

Automotive Centre of Excellence



Facility Fact Sheet

What is ACE?

The Automotive Centre of Excellence (ACE) is the first testing and research centre of its kind in Canada, and in many respects the world. It is wholly owned and operated by the University of Ontario Institute of Technology (UOIT) and is located on the north campus in Oshawa, Ontario.

ACE is a truly independent test facility that is commercially available to customers who are seeking to bring their ideas into a proof of concept and ready for market. This is where the next generation of electric and alternative fuel vehicles, green energy technology and products we haven't even thought of yet will be discovered, tested and validated.

ACE is a multi-purpose centre with an area of approximately 16,300 square metres. It is divided into two distinct sections: a core research facility and an integrated research and training facility. The total cost of the facility is approximately \$100 million.

ACE was developed in partnership with UOIT, General Motors of Canada, the Government of Ontario, the Government of Canada and the Partners for the Advancement of Collaborative Engineering Education (PACE).

What is the core research facility?

The core research facility is a heavy lab area with five distinctive test chambers:

- **Climatic Wind Tunnel** – ACE has one of the largest and most sophisticated climatic wind tunnels in the world. In this test chamber, wind speeds can exceed 250 kilometres per hour, temperatures range from -40 to +60°C and relative humidity ranges from 5 to 95 per cent. The climatic wind tunnel has a unique variable nozzle that can optimize the airflow from 7 to 13 metres squared allowing for an unprecedented range of vehicle and other test property sizes. Coupled with this feature is a large chassis dynamometer that is integrated into an 11.5-metre turntable. Now, for the first time anywhere, vehicles and test properties can be turned into the airstream under full operating conditions to facilitate vehicle performance testing in a crosswind development. The large open chamber has a readily reconfigurable solar array that will replicate the effects of the sun and is hydrogen-capable, allowing for alternative fuels and fuel cell development.
- **Climate Chambers** – ACE has a large and a small climate chamber that provide exacting conditions of both temperature and humidity. The large climate chamber is a high feature chamber that includes an input dynamometer coupled with a solar array. Temperatures range from -40°C to +60°C and relative humidity from 5 to 95 per cent.

- **Climatic Four-Poster Shaker** – ACE has a drive-on four-poster shaker within a climatic chamber. This vertical axis shaker can provide the motion for simulated drive surfaces to validate suspension and body durability for applications like squeak and rattle. In addition, the four-poster is capable of providing highly accelerated motion further enhancing its capabilities to support advanced structural durability and life cycle testing. Temperatures range from -40°C to +60°C and relative humidity from 5 to 95 per cent.
- **Multi-Axis Shaker Table (MAST)** – ACE has a multi-axis shaker table or MAST in a hemi-anechoic chamber. The six axis inverted hexapod design allows for products to be tested for structural durability and the detection of noise and vibration in three dimensions.
- **Secure Preparation Garages** – ACE has three secure preparation garages, with exhaust extraction system, tool chest, work bench and electric power.

What is the Integrated Research and Training Facility?

The integrated research and training facility spans five floors with space dedicated for research, education and training. It has offices, laboratories, conference rooms and common work areas that are available to rent. This facility will foster an environment for collaboration and interaction between industry, researchers and students.

What are the potential markets?

In addition to conventional automotive applications, ACE is suitable for testing alternative fuel, hybrid and electric vehicles. It is large enough to accommodate trucks, tandem drive systems, full coach buses, light rail transit, aerospace, military and agricultural applications, wind turbines and solar panels. Furthermore, ACE could be used to train military personnel, rescue crews or competitive athletes, to carry out performance testing of outdoor survival gear. It has the potential to assist the movie industry or test products that are subject to severe wind, humidity, snow, icing or desert heat.

Booking ACE

ACE is available to rent by those with a need for its unique capabilities, including: manufacturers of all descriptions, start-up companies and researchers in Canada and from around the world. Clients can rent the entire facility or specific chambers at an hourly rate that is globally competitive.

For more detailed information or to take a tour of ACE, please visit our website at: www.ontariotechu.ca/ace.

ACE WIRELESS ENVIRONMENT - Key Features

ACE has invested in additional capabilities to help developers of autonomous, connected car and wireless automotive systems.

GNSS (Global Navigation Satellite Systems) simulation. Allow generation of fixed and moving profile of coordinates based on GPS, Galileo, BeiDou and/or GLONASS networks. Power levels are controllable and any coordinates are possible. Useful for checking GNSS module sensitivity vs. climate or for doing other tests when GNSS system like GPS is required to enhance the simulation.

Summer (June 2019)

V2X transmission standards, specifically DSRC, ITS-G5 and WAVE power analysis vs. climate using the 802.11p standard. Set a reference power level with your module, change the environment and see how your transmission power has been affected.

