ´ hours.

1332. The emergency lighting requirements of Section 1331 shall provide adequate illumination of:-

a) Life-raft stowages;

b) All exits, evacuation paths, and life-raft embarkation points;

c) Passenger accommodation, and

d) Crew compartments, control stations and machinery spaces sufficient to permit operation and monitoring of all controls and displays essential for the safety and safe operation of the vehicle.

1333. In assessing the power requirements for communication prescribed in Section 1331, it should be assumed that the total accumulated usage of internal communication will not exceed 30 minutes, and that radio transmissions will not exceed a total accumulation of 30 minutes.

1334. With the exception of supplying essential power for equipment within Designated Fire Zones, all components and wiring of the emergency electrical power system shall be as remote as practicable from Designated Fire Zones.

1335. The source of emergency electrical power shall be located above the final floating waterline resulting from any damage considered in Chapter 3, and the emergency electrical system shall be capable of satisfactory functioning under such conditions.

1336. Where the source of emergency electrical power is a generator driven by an independent prime mover, any fuel required by that prime mover shall be supplied independently of the vehicle main fuel system, with storage to ensure continuous operation consistent with Section 1331.

1337. Where the source of emergency electrical power is a storage battery, it shall be of sufficient capacity to provide the emergency power required by Section 1331 without recharging, while maintaining the voltage to within 12% of nominal.

1338. Any emergency switchboard associated with distribution of power to emergency circuits should be installed in close proximity to the source of emergency power.

1339. Where the emergency circuit voltage and frequency is the same as that provided by the normal power source, the emergency switchboard should be supplied in normal operation from the main switchboard by a feeder protected with suitable overload and short-circuit devices; the emergency source of power should be connected automatically in the event of failure of normal power supply. Indication that electrical power is being supplied by the emergency power source shall be provided at a crew member's station in the compartment from which the vehicle is normally manoeuvred.

Electrical Equipment Installation.

1340. All equipment associated with normal and emergency generation and distribution of power shall be capable of satisfactory operation under the acceleration loadings of Section 506.

1341. Equipment installations shall be designed paying due regard to the space required to ensure adequate ventilation, cooling, heat dissipation and servicing.

1342. All wiring and cables shall be supported and protected to eliminate chafing, vibration and undue strain on terminations and connections.

1343. Any live, rotating, or high temperature equipment shall be so installed or protected as to minimise the possibility of injury.

1344. Any exposed metal part of electrical equipment not intended to conduct current shall be effectively grounded; where necessary, the vehicle hull structure is to incorporate an adequate ground conductor.

1345. All ground connections shall be made using copper or corrosion resistant material; connections are to be made paying due regard for the need to avoid dissimilar metallic contact, and all ground connections shall be readily accessible for inspection.

1346. All connections and terminations shall be made paying due regard to the corrosive effects of the operating environment, and shall be positioned or protected to minimize the accumulation of moisture and dust, and to minimize the possibility of damage.

1347. All electrical equipment shall be installed and connected so as to minimize so far as is practicable, galvanic action arising from contact of dissimilar metals.

1348. All electrical equipment, cables and wiring, shall be installed, and where appropriate electrically protected, to minimize, so far as is practicable mutual electromagnetic or electrostatic interference between circuits or equipment.

1349. Where environmental conditions require the installation of equipment which is certified as safe in the particular atmosphere - e.g. "explosion-proof" - the integrity of the equipment shall be maintained by the use of seals or connections of equivalent rating.

1350. In vehicles incorporating distribution of electrical power of more than one voltage or frequency, outlets and plugs shall be provided to ensure that incorrect connection cannot be made; placards adjacent to outlets shall be provided indicating the voltage and frequency.

1351. Power outlets in toilets and washrooms shall only be provided with an A.C. supply, connected through an isolating transformer.

1352. Switches in toilets and washrooms shall be of watertight construction, or enclosed in a durable continuous insulation.

1353. Cargo and Motor Vehicle Spaces.

Electrical equipment in spaces designed for the carriage of cargo or motor vehicles shall be certified as safe for operation in explosive vapour/air mixtures, and their installation and connection shall preserve that integrity. No electrical equipment shall be installed in such spaces less than 0.45 m. above the deck.

1354. Wires and Cables.

All wires and cables shall be selected taking into consideration their permissible load and temperature ratings, and the service and environment to which they will be subjected.

1355. Any wires or cables passing through, or supplying equipment in, Designated Fire Zones, shall be covered with a covering which is incombustible as defined in section 1002(b). All other wiring shall have at least low flame-spread or fire-retardant covering.

1356. No wires or cables providing the services required by section 1231, other than those associated with fire detection and fire extinguishing, shall pass through, or be attached to the boundary of, a Designated Fire Zone.

1357. The covering of all wires and cables shall be impervious to moisture, and shall not be damaged by any fluid or temperature to which, by virtue of their installation, they may be subject.

1358. Lights. (See also Chapter 14)

All light bulbs and fluorescent tubes shall be mounted so as to minimize the effect of shock and vibration upon their effective operation, and should be suitable for "heavy duty".

1359. All external lights and lights in spaces subject to moisture shall be in effectively watertight closures provided with means of draining entrained moisture.

1360. All lights shall be positioned to permit adequate dissipation of heat, and to minimize the possibility of contact with flammable material.

1361. Batteries.

All installed batteries shall be securely fastened in stowages constructed of, or treated with, material resistant to corrosion from battery electrolyte.

The fastening shall ensure that the danger of spilt electrolyte in the event of experiencing the accelerations quoted in Section 506 is minimized.

1362. Battery stowages shall be adequately vented to atmosphere, either naturally from the top of the stowage, or by forced ventilation; the vent opening shall be remote from any other hull openings.

1363. Batteries employing differing forms of construction or electrolyte shall be secured in separate stowages; all stowages shall be located where the batteries are not exposed to extremes of temperature or humidity.

1364. Batteries shall not be stowed in or adjacent to Designated Fire Zones, nor in spaces designed to be normally occupied by passengers or crew members.

1365. Consistent with 1364, any battery used for starting engines or prime movers shall be stowed as close as practicable to the starter motor in order to minimize voltage drop.

1366. Batteries connected to a charging circuit shall be provided with reverse current protection; if charged through rectifiers, the rectifiers shall also be protected against overloading.

1367. Where battery charging arrangements provide for alternate sources of charging power, protection against reverse current in each circuit shall be provided.

1368. Batteries which may experience thermal runaway during charging shall be equipped with temperature warning devices activating a distinctive warning in the compartment from which the vehicle is normally manoeuvred. Such batteries shall be connected with quick-release terminal connections, and their charging circuits shall incorporate an isolating switch or circuit breaker.

1369. No equipment which may constitute a potential source of ignition of flammable vapours shall be installed in a battery stowage.

1370. Where batteries are installed as the main source of electrical power, arrangements shall be made on board to fully charge them within 8 hours. Batteries installed as a main source of power shall be of sufficient capacity to at least provide the services required by section 1331, plus starting a main engine.

1371. Charging circuits shall be so arranged to permit a battery being charged to simultaneously provide power to the vehicle systems.

1372. Bonding.

All metal sheaths of electrical conductors shall be electrically continuous and shall be grounded (earthed).

1373. All metal piping systems containing flowing fluids which could potentially generate static electricity shall be electrically continuous and grounded.

1374. Where hull return systems are used and approved, all metal parts of the vehicle structure shall form a continuous electrical path providing electrical contact when the vehicle alights.

1375. The design of all fuel replenishment points shall include bonding connections.

1376. Primary conductors designed for the discharge of lightning strikes shall have a current-carrying capacity at least equal to that of 6mm^2 of pure copper.

1377. External Power Supply.

Any external power supply connection shall be certified waterproof, and shall be arranged such that the external power source may only be connected with polarity and phasing compatible with the vehicle systems.

1378. All external power supply connections shall be clearly identified with the voltage and type of power for which it is intended.

1379. External power connnections shall be arranged such that the external power source cannot be paralleled with any installed power source.

