

# International vehicle emission standards

## New vehicles versus Used

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Southern Africa Sub Regional Workshop 2023

## South Africa : Key Points

- **Significant producer of new vehicles** : BMW, Ford, GM, Mercedes Benz, Nissan, VW and Toyota all have assembly plants supporting local and export markets. EU Trade agreements in place. **Used vehicles prohibited**
- **SA follows Europe** in terms of vehicle design. SA participates in WP 29 and adopts ECE vehicle regulations.
- Fuel quality aligned with that of Europe is seen as a key enabler for local producers to import and manufacture latest generation fuel efficient vehicles.
- Currently at EU Stage 2 in line with fuel quality. Move to **Stage 5 with CF2 (low Sulphur 10 ppm)** anticipated
- **No periodic or in service emission tests** currently prescribed.

# Presentation sections

- Vehicle emission measurement
- New vehicle emission regulations
- Used vehicle emission regulations
- Possible regional regulations for Southern Africa

# New Vehicle emission measurement (CO<sub>2</sub> and NON CO<sub>2</sub>)

# Light Vehicle Emissions Test Cell



Small vehicles only ( Fully Laden < 3.5 t).

**Multi million dollar investments**

On-going calibration / correlation / maintenance requirements  
to maintain accuracy, precision and reliability

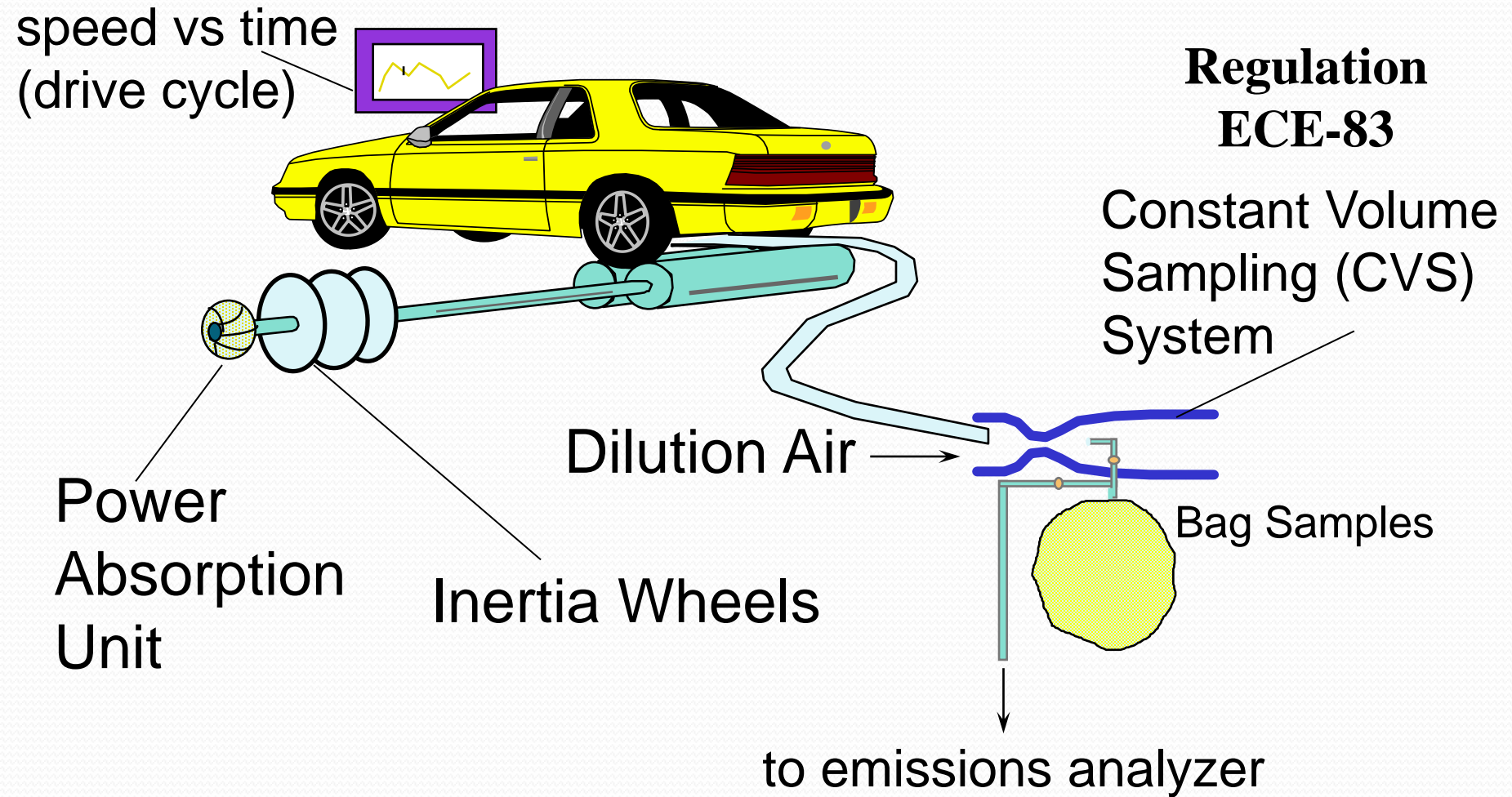
Highly skilled operators required

# Vehicle Emission Testing Facilities



Slide: Ford Motor Company

# Typical Light Duty Vehicle Test Facility



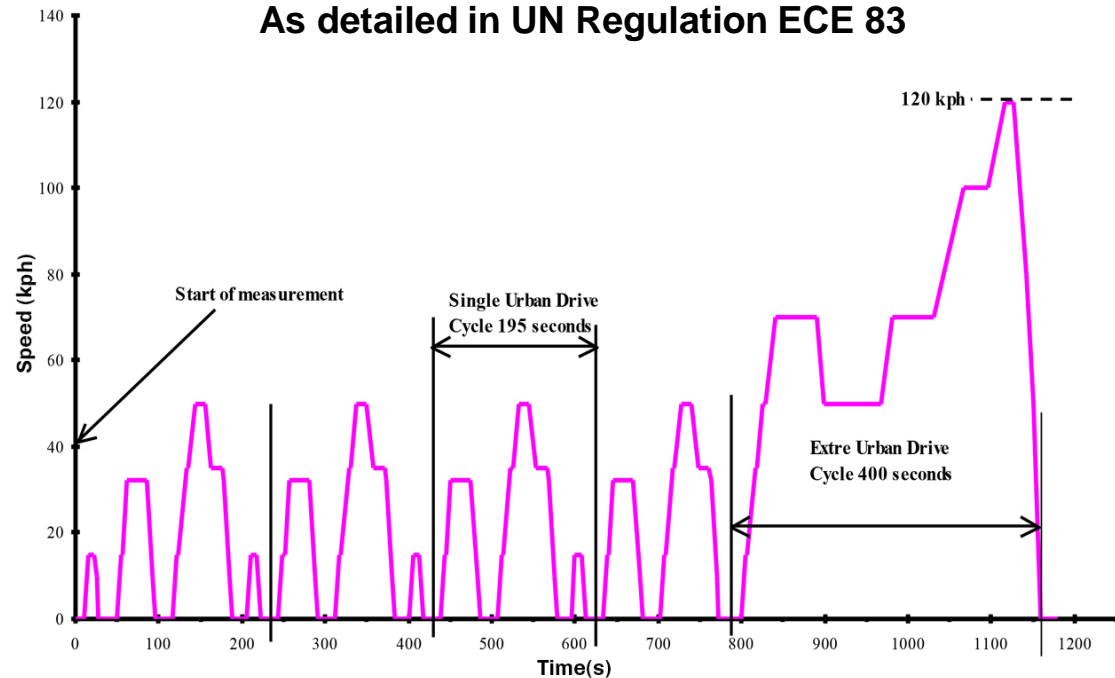
