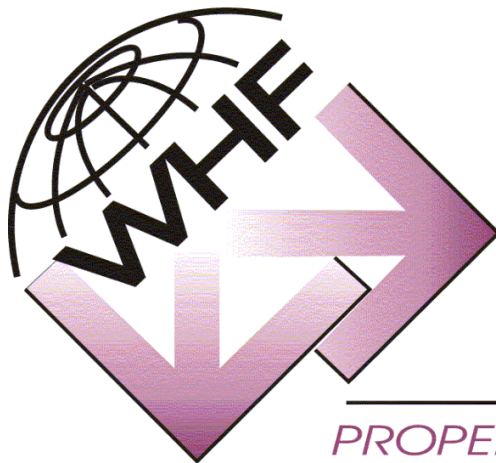


WHF002

Construction Regulations for Racing Hovercraft



**WORLD
HOVERCRAFT
FEDERATION**

PROPELLING GLOBAL HOVERSPORT

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1. INTRODUCTION

1.1 General

- A. These regulations cover the design, construction and safety regulations for Racing Hovercraft for use at World Hovercraft Championship events.
- B. The purpose of these regulations is to ensure that Racing Hovercraft are designed, constructed, operated and maintained in such a way as to prevent, so far as can be foreseen, the occurrence of incidents. Should an Incident occur, these rules are to ensure its effects are minimised as far as possible both to persons and property.
- C. It is the ultimate responsibility of the owner and driver to ensure that the craft fully complies with these regulations.

1.2 Interpretation

- A. Mandatory clauses are denoted by “SHALL”.
- B. Recommended but not mandatory practice is denoted by “SHOULD”. or ‘MAY’. Applicants SHOULD expect questioning on why these recommended practices have not been met.
- C. These regulations are not intended as a manual of hovercraft design but a set of minimum requirements to which a Hovercraft for Racing purposes SHALL adhere.
- D. Wherever practical, examples of methods that meet these regulations are included.
- E. Alternative practices which provide an equivalent level of safety MAY be accepted at the discretion of the WHF Technical Director or his appointed body of scrutineers. Persons wishing to “further the boundaries” should discuss their proposals with the scutineering committee. This SHOULD ensure that craft are permitted to operate at WHF events.
- F. It is implicit in the regulations expressed qualitatively (e.g. ‘readily visible’, ‘adequately tested’ etc.) that the Chief Scrutineer of the meeting will adjudicate in cases where there is any doubt of compliance.

1.3 Associated Publications

Ref No.	Title	Issuing Organisation
WHF001	World Hovercraft Championship, Racing Competition Regulations.	World Hovercraft Federation
WHF007	Appeals Procedures for WHF Events	World Hovercraft Federation
WHF008	Scrutiny and Compliance Procedure for Racing Hovercraft	World Hovercraft Federation
WHF009	Moment of Inertia and Blade Energy Calculations	World Hovercraft Federation
WHF010	Homologation Requirements for Replaceable Blade Fan Systems	World Hovercraft Federation
WHF012	Compliance Checklist for Racing Hovercraft	World Hovercraft Federation
WHF013	Safety Checklist	World Hovercraft Federation
WHF014	Hovercraft Registration Document	World Hovercraft Federation
WHF015	Homologated Fans for use at WHF Events	World Hovercraft Federation

Table 1-1:- Associated Publications

1.4 Implementation of the Regulations

- A. The WHF reserves the right to amend any regulation herein in the light of practical application. Amendments to these regulations will come into force immediately following sanction by the WHF Council
- B. The WHF will always consider new innovation and progress in design. Where a craft designer wishes to introduce new systems, materials or methods of manufacture, which could be outside/contrary to these regulations, they are advised to seek the approval of the WHF Technical Director.

1.5 Compliance, Initial Scrutiny and Certification

Operators should refer to the WHF Scrutiny and compliance procedure, WHF008, for information regarding obtaining a Craft Registration Document.

1.6 Appeals Procedure

In the case of an operator disagreeing with the ruling of a Scrutineer, he/she SHOULD refer to the WHF Appeals procedure, WHF007.

1.7 Definition of Terms

- A. Throughout this document a number of special terms and acronyms are used, the meanings of these are shown below:

Term	Explanation
Connecting Elements	Bolts and nuts, rivets, pop rivets, nails, wire, cable ties
Safety Margin	A margin of safety against the design condition. For example a margin of 10% of calculated weight to give the design craft weight for calculation of the required buoyancy.
Max. Operating Weight	Maximum weight at which the craft is to operate under design conditions, including all exclusions under dry weight.
Prime Mover	Engines, pumps and electrical motors
Rotating Equipment	Fans, drive shafts, belts and pulleys, drive couplings and chains and sprockets
Unladen Weight	Weight of craft ready to use, excluding fluids, occupants, and non-permanent ballast.

Table 1-2:- Definition of terms

- B. Where a measurement in the text is given, the governing units in the text take precedent, any other units given in brackets are for reference comparison purposes only.

