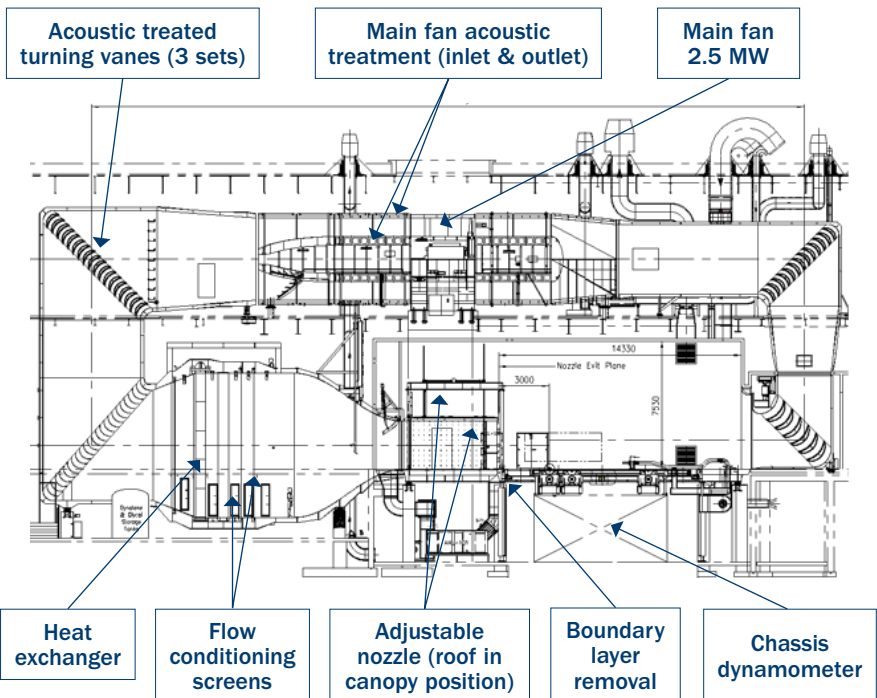


# Climatic Wind Tunnel

## Key features

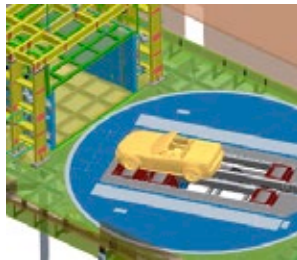
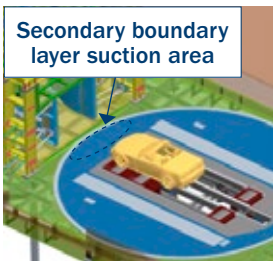
- Adjustable nozzle 7 to 13 m<sup>2</sup> and long test section to accommodate a wide range of vehicle sizes and type, from small cars to Class 8 trucks and buses, with wind speeds in excess of 240 km/h.
- Temperature from -40°C to +60°C and humidity from 5 to 95 per cent.
- Exceptional flow quality for advanced aerodynamic simulation in thermodynamic testing
- Low background noise level (64 dBA at 50 km/h) for the detection of vehicle drive-away anomalies such as misfires, transmission hesitation, etc.
- Unique independently-power rolls chassis dynamometer in a turntable to enable cross-wind testing.
- Solar simulation system up to 1200 W/m<sup>2</sup> intensity with sunrise-sunset simulation capabilities.
- Blowing rain, falling and blowing snow simulation.
- Complete suite of ancillary systems for customer vehicle operation, including hydrogen and electric vehicle compatibility.
- Wireless capability to generate and detect sub-6 GHz signals using integrated antennas.





