HOVERCLUB OF AMERICA, INC.

CONSTRUCTION REGULATIONS FOR LIGHT HOVERCRAFT

Hoverclub of America Inc.

Construction Regulations
For Light Hovercraft
Revision 2002-8A

CONSTRUCTION REGULATIONS
FOR LIGHT HOVERCRAFT
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Requirements For The Construction Of Light Hovercraft

1. Introduction

1.1. General

1.1.1. These regulations will be binding on all drivers and all craft operated at all Club-sponsored events. They may be used by others for reference purposes.

1.1.2. The Club takes no responsibility for the compliance of the hovercraft to these regulations. Note that is up to the craft user to give proof of compliance of their craft with the rules. The craft user takes the complete responsibility for any hazard generated by their hovercraft.

1.1.3. This publication overall reflects the views of a substantial and well informed body of professional and amateur experience with which all constructors and operators of Light Hovercraft will consider it wise to comply.

1.1.4. The Club greatly acknowledges the World Hovercraft Federation (WHF) and the European Hovercraft Federation (EHF), whose "*Racing* Hovercraft Construction Requirements" are used as a basis for recreational hovercraft safety rules throughout the world. A special "Thanks" goes to the U.S. Coast Guard for their "Safety Standards for Backyard Boatbuilders" and "Rules and Regulations for Recreational Boats" and to the Canadian Coast Guard for their "Standard for the Safety Certification of "Light" Air Cushion Vehicles in Canada".

1.1.5. The Club will update these rules as necessary. Any amendment(s) will be published in HOVERNEWS, the official Club newsletter, and on the Club website prior to enforcement unless the Board of Directors deems immediate action is necessary.

1.2. Purpose of these Requirements

1.2.1. The purpose of these requirements is to ensure that light hovercraft are designed, constructed, operated, and maintained in such a way as to prevent, so far as can be foreseen, the occurrence of accidents. Should an accident occur, the purpose of these rules is to ensure its effects are minimized as far as possible to both persons and property.

1.3. Application

1.3.1. These requirements apply to light hovercraft for sporting use having a dry weight of less than 1340 lb. (500 kg). Craft over 1340 lb. (500 kg.) will need special consideration by the Chief of Operations of the meeting.

1.3.2. Craft built to these requirements are not necessarily suitable for use in open environments. Certification for use in open environments is provided for under the U.S. Coast Guard, your State's Department of Natural Resources, Federal Park Administrator (currently prohibits hovercraft), State Park Association, Local Government and/or Land/Water Management Bureau.

1.4. Interpretation

1.4.1. These requirements are not intended as a manual of hovercraft design but wherever practical examples of methods that meet these requirements are included. Alternative practices, which provide an equivalent level of safety, may be accepted at the discretion of Club safety inspector(s).

1.4.2. Mandatory clauses are denoted by "shall" or "must", whereas recommended but not mandatory practice is denoted by "should" or "may".

1.4.3. It is implicit in the requirements expressed qualitatively (e.g. "readily visible", "adequately tested" etc.) that the Chief Safety Inspector of the meeting will decide in cases where doubt of compliance exists.

1.5. Appeals

1.5.1. In the case of an operator disagreeing with the ruling of an inspector or the Chief Safety Inspector of the meeting, he or she may appeal as follows:

a) Submit an appeal in writing to the Club Safety Director by sending it to the Club Secretary: a written and complete description of each appealed item, a $20 appeal bond and a copy of the above items to the Safety Inspector involved.

b) The appeal will be considered by the Hoverclub Board of Directors at its next scheduled meeting, or specially convened. The Committee will judge the case, taking whatever additional technical or legal advice is considered necessary. The appeal bond will be returned only if the appeal is upheld on all counts.

1.5.2. In the case that legal or other professional advice need be taken, the cost of such consultant will be required to be paid by the complainant, regardless of the outcome of the dispute.

1.6. Method of Compliance

1.6.1. Compliance with these requirements shall be established by calculation, testing, or other evidence to the satisfaction of the Safety Inspector. An example of "other evidence" may be a certificate of compliance from an approved component manufacturer.

1.6.2. Where an applicant proposes to use a proprietary component in a manner other than provided for its manufacturer certificate, then compliance shall be demonstrated to the Club.

1.6.3. Where a requirement is not susceptible to quantitative proof of testing, compliance must be established to the satisfaction of the inspector, by inspection during the construction stage of the craft, by reference to the precedent, or by reference to good engineering practice.

