

## Test cell 3, Main specifications

AVL PUMA test system equipped with following measurement and control modules.

The test cell is capable of high altitude simulation and non standard conditions for combustion air.

**Speed and torque control.**

Load unit	Measurement range	Accuracy
AVL Asynchronous dynamometer	0 – 660 kW (826 kW short term) from 1 500 – 3 500 RPM 0 – 4 400 Nm (5 500 Nm short term) from 0 – 1 500 RPM	± 0.1 % of full scale for the total system

**112 input channels for temperature, voltage, resistance and current measurements.**

Sensor / signal	Measurement range	Accuracy	Measurement rate Values / second
Pt100, Pt 1000	-50 to 650 °C	-50 to 200 °C ± 0,1 °C 200 to 650 °C ± 0,2 °C	1, 5, 10
Thermocouple Type K Other types:J,R,S,T,B,E	-200 to 1 370 °C	± 0,5°C	1, 5, 10
Voltage	± 11 V	1 mV	1, 5, 10, 100
Current	± 20 mA	10 µA	1, 5, 10, 100
Resistance	20 to 200 Ω	± 0,2 Ω	1, 5, 10
	200 to 2 000 Ω	± 2 Ω	1, 5, 10

Strain gage	Max. bridge Detuning	Accuracy	Supply voltage	Measurement rate Values / second
120 Ω	± 35 mV/V	± 5 µV/V	0.58 V	1, 5, 10
35 Ω	± 15 mV/V	± 2,5 µV/V	1.34 V	1, 5, 10
3,5 Ω	± 8 mV/V	± 1.25 µV/V	2.63 V	1, 5, 10

**30 input channels for pressure measurement.**

Sensor / signal	Number of sensors	Measurement range	Accuracy	Measurement rate Values / second
Pressure	3	-300 to 300 mbar	For ambient Temp.  -20 to 80 °C ± 0.1 % FSO	0.1, 0.2, 0.5, 1, 2, 5, 10
	8	-1 to 2.5 bar		
	4	-1 to 3 bar		
	4	0 to 6 bar		
	10	0 to 10 bar		
Barometric press.	1	800 to 1 200 mbar	± 0.5 mbar	

#### 4 input channels for speed and frequency measurement.

Sensor / signal	Measurement range	Accuracy	Measurement rate Values / second
Frequency	1 Hz to 300 kHz	25 ppm	1, 10, 100
	10 Hz to 300 kHz		
	100 Hz to 300 kHz		
Period	< 10 s	25 ppm	0.1, 1, 10, 100
	< 1 s		
	< 0.5 s		
	< 0.01 s		
Speed (e.g.: 100 pole pulse wheel standstill recognition 0.1 RPM recognition of direction of rotation)	1 to 15 000 RPM	< 0.1 RPM	1, 10, 100
Event	2 <sup>32</sup> Events Input freq. < 300 kHz	1	Measurement time 1 to 10 000 s

#### 16 digital inputs and 16 digital outputs for processing digital control signals.

Input voltage	5 – 24 VDC
Relays	5 A, 50V

#### 8 analog outputs for demand value setting from the automation system.

Specification	Output signal type	
	Voltage	Current
Signal range	-11 to 11 V	± 25 mA
Resolution (16 bit)	336 µV	763 nA
Max. error at 25 °C	± 2 mV	± 10 µA
Max. error from 0 to 45 °C	± 4 mV	± 12 µA
Setting time	3.5 ms on 0.1 %	
Load	≥ 1 100 Ω	≤ 500 Ω

#### Dynamic fuel meter (AVL 735 with fuel cooling system 753C)

Measuring principle	Measurement range	Accuracy
Coriolis principle	0-125 kg/h	± 0,1 %

#### Air mass flow meter

Measuring principle	Measurement range	Accuracy
Hot film anemometer	0 – 2 400 kg/h	± 1 %
	0 – 4 000 kg/h	± 1 %
	0 – 5 500 kg/h	± 4 %

