Evaporative Emissions

EVAP – Herausforderungen und Lösungen für SHED-Prüfstände (Euro 7, BEV, VOC, VIAQ, …)

AVL Emission TechDay 2023, Leimen

Patrick Ulmerich

Today's Presenter

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Application & Business Development Manager
Deputy GBSM EV

Since 1994 working in Emission business
Engagement of EVAP Applications started in 1999
Member of IWG EVAP TF in Brussel

CONTENT - EVAP “The Way to Euro 7”

1 **EVAP Emission – Euro 7 Challenges**

General requirements, Fuels variety, Legislation, etc.

2 **Euro 7 – New Test Procedures**

Refueling Test Workflow & Hot Soak 38

3 **Summary & Outlook**

How does AVL support the industry?

“The Way to Euro 7” - TIMELINE…

EUROPEAN COMMISSION

Brussels, 10.11.2022
COM(2022) 586 final

2022/0365 (COD)

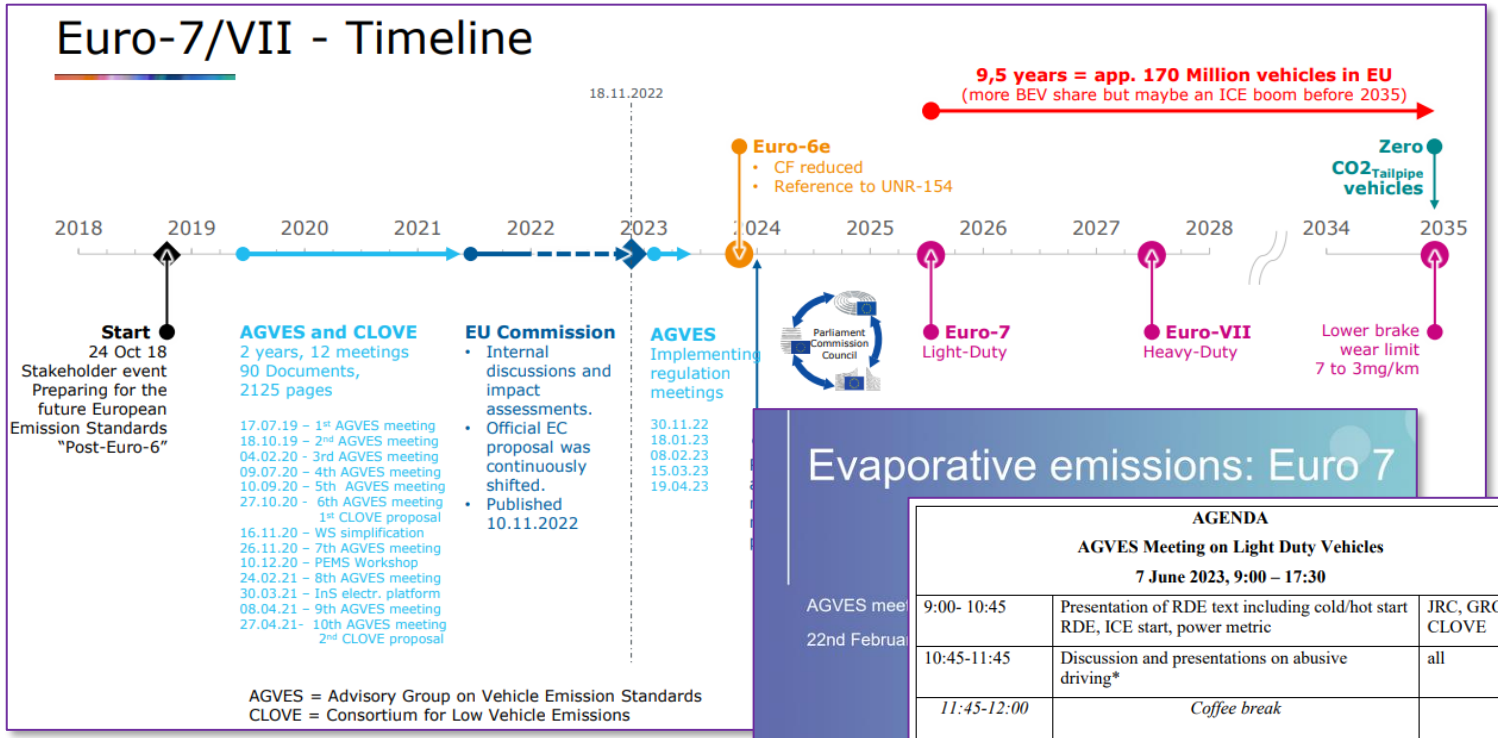
Proposal for a

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7) and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009

(Text with EEA relevance)

{SEC(2022) 397 final} - {SWD(2022) 358 final} - {SWD(2022) 359 final} - {SWD(2022) 360 final}



Picture: Webinar “Insights and 1st Interpretations”

AGENDA

AGVES Meeting on Light Duty Vehicles

7 June 2023, 9:00 – 17:30

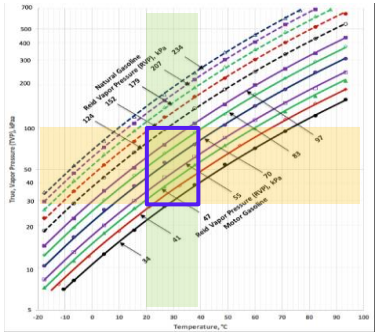
9:00- 10:45	Presentation of RDE text including cold/hot start RDE, ICE start, power metric	JRC, GROW, CLOVE
10:45-11:45	Discussion and presentations on abusive driving*	all
11:45-12:00	*Coffee break*	
11:00-12:30	Presentations by stakeholders*	all
12:30-14:00	*Lunch Break*	
14:00-15:00	Presentation of RDE in the lab and measurement equipment	JRC
15:00-15:30	Discussion	
15:30-15:45	*Coffee break*	
15:45-17:00	Presentation of changes to the EVAP text	JRC
17:00-17:00	Planning future work, AOB	

- This proposal needs to be accepted by the EU-Parliament. An agreement can be typically expected in 15-18 month (average Parliament process duration)
- Phase-In for LD will start mid of 2025, mid of 2027 for HD

EVAP - NEWS & CHALLENGES

$$Emissions \sim f(Fuel_{RVP},\ Temperature,\ Pressure)$$

- Summer Fuel Gasoline mix. RVP* (45…60 kpa)
- Winter Fuel Gasoline mix. RVP* (60…90 kpa)
- RVP * Determination prior test run
- Further R&D topics will be based on fuel mixtures with biofuels and eFuels