2. CRAFT STRUCTURE

2.1 General

- A. Craft Unladen weight SHALL be less than 300 kg.
- B. All occupants SHALL be positioned in front of the Thrust Fan.
- C. Interior surfaces and edges of structural members within the cockpit SHOULD be designed to minimise injury to occupants in the event of a collision.
- D. Consideration SHOULD be given to prevent limbs becoming trapped in engine frames, structural members and exhaust systems.
- E. The exterior periphery of the craft SHALL be constructed such that any sharp edges or corners are conformable or have built in compliancy. Example: Aluminium angle SHOULD be fitted with edge trim.
- F. There SHOULD be no noticeable protrusions on the underside of the hull. A protrusion is defined as either:
 - a) A feature whose height is greater than twice it's diameter for round objects.
 - b) A feature whose height is greater than it's width + it's length.
- G. No rigid components SHALL overhang the hull structure, with the exception of moveable aerodynamic control surfaces. See 7.2 for definition.
 - a) "Aerodynamic control surfaces" includes their consummate components such as tie bars and control rods.
 - b) A tolerance of 10 mm will be applied to the "edge" of the craft to account for skirt thickness and trim.
- H. Consideration SHOULD be given to the pipe work and hoses on water cooled engines to reduce the possibility of failure which could result in injury.
- I. 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 crew, *or any third party*.
- J. Mountings and connections between main machinery and primary structure, and between main machinery and rotating assemblies SHALL be designed in order that failure of 25% of the mountings or connections will not lead to any uncontained failure.
- K. The designer SHOULD keep in mind the environment in which the craft and systems will operate. Where systems are likely to be sensitive to dampness, salt water, sand ingress, wear and tear, vibration, and relative movement of craft sub-structures, they should be rejected or designed for protection against such effects.

2.2 Strength of Structure

- A. The structure of the craft SHOULD have adequate strength to withstand loads encountered during normal conditions of operation in such a manner that structural deformations occurring will not interfere with the safe operation of the craft.
- B. The stiffness of the craft structure SHOULD be such that any vibrations due to prime movers or rotating equipment, or flexure of the structure due to dynamic loads, will not affect the safe functioning of the craft or machinery.

- C. Load cases which SHOULD be considered by the designer are given in Table 2-1.

Load Case	Definition
MANOEUVRING	Forces applied to the controls and machinery frame
FLOATING	Forces applied to the hull
WATER IMPACT	Forces applied to the front or side planing surfaces of the hull
WIND LOADS	Forces applied to the structure
IMPACT	Forces due to a skid stop over land

Table 2-1:- Load Cases

2.3 Impact Strength

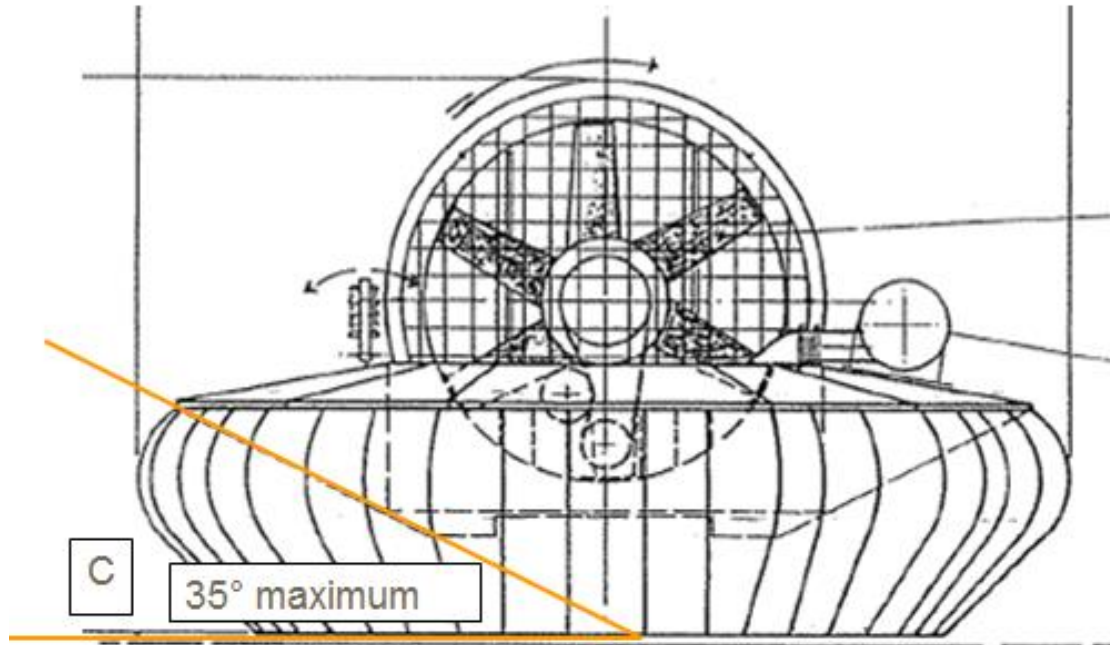
- A. The craft SHALL be designed so as to reduce the risk of injury to the pilot in the event of a collision.
- a) Areas include, but are not limited to:
- Sharp edges
 - Control levers
 - Protruding bolt heads
 - Bolt shanks
 - Handle bar end caps
- b) All Major Components and items of equipment SHALL be attached to the craft primary structure with arrangements sufficient to withstand inertia forces of magnitude 6 g (6 x component weight) in any direction.
- c) Major Components include, but are not limited to:
- Engines
 - Transmissions
 - Fuel tanks
 - Batteries
- B. All Major Components (See 2.3A.c) flexibly mounted SHALL have adequate mountings of the fail safe type or be fitted with secondary restraints such as webbing straps.
- C. A roll bar of adequate strength SHALL be built into the craft structure. This may take the form of structural members primarily designed for other purpose, e.g. engine or duct mounting. They SHOULD maintain adequate clearance for the occupants when the craft is inverted.
- D. The duct and/or guarding system SHOULD be constructed and mounted in such a way that it will still serve its purpose after an impact. Gross deformity is acceptable and clause 6.3C.a) (deflection into the fan) is not applicable, but no openings in the guard SHOULD appear.