Possible in the future (2020)

Enhancement to include C-V2X based on 3Gpp release 16 to measure module transmission power analysis vs. climate on this new standard.

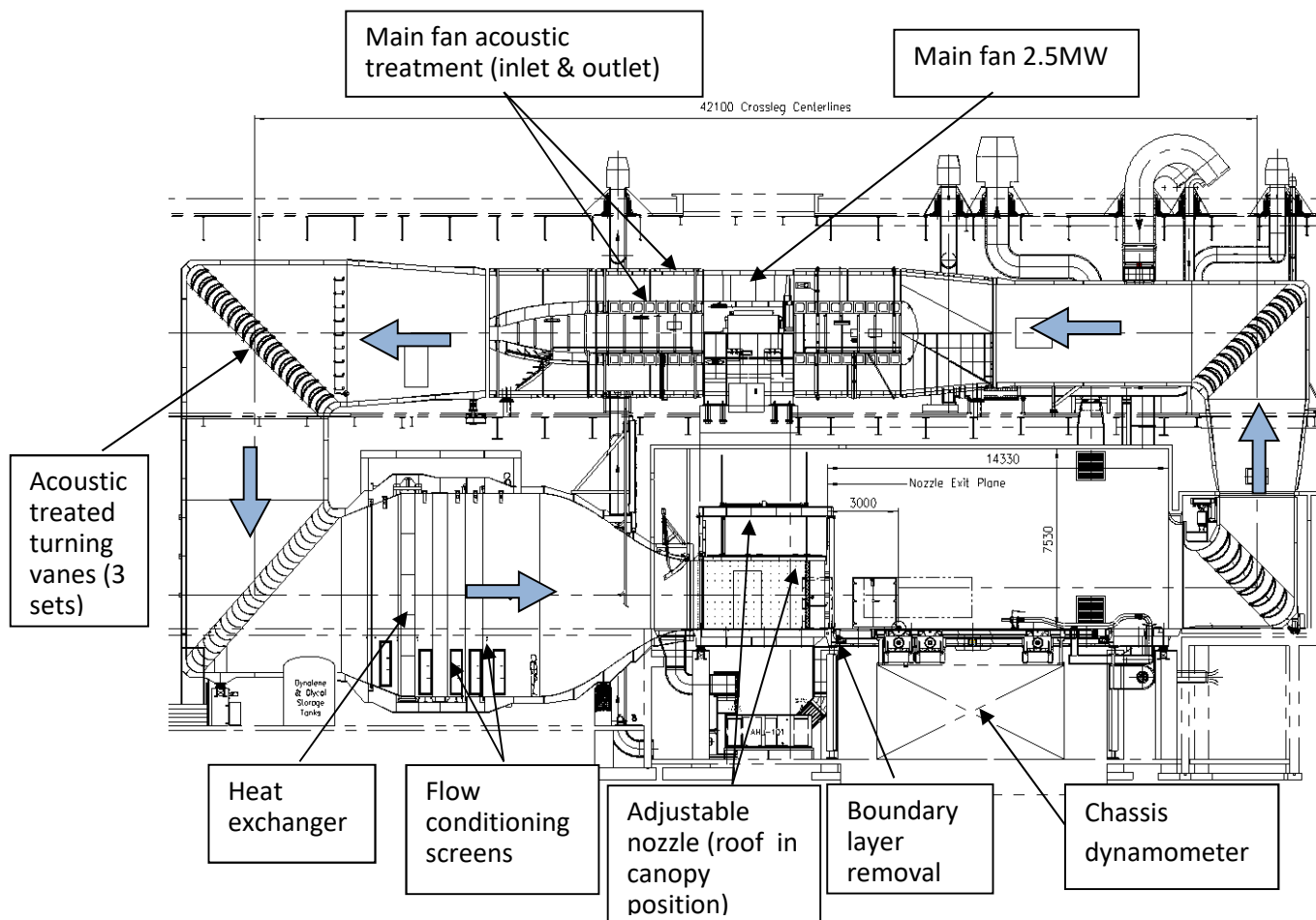
High performance electronic troubleshooting equipment provided by Keysight (formerly Agilent) Technologies. Exceptional array of general-purpose equipment covering DC to 6.5GHz and thermal imaging allow visitors to repair, or tweak their modules without having to fly home or import/bring their own test equipment.

- 4.5 digit True RMS Handheld DMM
- Digital multimeter, 6 1/2 digit, including voltage, current 4 wire resistance, capacitance and digitizing over LAN or USB
- DC power supply, triple-output, 6 V, 10 A and 2 x 25 V, 2 A, 160 W: LAN, USB controllable
- DC Power Supply 60V, 12.5A, 750W; GPIB, LAN, USB, LXI compliant
- Data Acquisition Switch Unit with LAN and USB, and 20 channel Relay mux based on DAQ970A
- Multifunction DIO and analog output for data acquisition system
- Oscilloscope, 4-channel, 500 MHz with built in Function Generator, CAN/LIN/I2C, SPI, and more decodes. USB controllable.
- 6.5 GHz FieldFox RF Analyzer including Vector Network analysis, Spectrum analyzer with preamplifier and interference analysis, CW signal generation TDR cable measurements and GPS receiver
- Perpetual transportable license BenchVue CCC, Control and Automation
- TrueIR Thermal Imager, -20 to 350 degree Celsius
- BenchVue Instrument control and automation with easy export of data and saving bench states.

