VSL

# Gas Metrology

*SI-traceable:*
*Primary Reference Materials*
*Certified Reference Materials*
*Calibrated Gas Mixtures*
*Interlaboratory Comparisons*

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This guide provides a comprehensive overview of our program of binary and multicomponent gas mixtures.

Specific gas compositions may be prepared according to your specifications.

Do you want to know more about our services or order your gas mixture? Please contact us at:

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# Index



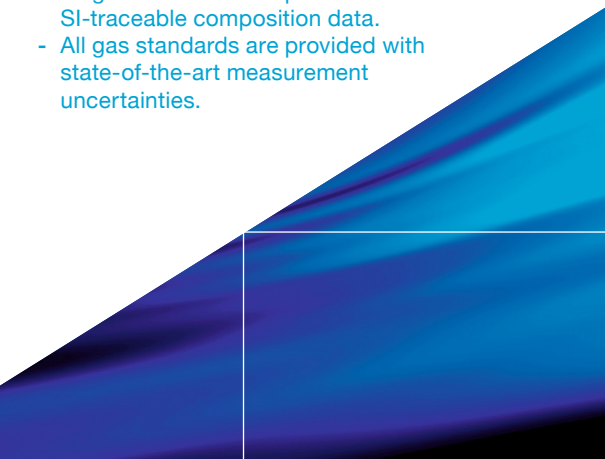


# Gas mixtures traceable to international standards

Traceability of your measurement results requires traceable measurement standards and calibration. VSL provides a wide range of such standards to address your gas analysis needs.

VSL supplies a wide program of Primary Reference Materials (PRMs), Certified Reference Materials (CRMs) and Calibrated Gas Mixtures (CGMs). By ordering your reference materials at VSL, you are assured that the measurement uncertainty is kept to a minimum and that your measurement results are traceable to international standards. VSL's gas standards are used worldwide to provide metrological comparability of measurement results. Of course they can also be used for method evaluation and validation.

- All gas standards are provided with SI-traceable composition data.
- All gas standards are provided with state-of-the-art measurement uncertainties.



# (PRMs) Primary Reference Materials

PRMs have a very small measurement uncertainty and will help you to realise a state-of-the-art international traceability of your measurement results. VSL supplies almost any desired composition of, for example, environmental and energy gases. After the preparation of the PRM its mixture composition is verified against VSL's own primary standard gas mixtures to confirm the assigned value and stated measurement uncertainty.

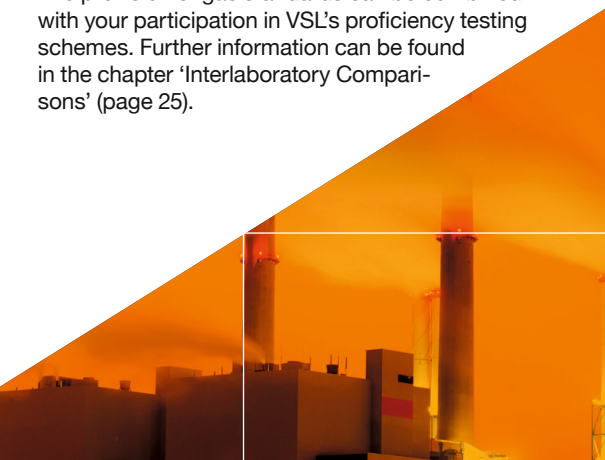
- PRMs represent the highest grade gas standards.
- PRMs are prepared gravimetrically based on your specification of the composition, performed in accordance with ISO 6142-1:2015.
- PRMs always come with a warranty regarding the mixture stability period.
- A Declaration of Equivalence (DoE) between NIST and VSL is in place for a range of gas mixtures. This DoE ensures that PRMs can be used for applications related to US legislation.

# (CRMs) Certified Reference Materials

CRMs are an undisputed foundation for your quality system and ensure international traceability of your measurement results. VSL supplies almost any desired composition of, for example, environmental and energy gases. The values of the composition are assigned based on a characterisation of the mixture using VSL's own primary standard gas mixtures or, in case of water, primary standard of humidity. CRMs are in particular provided for those ranges and components for which no PRMs are available.

- CRMs are prepared gravimetrically based on your specification of the composition, performed in accordance with ISO 6142-1:2015.
- CRMs always come with a warranty regarding the mixture stability.

The provision of gas standards can be combined with your participation in VSL's proficiency testing schemes. Further information can be found in the chapter 'Interlaboratory Comparisons' (page 25).



# (CGMs) Calibrated Gas Mixtures

CGMs are gas mixtures prepared by a third party. VSL can analyse and calibrate your gas mixture. CGMs are characterised using VSL's primary standard gas mixtures.

- The certificate provides information on the composition and measurement uncertainty of the gas mixture.
- Accreditation in accordance with ISO/IEC 17025 for most mixtures.
- State-of-the-art measurement uncertainties.

# Accreditations and recognitions

## Mutual Recognition Arrangement

VSL may provide you with a wide range of gaseous reference materials. Please see VSL's Calibration and Measurement Capabilities (CMCs) that are included in Appendix C of the Mutual Recognition Arrangement (MRA) drawn up by the International Committee for Weights and Measures (CIPM). All participating countries recognize the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified.

VSL holds an accreditation on the basis of ISO Guide 34 (RvA P002) for its PRM and CRM services, and on the basis of ISO/IEC 17025 (RvA K999) for CGMs and other calibration services.

Accreditations evidence the high quality standards that VSL is able to supply gaseous reference materials. Unless otherwise indicated, all gas standards are provided under accreditation.

# NIST – VSL: Declaration of Equivalence

The U.S. National Institute of Standards and Technology (NIST) and VSL have signed a Memorandum of Cooperation for regular intercomparisons of their Primary Standard Gas Mixtures. As a result a Declaration of Equivalence (DoE) was signed. The declaration is based on the results of both BIPM (CCQM) Key Comparisons and intercomparisons carried out between the two institutes.

In conformity with the US EPA Clean Air Act, reference gas mixtures that are traceable to NIST must be used for certain measurements. Via the DoE, gas mixtures originating from 'VSL in The Netherlands' also comply. VSL is the only metrology institute outside the US with this status. The DoE is renewed biannually.

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

NIST and VSL Primary Gas Mixture Suites that are declared to be Equivalent, in conformity with the US EPA Clean Air Act.

| Certified component in nitrogen | Range | Uncertainty (% relative) |
|---|---|---|
| **hydrogen sulfide** | 10 to 1000 ppm | ≤ 1.0 |
| **natural gas** | Typical | ≤ 0.5 |
| **methane** | Typical | ≤ 0.3 |
| **nitric oxide** | 0.5 ppm to 1% | ≤ 0.5 |
| **oxygen** | 10 ppm to 25% | ≤ 0.2 |
| **sulfur dioxide** | 1 ppm to 1% | ≤ 0.5 |
| **carbon dioxide** | 10 ppm to 20% | ≤ 0.3 |
| **carbon monoxide** | 1 ppm to 10% | ≤ 0.3 |
| **ethanol** | 75 to 500 ppm | ≤ 0.5 |
| **nitrogen dioxide** | 10 ppm to 1% | ≤ 0.5 |
| **propane** | 1 ppm to 1% | ≤ 0.3 |
| **volatile organic compounds** | 1 ppb to 1 ppm | ≤ 2 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

NIST and VSL Primary Gas Mixture Suites that are declared to be Equivalent, in conformity with the US EPA Clean Air Act.

| Certified component in air | Range | Uncertainty (% relative) |
|---|---|---|
| **carbon monoxide** | 1 ppm to 10 % | ≤ 0.3 |
| **ethanol** | 75 to 500 ppm | ≤ 0.5 |
| **nitrogen dioxide** | 10 ppm to 1 % | ≤ 0.5 |
| **propane** | 1 ppm to 1 % | ≤ 0.3 |
| **carbon dioxide** | 100 to 500 ppm | ≤ 0.5 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Stability warranty

For all components in gas mixtures provided as PRMs and CRMs, VSL studied their behaviour over time. The stability data generated over time forms the basis of our warranty for the stability of the mixture's composition. It is VSL's assurance to you that you can use the gas standard for the entire period of validity of the certificate as long as the pressure remains above 1 MPa.