- Measurements in g/km

# New European Driving cycle (NEDC)

## (EU Stage 2-5)

- New European Drive Cycle applied from year 2000.
- Excellent for repeatability and assessment against legislative standards.
- Recognised by both Industry and Legislators for some time as not representative of real driving.
- Basis of EU stage 2 -5 emission requirements
- Stage 6 uses new WLTP cycle

**New European Driving Cycle (NEDC)**  
**As detailed in UN Regulation ECE 83**





# Vehicle emissions: test loads, durability and evaporative loss

- The load to be applied to the dynamometer rollers is determined through a 'coast down' test or in some instances the vehicle mass.
- Specified maximum tailpipe limits must be met after either 100,000 or 120,000 km.
- The stationary evaporative emissions from the fuel tank and fuel system are measured separately using a different test facility

# Vehicle emission legislation and standards

# UN ECE Regulation No. 83: Motor Vehicle Emissions

Formal title: *'Uniform Provisions Concerning the Approval of Vehicles with regard to the Emission of Pollutants According to Engine Fuel Requirements'*

UN Regulation **83** addresses vehicle emissions from all light vehicles regardless of engine type (and from heavier vehicles only if equipped with a gasoline engine).

UN Regulation **49** typically addresses larger vehicle (over 3.5t GVM) and is an engine test rather than a vehicle test

R83 or R49 can apply to light vehicle CNG/LPG engines. Latest levels of R83 also contains provisions specific to hybrid vehicles.