CLIMATIC WIND TUNNEL - Key Features

- Adjustable nozzle 7- 13m² 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 240kph
- Temperature from -40°C to +60°C and humidity from 5% to 95% RH
- Exceptional flow quality for advanced aerodynamic simulation in thermodynamic testing
- Low background noise level (64dBA at 50kph) 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 1200W/m² 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

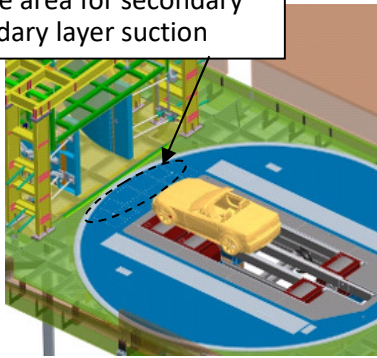
Wind Tunnel Circuit



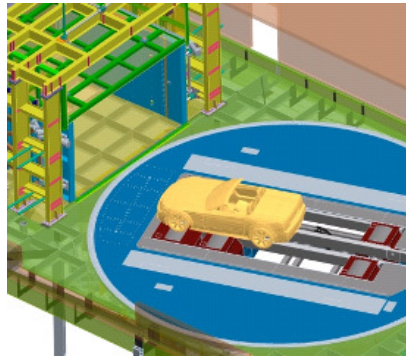
Test Section Features

Overall dimensions	L20.1m x W13.5m x H7.5m
Useable length	<ul style="list-style-type: none"> • 14.3m for cars & trucks • 19.1m for trucks & buses
Vehicle entry clearance	W3.93m x H4.49m (Corner No.1 turning vane set open)
Adjustable nozzle	• 7.0 – 13.0m ² : H2.9m x W2.4 – 4.5m
Canopy for buses	22m ² : H4.4m x W5m (used with 13.0m ² nozzle)
Turntable diameter	11.7m
Boundary layer removal	<ul style="list-style-type: none"> • W5.25m main suction system • Provision for secondary suction
Vehicle exhaust extraction system	<ul style="list-style-type: none"> • Dual or single exhaust pipes • Open or closed mode with back pressure regulation • Maximum flow rate: 0.62kg/sec (8.5 liter, 400 HP engine) • Maximum inlet exhaust temperature: 650°C
In-chamber fuelling	<ul style="list-style-type: none"> • Station for Regular, RVP and Diesel • Plumbed in for hydrogen
In-chamber power	Outlets for plug-in vehicles

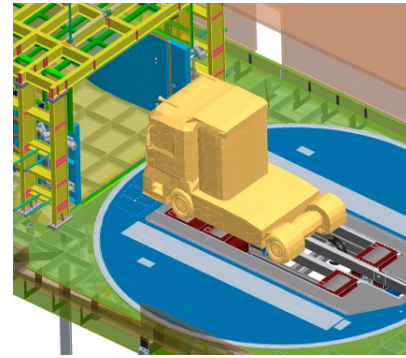
Future area for secondary boundary layer suction