1380. Lighting Systems.

All spaces provided for the accommodation or use of passengers, all crew compartments, and all spaces accessible which contain machinery or equipment requiring periodic attention or servicing, shall be provided with adequate lighting supplied by the normal power source.

1381. The lighting system provided to meet the requirement of section 1380 shall be arranged so that, in the event of fire or failure of the normal power source, the emergency lighting system will not be rendered inoperative.

1382. The system providing power for emergency lighting should become operative automatically upon failure of the normal lighting system power supply, or upon connection of the emergency source of electrical power to the distribution system.

Chapter 14 - Navigation and Communication Equipment.

1400. General

Operational safety certification (as opposed to design certification) of Canadian A.C.V's require the installation of navigation and communications equipment appropriate to, and compatible with, the service and local available facilities. As a minimum, for daylight operation, at least one fixed radio transceiver, one portable radio transceiver for use with installed life-saving appliances, and one intercom system will be required; for night or limited-visibility operation, at least radar would also be required.

The vehicle manufacturer should therefore make spatial, structural and power provision to permit the installation of such equipment as may be required, and which may be selected by the vehicle owner.

1401. Equipment Approval.

No radio communication or navigation equipment which may emit electro-magnetic radiations may be installed in an A.C.V. operating in Canada unless such equipment has been type-approved by the Department of Communications. Comprehensive lists of type-approved equipment are published regularly and are available from the Department of Communications Telecommunications Regulatory Service.

1402. Equipment Installation.

The relevant provisions regarding installation, circuit protection, switching and bonding, contained in Chapter 13, shall be observed.

1403. In providing circuit protection, supply protection provided in the equipment shall either be readily accessible and externally identified, or it shall be rendered inoperative.

1404. Any equipment capable of emitting electro-magnetic radiations shall be installed so as to minimise the exposure of personnel to the radiations, and to minimize mutual interference between installed equipments.

1405. The design of all installations shall include protection of the equipment from the operational environment, paying particular attention to the prevention of corrosion, condensation and the ingress of spray or dust.

1406. Except where required for performing it's normal function, no component of a communication or navigation system shall be installed:-

a) In spaces provided for passenger accommodation;

b) Less than 10 cm. above the floating waterline at the maximum weight for which certification is sought;

c) In a Designated Fire Zone.

1407. Equipment shall be installed such that all displays and controls are readily visible and accessible to the appropriate crew member when seated at his normal duty station. No radar or other navigational display shall be positioned such that it distracts, or requires distraction of, the attention of a crew member from his primary assigned duty.

1408. Antennae.

Antennae shall be installed and supported to withstand all aerodynamic, vehicle motion, and icing loads to which they may be subjected resulting from vehicle operating within it's operational and environmental envelope.

1409. Due attention shall be paid to the positioning of antennae relative to fan intakes, airscrews and directional control devices.

1410. Provision shall be made to ensure that antennae cannot be energized when personnel are working on or in close proximity to them.

1411. Where antennae depend for their effective performance upon the maintenance of a pressurized atmosphere in the wave-guide, the manufacturer shall ensure adequate provision is made to seal the wave-guide and provide accessible means to indicate and replenish the pressure.

1412. Antennae shall be positioned relative to each other so as to avoid, to the maximum extent practicable, mutual interference of performance, and to avoid physical interference.

1420. Compass Installations. (See also Section 1460)

All A.C.V's shall be provided with at least one compass; in A.C.V's with a mechanically or electrically operated compass system, a second direct-reading magnetic compass shall be installed.

1421. At least one direct-reading magnetic compass shall be readily visible at the crew station from which the vehicle is normally manoeuvred; all compass instrument installations shall minimise parallax error.

1422. The installation of any compass which is dependent for it's indication upon the earth's magnetic field shall provide for adjustment to reduce deviation to a maximum of 2° on any heading, taking due account of the operation of installed electrical or electronic equipment.

1423. Flux valves or other sensing elements shall be installed in spaces as remote as practicable from electro-magnetic noise, and shall be secured and enclosed using non-magnetic materials.

1430. Other Navigation Aids.

Speed Measurement.

Manufacturers shall provide, to the maximum extent practicable, a means whereby the speed of the vehicle may be determined along it's track.

1431. Depth Indication.

Non-amphibious marine A.C.V's shall be equipped with an efficient depth sounding device capable of providing depth indication at least when in the displacement mode.

1432. Displays of navigation aids which are not essential for the immediate attention of the person manoeuvring the vehicle shall be positioned so as to provide minimum distraction.

1450. Sources of Power.

All permanently installed communications and navigation equipment dependent for their operation upon electrical power shall be provided with electrical power, as required by the equipment specification, from the normal electrical distribution system of the vehicle.

1451. The vehicle sources of electrical power and distribution system shall be so arranged to provide electrical power to at least one radio communication transceiver as required by section 1400 under emergency conditions, including failures of normal power supply generation and conditions resulting from any damage considered as required by Chapter 3.

1452. Provision shall be made to ensure that the portable radio transceiver required by section 1161 shall be maintained in a fully charged condition; any charging supplied from the vehicle electrical system shall be capable of being delivered from all installed sources of electrical power.

1460. Navigation Equipment for Remote or High Latitude Areas.

The requirements of section 1420 thru' 1423, and of section 1430 may require to be modified or supplemented for Air Cushion Vehicles intending to be operated in remote areas, in high latitudes, or in areas of large magnetic anomalies.

1470. Navigating Safety

Navigation Lights.

All A.C.V's shall be provided with navigation lights in compliance with the requirements of the International Rules for the Prevention of Collision at Sea applicable to a conventional power-driven vessel of the same length.

1471. In addition to the lights required by section 1470, all A.C.V's shall be provided with an amber flashing light, visible all round for a distance of not less than 2 nautical miles. The flashing characteristic, which may be obtained by rotation, switching or shutters, shall be adjusted to a rate of flashing of not less than 120 per minute.

1472. All navigation lights shall be so positioned and screened to minimise back-scatter of light in conditions of low visibility or spray.

1473. All navigation lights shall be constructed and possess the chromaticity requirements in accordance with the International Rules quoted in section 1470, and shall be installed to provide the visibility ranges of sectors contained therein.

1474. In complying with section 1470, the following lights shall be permanently fitted:-

a) Port and starboard sidelights;
b) Masthead light(s);
c) Stern light;
d) Not-under-Command lights,

positioned and spaced in compliance with the International Rules. Where vehicle configuration renders full compliance impractical, exceptional consideration may be given to alternate arrangements proposed by the manufacturer.

1475. Separate switching shall be provided to enable independent display of lights as follows:-

a) Sidelights, stern light and masthead light(s) together;

b) Amber flashing light;

c) Not-under-Command lights;

d) One all-round white light for use when anchored.

1476. With the exception of the amber flashing light, all navigation lights shall be duplicated; warning of the extinction of any bulb shall be provided in the compartment from which the vehicle is normally manoeuvred, and switches shall be provided to select alternate bulbs.

1477. Arrangements shall be made for the control of electric navigation lights to be supplied from normal and emergency sources of power.

Chapter 15 - Marine Equipment.

1500. Securing, Anchoring, Mooring.

The vehicle design shall provide bollards, rings or cleats, and fairleads, such that it may:-

a) Be safely secured alongside a dock or another vessel;

b) Be secured to a buoy, or anchored;

c) Be towed, and

d) Tow another vessel.

In determining the strength of securing arrangements and support structure, proof and ultimate factors of 1.33 and 2.0 respectively shall be applied. The designer shall declare the assumed maximum loadings and direction of loads which may be applied to any securing fitting.

1501. In designing fittings for securing to a buoy or for anchoring, the designer shall consider, as a minimum, a 4 knot current combined with the maximum wind speed and wave conditions for which certification is sought.

1502. Fittings and their support structure shall de designed to minimize the transfer of loads from them into or across hull sub-divisions designed to contribute to water-tight integrity.

1503. Provision shall be made to ensure that anchors are stowed securely in positions from which they may be released into the water by one person without the need for special equipment. Due regard shall be paid to the effects of icing upon the stowed anchors.