# UN EMISSION RECOMMENDATIONS: PETROL EU2, 3 & 4

## *Consolidated Resolution on the Construction of Vehicles (RE3)*

Fuel Quality Recommendations – on road vehicles:

Unleaded Gasoline:	R83.03	R83.05 (row A)	R83.06 (row B)	Test method
Lead [g/l] <sup>1)</sup>	No intentional addition, with a max $\leq 0,013^2$	No intentional addition, with a max $\leq 0,005^1$	No intentional addition, with a max $\leq 0,005^1$	EN 237
Sulphur [mg/kg] <sup>1)</sup>	$\leq 500^1$	$\leq 150^1$	$\leq 50^1$	EN ISO 20846 EN ISO 20884
Metal Additives [mg/l]	————— Not permitted —————			
Oxygen [%m/m]	[ $\leq 2,7$ ]	$\leq 2,7$	$\leq 2,7$	EN 1601 EN 13132
Oxygenates [%v/v]				
- methanol	$\leq 3,0^2$	$\leq 3,0^2$	$\leq 3,0^2$	
- ethanol	$\leq 5,0$	$\leq 5,0$	$\leq 5,0$	
- iso-propyl alcohol	$\leq 10,0$	$\leq 10,0$	$\leq 10,0$	
- iso-butyl alcohol	$\leq 10,0$	$\leq 10,0$	$\leq 10,0$	EN 1601 EN 13132
- tert-butyl alcohol	$\leq 7,0$	$\leq 7,0$	$\leq 7,0$	
- ethers	$\leq 15,0$	$\leq 15,0$	$\leq 15,0$	
- other oxygenates	$\leq 10,0$	$\leq 10,0$	$\leq 10,0$	
RVP [kPa]	35 - 100	45 - 100	45 - 100	EN 13016/1 DVPE
Density [g/cm <sup>3</sup> ]	725 - 780	720 - 775	720 - 775	EN ISO 3675 EN ISO 12185
RON	[ $\geq 95$ ]	[ $\geq 95$ ]	[ $\geq 95$ ]	EN ISO 5164
MON	[ $\geq 85$ ]	[ $\geq 85$ ]	[ $\geq 85$ ]	EN ISO 5163
Benzene [%v/v]	$\leq 5$	$\leq 1$	$\leq 1$	EN 238 EN 14517
Aromatics [%v/v]	-	$\leq 42$	$\leq 35$	EN 14517 EN15553
Olefins [%v/v]	-	$\leq 21$ & 18	$\leq 18$	EN 14517 EN15553
VLI (10VP + E70)	-	1050 - 1250	1050 - 1250	
Residue [%v/v]	<2	<2	<2	EN ISO 3405

Petrol Sulphur level

### UN ECE 83 levels for passenger cars and LCV

ECE 83.03/4 - Euro 2

ECE 83.05A - Euro 3

ECE 83.05B - Euro 4

<sup>1)</sup> Already agreed in annex to the Consolidated Resolution on the Construction of Vehicles (RE3). Industry recommends maximum 50ppm sulphur.

<sup>2)</sup> Industry recommends no methanol content (non-detectable).

# RECOMMENDATIONS: DIESEL EU 2,3 & 4)

500 ppm = Euro 2  
350 ppm = Euro 3  
50 ppm = Euro 4

Diesel – on-road vehicles:

	R83.03 and R49.02 (Stage II)	R83.05 (row A) and R49.03 (row A)	R83.05 (row B) and R49.03 (row B)	Test method
Sulphur [mg/kg] <sup>1)</sup>	≤ 500 <sup>1)</sup>	≤ 350 <sup>1)</sup>	≤ 50 <sup>1)</sup>	EN ISO 20848 EN ISO 20884
Ash [%m/m] <sup>2)</sup>	≤ 0,01 <sup>1)</sup>	≤ 0,01 <sup>1)</sup>	≤ 0,01 <sup>1)</sup>	EN ISO 6245
Total Contamination [mg/kg] <sup>3)</sup>	≤ 24 <sup>4)</sup>	≤ 24 <sup>4)</sup>	≤ 24 <sup>4)</sup>	EN 12662
Cetane Number <sup>5)</sup>	[≥ 49]	[≥ 51]	[≥ 51]	EN ISO 5165
Cetane Index <sup>5)</sup>	[≥ 46]	[≥ 46]	[≥ 46]	EN ISO 4264
Density [kg/m <sup>3</sup> ] <sup>6)</sup>	820 – 860	820 – 845	820 – 845	EN ISO 3675 EN ISO 12185
Viscosity [mm <sup>2</sup> /s] <sup>6)</sup>	2,0 - 4,5	2,0 - 4,5	2,0 - 4,5	EN ISO 3104
Flash Point [°C]	> 55	> 55	> 55	EN ISO 2719
T50 [°C]	-	T65 = 250 min	T65 = 250 min	EN ISO 3405
T85 [°C]	≤ 350	≤ 350	≤ 350	EN ISO 3405
T95 [°C]	≤ 370	≤ 360	≤ 360	EN ISO 3405
PAH [%m/m]	≤ 11	≤ 11	≤ 11	EN 12916
Carbon residue [%m/m]	≤ 0,3	≤ 0,3	≤ 0,3	EN ISO 10370
CFPP [°C] <sup>7)</sup>	-44 to +5	-44 to +5	-44 to +5	EN 116
Cloud Point [°C] (severe winter conditions) <sup>8)</sup>	-34 to -10	-34 to -10	-34 to -10	EN 23015
Copper strip corrosion (3h at 50°C) (rating)	Class 1			EN ISO 2160
Water [mg/kg]	≤ 200	≤ 200	≤ 200	EN ISO 12937
Lubricity [micron]	≤ 460	≤ 460	≤ 460	EN ISO 12156-1
Oxidation stability [hours] <sup>9)</sup>	> 20	> 20	> 20	EN15751
FAME [%w/w]	≤	≤	≤	EN14214 ASTM D6751
Appearance	Clear and bright, no free water or particulates			D4176 visual inspection
Ethanol/Methanol [%v/v]	Non-detectable <sup>10)</sup>			

<sup>1)</sup> Already agreed in annex to the Consolidated Resolution on the Construction of Vehicles (RE3). Industry recommends maximum 50ppm sulphur.

<sup>2)</sup> Implementing country to choose value appropriate within range for arctic or severe winter conditions.

<sup>3)</sup> More detailed arctic or severe winter specifications for these parameters to be considered.

<sup>4)</sup> Applicable for diesel containing more than 2%w/w FAME.

<sup>5)</sup> Up to 5%w/w FAME permitted if FAME complies with ASTM D6751. Up to 7%w/w FAME permitted if FAME complies with EN14214. Industry recommends that vehicle owners refer to their vehicle handbook.

<sup>6)</sup> At or below detection limit of method used.

## ECE 49 levels for heavy duty vehicles

ECE 49.02 - Euro 2

ECE 49.03A- Euro 3

ECE 49.03B- Euro 4

# Nigeria: Emission standard extract

Drive cycle? UN ECE Regulation Reference?

## SCHEDULE II

Regulation 3(6)

### EMISSION STANDARD OF POLLUTANTS FOR NEW MODELS OF PETROL ENGINES ON OR AFTER 1ST JANUARY, 2015

1. For a petrol engine with a Gross Vehicle Weight (GVW) of more than 2500kg, the exhaust emission of the gaseous pollutant of Carbon Monoxide and the combination of Hydrocarbons and Nitrogen Oxides shall not exceed the following standards :

<i>Reference Mass (rm)(kg)</i>	<i>Mass of Carbon Monoxide (g/km)</i>	<i>HC (g/km)</i>	<i>NO<sub>x</sub> (g/km)</i>	<i>Combined Emission Mass of Hydrocarbons and Nitrogen Oxides (g/km)</i>
<b>(Class I ) rm &lt; 1305kg</b>	2.3	0.20	0.15	—
<b>(Class II ) 1305 &lt; rm &lt;= 1760</b>	4.17	0.25	0.18	—
<b>(Class III ) 1760 &lt; rm</b>	5.22	0.29	0.21	—

Source : National Automotive Council (NAC).

Key

< Less than.

# South Africa: vehicle emission legislation

reference to UN ECE Regulations

## Passenger car and light commercial vehicles

*4.2.3 The gaseous and particulate emissions from the vehicle shall comply with the requirements of SABS ECE R83 Uniform provisions concerning the approval of vehicle with regard to the emissions of pollutants according to engine fuel requirements to the level of **ECE R83.04**.*