## Recommended use

VSL recommends using its gas standards in accordance with the documentary standard ISO 16664. In doing so, you will benefit most from the quality of the gas standard supplied by VSL. Furthermore, this will ensure that the certificate provided remains valid until reaching its expiry date or the minimum utilisation pressure.

# Interlaboratory Comparisons

Laboratories strive for optimum quality of instruments, procedures and measurement capabilities. Audits are held regularly to ensure consistent quality. Different accreditation organisations and ISO/IEC 17025 demand participation in what are known as Proficiency Tests (PT schemes), in which the measurement results are compared anonymously to those from other laboratories and deviations are tracked down. Interlaboratory comparisons enable participants to have their performance independently verified and confirmed, which is not only important to underpin present accreditations, but also for trading products and customer confidence.

# Accredited PT provider

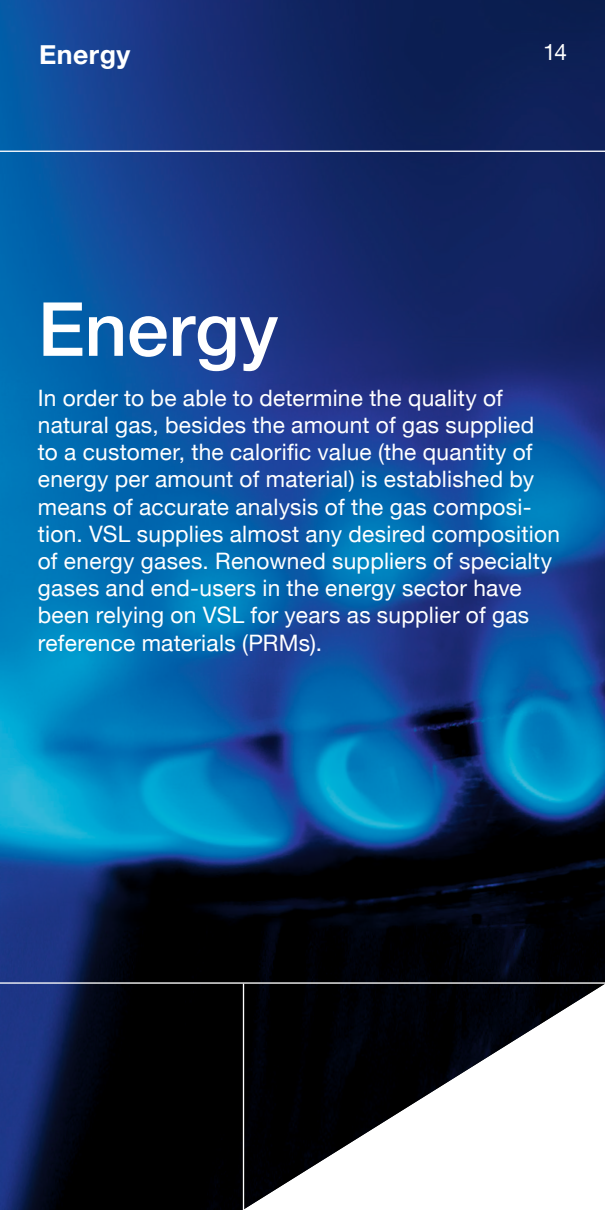
VSL is an accredited organizer (ISO/IEC 17043) of interlaboratory comparisons with over 30 years experience. The provision of gas standards can be combined with participation in our Proficiency Test schemes (PT on demand).

## About Proficiency Testing

During a Proficiency Test, all participating laboratories perfrom analyses on the same type of sample under test. The results are benchmarked against an independently determined traceable reference value. Participants receive their own data, so that they can compare their results anonymously with those from other laboratories. The data are handled confidentially and are only made available to the laboratory itself.

# Energy

In order to be able to determine the quality of natural gas, besides the amount of gas supplied to a customer, the calorific value (the quantity of energy per amount of material) is established by means of accurate analysis of the gas composition. VSL supplies almost any desired composition of energy gases. Renowned suppliers of specialty gases and end-users in the energy sector have been relying on VSL for years as supplier of gas reference materials (PRMs).



## PT scheme natural gas

Twice a year, approximately 25 laboratories participate in this PT scheme. Each participant is supplied with a gas cylinder to analyze its gas composition. VSL subsequently evaluates the results and rates the performance. This PT can be used to fulfill requirements of international standards (e.g.: ASTM D1945, GPA2261, GPA2286, ISO 6974, ISO 10723) and all in house methods for (liquefied) natural gas composition measurement.

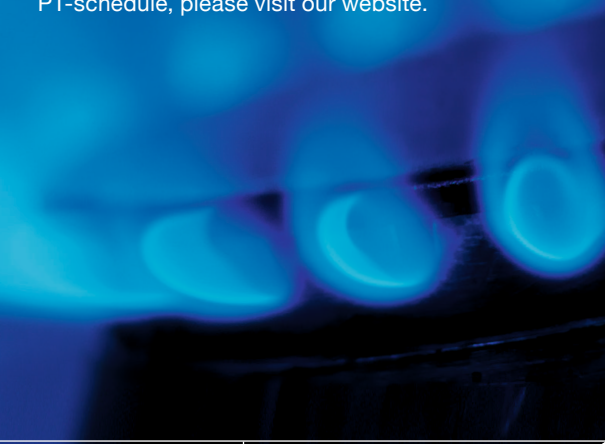
## PT scheme sulfur compounds in natural gas

This international PT scheme allows you to evaluate the analytical performance of your laboratory in analyzing sulfur compounds found in natural gas. It can be used to evaluate methods prescribed in various international standards (e.g.: ASTM D5504, D6968, ISO 19739) and all in house developed methods for the determination of sulfur compounds in natural gas.

## PT Refinery Gas

A specific PT scheme is available for refinery type gas compositions. Being different in composition and requiring dedicated GC techniques, participation in this Refinery Gas PT will be highly informative in evaluating your laboratory performance. It will again be helpful to fulfill requirements in international standards and all in house methods for refinery gas composition measurements (e.g.: ASTM D1945, GPA2261, GPA2286, ISO 6974, ISO 17023, DIN 51666, EN 15984).

For information on our current planning of the PT-schedule, please visit our website.



