nmisa
National Metrology Institute of South Africa

How Metrology Supports Policy:

Accurate Alcohol Testing for Safer Roads and Workplaces

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Senior manager: Analytical & Material Sciences

World Metrology Day

20 May 2026

Your measure of excellence

THE HUMAN COST

ROAD FATALITIES

3 200

South Africans killed on our roads in 2023 linked to alcohol (27% of all road deaths)

Source: RTMC State of Road Safety Report 2023

WORKPLACE INJURIES

1 in 4

workplace injuries in South Africa involve employees under the influence of alcohol

Source: SA Labour Guide via HRworks.co.za

Alcohol-related road incidents cost South Africa an estimated R18.2 billion annually
SA has one of the highest rates of alcohol-related road fatalities globally

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SOCIETY HAS DRAWN A LINE

ROAD TRAFFIC

National Road Traffic Act 93 of 1996

General Driver

0.05 g/100 ml blood

| 0.24 mg/L breath

Professional Driver

0.02 g/100 ml blood

| 0.10 mg/L breath

Penalty: Fine up to R120 000 | Up to 6 years imprisonment | Criminal record

WORKPLACE

Occupational Health & Safety Act 85 of 1993

Employer Duty

Must maintain a safe environment and may not allow employees under the influence on premises.

Machinery Operators & Pro drivers

blood limit of 0.02 g/100 ml | 0.10 mg/L breath

CCMA Position

Zero-tolerance policies are lawful; dismissal is competent if the measurement holds up.

Source: OHS Act 85/1993 | CCMA Info Sheet 2023-02

These legal thresholds are only enforceable if the underlying measurements are accurate and traceable

WHEN MEASUREMENT IS CHALLENGED IN COURT

Samancor Chrome Ltd (Western Chrome Mines) v Willemse & Others [2023]
ZALCJHB 150 | Labour Court | 29 May 2023

3

POSITIVE TESTS

Willemse tested positive on 3 breath tests, conducted on 2 different devices. The breath analyser recorded 0.013% above the company's zero-tolerance threshold.

0

BLOOD RESULT

Subsequent blood test at Pathology Laboratory: negative. However, the plasma ethanol method used could not detect below 0.010 g/100 mL. The test had an unacknowledged detection limit.

X

OUTCOME: REINSTATED

Labour Court upheld reinstatement.

The court found the breathalyser results may have been false positives. The employer's own expert confirmed the blood test was more reliable.

The case was not decided on behaviour
it was decided on the credibility of a number

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Overview

- Role players
- Certified reference materials (CRMs)
- Proficiency testing schemes (PT)
  - Forensic Blood Alcohol Analysis
  - Evidential Breath Analysers

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Role players

National prosecuting authority (NPA)

- Prosecution
  - Ensures that perpetrators of crime are charged and held responsible

National Metrology Institute of South Africa (NMISA)

- Metrology
  - Underpins testing and calibration through measurement accuracy & traceability
  - Calibration of EBA
  - Metrologically traceable CRMs

National Regulator for Compulsory specifications (NRCS)

- Regulation
  - Administrates regulation to ensure compliance and protect human health and safety
  - Granted approval and Drager 9510 EBA in South Africa

South African Bureau of Standards (SABS)

- Standardization
  - Documentary standards for validated methods used in industry
  - SANS 1793:2013
  - Technical working group for drug and alcohol testing

Department of Transport

- Law enforcement
  - Road safety
  - Regulation of transport sector

Department of Health (NHLS & Pathology laboratories)

- Law enforcement
- Cause of death (post-mortem)

Employer

- Construction sites
- Mining
- Professional driving, aviation industry
- Manufacturing