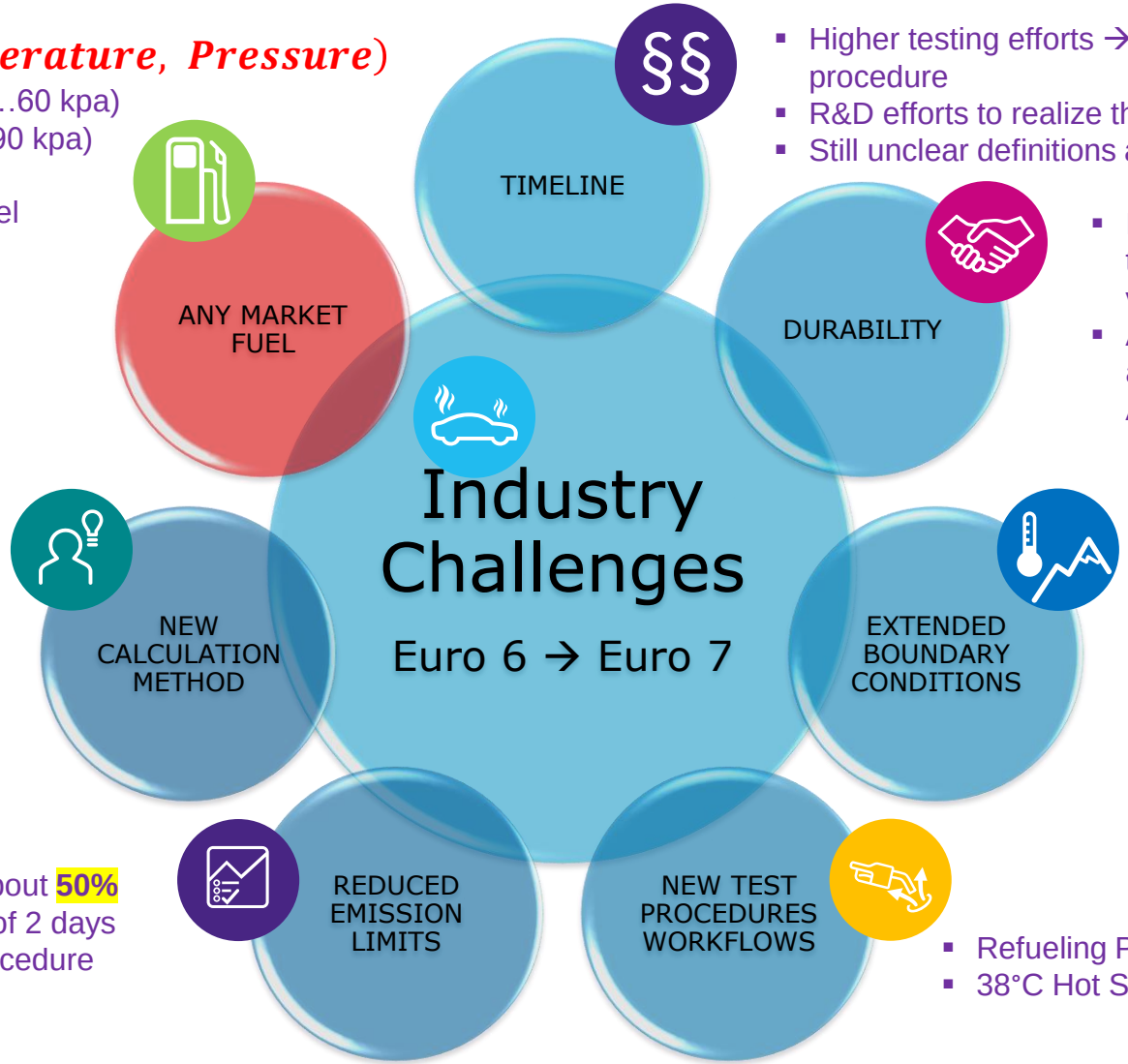
Euro 7

$M_{HS} + M_{D\_worst} + PF < 0.5g\ (0.7g)$

~~$M_{HS} + M_{D\_worst} < 0.5g\ (0.7g)$~~

Euro 6

$M_{HS} + M_{D1} + M_{D2} + PF + PF < 2g$



- Higher testing efforts → new testing workflows incl. a new test procedure
- R&D efforts to realize the new targets
- Still unclear definitions and requirements

- Impact of the fuel system (tank, pumps, tubing, canisters, etc.) of the European vehicle models
- Available technologies can be used to achieve the targets (see US Standards) – Alignment strategies

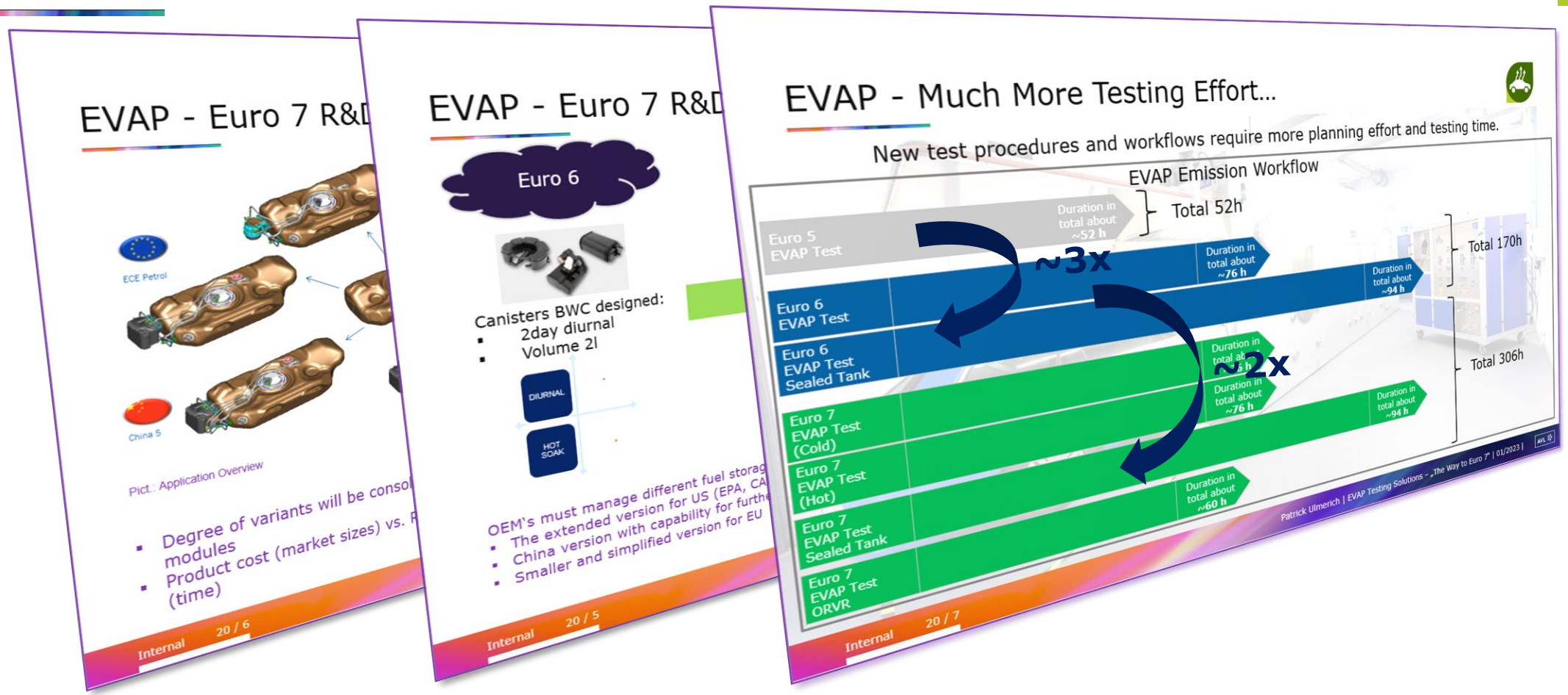
- Vehicle pre-conditioning drive cycle at high temperature of 38°C
- Results in a high temperature Hot Soak at 38°C aligned with a high temperature diurnal test procedure