1.6.4. Since it is not possible to prescribe requirements to cover every detail that designers may introduce, the inspector may reserve the right to with-hold approval of a craft or part thereof, if in his or her opinion such a craft or part thereof is unsafe, even though it complies with the letter of these requirements. Any disagreement with this decision is to be resolved by the majority vote at a meeting of all Official Safety Inspectors.

1.7. Craft Design General Requirements

The following general requirements apply to the more detailed specifications given in chapters 2 to 6 below.

1.7.1. All connecting elements essential to safe operation of the craft shall be locked to prevent failure due to vibration, rotation, and torque, flexing of the craft structure or impact

1.7.2. All personnel must be protected from contact with rotating components, surfaces with temperatures exceeding 158 °F (70 °C), live electrical circuits, and sharp edges or corners.

1.7.3. Services essential for personnel safety shall function at all times during operation, independent of the functioning of the main power unit(s).

1.7.4. Adequate access shall be provided to all parts of the craft requiring periodic inspection.

2. Structure and Main Machinery

2.1. General

2.1.1. The structure of the craft shall have adequate strength to withstand all load cases as defined in 2.2 below and in either cushion borne or floating/static mode. Structural deformations will not interfere with the safe operation of the craft.

2.1.2. The stiffness of the craft structure shall be such that any vibrations due to engines or rotating equipment, or flexing of the structure due to dynamic loads, will not affect the safe functioning of the craft or machinery.

2.1.3. The craft shall have buoyancy equal to the craft dry weight. The buoyancy shall be distributed in such a manner that when floating either intact or when damaged, the craft will not sink. In this context, to “sink” shall be interpreted as when the craft becomes completely immersed.

2.1.4. The craft should float in a stable manner when intact such that flooding of open areas (e.g. the cockpit) will not immediately occur when floating, and with personnel moving around in the craft. Freeboard of 3 to 6 in. (75 to 150 mm) at the stern, when the driver is positioned to restart a rear mounted engine, is advised. Less than this will mean the cockpit is likely to flood, so disabling the craft.

2.1.5. Engines should be able to be restarted from cold with the craft floating in the maximum design environment without external assistance.

2.2 Strength and Stiffness of Structure

2.2.1. The structure of the craft shall have adequate strength to withstand loads encountered under all conditions of operation. Load cases, which should be considered by the designer, are:

1) Maneuvering: forces applied to controls and machinery frame.
2) Floating: forces applied to the hull.
3) Water impact: forces applied to the front or side planing surfaces of the hull.
4) Transition: forces due to craft dropping over a step.
5) Wind loads: forces applied to the structure.
6) Impact: forces due to skid stop over land.
7) Parking: forces due to three point random support on the craft bottom.
8) Towing: forces due to towing equal to twice craft weight.
9) Machinery: forces on machinery mounts due to mass, torque and dynamic loads.
10) Collision: forces due to collision with an immovable object.

2.2.2. Compliance with 2.2.1. may be proved by inspection and possibly trials carried out by an inspector.

2.2.3. Inflatable structures forming a part or whole of the hovercraft primary structure shall conform to these regulations.

2.3. Crash Worthiness

2.3.1. The craft shall be designed to minimize the risk of injury to the driver in the event of a collision. This shall be achieved by craft construction conforming to 2.3.2. to 2.3.8. below.

2.3.2. All major components and items of equipment shall be attached to the craft primary structure with arrangements sufficient to withstand inertia forces in any direction.

2.3.3. Machinery and frame mountings shall be fail safe by mounting design, or by secondary restraint.

2.3.4. A roll bar of adequate strength shall be built into all craft. This may take the form of structural members primarily designed for other purposes (engine mounts, duct, etc.) if they will maintain adequate clearance for the driver when the craft is inverted.

2.3.5. Interior surfaces and edges of structural members within the cockpit and cabin areas shall be designed to minimize injury to drivers in the event of a collision, by protection with crushable padding. Guarding shall be provided to prevent limbs becoming trapped in engine frames, structural members or exhaust systems.

2.3.6. The exterior periphery of the craft shall be constructed so that any sharp edges or corners are protected by crushable material (padding).

2.3.7. No components such as handling points, towing eyes, exhaust pipes, etc., shall overhang the hull structure, with the exception of aerodynamic control services.

2.3.8. Removable items, such as batteries, fuel tanks, fire extinguishers, etc., shall remain securely in position even if the craft is inverted.

2.4. Buoyancy and Stability

2.4.1. Craft intended to be operated over water should be capable of floating in a reasonable attitude in the event of loss of cushion lift, with the driver aboard, either to allow the craft to be restarted, or until the driver can be rescued if the craft becomes flooded.

2.4.2. The units of buoyancy shall be so located in the craft as to provide adequate stability when the craft is water borne.