Department of Labour

- CCMA

SANAS

- ISO/IEC 17025 Accreditation of calibration & testing laboratories

OEM – breath analysers

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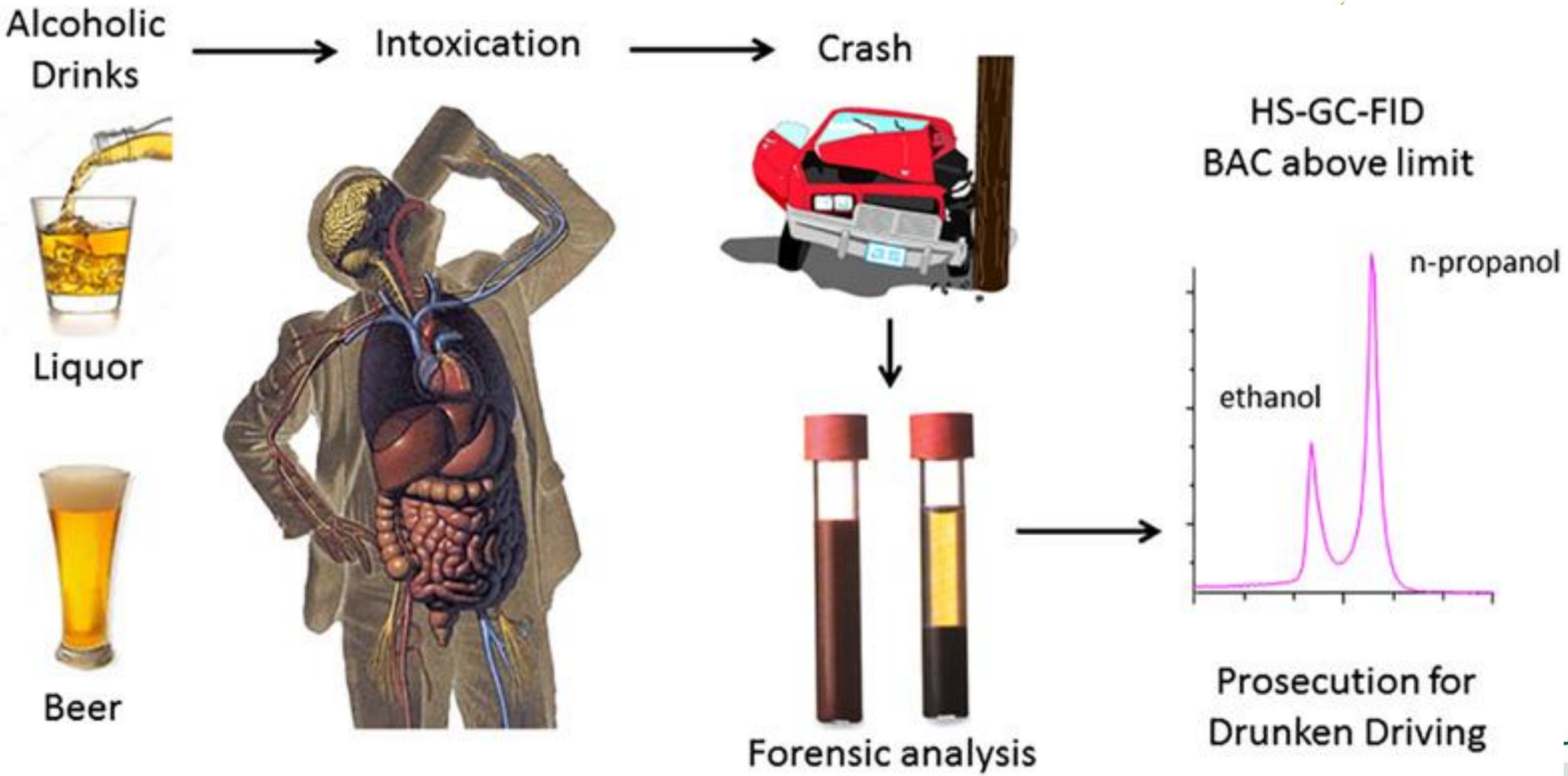

Jones AW. Alcohol, its analysis in blood and breath for forensic purposes, impairment effects, and acute toxicity. WIREs Forensic Sci. 2019;1:e1353. https://doi.org/10.1002/wfs2.1353

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Aqueous ethanol certified reference materials – For accurate ethanol-in-blood determination

GRAVIMETRIC PREPARATION

- Aqueous ethanol solutions are **prepared** by mixing known weights of pure ethanol and organic-free water.
- Batches of five litres or less are prepared. The concentrations are then verified by a titrimetric method.
- The batches are **bottled** and **sealed**. Eight aliquots of each batch analysed by the titrimetric method.
- Aliquots from 8-12 bottles throughout the batch are analysed by the titrimetric method (< 130 units per batch of 5 litres)

Archer, M., de Vos, J., Visser M. The preparation, assay and certification of aqueous ethanol reference solutions. (April 2007). Accreditation and Quality Assurance

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Titrimetric assay

- Known weights of dilute ethanol solutions are reacted with known quantities of potassium dichromate in the presence of sulphuric acid. The ethanol is oxidised to acetic acid:

$$3C_2H_5OH + 2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow$$
$$3CH_3COOH + 2K_2SO_4 + 2Cr_2(SO_4)_3 + 11H_2O$$

- The excess potassium dichromate in the solution is back-titrated with ammonium iron thiosulphate solution.
- $6FeSO_4 + 7H_2SO_4 + K_2Cr_2O_7 = K_2SO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O$

Archer, M., de Vos, J., Visser M. The preparation, assay and certification of aqueous ethanol reference solutions. (April 2007). Accreditation and Quality Assurance

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Aqueous sodium fluoride certified reference materials For assessing blood sample preservation levels

GRAVIMETRIC & VOLUMETRIC PREPARATION WITH TITRIMETRIC ASSAY

- Aqueous sodium fluoride solutions are **prepared** by mixing known weights of pure sodium fluoride and organic-free water.
- Batches of five litres are prepared. The concentrations are then verified by a titrimetric method.
- The batches are **bottled** and **sealed**. Four aliquots of each batch analysed by the titrimetric method.
- Aliquots from 4 bottles throughout the batch are analysed by the titrimetric method (< 10 units per batch of 5 litres)

Archer, M., Brits, M., Prevoo-Franzsen, D., Quinn, L.P. High concentration aqueous sodium fluoride certified reference materials for forensic use certified by complexometric titration. (October 2014). *Analytical and Bioanalytical Chemistry*

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International Equivalence of South African National Measurement Standards for Forensic Alcohol

All data listed in the KCDB have been reviewed and approved within the CIPM Mutual Recognition Arrangement