# Energy
## Synthetic natural gas

Primary Reference Materials (PRMs) containing Synthetic Natural Gases have a guaranteed stability period of 5 years.

| Certified component | Range (% mol/mol) | Uncertainty (% relative) |
|---|---|---|
| **methane** | 60.0 to 99.9 | ≤ 0.15 |
| **ethane** | 0.25 to 11.0 | ≤ 0.2 to 0.5 |
| **propane** | 0.10 to 10.0 | ≤ 0.2 to 0.5 |
| **i-butane** | 0.03 to 0.70 | ≤ 0.2 to 0.5 |
| **n-butane** | 0.03 to 0.70 | ≤ 0.2 to 0.5 |
| **i-pentane** | 0.02 to 0.80 | ≤ 0.2 to 0.5 |
| **n-pentane** | 0.02 to 0.80 | ≤ 0.2 to 0.5 |
| **neo-pentane** | 0.02 to 0.80 | ≤ 0.5 to 1.0 |
| **n-hexane** | 0.01 to 0.40 | ≤ 0.2 to 0.5 |
| **n-heptane** | 25 to 200 µmol/mol | ≤ 2.0 |
| **n-octane** | 15 to 100 µmol/mol | ≤ 2.0 |
| **n-nonane** | 10 to 25 µmol/mol | ≤ 2.0 |
| **n-decane** | 5 to 20 µmol/mol | ≤ 2.0 |
| **carbon dioxide** | 0.10 to 20.0 | ≤ 0.5 to 0.2 |
| **nitrogen** | 0.10 to 20.0 | ≤ 0.2 to 0.7 |
| **helium** | 0.05 to 0.40 | ≤ 0.5 to 1.0 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Energy
## Sulfur components in methane

Primary Reference Materials (PRMs) containing sulfur component have a guaranteed stability period of 2 years.

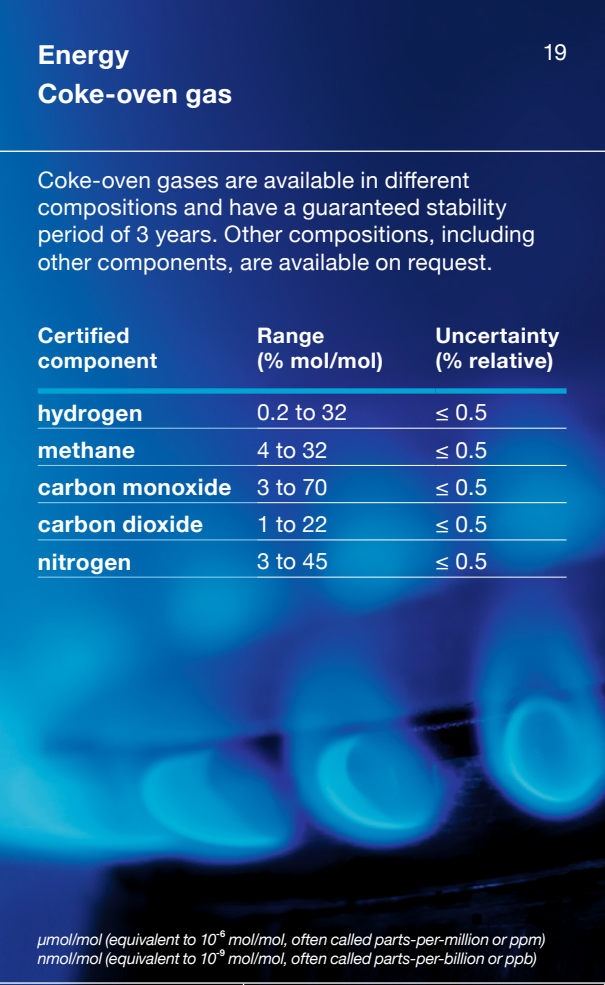
| Certified component | Range (µmol/mol) | Uncertainty (% relative) |
|---|---|---|
| **hydrogen sulfide** | 10 to 50 | ≤ 3.0 |
| **carbonyl sulfide** | 10 to 50 | ≤ 3.0 |
| **methyl mercaptan** | 10 to 50 | ≤ 3.0 |
| **ethyl mercaptan** | 10 to 50 | ≤ 3.0 |
| **dimethyl sulfide** | 10 to 50 | ≤ 3.0 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Energy
# Coke-oven gas

Coke-oven gases are available in different compositions and have a guaranteed stability period of 3 years. Other compositions, including other components, are available on request.

| Certified component | Range (% mol/mol) | Uncertainty (% relative) |
|---|---|---|
| **hydrogen** | 0.2 to 32 | ≤ 0.5 |
| **methane** | 4 to 32 | ≤ 0.5 |
| **carbon monoxide** | 3 to 70 | ≤ 0.5 |
| **carbon dioxide** | 1 to 22 | ≤ 0.5 |
| **nitrogen** | 3 to 45 | ≤ 0.5 |



*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

Biogases are available in different compositions and have a guaranteed stability period of 3 years. Other compositions, including other components, are available on request.

| Certified component | Range (% mol/mol) | Uncertainty (% relative) |
|---|---|---|
| **carbon dioxide** | 10 to 50 | ≤ 0.5 |
| **methane** | 50 to 75 | ≤ 0.5 |
| **nitrogen** | 1 to 25 | ≤ 1.0 |
| **hydrogen** | 0.1 to 2 | ≤ 1.0 |
| **oxygen** | 0.1 to 2 | ≤ 2.0 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Energy
## Synthetic refinery gas

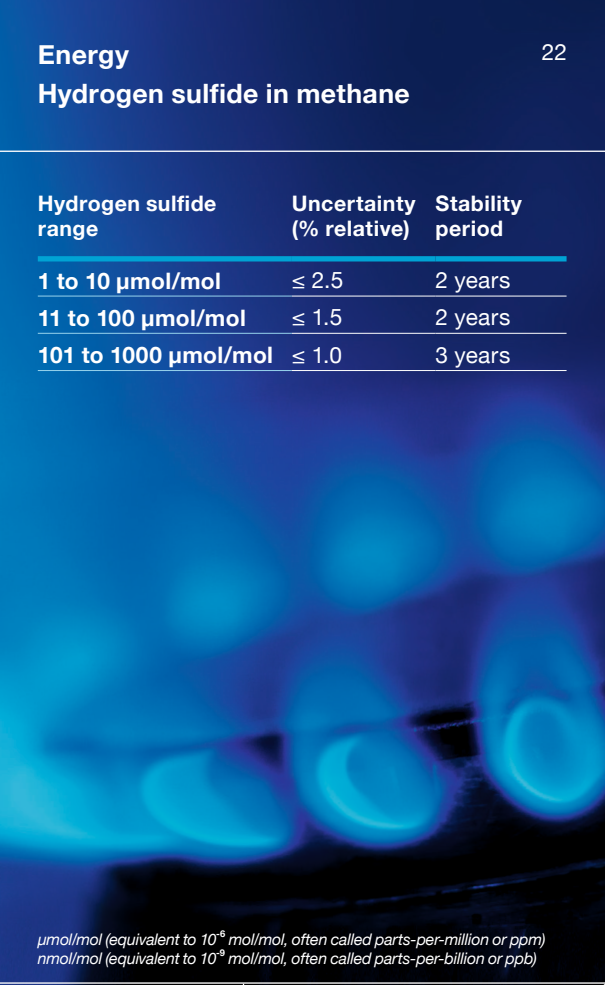
Synthetic refinery gases are available in different compositions and have a guaranteed stability period of 3 years. Other compositions, including other components, are available on request.