2.4.3. Consideration shall be given to the provision of adequate buoyancy and stability of the craft when water borne when those units of buoyancy likely to be damaged have sustained such damage.

2.4.4. Buoyancy sufficient to keep the craft afloat when swamped with water shall be provided by non-absorbent foam, inspectable air bags, or multi cellular inspectable boxes / containers.

2.4.5. Temporary additional external buoyancy may have to be added onto the hull for rallies on rivers or at the coast.

2.4.6. Designers are advised to add a design margin to the weight used to design the buoyancy, and to be careful to account for the fact that the effective buoyancy of foam filled compartments is reduced by the weight of the foam that is added to the craft. It is further advised that retrieval of a craft with a flooded cockpit using a towrope is much easier and safer if it floats level. Buoyancy should be placed in such a manner therefore, that the propulsion system, or any other major components above the line of the top of the craft hull are supported in air. This will generally require about 2/3 of the total craft buoyancy to be placed in the rear half of the craft length.

2.4.7. Special note should be taken of designs having internal air ducting to segmented skirts. Any ducting areas extending below the waterline need to be designed to allow water to freely drain out when hovering up.

2.4.8. Intact Stability. The intact floating stability of the craft should be such that when floating in calm water, the driver is able to move about the craft within reasonable limits, and to restart the engine(s) without flooding the cockpit. The placing of buoyancy as in 2.4.7. above should therefore take account of the weight of the driver in the pull starting position.

2.4.9. Damaged stability. The craft shall not sink in the case of the cockpit being flooded due to an accident. The flooded craft shall retain sufficient residual buoyancy to allow the driver to hold onto it while floating in the water supported by a personal flotation device (PFD).

2.4.10. Hull outer surface configuration. The outer surface of the hull shall be so configured as to provide a planing surface with a dihedral angle of 10° to 35° in case the skirt should totally collapse on one side, front, or rear of the craft, at maximum operating speed in still air over land or water. The planing surface(s) shall be present over a depth not less than that defined by the skirt outer and inner hull attachment points. Some provision should be provided to prevent laminar water flow over collapsed planning surface. For example, use a sharp step.

2.5. Main Machinery, Mounting and Transmissions

2.5.1. All components of machinery and transmissions shall be constructed, arranged within the craft, and protected as necessary to ensure their safe functioning at all times.

2.5.2. The possibility of failure of a given power unit, transmission or support system shall be considered. In any such case, the system shall fail safe, and not endanger the driver.

2.5.3. Mountings and connections between main machinery and primary structure and between main machinery and rotating assemblies shall be positively locked. Such mountings and connections shall be designed in order that failure of 25% of the mountings or connections will not lead to any subsequent failure, or endanger the safe operation of the craft.

2.5.4. Pipe work and hoses on liquid cooled engines shall be designed and installed in such a way as to minimize the possibility of failure, which may result in injury to the driver or bystander.

3. Rotating Assemblies

3.1. Design and Operation

3.1.1. All rotating assemblies shall be designed and operated such as to preclude, as far as possible, failure during normal operating life of the assembly.

3.2. Fans

3.2.1. A number of proprietary fans are available and suitable for use on Light Hovercraft. The rotating speed of these fans is to be limited following the guidelines in Appendix B.

3.2.2. Propulsion systems designed for tip speeds in excess of 450 ft/s (137 m/s) are likely to produce noise levels in excess of 78 dB at 50 ft. (15 m) distance. A maximum design tip speed of 400 ft/s (122 m/s) is recommended to be used for this reason where practical.

3.2.3. Fan speeds for given diameters. A table given in Appendix B indicates fan r.p.m. for the limiting tip speeds, based on the recommended limits of 400 ft/s (122 m/s) for normal operation, 450 ft/s (137 m/s) for design maximum, and 550 ft/s (168 m/s) which is the absolute limit for Multi-wing Z and Nylon blade fans and Breeze A plus blades.

3.3. Propellers

3.3.1. Wherever possible, it is recommended that reliable commercial units (with a test certificate) be used. If it is essential to home produce a propeller or fan, the material should be very carefully selected, and if possible tested for tensile strength. Wooden blades shall be laminated. It is very important to provide adequate blade cross section in the region of the blade root. Glass Fiber is unreliable for propellers - even when laid up under carefully controlled conditions - and should be avoided. On no account shall cast materials (aluminum, resin, etc.) be used. If accurate materials and stressing data is not provided, then maximum permissible tip speed shall be 450 ft/s (137 m/s) for normal operation.