## Heavy vehicles and buses

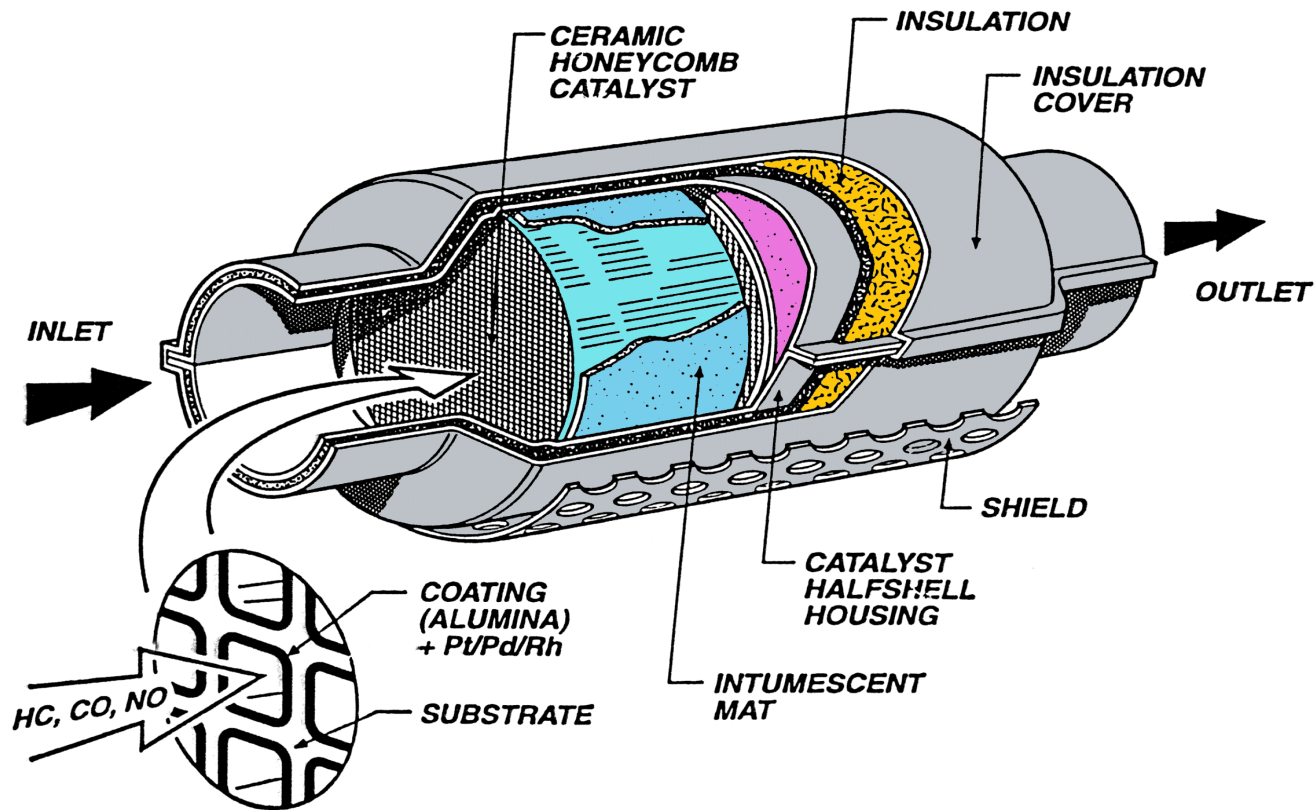
*4.2.2.1 SANS 20049:2004 Uniform provisions concerning the approval of compression- ignition(C.I.) and natural gas (NG) engines as well as positive - ignition(P.I.) engines fuelled with liquefied petroleum gas (LPG) and vehicles equipped with C.I. and NG engines fuelled with LPG, with regard to the emissions of pollutants by the engine to the level of **ECE R49.02B**;*

Reference [www.nrccs.org.za](http://www.nrccs.org.za) – NRCS website: Compulsory Specifications