2.4 Numbers

- A. The craft registration number (Refer to WHF008) SHALL be clearly displayed on the craft hull.
- B. The craft SHALL clearly display the racing number issued to the driver by the organising authority. The number SHALL comply with the regulations stipulated by that authority.

2.5 Planing Surface

- A. The lower surface of the hull SHALL be configured so as to provide a planing surface at the sides, front and front corners extending between the skirt outer and inner hull attachment points, in the case that the skirt should totally collapse.
- B. The planing surface SHALL form a dihedral upto 35° , in the lower 50%.



- C. The lower 25% of the planing surface SHALL NOT be perforated. Perforations in the planning surface SHALL not affect the requirements of section 2.2.

2.6 Flotation

- A. All craft SHALL be capable of floating in a reasonable attitude in the event of total loss of engine power, with the driver aboard, either to allow the craft to be restarted or until the craft can be rescued.
- B. All new craft SHALL undergo a floatation test of at least 5 minutes duration, during which all engines SHALL NOT be running.
- C. At the end of the test the driver SHALL be able to restart the engine(s), and move under it's own power.

2.7 Buoyancy

- A. All craft SHALL have a minimum buoyancy volume equal to the craft unladen weight.
- B. The buoyancy SHALL be distributed in such a manner that when floating either intact or damaged, the craft will not sink. In this context to 'sink' SHALL be interpreted as the craft being fully submerged.
- C. Buoyancy, MAY be provided by non-absorbent foam, air-bags (must have means of inspection) or multi-cellular boxes (must have means of inspection).
- D. Craft designers are advised to add a design safety margin to the weight used to calculate the amount of buoyancy. Consideration SHOULD be taken to account for the fact that the effective buoyancy of foam-filled compartments is reduced by the weight of the foam.
- E. Consideration SHOULD be given to distribute buoyancy in the craft in such a manner to support major components.

2.8 Recovery aids

- A. Handling Points
 - a) All craft SHALL be fitted with handling points, adequate for manhandling the craft and for grasping by personnel who may be overboard. Cleats SHALL not be accepted.
 - b) The handling points SHALL be of contrasting colour to their location.
 - c) A minimum of four handling points SHALL be fitted. One at the front and rear of each side of the craft.
 - d) Handling points SHOULD NOT be fitted in close proximity to hot components.
 - e) Each handling point SHALL withstand a minimum pull load of 500N.
- B. Towing Eye and Rope
 - a) Craft SHALL be fitted with a towing eye. The towing eye SHALL be permanently fitted with a rope at the bow.
 - b) The towing eye SHALL withstand a minimum pull load of 2000 N (\approx 204kg) (\approx 450lbs).
 - c) The tow rope SHALL be a minimum of 5 m in length, **and 6mm in diameter.**
 - d) The tow rope SHALL be fitted with a floating loop at the free end.
 - e) The tow rope breaking strength SHALL be at least 2000 N (\approx 204kg) (\approx 450lbs).

3. TRANSMISSIONS

3.1 Over-speed Conditions (Transmission Failure)

- A. Where there is a possibility that an overspeed condition may occur (e.g. twin thrust fan or shaft drive lift fan) as a result of fan or transmission failure, the design must prevent the over-speed of the remaining unit(s).
- B. This overspeed condition SHALL be:
 - A 50% increase in tip speed for replaceable blade systems.
 - A 50% increase in tip speed for Single component fans.
- C. It may be necessary to fit a rev. limiter or torque limiter to meet this requirement.

3.2 Gearboxes, Use of:-

- A. Where the transmission includes a multi-ratio gearbox, the requirements of clauses 4.3. and 4.4 SHALL be met in all selectable gears.
- B. Selectable is defined as being able to select that gear. If it is not possible to select a gear due to mechanical block or other means, this SHALL be demonstrated.

4. FANS / PROPELLERS

4.1 General

For the purposes of this section:

- A. The terms fan and propeller are interchangeable.
- B. The fan hub is considered a component of the fan.
- C. Fans used purely for engine cooling are excluded.

4.2 Fan materials

The following restrictions apply:

- A. Metal fan blades SHALL NOT be used.
- B. Wherever possible only commercial units (with a test certificate) are to be used. If it is essential to home-produce a propeller or fan, the material should be very carefully selected and tested for tensile strength.

4.3 Strength in Normal Operation

- A. Hub and replaceable blade systems:
 - a) Components of the fan system SHALL be shown capable of withstanding the stresses due to centripetal force at maximum operating rpm with the safety factors shown in Table 4-1.
 - b) The Test safety factor for multiple lobe hubs needs to take into account of not only the load for the Lobe under test, but also a contribution from the adjacent lobe.
 - c) A procedure for testing fan blades and hubs is given in WHF010.

Item	Safety factor	Test Safety Factor (see 4.3Ab)
Industrial Fan Blades	2	
Two Blade Socket Fan Hubs	2	
>Two Blade Socket Fan hubs	2 on every Lobe/Socket.	4 If only one Lobe/Socket is to be tested.
All Other Components	2	
Fan Blades Manufactured Using A Hand Layup Process	5	

Table 4-1:- Safety Factors for fan systems with replaceable blades

- B. Single component fans
 - a) Blades SHALL be laminated and continuous through the hub. It is very important to provide adequate blade cross section in the region of the blade root.
 - b) Tip speed SHALL not exceed 200 m/sec (≈ 656 ft/sec) where tests show the blades have been stressed for 300 m/sec (≈ 984 ft/sec).

4.4 Fan Systems Guarding Levels

- A. General
 - a) Guarding levels are defined by the Kinetic Energy contained within each blade.
 - b) For any fan system a maximum permissible tip speed can be established below which the kinetic energy is within the appropriate limit. Craft designers and operators SHALL ensure that this tipspeed is not exceeded in normal operation.