GROUP ID	SERVICE PROVIDER	INSTITUTE SERVICE CODE	MATRIX	ANALYTE OR COMPONENT	QUANTITY	VALUE CMC
	South Africa **NMISA**	ORG-Q3-02	water	ethanol	Mass fraction	[1 to 20] g/100 g
	South Africa **NMISA**	ORG-Q3-05	single component organic solution (acetonitrile)	aflatoxin G1	Mass fraction	[10 to 100] µg/g
	South Africa **NMISA**	ORG-Q3-09	single component organic solution (ethylacetate)	deoxynivalenol	Mass fraction	[50 to 500] µg/g
	South Africa **NMISA**	ORG-Q3-07	single component organic solution (acetonitrile)	Zearalenone (ZEN)	Mass fraction	[10 to 100] µg/g
	South Africa **NMISA**	ORG-Q3-01	water	ethanol	Mass fraction	[5.00E-3 to 0.5] g/100 g
	South Africa **NMISA**	ORG-Q3-04	single component organic solution (acetonitrile)	aflatoxin B2	Mass fraction	[10 to 100] µg/g
	South Africa **NMISA**	ORG-Q3-08	single component organic solution (acetonitrile)	ochratoxin-A	Mass fraction	[10 to 100] µg/g
	South Africa **NMISA**	ORG-Q3-03	single component organic solution (acetonitrile)	aflatoxin B1	Mass fraction	[10 to 100] µg/g
	South Africa **NMISA**	ORG-Q3-06	single component organic solution (acetonitrile)	aflatoxin G2	Mass fraction	[10 to 100] µg/g
	South Africa **NMISA**	ORG-Q2-01	water	sodium fluoride	Mass concentration	[0.3 to 3] g/100 mL

QUALITY MANAGEMENT SYSTEM

ISO 17025
ACCREDITED
LABORATORY

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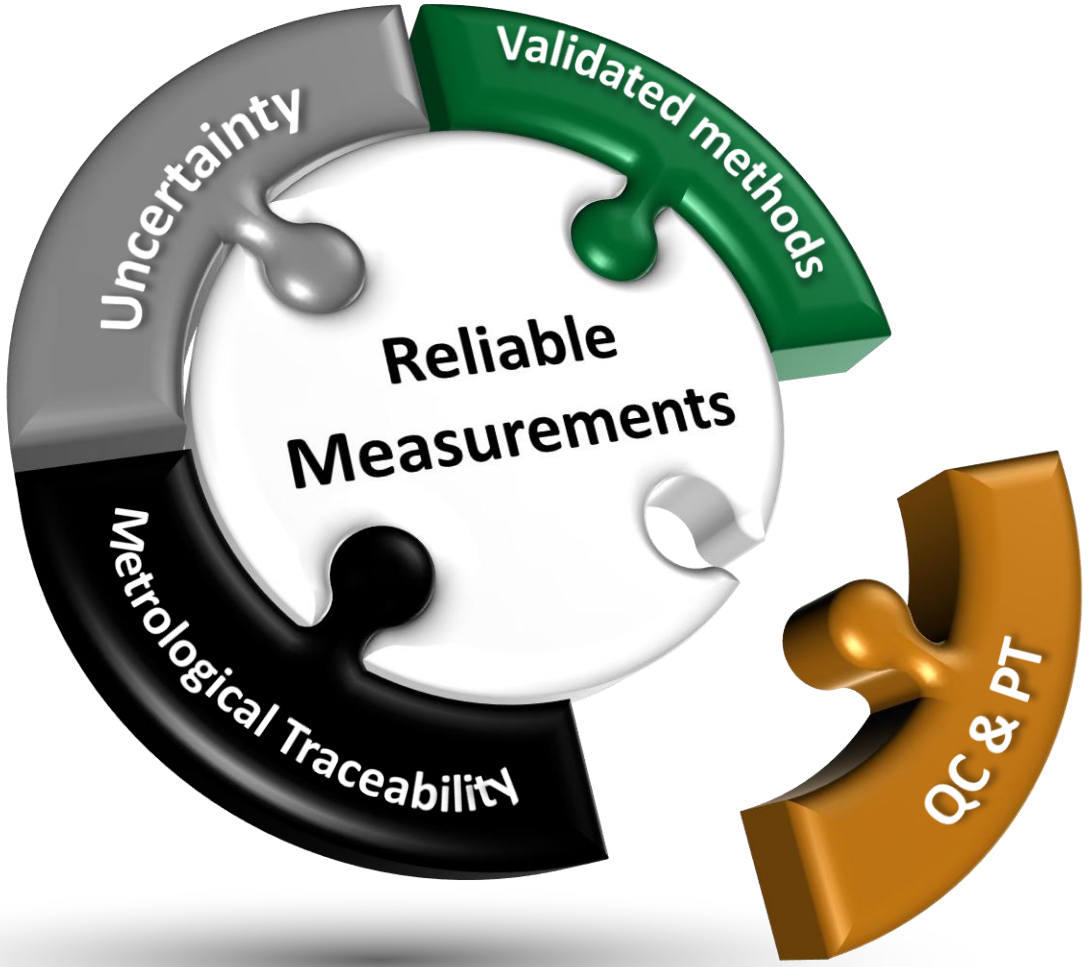

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Aqueous ethanol proficiency testing schemes

- In 2004, the NMISA coordinated the first ethanol PT scheme for forensic laboratories.
- The samples were relabelled blood and serum CRMs

- Only the laboratory that CRMs produced results within 5% of the certified value.
- This was convincing evidence for the other laboratories to stipulate the use EtOH CRMs on a routine basis.
- NMISA CRMs are accepted as prima facie evidence in court.

