WHF010

Homologation Procedure; Replaceable Blade Fan Systems

WORLD HOVERCRAFT FEDERATION

PROPELLING GLOBAL HOVERSPORT

www.worldhovercraftfederation.org

World Hovercraft Federation

19 December 2011

Whilst every effort is made to ensure the accuracy of the information contained in these regulations, the World Hovercraft Federation cannot accept responsibility for any injury or damage resulting from this information

Publication Reference		WHF010
Issue	**Date of Issue**	**Changes**
1	December 2011	

For further information regarding this publication, please contact the Secretary:

Christel Martens
World Hovercraft Federation
Franciscusstraat 41
6681 VP Bemmell
The Netherlands
Tel:+31-481-450471

Email: worldhovercraftfederation@planet.nl

CONTENTS

1. INTRODUCTION

1.1 General

A. This procedure details the tests and calculations required to produce the data required for homologation of Replaceable Blade fan systems to comply with the requirements of WHF002.

B. The procedure is broken into sections, detailing the different phases of the testing. All phases must be completed in order for homologation.

C. All testing of blades and hubs should be conducted with an expert witness present to countersign and date all results. Where possible the expert witness should be a Qualified Hovercraft Scrutineer. (See Document WHF008 Para 1.4C)

D. All equipment to be used in the test should be calibrated and adjusted according to the manufacturers specifications.

E. All results of the test must be presented to the WHF or National Authority in a single submission, containing the data, photographs, and preliminary calculations. All test results must be retained for inspection by National Authority Officials, International Organisations and WHF.

F. The data will be reviewed and approved by the WHF, and approval given for use of the fan system.

1.2 Reference Publications

Ref No.	Title	Issuing Organisation
WHF002	Construction Regulations for Racing Hovercraft	World Hovercraft Federation
WHF008	Scrutiny and Compliance Procedure	World Hovercraft Federation
WHF009	Moment of Inertia and Energy Calculations	World Hovercraft Federation

Table 1-1:- Reference Publications

2. TEST PROCEDURE

2.1 Fan Blades Centre of Gravity and Weight

A. The Centre of Gravity CofG of the blade may be determined as follows:

a) One sacrificial blade is required to complete this test.

b) With the blade at it's maximum length, balance the blade horizontally on a knife edge, and mark the point of balance.

c) Measure the point of balance relative to the hub reference point. The hub reference point is the point of the blade at it's root, that intersects with the outer diameter of the hub.

d) Weigh the blade.

e) Cut 50mm from the tip of the blade, and repeat the balance test.

f) Repeat steps c), d) and e) until approximately 200mm of the blade remains.

B. The CofG may also be determined using computer modelling.

2.2 Blade Pull Test

A. Two blades are required (one may be the remainder of the blade used in 2.1)

B. Fit the test blade to one of the hubs using the normal fixing method

C. The hub should be mounted in a suitable fixing device in a similar manner to normal use.

D. All normal fixings should be fitted, and tightened to the normal Torque.

E. The aerofoil section of the blade needs to be fitted with a jig to provide a pulling point. The jig should rely on compression for fitting as drilling holes for fixing may weaken the blade and corrupt results.

F. The blade is subjected to a metered tensile loading until destruction. The maximum tensile load before breakage is measured. A minimum of two blades should be tested and lowest failure rate should be used.

2.3 Fan Hub Pull Test

A. Remove the blade under test

B. The hub should be fitted with a steel jig simulating a blade root.

C. The steel jig is subjected to a tensile load sufficient to prove a factor of Safety of 4 against the operating centripetal force. If the hub is to be used in multiple configurations and with differing blades, then the test must be to destruction, with the maximum tensile loading noted.

3. CALCULATIONS

3.1 Safety Factor of Fan Blade

A. To calculate the safety factor of the blade, the centripetal force of the blade needs to be calculated, however other variables need to be calculated first.

B. Calculate the Frequency of the Fan:

$$f = \frac{2\pi R_T}{V_T}$$

C. Where:

- R_T = Radius of Blade Tip
- V_T = 168m/s

D. From this the Velocity at the CofG can be calculated:

$$V_C = \frac{2\pi R_C}{f}$$

E. Where:

- R_C = Radius of CofG (Hub radius + radius of CofG from section 2.1.
- f = Frequency calculated above.

F. Calculate the Centripetal Force:

$$F_{CF} = \frac{m{V_C}^2}{R_C}$$

G. Where:

- m = Mass of Blade in N (Weight of blade in kg/9.81)

- V_C = Velocity at the CofG calculated above
- R_C = Radius of CofG (Hub radius + radius of CofG from section 2.1

H. Finally, calculate the Safety Factor:

$$SF_B = \frac{F_{BF}}{F_{CF}}$$

I. Where:

- F_{BF} = Blade failure Force measured in section 2.2
- F_{CF} = Centripetal Force calculated above

J. The Safety Factor Must be >2

K. The calculations should be repeated with the blade at its shortest length, using the data from section 2.1.

3.2 Safety Factor of Fan Hub

A. Calculate the Safety Factor:

$$SF_H = \frac{F_{HF}}{F_{CF}}$$

B. Where:

- F_{BF} = Blade failure Force measured in section 2.2
- F_{CF} = Maximum Centripetal Force calculated above

C. The required Safety Factor depends on the number of blades in the hub, since the Load on any Lobe will be affected by the load from each lobe either side.

D. Calculate the required safety factor:

$$SF = \left(2\left(\cos\frac{360}{N}\right)\right) + 2$$

E. The Hub safety factor SF_H>SF calculated above for full clearance.

3.3 Conclusions

A. If the safety factors calculated above are sufficient, then full homologation can be given, otherwise restrictions may apply.

4. MOMENT OF INERTIA AND ENERGY

A. The Moment of Inertia and Energy of each blade shall be measured and calculated in accordance with dcoument WHF009.

5. HOMOLOGATION

A. The data from section 3 is used to calculate the maximum Tip speed, which must not exceed 168m/s.

B. The data from section 4 is used to specify the guarding levels required to contain the blade in event of failure.