| Certified component | Range (% mol/mol) | Uncertainty (% relative) |
|---|---|---|
| **methane** | 10 to 13 | ≤ 0.3 |
| **ethene** | 12 to 16 | ≤ 0.3 |
| **propene** | 3 to 5 | ≤ 0.3 |
| **propane** | 0.4 to 0.7 | ≤ 0.3 |
| **1,3-butadiene** | 0.75 to 1.5 | ≤ 0.5 |
| **1-butene** | 0.40 to 0.65 | ≤ 0.5 |
| **i-butene** | 0.40 to 0.65 | ≤ 0.5 |
| **hydrogen** | 7 to 9 | ≤ 0.4 |
| **nitrogen** | 3.5 to 4.5 | ≤ 0.3 |
| **helium** | 50 to 60 | ≤ 0.3 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Energy
## Hydrogen sulfide in methane

| Hydrogen sulfide range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **1 to 10 µmol/mol** | ≤ 2.5 | 2 years |
| **11 to 100 µmol/mol** | ≤ 1.5 | 2 years |
| **101 to 1000 µmol/mol** | ≤ 1.0 | 3 years |

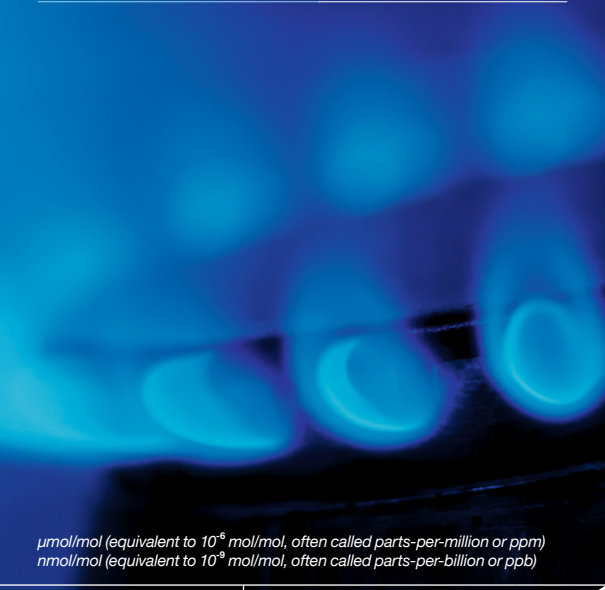


*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Energy
# Moisture in methane

The Certified Reference Material (CRM) is prepared by VSL and the molar amount fraction of $H_2O$ is traceable to the primary humidity standard at VSL.

| Moisture range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **20 to 50 µmol/mol** | ≤ 5.0 | 2 years |

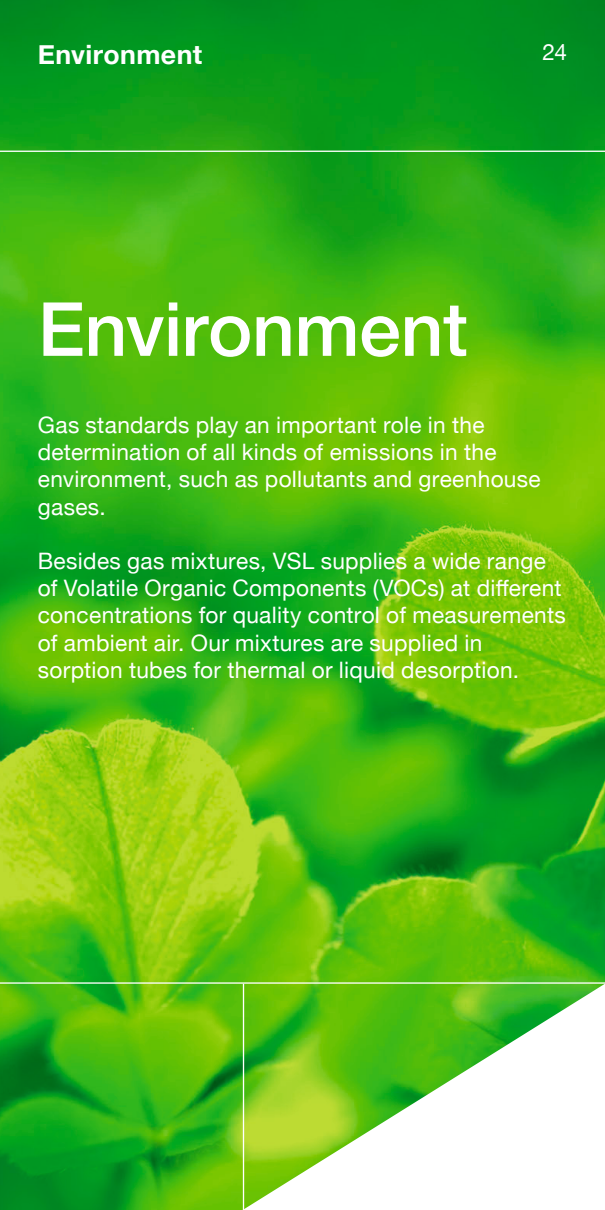


*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Environment

Gas standards play an important role in the determination of all kinds of emissions in the environment, such as pollutants and greenhouse gases.

Besides gas mixtures, VSL supplies a wide range of Volatile Organic Components (VOCs) at different concentrations for quality control of measurements of ambient air. Our mixtures are supplied in sorption tubes for thermal or liquid desorption.



## Proficiency Test Schemes

For binary gas mixtures, VSL organizes about 2 to 3 different Proficiency Tests each year. Components and compositions vary from year to year. Participants of these PTs are typically specialty gas suppliers and (calibration) laboratories performing calibrations on analyzers in the laboratory or in the field.

## On demand PT in Gas Analysis

Any PRM, CRM or CGM can in principle be used as a proficiency test (PT) sample. In practice, this means that a range for the target composition can be specified by the customer, after which e.g. a PRM will be prepared and undergo subsequent certification, just as usual. Instead of providing the certificate with the PRM, the PRM is sent first for the bilateral PT. Once the PRM has been analyzed by the customer and results have been received, a report on the PT is issued, and sent together with the PRM certificate. Please consult our technical staff first, to assess the eligibility of the gas mixture for proficiency testing.

For information on our current planning of the PT-schedule, please visit our website.

| Carbon monoxide range in nitrogen | Uncertainty (% relative) | Stability period |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 1.0 | 4 years |
| 11 to 100 µmol/mol | ≤ 0.3 | 4 years |
| 101 to 1000 µmol/mol | ≤ 0.2 | 5 years |
| 0.11 to 1 % mol/mol | ≤ 0.2 | 5 years |
| 1.1 to 10 % mol/mol | ≤ 0.1 | 5 years |

| Carbon monoxide range in synthetic air | | |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 1.0 | 2 years |
| 11 to 100 µmol/mol | ≤ 0.3 | 2 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Environment
# Carbon dioxide

| Carbon dioxide range in nitrogen | Uncertainty (% relative) | Stability period |
|---|---|---|
| 10 to 100 µmol/mol | ≤ 0.4 | 4 years |
| 101 to 1000 µmol/mol | ≤ 0.2 | 5 years |
| 0.11 to 20 % mol/mol | ≤ 0.1 | 5 years |
| **Carbon dioxide range in synthetic air** | | |
| 100 to 1000 µmol/mol | ≤ 0.2 | 5 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Nitric oxide in nitrogen

| Nitric oxide range | Uncertainty (% relative) | Stability period |
|---|---|---|
| 0.1 to 0.40 µmol/mol | ≤ 3.6 | 1 year |
| 0.41 to 1 µmol/mol | ≤ 3.0 | 2 years |
| 1.1 to 10 µmol/mol | ≤ 1.0 | 2 years |
| 11 to 100 µmol/mol | ≤ 0.5 | 3 years |
| 101 to 1000 µmol/mol | ≤ 0.3 | 4 years |
| 0.11 to 1 % mol/mol | ≤ 0.2 | 5 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Environment
# Nitrogen dioxide

| Nitrogen dioxide range in nitrogen | Uncertainty (% relative) | Stability period |
|---|---|---|
| **10 to 100 µmol/mol** | ≤ 2.0 | 12 months |
| **101 to 1000 µmol/mol** | ≤ 1.0 | 2 years |

| Nitrogen dioxide range in synthetic air | | |
|---|---|---|
| **10 to 100 µmol/mol** | ≤ 2.0 | 12 months |
| **101 to 1000 µmol/mol** | ≤ 1.0 | 2 years |

Please note that mixtures of $NO_2$ in nitrogen also contain approximately 1000 µmol/mol oxygen.