- The scheme was then offered annually and currently consists of three round per year with three different concentration levels per round.

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Proficiency testing

- NMISA accredited to ISO/IEC 17043 PT scheme providers
- Provides laboratories with an independent check on their analytical performance
- Primary aim is to provide laboratory with information to continuously monitor and improve the quality of measurements (analyst, instrument, environment)
- PTS providers are teachers not policemen!
- Schemes are confidential

|z| ≤ 2 is satisfactory;

|z| > 2 < 3 is questionable;

|z| > 3 is unsatisfactory.

- Performance statistics
- A z-score
- Standard deviation of proficiency assessment

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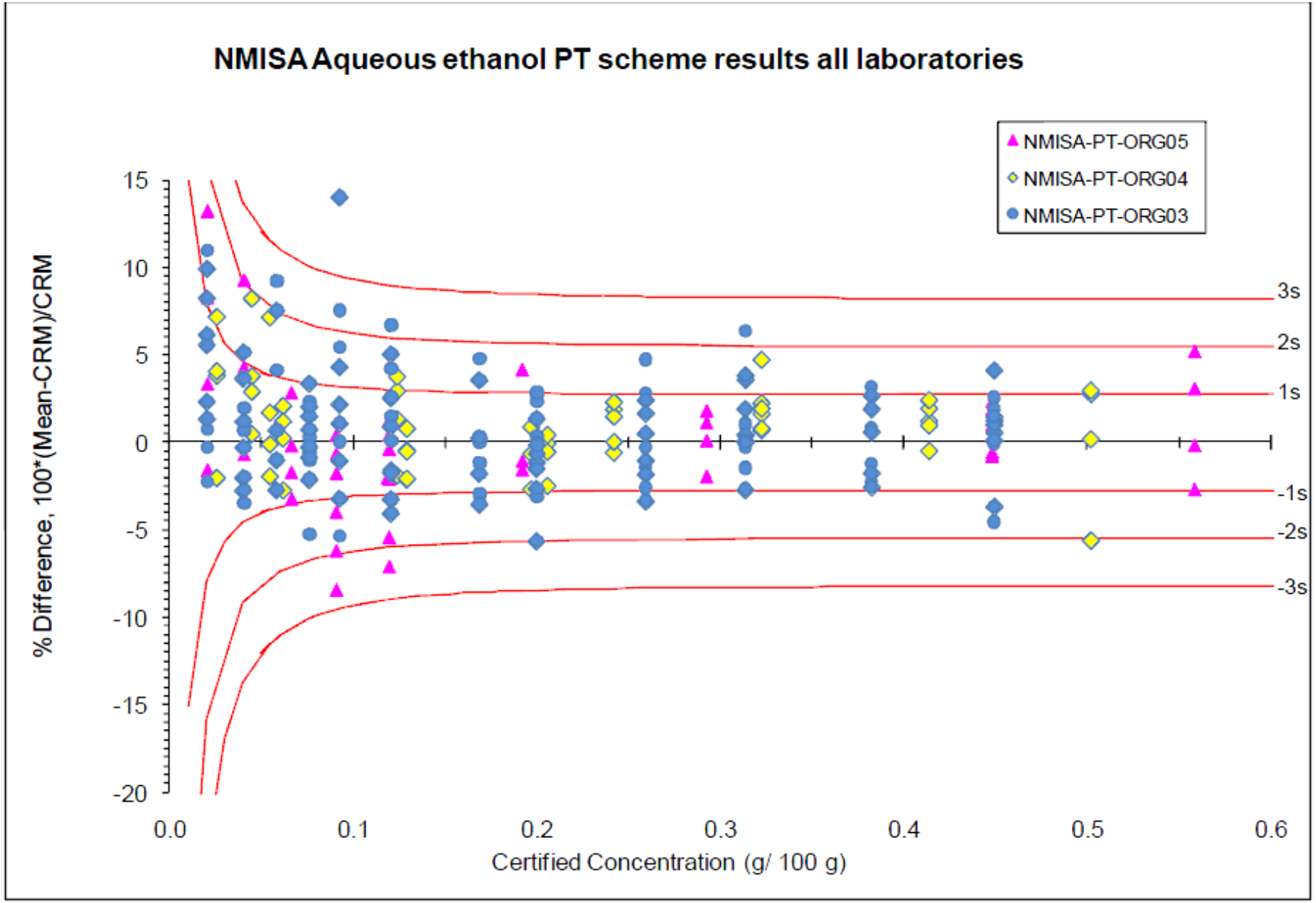

Figure 1: Results submitted from May 2007 to May 2010 for NMISA aqueous ethanol PT schemes, using the uncertainty limits proposed in report NMISA-09-0221.