- B. Kinetic Energy Calculation
- a) The kinetic energy of a rotating system is set by the moment of inertia and the rotational speed. Moment of inertia may be found by measurement or calculation.
 - b) Document WHF009 details a method of measuring Moment of Inertia, and calculating the energy.
 - c) A computer program is available from the WHF Website that SHALL be used in calculating these results.
- C. Guarding Levels
- a) The following fan systems require Category A guarding:
 - Hub and replaceable blade systems, with a kinetic energy per blade not more than 1850 J.
 - Continuous wooden laminated propellers with total kinetic energy not more than 4000 J, but no greater than 1850 J per blade.
 - b) The following fan systems require Category B guarding:
 - Hub and replaceable blade systems, with a kinetic energy per blade not more than 3000 J.
 - Continuous wooden laminated propellers with total kinetic energy not more than 8000 J, but no greater than 3000 J per blade.

4.5 Homologated Fan Systems

- A. Approved fan systems are contained in document WHF014 which lists example fan systems and tipspeed limits that are accepted as meeting the requirements of these regulations.
- B. Document WHF014 may be updated at any time. Users should ensure they have the latest version, which is available from the WHF website or secretary.

5. THREAD LOCKING SYSTEMS

5.1 General

- A. All connecting elements essential to safe operation of the craft SHOULD be provided with adequate means of locking against loosening from vibration, rotation and torque, or flexure of the craft structure.
- B. Acceptable Thread Locking Systems SHALL be used on all threads used on all threads employed on rotating assembly components.
- C. Acceptable Thread Locking Systems SHALL be used on all threads employed in the rotating assembly mounting structure/Frame, where loosening might cause dangerous misalignment.

5.2 Acceptable Locking Systems

Acceptable Locking Systems are classified as follows:

- A. Locking wire
- B. Split/Cotter pins
- C. Stiff nuts/ Nyloc nuts. There SHALL be a minimum of two exposed threads clear of any nut.
- D. Locking Washers (Spring, Serrated, Tab).

5.3 Anaerobic Adhesives

In some circumstances where none of the options listed in 5.2 are suitable, anaerobic adhesive, e.g. Loctite may be sufficient. (Where there are alternatives, anaerobics SHOULD be avoided as inspection is not normally possible.)

6. GUARDING OF ROTATING ASSEMBLIES

6.1 Introduction

Guarding of rotating assemblies, including fan systems, shafts, couplings, flywheels etc, is intended to achieve two purposes:

- A. To ensure that 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:
 - In collision with the Hovercraft
 - Manhandling the Hovercraft
 - Operating the Hovercraft
- B. To ensure that in the event of failure, the component parts of the system are contained by the guards. Events that SHOULD be considered that may lead to a failure include:
 - Ingestion of foreign object
 - Collision
 - Rollover

6.2 General

- A. Guarding MAY be provided in the form of continuous sheet material or structures with openings, such as frameworks and mesh material.
- B. Components such as hull structure, engines, rudders, elevators, support framework, fan centre bodies or flow straightening vanes, MAY be considered part of the guard system.

6.3 Ingress

- A. Openings:-

The size of any permissible aperture or opening in the guard structure varies with distance from the swept volume according to Table 6-1.

Distance of Guard From Rotating Device Swept Volume	Maximum Aperture
<50 mm	10 mm minor dimension
>50 mm	15 mm minor dimension
>110mm (>125mm to blades)	50 x 50 mm
>200 mm aft of swept volume	A diameter of 300 mm SHALL not pass

Table 6-1:- Maximum aperture sizes of openings

- B. The gap between the wire mesh guard and the bell mouth of the duct (Lift or Thrust) SHALL be a maximum of 15 mm.
- C. Strength
 - a) No device (wire mesh or duct structure) SHALL deflect into the swept volume of the rotating assembly when a force of 440 N (≈45 kg)(≈100 lbs) is applied over an area of 90 mm diameter at any point of the device. This is to prevent failure of the rotor, or injury, in the case of a person falling onto the guard and taking the impact on one hand.

- b) All components employed to prevent ingress at the rear of the duct SHALL support a load of 350 N (≈ 36 kg) (≈ 80 lbs) when applied over an area of 300 mm diameter in the normal axial direction of the fan.

