

The UOIT Automotive Centre of Excellence - Climatic Test Facility

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ABSTRACT

The University of Ontario Institute of Technology (UOIT) is the home of the General Motors of Canada Automotive Centre of Excellence (ACE), a university owned and operated facility that is funded by the university and the provincial and federal governments of Canada. As such, ACE is available to all automotive manufacturers (OEM's), Tier 1 suppliers, university researchers, or any other industry requiring the need for independent research and development test capability.

A large climatic wind tunnel is the signature feature of ACE, which also includes climatic chambers (one of which is a high feature chamber), a climatic 4-post shaker test cell and a hemi-anechoic chamber equipped with a multi-axis shaker table. Some key design features of the climatic wind tunnel include a variable nozzle geometry (from 7 m² to 13 m²), a chassis dynamometer inserted in an 11.7 metre turntable, a boundary layer control system and circuit acoustic treatment for low background noise levels. The climatic wind tunnel performance envelope covers wind speeds up to 250 km/h, temperature range from -40 °C to +60 °C, relative humidity from 5% to 95%, and the test section is equipped for solar, rain and snow simulation.

This paper provides an introduction to the ACE facility and presents the results of the aerodynamic commissioning program. The climatic performance and flow quality test results of the wind tunnel are given, as well as the climatic performance for each chamber.

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INTRODUCTION

The Automotive Centre of Excellence (ACE) is the first testing and research centre of its kind in Canada. 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 an independent research and development 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 and green energy technologies will be 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 core research facility comprises a large climatic wind tunnel, two climatic test chambers, a climatic 4-poster shaker and a hemi-anechoic

chamber hosting a multi-axis shaker table. 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).

Construction of ACE began in the spring of 2008 and was largely completed by May 2011. Aerodynamic commissioning began at this time and was completed on 26 January 2012. This paper will focus on the aerodynamic design and commissioning of the climatic wind tunnel and climatic test chambers.

AUTOMOTIVE CENTRE OF EXCELLENCE

The core research facility of the UOIT ACE is a multifaceted test facility including a large climatic wind tunnel, two climatic chambers, a climatic 4-poster shaker test

cell and a hemi-anechoic chamber equipped with a multi-axis shaker table. The key features and capabilities of each of these chambers are introduced in the following sections.

Climatic Wind Tunnel

ACE has a large and sophisticated climatic wind tunnel. In this test chamber, wind speeds can exceed 250 kilometres per hour, temperatures range from -40 to $+60^{\circ}\text{C}$ and relative humidity ranges from 5 to 95 per cent. The climatic wind tunnel has a variable nozzle that can optimize the airflow from 7 to 13 square metres allowing for a range of vehicle and other test property sizes. Coupled with this feature is a large chassis dynamometer that is integrated into an 11.7 metre turntable. The combination of variable nozzle and large turntable in a climatic wind tunnel is unique. Together, these allow vehicles and test properties to be turned into the airstream under full operating conditions to facilitate vehicle performance testing in a crosswind development. The large open chamber has a reconfigurable solar array that will replicate the effects of the sun. The test section safety system is hydrogen-capable, allowing for alternative fuels and fuel cell development.

The ACE climatic wind tunnel (CWT) is a closed-circuit overhead return type of steel construction. The general airline for the CWT is given in Figure 1.