Archer, M., Marajh, D., Visser M, Fernandes-Whaley, M.
Use of accumulated proficiency testing scheme results to evaluate laboratory performance in forensic ethanol analysis. (Nov 2017). *Journal of Chemical Metrology*

Anchor:
The PT assigned value is the metrologically traceable CRM concentration

Not limited by

- **Consensus values**
- **No. of participants**
- **Competency level**

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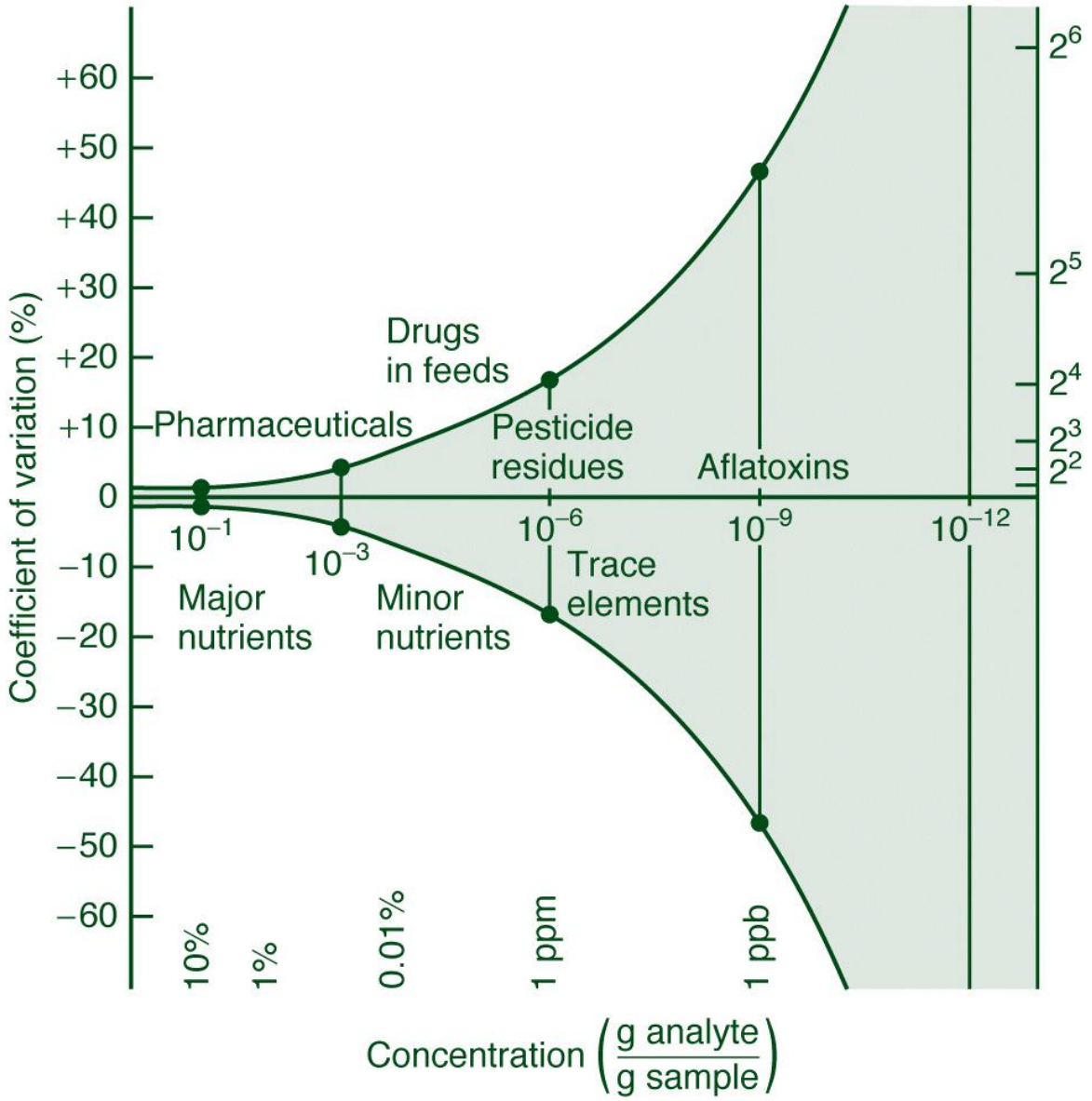
$$\sigma_R = 0{,}02c^{0{,}8495}$$

Horwitz model



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Ethanol concentration (g/ 100 ml)	2u = U	Rel 2u (%)	Horwitz 2s (%)
0,01	0,003002	30,0	16
0,02	0,003147	15,7	14
0,03	0,003374	11,2	14
0,04	0,003668	9,2	13
0,05	0,004014	8,0	13
0,06	0,004401	7,3	12
0,07	0,004818	6,9	12
0,08	0,005258	6,6	12
0,09	0,005717	6,4	11
0,1	0,006189	6,2	11
0,2	0,01127	5,6	10
0,3	0,01658	5,5	10
0,4	0,02195	5,5	9
0,5	0,02735	5,5	9
0,6	0,03277	5,5	9