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

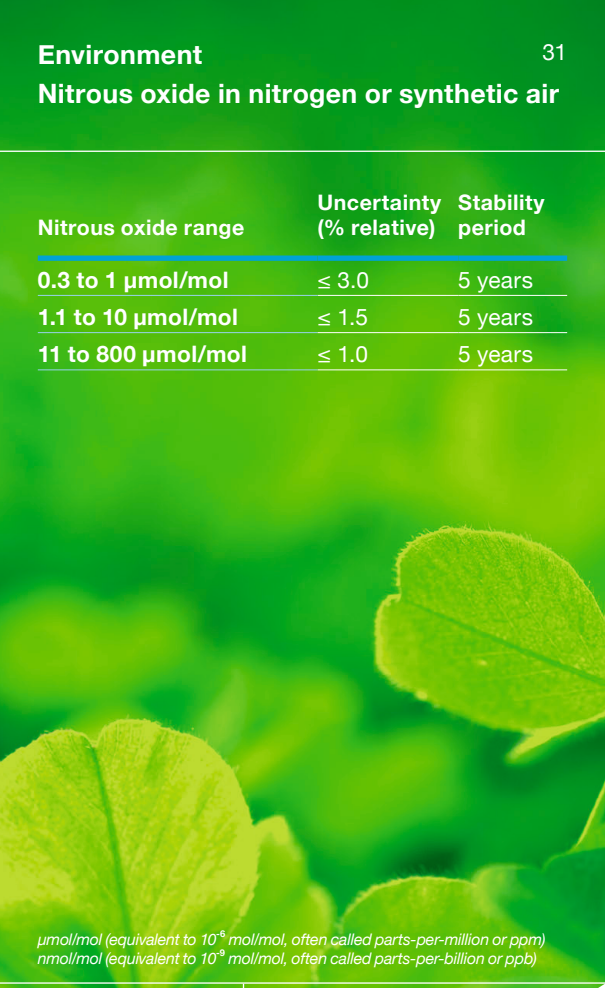
| Sulfur dioxide range in nitrogen | Uncertainty (% relative) | Stability period |
|---|---|---|
| 1 µmol/mol | ≤ 2.0 | 12 months |
| 2 to 9.5 µmol/mol | ≤ 1.5 | 12 months |
| 10 µmol/mol | 0.5 | 18 months |
| 11 to 100 µmol/mol | ≤ 0.5 | 2 - 3 years |
| 101 to 1000 µmol/mol | ≤ 0.3 | 4 years |
| 0.11 to 1 % mol/mol | ≤ 0.2 | 5 years |

| Sulfur dioxide range in synthetic air | | |
|---|---|---|
| 10 µmol/mol | ≤ 0.5 | 18 months |
| 11 to 100 µmol/mol | ≤ 0.5 | 2 - 3 years |
| 101 to 1000 µmol/mol | ≤ 0.3 | 3 years |
| 0.11 to 1 % mol/mol | ≤ 0.2 | 4 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Nitrous oxide in nitrogen or synthetic air

| Nitrous oxide range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **0.3 to 1 µmol/mol** | ≤ 3.0 | 5 years |
| **1.1 to 10 µmol/mol** | ≤ 1.5 | 5 years |
| **11 to 800 µmol/mol** | ≤ 1.0 | 5 years |

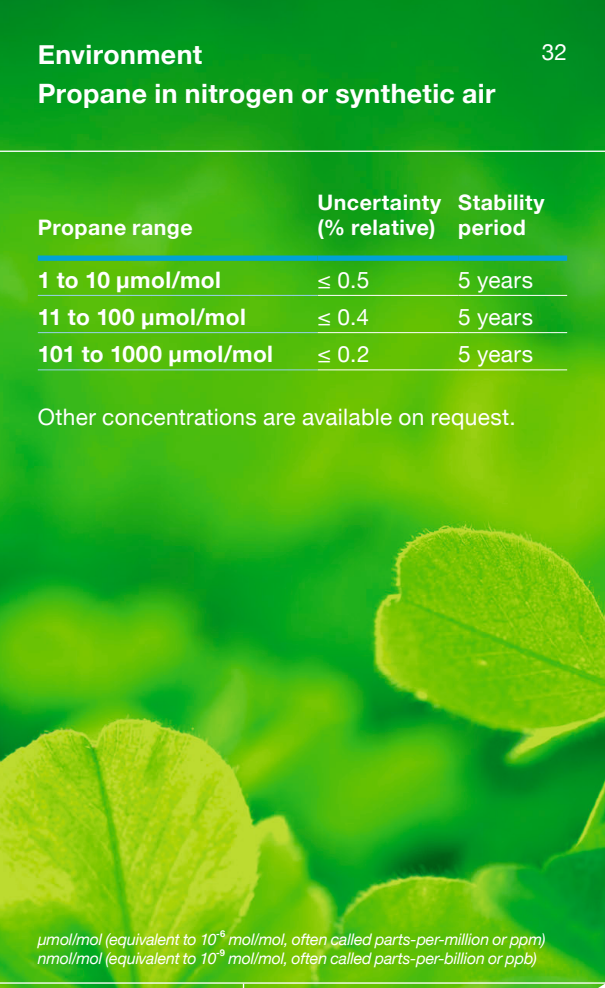


*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Propane in nitrogen or synthetic air

| Propane range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **1 to 10 µmol/mol** | ≤ 0.5 | 5 years |
| **11 to 100 µmol/mol** | ≤ 0.4 | 5 years |
| **101 to 1000 µmol/mol** | ≤ 0.2 | 5 years |

Other concentrations are available on request.