7.0m² nozzle, 0° yaw



13.0m² nozzle, 30° yaw



13.0m² nozzle, 22m² canopy; 0° yaw



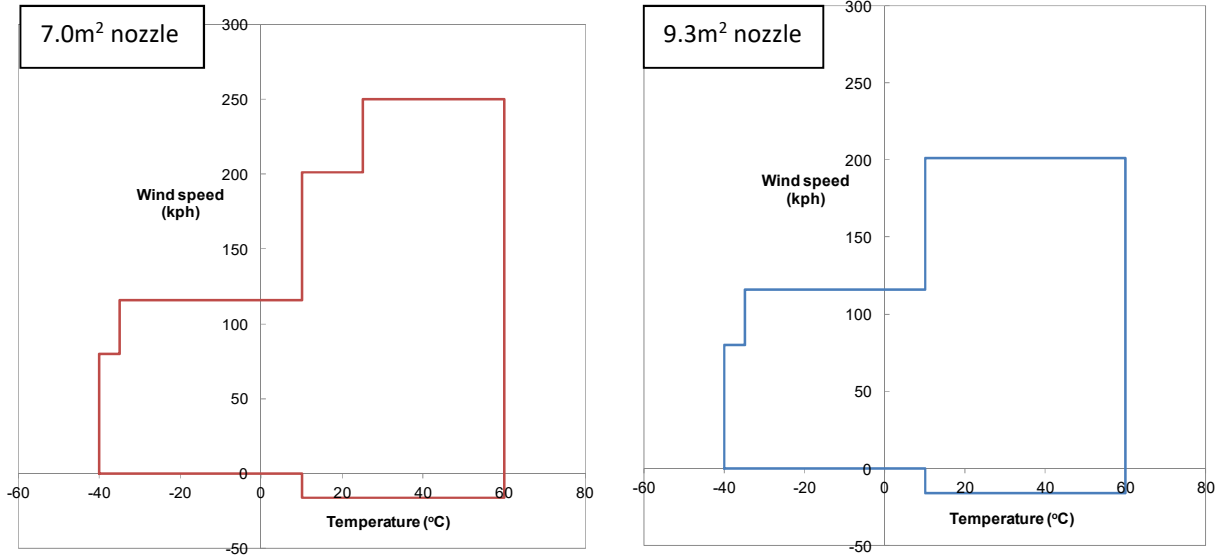
Dual closed-pipe vehicle exhaust extraction system



In-chamber refuelling station

Wind Speed and Thermal Performance

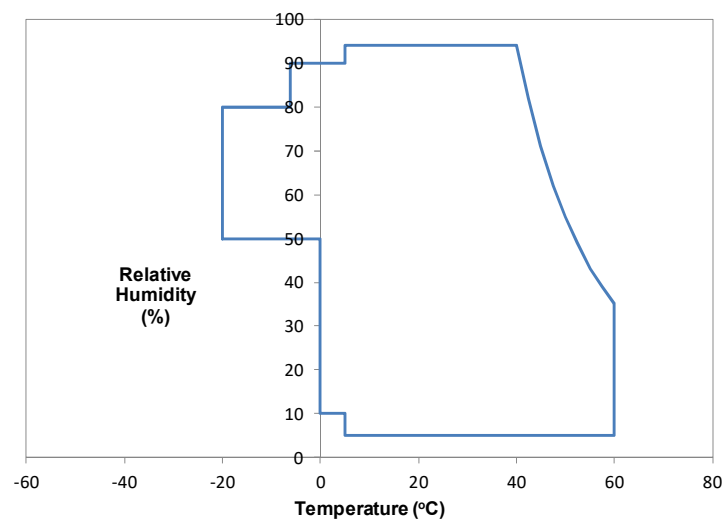
Full thermal control wind speed: 7.0-9.3m² nozzle settings



Increased maximum wind speed: ambient conditions

Nozzle (m ²)	Wind speed (kph)	Temperature (°C)
7.0	280	25
9.3	250	25
13.0	225	25

Humidity - temperature performance



Thermal Performance and Flow Quality Specifications

Cooling system

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

Thermal performance

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

Flow quality

Parameter	Uniformity (σ)	Stability
Wind speed	1% of set point	± 0.5 kph
Flow angularity	0.5°	
Temperature	0.3°C	± 0.2 °C at velocity > 48kph
Humidity	0.5°C (dew point)	± 0.5 °C (dew point)

Boundary layer displacement thickness

δ^* less than 5mm at 0.9m ahead of the front chassis dynamometer roll set at 90kph, 25°C air temperature.