- Reduction of the emission limit about **50%**
- Emission Result based on worst of 2 days
- New Limits for Refueling Test Procedure
- **$M_{ORVR} < 0.05$ g/L**

- Refueling Procedure
- 38°C Hot Soak & Diurnal Procedure

*RVP = Reid Vapor Pressure

EVAP – INDUSTRY TASKS



- Euro 6 → Euro 7 requires much more R&D and testing effort for the industry (OEM's, TIER1 and Testing Services)
- New requirements for conformity of production (CoP), in-service conformity (ISC) and market surveillance

EVAP Summary – Checklist

High Temp 38°C
Chassis Dyno TC

CD Automation
Prep-Cycle EVAP

ORVR SHED

ORVR SHED
Accessories

SHEDCon
Automation System

AVL FUELLOAD with
Stage II Simulation

CANLOAD Canister
Conditioning System

FID

FO)

/

CONTENT - APPLICATION VIEWS

1 **EVAP Emission – Euro 7 Challenges**

General requirements, Fuels variety, Legislation, etc.

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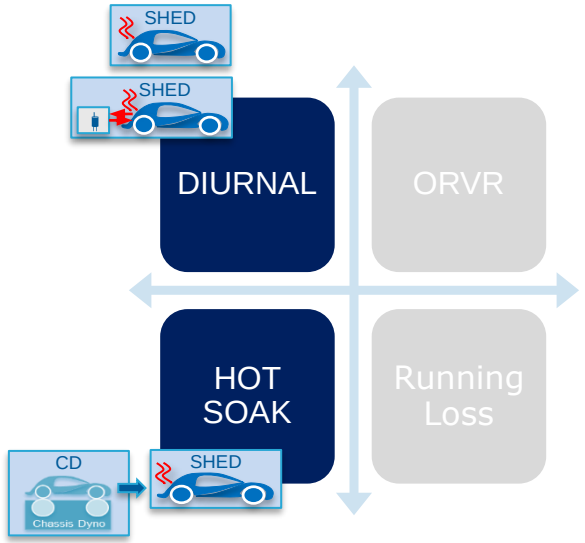
3 **Summary & Outlook**

How does AVL support the industry?

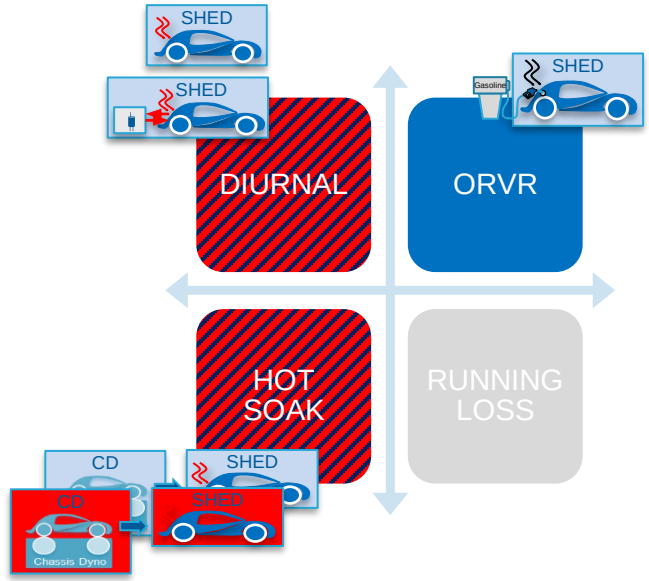
EVAP - NEW TEST PROCEDURES / WORKFLOWS



Euro 6: EVAP Testing Segments

EVAP Testing Segments

Euro 6 → 7



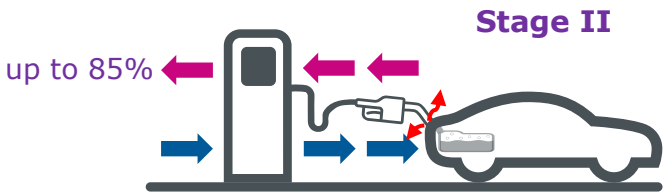
Euro 7 Proposal: EVAP Testing Segments

ORVR
- Refueling Emission Test Workflow → Exhaust emission test required (canister purge control evaluation)
- Refueling Event control → New Refueling SHED test procedure incl. SOAK 27 period

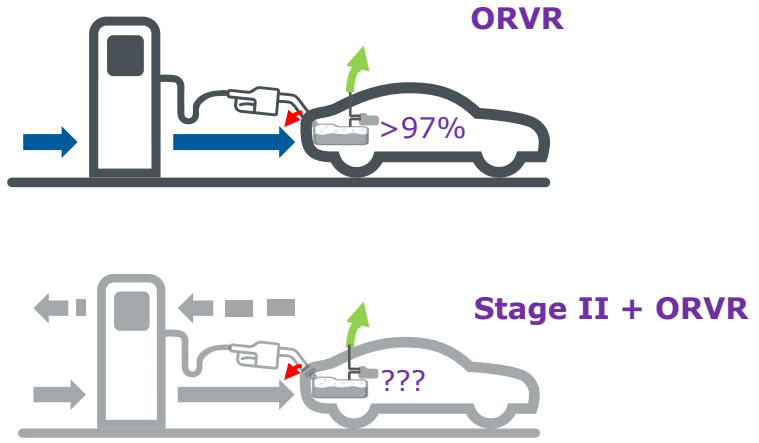
HOT SOAK
- Additional Hot Pre-Con Drive Cycle at 38°C → climate CD test cell, Host automation test template (like CHINA
- Additional Hot Soak 38 → high temperature Hot Soak at 38°C (like CHINA 6), HS 25 is still required

DIURNAL
- Diurnal Test → 2DD with increased temperature profile 38°C, incl. Puff-Loss Test

EVAP - NEW REFUELING TEST PROCEDURE



Euro 6 → 7



Stage II vapor recovery

- The fuel nozzle has a second line which draws the air/fuel vapor coming out of the tank back into the underground fuel storage tank of the service station. i.e., the air volume of the tank and fuel is exchanged between the tank of station and the vehicle tank. That is called Stage-II.
- It is assumed (in case the fuel station is well maintained, and the gas return system is working) that this will recover **up to 85%** of the fuel vapor.
- This option is used in Europe and several other countries.

ORVR: On-board Refueling Vapor Recovery

- An On-board Vapor Recovery System (ORVR) forces the air/vapor mixture to exit the tank system through the installed carbon canister. The carbon canister will remove VOC's and releases only the clean air to atmosphere.
- This option is considered to work better **(>97%)** and with less costs than the Stage-II concept.
- It is used in the US, China and Brazil but it also requires a specific ORVP EVAP vehicle test.

- There is **no** specific vehicle SHED test required

- A **new** Refueling vehicle SHED test is required.