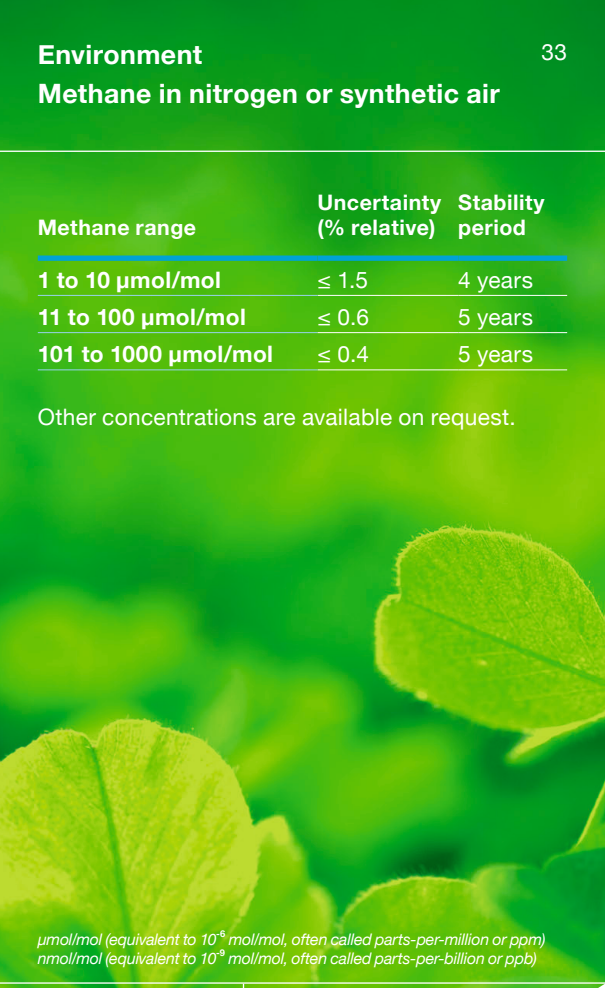


*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Methane in nitrogen or synthetic air

| Methane range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **1 to 10 µmol/mol** | ≤ 1.5 | 4 years |
| **11 to 100 µmol/mol** | ≤ 0.6 | 5 years |
| **101 to 1000 µmol/mol** | ≤ 0.4 | 5 years |

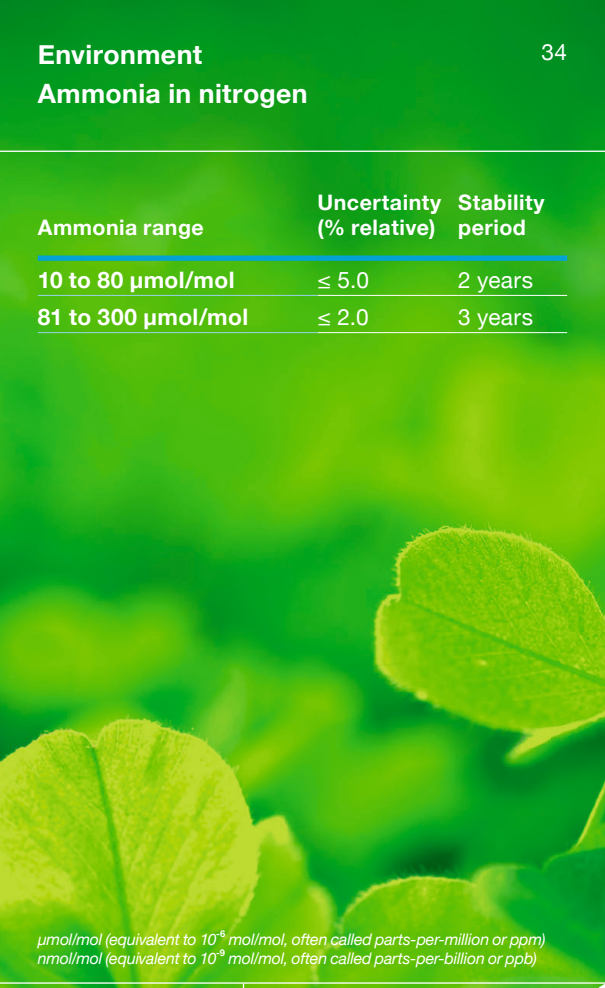
Other concentrations are available on request.



*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Ammonia in nitrogen

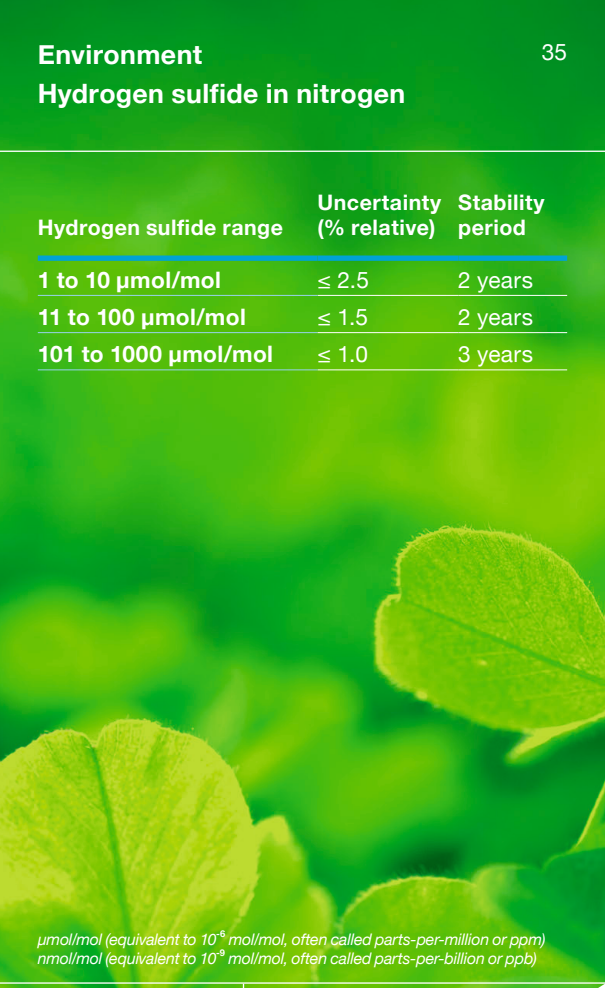
| Ammonia range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **10 to 80 µmol/mol** | ≤ 5.0 | 2 years |
| **81 to 300 µmol/mol** | ≤ 2.0 | 3 years |



*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Hydrogen sulfide in nitrogen

| Hydrogen sulfide range | Uncertainty (% relative) | Stability period |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 2.5 | 2 years |
| 11 to 100 µmol/mol | ≤ 1.5 | 2 years |
| 101 to 1000 µmol/mol | ≤ 1.0 | 3 years |



*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Volatile Organic Compounds (VOCs)

VSL offers a PRM with 30 Volatile Organic Compounds as listed in the European Directive covering ambient ozone measurements (Directive 2002/3/EC) in nitrogen. Within the listed range any composition can be supplied.

| Range | Uncertainty (% relative) | Stability period |
|---|---|---|
| 2 to 1000 nmol/mol | ≤ 5.0 | 3 years |

**Certified components**

| | |
|---|---|
| benzene | ethene |
| ethylbenzene | ethyne |
| 1,3,5-trimethylbenzene | n-octane |
| 1,2,4-trimethylbenzene | i-octane |
| n-butane | propane |
| i-butane | propene |
| 1-butene | n-pentane |
| i-butene | i-pentane |
| trans-2-butene | 1-pentene |
| cis-2-butene | 2-methyl-pentane |
| 1,3-butadiene | trans-2-pentene |
| 2-methyl-1,3-butadiene | toluene |
| n-heptane | m-xylene |
| n-hexane | o-xylene |
| ethane | p-xylene |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Oxygenated Volatile Organic Compounds

VSL offers a PRM with 3 oxygenated volatile organic compounds in nitrogen, with a guaranteed stability period of 2 years. Within the listed ranges any composition can be supplied.

| Certified components | Range (µmol/mol) | Uncertainty (% relative) |
|---|---|---|
| methanol | 5 to 10 | ≤ 2.0 |
| ethanol | 5 to 10 | ≤ 3.0 |
| acetone | 5 to 10 | ≤ 3.0 |

This PRM is outside our accreditation.