3.3.2. Every prototype propeller should comply with the “prototype propulsions guide lines” given in Appendix B.

3.4. Over Speed Conditions

3.4.1. The normal operating rotational speed for more than one fan unit driven from a single engine must allow for the over-speed of the remaining unit(s) resulting from a single failure in the transmission system. The maximum stress allowed in rotating assemblies shall not exceed 0.66 x the material design stress for the following:

Failure	Over-speed limit for design
1 fan out of 2	30%
1 fan out of 3	15%
2 fans out of 3	50%

3.5. Positive Locking of Fastenings

3.5.1. Inspectable positive locking devices (wire, split pins, nylon nuts) will be employed in the rotating assembly and its mounting structure, where loosening might cause a dangerous misalignment. Adhesive (Loctite or Casio ML or equivalent) will not be deemed sufficient, mechanical locking will be required.

3.6. Guarding of Rotating Assemblies

3.6.1. All rotating assemblies shall be guarded in such a way that under all operating conditions no part of a person or their clothing may enter the space swept by the rotating assembly, or force the guards or the duct structure into that space whether the person be:
a) in collision with or
b) manhandling or
c) operating the hovercraft.

3.6.2. A fail-safe device shall be fitted to all transmission shafts transmitting more than 20 hp (15 kW) per shaft, in order to prevent shaft "flailing" in consequence of bearing or bearing housing failure. Suitable flail guard devices include a suitably sized metal strap over pedestal bearing housings or suitably sized plates with a clearance hole around the shaft to act as temporary plain bearing, and limit shaft movement. Such flail guards should be securely attached to a substantial part of the transmission-mounting frame in order that the shaft movement will not cause failure in the guard itself.

3.6.3. Minimum guarded area. Fans and propellers must have guards at the intake, around the periphery and at the discharge side of the unit, to the following standards:
1) The inlet side of all fans or propellers must be guarded to the standard of 3.6.4. and 3.6.5. below.

2) The periphery of the volume swept by the fan or propeller must be surrounded by a guard extending at least 5 in. (125 mm) or forward and 10 in. (250 mm) aft of the swept volume, to avoid fingers gripping the edge of the guard from contacting the blades.
3) Special care should be taken to provide adequate guarding at the exit area from a fan or propeller. There should be no open areas greater than 12 in. (300 mm) diameter at a position 10 in. (250 mm) aft of the fan or propeller swept volume. Guarding may be provided in the form of rudder(s), elevator(s), duct support framework, fan center bodies or flow straightener vanes, or wire mesh conforming to the strength requirements of 3.6.5. below.
4) All rotating shafts, transmission belts, chains or gears shall be guarded by containment inside a closed space (engine compartment, fan center body, engine or component solid cover) or by wire mesh guarding to the requirements of 3.6.5. below.
5) No guard shall extend beyond the edge of the main hull structure. Local extensions to the hull shall not be considered part of the craft main hull.
6) Guard attachment shall be mounted at intervals of no more than 12 in. (300 mm) around the periphery of each guard.

3.6.4. Guard material and configuration. Guarding may be provided in the form of wire mesh, wire rod, tubular metal framing, and solid wall ducting. Where wire mesh is used to make a guard, the following mesh sizes shall be the maximum acceptable:

Distance from rotating device swept volume	Maximum mesh dimension
less than 6 in.(150 mm)	0.5 in. (12 mm)
less than 32 in. (800 mm)	2.0 in. (50 mm)
more than 32 in. (800 mm)	12.0 in. (300 mm)

3.6.5. Guard overall strength and rigidity. No guard or structure shall deflect into the swept volume of the rotating device when a force of 135 lb. (50 kg) Is applied over an area of 5 x 5 in. (127 x 127 mm) At any point of the guard. This is to prevent failure of the rotor, or injury to a third party in the case of a person falling onto the guard and taking the impact on one hand.

3.6.6. Containment of failed blades.
1) All fan and propeller guarding shall be designed to contain, so far as is possible, failed blades or blade pieces caused by collision or ingestion of foreign objects.