1504. Masts.

The vehicle shall be provided with a mast or masts, suitably secured, equipped with halliards and electric power such that it may display such navigation lights by night, or shapes by day, as are required by the International Rules for the Prevention of Collision at Sea for a conventional vessel of similar length.

1505. In vehicle designs where the permanent mounting of the mast required by section 1504 is impractical or inappropriate, adequate provision, subject to exceptional approval, shall be made for the temporary installation of means whereby display of required lights and shapes may be made.

1506. Sound Signals.

The vehicle shall be provided with means to make sound signals as required by the International Rules for the Prevention of Collision at Sea.

Chapter 16 - Life-Saving Equipment.

1600. Lifejackets.

Secure stowages shall be provided in all passenger and crew accommodation spaces for one approved lifejacket for each person on board for which certification is sought. In addition, stowage immediately accessible to a crew member shall be provided for :-

a) A number of lifejackets suitable for children, not less than 10% of the number of passengers for whom seats are provided,

and

b) A number of standard lifejackets, not less than 5% of the total number of persons on board for which the vehicle is certified.

1601. Liferafts.

The design shall provide readily accessible secure external stowages for liferafts of sufficient capacity to accommodate not less than 110% of the total number of persons carried for which certification is sought.

1602. Liferaft stowages shall be evenly distributed around the vehicle, as remote as possible from any Designated Fire Zone, exhaust or discharge. Where a centrally located stowage is provided, the liferaft shall be equally accessible from both sides.

1603. Liferaft stowages shall provide for the ready deployment of each liferaft into the water, without the use of special tools or risk of damage to the liferaft or injury, by one person. Due attention shall be paid to effects of icing on the release arrangements for liferafts.

1604. Liferaft stowages shall permit the deployment of liferafts into the water with the vehicle floating in the damaged condition with an associated trim attitude of up to 8°.

1605. Only approved liferafts shall be installed; they shall be provided with survival packs appropriate to the service upon which the vehicle is engaged.

1606. Liferaft stowage arrangements shall ensure that, upon deployment, liferafts are retained alongside secured to the vehicle. Where the liferaft is inflatable, the length of securing should be adjusted to initiate inflation upon deployment. Securing lines and stowage positions should also be selected to minimise mutual interference of deployed liferafts.

1607. Inflatable liferafts may be stowed with hydrostatic devices arranged to release and inflate the liferaft in the event of the A.C.V. sinking.

1608. Lifebuoys.

Subject to a minimum total of two, provision shall be made for the secure stowage of one approved lifebuoy adjacent to each normal exit; each lifebuoy shall be provided with a minimum of 27.5 metres of buoyant line. At least one lifebuoy should be provided with a self-igniting light and a self-activating smoke signal.

1620. Survival Equipment - Remote Area Operation.

The requirements for life-saving equipment contained in sections 1600 thru' 1608 may require to be modified or supplemented for Air Cushion Vehicles operating in remote areas or high latitudes, or in seasonal environmental conditions which render the use of such equipment impractical or inappropriate for the achievement of required levels of safety.

Division 2 - Operational Equipment

2100. Any equipment intended for installation and use in an A.C.V., additional to that required by Division 1 of these Standards shall be designed and installed in compliance with the applicable section(s) of these Standards.

2101. The design and installation of operational equipment required by these Standards, but which may be subject to optional choices of installation or equipment shall in all cases comply with the relevant section(s) of these Standards.

2102. Where applicable and necessary for the demonstration of compliance with operational safety provisions, the vehicle designer shall carry out such additional tests of the installed equipment as may be required, to an approved schedule.

Division 3 - Construction & Installation.

Chapter 1 - General.

3100. This Chapter assumes that all construction, fabrication and installation complies with drawings, specifications and other relevant data provided by the design organisation, and which has been approved.

3101. All construction, fabrication and installation operations shall be performed or supervised by persons holding appropriate and valid qualifications, licences or permits. All welding shall be performed by persons holding current certificates issued by a recognized organization valid for the welding operation being performed.

3102. No departure shall be made from design data or drawings provided by the design organization without reference to the designer, who shall review and if necessary re-issue the data or drawings.

3103. All fabrication processes and treatments shall be performed under appropriately controlled conditions, using materials and correctly adjusted equipment as required to provide the specified product.

3104. Recognized standards appropriate to the work being performed shall be employed unless specifically authorized otherwise by the design organization.

3105. The installation of any equipment or component shall comply with any special instructions provided by the equipment manufacturer.

3106. All fluid-carrying pipes shall be identified as to contents and function (e.g. fuel vent; hydraulic oil return) at each end and at intervals where servicing or maintenance operations require identification.

3107. All electrical wires and cables shall be marked to identify their circuit or service.

3108. Electrical connections requiring soldered assembly shall be made using non-corrosive solder.

3109. All electrical connectors shall be installed to provide accessibility for inspection and maintenance.

3110. All connections in electrical circuits associated with essential services shall be positively secured.

Chapter 2 - Tests during Construction.

3200. Rigid Structure.

The manufacturer shall make arrangements for suitable testing of structural samples of fabricated structure to confirm structural properties assumed in design calculations. Tests shall be conducted according to an approved method, and the selection of sample locations may require to be approved.

3201. In addition to the structural testing required by section 3200, the manufacturer may be required to arrange for non-destructive testing of selected sections of the vehicle structure or assemblies. The selection of such test requirements will be related to results of the structural tests, and to the design structural analysis.

3202. Fire Safety.

The manufacturer shall submit a full-scale specimen of each type of boundary intended to be installed to provide structural fire protection of a Designated Fire Zone. The specimens shall be not less than 4.65 square metres in surface area, and shall have one axial dimension at least 2.44 metres in length. The specimen shall be fully representative, including all treatments and finishes to be installed integral with the boundary, and shall include representative joints and fire-resistant penetrations. The fire test shall be the standard fire test as defined in Division 1 Section 1002(c) of these Standards, and shall be performed by a recognised fire testing agency.

3203. The manufacturer may be required to submit representative samples of any deck, bulkhead, deck-head, trim or furnishing fabric, and of electrical wiring for appropriate fire safety testing by a recognised fire testing agency.

3204. Upon completion of the prototype vehicle, all electrical supply and distribution circuits and mechanical devices associated with fire detection and extinguishing shall be tested for each Designated Fire Zone to establish electrical continuity and correct functioning. Where the vehicle design includes fixed remote-controlled fire extinguishing systems, the vehicle system shall be used to demonstrate the satisfactory discharge and retention of the fire extinguishant used in a Designated Fire Zone. Where Designated Fire Zones or fire extinguishant discharge arrangements are significantly different, satisfactory demonstration of each arrangement may be required.

3205. The testing required by section 3204 shall be arranged to provide a record of fire extinguishant penetration and retention within the Designated Fire Zone, and shall be conducted with the assistance of a recognised fire protection specialist agency.

3206. Flexible Structures.

The manufacturer shall provide satisfactory evidence of such testing of flexible structure joints or bonds as may be required and agreed. Destructive testing by recognised test methods shall be performed to determine tensile, adhesion or peel strength as appropriate, on representative coupons made during manufacture of the flexible structure. These tests shall be performed under temperature conditions paying due regard to the environmental envelope of the vehicle for which certification is sought.

3207. Buoyancy spaces.

All structural spaces and all tanks, bladders or cells designed to contribute to buoyancy, and for which buoyancy credit is claimed, shall satisfactorily complete a pressure test. The testing medium shall be air or an inert gas, and the initial test pressure shall be not less than 1.5 times the theoretical draft of the space when the vehicle is floating in water at the maximum weight for which certification is sought. The test will be satisfactory if, at the end of 30 minutes, the pressure has not decreased by more than 10% of the initial value.

3208. No pressure testing of buoyancy spaces, tanks, bladders or cells shall be performed for the purposes of approval until all fabrication and installation which requires penetration of water-tight boundaries, or adjacent work which may affect water-tight integrity, has been completed.

