Stichting Wind Energie Events

Racing Aeolus 2024

Calculation Handbook

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WINDENERGY EVENTS

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HELDERSE ZEEDIJK

www.RACINGAEOLUS.online

Introduction

This handbook is a collection of formulas and calculation strategies for the Racing Aeolus event taking place every year in Den Helder, The Netherlands. The formulas and approaches described in this handbook are assigned to one of two categories:

- Mandatory
  - Every team must use the exact formulas and strategy described. No deviations are allowed.

- Guideline
  - A “best practice” suggestion.

Note:
The content provided in this handbook is to be regarded as advice. You are responsible for applying sound engineering principles and you are responsible for designing a safe vehicle.

This is the first issue of the Calculation Handbook and only contains formulas moved from the Racing Aeolus rules. The Calculation Handbook will be improved and expanded over the years.

Changes to the 2023 final release:
None – first issue

Please note that minor wording changes are not highlighted in the text.

Abbreviations

WPV	wind powered vehicle
SOC	state of charge
ROPS	rotor overspeed protection system
Wach number*	$\frac{avg.carspeed}{avg.windspeed}$ with $avg.\,carspeed = \frac{racedistance}{chargingtime+racetime}$
Wind speed	unless otherwise specified always refers to the velocity of the wind over ground

*Named after Gustav Winkler, one of the contemporary WPV pioneers

Contents

1. Flipping by wind – MANDATORY

1.1 Drag-momentum rotor (horizontal axis):

$$M_R = \frac{1}{2}\rho v^2 \pi r^2 c_{th.rot} h_{hub}$$

$r = \text{rotor radius}$ $h_{hub} = \text{height of rotor hub from ground}$

$\rho = 1.225 \frac{kg}{m^3}$ $v = 18 \frac{m}{s}$

$c_{th.rot} = 1$

1.2 Drag-momentum rotor (vertical axis):

$$M_{R.Vertical} = \frac{1}{2}\rho v^2 \cdot width \cdot height \cdot c_{th.rot} h_{middle} \text{with } c_{th.rot} = 1$$

1.3 Drag-momentum diffuser: $M_{Diff} = \frac{1}{2}\rho v^2 l d c_{d.diff} h_{hub}$

$l = \text{length of diffuser}$ $d = \text{diameter of diffuser}$

$\rho = 1.225 \frac{kg}{m^3}$ $v = 18 \frac{m}{s}$

$c_{d.diff} = 0.5$ $h_{hub} = \text{height of rotor hub}$

1.4 For each rotor, decide which is bigger: M_R or M_{Diff}.
Add the bigger values for each rotor/diffusor to find the total drag-momentum M_D.

1.5 Determine the location of the car's center of gravity (CG) and the weight of the car by placing scales under each wheel at the same time. You may simulate the driver's weight by putting a 65kg weight in the driver's seat.
Simplification: Weigh (both) front wheels, then both aft wheels – make sure not to twist the car frame.

1.6 Calculate the momentum of inertia of the car:

$$M_{inertia} = distance\ of\ CG\ to\ closest\ flipping\ edge\ in\ m \cdot car\ weight\ in\ kg \cdot 9.81\ \frac{m}{s^2}$$

Note: For classic 4-wheel design cars the closest flipping edge will probably be the rear axis, for 3-wheel cars this will probably be the line connecting the front wheel and one rear wheel

1.7 The car's inertia $M_{inertia}$ must be bigger than the total drag momentum M_D:

$$M_{inertia} > M_D$$