D. Materials

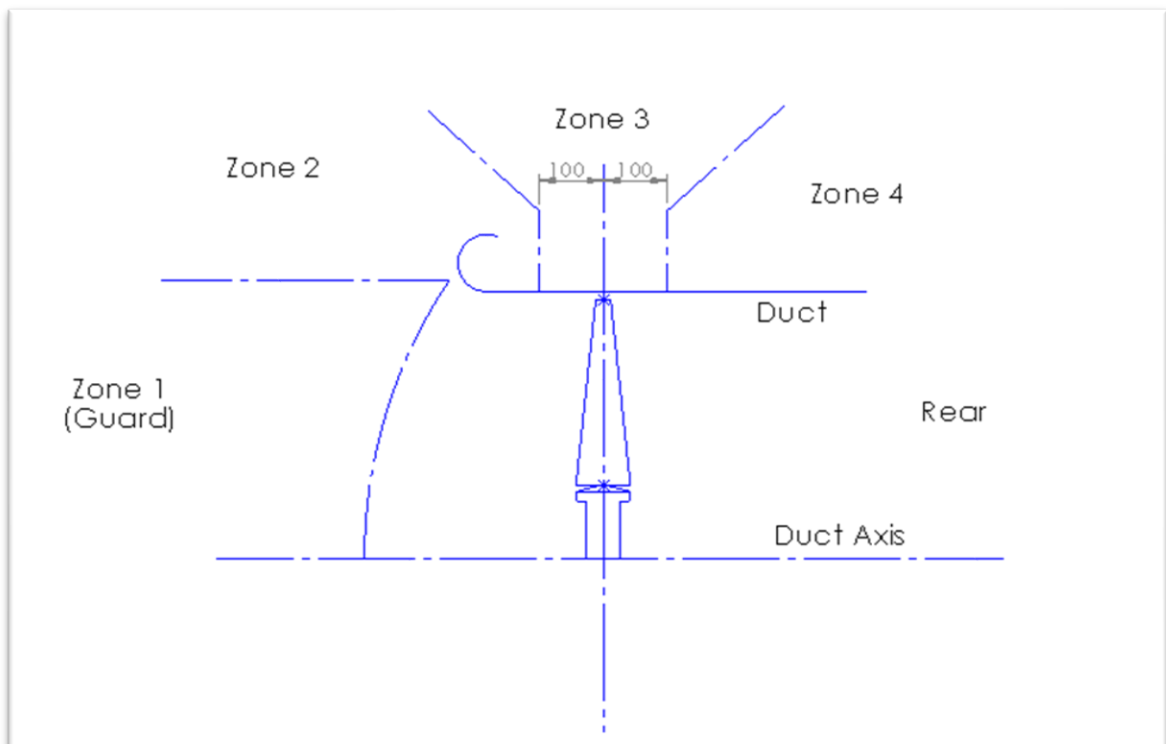
Materials such as string or wire (unless formed as weldmesh) SHALL NOT be used.

E. Demonstration of Compliance

A suitable tool for measuring these apertures is shown in Appendix A.

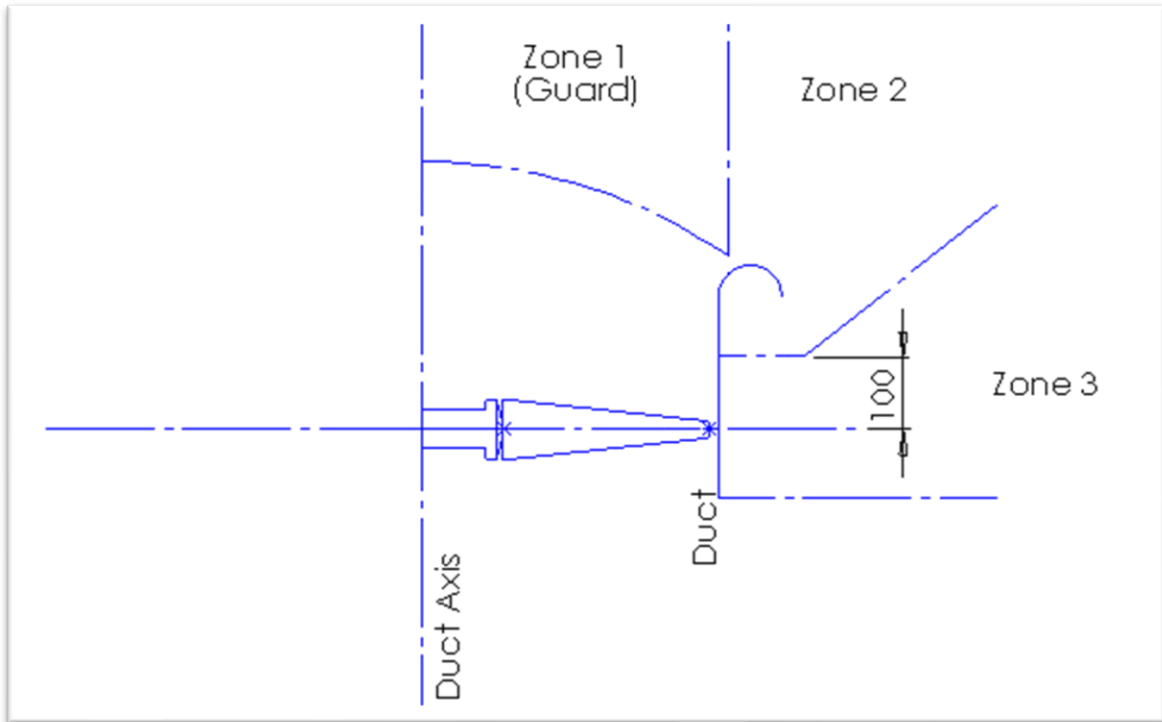
6.4 Containment

- A. Containment zones For Thrust / Integrated ducts are defined as follows:



- a) Note:- On Integrated ducts, The rear 100 mm of Zone 3 may be omitted below the splitter plate, providing the splitter plate occurs within the bottom 3rd of the Thrust duct.

B. Lift Ducts



- a) The lower edge of the lift duct (Lower extent of Zone 3) SHALL extend downwards covering the entire swept volume of the fan blade.
- b) If the fan axis is located above the “main deck” of the craft, then Zone 3 SHALL extend as far as the main deck surface.

C. Strength Requirements

- a) The guard SHALL be capable of stopping a projectile of “D” diameter, 500 g mass, with Kinetic Energy “W”, where “D” and “W” are defined in Table 6-2.