3209. In designs where buoyancy spaces have common boundaries, each space shall be tested individually.

3210. Fuel Tanks and Fuel Tank Bays.

Fuel tanks which are integral structural spaces of the vehicle, designed to contain fuel or a bladder containing fuel, shall satisfactorily complete a pressure test, arrangements being made to blank any pipes or openings not normally subjected in service to fuel pressure. The test medium shall be air or an inert gas, and the initial pressure shall be a water head of not less than 1.5 times the maximum depth of the tank, or 1.5 times the maximum pressure to which the tank may be subject in service, whichever is the greater. The test will be satisfactory if, at the end of 30 minutes, the pressure has not decreased by more than 10% of the initial value.

3211. All rigid fuel tanks which do not form part of the vehicle structure shall comply with the pressure testing requirements of section 3210.

3212. All flexible bladder fuel tanks shall comply with the pressure testing requirements of section 3210. The manufacturer may submit for consideration that testing of bladders contained within a structural space may be integrated with the testing of that space as required by section 3210.

3213. No pressure testing of structural spaces designed to contain fuel, or of any tank or bladder designed to contain fuel, shall be performed for the purposes of approval until all connections and installation work have been completed.

3214. Hull Openings.

Any vents, discharges or openings in the hull below 76 mm. above the floating waterline in the damaged condition arising from any damage considered in Chapter 3 of Division 1 of these Standards at maximum weight for which certification is sought shall be tested for water-tight integrity. The hull joint of the opening shall be subjected to an externally applied jet of water at a pressure of not less than 207 kPa, for not less than 1 minute, during which time no internal seepage shall occur.

3215. Where hull openings referred to in section 3214 are fitted with closings, the closings are to be additionally subjected to a similar test when in the closed position.

3216. Bilge Pumping System.

All pipes, branches and components of permanently installed bilge pumping systems shall be subjected to an internal pressure test during the course of which an initial pressure of not less than 1.5 times the pressure which the pipe or component may experience in service shall not fall by more than 10% in 30 minutes.

3217. Systems Containing or Carrying Pressurized or Flammable Fluids.

Piping systems designed to carry fluids under pressure or flammable shall be subject to a pressure test to ensure integrity of all pipes, couplings and fittings. Test standards and procedures for each system shall be approved, generally requiring a pressure of not less than 1.5 times the pressure to which the system will be subjected in normal service. For special application system, e.g. fixed fire extinguishant, test standards required by an applicable system approval authority shall be observed.

3218. All metal pipes carrying flowing fluids which may generate static electricity shall be subjected to an electrical continuity test to ensure an adequate conducting discharge path to ground.

3219. Electrical Systems.

All switchboards and distribution panels shall be subjected to an insulation resistance test. With all circuit breakers and switches open and all fuse links removed, the insulation resistance shall be not less than 1 megohm measured between each bus-bar and ground and between each insulated bus-bar and the other pole(s).

3220. Paying due regard to normally applied voltages in service, all lighting and power circuits may be required to be subjected to an insulation resistance test between all insulated poles and ground, and where practical between poles.

3221. All circuits or systems provided for electrical bonding shall be tested to ensure that a continuous electrical path is provided.

Chapter 3 - Inspection during Construction.

3300. The manufacturer shall be responsible for ensuring that adequate inspection procedures are established and instituted in order to ensure that safety of operation of the vehicle, it's machinery and systems is not impaired during construction.

3301. The inspection function shall exercise adequate control to ensure quality of:-

a) Materials, components and equipment used in the vehicle manufacture;

b) Fabrication and treatment processes used in the vehicle manufacture;

c) Tools, equipment and machinery used in vehicle manufacture or in fabrication or treatment processes;

d) Workmanship during fabrication or treatment processes and vehicle manufacture;

e) Standards and practices employed during vehicle manufacture, and during installation and assembly of equipment and components.

3302. The inspection function shall also be responsible for maintaining adequate standards of calibration or testing of tools, equipment or machinery used in the fabrication, manufacture and testing of the vehicle and it's machinery and systems.

3303. The inspection function shall conduct, or arrange for the conduct of, progressive inspections of the vehicle, it's sub-assemblies, components and installations during the course of manufacture or assembly to ensure compliance with drawings or design data and with established standards and practices.

3304. The inspection function shall also conduct, or arrange for the conduct of, such tests during construction as required by these Standards and by the vehicle designer.

3305. Permanent records of all inspections and tests required, and of their results, shall be maintained and made available where required for the purposes of approval.

Division 4.

Functional Tests and Trials.

Part A - Pre-operation - All A.C.V's.

4000. Before any A.C.V. may be operated for the purpose of approval or certification, the vehicle, it's machinery and systems shall be subjected to a schedule of tests to ensure the correct functioning and safety of operation of all systems and machinery. The schedule, which may include recommended procedures provided by machinery or equipment manufacturers, shall be approved.

4001. In submitting test schedules for approval, data shall be included relating to the proposed test methods, values of test parameters to be achieved, and any standards proposed.

4002. Testing shall include, but not necessarily be limited to, functioning of the following:-

a) Main propulsion machinery;

b) Main lift machinery;

c) Fuel filling, feed, transfer and vent systems;

d) Directional control systems and devices;

e) Bilge pumping systems;

f) Liquid ballast or trim systems;

g) Propulsive thrust controls;

h) Lift or cushion air controls;

i) Auxiliary power units;

j) Normal electrical power generation and distribution systems;

k) Emergency electrical power generation and distribution systems, including the operation of any switching or interlocks;

l) Emergency lighting;

m) All instrumentation and displays provided at crew duty stations;

n) All controls provided at crew duty stations;

o) All alarms;

p) All emergency controls provided;

q) Internal communication, including passenger broadcast system;

r) Compass system;

s) Ventilation and environmental control systems;

t) Radio communication equipment;

u) Any navigation equipment fitted.

4003. In addition, the following tests shall be carried out:-

a) All doors, windows and hatches shall be subjected to a water spray test, using a water jet or not less than 207 kPa, to establish that the vehicle is effectively water-tight;

b) The vehicle flexible structure shall be inspected with the vehicle on full hover, and such adjustments and measurements shall be made as may be necessary to ensure that the air cushion and it's components conform to design geometry and parameters;

c) The vehicle is to be subjected to static stability trials, in the course of which sufficient measurements are to be recorded to establish that cushion geometry and vehicle static roll and pitch stability conform to design data at weights up to the maximum for which certification is sought;

d) The vehicle is to be weighed in such a manner that it's weight and longitudinal and lateral c.g. positions may be calculated for any loading condition within the operating envelope for which certification is sought;

e) All propellers, lift fans, and their transmissions shall be subjected to tests and adjustments to ensure that they are dynamically balanced, at normal operating conditions, in accordance with recommendations of the component manufacturer or vehicle designer.

4004. All navigation lights shall be tested and adjusted to ensure that visibility sectors comply with the applicable requirements of the International Rules for the Prevention of Collision at Sea, and that screening is provided to minimise the effects of glare and reflection upon vision of crew members.

Division 4

Functional Tests and Trials.

Part B - Pre-operational - Prototype Vehicles and Installations.

4100. In addition to the tests and trials required by Part A of Division 4, before a prototype vehicle or prototype installation in a vehicle is operated for approval or certification, tests or trials shall be carried out to establish integrity of installations and compliance where appropriate with design data.

4101. Such additional tests as may be required shall be scheduled by agreement between the manufacturer and the certification authority in conjunction where appropriate with component manufacturers or other specialised testing agencies.

4102. Machinery.

Main machinery components of propulsion and lift systems shall be subjected, either separately or collectively, to such testing as may be required to establish structural integrity of the installed component or system, it's vibratory or oscillatory loading spectra, and the effects of such spectra on the vehicle structure and safe operation. Testing shall include, but not necessarily be limited to, that required by Section 792 of this Standard.

4103. Electrical Systems.

The normal electrical power generation and distribution systems are to be operated and subjected to sufficient testing to establish a representative electrical load analysis to which the systems will be subjected during all anticipated combinations of electrical loading.