# Vehicle emission legislation for used vehicles

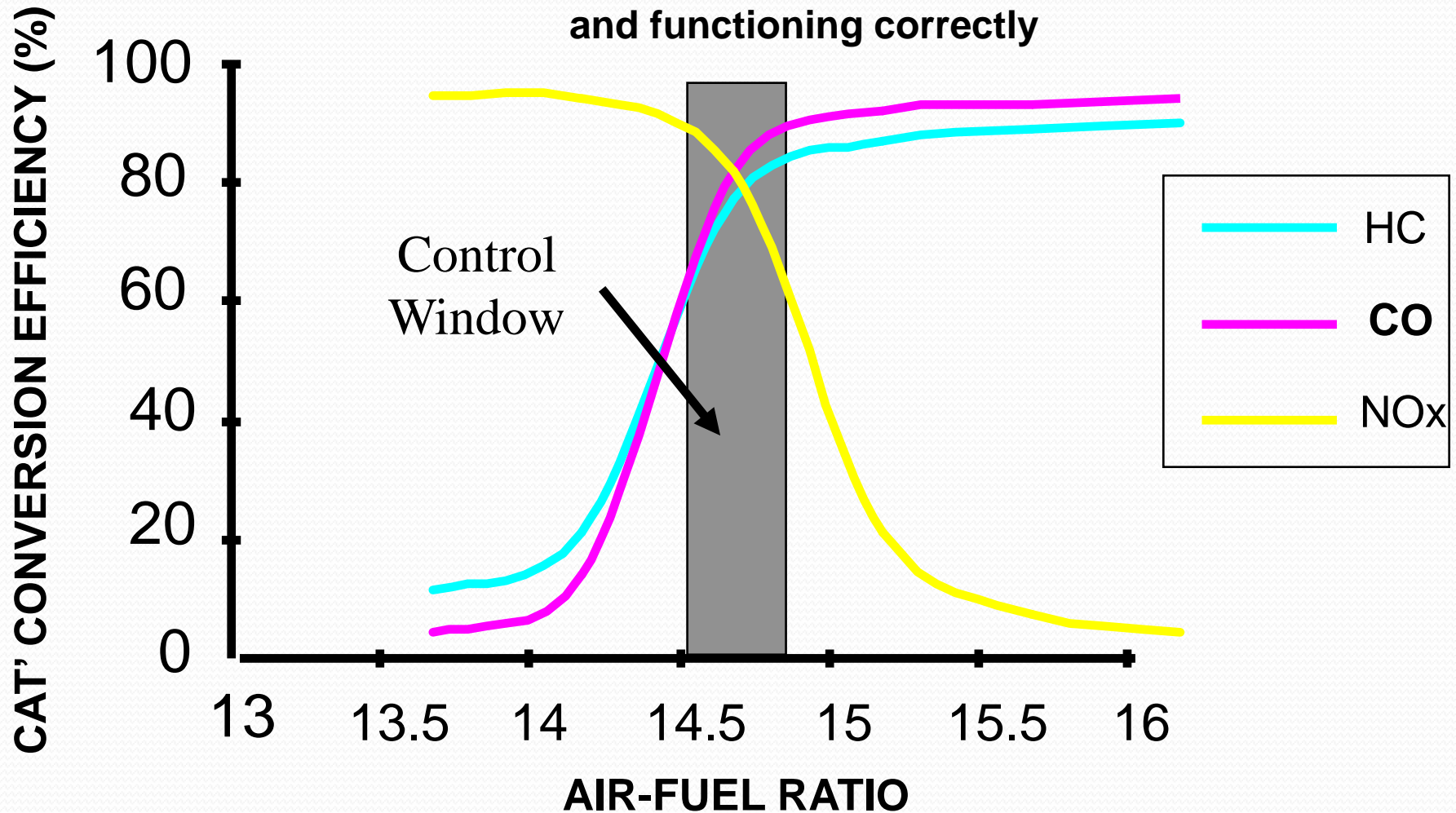


# Catalytic Converter



# Use of CO measurement to check catalyst operation

CO level is reduced massively by the catalytic converter – if it is fitted and functioning correctly



# Typical CO meter as used by automotive Dealers

- Inexpensive
- Well proven
- Already available at most auto dealerships
- Portable
- Simple to use



Photo: Horiba



## Possible regulation wording: Where the exhaust emissions are controlled by an advanced emission control system such as a three-way catalytic converter

1. Visual inspection of the exhaust system in order to check that there are no leakages and that all parts are complete.
  2. Visual inspection of the emission control system in order to check that the required equipment has been fitted.
  3. Determination of the efficiency of the vehicle's emission control system by measuring the lambda value and the CO content of the exhaust gases in accordance with Section 4 or with the procedures proposed by the manufacturers and approved at the time of homologation. For each of the tests the engine is conditioned in accordance with the vehicle manufacturer's recommendations.
  4. Exhaust pipe emissions - limit values
    - (a) Measurement at engine idling speed: The maximum permissible CO content in the exhaust gases is that stated by the vehicle manufacturer. **Where this information is not available, the maximum CO content must not exceed 0,5% vol.** (Stage 3 - 0,3% and post 2002)
    - (b) Measurement at high idle speed, engine speed to be at least 2 000 revs/min.: The maximum permissible CO content in the exhaust gases is that stated by the vehicle manufacturer at high idle speed. **Where this is not available, the maximum CO content must not exceed 0,3% vol.** (Stage 3 – 0.2% and post 2002)
- The air/fuel ratio, Lambda shall be =  $1 \pm 3\%$  or in accordance with manufacturer's specifications.

Possible regulation wording: **Motor vehicle equipped with positive-ignition (petrol) engines where the exhaust emissions are not controlled by an advanced emission control system such as a three-way catalytic converter**

1. Visual inspection of the exhaust system in order to check that there are no leakages.
2. After a reasonable period of engine conditioning (taking account of the vehicle manufacturer's recommendations) the carbon monoxide (CO) content of the exhaust gases is measured when the engine is idling (no load). The maximum permissible CO content in the exhaust gases is that stated by the vehicle manufacturer. Where this information is not available as a reference value, **the CO content must not exceed 4.5%.**

# Possible regulation wording: Motor vehicles equipped with diesel engines

(a) **Exhaust gas opacity** to be measured during free acceleration (no load from idle up to cut-off speed) with gear lever in neutral and clutch engaged.