# Test section features

<b>Overall dimensions</b>	L 20.1 m x W 13.5 m x H 7.5 m
<b>Useable length</b>	<ul style="list-style-type: none"> <li>• 14.3 m for cars &amp; trucks</li> <li>• 19.1 m for trucks &amp; buses</li> </ul>
<b>Vehicle entry clearance</b>	W 3.93 m x H 4.49 m (Corner No.1 turning vane set open)
<b>Adjustable nozzle</b>	7.0 to 13.0 m <sup>2</sup> : H 2.9 m x W 2.4 to 4.5 m
<b>Canopy for buses</b>	22 m <sup>2</sup> : H 4.4 m x W 5 m (used with 13.0 m <sup>2</sup> nozzle)
<b>Turntable diameter</b>	11.7 m
<b>Boundary layer removal</b>	<ul style="list-style-type: none"> <li>• W 5.25 m main suction system</li> <li>• Provision for secondary suction</li> </ul>
<b>Vehicle exhaust extraction system</b>	<ul style="list-style-type: none"> <li>• Dual or single exhaust pipes</li> <li>• Open or closed mode with back pressure regulation</li> <li>• Maximum flow rate: 0.62 kg/s (8.5 L, 400 HP engine)</li> <li>• Maximum inlet exhaust temperature: 650°C</li> </ul>
<b>In-chamber fuelling</b>	<ul style="list-style-type: none"> <li>• Station for Regular, RVP and Diesel</li> <li>• Plumbed in for hydrogen</li> </ul>
<b>In-chamber power</b>	Outlets for plug-in vehicles



**Dual closed-pipe vehicle exhaust extraction system**

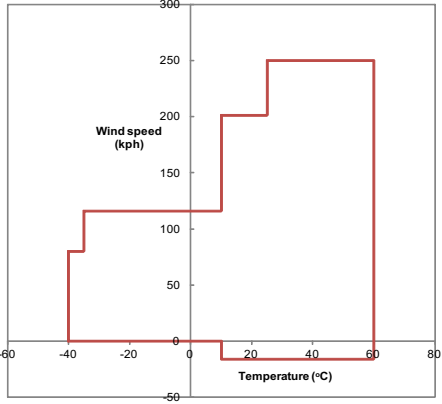


**In-chamber refuelling station**

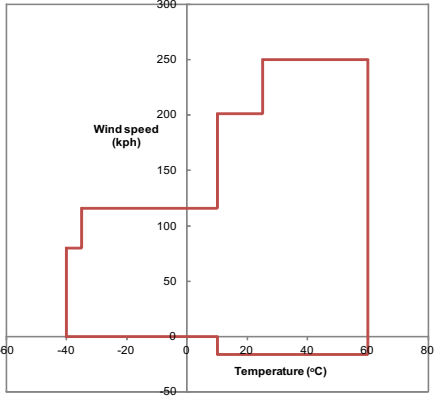
# Wind speed and thermal performance

Full thermal control wind speed: 7.0 to 9.3 m<sup>2</sup> nozzle settings

7.0 m<sup>2</sup> nozzle



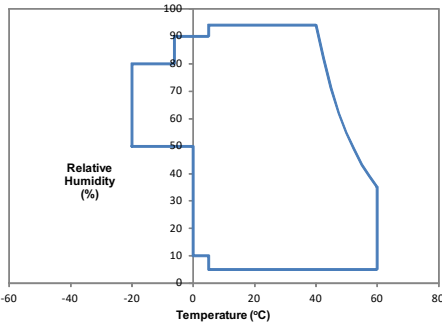
9.3 m<sup>2</sup> nozzle



Increased maximum wind speed: ambient conditions

Nozzle (m <sup>2</sup> )	Wind speed (km/h)	Temperature (°C)
7.0	280	25
9.3	250	
13.0	225	

Humidity – temperature performance



Central floor track cover

Side floor track covers



Elevator

Air bearing



# Thermal performance and flow quality specifications

## Cooling system

- R507 primary loop with Dynalene HC-50 secondary loop
- Total heat capacity: 500 kW at -40°C , 2100 kW at ambient

## Thermal performance

Parameter	Set Point Change	Rate	Test Condition
Temperature	<12°C	0.8°C/min	70 to 105 km/h; 32°C to 50°C
	<6°C	0.6°C/min	<115 km/h
	>6°C	0.08°C/min	<115 km/h
Humidity	20% RH	1.0% RH/min	38°C dry bulb

