

W i n d T u n n e l D i v i s i o n

BD2

Nozzle Thrust Measurement Bench

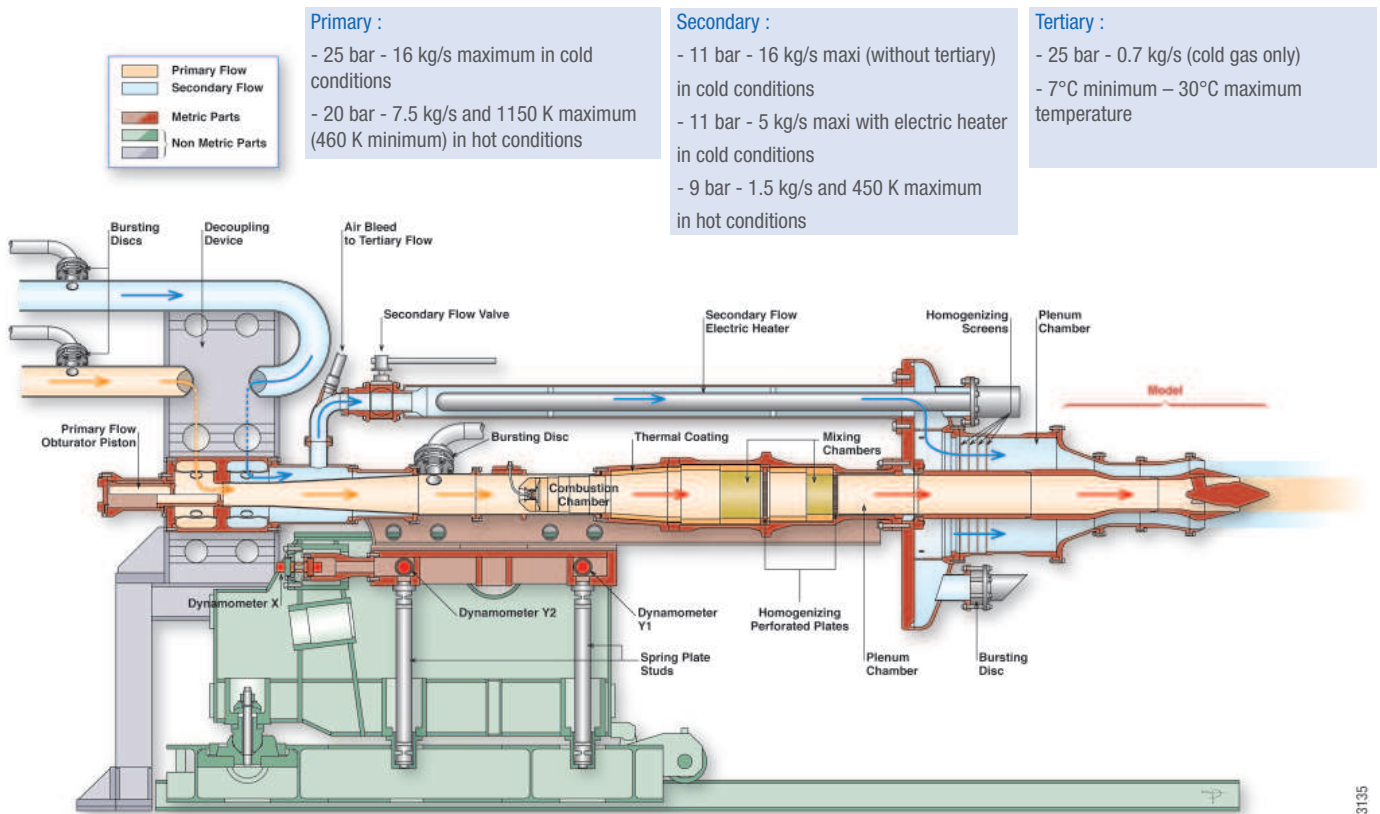
Modane-Avrieux Center

**High accuracy in thrust measurement
for civil and military nozzles
with hot and cold conditions simulated**

BD2 test bench

Thrust, Mass flow, Pressure measurements on different types of nozzles (with primary, secondary and even tertiary flow capabilities).

Air supply 25 bar, 18 kg/s to be shared between primary and secondary flow.



BD2 test bench main characteristics

- The bench frame consists of a fixed and a metric support linked by:
 - A thrust dynamometer parallel to the model longitudinal axis in the horizontal plane.
 - Two dynamometers for the lateral force measurement.
- A decoupling manifold feeds the compressed air from the fix to the metric part, to avoid parasitic pressure effects.

Performance

- Flow measurements : hot or cold mass-flow rates controlled by sonic throat mass-flow meters, upstream the bench itself. Mass flow accuracy: $\leq \pm 0.1\%$
- Dynamometer thrust capacity: 9000 N. Two calibration range: 3600 or 9000 N. Thrust accuracy: $\leq \pm 0.15\%$ calibration range.
- Lateral component of the thrust capacity: 1200 N. Accuracy of lateral thrust: $\leq \pm 4\%$ calibration range.
- Bench accuracy checked using a reference nozzle with primary and secondary flows.
- Maximum mass flow is 18 kg/s shared between primary and secondary flows, with 16 kg/s maximum per flow.
- A heater ensures stable temperatures close to atmospheric.
- Constant mass-flow delivery using high pressure storage monitored between 2 & 64 bar, with an accuracy of ± 0.01 bar.
- Up to 10 blow-downs per day possible.
- Primary, secondary and tertiary expansion ratios are controlled independently.
- A combustion chamber fed with kerosene controls the model primary flow conditions (temperature & gas composition).
- An electric heater controls the secondary flow temperature.