Zone	Projectile Diameter “D” (mm)	Energy Level “W” (J)	
		Fan Guarding Level	
		Category A	Category B
1	70	1850	3000
2	70		
3	35		
4	70		

Table 6-2:- Guard Strength Requirements

- D. Example Construction methods accepted as meeting the requirements of paragraph 6.4C are:

- a) Zone 1:- A welded mesh of “X” mm steel wire on a 51 mm or finer grid. “X” is defined in Table 6-3 dependant on the strength category required.
- b) A minimum thickness of GRP of the equivalent of “Y” layers of 450 g/m² (≈1.5oz/ft²) chopped strand glass fibre mat in a single laminate. “Y” is defined in Table 6-3 dependant on the strength category required.
- c) The equivalent weight of aramid fibre (Kevlar) may be substituted for 2/3rds of the GRP layers. Aramid fibres must be protected from UV radiation.
- d) Carbon fibre is acceptable as an addition but not as a substitute in Zone 3, but is an acceptable alternative in other zones.

Zone	Weld Mesh Wire Diameter (“X”) (mm)		No. of GRP Layers (“Y”)	
	Strength Category		Strength Category	
	A	B	A	B
1	2.5	2.8		
2			3	5
3			6	8
4			3	5

Table 6-3 :- Example Construction Methods

- E. Primary Zone 1 Guard Attachments
- a) The Mesh guard in Zone 1, SHALL be attached to the duct by such means that the Guard can withstand a force at any point of:
 - 750 N pull for Category A.
 - 1000 N pull for Category B.
 - b) Example methods accepted as meeting the requirements of 6.4F.c) include:
 - Cable ties positioned 200 mm apart around the periphery of the duct:
 - 5 mm cable ties for Category A.
 - 7 mm cable ties for Category B.
- F. Secondary Zone 1 guard tethers
- a) Where a wire mesh guard is fitted to a duct, in addition to the fasteners, four failsafe tethers SHALL be fitted evenly spaced around:
 - The upper 2/3rds of the thrust duct
 - Equispaced on the lift duct.
 - b) The tethers SHALL accommodate a relative movement of approximately 12 mm between the wire mesh and the supporting structure and SHALL allow a separation of the guard from the supporting structure of no more than 20 mm.
 - c) The Secondary Guard Tethers SHALL withstand a force of 440 N.
 - d) Example methods accepted as meeting the requirements of 6.4F.c) include:
 - Webbing of at least 19 mm wide
 - Single 6.8 mm wide cable tie.
- G. Transmission Shaft Containment
- a) All transmission shafts SHALL be fitted with a fail-safe device in order to prevent shaft "flailing" in consequence of bearing, bearing housing or coupling failure.
 - b) "Transmission shafts" include, but are not limited to:
 - Prop shafts
 - Crank extenders
 - Couplings
 - Drive Hubs
 - c) Suitable flail guard devices include a suitably sized metal or composite 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.
 - d) Flail guards SHALL be securely attached to a substantial part of the transmission mounting frame or hull in order that the shaft movement will not cause failure in the guard itself.

7. CONTROLS

7.1 General

- A. All systems and controls SHALL be designed to be safe in operation and, where possible, fail-safe when stopped or released by the operator.
- B. Any system or control installed, which are not specifically referred to in the section, SHOULD be designed and constructed to this same principle.

7.2 Aerodynamic Surfaces and Controls

- A. Aerodynamic control surfaces may be any of two types:
 - a) **Fixed surfaces:** providing aerodynamic stabilising forces while in operation, which are fixed or able to be moved (trimmed) when the craft is stopped such as fixed elevators, fins or fan straightener vanes.
 - b) **Moving surfaces:** driver controlled aerodynamic control surfaces such as rudders, controllable elevators or elevons.
- B. Control surfaces and associated control systems SHALL be attached to the craft structure with arrangements sufficient to maintain them securely in position under the maximum design airspeed over the device, at the position of maximum control force generation.
- C. Overhangs SHALL only occur at the rear of the craft, and by a maximum of 500 mm.

7.3 Engine Throttle Controls

- A. Engines used for THRUST, SHALL have a throttle control which has a rapid spring return to the engine idle position.
- B. Engines used for LIFT only, may have a friction throttle, to hold the throttle in a fixed position, but SHALL return to idle on demand.
- C. All throttle controls SHALL be capable of full range operation by the driver in the normal driving position, with sufficient ease to permit the engine to return to idle.

7.4 Other Controls

- A. Manually operated control systems SHOULD be designed with adequate safety margin against the loads shown in **Table 7-1**. applied with the maximum lever arm possible.

Control	Load
FOOT	600 N (\approx 61 kg)
STICK LEVER	500 N (\approx 51 kg) Fore and Aft and 300 N (\approx 31 kg) lateral
WHEEL	500 N (\approx 51 kg) Fore and Aft and 20 x D kg/m Torque where D = diameter in m
HANDLEBAR	500 N (\approx 51 kg) Fore and Aft, 250 N (\approx 25.5 kg) in Rotation

Table 7-1:-Typical Control Loads

- B. Control cables, chains, torque tubes and push rods SHOULD have an adequate safety margin against the applied loads shown in the above table.
- C. Consideration should be given to driver protection, to prevent possible entrapment or injury. (e.g. end caps fitted to handlebars, sharp corners etc.)
- D. All primary controls SHALL be capable of full operation by the driver in the normal driving position, whilst wearing appropriate protective clothing and safety equipment, with sufficient ease and smoothness of operation to permit the proper performance of their function.

- E. It is recommended that steering columns/handlebars etc. be fitted with mechanical stops to reduce the likelihood of cable failure.
- F. It is strongly recommended that high performance craft (F1, F2 etc), especially craft fitted with separate lift engines, be fitted with redundant steering cables, to prevent loss of control in the event of cable failure.