4104. Fault Conditions.

All main and auxiliary machinery, fluid systems, directional control systems, and electrical power generation and distribution systems shall be subjected to such tests as may be necessary to determine that, under all reasonable fault conditions that may be experienced in service:-

a) Adequate indication is provided to crew members;

b) Any automatic function of the system consequent upon the fault operates correctly;

c) The fault and it's effects do not impair the safety of operation of other systems;

d) The fault can be contained without additionally impairing safety, by corrective measures.

4105. Special Tools and Equipment.

Where maintenance or servicing operations, or operation of the vehicle, depend for their safety upon the use of special tools or equipment designed and manufactured, or adapted, specifically for use on the vehicle, the safe operation of such equipment is to be demonstrated, and any limitations on it's use are to be recorded.

4106. Installations.

All equipments, systems and controls shall be operated according to agreed schedules in order to determine that all machinery and it's systems, controls, components and equipment may operate under all conditions for which they were intended within any prescribed limitations.

Division 4

Functional Tests and Trials.

Part C - Operating Safety Trials - Prototype Vehicles and Equipment.

4200. An Air Cushion Vehicle of a model or configuration which has not previously been issued with a safety certificate permitting it's general use shall be subjected to a schedule of trials to determine any loading, operational or environmental limitations with which the vehicle type shall comply in order to provide the required level of safety in service.

4201. The schedule of tests shall attempt to demonstrate safety of operation of the vehicle and management of it's systems and controls in loading and environmental conditions up to and including those declared in the design specification. It is emphasised that any safety certification given will relate to the conditions achieved during the course of trials; all trials documentation duly authenticated by the representative designated by the manufacturer for the conduct of the trial and submitted in substantiation of claims for certification will be considered.

4202. For vehicles operating in the marine environment, quantitative results should be provided to demonstrate:-

a) Directional and speed control characteristics during low speed manoeuvring in the displacement mode, both hull-borne and cushion-borne;

b) Directional and speed control characteristics during transition to, and operation at, speeds up to the maximum for which certification is sought;

c) Turning circle diameters at all speeds, and associated roll stability;

d) Any limiting safe deflection of any directional control device, either when applied singly or in combination;

e) Normal and emergency stopping distances from pre-determined speeds up to the maximum for which certification is sought, when operating with zero hydrodynamic yaw angle;

f) Any limitations of the vehicle speed/hydrodynamic yaw angle envelope to be observed in order to maintain safe operation;

g) Any limitations of longitudinal c.g. position affecting safety of operation;

h) Any adverse longitudinal trim changes dependent upon aerodynamic or hydrodynamic velocity or wind or wave direction;

i) Vehicle response to a single failure of one propulsion main engine, one lift main engine, and one directional control device (other than a fixed-axis propeller), during turns in each direction;

j) Any adverse effects upon safe handling and control resulting from operation over shallow water.

4203. In addition to the results by section 4202, qualitative results should be provided to demonstrate:-

a) Adequate authority of directional control to maintain desired vehicle heading under normal operating conditions without undue control movements or operator fatigue;

b) Adequate authority to maintain vehicle longitudinal trim angle under all loading conditions within the operating envelope for which certification is sought;

c) Adequate control authority to maintain safety of operation with reduced capability subsequent to any one of the single failures examined in section 4202 (i);

d) Adequacy of outboard vision and transparency clearance systems for safe operation under all environmental conditions for which certification is sought, including operation at night where this is a certification objective;

e) Adequacy of visibility and accessibility of an instrumentation, displays and controls provided for crew members for safe operation and management of the vehicle and it's systems, under all lighting conditions;

f) Adequacy of all ventilation and environmental control systems provided;

g) Audibility of all internal communication and broadcast systems during normal vehicle operation;

h) Management of vehicle systems, and of vehicle control and handling with 50% (minimum of one) of electrical power generators inoperative.

4204. For amphibious vehicles, additional trials shall be conducted to demonstrate adequacy of control and any limitations required to maintain operational safety during transitions to and from solid and liquid surfaces, and during manoeuvring when overland.

4205. An evacuation trial shall be conducted, using evacuation procedures and facilities provided for emergency evacuation and using lifejackets and liferafts proposed and stowed in their normal positions. The trial shall be arranged to simulate as closely as practicable the activation of a fire alarm in a Designated Fire Zone and the subsequent initiation and completion of an evacuation. Personnel involved shall be crew members not more than those carrying out normally assigned duties of the vehicle in service, initially at their normal duty station; a number of representative passengers not less than 50% of the maximum complement for which certification is sought, distributed representatively in passenger accommodation, and observers from or representing the certification authority. The result of this trial shall determine any passenger loading restriction which may be required in complying with the evacuation time allowance provided for in Section 1004 of Division 1 of these Standards.

4206. In trials to determine the vehicle response and control subsequent to a main lift engine failure, in vehicle designs employing multiple lift fans and intakes, the adequacy of the intake closure on the failed lift fan intake to prevent total loss of cushion air shall be demonstrated.

4207. The vehicle shall be subjected to a towing trial, during which any limitations imposed by directional control characteristics when being towed in both the displacement and hovering modes at speeds up to the maximum towing speed for which certification is sought shall be determined.

4208. Any vehicle which is of a design which has previously been subjected to prototype safety certification trials, but which incorporates such changes to structure, machinery or equipment that may render invalid any results of such trials shall be subjected to additional trials to establish the effects of such changes upon safety certification.

4209. Instrumentation or recording equipment required for trials data gathering shall be installed such that the accuracy of normal vehicle instrumentation and displays is not impaired, and that crew members may perform their normal duties with minimal distraction.

4210. Vehicles engaged upon prototype safety certification trials shall carry two-way radio communication equipment capable of maintaining communication with local safety services and weather information facilities.

Division 4.

Tests and Trials.

Part D - Operating Safety Trials - Production Vehicles.

4300. Every Air Cushion Vehicle shall be subjected to a schedule of trials which shall be agreed between the manufacturer and the certification authority. The trials schedule will require that the vehicle demonstrates performance, handling and control characteristics essentially similar to those previously established during trials of the prototype vehicle.

4301. In addition, every Air Cushion Vehicle will be subjected to a flotation trial, during which the vehicle is to be moored or anchored in water for a period of not less than 12 hours. During this trial, any automatic bilge pumping system is to be rendered inactive and upon completion, all watertight compartments shall be sounded and/or bilged. The source of any leaks resulting in an accumulation in any watertight space in excess of 100 1. shall be investigated and corrected, and the vehicle subjected to a repeat trial.

4302. Trials shall be conducted during vehicle operation of any installed radio-communication equipment and navigational equipment, instruments or aids with which the vehicle may be equipped to meet operational requirements for the service intended. Trials shall establish that the equipment may be operated safely without mutual interference, and without impairing the safety of operation of the vehicle and it's systems or the accuracy of any instrumentation or display.

Division 4.

Functional Tests and Trials.

Part E - Vehicles of other than Canadian Manufacture.

4400. Before any Air Cushion Vehicle which has been manufactured in a country other than Canada may be issued with an Inspection Certificate, the importer shall submit to the safety certification authority such technical data and certification as may be required to enable the degree to which the vehicle complies with these standards to be determined.

4401. Upon satisfactory evidence that the vehicle complies with these standards, safety certification trials may be required in order to confirm that the vehicle may safely operate in the intended Canadian environment. In establishing such confirmation, the certification authority may require modifications to the vehicle or it's installed equipments, or may revise any operating limitations or restrictions where such revision is essential for the preservation of the required level of safety.

Division 5.
Vehicle Technical Information.

5000. The vehicle manufacturer shall be responsible for providing technical manuals containing adequate information to enable the vehicle to be operated and maintained safely. Where necessary, such information shall be supplemented by additional information provided by manufacturers of machinery, equipment or components installed in the vehicle.