Background noise level: 9.3m² nozzle

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

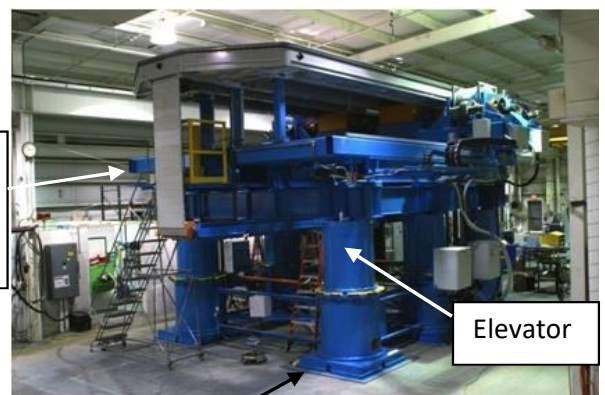


Chassis Dynamometer Specifications

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



Side floor track covers



Central floor track cover

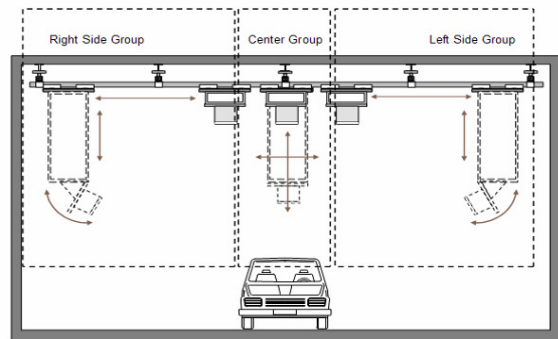
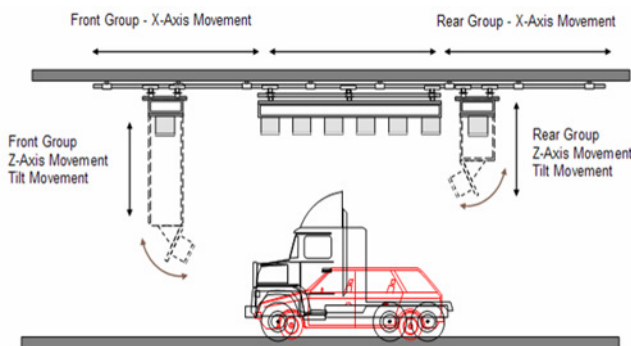
Elevator

Air bearing

Solar Simulation System Specifications

- Full diurnal function with azimuth and altitude
- Full spectrum capability with vertical and bi-axial movement

Manufacturer	KHS Steuernagel
Target size	<ul style="list-style-type: none"> • L6.5m x W2.5m • 1.5m above test section floor
Intensity range	600-1200W/m ²
Intensity incidence	0 to 52.5°
Spectrum	ASTM Std E-892
Intensity quality	<ul style="list-style-type: none"> • Uniformity ±10% • Stability ±2%
Lamps	<ul style="list-style-type: none"> • Metal halide • 21 total



Solar array showing front illumination
(9.3m² nozzle)



Solar array arranged for a bus
(13m² nozzle and 22m² 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 150kph at 20°C but will operate as low as -5°C to perform freezing rain tests.



Blowing rain test on a bus



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.



Blizzard: 30° yaw into the wind

Ancillary Equipment

Vehicle starting power	200amp 12vDC and 24vDC
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"> • Two charging systems, one for R134A or equivalent, the other for alternative refrigerants • Capability to pull a vacuum once refrigerant has been reclaimed.



Secure preparation garage

LARGE CLIMATE CHAMBER - Key Features

- Exceptionally long test section to permit articulated buses
- Temperature from -40°C to +60°C and humidity from 5% to 95% RH
- Chassis dynamometer
- Solar simulation system up to 1200W/m² intensity
- Inter-chamber door to Small Climate Chamber to permit insertion of a test bench to effect a 'three chamber' mode
- Complete suite of ancillary systems for customer vehicle operation, including hydrogen and electric vehicle compatibility

Test Section Features

Overall dimensions	L20.8m x W6.0m x H5.55m
Vehicle entry clearance	<ul style="list-style-type: none"> • W3.93m x H4.49m to outside • W4.26m x H4.49m to transfer area
Inter-chamber door clearance	W2.01m x H2.01m
Primary exhaust extraction system	<ul style="list-style-type: none"> • Dual mode: open pipe or closed pipe with back pressure regulation • Maximum flow rate: 0.62kg/sec (8.5 liter, 400 HP engine) • Maximum inlet exhaust temperature: 650°C
Secondary vehicle exhaust extraction system	<ul style="list-style-type: none"> • Garage type open pipe (2 pipes)
In-chamber power	<ul style="list-style-type: none"> • Outlets for plug-in vehicles

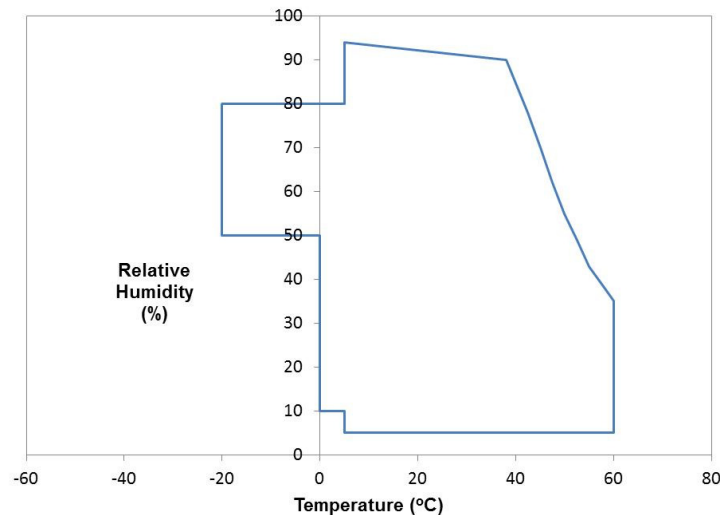


Door to outside



Inter-chamber door

Thermal Performance Specifications



Other performance:

- Maximum cooling rate: +60°C to -40°C in 6 hours
- Temperature uniformity: $\sigma = 0.33\text{ }^{\circ}\text{C}$ (tested at 20 °C)

