Engine Calibration Facility (ECF)

Facility for calibration of propulsion simulators and mass flow devices

German-Dutch Wind Tunnels

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Engine Calibration Facility (ECF)

Key Aspects at a Glance

- Supports the calibration of Turbofan Propulsion Simulators (TPS), Through-Flow Nacelles (TFN), Mass Flow metering Units (MFU) and bellmouths.

- Provisions for both compressed air (80 bar, 4.7 kg/s) and electrically driven (1000 VDC) engine simulators up to 0.6 m diameter.

- Controlled vacuum tank to simulate discrete ram pressure ratios across a propulsion unit, flow ducts or bellmouth, without external flow. Attainable ram pressure ratios ranging van 1.01 to 1.57, equivalent to Mach numbers from 0.1 to 0.83.

- High-accuracy mass flow rate measurements up to 9 kg/s via a set of sonic venturis at the back of the vacuum tank.

- 6-component external balance for high-accuracy measurement of the propulsion unit thrust vector, or flow duct internal drag, within ± 3000 N.

Why Model Engine Calibration?

For powered wind tunnel testing, it is essential to separate between the propulsion forces and the aerodynamic forces on the test model. The ECF allows the propulsion forces to calibrated in isolation, prior to testing the propulsion unit(s) on an actual test model in one of DNW's wind tunnels.