5001. Information shall be provided in a form that separately presents an operating manual, a maintenance manual, and a servicing schedule. Drafts of all information shall be submitted to the safety certification authority for approval. Mandatory information relating to limitations and restrictions, and to emergency procedures, as required in following sections, shall be specifically approved; approval of other information will be based upon accuracy, clarity and depth of content.

5002. Approval of technical manuals is an integral part of the vehicle certification process, and is an essential pre-requisite to the certification of vehicles for other than prototype testing or vehicle development purposes.

5003. Technical Manuals shall relate to a specified standard and configuration of the vehicle, but shall also provide for the addition of supplementary information pertaining to optional equipments or vehicle configurations which may be incorporated to meet individual customer or vehicle role requirements.

5004. Not less than two copies of a vehicle's technical manuals, when approved, shall be provided to the safety certification authority, and not less than one copy shall be delivered with each vehicle.

5005. The manufacturer shall establish an effective procedure to ensure that technical manuals are amended as required by changes or modifications to the vehicle. Such amendments shall be subject to the requirements of this standard.

5010. Operating Manual.

The Operating Manual shall contain pictorial and descriptive information pertaining to the vehicle and it's systems in sufficient detail that crew members may become fully conversant with the layout, operation and management of the vehicle and it's systems.

5011. The Operating Manual shall include instruction for preparing and inspecting the vehicle prior to operating, and for inspection upon completion of operations. Specific sequential instruction shall be provided relating to starting and shutting down of all machinery and of management of electrical power generation and distribution equipment. Appropriate instruction shall also be provided to ensure the safe operation and management of all other systems and equipment installed.

5012. The Operating Manual shall include the leading particulars of the vehicle, and the name of the manufacturer, and identification, of all major machinery components. Capacities of all replenishible systems shall be provided, together with specifications of replenishibles to be used.

5013. The Operating Manual shall contain instruction sufficient to enable the crew to calculate passenger and cargo distribution and to manage any systems provided for the purpose, to ensure that the vehicle c.g. position limitations are complied with.

5014. The Operating Manual shall contain a prominently displayed statement to the effect that:-

"Safety Certification of the ..... type of Air Cushion Vehicle is granted on condition that vehicles of this type will not be intentionally operated such that any limitations contained in this Manual are exceeded, other than at the discretion of the vehicle Commander to safeguard the vehicle and it's complement in emergency situations. Any operation in which these limitations are exceeded is a violation of the conditions upon which Safety Certification was granted, and may render invalid any Inspection Certificate issued in respect of the particular vehicle."

5015. Specific instruction shall be provided, including such precautions as may be necessary, relating to anchoring, securing, towing, and being towed.

5016. The Operating Manual shall include all relevant information required, instructing the crew member manoeuvring the vehicle, in handling and manoeuvring characteristics of the vehicle in both the hull-borne and cushion-borne modes, such that the vehicle may be safely operated within limitations imposed. Specific reference should be made to any effects upon handling, control or control effectiveness caused by relative wind velocity, waves, surface irregularities, and transitions, together with any precautionary or recommended information necessary to maintain safety.

5017. Safety instructions shall be provided for all crew members related to their duties for ensuring the safety of passengers and cargo.

5020. Operating Manual - Mandatory Approved Information.

Information as required in the following Sections 5021 - 5041 shall be specifically approved, and shall be clearly and separately identified under appropriate headings in the Operating Manual.

5021. Operating Limitations.

Information shall be provided relating to any limitations or restrictions established during safety certification trials or resulting from designer's or manufacturer's recommendations for the following:-

a) Any maximum speed restriction relative to the surface, for any surface over which the vehicle is capable of operating;

b) Maximum permissible hydrodynamic yaw angle at various vehicle speeds of entry into the yaw manoeuvre;

c) The maximum wind speeds at which the vehicle is permitted to operate;

d) Any ambient temperature restrictions, with particular reference to the possibility of icing;

e) The maximum significant wave height, and any critical wave length limitation, in which the vehicle is permitted to operate;

f) Any speed or attitude restriction to be complied with during transition manoeuvres between solid and liquid surfaces (amphibious vehicles);

g) Any speed or attitude restriction to be complied with when operating any directional control device;

h) Maximum permissible over-water speed at which the vehicle may be towed in both hull-borne and cushion-borne modes;

i) Any limitations to be complied with when the vehicle is being used to tow other vessels;

j) Minimum water depth in which the vehicle is permitted to operate (non-amphibians);

k) Any additional restrictions to be complied with when operating over irregular solid surfaces (amphibians);

l) Any additional restrictions to be complied with when operating at night or in reduced visibility.

5022. Loading Information.

The following information shall be provided:-

a) The maximum permissible weight at which the vehicle is permitted to operate, including any restrictions to be complied with when operating in waves or over irregular solid surfaces;

b) Limits of c.g. position within which the vehicle is permitted to be loaded for safe operation, including any restrictions to be complied with, should the limits be dependent upon environmental or surface conditions;

c) Any structural limitations or restrictions pertaining to cargo loading, distribution or securing.

5023. Endurance.

Information shall be provided to enable the vehicle commander to calculate the maximum endurance of the vehicle, taking into consideration the fuel consumption of the main engines at various power settings, and the operation of any other machinery using the same fuel.

5024. Crewing.

The minimum number of crew with which the vehicle may be safely operated shall be stated, taking into due consideration the requirements of any emergency situation and of the service upon which the vehicle may be engaged.

5025. Machinery and System Limitations.

Any limiting values of parameters, or conditions, requiring compliance for the safe operation of any machinery or system shall be stated.

5026. Vehicle Lifting.

Any restriction upon the weight of the vehicle, or of the position of c.g., and any limitations relating to wind velocity, surface gradient or rate of lifting, to be complied with when lifting, slinging or jacking the vehicle, shall be stated. This statement shall also make reference to the procedures to be observed when lifting the vehicle, which should be contained in maintenance manual.

5030. Mandatory Approved Information - Warnings and Precautions.

The Operating Manual shall include a clearly identified section providing information on all precautionary warning devices with which the vehicle is equipped, and on fault conditions requiring discretionary action.

5031. The information shall include the condition causing the warning to activate and the reason for taking action, and details of the remedial action(s) or restrictions to be complied with to maintain vehicle and personnel safety. Subsequent actions to be taken, including any restrictions to be complied with, in the event of failure of the remedial action to correct the condition shall be stated.

5032. Information shall also be provided detailing the remedial actions, and any subsequent restrictions or limitations imposed as a result of remedial action, in the event of:-

a) The value of any monitored parameter which is subject to limitations exceeding, or trending without apparent cause to exceed, those limitations;

b) Single faults or failures of any system component which affects vehicle or personal safety.

5033. The information shall clearly indicate whether or not the remedial action is discretionary or mandatory in respect of compliance with the vehicle safety certification.

5040. Mandatory Approved Information - Emergencies.

The Operating Manual shall include a clearly identified section providing information on the mandatory warnings provided and actions to be taken in the event of:-

a) Fire, or the activation of a fire detection system;

b) Collision, or rupture of a buoyancy space;

c) Failure of primary directional control system;

d) Failure rendering one main propulsion plant inoperable;

e) Failure rendering one main lift system inoperable;

f) Failure of one main electrical power generator;

g) Evacuation into survival craft carried by the vehicle; h) Any other failure or event requiring immediate and mandatory action to prevent the vehicle or complement being put in danger.

5041. Such information shall be clearly, concisely and sequentially provided in sufficient detail that, when followed, all provision has been made to maintain safety of the vehicle and it's complement, and safe conditions have been restored. The information shall address the duties of such crew members as may be required to respond to the emergency.

5050. Maintenance Manual

The vehicle manufacturer shall provide a maintenance manual containing descriptive, illustrative and instructional information relating to the maintenance, repair, adjustments, inspections and component replacements as may be necessary to ensure that the vehicle is capable of being operated safely in compliance with safety certification limitations and requirements.

This manual should contain, or be supplemented by, information provided by component manufacturers.

5051. The maintenance manual shall include leading particulars of the vehicle and of all machinery components and major equipments, together with the capacities of all replenishible systems and specifications of replenishibles to be used.