EVAP REFUELING - FUELLOAD

AVL FUELLOAD with
Stage II Simulation

New
System
Upgrade

	AVL
	FUELLOAD 200
	LAN/TCPIP; Analog-Interface (Option)
	180 l
min)	5 - 40 l/min
re Range (°C)	10 – 50 °C
ure precision	+- 0.5 °C
Flow ision	+- 0.5 l/min
Precision fuel volume	+- 0.1 l
Heating capacity	Min. 1 K/min
Cooling capacity	Min. 1.2 K/min
Dimensions HWD [mm]	1980 x 1600 x 1100
Weight [kg]	ca. 800 kg
Power Supply	400/230 VAC, 32A, 50 Hz; 3 Ph (N) PE
Certification	ATEX, TÜV, CE
Minimum fuel amount in tank	30 litres
Pressurized Air supply	Max. 15 l/min (at 5 bar)
Operating conditions	Temperature trange: 5°C - 35°C Humidity range: 30% rF - 85% rF dustfree adequate ventilation

The AVL FUELLOAD is designed to support actual US Standards, fulfilling the Chinese and Brazilian regulations as well as Euro 7 proposals concerning refueling simulation and testing.

The adjustable gas return pump control **simulates the Stage II refueling process**
(flow control 0…2x of dispensing flow rate).
Supports (calibration) the higher accuracy requirements for temperature and flow control (±0.5°C, (±0.5l/min)

EVAP REFUELING – FUELLOAD News…

ORVR SHED

New

ATEX Tablet with WIFI
Remote control

New

Standardized
AK-Interface

New

Local datalogger for
stand-alone operation

New

Remote Controlled
Facility Interface

New

E85 Ready
E100 / M100
On demand

New

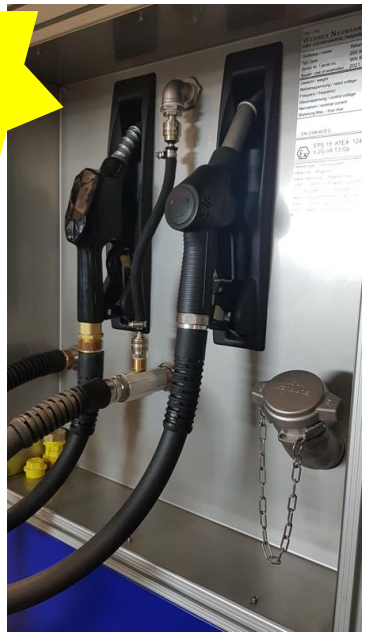
High precision
counter module
(calibration)

New

Integrated active
carbon filters for low
emission areas

Adjustable active gas
return (EU Stage II)

New
Retrofit
Solution



REFUELING HW-MODULES…

ORVR SHED Accessories

ORVR SHED Interface
(Window + Refueling access door)

Adjustable active gas return PID controller module
(Stage II Simulation)

ORVR Bag module

Fuel nozzle quick connect adapters
(Dry Link®)

ORVR mixing fan

WIFI Remote ATEX Tablet control

2nd fuel path for either w/o active gas return function

Fuel facility interface module

ORVR Bag / Nozzle adapter kit (EU Nozzle incl. Adapter)

FUELLOAD Integration/Interface panel

SHEDCon “Euro 7” SW-Patch

SHEDCon
Automation System

SHEDCon: Pre-Test Dialog

“Developer Package”

250+ pre-installed test templates

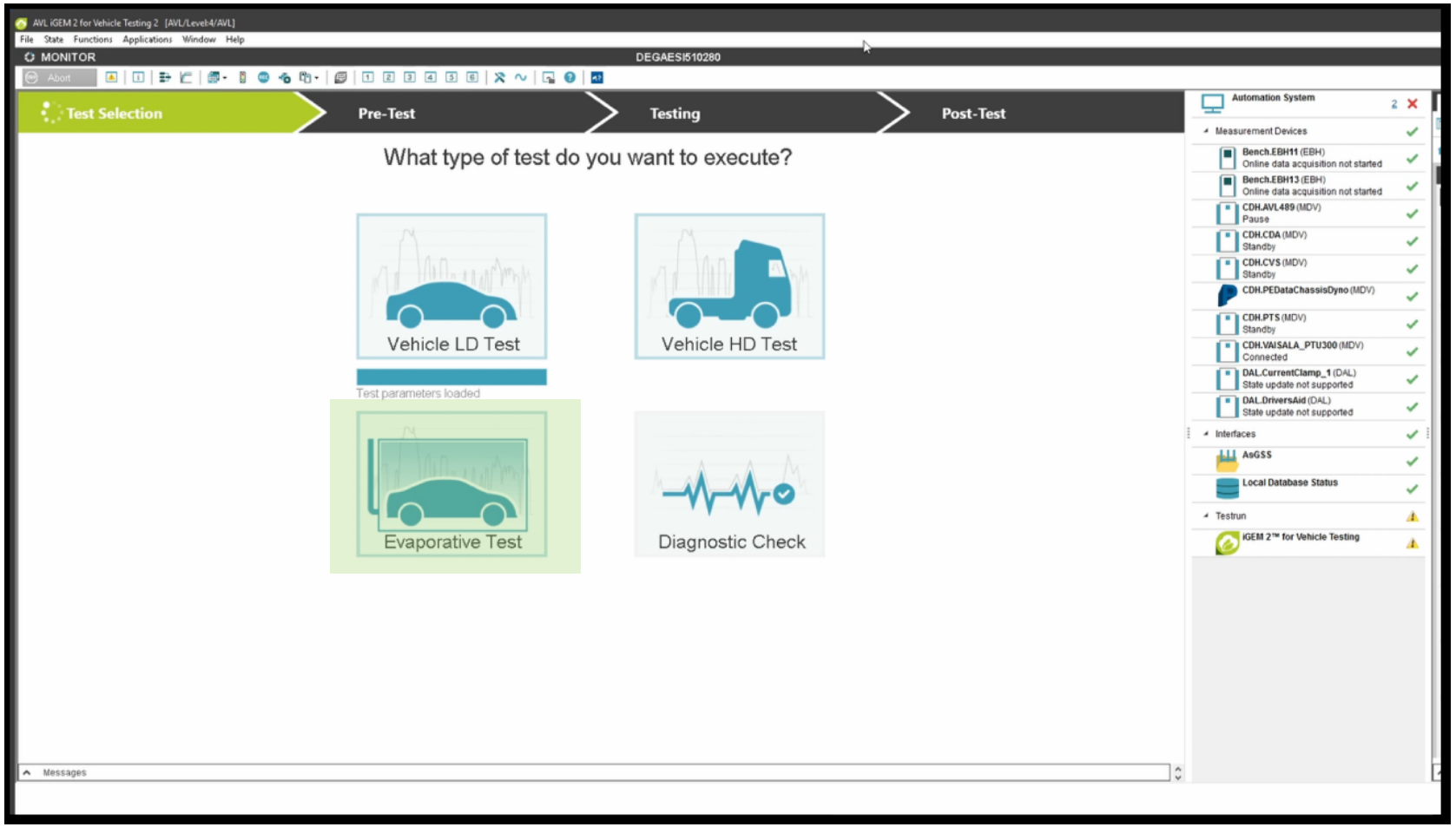
- CARB
- CARB-MC
- CARBRL
- China6
- CN-MC
- CN-VIAQ
- EPA
- EPA-MC
- EPARL
- EUIII
- EUIV
- EUIV-MC
- Euro7-Proposal-(2022-11-10)
  - Background
  - DBLT
  - Diurnal35
  - Diurnal38
  - HotSoak
  - Hotsoak38
  - ORVR
  - Puff-Loss35
  - Puff-Loss38
  - RetentionCFO
  - RetentionGRAV
- EUV
- EUVI
- EUV-MC
- JP
- KR-LEVIII
- KR-VIAQ
- PROCONVE-L6
- PROCONVE-L7