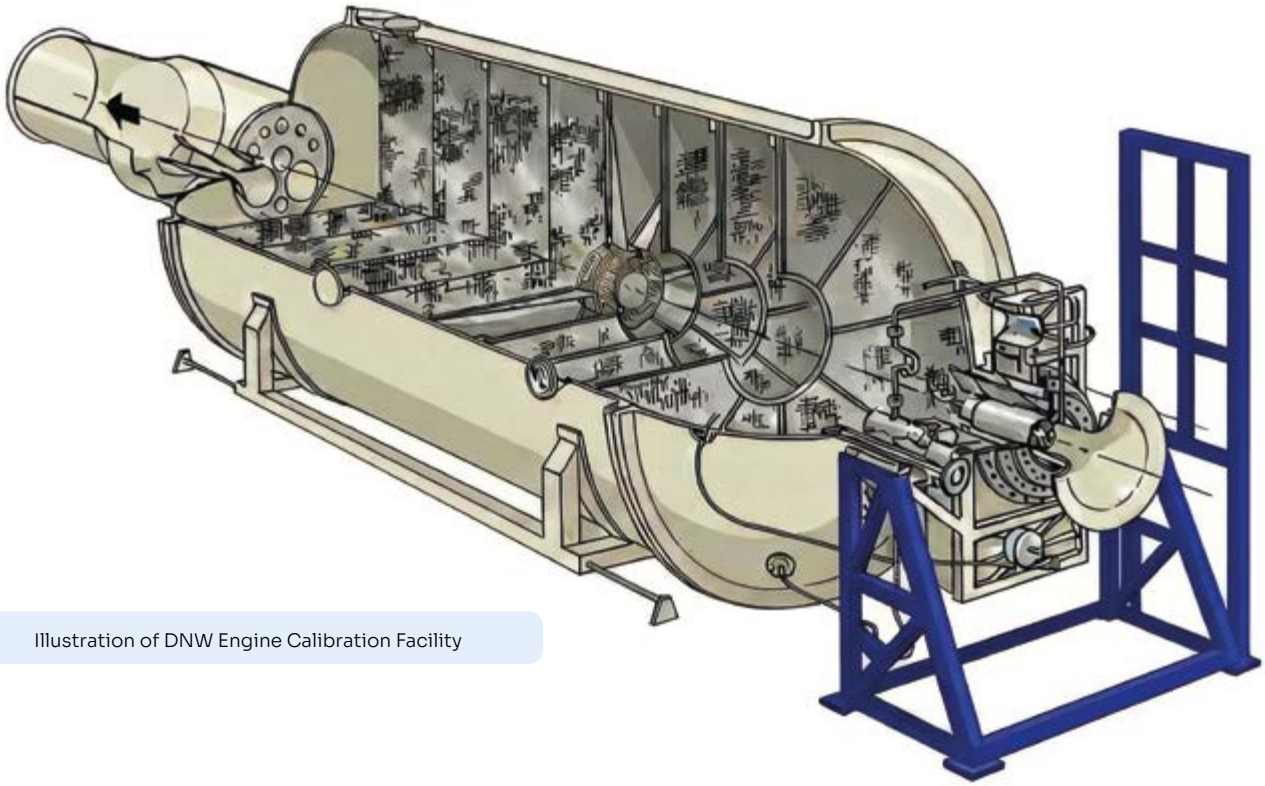


Illustration of DNW Engine Calibration Facility

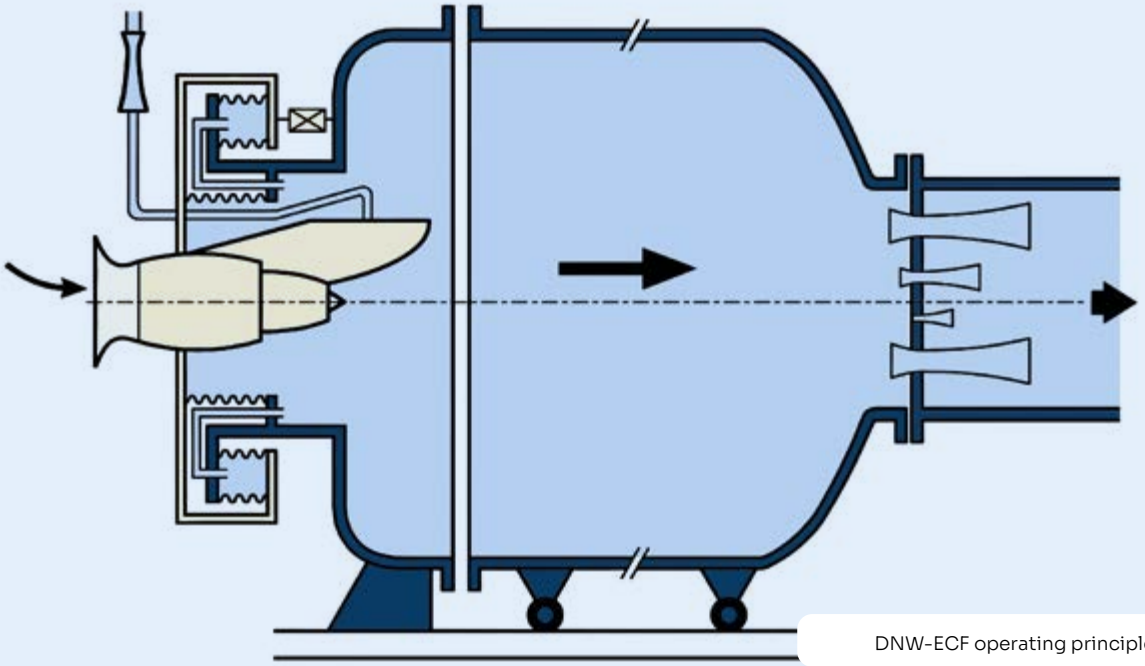
Model engine calibration provides:

- Isolated performance data for thrust and mass flow
- Calibration coefficients linking measured pressures and temperatures to actual propulsion performance
- Consistent thrust and drag bookkeeping across different wind-tunnel facilities and test campaigns

Without dedicated calibration, uncertainties in propulsion simulator behaviour directly propagate into installation effects, performance assessment and force accounting. The ECF addresses this by reproducing wind-tunnel operating conditions in a controlled, interference-free environment.

Facility Concept and Operating Principle

The ECF is based on a vacuum-tank concept. The test article (engine simulator, nacelle or flow unit) is mounted in a drum at the front of a closed tank.



DNW-ECF operating principle

The engine inlet is open to ambient (atmospheric) conditions and the nozzles exhaust into the tank. The wind tunnel ram pressure ratio is simulated in the facility whilst maintaining quiescent conditions in the vicinity of the nozzle.

Wind-tunnel conditions are simulated by controlling the tank pressure using high-capacity suction pumps connected to the tank exit. Lowering the tank pressure reproduces the correct ram pressure ratio (effective Mach number) across the model, without introducing external aerodynamic flow.

During a test run, the simulated Mach number is held constant while propulsion operating conditions are varied. Depending on the application, total mass flow is determined using sonic venturis, bellmouth instrumentation, or a combination of both.