5052. The vehicle rigid and flexible structures shall be described and illustrated sufficiently that permissible repairs or adjustments may be carried out. Specifications of any materials to be used for repairs, procedures or standards to be adopted for repairs shall be provided, and any limits on repairs or permissible wear of structural components shall be stated.

5053. The installation of all main machinery components and associated services shall be described in sufficient detail to enable such maintenance, adjustment or replacement operations to be performed as may be necessary to ensure safety of operation within permissible limitations. Any special materials, tools or procedures required to perform the maintenance operations shall be specified, together with information of any wear limitations to be observed and special instructions relating to any testing of components or systems upon completion of replacement.

5054. Instruction shall be provided relating to any limitations of vibration resulting from imbalance of rotating machinery, measurement of vibration, and procedures to be followed to correct unacceptable imbalance.

5055. Each system installed in the vehicle shall be described in sufficient detail that all components may be maintained, adjusted or replaced to ensure safety of operation within permissible limitations, and that the cause of any malfunction may be readily diagnosed and corrected. Where special tools, materials or procedures are necessary to carry out required operations, they shall be stated.

5056. Descriptive information provided shall include specifications and identifications, with sizes, values or ratings where appropriate, of all components, materials and special tools necessary to perform any maintenance, adjustment or replacement operation described.

5057. Where any maintenance, adjustment or replacement operation requires any subsequent testing or calibration to establish correct functioning, the test procedure shall be described, stating the permissible limits of any parameters that are to be observed.

5058. Where appropriate, any precautions to be observed during maintenance, adjustment or replacement operations shall be stated.

5059. The maintenance manual shall include the recommended procedure for lifting, slinging or jacking the vehicle, including any limitations of vehicle weight and c.g. position to be observed, and any precautions to be taken.

5060. Special procedures, and any equipment required, necessary for weighing the vehicle and establishing the longitudinal c.g. position shall be described, together with a typical weight and c.g. position calculation. Sufficient information shall be provided relating to the weight and c.g. positions of vehicle components and removable equipment to enable basic datum calculations to be made.

5061. Information shall be provided relating to any special procedures relating to vehicle securing or picketing, securing or rotating machinery and protection from the environment when out of service. Where such procedures may depend upon the period for which the vehicle is out of service, each procedure shall be described.

5062. Where vehicle design and construction provides for disassembly of the structure for transportation, the procedure for disassembly and re-assembly shall be described, including the identification and use of any special tools or equipment, and precautions to be observed to prevent damage during transportation.

5080. Servicing Schedule.

The vehicle manufacturer shall provide a schedule describing all periodic checks, inspections, adjustments and replacements to be performed as necessary to ensure that the vehicle is capable of being operated safely in compliance with safety certification limitations and requirements. Any scheduled operations required to be performed on machinery, components or equipment shall comply with any recommendation made by the machinery, component or equipment manufacturer, taking into consideration any special or adverse features of the installation in the vehicle.

5081. Unless otherwise agreed by the vehicle certification authority, the servicing schedule shall comprise a series of checks and inspections progressively increasing in depth with vehicle utilization. Notwithstanding this, any components or equipment subject to calendar life or inspection in order to maintain their safe and effective functioning shall be scheduled separately in accordance with established calendar periods. Such components and equipment shall be clearly and separately tabulated showing their calender periods of inspection.

5082. The periodicity of servicing checks required shall be approved by the safety certification authority.

5083. Each servicing operation shall be described in sufficient detail to determine it's objective, provide any necessary instruction to perform the operation, including the specifications and application of any lubricants, greases, fluids or protective treatments or cleaning agents to be used, and information regarding adjustments which may be required.

5084. Any precautions to be observed during servicing operations in order to safeguard personnel or the vehicle shall be stated.

5085. Where a servicing operation involves the use of special tools or equipment, or adjustment to pre-determined values, instructions shall be provided.

5086. The servicing schedule shall contain information on the capacities of all tanks, reservoirs and pressure vessels liable to require periodic replenishment, and the specification of replenishibles to be used.

5087. The use of visual aids such as lubrication diagrams is to be encouraged.

5088. The servicing schedule shall contain clear definitions of the scope of operations to be performed when using terms such as "check", "inspect", "adjust", etc.

5089. The layout and format of the servicing schedule shall provide the information and instruction in such a manner that the possibility of error or omission is minimised.

5090. The servicing schedule shall, in addition to the periodic and calendar operations required, provide instruction on any additions or modifications to the schedule necessary as a result of a change in operational role or operating conditions.

Division 6.

Vehicle Certification Documentation.

6000. Upon satisfactory compliance with the requisite requirements of these standards, every Air Cushion Vehicle will be issued with a Safety Certificate in one of two categories.

6001. Additionally, when the first vehicle of a design for which series manufacture of essentially similar vehicles is intended has satisfactorily complied with these standards and has satisfactorily completed the tests and trials required by Division 4 Parts A, B and C, a Type Design Certificate for the vehicle class may be issued.

6002. No Air Cushion Vehicle to which these standards apply shall operate over Canadian waters under Canadian federal jurisdiction unless that vehicle has been issued with a valid Safety Certificate.

6003. The categories of Safety Certificates which will be issued shall be "Special" and "General". Specimens of each of these Certificates are shown in Appendices 2 and 3 of this Division.

6010. Type Design Certificate.

The issue of a Type Design Certificate for an Air Cushion Vehicle signifies that the vehicle design and construction comply with all relevant requirements of these standards, and have been performed by designers and manufacturers with appropriate qualifications and under approved conditions, and that the operational safety of the vehicle has been satisfactorily demonstrated within any environmental or operational limitations which have been established and recorded.

6011. The format of, and information contained in, a Vehicle Type Design Certificate, shall generally conform to that portrayed in Appendix 1 of this Division.

6012. The Type Design Certificate, upon completion of such trials as may be required and agreed, shall be completed and signed by a designated senior representative of the manufacturer and submitted to the certification authority for approval and return to the manufacturer; a minimum of two copies shall be submitted.

6013. Upon receipt of an approved Type Design Certificate, the manufacturer may manufacture and deliver production models of the Type, provided that such models conform in all respects with the Build and Equipment standard quoted in the Type Design Certificate, or with any approved amendments with which the Certificate may be endorsed.

6014. Each Air Cushion Vehicle for which an approved Type Design Certificate is in effect shall be delivered with a certified copy of the Certificate, the manufacturer having completed the Compliance Certification section, attesting to that vehicle's compliance with Type Design Certificate and the basis upon which the Certificate was approved.

6015. Any changes proposed for a vehicle of a type for which a Type Design Certificate has been approved which may modify the safety of the vehicle or of it's occupants, or may modify the approved limitations stated in the Certificate, or which modify the basis upon which the Type Design Certificate was approved, shall be submitted to the certification authority for approval before incorporation. The incorporation of such changes may require additional trials or tests to substantiate amendment or re-approval of the Type Design Certificate.

6016. In complying with the requirements of Sections 6014 and 6015, the manufacturer shall endorse the Compliance Certification section of the Type Design Certificate in the event that approved changes which may modify the safety of the vehicle or of it's occupants, or may modify the approved limitations, have been incorporated in a particular vehicle to meet individual requirements.

6020. Air Cushion Vehicle Safety Certificate - Special Category.

The "Special" Category of A.C.V. Certificate will normally be issued for a specific purpose of a special operation of limited duration or service. The period of validity will be limited, and in no circumstance will it exceed 12 months. Exceptionally, it may be re-newed upon expiry.

6021. A "Special" Category A.C.V. Safety Certificate shall, upon compliance with all pre-requisite requirements of these standards, be issued to an A.C.V. of Canadian manufacture before it operates in Canadian waters for the purposes of:-

a) Tests and trials of a production model, required to establish compliance with previously established operational safety characteristics of the A.C.V. type;

b) Tests and trials to establish the operational safety characteristics of a prototype A.C.V. model, or of a previously certificated A.C.V. model incorporating such changes as to require re-issue of the Type Design Certificate;

c) Operating in support of developing or testing experimental installations or equipment;

d) Experimental operations or applications for which no previous data is available or relevant;

e) Demonstrations or promotions;

f) Any other operation for which the issue of a "General" Category of Safety Certificate would be inappropriate.