2) Fans. Polypropylene blade materials tend to break into many pieces while Nylon or Delrin blades tend to fail at the blade root or into larger pieces. Minimum thickness of fiberglass ducting over an area 4 x 4 in. (100 x 100 mm) forward and aft of the centerline of the rotor swept volume shall be 4 layers of 16 oz (450 g) chopped strand mat for maximum tip speed of 450 ft/s (137 m/s). Where tip speed is greater than 450 ft/s (137 m/s) duct reinforcement shall be added to by 2 x 16 oz (2 x 450 g) layers chopped strand mat. The addition of stronger materials such as woven roving, Kevlar or wire mesh within the laminate is highly recommended.
3) Ducted propellers are guarded by a duct system with mesh guarding at the inlet, the duct shall have 4 layers of 16 oz (450 g) chopped strand mat for maximum tip speed of 450 ft/s (137 m/s). Where tip speed is greater than 450 ft/s (137 m/s) duct reinforcement shall be added to by 2 x 16 oz (450 g) layers chopped strand mat reinforcement over an area 4 x 4 in. (100 x 100 mm) forward and aft of the propeller swept volume. The addition of stronger materials such as woven roving, Kevlar or wire mesh within the laminate is highly recommended. The reinforced duct shall be of sufficient strength to contain a blade component in the manner and condition of item 4 below. The duct outlet may require mesh guarding to contain a blade component as in item 4 below.
4) Propellers with mesh guards. Where guarded by wire and tube mesh cage(s), the propeller shall be guarded by mesh to the sizes as in 3.6.4. above. The guard shall be of sufficient strength to contain a blade component comprising the outer two thirds of a single blade, ejected in any direction from directly ahead to 45° aft from the propeller swept disc at a rotational speed corresponding to the application of maximum engine power, plus a margin of 10% of engine power.
5) Failure conditions. It should be noted that the requirements in items 1 to 4 above do not require that the guarding shall remain undamaged in failure conditions. The requirement is for the containment of rotating components. Gross deformation of the guard structure is acceptable, though the designer should bear in mind that in such a case the craft is likely to be disabled.

3.7. Transmissions

3.7.1. Machinery transmissions shall fulfill the requirements of chapter 2 above.

3.7.2. Transmission shafts of capacity greater than 20 hp (15 kW) shall be protected by flail guards sufficient to contain a failed shaft rotating as specified in 3.6.2., in addition to bearing failures.

3.7.3. Transmission shaft linkages and support bearing mountings shall be positively locked to the requirements of 3.5..

3.7.4. All transmission rotating components shall be guarded to the level of section 3.6. against contact with personnel.

4. Systems and Controls

4.1. General

4.1.1. This chapter specifically covers the following:
Aerodynamic control surfaces.
Engine, transmission and associated controls.
Fuel systems.
Electrical systems.

4.1.2. All systems and controls shall be designed to be safe in operation and, where possible, fail-safe when released by the operator. Any systems and controls installed in a light hovercraft, which are not specifically referred to here, should be designed and constructed to this same principle. Acceptance of such systems will be at the discretion of the Chief Inspector.

4.1.3. The designer should keep in mind the environment in which the controls and systems will operate. Where systems are likely to be sensitive to dampness, salt water, sand particles, vibration, and relative movement of craft substructures, they should be designed for protection against such effects.

4.2. Aerodynamic Control Surfaces and Operating Systems

4.2.1. Aerodynamic control surfaces may be of two types:
A) Fixed surfaces providing aerodynamic stabilizing forces while in operation, which are fixed or able to be moved (trimmed) when the craft is stopped such as fixed elevators, fins or thrust straightener vanes.
B) Moving surfaces providing aerodynamic control forces, such as rudders, controllable elevators, or elevons.

4.2.2. Fixed surfaces shall be attached to the craft structure with arrangements sufficient to maintain them securely in position under the maximum design air speed over the device, at the position of maximum control force generation.

4.2.3. Moving surfaces shall be attached to the craft structure with hinging arrangements sufficient to maintain them securely in position under the maximum design airspeed over the device, at the position of maximum control force generation.

4.3. Engine, Transmission and Primary Controls

4.3.1. Craft with one main power plant shall have a throttle control, which has a spring return to the engine idle position.

4.3.2. Craft with separate lift and propulsion power plant shall have spring return throttle(s) on propulsion engine(s) to engine idle position.

4.3.3. Manually operated control systems should be designed with adequate safety margin against the following load applied with the maximum lever arm possible :
Foot Controls - 132 lb. (60 kg).
Stick Lever Controls - 110 lb. (50 kg) fore and aft, and 66 lb. (30 kg) lateral.
Wheel Controls - 110 lb. (50 kg) fore and aft, and 145 x D ft. lb. (20 x D kg/m) torque, where D = diameter.
Handlebar Controls - 110 lb. (50 kg) fore and aft, 55 lb. (25 kg) in rotation.

4.3.4. Control cables, chains, torque tubes and push rods should have an adequate safety margin against the loads applied in 4.3.3. above.

4.3.5. All primary controls shall be capable of operation by the driver when in the normal driving position, with sufficient ease, and smoothness of operation, to permit the proper performance of their function.

4.3.6. Full movement of every control shall be possible when the driver is in place while wearing appropriate protective clothing and safety equipment.

