

Development of Full-Scale Automotive Aerodynamic and Aero-Acoustic Wind Tunnel that Enables Simulation of On-Road Conditions



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Today's passenger vehicles require running stability, the improvement of fuel efficiency and comfort. In order to develop the level of performance necessary to achieve these goals, wind tunnel test facilities are normally used. Recently, as emission controls and fuel economy regulations have become increasingly stricter around the world every year for the preservation of the global environment, expectations for a reduction in the air resistance of vehicles have increased further, and the deployment of wind tunnels certified for related testing has advanced at a fast pace. In the background of this are the global unification of the test cycle and the test method of exhaust emissions and fuel consumption of passenger vehicles (commonly called WLTP^{*1}).

Under such circumstances, the latest wind tunnel test facilities are required to have stable air flow quality as specified by WLTP, be able to reproduce air flow under the floor and around the tires of a running vehicle, and attain quietness in order to allow the evaluation of wind noise.

We delivered the latest automotive wind tunnel with the world's top class aerodynamic and low-noise performance to Toyota Motor Corporation in March 2013. This paper presents an outline of the wind tunnel.

*1: WLTP stands for Worldwide harmonized Light vehicles Test Procedure, which was established by the United Nations as a uniform international test procedure for the appropriate evaluation of the fuel economy performance of vehicles.

1. Primary specifications

Figure 1 shows a panoramic view of the wind tunnel. **Table 1** lists the main components and specifications.



Figure 1 Panoramic view of aero-acoustic wind tunnel

Table 1 Primary specifications

Item		Description
Wind tunnel type		3/4 semi-open, Gottingen type
Maximum wind speed		250 km/h
Nozzle size		Width 7.0 m x Height 4.5 m (31.5 m ²)
Measuring section length		15 m
Operating temperature		20°C to 25°C (wind air-line air-conditioning facility)
Main fan	Diameter	9.0 m
	Blade	12 blades, CFRP
	Motor output	8.0 MW
Balance system	Type	Platform type
	Rolling Road maximum speed	250 km/h
	Belt	5 belts type (center belt/tire belt)
Auxiliary devices		Fabric material sound transmission collector (patented)
		Semi-anechoic plenum test section
		Fluid measurement traversing system (Maximum usage wind speed: 250 km/h)
		Noise measurement system (with traverse function)
		Wind air-line temperature control system
		Boundary layer control device (1st : scoop/2nd: suction)
		Central control/monitoring linked to measurement system network

2. Features

2.1 Aerodynamic and low-noise performance

The wind tunnel has high aerodynamic stationary performance and can evaluate non-stationary aerodynamic performance as well due to sufficient reduction of the pulsation specific to wind tunnels. The background noise at the test section during the generation of a wind speed of 150 km/h (during operation of the first boundary layer control device) is as low as 59.8 dB(A) or less. This is the top level actual running reproduction performance among automotive wind tunnels in the world. Therefore, the wind tunnel test facility can be applied at a high level to the development of various vehicle features such as reduced aerodynamic drag, enhanced ride comfort and improved silence.

2.2 Main fan

The main fan (**Figure 2**) that generates wind for the wind tunnel consists of a 9-m diameter, twelve-CFRP blades and a motor with an output power of 8.0 MW. Sound absorbing processing (**Figure 3**) is provided for the wind air-line on the downstream side of the main fan.



**Figure 2 Main fan
(upstream side)**



**Figure 3 Main fan
(downstream side, sound absorbing processing)**

2.3 Test section

For the test section, the six-component balance system with moving ground simulating function that enables the stable simulation of a running vehicle and accurate measurement, and a high-rigidity suspended fluid measurement traversing system and a noise measurement system with traversing function that are used for various measurements around the vehicle are installed.

2.4 Operability

The operation of the wind tunnel can be controlled from a single central control/monitoring PC, and the state of wind tunnel devices can also be monitored in a real-time manner. In addition, these controls form a user-friendly system that is linked to a network of various measurement systems (**Figure 4**), allowing collected data to be processed quickly after a test.

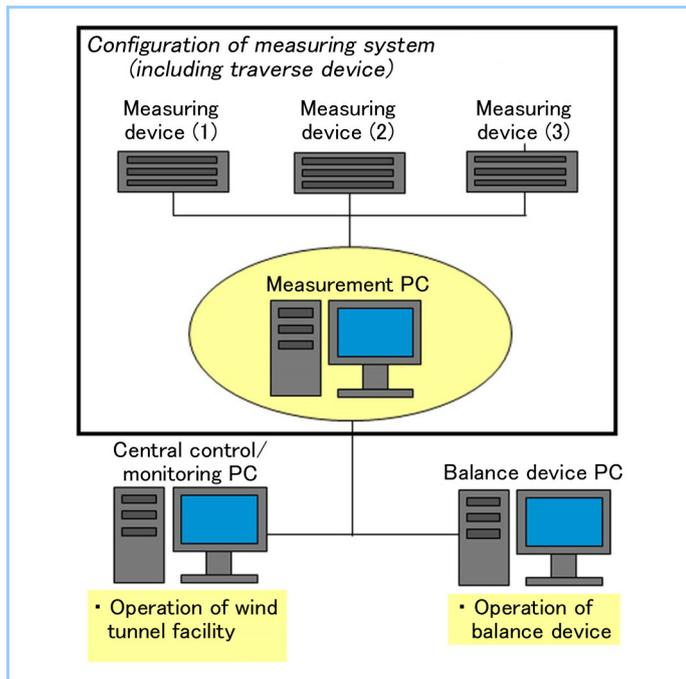


Figure 4 Wind tunnel operation and measurement system