Measurement techniques

- Exhaust jet probing: pressure & temperature maps at different distances downstream of the nozzle exit.
- Exhaust jet visualization: done by carbon gas injection in the internal flow.
- Coloured oil flow visualizations.
- Flow angularity: measured by probing or by laser velocimetry.
- Temperature measurement by thermocouples.
- B.O.S. : Background Oriented Schlieren available.
- Infrared exhaust signature visualization.
- M.D.M. : Model Deformation Measurements.
- Estimation of acoustics measurements on request.
- Simultaneous measurements of thrust loads (axial and lateral), and of steady and unsteady pressures and temperatures.

Typical tests

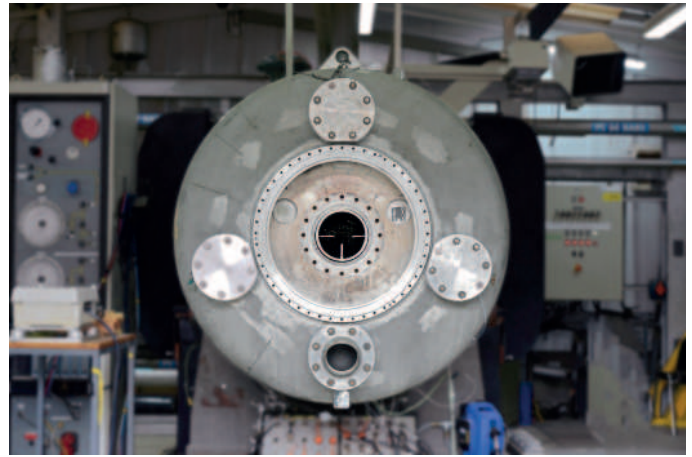
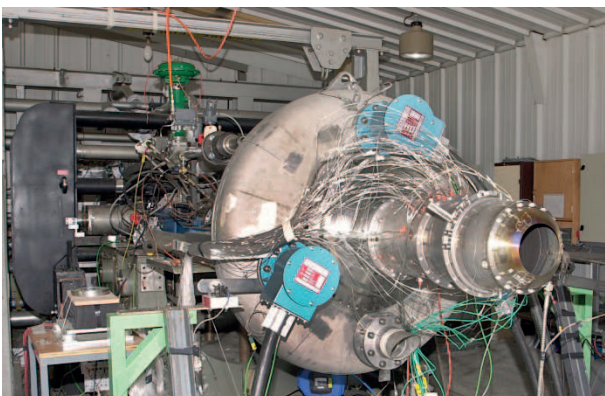
- Nozzle or engine after-bodies performance (mass-flow, and thrust)
- Flow mixers (pressure and temperature maps at different distances downstream of the nozzle exit)

Model supports interfaces

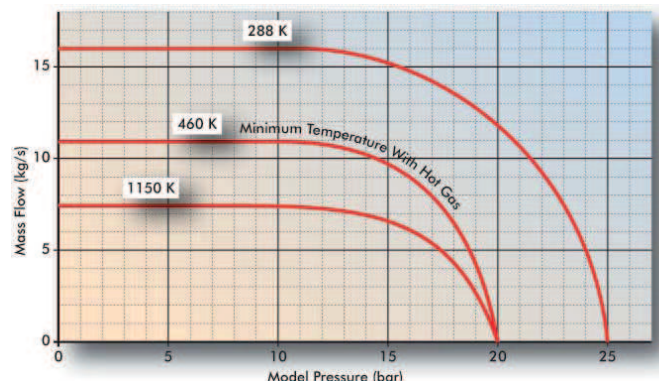
- The maximum internal diameter of the interface supplying the primary air steam is 170 mm.
- The maximum internal diameter of the interface supplying the secondary air stream is 500 mm.

Data acquisition and processing

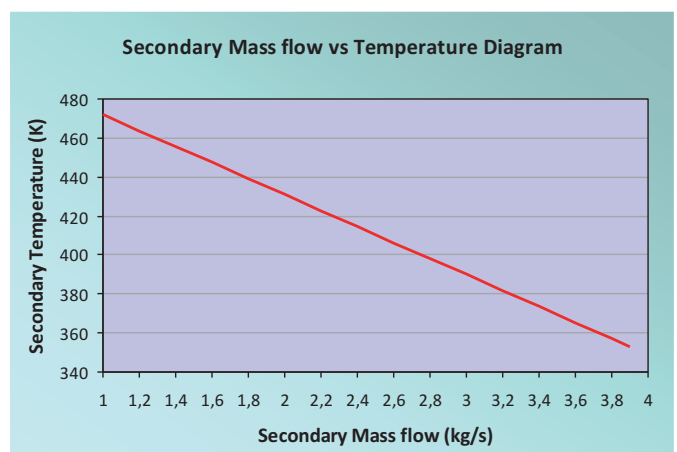
- Pressure data acquisition system done by pressure scanner (PSI®), the system offers up to 992 measurements.
- Static Data Acquisition System with digital filtering for 64 channels extendable to 128 -Static bandwidth: 0 to 10 Hz.
Accuracy : 10^{-4} of FS.
- Dynamic Data Acquisition System with digital filtering for up to 120 channels. Sampling up to 100 kHz.
Dynamic bandwidth: 10 Hz to 30 kHz.
Accuracy : 10^{-3} of FS.