Chassis Dynamometer Specifications

Manufacturer & Model	Mustang Engineering Co (MD-AWD-500-SE)
Vehicle types	Passenger car, light duty trucks
Axle configurations	FWD, RWD, 4WD, AWD
Roll width	940mm (7 identical per side: 5 front, 2 rear)
Clear space between rolls	610mm (identical front and rear)
Wheelbase range	2134 to 3556mm
Mechanical Inertia	<ul style="list-style-type: none"> • 636kg Front (Motorcycle mode) • 888kg Front • 983kg Rear
Total inertial simulation range	655 (motorcycle) to 907 (single axle) to 5448kg (dual axle)
Maximum axle load	2727kg
Maximum vehicle weight	5448kg
Maximum speed	<ul style="list-style-type: none"> • 280kph FWD • 240kph AWD
Motor type	• Eddy current, power absorbing only
Nominal maximum power	<ul style="list-style-type: none"> • 447kW Front roll set • 894kW Total
Continuous tractive force rating	<ul style="list-style-type: none"> • 6227N Front roll set • 12455N Total
Features	Robot driver; customer specified drive cycles

Solar Simulation System Specifications

Manufacturer	KHS Steuernagel
Target size	<ul style="list-style-type: none">• L5.6m x W2.5m (fixed)• 1.5m above test section floor
Intensity range	600-1200W/m ²
Spectrum	ASTM Std E-892
Intensity quality	<ul style="list-style-type: none">• Uniformity $\pm 10\%$• Stability $\pm 2\%$
Lamps	<ul style="list-style-type: none">• Metal halide• 18 total



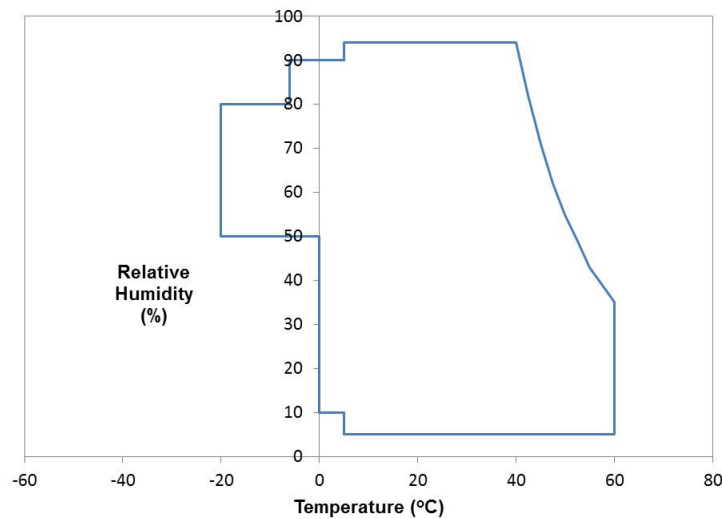
SMALL CLIMATE CHAMBER – Key Features

- Large enough to accommodate two cars
- Temperature from -40°C to +60°C and humidity from 5% to 95% RH
- Inter-chamber door to Large Climate Chamber to permit insertion of a test bench to effect a ‘three chamber’ mode
- Directly linked to climatic wind tunnel via dry transfer area
- Complete suite of ancillary systems for customer vehicle operation, including hydrogen and electric vehicle compatibility

Test Section Features

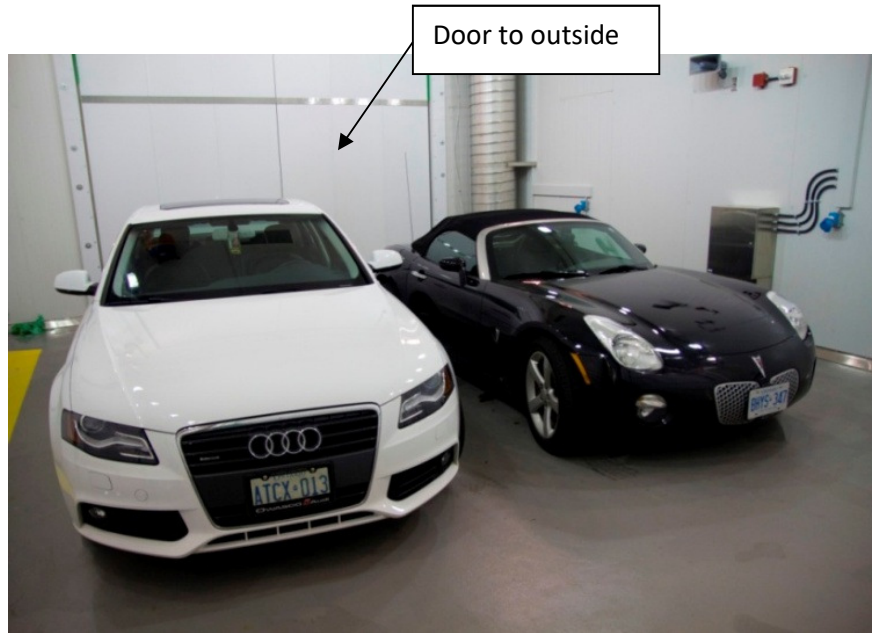
Overall dimensions	L9.0m x W6.0m x H5.5m
Vehicle entry clearance	<ul style="list-style-type: none"> • W3.68m x H4.49m to outside • W4.26m x H4.49m to transfer area
Inter-chamber door clearance	W2.01m x H2.01m
Passive exhaust extraction	Garage type
In-chamber power	Outlets for plug-in vehicles