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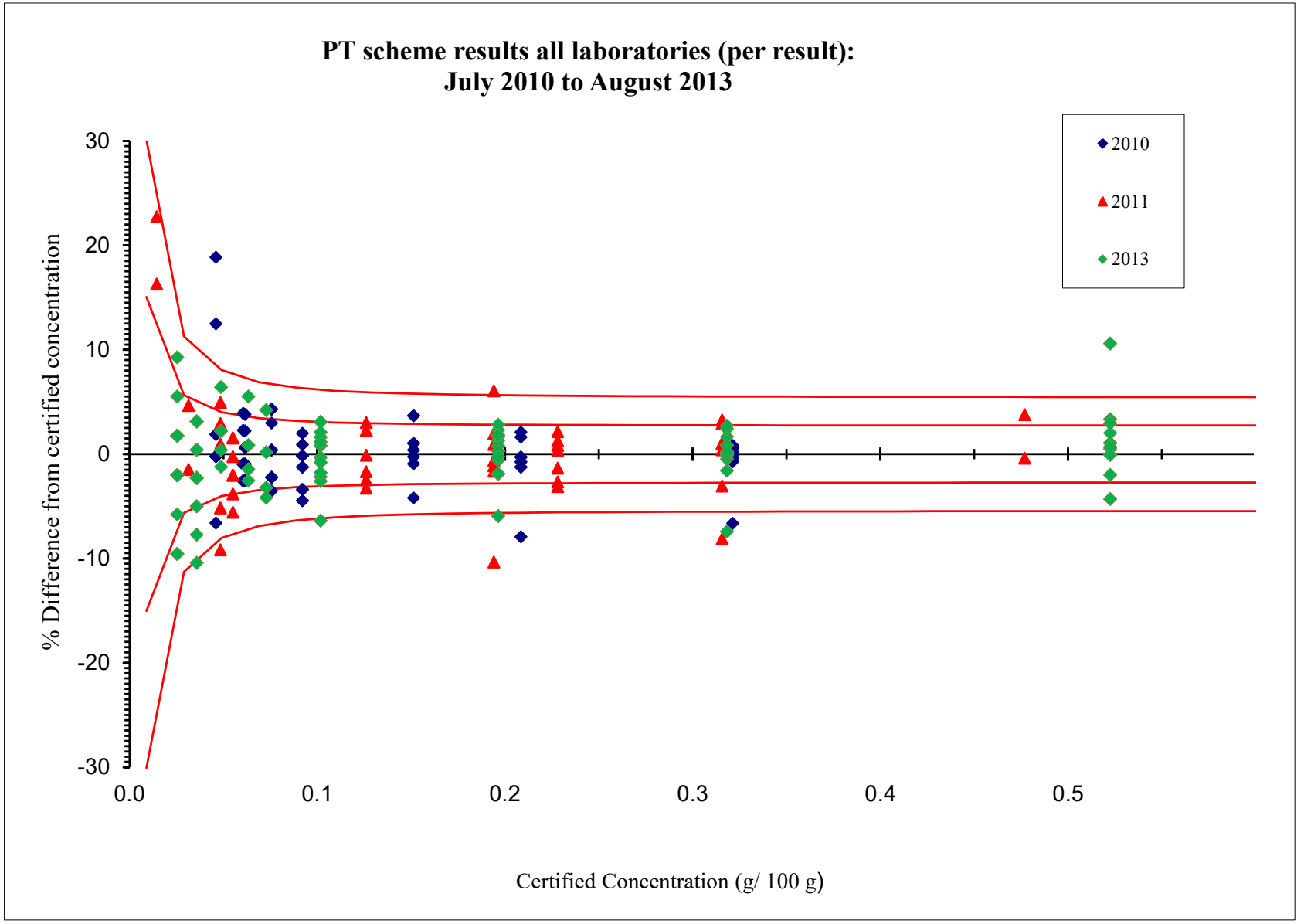
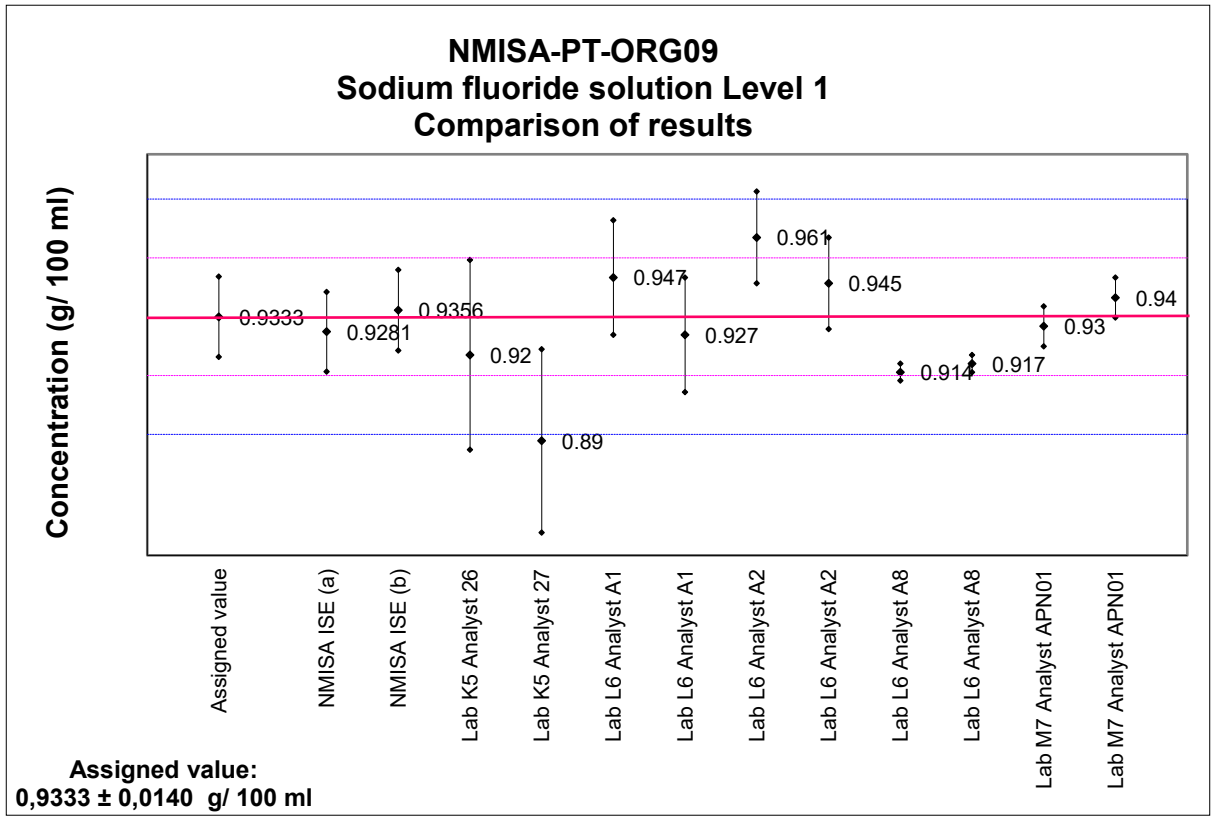