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Chlorinated Volatile Organic Compounds

VSL offers a PRM with 6 chlorinated organic compounds in nitrogen, with a guaranteed stability period of 2 years. Within the listed ranges any composition can be supplied.

| Range | Uncertainty (% relative) | Stability period |
|---|---|---|
| 100 to 1000 nmol/mol | ≤ 5.0 | 3 years |

**Certified components**

vinyl chloride
dichloromethane
trichloroethene
trichloromethane
1,2-dichloroethane
tetrachloroethene

This PRM is outside our accreditation.

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Volatile organic compounds (BTEX)

VSL offers a PRM with 6 volatile organic compounds (BTEX) in nitrogen. Within the listed range any composition can be supplied.

| Range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **2 to 1000 nmol/mol** | ≤ 5.0 | 3 years |

**Certified components**

benzene
toluene
ethyl benzene
o-xylene
m-xylene
p-xylene

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Environment
## Stack gases in nitrogen

Stack gases are available in different compositions and have a guaranteed stability period of 3 years. Other compositions, including other components, are available on request.

| Certified component | Range (µmol/mol) | Uncertainty (% relative) |
|---|---|---|
| **carbon monoxide** | 50 to 1000 | ≤ 0.5 |
| **carbon dioxide** | 12 to 18 % mol/mol | ≤ 0.2 |
| **propane** | 5 to 1000 | ≤ 1.0 |
| **nitric oxide** | 10 to 1000 | ≤ 1.0 |
| **sulfur dioxide** | 20 to 1000 | ≤ 1.0 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Environment
## Greenhouse gases

Primary Reference Material (PRM) in synthetic air, including $0.93 \times 10^{-2}$ mol/mol argon, for atmospheric monitoring analyses. Any combination within the listed ranges can be prepared with a guaranteed stability period of three years.

| Certified component | Range (µmol/mol) |
|---|---|
| **methane** | $(1.6 \text{ to } 3.2) \times 10^{-6}$ |
| **carbon monoxide** | $(120 \text{ to } 600) \times 10^{-9}$ |
| **carbon dioxide** | $(300 \text{ to } 800) \times 10^{-6}$ |
| **nitrous oxide** | $(280 \text{ to } 380) \times 10^{-9}$ |

This PRM is outside our accreditation.

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Hydrogen Chloride reference materials

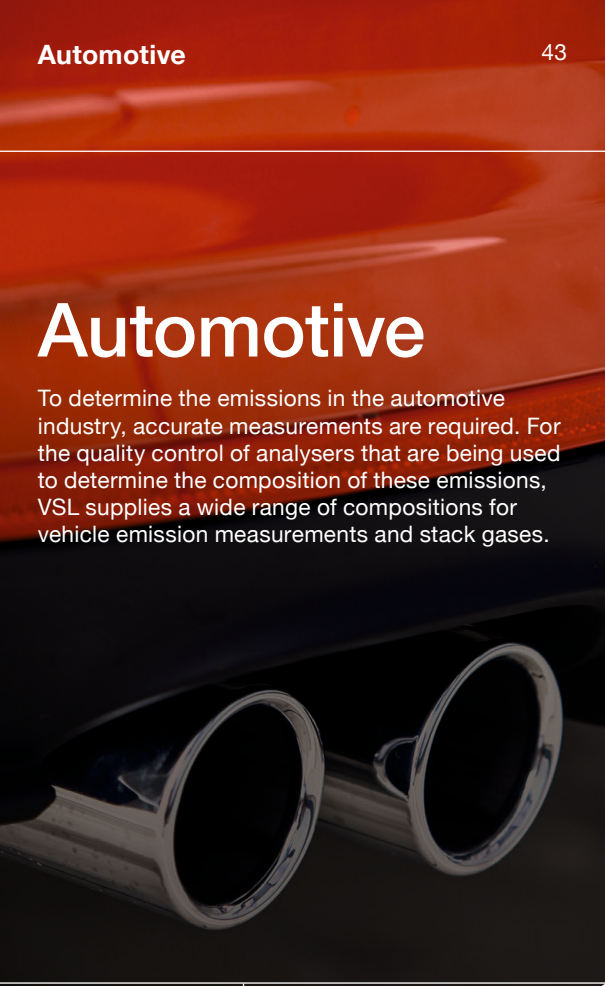
Certified Gas Mixtures (CGM) containing HCl in nitrogen or synthetic air.

| Certified component | Range (µmol/mol) | Uncertainty (% relative) |
|---|---|---|
| **HCl** | 10 to 300 | 2.5 to 5.0 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Automotive

To determine the emissions in the automotive industry, accurate measurements are required. For the quality control of analysers that are being used to determine the composition of these emissions, VSL supplies a wide range of compositions for vehicle emission measurements and stack gases.



# Automotive Gases-OIML

The listed Primary Reference Materials (PRMs) are typical examples of automotive test gases which are prescribed in OIML recommendation R 99 “Instruments for measuring vehicle exhaust emissions” and have a guaranteed stability period of 4 years. Matrix gas is nitrogen. Other compositions are available on request.

| Standard #1 Component | Range (%mol/mol) | Uncertainty (% relative) |
|---|---|---|
| **carbon monoxide** | 0.5 to 9.0 | ≤ 0.2 |
| **carbon dioxide** | 3.6 to 18.0 | ≤ 0.2 |
| **oxygen** | 0.5 to 21.0 | ≤ 0.2 |
| **propane** | 0.02 to 0.32 | ≤ 0.2 |
| **Standard #2 Component** | | |
| **carbon monoxide** | 0.1 to 0.45 | ≤ 0.5 |
| **carbon dioxide** | 3.6 to 18.0 | ≤ 0.5 |
| **oxygen** | 0.1 to 21.0 | ≤ 0.5 |
| **propane** | 0.005 to 0.02 | ≤ 0.5 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Automotive
# Propane

| Propane range in nitrogen | Uncertainty (% relative) | Stability period |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 0.5 | 5 years |
| 11 to 100 µmol/mol | ≤ 0.4 | 5 years |
| 101 to 1000 µmol/mol | ≤ 0.2 | 5 years |
| 0.11 to 5.0 % mol/mol | ≤ 0.1 | 5 years |

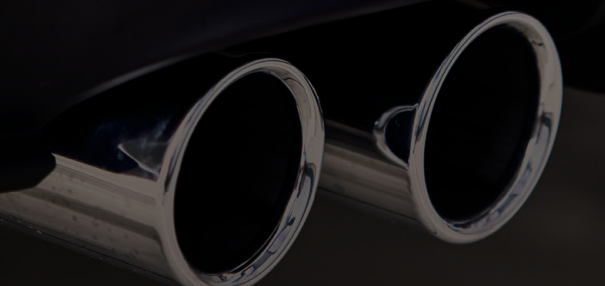
| Propane range in synthetic air | | |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 0.5 | 5 years |
| 11 to 100 µmol/mol | ≤ 0.4 | 5 years |
| 101 to 1000 µmol/mol | ≤ 0.2 | 5 years |
| 0.11 to 0.8 % mol/mol | ≤ 0.1 | 5 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Automotive
# Methane

| Methane range in nitrogen | Uncertainty (% relative) | Stability period |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 1.5 | 4 years |
| 11 to 100 µmol/mol | ≤ 0.6 | 5 years |
| 101 to 1000 µmol/mol | ≤ 0.4 | 5 years |
| 0.11 to 10 % mol/mol | ≤ 0.2 | 5 years |

| Methane range in synthetic air | | |
|---|---|---|
| 1 to 10 µmol/mol | ≤ 1.5 | 4 years |
| 11 to 100 µmol/mol | ≤ 0.6 | 5 years |
| 101 to 1000 µmol/mol | ≤ 0.4 | 5 years |