## Flow quality

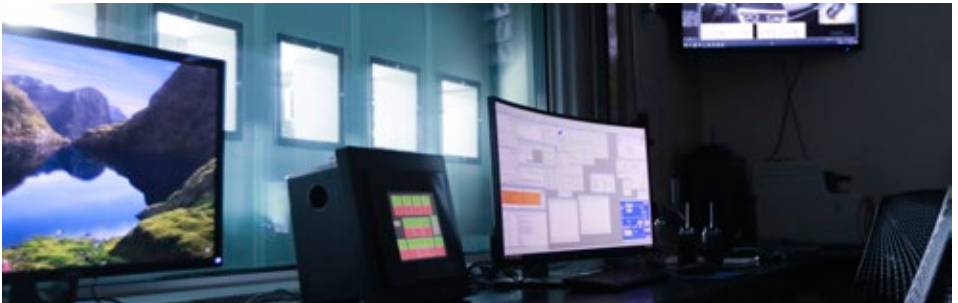
Parameter	Uniformity ( $\sigma$ )	Stability
Wind speed	1% of set point	$\pm 0.5$ km/h
Flow angularity	0.5°C	
Temperature	0.3°C	$\pm 0.2$ °C at velocity > 48 km/h
Humidity	0.5°C (dew point)	$\pm 0.5$ °C (dew point)

## Boundary layer displacement thickness

$\delta^*$  less than 5 mm at 0.9 m ahead of the front chassis dynamometer roll set at 90 km/h, 25°C air temperature.

## Background noise level: 9.3 m2 nozzle

Wind speed (km/h)	Out-of-flow SPL (dBA)
50	64
100	81
140	90
250	107



# Chassis Dynamometer specifications

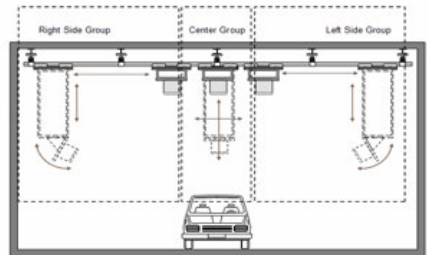
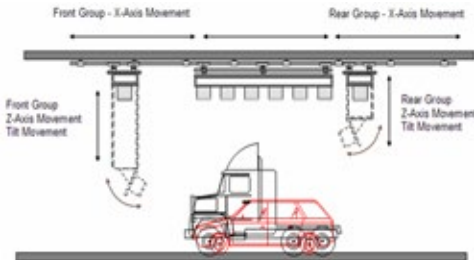
Manufacturer and Model	Burke E. Porter (custom design)
Vehicle types	Passenger car, light and medium duty trucks, buses
Axle configurations	FWD, RWD, 4WD, AWD (4 independent rolls)
Roll width	812 mm (4 identical)
Roll diameter	1219 mm (4 identical)
Roll surface	Tungsten carbide, aggressive finish (0.8 $\mu$ )
Clear space between rolls	1067 mm (identical front and rear)
Wheelbase range	1600 to 5842 mm
Location of front fixed axle from nozzle exit plane (0° yaw)	3000 mm
Location of rear fixed axle from nozzle exit plane (180° yaw)	9200 mm
Normal maximum yaw angle range	$\pm 30^\circ$
Floor features	<ul style="list-style-type: none"> <li>• Automatic floor track and side roll cover system</li> <li>• Moveable central inspection port with infrared camera</li> </ul>
Total inertial simulation range	907 to 9072 kg
Maximum axle load	5000 kg
Maximum vehicle weight	9072 kg
Maximum speed	250 km/h
Motor type	AC (Vector Drive Duty)
Nominal maxim power	187 kW per roll, motoring and absorbing; 92 to 250 km/h
Base speed	92 km/h
Continuous tractive force rating	7301 N per roll; 0 to 92 km/h
Tractive force overload	150% for 60 seconds; 0 to 92 km/h
Features	Robot driver; customer specified drive cycles
Configuration	Elevator and air bearings permit removal from test section



# Solar Simulation System specifications

- Full diurnal function with azimuth and altitude.
- Full spectrum capability with vertical and biaxial movement.