4.4. Fuel Systems

4.4.1. All tanks, containers, pipelines, structure and equipment shall be designed to comply with the strength requirements of the vehicle as described in Chapter 2, and the fire safety requirements of Chapter 5.

4.4.2. Fuel tanks shall be fuel tight against the operating conditions of the craft while providing for fuel expansion due to temperature changes, prevent siphoning of fuel through vents, and minimize entry of water through fillers. Fuel tanks shall be capable of drainage to completely empty condition.

4.4.3. Fuel tanks and supply lines shall be so located that, in the event of a leak occurring, the escaping fuel is prevented, so far as possible, from making contact with any of the hot parts (e.g. engine, exhaust pipe etc.), or electrical circuits of the craft.

4.5. Electrical Systems

4.5.1. Electrical systems shall be so designed that their normal operation will not create a fire hazard, and also that additional hazards will not be created in the event of a fire in a designated fire zone.

4.5.2. It is recommended that it should be possible for the driver of the craft to switch off engines and power to all electrical systems while in the normal driving position. Switches must be of the positive-off type.

4.5.3. Battery power supplies should in addition have a separate circuit breaker in a clearly accessible position outside any fire zone.

4.5.4. All engines shall have a pull-out type lanyard ignition switch, the lanyard of which shall be attached to the driver at all times during operation, so that in the case of an accident where the driver is thrown out, the craft will be stopped. The Safety Inspectors at meetings as part of the checkout will regularly check the operation of this lanyard switch.

5. Fire Safety

5.1. General

5.1.1. The design of craft shall be such as to minimize the risk of fire occurring.

5.1.2. Engine exhausts shall be designed so that no appreciable amount of exhaust gas can enter the air cushion system of a no-flow bag skirt. The exhaust outlet must be clear of the lift fan intake suction on a no-flow bag skirt.

5.1.3. Craft designed with a substantially or totally enclosed cockpit should be separated from the engine or engines by flame resistant or non-flammable bulkheads. Metal or metal clad bulkheads are recommended.

5.2. Fuel Tanks

5.2.1. Fuel Tanks and supply lines will be constructed and mounted so that any vibration or distortion of the craft structure during operation will not damage the tank, or cause leaks in the supply line(s).
5.2.2. Gravity feed fuel tanks should be fitted with a cut-off tap, which can be easily operated by the driver.

5.2.3. Fuel tanks with feed from the base of the tank shall be fitted with a cut-off tap, easily operable by the driver, so that if the fuel line fails, the tank can be stopped from draining out.

5.2.4. Fuel containment system shall be so designed that liquid fuel cannot leak and directly contact any hot parts or electrical components, when the craft is inverted, or in any attitude such that fuel may leak from the vent or breather systems.

5.2.5. Fuel lines of PVC or other plastics, which degrade over time, shall be replaced annually.

5.3. Hot Parts

5.3.1. The parts of a craft within 2 in. (50 mm) from hot parts, for example engine exhaust pipes or silencers, shall be of nonflammable or fire inhibiting material.

5.3.2. Hot parts shall have an adequate supply of cooling water or air-to maintain a steady design temperature during all normal operations.

5.3.3. Hot exhaust pipes or silencers should be protected by a standoff wire mesh guard if mounted in locations close to normal craft manhandling points.

5.4. Fire Extinguishing Systems

5.4.1. Structures surrounding all enclosed engines and fuel tanks shall be fitted with readily accessible aperture(s) for the purpose of efficiently extinguishing a fire.

6. Skirt Design and Attachment

6.1. Stability

The skirt system as fitted to the craft should be such as to ensure adequate stability when hovering under all possible operating conditions. Adequate stability is defined as follows :

6.1.1. For the craft trimmed level in a static hovering condition, the skirt shall provide sufficient righting moments in the conditions of maximum design speed, and maximum design environment of wind and waves or hard surface, so as to prevent plow-in during application of a moment equal to transfer of 10 % payload fore and aft or cross the beam of the craft the maximum distance feasible for the craft design.

6.1.2. The righting moment generated by the skirt system in pitch and roll shall steadily increase at a linear or greater rate with rotation, to the point that the hull contacts ground or water.

6.1.3. The skirt system shall be intrinsically stable in heave (vertical motions) at any power setting.

6.2. Hard Structure Clearance

6.2.1. Hard structure clearance shall not exceed 12.5 % of hard structure width (Hard Structure Width/8.0) unless it can be demonstrated that both dynamic and static stability characteristics are adequate by calculation and/or trials, in accordance with 6.1 above.