Thermal Performance Specifications



Other performance:

- Maximum cooling rate: +60°C to -40°C in 6 hours
- Temperature uniformity: $\sigma = 0.17$ °C (tested at 20 °C)



4-POST CLIMATE CHAMBER – Key Features

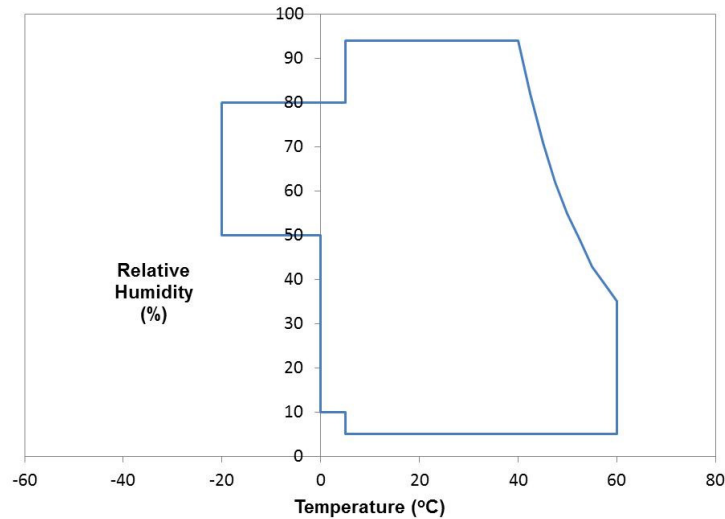
- Drive-on post feature with automatic positioning system
- Temperature from -40°C to +60°C and humidity from 5% to 95% RH
- Dual modes: road load simulation and high flow high-G
- Complete suite of ancillary systems for customer vehicle operation

Test Section Features

Overall dimensions	L8.3m x W7.2m x H5.6m
Vehicle entry clearance	W4.26m x H4.49m
Drive-on wheel pans	Remotely adjustable track and wheelbase
Exhaust extraction system	Garage type
Safety	Man-down pull cord
In-chamber power	Outlets for plug-in vehicles



Thermal Performance Specifications



Other performance (measured):

- Maximum cooling rate: +60°C to -40°C in 6 hours
- Temperature uniformity: $\sigma \leq 1.05$ °C over the entire temperature range -40 °C to +60 °C
- Temperature stability: $\sigma = 0.28$ °C over the entire temperature range -40 °C to +60 °C

4-Post Shaker Specifications

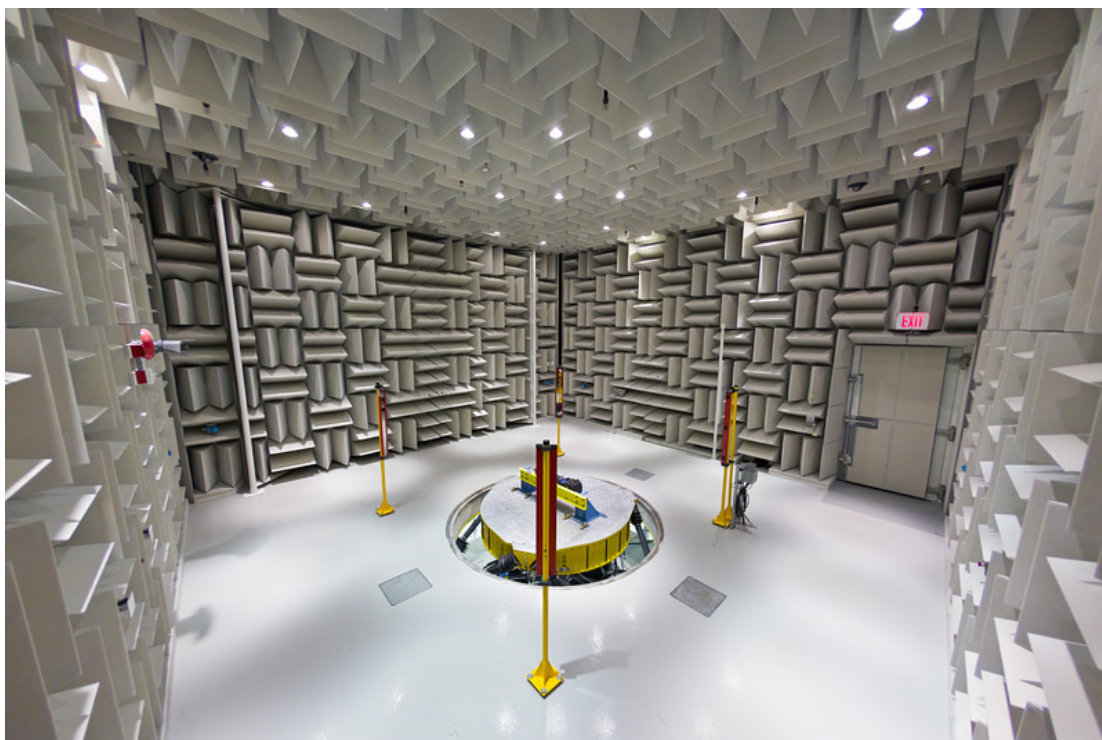
Manufacturer & Model	MTS 248.05
Control System	Flextest GT w/ 793 system software
Simulation Software	MTS RPC Pro software
Actuator Force	50,000N
Servovalve Flow	11.3L/s
Vehicle types	Passenger car, light duty trucks
Track range	1270mm to 2110mm
Wheelbase range	1572mm to 4572mm
Vehicle weight	4500kg
Range of motion	+/- 150mm
Frequency response	0.5Hz to 50Hz
Maximum acceleration	19.5g to 100g (depending on moving mass)
Maximum Velocity	5m/s