SHEDCon: Database structure

The Euro 7 patch does include test templates, formular db update and a *.xls-reporting workbook

iGEM 2 Vehicle “Euro 7 EVAP” SW-Patch

CD Automation
Prep-Cycle EVAP



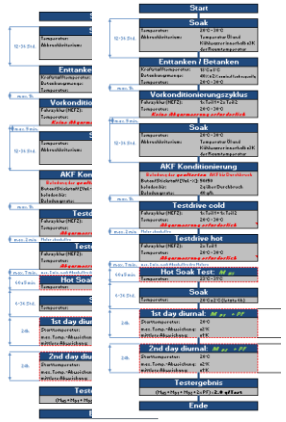
- New EVAP Test Cycles (workflow specific prep-cycles, exhaust emission measurement, high-temp cycle, etc.)
- FEM I/O for online canister purge profile measurement and fuel temperature readings

REFUELING Workflow…as proposed

VITA 2 Workflow Management Interface

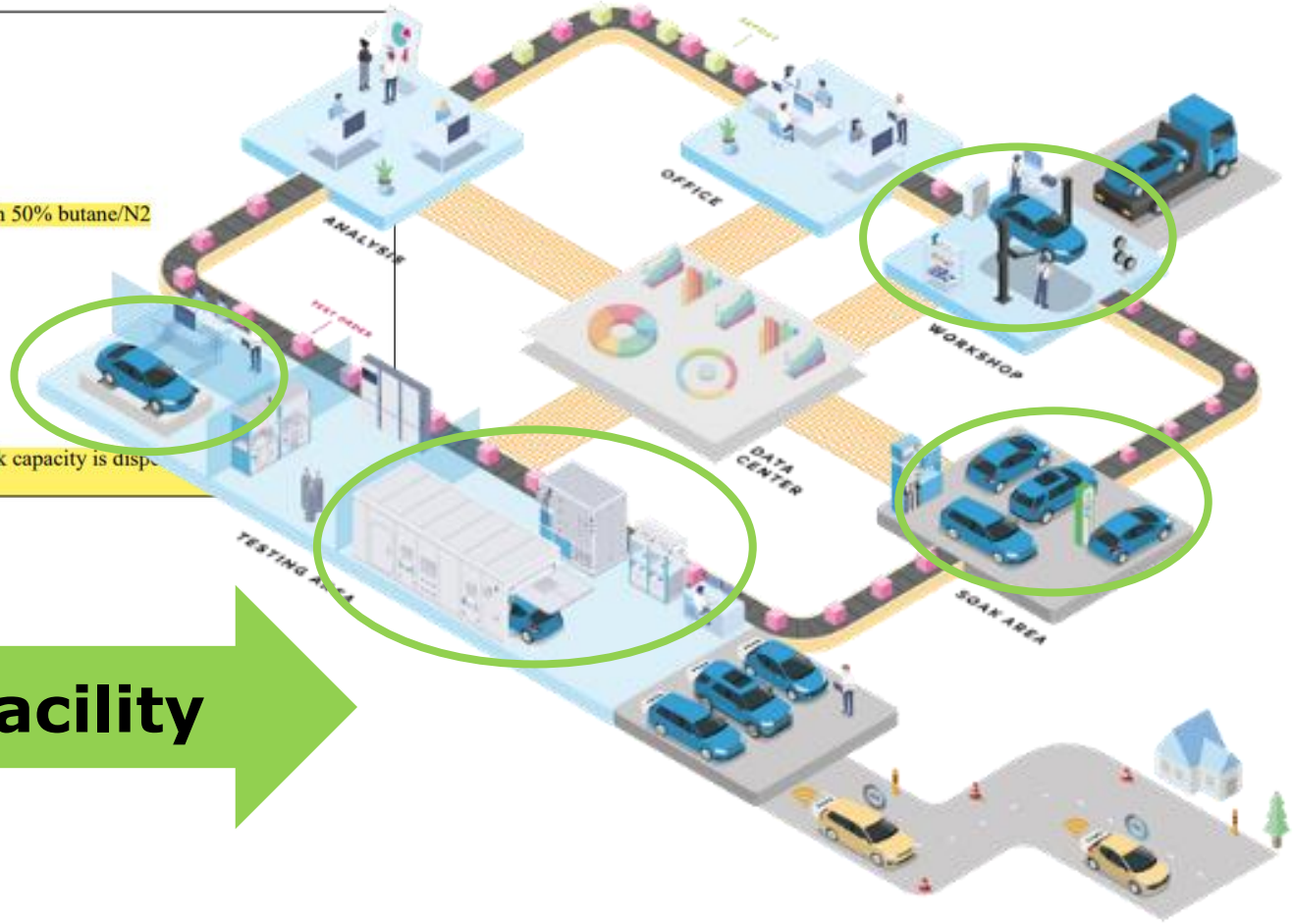
Refuelling emission test	
	Vehicle preconditioning • Fuel drain and fill to 40% • 6 h min soak at 20-30°C • preconditioning drive **Canister preconditioning** • Fuel drain and fill to 40% • 12-36 h soak • Load canister with hydrocarbon vapours until 2g breakthrough at 40 g/h 50% butane/N2 • Exhaust test: WLTP (recording emissions) • 0-1 h soak at 20-30°C • Canister purge drive at 20-30°C **Refuelling event** • Disconnect canister(s) • Fuel drain and fill to 10% • 6-24h soak at 27°C. • Reconnect canisters • Dispense fuel at 38 l/min until automatic shut-off. If < 85% of total tank capacity is disp refuelling until fuel dispensed is ≥ 85%. Authorities may use 15 l/min