8. FUEL SYSTEMS AND COMPONENTS

8.1 Fuel Tanks and systems

- A. Fuel tanks and supply lines SHALL be constructed and mounted such that any vibration or distortion of the craft structure during operation will not damage the tank or cause leaks in the supply lines.
- B. Gravity feed fuel tanks SHALL be fitted with a cut-off tap which can be easily operated by the driver.
- C. Fuel containment systems SHALL be so designed that liquid fuel cannot leak and come into direct contact with any hot parts, electrical components or occupants, even when the craft is inverted, or in any other attitude where fuel may leak from a vent or breather system.
- D. All tanks, containers, pipelines, structure and equipment SHALL be designed to comply with the strength regulations of the vehicle as described in section 2.3A.b) when full of fuel, and the fire safety regulations described in section 10.
- E. Elasticised straps (e.g. bungy cord etc) SHALL NOT be used for mounting fuel tanks.
- F. Fuel tanks SHALL be fuel tight against the operating conditions of the craft whilst providing for fuel expansion due to temperature changes, to prevent siphoning of fuel through vents.
- G. Fuel tank vents may have an open vent of maximum 2mm diameter, provided a pigtail is fitted, any larger vent SHALL be fitted with Non-Return valves to prevent fuel leakage.

8.2 Alternative Fuels

Any craft running with >90% ethanol or methanol fuel SHALL display a 75 mm min diameter orange circle adjacent to their racing number.

8.3 Carburettor Supplementary Restraint / Support

- A. Note:- A majority of carburettors on two stroke engines are primarily attached by a rubber boot, and a jubilee clip, with an air filter attached to the outboard side. The whole carburettor assembly cantilevers from the side of the engine. In this situation they are susceptible to vertical shock loads during land water transitions, which can cause failure of the rubber, or for the carburettor to become detached, this can lead to craft stopping suddenly.
- B. Cantilevered carburettors described above, on both thrust and Lift engines shall be fitted with a secondary restraint or support to supplement the rubber manifold. This restraint may be vertical, supporting the weight of the carburettor, or horizontal, preventing the carburettor from pulling away from the engine.
- C. Carburettors mounted using alternative methods to those described above, e.g. four stroke engines shall be assessed as to whether the situation described in 8.3A applies, if so, then secondary restraints shall be fitted.

9. ELECTRICAL SYSTEMS

9.1 General

- A. Electrical systems SHOULD 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.
- B. It SHALL be possible for the driver of the craft to switch off engines and power to all electrical systems from within the cockpit.
- C. Batteries SHOULD be mounted in accordance with section 2.3A.b), and terminals protected from short circuit, with the craft in any attitude.
- D. Battery Isolator
 - a) Craft fitted with a battery SHALL have a circuit breaking switch in a clearly accessible position.
 - b) The isolator SHALL be marked by either:
 - 80 mm sided RED equilateral triangle with a 10 mm wide white border.
 - International Lightning Strike Symbol, approximately 50 mm high.
- E. Engine kill switch (Lanyard)
 - a) All engines SHALL have a lanyard kill switch, which on removal will immediately stop the engine.
 - b) Consideration SHOULD be given to location and attachment to the driver, to prevent accidental operation, or entanglement causing or preventing correct operation.
 - c) Fork Type Lanyard switches are recommended over simple rubber caps. Coil type lanyard cords are recommended as they are less likely to become entangled.
- F. Radio Frequency (RF) suppression
 - a) Engines SHALL have adequate Radio Frequency (RF) suppression fitted. This may be in the form of either:
 - Spark plugs with integral resistors, and Non resistor spark plug caps
 - Spark plug caps with integral resistors, and Non resistor spark plugs.
 - b) A simple check on the effectiveness of RF suppression is to turn on a transistor radio in close proximity to the craft. If there is substantial interference then the craft RF suppression is inadequate.
- G. *Electrical connections / joints***
 - a) **NOTE:- The quality and suitability of electrical connections and joints is often overlooked and is often the cause of engine stoppages and a significant contributor to apparent lanyard failures. There is a large variation in the quality of DIY type crimps such as spades or bullets. There is an even bigger variation in the quality of various crimp tools and their ability to create a good crimp especially if the gauge of wire and crimp are not correct.**
 - b) **Cables should not be excessively short, such that they could pull on the connection. "Service loops", or other form of strain relief may be required.**
 - c) **Cables should be adequately supported, to avoid the potential for snagging, vibration and fatigue.**
 - d) **Both Soldering and crimp connections are permitted.**
 - e) **Where there is a possibility of wire chafing occurring, additional protection such as securing or sleeving (e.g heatshrink) shall be applied.**

9.2 Electric Energy for Use in Thrust and Lift Systems

- A. This section refers to the use of electric energy (e.g. batteries) combined with electric motors to power a hovercraft (either lift or thrust systems).
- B. It is encouraged that low voltage systems (e.g. below 50V) should be used.
- C. Considering the entire electrical system (e.g. motors, controllers and all stored electrical energy), the craft operator must be able to demonstrate (through documentation or otherwise) a safe working system in all possible situations (e.g. dry, damp and craft fully water submerged).

9.3 Safe Working Electrical System Considerations

- A. Demonstration by the operator of a safe working system must include consideration to:
 - a) Maximum voltage levels
 - b) Arcing of the system
 - c) Risk of electric shock – both driver protection and marshal protection
 - d) Battery and motor temperature
 - e) Fire protection
 - f) Short circuit protection (see also 9.1.C)
 - g) Battery isolation (see also 9.1.D)
 - h) Cable protection
 - i) Waterproofing
 - j) Magnetic fields
 - k) Ingress of debris into the motors
 - l) Battery security / fixation (see also 9.1.C)
 - m) Speed controller water protection
 - n) Lanyard systems
 - o) Overspeed protection
 - p) Arcing and flammability risk for craft with both electric and hydrocarbon fuel systems

10. FIRE PROTECTION

10.1 Design Safety

- A. The design of craft SHALL be such as to minimise the risk of fire occurring.
- B. Engine exhausts SHALL be designed such that no appreciable amount of exhaust gas can enter the air cushion system of a “No Flow” pressurised bag skirt. The exhaust outlet SHALL be clear of the lift fan suction area.