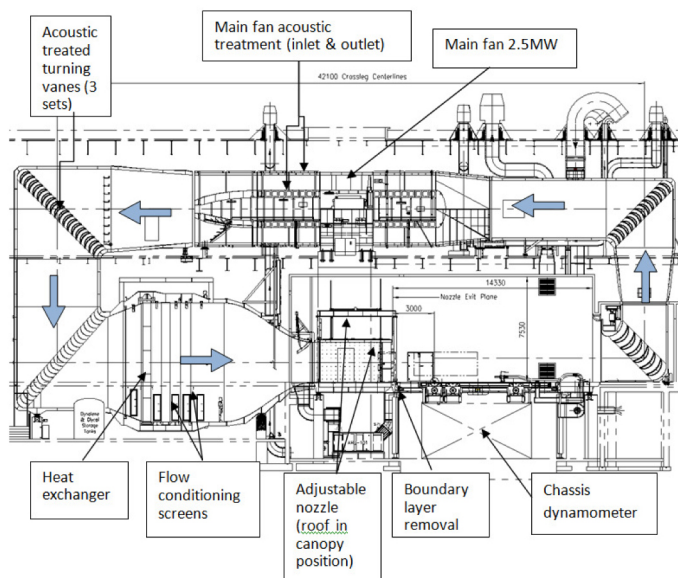


Figure 1. Climatic Wind Tunnel circuit and major design features

Key features

- Adjustable nozzle 7- 13 m^2 and long test section to accommodate a wide range of vehicle size and type, from small cars to Class 8 trucks and buses, with wind speeds in excess of 250 kph
- Temperature from -40°C to $+60^{\circ}\text{C}$ and humidity from 5% to 95% RH

- Automatic boundary layer control system
- Good flow quality for advanced aerodynamic simulation in thermodynamic testing
- Low background noise level (64 dBA at 50 kph) for the detection of vehicle drive-away anomalies such as misfires, transmission hesitation, etc.
- Unique independently-power rolls 750 kW (combined) chassis dynamometer in a turntable to enable cross-wind climatic testing
- Solar simulation system up to 1100 W/m^2 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

Turntable and flex nozzle

The test section is equipped with a large 11.7 m diameter turntable, in which the chassis dynamometer is mounted. This allows the vehicle to be yawed relative to the wind in order to examine the effects of crosswind.

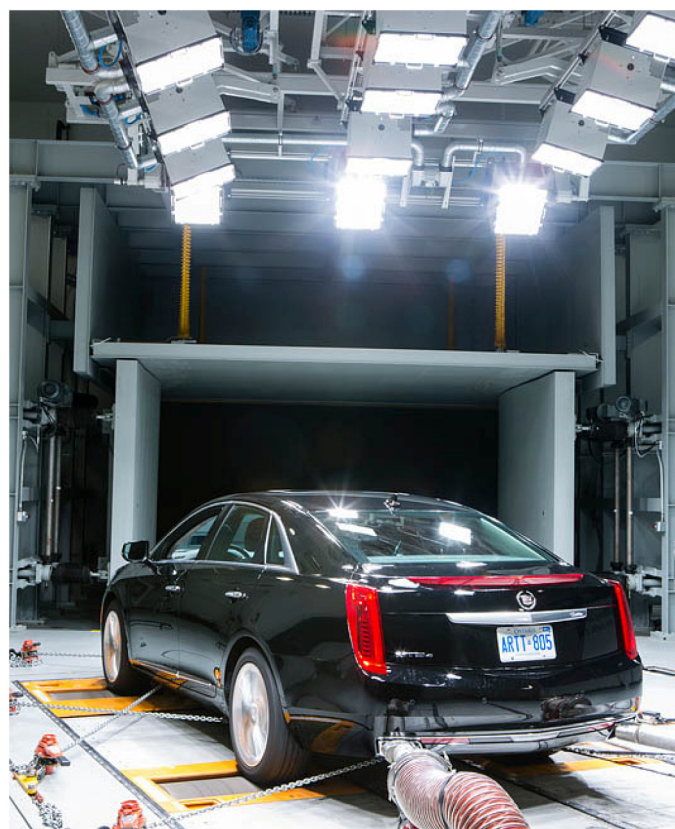


Figure 2. Passenger car mounted on the dynamometer and yawed to the wind with the 13 m^2 nozzle.