The continuous red lines closest to zero bias represent the expected ±1s limits. The continuous red lines furthest from zero bias represent the ±2s (expected U) limits. The s values are fixed from a combination of PT scheme result uncertainty and possible regression uncertainties.

Sodium fluoride proficiency testing

In 2012, the first sodium fluoride proficiency testing scheme was introduced by the NMISA.

- Confirming sufficient preservative is in blood sample (1%)
- Decomposition may lead to false positives



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Alcohol breath analysers

Daily Record

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Drivers warned of Easter treat that can trigger a false breathalyser test

The popular Easter snack, of which 20 million packs are sold every year, could land you in a pickle with the police

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Evidential breath analyser (EBA) – Drager 9510

- Measures the mass concentration of ethanol by analysing deep-lung air (exhaled air)
- EBAs shall be capable of expressing measurement results in terms of ethanol content in the exhaled breath
- Measurement unit as per SANS 1793:2013 is mg/L in breath
- The relationship between the blood alcohol content and the breath alcohol composition is governed by Henry's law
- "At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid"

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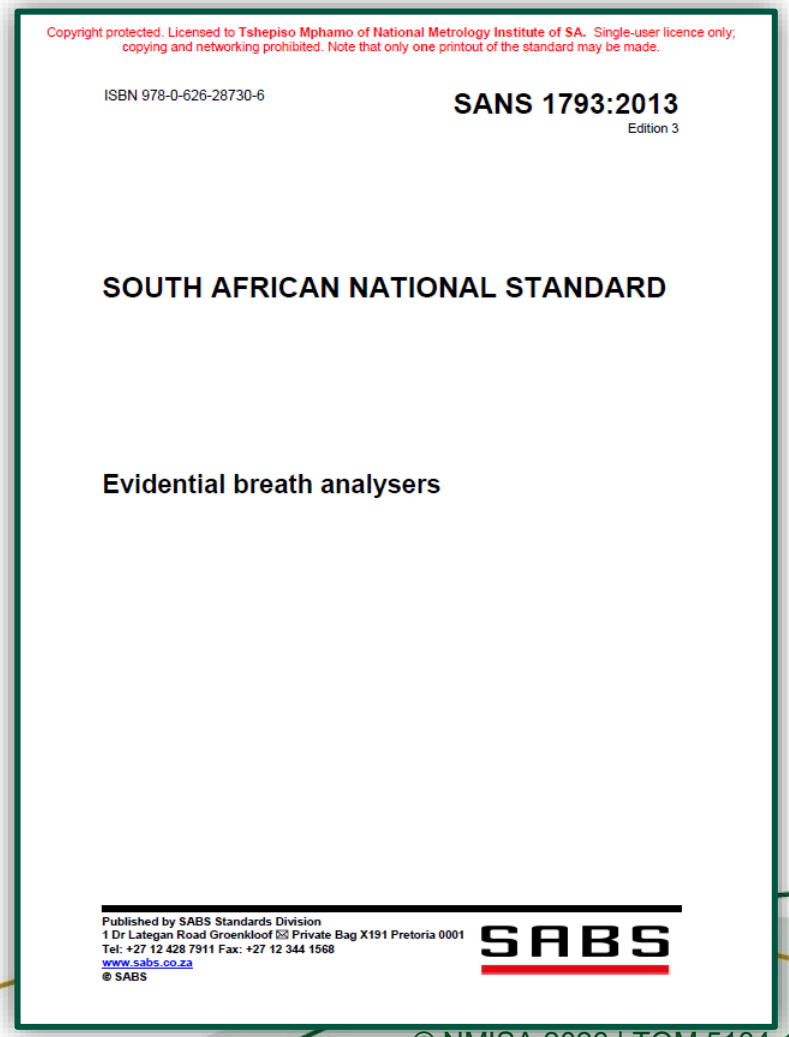
Evidential breath alcohol analyser calibration