Workflow



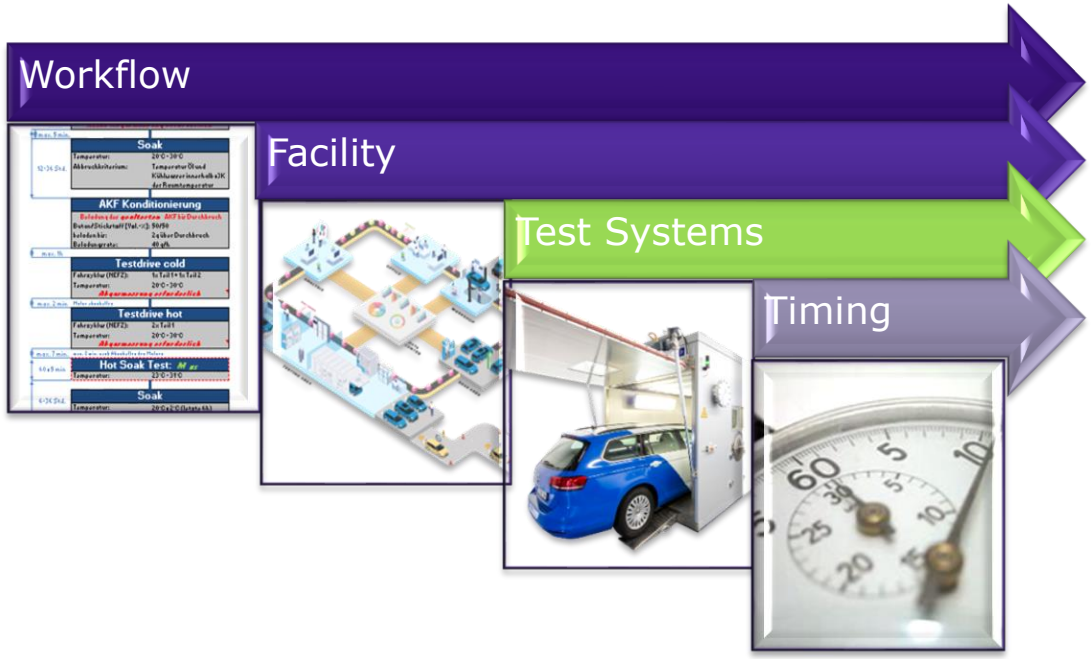
Linked to

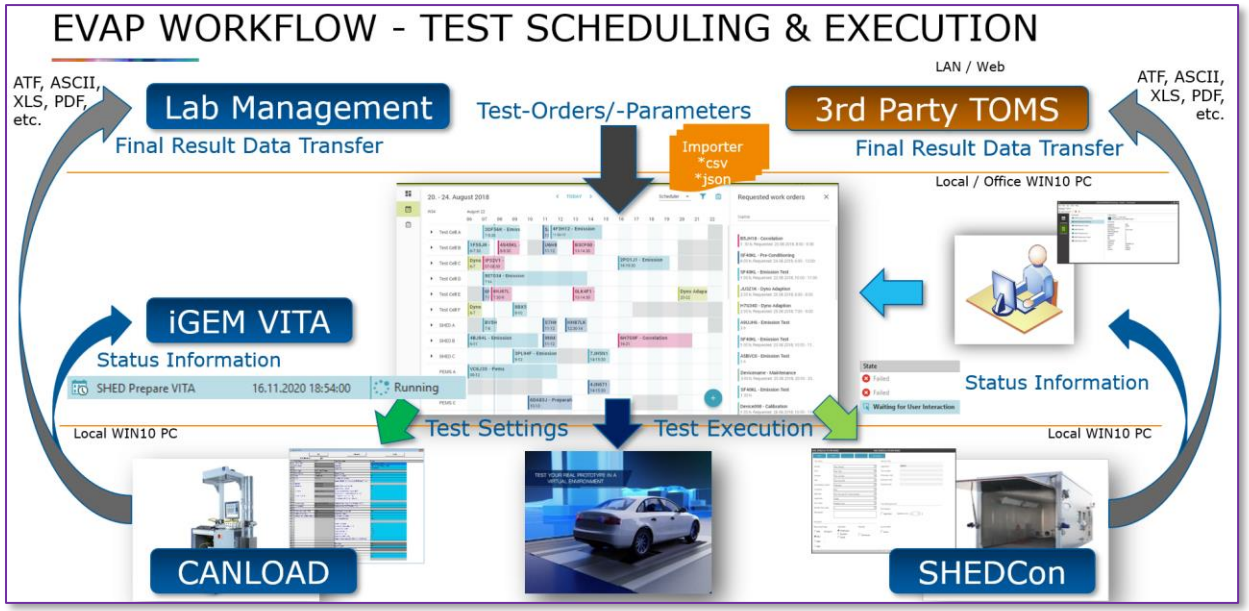
Facility



EVAP - NEW WORKFLOWS

VITA 2 Workflow Management Interface





More complex WORKFLOW scenarios and demands are requiring adequate tools and standardized interfaces

→ **AVL VITA 2** as local device planning and scheduling module (SHED Service Tests – unmanned operation)
→ **AVL VITA 2** as standard interface to centralized Lab Management system

SHED FID SL

New

Analytics SHED FID
iCal Calibration
Units (GDU + CFO)

SL Design

- SL characteristics (low flow, small size)
- Wall mounting capability
- SHED Application oriented design
- Embedded analyzer concept
  no “closed” modules in the cabinet: analyzer, MSR, PDU
- Wide range power supply concept
- 2 variants: with and w/o Panel PC

- Easy access to all components – service friendly
- Ready for shipment from analyzer production/CO area

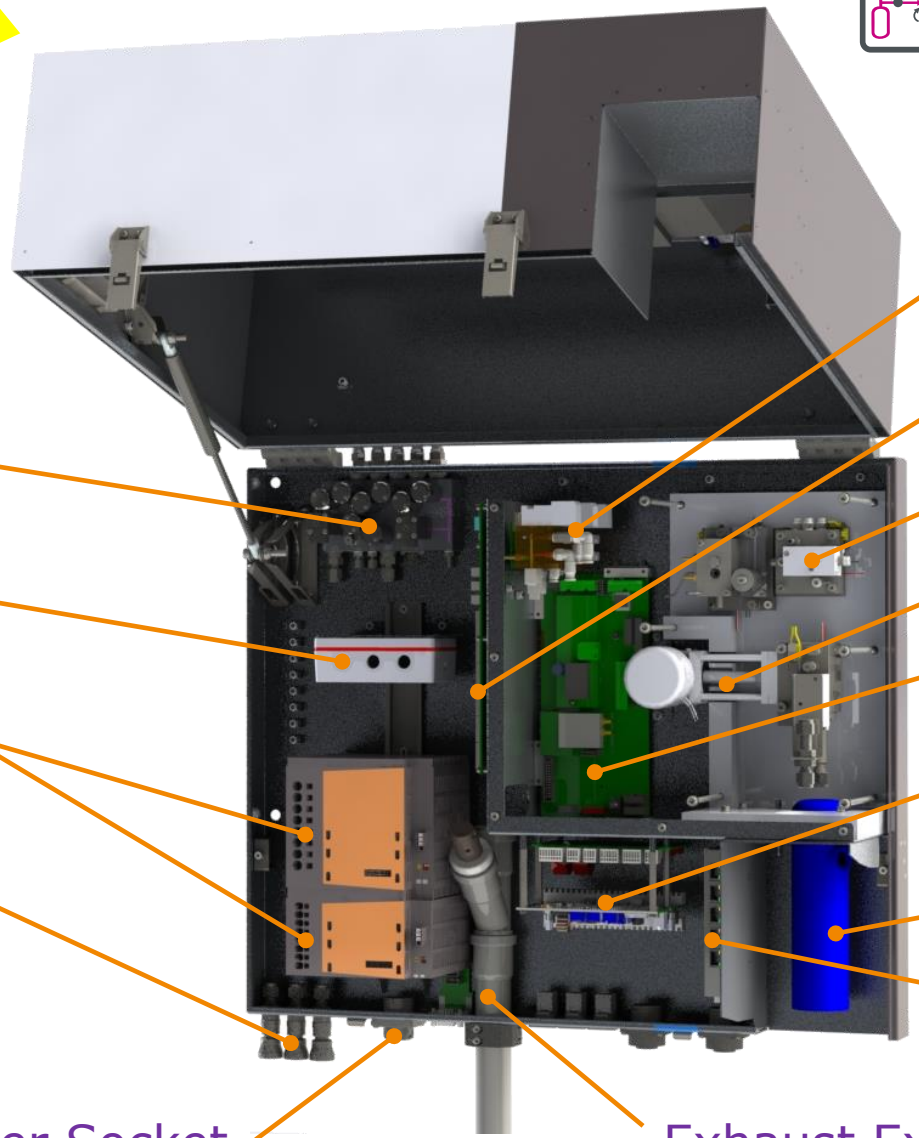
- Significantly reduced costs (30 – 40%)