(b) Vehicle preconditioning:

1. Vehicles may be tested without preconditioning although for safety reasons checks should be made that the engine is warm and in a satisfactory mechanical condition.
2. No vehicle will be failed unless it has been preconditioned according to the following requirements.
3. Engine shall be fully warm, for instance the oil temperature measured by a probe in the oil level dipstick tube to be at least 80° C, or normal operating temperature if lower, or the engine block temperature measured by the level of infrared radiation to be at least an equivalent temperature. If, owing to vehicle configuration, this measurement is impractical, the establishment of the engine's normal operating temperature may be made by other means, for example by the operation of the engine cooling fan.
4. Exhaust system shall be purged by at least three free acceleration cycles or by an equivalent method.

(c) Test procedure:

1. Visual inspection of the relevant parts of the motor vehicle's emission system to check that there are no leaks.
2. Engine, and any turbo-charger fitted, to be at idle before the start of each free acceleration cycle. For heavy-duty diesels, this means waiting for at least 10 seconds after the release of the throttle.
3. To initiate each free acceleration cycle, the throttle pedal must be fully depressed quickly and continuously (in less than one second) but not violently, so as to obtain maximum delivery from the injection pump.

Coeff of Absorption Limit Values (or equivalent)

**Normally Aspirated diesel**

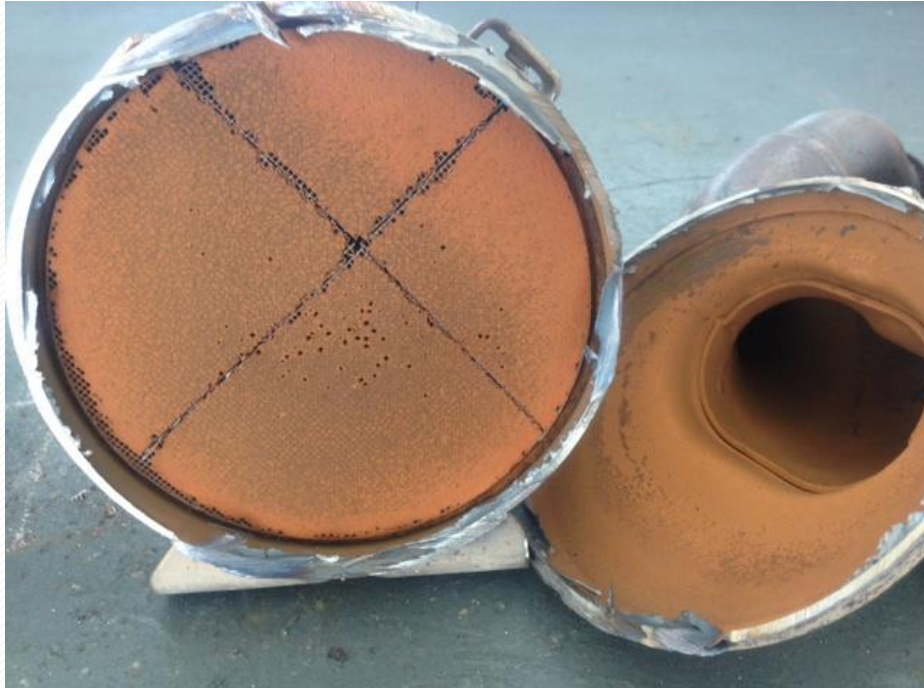
**2.5 /m**

**Turbocharged diesel**

**3.0 /m**

# Issues for catalysts: metal additives in petrol

Recent issues in East Africa



ISSUE : Manganese being increasingly used at uncontrolled levels at a time when catalyst cell mesh density is increasing

EU Mn limit – 2mg/l (with warning label)



Manganese related blockages of catalytic converters : Tanzania 2016...still an issue

Iron addition now becoming a major issue

# Metal additives in Southern African unleaded petrol : Reported status 2023

- Countries with reported high (over 6mg/l) levels of manganese (Mn)

*Angola, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe*

- Countries with reported high (over 6mg/l) levels of iron (Fe)

*South Africa, Tanzania, Zimbabwe*

*Note: Namibia, Botswana, Kenya, Seychelles, Mauritius and Madagascar are reported metal free*



# Summary: 'Used vehicle standards for used vehicles'

- A simple, low cost carbon monoxide (CO) tailpipe test as applied as part of a roadworthy test in European markets to petrol engine vehicles is an effective indicator of whether a catalytic converter is fitted and is functional and should be considered as a requirement for all used vehicles entering SADC markets.
- Diesel vehicle emissions can be significantly reduced by the adoption and sustained enforcement of 'low cost' opacity requirements. SADC states/cities should be encouraged to adopt such measures as a first step to reducing visible smoke emissions.