- Calibration is based on SANS:1793:2013 (Evidential breath analysers)
- Calibrated using NMISA ethanol certified reference materials.
- Comparison with known values to determine accuracy
- The calibration is aimed at verifying the accuracy, repeatability and temperature conversion of the EBA sensors
- NMISA Gas Analysis Section ISO/IEC 17025 accredited through the South African National Accreditation System (1601)



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SANS 1793:2013
Edition 3

SOUTH AFRICAN NATIONAL STANDARD

Evidential breath analysers

Published by SABS Standards Division
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Tel: +27 12 428 7911 Fax: +27 12 344 1568
www.sabs.co.za
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Calibration of evidential breath analysers

Calibration process (wet gas method) – simulates human breath

- Three certified ethanol solutions are used : 0,1 mg/L, 0,24 mg/L and 0,8 mg/L range specified in SANS 1793:2013
- Zero calibration using deionised water
- Temperature conversion using 0,24 mg/L at 32 °C , 34 °C and 37 °C
- Traceable to SI through NMISA Organic Analysis Section (ISO 17034 RM accredited)

SANS 1793:2013 calibration requirements

- **Maximum permissible errors**
  - Deviation of ≤ 0,02 mg/L for all mass concentration less than 0,4 mg/L;
  - Deviation of ≤ 5 % of the measured concentration for all mass concentration greater than or equal to 0,4 mg/L, and less than or equal to 2,0 mg/L

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Accurate alcohol testing is exactly that …
A measurement

- **supporting policies & regulations that keep our roads and workplaces safe,**
- **that must be reliable for all people:**
  the driver at a roadblock, the mineworker at a gate, the accused in a labour Court.

CERTIFIED REFERENCE MATERIALS (CRMs)

- Ethanol CRM: primary standard for breath and blood alcohol measurement
- Sodium Fluoride CRM: forensic blood sample preservative
- SI-traceable, ISO 17034 CRM accredited
- Underpins both workplace, roadside and forensic laboratory testing

PROFICIENCY TESTING SCHEMES (PTs)

- Forensic blood alcohol PT scheme
- Evidential breathanalyser PT scheme
- SI-traceable, ISO 17043 PT accredited
- Enables independent verification of OEM/ calibration lab performance
- Provides the metrological reference value courts require

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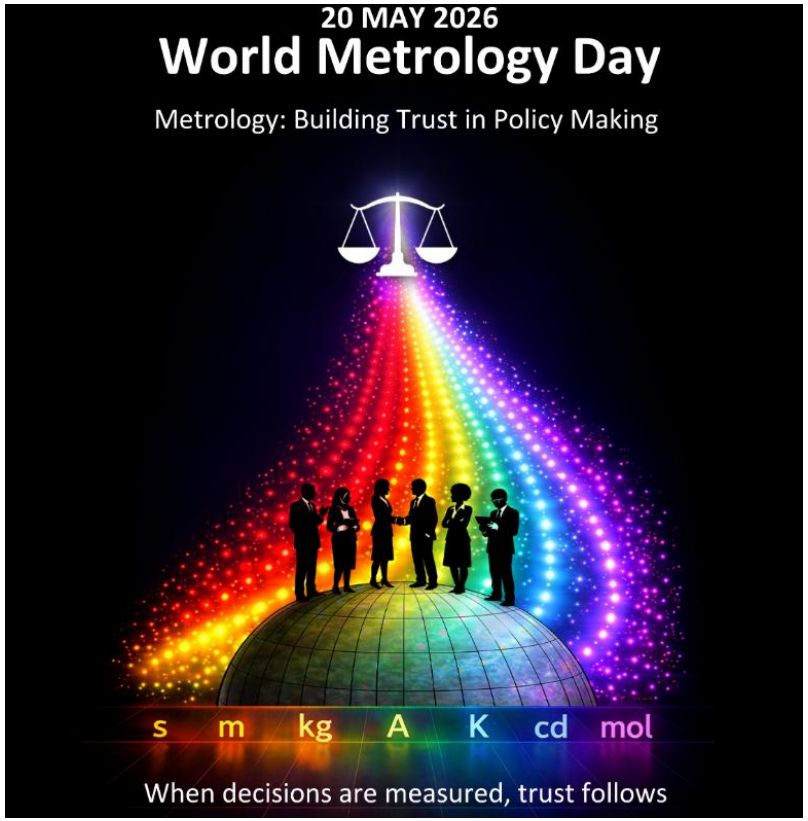
With sincere appreciation to



the NMISA Chemistry team
that have over the years through their hard work and dedication delivered these vital services to our law enforcement agencies, helping to keep our roads and workplaces safe!

the RTMC, Drager, Municipalities and Breathalyser clients

the National Department of Health -
NHLS Forensic pathology laboratories

Thank you for your participation!

www.nmisa.org

Happy World Metrology Day!

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