*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Automotive
## Oxygen in nitrogen

| Oxygen range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **0.11 to 2 % mol/mol** | ≤ 0.3 | 5 years |
| **2.1 to 50 % mol/mol** | ≤ 0.1 | 5 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Water vapour
# Moisture in nitrogen

The Certified Reference Material (CRM) is prepared by VSL and the molar amount fraction of $H_2O$ is traceable to the primary humidity standard at VSL and therefore is a fully traceable reference material under ISO Guide 34 and ISO/IEC 17025.

| Moisture range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **10 to 99 µmol/mol** | ≤ 5.0 | 2 years |
| **100 to 200 µmol/mol** | ≤ 5.0 | 2 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Noble gases
# Noble gas mixtures

The listed Primary Reference Materials (PRMs) are typical examples of standard noble gas mixtures and have a guaranteed stability period of 3 years. Other compositions, including other components, are available on request.

| Helium matrix | Range (µmol/mol) | Uncertainty (% relative) |
|---|---|---|
| **argon** | 10 | ≤ 3.0 |
| **xenon** | 10 | ≤ 3.0 |
| **krypton** | 10 | ≤ 3.0 |
| **Nitrogen matrix** | | |
| **oxygen** | 10 | ≤ 3.0 |
| **argon** | 10 | ≤ 3.0 |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Explosimetry
## 50 % LEL level in synthetic air

The listed Primary Reference Materials (PRMs) are typical examples of standard gas mixtures used in the calibration of explosive concentration monitors. The compositions listed are all on 50 % LEL level.

| Component | Uncertainty (% relative) | Stability period |
|---|---|---|
| **2.2 % mol/mol methane** | ≤ 0.5 | 5 years |
| **0.9 % mol/mol propane** | ≤ 0.3 | 5 years |
| **2.0 % mol/mol hydrogen** | ≤ 2.0 | 3 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

The listed Primary Reference Materials (PRMs) are examples of standard gas mixtures used in leak detection. Some of these gases are used as tracers in dispersion modelling. Other compositions are available on request.

| Component and amount fraction in synthetic air | Uncertainty (% relative) | Stability period |
|---|---|---|
| **40 nmol/mol sulfur hexafluoride** | ≤ 6.0 | 2 years |
| **400 nmol/mol sulfur hexafluoride** | ≤ 3.0 | 2 years |
| **4 µmol/mol sulfur hexafluoride** | ≤ 1.0 | 2 years |
| **40 µmol/mol sulfur hexafluoride** | ≤ 1.0 | 2 years |
| **Component and amount fraction in nitrogen** | | |
| **10 µmol/mol helium** | ≤ 4.0 | 3 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Breath alcohol
## Ethanol in nitrogen or synthetic air

The listed ranges are suitable for use in compliance with OIML R 126 (Evidential breath analyzers). Other compositions, including interfering substances, are available on request.

| Ethanol range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **50 to 125 µmol/mol** | ≤ 1.0 | 3 years |
| **126 to 800 µmol/mol** | ≤ 0.5 | 3 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Medical diagnostic standards
## Blood gas standard

The listed Primary Reference Materials (PRMs) are typical examples of standard gas mixtures used in blood gas determination, respiratory and anesthesia monitoring. Other compositions, including other components, are available on request.

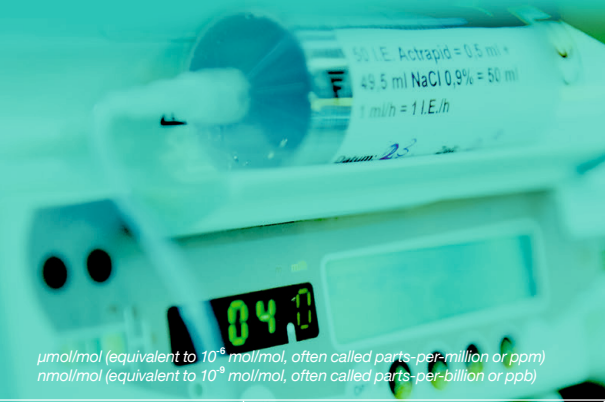
| Blood gas standard #1 | Uncertainty (% relative) | Stability period |
|---|---|---|
| 10 % mol/mol carbon dioxide | ≤ 1.0 | 3 years |
| 90 % mol/mol oxygen | ≤ 1.0 | |
| **Blood gas standard #2** | | |
| 5 % mol/mol carbon dioxide | ≤ 1.0 | 3 years |
| 95 % mol/mol oxygen | ≤ 1.0 | |
| **Blood gas standard #3** | | |
| 5 % mol/mol carbon dioxide | ≤ 1.0 | 3 years |
| 20 % mol/mol oxygen | ≤ 1.0 | |
| 75 % mol/mol nitrogen | ≤ 1.0 | |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Medical diagnostic standards
# Blood gas standard

| Lung function standard | Uncertainty (% relative) | Stability period |
|---|---|---|
| 0.3 % mol/mol carbon monoxide | ≤ 0.5 | 2 years |
| 20 % mol/mol oxygen | ≤ 0.5 | |
| 9 % mol/mol helium | ≤ 0.5 | |
| 70.7 % mol/mol nitrogen | ≤ 0.5 | |

| Entonox standard | | |
|---|---|---|
| 50 % mol/mol nitrous oxide | ≤ 1.0 | 3 years |
| 50 % mol/mol oxygen | ≤ 1.0 | |




*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Oxygen in nitrogen

| Oxygen range | Uncertainty (% relative) | Stability period |
|---|---|---|
| **1 to 10 µmol/mol** | ≤ 4.0 | 3 years |
| **11 to 100 µmol/mol** | ≤ 2.0 | 4 years |
| **101 to 1000 µmol/mol** | ≤ 0.4 | 5 years |
| **0.11 to 2 % mol/mol** | ≤ 0.3 | 5 years |
| **2.1 to 50 % mol/mol** | ≤ 0.1 | 5 years |

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# Formaldehyde

VSL's dynamic dilution facilities are ultimately suitable for testing and calibration of equipment and gas mixtures for the measurement of formaldehyde for work exposure or indoor/ambient air monitoring.

- Calibration of analysers
- Calibration of gas mixtures (CGM)

*µmol/mol (equivalent to $10^{-6}$ mol/mol, often called parts-per-million or ppm)*
*nmol/mol (equivalent to $10^{-9}$ mol/mol, often called parts-per-billion or ppb)*

# The Dutch Metrology Institute

As the Netherlands' national metrology institute (NMI), VSL makes measurement results of companies, laboratories and institutions directly traceable to international standards (SI units). By providing services such as calibrations, consultancy, reference materials, interlaboratory comparisons and training courses, VSL makes an important contribution to quality improvement and innovation of products and processes in commerce and society.

- Internationally authoritative measurement institute
- Maintenance and development of the Netherlands' national measurement standards
- State-of-the-art high-tech laboratories
- Operates on the interface between science and industry
- Working together with VSL means collaborating with professionals who are experts in their field

VSL offers calibrations, consultancy, reference materials, interlaboratory comparisons and training courses in the following fields of expertise:

- Chemistry
- Electricity
- Flow and Volume
- Geometry
- Humidity
- Ionising radiation
- Light
- Mass
- Pressure
- Temperature
- Time and Frequency
- Viscosity

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