HEMI-ANECHOIC CHAMBER WITH MULTI-AXIS SHAKER TABLE - Key Features

- Hemi-anechoic chamber, 150Hz cut-off frequency with exceptionally low background noise
- 6 degrees of freedom (3 translational, 3 rotational) inverted hexapod hydraulic shaker table

Test Section Features

Overall dimensions	<ul style="list-style-type: none"> • Inside room surface: L9.00m x W8.87m x H5.15m • Clearance to acoustic treatment: L7.6m x W7.5m x H4.4m
Test object entry clearance	W4.41m x H4.35m
Chamber acoustics	<ul style="list-style-type: none"> • Cut-off frequency: 150Hz • Background noise level measured to NC-16 with ventilation system operating (<25dB above cut-off frequency)
Pit opening for shaker table	2.77m diameter
Safety	Laser based light screen
Pure acoustic test set-up	Portable cover plates for pit





Multi-Axis Shaker Table Specifications

Manufacturer & Model	MTS MAST Table 353.20
Control system	Flextest 100 w/ 793 System Software
Simulation system	MTS RPC Pro Software
Table diameter	2.0m
Test object max payload weight	680kg

Maximum translation displacements	<ul style="list-style-type: none"> • Vertical: $\pm 150\text{mm}$ • Lateral: $\pm 120\text{mm}$ • Longitudinal: $\pm 120\text{mm}$
Maximum rotation displacements	<ul style="list-style-type: none"> • Pitch: $\pm 8^\circ$ • Roll: $\pm 8^\circ$ • Yaw: $\pm 6^\circ$
Maximum velocities	<ul style="list-style-type: none"> • Vertical: 1.0m/sec • Lateral: 0.8m/sec • Longitudinal: 0.8m/sec
Bare table response	<ul style="list-style-type: none"> • Frequency response: 150Hz • Vertical Acceleration: 17.8 g • Lateral Acceleration: 10.5 g • Longitudinal Acceleration: 10.5 g
Maximum payload response	<ul style="list-style-type: none"> • Frequency response: 100Hz • Vertical Acceleration: 11.0 g • Lateral Acceleration: 6.5 g • Longitudinal Acceleration: 6.5 g

INTEGRATED RESEARCH & TRAINING FACILITY - Key Features

- Five-floor building connecting the CRF with faculty of engineering building, containing heavy lab areas and industry-university collaborative research space
- Second and third floors are university-sponsored collaborative research areas
- First and fifth floors are secure areas (total area 2,190m²) containing preparation areas, machine shop, offices, laboratories, conference rooms and common work areas that are available to rent

Capabilities

First floor	<ul style="list-style-type: none"> • Total area: 731m² • Support shop with benches, machine tools, welding and grinding equipment and common use tools and equipment • High-bay heavy lab preparation hall with entry door to outside
Fourth and Fifth floors	<ul style="list-style-type: none"> • Office space <ul style="list-style-type: none"> ○ Outfitted with desks and internet ○ Conference room available • Lab space (reconfigurable) <ul style="list-style-type: none"> ○ Bare heavy lab floor ○ Drop-down power: single phase 120v, single phase 240v, three phase 575v ○ Shop air 125psi ○ Available natural gas and exhaust ventilation connections



Support shop area