AWTS II technical facts

In the AWTSII facility low pressure and low temperature environments of various solar system bodies can be re-produced. These include Mars, Lunar, Icy moons as well as high altitude in Earths atmosphere. The facility consists of a 35- 42 m^3 vacuum chamber, various vacuum pumps, a recirculating wind generation system and an array of flow, pressure, temperature, optoelectronic and imaging systems. It is unique in being able to recreate windy environments and recreate the Aeolian transport of aerosols and sand sized particulates.

http://pef.au.dk/

Dimensions

Chamber outer dimensions is Ø2300mm x 10000mm.

Full windtunnel cross section is (width x height) 1800mm x 995mm
Length of the windtunnel is 6400mm with Test section length of 2000mm and Long section length of 4400mm.

New additional test section (Europlanet funded) is +2000mm

(Narrow wind tunnel is used for wind speeds >16m/s):
Narrow windtunnel cross section is (width x height) 400mm x 800mm.
Narrow windtunnel length is modular and can be between 1000mm and 5500mm.

Flanges

Flanges are ISO320 bolt type. Please see drawing XX for information on what flanges typically are available for customers

Adapter flanges to smaller standards includes ISO250, ISO200, ISO160, ISO100, ISO63 and KF50, KF40, KF25, KF16. Also CF100.

Full size windows are PMMA

Smaller windows are various types of glass or PMMA

Electrical feedthroughs

D-sub 50 pin-pin (pins going straight through) http://www.vacom-shop.de/epages/VacomShop.sf/de_DE/?ObjectPath=/Shops/Store.VacomShop/Products/101001
D-sub 9 pin-pin (pins going straight through) http://www.vacom-shop.de/epages/VacomShop.sf/de_DE/?ObjectPath=/Shops/Store.VacomShop/Products/101002
BNC female - female, floating or shield to common ground
USB

Mains 230V

Rotation table

The rotation table is position in the center of the Lower cooling plate in the Test section. It is manually operated with a handle from outside the chamber and can rotate +-360deg. The position is recorded.

Wind flow

Wind is induced by a fan system with two opposite fans, recirculation the flow in the upper and lower parts of the chamber.

Full cross section wind speed 0-16m/s, turbulence around 15% this can be achieved for gas pressures up to 100mBar.
Wind speed is gradually reduced at higher pressure until 1Bar where maximum is 5m/s.
With turbulence reducing double-mesh or honeycombs wind speed can be 0-14m/s, turbulence around 3%.

Narrow cross section wind speed is 0-48m/s
Wind speed is gradually reduced at higher pressure until 1Bar where maximum is 15m/s.
(sand and dust remobilization can be achieved in this narrow wind tunnel, pressures 2 – 1000 mbar)

Cooling

4 individually controlled cooling units using flow through of liquid nitrogen:

Lower cooling plate is the floor in the test section, W=1800mm x L=2000mm. Maximum cooling rate 80degC/h. Minimum temperature -180degC.

Upper cooling plate is the ceiling in the test section, W=1800mm x L=2000mm. Maximum cooling rate 80degC/h. Minimum temperature -180degC.

Small cooling plate can be place anywhere, W=350mm x L=500mm. Maximum cooling rate 140degC/h. Minimum temperature -180degC.

Air cooler/heater is placed at the far end of the wind tunnel. Air can be cooled to -60degC, but is very inefficient; high wind speed increases air temperature.

Heating

Multiple aluminium heating plates that can be place anywhere, W=300mm x L=400mm x H=40mm. 2kW heating power.

Various heating bands that can be wrapped around equipment.

Air cooler/heater is placed at the far end of the wind tunnel. Air can be heated to >60degC.

Gas

The chamber can be pumped out from 1Bar to:
100mBar in 15min
10mBar in 25min
1mBar in 35min
0.1mBar in 90min
0.001mBar in <16 hrs

Different gas types can be used in the chamber including CO_2, Helium, Nitrogen, dry air.

Humidity can be controlled by injecting water vapour or steam or by freezing out water with small cooling plate. Relative humidity is measured.

Dust

Dust is injected with a simple manually operated injector system or an electrically operated valve depending on the scope of the experiment.

Particle size that can be injected and suspended is typically no larger than around 20µm diameter.
Sand (60µm – 500µm) can be transported by wind in the narrow wind tunnel.

Dust concentration decays exponentially after injection, with a half time dependent on particle size and chamber pressure.
A laser transmission opacity sensor can be used to monitor dust concentration.

Laser Doppler Velocimeter

Wind flow and particle concentration can be characterized with a 2D Laser Doppler Velocimeter system from Dantec. (fixed 500mm focal length lens)

Pitot tubes

Wind speeds can be measured with pitot static tubes. Low pressure and low wind speed decreases accuracy. A maximum of 8 channels are available. This systems operates down to a few mbar pressure.

Temperatur sensors

As many as 10 PT100 sensors are available.

Cameras

4 Logitech USB webcams. https://www.logitech.com/da-dk/products/webcams/brio-4k-hdr-webcam.960-001106.html

High speed camera Edgerton sc1 monochrome https://edgertronic.com/our-cameras/sc1

2 USB microscope, 5MP, 20x to 200x magnification, https://www.celestron.com/products/handheld-digital-microscope-pro

References;

1) ”An Environmental Wind Tunnel Facility for Testing Meteorological Sensor Systems”, Holstein-Rathlou, C., Merrison, J. P., Iversen, J.J, Jakobsen, A.B., et al., American Meteorological Society, 31, 447 (2014)
2) “Aeolian dust resuspension on Mars studied using a recirculating environmental wind tunnel”, A. Waza, J. Kjer, M. Peiteado, T. Jardiel, J. Iversen, K. Rasmussen, J. Merrison, Planetary and Space Science 227 (2023) 105638, https://doi.org/10.1016/j.pss.2023.105638
3) “A lower-than-expected saltation threshold at Martian pressure and below” Andreotti, B., Claudin, P., Iversen, J.J., Merrison, J.P., and Rasmussen, K.R., PNAS February 2, (2021) 118 (5). doi.org/10.1073/pnas.2012386118.
4) “Laboratory study of aerosol settling velocities using Laser Doppler velocimetry”, A. B. Jakobsen, J. Merrison*, J.J. Iversen, Journal of Aerosol Science 135 (2019) 58–71
5) “Laboratory investigations of the physical state of CO2 ice in a simulated Martian environment“, G. Portyankina, J., Merrison, J.J, Iversen, Z., Yoldi, C.J.., Hansen, K. M., Aye, A., Pommerol, N., Thomas, Icarus 322 (2019) 210–220
6) “Environmental wind tunnels”. Merrison J.P., In: Wind Tunnels, in: S. Okamoto (Ed.), Intech ISBN 978-953-307-295-1, pp. 1–22 (2011)
7) “Wind Tunnels for the Study of Particle Transport”. Rasmussen, K. R., Merrison, J.P., and Nørnberg, P., In: Wind tunnels and experimental fluid dynamics research. Edited Lerner, J.C. and Ulfilas, B., InTech. ISBN 978-953-307-623-2, pp. 51–74 (2011).