Manufacturer	KHS Steuernagel
Target size	<ul style="list-style-type: none"> <li>• L 6.5 m x W 2.5 m</li> <li>• 1.5 m above test section floor</li> </ul>
Intensity range	600 to 1200 W/m <sup>2</sup>
Intensity incidence	0 to 52.5°
Spectrum	ASTM Std E-892
Intensity quality	<ul style="list-style-type: none"> <li>• Uniformity <math>\pm 10\%</math></li> <li>• Stability <math>\pm 2\%</math></li> </ul>
Lamps	<ul style="list-style-type: none"> <li>• Metal halide</li> <li>• 21 total</li> </ul>



Solar array showing front illumination  
(9.3 m<sup>2</sup> nozzle)



Solar array arranged for a bus  
(13 m<sup>2</sup> nozzle and 22 m<sup>2</sup> canopy)

# Rain and Snow System specifications

## Rain simulation system

Frontal rain simulation system located at the nozzle exit provides:

- Up to 12 nozzles of various sizes as needed to provide adequate coverage of a given vehicle.
- Designed for 150 km/h at 20°C but will operate as low as -5°C to perform freezing rain tests.



Blowing rain intrusion test



Measuring freezing rain on a bus

## Snow simulation systems

There are two configurations of snow simulation possible: frontal (blizzard) and overhead. In both cases, snow guns are used to create the snow.

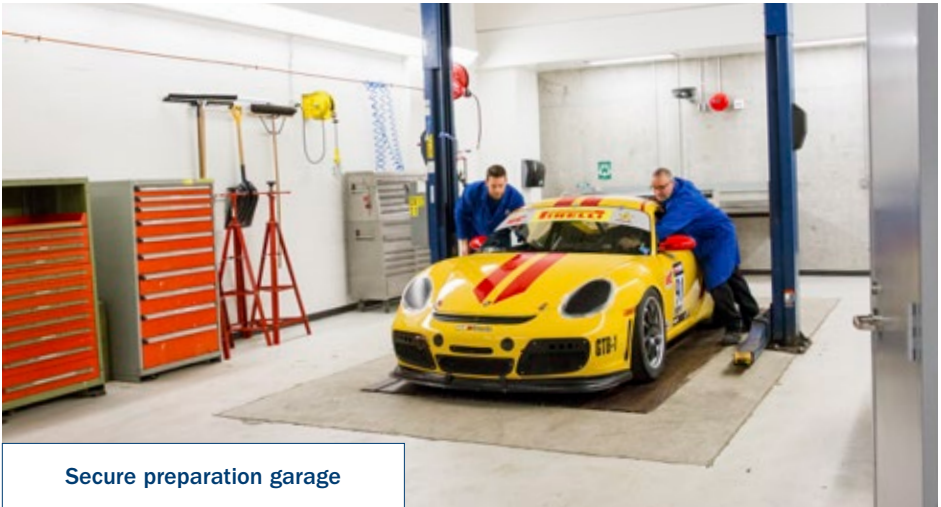


Emergency blizzard simulation



# Ancillary equipment

Vehicle starting power	200 amp, 12 V DC and 24 V DC
Pressure radiator fill	System capable of charging from a pressurized vessel
Gas tank and differential cooling	Cooling water system to provide cooling during high load tests
Refrigerant charging system	<ul style="list-style-type: none"><li>• Two charging systems, one for R134A or equivalent, the other for alternative refrigerants.</li><li>• Capability to pull a vacuum once refrigerant has been reclaimed.</li></ul>



Secure preparation garage



Electric vehicle and charger testing