6.3. Design Cushion Pressure or Bag Pressure

6.3.1. In order to avoid collapse of the skirt system at high speed, the pressure in the skirt bag, inflated segment area, or the cushion itself if there is no area inflated at a higher pressure around the periphery, shall not be less than the dynamic air pressure as in the table below:

Pressure		Maximum Design Speed	
(lb./sq.ft)	(kg/m²)	km/h	mph
3.1	15	48	30
7.0	34	72	45
12.3	60	96	60

As an example, a craft with a cushion area of 50 sq. ft. (4.64 sq.m) must weigh at least 350 lb. (158 kg) if it is designed to operate at 45 mph (72 km/h).

6.4. Construction and Materials

6.4.1. Skirt material should be coated, woven material with high resistance to ripping in any direction.

6.4.2. Attachments of the skirt to the hull shall be of sufficient strength that no damage is caused to the hull attachment if the skirt material is ripped or snagged with sufficient force to break the skirt-connecting device.

6.4.3. Attention should be paid to the configuration of seams on a bag or loop so that rips will be stopped by the seams, rather than guided by them.

6.5. Damage

6.5.1. The craft should maintain stability sufficient to prevent capsize in the event that any part of the skirt should collapse and be dragged back by the water surface during operation at maximum operational speed in any direction. Hull planning surfaces should be stepped to limit boundary layer suction.

6.5.2. The skirt should be designed so that damage to any part or area of the skirt will not cause other parts or areas of the skirt to fail as a direct consequence.

7. Handling, Performance and Operational Safety

7.1. General

7.1.1. The general principles of operational safety for a light hovercraft shall be that in the event of an accident, the driver shall be provided with reasonable means of escape and survival.

7.2. Demonstration of Characteristic

7.2.1. The Safety Director can ask for a trial demonstration of craft characteristics of buoyancy, freeboard, stability, adequate control, emergency stopping, and safe performance.

7.3. Arrangements for Operational Safety

7.3.2. A buoyancy aid or a personal flotation device (PFD) to National Standard (USCG) should be worn when a craft is operated over water.

7.3.3. The driver and passengers should wear suitable protective clothing covering arms, hands, legs, torso and feet. Hearing and sight protection are recommended.

7.3.4. The driver should have adequate all round vision directly, or by means of mirrors.

7.3.5. All craft shall be fitted with handling points adequate for manhandling of the craft itself, and for grasping by personnel overboard. The handling points should be handles designed for grasping.

7.3.6. Handles should be a minimum of one on either side (2 per side for craft over 670 lb. (250 kg) dry weight), and one each at bow and stern.

7.3.7. Craft should be fitted with a towing eye.

7.4. External and Internal Noise Level

7.4.1. The external noise level measured at a distance of 82 ft. (25 m) and height of 4 ft. (1.2 m) above flat, open grass land shall not be greater than 87 dBA, with the craft operating at maximum power (lift and thrust throttles fully open).
It may be noted that background noise in most outdoor environments generally only varies within 3 dBA, and noise meters are generally accurate to within 0.5 dBA. Craft registering greater than 92 dBA during a meeting check carried out by an official will therefore be deemed excessively noisy and may be stopped from further participation.

7.4.2. The internal noise level at the drivers normal head position should not be greater than 105 dBA. Levels higher than this can cause permanent hearing damage. It is recommended that the noise level at drivers head is kept below 100 dBA if at all possible, for comfort reasons.

8. Craft Certification

8.1. General

8.1.1. A Light Hovercraft may be certified by the issue of a Certificate of Compliance, following inspection by a Safety Inspector the execution of such trials as are considered necessary, and provision of such appropriate design documentation as may be requested by the Chief Safety Inspector.

8.1.2. Where special materials or methods are to be used in the craft design or construction, prior consultation with the Safety Committee, through the Safety Director, is strongly recommended, to ensure that such will be acceptable.

Appendix A- Suggested Design Limits And Margins

A.1. General

A.1.1. Design of a hovercraft will involve estimating the weights of various components in order to determine the loads applied to the structure, and then estimating the local pressures at support points, and the buoyancy distribution of the floating craft.

A.1.2. Apply a factor of 1.1 to all major masses during the design process. When estimating buoyancy it is advisable to use water density of 8.34 lb./gal (1.0 g/cc) (fresh water), and to be careful not to overestimate the buoyancy volume of the craft, as freeboard is also defined by the buoyancy.