### Environmental sensor, Vaisala HMI 33.

	Measurement range	Accuracy
Relative humidity	$\phi$ %-rh 0 – 100 %	$\pm 1$ % rh
Temperature	$^{\circ}\text{C}$ -40 -- 160	$\pm 0,5$ $^{\circ}\text{C}$

### Diesel exhaust smoke measurement, AVL Opacimeter 439.

Measuring principle	Measurement range	Accuracy
Light absorption	Light absorption 0 – 10 / m	$\pm 0.0025$ / m
	Opacity range 0 – 100 %	$\pm 0,1$ %

### Transient soot measurement, AVL Micro soot sensor MSS 483

Measuring principle	Measurement range	Accuracy
Photo-acoustic principle	$1\mu\text{g}/\text{m}^3$ – 1 000 $\text{mg}/\text{m}^3$	$1\mu\text{g}/\text{m}^3$ detection limit
		0,01 $1\mu\text{g}/\text{m}^3$ resolution

### ***Emission measurement equipment:***

AVL Heavy duty CVS system (CECU-T140-D) with triple venturi system to cover a flow range from 20 – 140  $\text{m}^3/\text{min}$ .

The CVS system includes:

- Heat exchanger for temperature stability better than  $\pm 5^{\circ}\text{C}$ .
- Bag sampler unit with teldar sampling bags.
- 70mm HD particulate filter holders with filter switch.

### **PM-stabilization and weighing equipment for gravimetric analysis**

	Controlled setpoint	Accuracy
Relative humidity	$\phi$ %-rh 45 %	$\pm 1$ % rh
Temperature	$22^{\circ}\text{C}$	$\pm 0,5$ $^{\circ}\text{C}$

### **Electronic microgram scale, Mettler Toledo XP 2U**

	Measurement range	Accuracy / Repeatability
Mass	0 – 2,1 g	0,00025 mg

**AVL emission bench 1 for exhaust gas measurements.**

Exhaust component	Measurement range	Accuracy
CO	0 – 100 ppm	Repeatability 1 % FS
	0 – 1 000 ppm	Linearity 1 % FS
THC	0 – 450 ppm	Repeatability 1 % FS Linearity 1 % FS
NO / NOx	0 – 400 ppm	Repeatability < 0.5% FS
	0 – 1 000 ppm	Linearity < 1 % FS
	0 – 1 500 ppm	
CO2	0 – 1 %	Repeatability 2 % FS
	0 – 10 %	Linearity 1 % FS
	0 – 14 %	
CO2 EGR (for EGR meas.)	0 – 10 %	Repeatability 1 % FS Linearity 1 % FS
O2	0 – 25 %	Repeatability < 1 % FS Linearity < 1 % FS

**AVL emission bench 2 for exhaust gas measurements.**

Exhaust component	Measurement range	Accuracy
CO	0 – 100 ppm	Repeatability 1 % FS
	0 – 1 000 ppm	Linearity 1 % FS
THC	0 – 450 ppm	Repeatability 1 % FS Linearity 1 % FS
NO / NOx	0 – 400 ppm	Repeatability < 0.5% FS
	0 – 1 000 ppm	Linearity < 1 % FS
	0 – 1 500 ppm	
CO2	0 – 1 %	Repeatability 2 % FS
	0 – 10 %	Linearity 1 % FS
	0 – 14 %	

**Additional equipment available for any test cell**

Equipment	Type
NH3 measurement	NEO laser for NH3 measurements
Particulate measurement	Control Sistem Pss-20 Mini dilute tunnel
NOx analyser	Additional stand alone NOx analyser
Particulate weighing camber	Temperature and humidity controlled
Micro soot sensor	AVL 483
Urea injection and control system	Air assisted atomization. PWM and frequency controlled dosing
Particle Counter	AVL APC Plus
HC injection and control system	Air assisted atomization. PWM and frequency controlled dosing
Exhaust cooler	Tubular heat exchanger