Main Technical Characteristics

Tank and Flow Generation

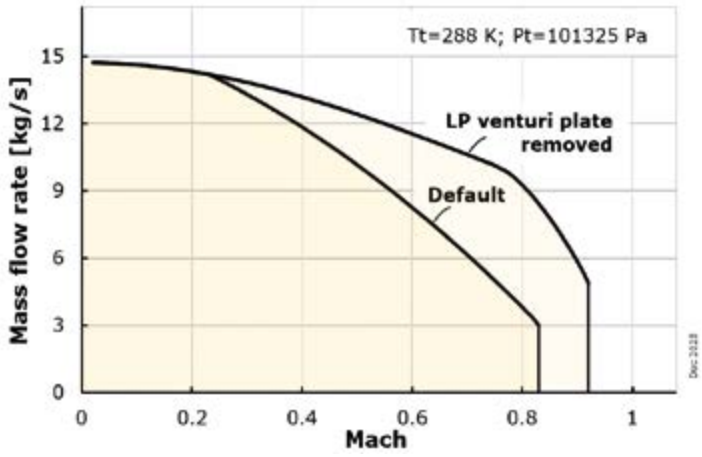
- Front entrance diameter: 0.60 m
- Suction system: 3 × 240 kW vacuum pumps
- Maximum suction capacity: 14.7 kg/s (Mach 0.0)
- Tank pressure range: 0.63–1.0 bar
- Simulated Mach number range: ≈ from 0.1 to 0.83.

Balance Capacity

- Maximum axial thrust: ± 3000 (±2.0) N
- Maximum lift force: ± 1200 (±4.0) N
- Maximum pitch moment: ± 500 (±1.5) Nm
- Maximum yaw moment: ± 1000 (±0.5) Nm
- Maximum roll moment: ± 650 (±10) Nm

Drive Air (when applicable)

- Compressed dry air supply up to 4.7 kg/s at 80 bar
- Temperature range: 293–343 K
- Fine mass-flow control capability



DNW-ECF operating envelope

Measurement Systems

External Balance System

The ECF is equipped with a six-component external balance for accurate force and moment measurements.

- Six high-accuracy load cells connect the metric model support to the non-metric tank structure
- Flexible seals and compensating drums minimise parasitic loads due to pressure differences
- All six force and moment components are measured; application-specific components are used in data reduction

The balance system is periodically calibrated to maintain the required accuracy.

ECF vacuum-tank with model drum in front

Bellmouth mass-flow calibration

Mass Flow Measurement

Mass flow rates are determined using complementary, cross-validated systems:

- Nine sonic low-pressure venturis at the tank exit for accurate total mass-flow measurement under choked conditions
- High-pressure ISO-9300 venturis, calibrated at NEL, for drive-air mass-flow measurement
- Instrumented bellmouth inlets for intake mass-flow determination

Data Acquisition

Pressures, temperatures and balance loads are measured using common instrumentation and data acquisition systems, which allow the calibrated propulsion unit(s) or flow duct devices to be efficiently applied in DNW's other facilities.

High testing productivity is enabled by DNW's GAIUS wind tunnel automation and data-acquisition system, which is deployed consistently across HST, LST, LLF and SST. GAIUS supports scripted test execution, continuous sweeps and synchronised data acquisition, improving data quality while reducing overall test time.

Typical Applications

Turbofan Propulsion Simulator (TPS) Calibration

- Gross thrust and thrust-vector determination
- Fan and/or core mass-flow calibration
- Nozzle discharge and velocity coefficients as a function of nozzle pressure ratio
- Thrust angle and engine reference point determination

Results are directly applicable to thrust and drag bookkeeping in powered wind-tunnel tests.

Through-Flow Nacelle (TFN) Calibration

- Measurement of internal nacelle drag (negative thrust)
- Nacelle mass-flow determination
- Input for internal/external force bookkeeping in propulsion installation studies

Mass Flow Unit (MFU) Calibration

- Calibration of MFUs used in turbine-powered simulators and ducted systems
- Bellmouth-based inlet mass-flow measurement
- Facility configuration adapted to achieve required flow rates

Blown Nacelle Calibration

- Intake mass-flow determination
- Thrust and force measurement under simulated ram conditions
- Reference data for powered installation testing

TPS calibration

Role Within the DNW Portfolio

The ECF is a calibration capability within DNW's propulsion-testing ecosystem. By providing high-accuracy, traceable reference data for propulsion simulators and flow systems, it ensures consistency between calibration results and powered wind-tunnel testing across DNW facilities.

This role enables reliable assessment of propulsion–airframe integration effects and supports coherent experimental programmes from calibration through to large-scale wind-tunnel validation.

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