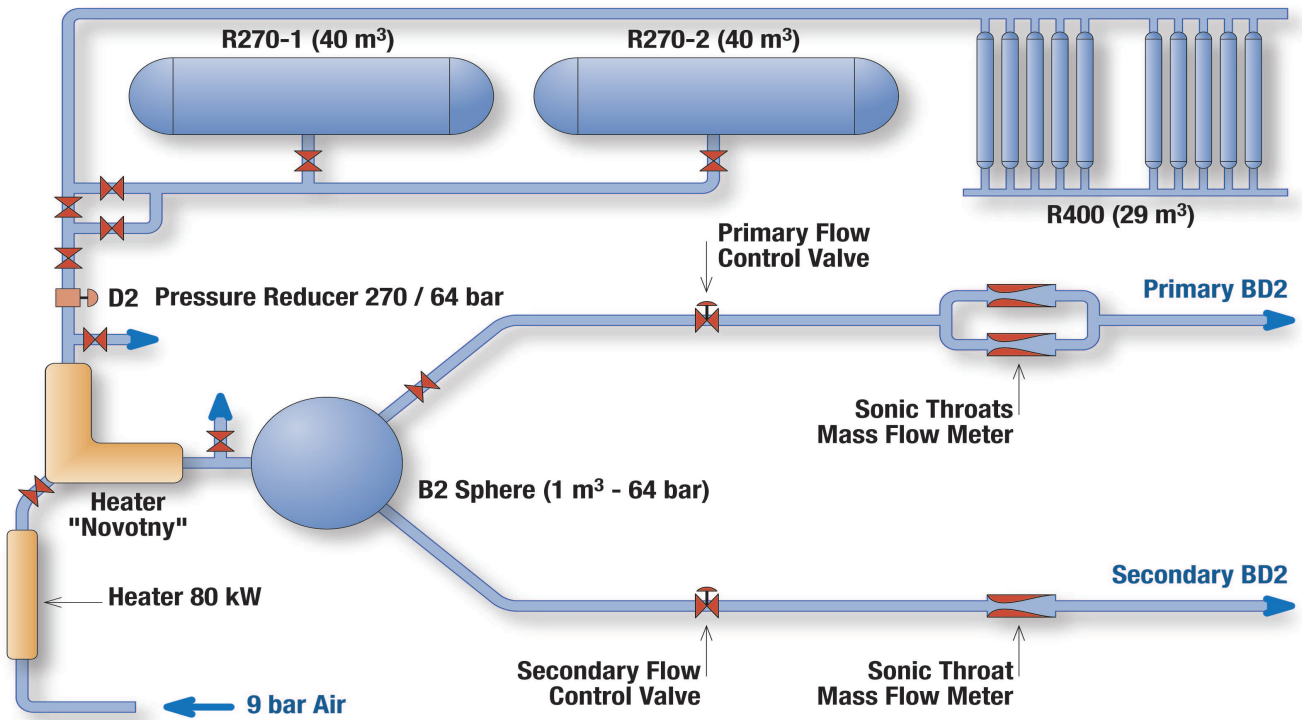


Flow characteristics



- Primary flow:
 - * 25 bar and 16 kg/s maximum in cold conditions (288 K).
 - * 20 bar, 7.5 kg/s and 1150 K maximum (460 K mini) in hot conditions.
- Secondary flow:
 - * 11 bar and 16 kg/s maximum in cold conditions (288 K).
 - * 11 bar and 5 kg/s maximum with electric heater in cold conditions.
 - * 9 bar and 1.5 kg/s maximum at 450 K in hot conditions.
- Tertiary flow:
 - The tertiary flow is drawn from the secondary flow.
 - 25 bar and 0.7 kg/s maximum (cold gas only).





Quality Management

- Quality Management system is certified to be ISO 9001 compliant.
- High level of customer service provided.
- The ONERA Wind Tunnel Division is committed to deliver the best service and value for money to its customers. Test matrices can be customised during the test itself to maximise value to the customer.
- Confidential areas for the test bench, measurements, data processing and customer rooms.

Quality in measurement techniques

- New capabilities are continually being developed.

Confidentiality

- Secure site with card access, data and computer firewalls.

Design office & workshop

- In-house model design and manufacture capabilities.

Productivity / Availability

- Test preparation and model assembly are performed directly on the bench. Productive testing. High stability in mass flow and pressure ratio control.



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