# African Regional Standards: Emissions and Safety requirements

The following listed standards have been harmonized through the ARSO Technical Committee (ARSO TC 59) on Automotive Technology and Engineering of which membership is composed of experts from 17 ARSO member states: (1) DR. Congo, (2)Egypt, (3)Ghana, (4)Kenya, (5)Madagascar, (6)Malawi, (7)Mauritius, 8.Namibia, (9)Nigeria, (10)Rwanda, (11)Seychelles, (12)Sierra Leone, (13)South Africa, (14)Tanzania, (15)Zambia, (16)Zimbabwe and (17)Zanzibar as an observer member.

- *ARS 1355-1:2020, Vehicle Standards — Specification for Vehicle Roadworthiness — Part 1: Roadworthiness of vehicles already in use*
- *ARS 1355-2:2020, Vehicle Standards — Specification for vehicle roadworthiness — Part 2: Roadworthiness of vehicles prior to entry into service and thereafter*

# Vehicle Emission Suggestions for Southern Africa

## (with supporting fuel quality)

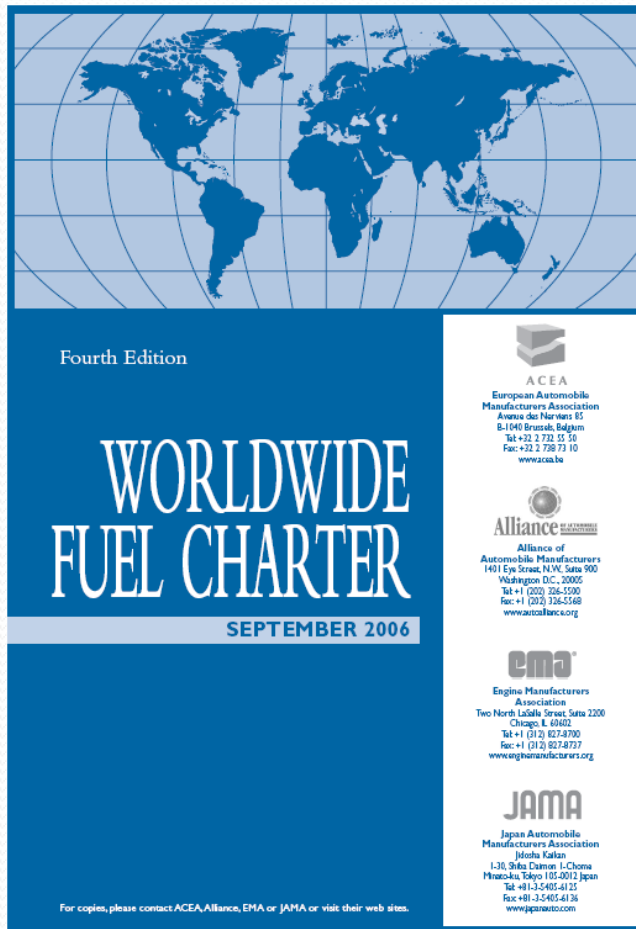
### New Vehicles

- Reference **UN ECE Regulations directly** (or ‘technical requirements’)
- Recognition needs to be made of legislation in **neighbouring countries** and the products available to local dealers
- Lead times need to be **two to three years** noting low volumes involved
- It is proposed that **ECE 83.04 and ECE 49.02B should be initially adopted in line with South Africa for countries sourcing SA product**
- A move to **EU stage 5 could be made in line with South Africa** (timing TBE) for countries that have supporting fuel quality

### Used vehicles (inc newly imported used imports)

- **A simple CO tailpipe test should be adopted as part of the roadworthy test** to check for catalytic converter fitment and operation on petrol vehicles
- Two CO levels should be adopted – one for newly registered vehicles and one for existing vehicles to allow for a phase in. (Assume catalysts are not fitted presently or not functional)
- **Opacity tests to be applied to diesel vehicles** as part of the roadworthy test
- Also refer ARS 1355 Part 1 and 2

# World-Wide Fuel Charter



- First established in 1998 to promote greater understanding of fuel quality needs of motor vehicle technologies and to harmonize fuel quality world-wide in accordance with vehicle needs
- This is the go-to document for fuel quality information.
- Covers both gasoline and diesel, with four levels of each for fuel quality based on emission requirements
- Biofuels covered by separate document
- Access from AutoAlliance.org
  - <http://www.autoalliance.org/files/WWFC.pdf>

End

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