A.1.3. When considering the craft standing on three points, the local point pressure applied by this case will determine the required floor thickness. A rule of thumb which may be applied for craft within these rules, of typical hull geometry currently used would be minimum thickness 0.25 in. (6 mm) for plywood bottom, 0.1 in. (3 mm) for fiberglass and approximately 0.6 in. (1.5 mm) (16 SWG) for aluminum. Such thickness' will avoid punching holes in the bottom. It should be noted that the use of dish type landing pads, landing strakes, or runners will both stiffen the floor panel and help further prevent punching damage.

A.1.4. If the craft floor is a sandwich construction with buoyancy foam between two panels then the lower panel should be as in the previous paragraph. The two panels should be connected with webs sufficient to transfer the load from the driver's feet, since otherwise the foam will crush, and the mechanical connection is lost.

A.2. Material Stresses

A.2.1. Typical property values of materials, which may be used for hovercraft design, are as follows:

Material	Ultimate Tensile Stress		Shear Stress	
	PSI	(daN/m²)	PSI	(daN/ m²)
Aluminum	18,000	(3,000)	8,000	(1,300)
Fiberglass mat	8,000	(1,300)	3,000	(300)
Plywood	5,000	(800)	2,000	(340)
Steel	50,000	(8,400)	40,000	(6,700)

A.2.2. These values are for guidance only. They are appropriate design values for non-fatigue type stresses. Where there is vibration and therefore fatigue, then the material strength above should be divided by 2.2 to give a design value for steel and aluminum, and divided by 4.0 for GRP or plywood. National Standards Office gives detailed specifications for all these materials, and designers will find comprehensive data in National Standards Office documents.

Appendix B - Thrust Systems

B.1. General

B.1.1. For the purposes of inspecting, it is irrelevant what the propulsion system is called as long as it is safely constructed. So in conjunction with existing guide lines on plastic fans, it is agreed to collate the required information to homologate laminated wooden propulsors.

B.2. Fans

B.2.1. A number of proprietary fans are available and suitable for use on Light Hovercraft. The use of these fans is to be limited to a combination of rotational speed and diameter giving blade tip speed less than the following:

Type	Maximum
Multiwing Type 2 (Polypropylene Blades)	450 ft./s (137m/s)
Multiwing Type 3 (Polypropylene Blades)	450 ft./s (137m/s)
Multiwing Type 6 (Polypropylene Blades)	450 ft./s (137m/s)
London Fan Co. ("Breeza") small hub	450 ft./s (137m/s)
Multiwing Type 2 (Glass filled Nylon Blades)	550 ft./s (168m/s)
Multiwing Type 3 (Glass filled Nylon Blades)	550 ft./s (168m/s)
Multiwing Type 4Z (Glass filled Nylon Blades)	550 ft./s (168m/s)
Multiwinq Type 5Z (Glass filled Nylon Blades)	550 ft./s (168m/s)
Centrifugal Fans	280 ft./s (85m/s)

NOTE : The use of “Truflo" axial fans with pressed steel hubs and nylon blades is expressly forbidden in Racing Craft. The use of Truflo fan blades with other than pressed steel hubs may be used

B.3. Speeds For Given Diameters

B.3.1. The table below indicates fan r.p.m. for the limiting tip speeds, based on the recommended limits of 400 ft./s (122 m/s) for normal operation, 450 ft./s (137 m/s) for design maximum, and 550 ft./s (168 m/s) which is the absolute limit for Multiwing Z and Nylon blade fans and Breeza plus blades.

Tip Speed		400 ft./s (122 m/s)	450 ft./s (137 m/s)	550 ft./s (168 m/s)
Diameter ft.	(m)	RPM	RPM	RPM
1.64	(0.5)	4660	5233	6417
1.97	(0.6)	3833	4360	5348
2.13	(0.65)	3585	4025	4936
2.3	(0.7)	3329	3738	4584
2.46	(0.75)	3107	3489	4278
2.62	(0.8)	2913	3271	4011
2.79	(0.85)	2741	3078	3775
2.95	(0.9)	2589	2907	3565
3.12	(0.95)	2453	2754	3377
3.28	(1.0)	2330	2616	3208
3.61	(1.1)	2118	2379	2917
3.94	(1.2)	1942	2180	2674
4.26	(1.3)	1792	2013	2468
4.59	(1.4)	1664	1869	2292
4.92	(1.5)	1553	1744	2139

Wooden or fabricated propellers also subject to the same limits, but for small hovercraft tip speed should not exceed 656 ft./s (200 m/s) where blades have been stressed for 984 ft./s (300m/s).

B.3.2. Propulsor systems designed for tip speeds in excess of 450 ft./s (137 m/s) are likely to produce noise levels in excess of 78 dBA at 50 ft. (15 m) distance. A maximum design tip speed of 400 ft./s (122 m/s) is recommended to be used for this reason where practical.