The nozzle is equipped with flexible plate side walls, which are driven by jacks in order to allow a large variation

in nozzle exit area. The nominal nozzle area is 9.3 m^2 , and this may be reduced to 7 m^2 or increased to 13 m^2 . The smaller nozzle allows an increased performance envelope: higher wind speeds may be achieved over a greater temperature range while staying within the maximum CWT cooling system load capacity. The larger nozzle is used where a larger jet is desirable, e.g. for larger vehicles or to accommodate tests with large yaw angles.

The nozzle may also be set to a “tall” configuration, for class 8 vehicle testing. This configuration has the side walls at maximum width (as per the 13 m^2 nozzle) and also has the top panel of the nozzle raised to 4.4 metres. This provides a nozzle area of 20 m^2 .

Environmental simulation

The CWT provides a large range of environmental conditions, including temperatures from -40°C to $+60^\circ\text{C}$ and relative humidity from 5% to 95%. The temperature versus wind speed and humidity versus temperature performance envelopes are shown in Figure 3 and Figure 4, respectively.

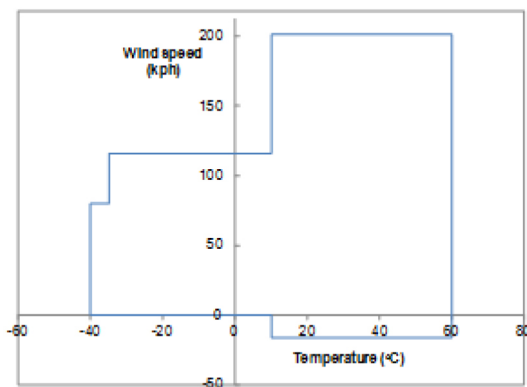


Figure 3. Full thermal control wind speed range for the 9.3 m^2 nozzle

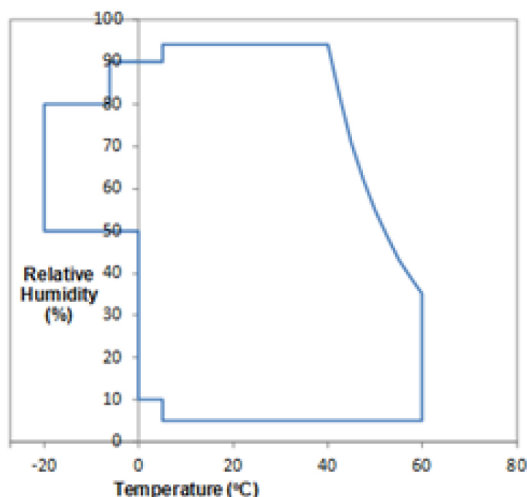


Figure 4. Humidity - temperature performance envelope

The CWT test section is equipped with solar simulation providing intensities up to 1100 W/m^2 . A rain rig can be mounted at the nozzle exit to provide rain or freezing rain simulation. Blowing snow is provided by a snow gun mounted in the contraction upstream of the nozzle, and falling snow is provided by two movable floor-mounted snow guns. Figure 5 shows an electric bus mounted on the chassis dynamometer in the CWT ready for freezing rain and solar simulation testing.



Figure 5. CWT test section configured for icing and solar simulation with 20 m^2 nozzle for a large vehicle

Upgradability

The CWT was designed and built with consideration for future upgrades. These include:

- an allowance for a honeycomb installation in the settling chamber,
- room for a secondary boundary layer removal system to take the form of a perforated plate built into the turntable upstream of the dynamometer,
- provision for acoustic panels to be installed in the test section, and
- capability of precision insertion of other test devices; eg. external balance, 5-belt, rolling road into the turntable.

The CWT as built is suitable for the full range of climatic testing and some aerodynamic tests. The upgrades listed above will enable improved aerodynamic characteristics and acoustic performance.

Climate Chambers

In addition to the CWT, ACE hosts three climatic chambers, including a large chamber, small chamber and 4-post chamber.

Large climate chamber

The large climate chamber is sized to fit a class-8 truck or bus, and may alternately be used as a temperature