6022. A "Special" Category of A.C.V. Safety Certificate shall also be issued, upon compliance with all pre-requisite requirements of these standards, to an A.C.V. manufactured outside of Canada before it operates in Canadian waters for the purposes of:-

a) Operating to establish compliance with Canadian requirements in respect of operational safety in the Canadian environment prior to the issue of a "General" Category Safety Certificate;

b) Demonstrations or promotions;

c) Specifically approved operations of limited duration or service.

6023. With the exception of operations considered under Section 6022(c), no operation of an A.C.V. issued with a "Special" Category Safety Certificate for hire or reward will generally be permitted.

6024. The form of the "Special" Category A.C.V. Safety Certificate is shown in Appendix 2 of this Division.

6025. A copy (not the original) of the Certificate shall be displayed prominently in the vehicle.

6030. Air Cushion Vehicle Safety Certificate - General Category.

All Air Cushion Vehicle operating in Canadian waters, which are subject to these standards, shall be in possession of a valid General Category A.C.V. Safety Certificate, unless otherwise provided for under Sections 6020 - 6024 of these standards.

6031. The normal period of validity of a General Category A.C.V. Safety Certificate will be 12 months; it may be re-issued upon satisfactory completion of an inspection by the safety certification authority of the vehicle, it's equipment and it's technical records.

6032. The form of the General Category A.C.V. Safety Certificate is shown in Appendix 3 of this Division.

6033. A copy (not the original) of the Certificate shall be displayed prominently in the vehicle.

Form of A.C.V. Type Design Certificate.

CANADIAN COAST GUARD.

AIR CUSHION VEHICLE TYPE DESIGN CERTIFICATE

Serial No.....

Air Cushion Vehicle Designation and variant

.....

Design Organization.....

Manufacturing Organization.....

THIS IS TO CERTIFY THAT:-

The above-mentioned Air Cushion Vehicle, having been designed and constructed in compliance with the Canadian Coast Guard "General Standards relating to Design, Construction and Operational Safety of Air Cushion Vehicle in Canada", and having been subjected to operational safety trials in compliance with those Standards, is approved for production and for commercial operation subject to the operational safety limitations and restrictions contained in the attached Data Sheet.

Issued on the day of 19

.....

for Canadian Coast Guard.

Production Vehicle Compliance.

This is to certify that (A.C.V. Designation and variant) Serial Number..... has been constructed and subjected to operational safety trials in accordance with procedures and schedule approved by Canadian Coast Guard, and complies with the Data Sheet attached.

Date..... .....

for (manufacturer)

THIS CERTIFICATE NOT VALID UNLESS DESIGN DATA SHEET IS ATTACHED.

Appendix 1

Form of A.C.V. Type Design Certificate Design Data Sheet.

AIR CUSHION VEHICLE DESIGN DATA SHEET

A.C.V. Designation and variant:-

This Data Sheet forms part of Air Cushion Vehicle Type Design Certificate Serial No.....

Length of rigid structure .....

Beam of rigid structure .....

Floating draft at maximum weight .....

Maximum Design Conditions.

Weight .....

Speed .....

Wave Height .....(Significant)

Wind Speed .....

Maximum weight/wave height/speed envelope(s) considered:

.....

.....

Machinery

Lift engine .... (Manufacturer and model) No.....

Lift fan ..... (Manufacturer and model) No.....

Propulsion engine (Manufacturer and model) No.....

Propulsion device (Manufacturer, type, model) No....

Auxiliary Power Unit (Manufacturer and model) No....

Electrical Generator (Manufacturer, type, rated output) No....

Maximum number of passengers .....

Minimum number of crew .....

Maximum cargo capacity .....

Approved Operational Safety Data.

Maximum permissible weight .....

Maximum permissible speed relative to surface...(water)...(land)

Maximum significant wave height ..... Maximum windspeed .....

Maximum hydrodynamic yaw/speed boundary .....

Longitudinal limits of c.g. position .....

Maximum towing speed ..... Minimum water depth .....

Ambient temperature limits .....

Form of Special Category A.C.V. Safety Certificate. - Obverse.

AIR CUSHION VEHICLE SAFETY CERTIFICATE - SPECIAL.

Issued in compliance with the provisions of the Canadian A.C.V. Safety Standards.

Vehicle Type and Model	Date of issue of initial certificate
.....	.....
Manufacturer	Vehicle Identification
.....	(name, serno, registration, etc.)

THE UNDERSIGNED hereby certifies:-

1. That the vehicle identified above has been satisfactorily inspected in accordance with the provisions of Canadian A.C.V. Safety Standards in respect of:-

a) Design calculations relating to operation of the vehicle within the limitations stated overleaf;

b) Structural integrity of the hull, buoyancy, machinery and systems;

c) Installation of life saving appliances as follows:-..... survival craft .....lifejackets, and is accordingly permitted to operate when carrying not more than... persons;

d) Structural fire protection and installation of fire detection and fire extinguishing appliances;

e) Installation of navigation equipment and lights, and provision for making visual and sound signals in accordance with Collision Regulations.

2. That a satisfactory examination of the vehicle technical records has been completed.

THE VEHICLE is hereby permitted to operate in compliance with the limitations stated overleaf, for the purposes of:-

.....

THIS CERTIFICATE is not valid after ....., and in any case is rendered invalid by non-compliance with approved information and limitations, unauthorized modifications affecting safety, or non-compliance with maintenance recommendations.

SIGNATURE DATE

Division 6
Appendix 2

Form of Special Category A.C.V. Safety Certificate - Reverse.

The Air Cushion Vehicle identified overleaf, it's machinery and systems, shall not intentionally be operated such that either:-

a) The approved limitations contained in (Type Technical Manual) or

b) The limitations stated below are exceeded.

Vehicle weight:- Limits of c.g. position:-

Maximum speed relative to surface:-

Speed/Yaw limitations:-

Maximum wind speed:-

Maximum significant wave height:-

Maximum speed when under tow:- (hullborne) (cushionborne)

Ambient temperature limitation:-

Minimum water depth:-

Visibility or night operation limitations:-

Distance from nearest refuge:-

Machinery limitations

Main propulsion engines:-

Propulsion device:-

Main lift engines:-

Lift fans:-

Any other systems subject to limitations:-

Other restrictions or comments to be complied with:-

Division 6
Appendix 3

Form of General Category A.C.V. Safety Certificate -

AIR CUSHION VEHICLE SAFETY CERTIFICATE - GENERAL.

Issued in compliance with the provisions of the Canadian A.C.V. Safety Standards. Serial No.....

Vehicle Type and Model
.....

Vehicle Identification
(Name, number, registration)

Manufacturer
.....

Date of completion.
.....

THIS IS TO CERTIFY THAT;-

1. The above mentioned Air Cushion Vehicle has been duly inspected in respect of life-saving appliances, fire safety measures, operational safety procedures and equipment, and maintenance procedures, and that subject to such limitations as are approved for the Air Cushion Vehicle Type and to any additional limitation specified herein, the vehicle is approved for service.

2. The inspection showed that:-

a) approved life-jackets and.....life-buoys are carried;

b) approved liferafts, type.....are carried, have valid inspection certificates, and are capable of accommodating.....persons;

c) Fire detection systems are operating, and that the following fire extinguishing appliances are installed or carried, and have valid inspection certificates:-

..... (Fixed installation)
..... (Portable)

d) Satisfactory operating safety procedures are practiced;

e) The vehicle maintenance records are satisfactory and correct maintenance procedures are practiced.

Limitations. In addition to approved limitations for Air Cushion Vehicle of this Type, this Certificate is only valid when the vehicle is operated as follows.....
.....This Certificate is not valid after.....
This Certificate is issued on .....

.....
(Signature)