10.2 Hot Parts

- A. The distance between hot parts and other components SHOULD be of sufficient space to prevent degradation or heat deformation; it is found that 20 mm is normally sufficient.
- B. If an exhaust is within 20 mm of a GRP surface, a heat reflective pad of aluminium or similar SHALL be fitted to prevent burning of the GRP surface.
- C. Hot parts SHALL have an adequate supply of cooling water or air, to maintain a steady design temperature during all normal operating conditions.

- D. Hot exhaust pipes and silencers SHOULD be protected by guards, in order to minimise possible injury to the driver or third parties in the event of an Incident.

11. OPERATIONAL SAFETY

11.1 Demonstration of Characteristics

The Technical Director, or appointed scrutineers reserve the right to call for a trial demonstration of craft characteristics of buoyancy, freeboard, stability, adequate control, emergency stopping and safe performance.

11.2 Driver Protection

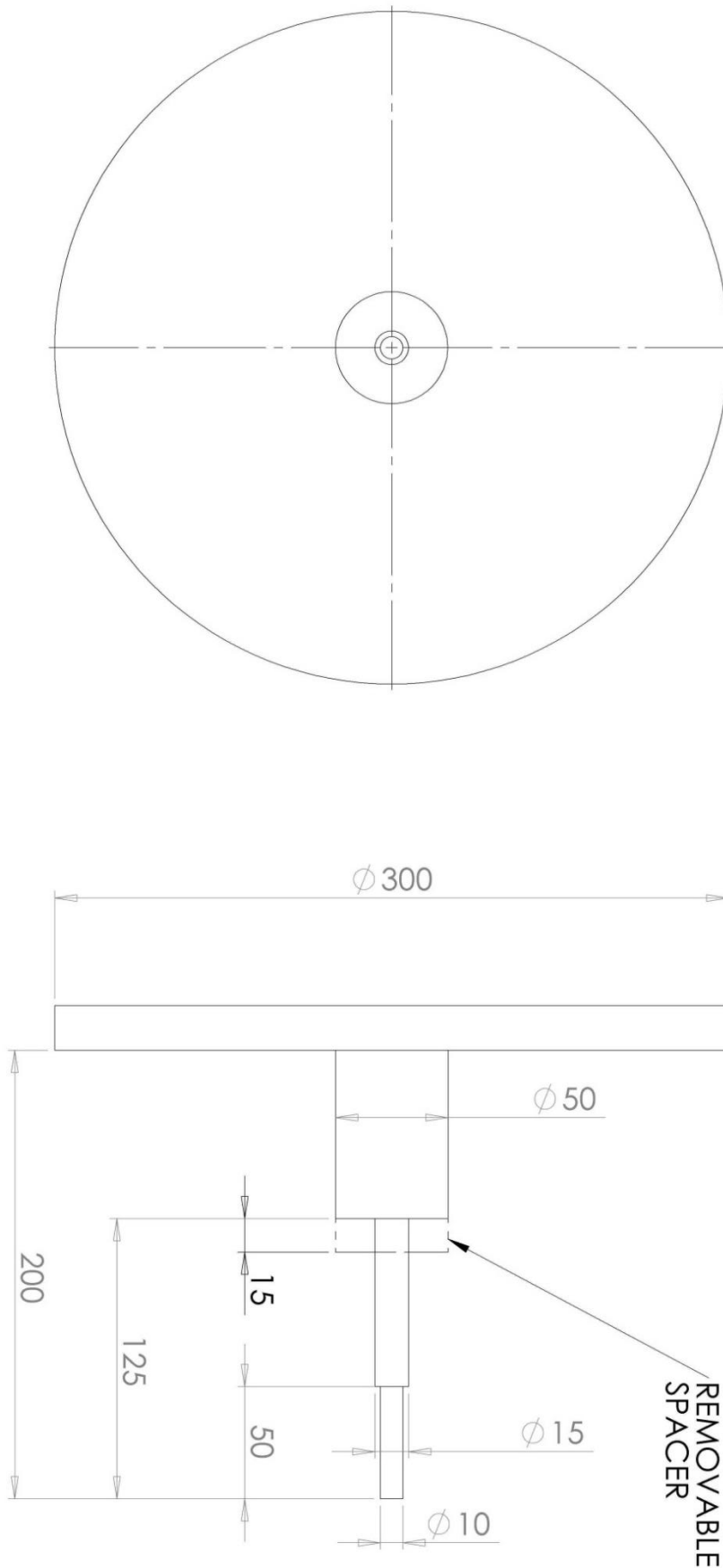
- A. (Drivers Helmet, buoyancy and protective clothing will be checked to ensure it conforms with the WHF Hovercraft Competition Regulations (WHF001).
- B. All personnel SHOULD be protected from contact with rotating components, surfaces with temperatures exceeding 70° C, live electrical circuits and sharp edges or corners.

12. NOISE

- A. All craft SHALL comply with the noise regulations specified in the relevant competition regulations.
- B. The internal noise level at the driver's normal head position should not be greater than 105 dBA. Levels higher than this can cause permanent hearing loss. It is recommended that the noise level at the driver's head be kept below 100 dBA if at all possible, for comfort reasons.

13. APPENDIX A:- GUARDING GAUGE

GUARD APERTURE GAUGE 2013



The tool should be used in a single axis. It should not be moved from side to side.