SHED FID SL

New

SL Design - inside

Analytics SHED FID
iCal Calibration
Units (GDU + CFO)



Valve Block (AVU/SGU)

Smart Hub

voltage converter blocks (48V / 24V)

Gas Divider Interface

Power Socket

Pressure Regulator

Device Builder Board (MSR) & I/O Board

Detector

Sample Gas Pump

FID Controller Board

Power Board

2x Heated Line

LAN Router

Exhaust Extraction

SHED FID SL – SHED Integration

New

Analytics SHED FID
iCal Calibration
Units (GDU + CFO)

Application Setup

- Modular solution for modernization, replacement or upgrade projects
- Migration benefits concerning system response and reliability

EVAP – Analytic Readiness?

Analytics SHED FID
iCal Calibration
Units (GDU + CFO)

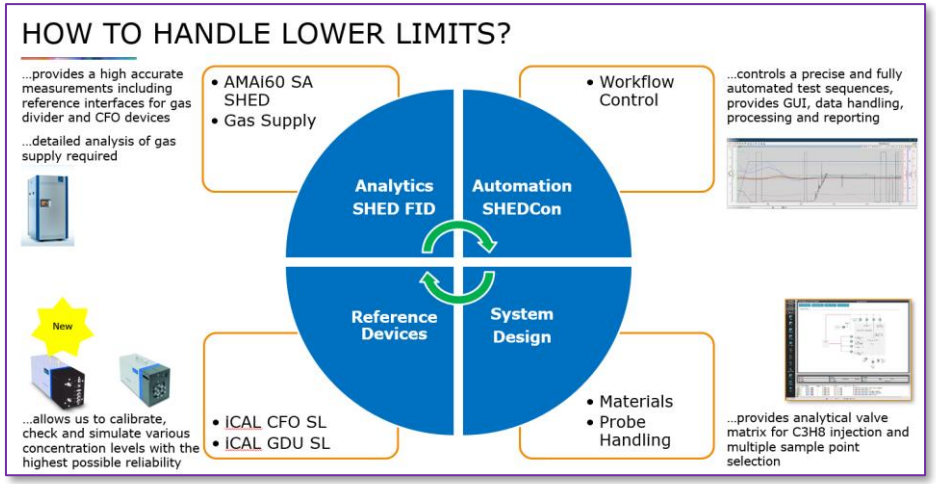
Testing and Measurement: Can we test and measure it?

Application	Notes	Status	AVL Systems
Chassis dyno	• Some improvement required • Analyzers with appropriate accuracy available • Analyzers for new components available. • NH3 measurement needs to be defined • Automation systems needs an up-date	✓	
Engine test bed	• Some improvement required. Important is zero calibration, drift and time alignment. • Low NOx analyzer available, mainly for US and China. • Analyzers for new components available • Automation systems needs an up-date	✓	
RDE PEMS	• Up to 10.11.2022 unclear requirements. Which components must be tested N2O, NH3, THC, CH4 and Aldehyde? • Most likely different set-ups for Light- and Heavy-Duty (FTIR) • High accuracy requirement due to CF=1. • New improved PEMS and mobile FTIR under development.	!	
EVAP	• No issues for SHED and analyzer itself. • 38°C Chassis dyno preconditioning capability required • ORVR (Onboard Refueling Vapor Recovery) test systems available.	✓	
Brake wear	• EU-7 is now a vehicle and component legislation • New test and measurement systems are available • Little practical experience up to now in the industry	✓	

Ready for Carbon-Free Fuels, like H2

Picture: Webinar "Insights and 1st Interpretations"

HOW TO HANDLE LOWER LIMITS?



Yes, we can!

LEGISLATION INFORMATION - CHINA

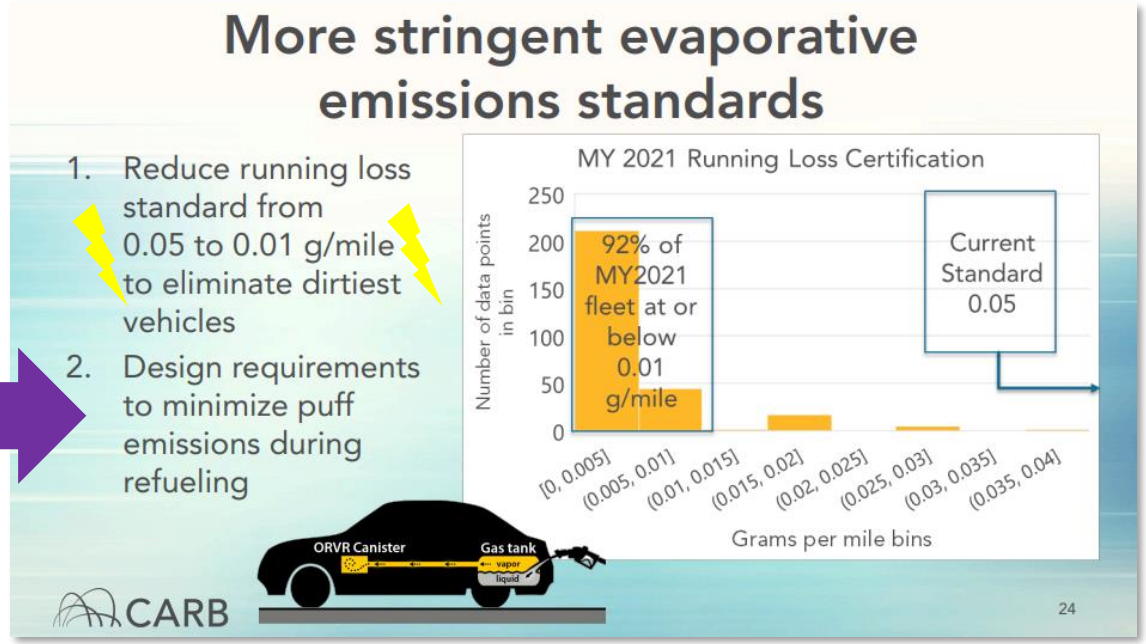
CHINA → POST CHINA 6 / CHINA 7 - Discussion…

…defining the Future…

- Checking the global legislation and references (Euro 7)
- Understanding the technology trends of vehicles
- Different departments and responsibilities concerning type approval and durability testing requirements
- Durability requirements based on latest GTR-19 / EU6 rules are in focus of evaluation
- Solution for sealed tanks systems required (PHEV) – Puff-Loss Testing expected
- **Individual Bleed Emission sampling and evaluation ongoing (BETP reference solution)**
- New limits for evaporative emissions aligned with other global standards expected

LEGISLATION INFORMATION - CARB

CARB Running-Loss Testing



- Industry is sensitized concerning the 80% emission limit reduction (50mg/mile → 10mg/mile)
- How does the reduced emission level correspond to the test type (RL-SHED vs. Point-Source)
- Industry is confused about the dual path of RL-Testing and their correlation → **Risk Management**
- Improvement of reliable RL-Testing equipment needed? e.g., Point-Source or even RL-SHED solutions

READY for „…any market fuels…“ Requirement

SESAM FTIR Diluted – SHED…

- **Ethanol**
- Methanol

- OME1, OME2, OME3
- DME, MEFO
- ETBE, MTBE, Ethyne, Ethen, Ethane, Methane
- Propene, Propane, Benzol
- Butadiene, Toluene
- CNG ready!
- LPG ready!

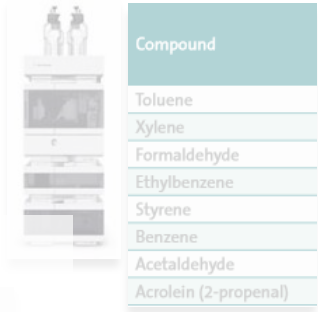
- Glycol

- (R12), R134, R134a
- R1234yf, R744
- CO_2

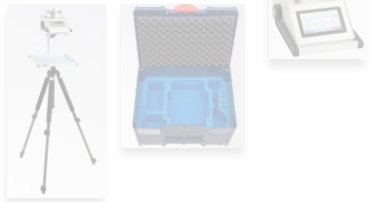
SHED FID…

H2D/H2D+ Mass Spectrometer…

Chem Lab solutions…
HPLC, GC-MS



Online Mass Spectrometer…



Specific Sampling Systems…

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General requirements, Fuels variety, Legislation, etc.

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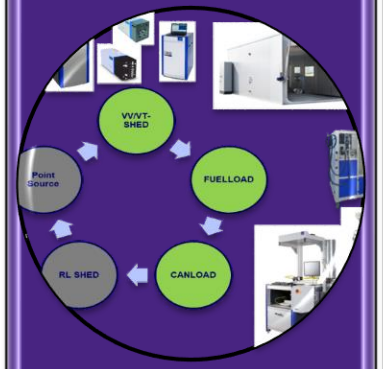
How does AVL support the industry?

SUMMARY - HOW DOES AVL SUPPORT THE INDUSTRY?

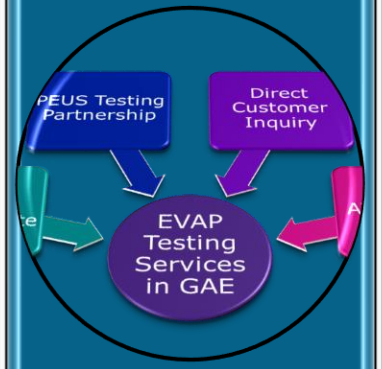


Adequate Equipment & Devices

Modernization Packages & Kits for existing Test Systems incl. 3rd party SHED's

"Leasing as a Service" and individual financing packages

Testing Services as part of the overall project



Outsourcing → Testing Services with or without Engineering Tasks

Training & Skill Centers for Hands-On Workshops, etc.

AVL EVAP Solution Portfolio

EVAP Euro 7 …

EVAP Topics at AGVES* Meetings…

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10:45-11:45	Discussion and presentations on abusive driving*	all
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- Defeating device detection?
- Fuel Storage Leak Check like US standards for ISC?
- Durability Refueling "market surveillance" ?
- 38°C Prep-Cycle?
- Ethanol Factor --> 1.08 in USA, FID Response, sampling equipment for ethanol / methanol?
- ISC Testing – Purge Flow Measurement during Prep-Cycles?
- Puff-Loss Test as combination of Refueling test procedure?
- R83 parts & references → copy into Euro 7?
- Etc.

*AGVES = Advisory Group of Vehicle Emission Standards

OUTLOOK - SHED „Extended“ APPLICATION …

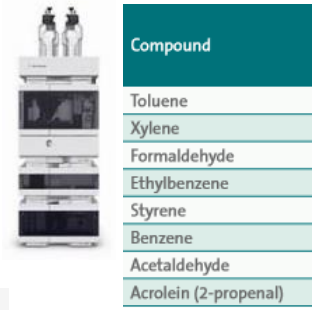
SESAM FTIR Diluted – SHED…

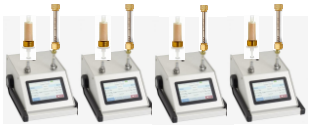
- Ethanol
- Methanol
- OME1, OME2, OME3
- DME, MEFO
- ETBE, MTBE, Ethyne, Ethen, Ethane, Methane
- Propene, Propane, Benzol
- Butadiene, Toluene
- CNG ready!
- LPG ready!
- Glycol
- (R12), R134, R134a
- R1234yf, R744
- CO_2

SHED FID…

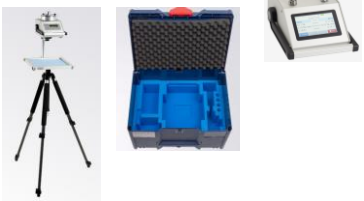
H2D/H2D+ Mass Spectrometer…

Chem Lab solutions…
HPLC, GC-MS





Online Mass Spectrometer…



Specific Sampling Systems…

Q&A's?

Designed for compliant Certification, CoP, ISC and R&D Testing purposes

Complete gasoline application range from Components, SORE, Offroad, MC's, ATV's, LD, MD, HD

Handheld | Garden | 2-Wheeler | Motorcycle | 3-Wheeler | ATV | Passenger Car | LD Commercial | Truck

Thank You

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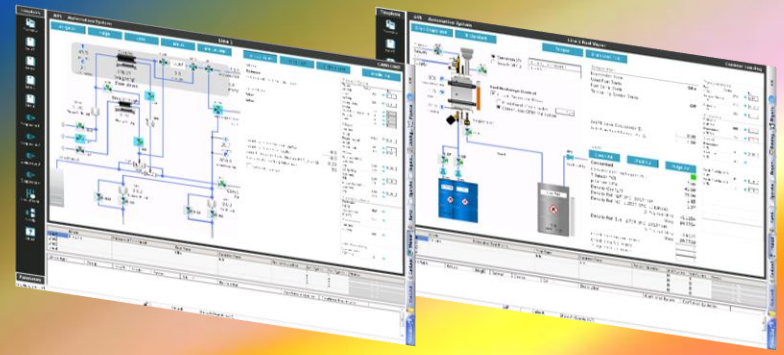

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