MEMORANDUM OF COOPERATION

between

the Chemical Sciences Division
of the Materials Measurement Laboratory
of the National Institute of Standards and Technology - NIST
Gaithersburg, MD, United States of America

and

the National Physical Laboratory - NPL
Teddington, Middlesex, United Kingdom

Cooperative Program for Comparison of Primary Standard Gas Mixtures

A comparison program between the National Physical Laboratory (NPL) and the Chemical Sciences Division (CSD) of the Materials Measurement Laboratory (MML) of the National Institute of Standards and Technology (NIST) has been mutually agreed upon to demonstrate the comparability of Primary Standard Gas Mixtures (PSMs), including dynamically prepared Standard Gas Mixtures, that have been developed and maintained by the two institutions. PSMs are used to provide traceability of their respective Standard Reference Materials (SRMs), Primary Reference Materials (PRMs) and Certified Reference Materials (CRMs) to the International System of Units (SI). NIST and NPL have agreed on the following protocol:

* Identification of PSM suites that are to be intercompared on a regular basis. A list of these PSM suites is provided in Table 1. This table is updated periodically to reflect additions and deletions of PSM suites to be intercompared.

* Agreement on the frequency of exchange and the statistical model that form the basis for the comparison exercise. Frequencies for the comparisons are given in Table 1. Specific compositions to be exchanged will be identified for each PSM suite.

* In those cases where the scheduled comparisons are not covered by ongoing or scheduled Bureau International des Poids et Mesures (BIPM) Consultative Committee for Amount of Substance (CCQM) Key comparisons, exchange of PSMs will take place on a bilateral basis for analysis against the receiving laboratory's primary standards. Exchange will consist of a representative set of PSMs comprising the suite. Analyses at the receiving laboratory will proceed within two months of receipt of the PSMs. Each party recognizes the value and importance of these materials and understands that they must be returned as soon as possible to the originating laboratory. Neither institute will hold a PSM longer than three months after receipt of cylinders. Exchange of the complete data set generated by each comparison exercise will proceed within two months after completion of all analyses. Each year before October 1, a complete comparison program will be agreed for the following calendar year. This comparison program will be registered as appropriate within the Regional Metrology Organizations.

* A result of the comparison program will be the **declaration of equivalence** (DoE) for PSMs that agree to within defined limits previously agreed upon by both NPL and NIST. The level of equivalency for each PSM will be based on the difference between the NPL and NIST measurements and the uncertainty of the difference. Suites that do not agree to within these limits will not be declared as equivalent and will be the subject of additional bilateral work to identify and eliminate sources of bias. Until such time that equivalence is declared, all data concerning the comparison shall be confidential to NPL and NIST.

* The method for demonstrating equivalency between PSMs from NPL and NIST are based on the following two situations and corresponding criteria:
  a. *Comparison of an analyzed value of NIST with an analyzed value of NPL*. The difference between the two analyzed values must be smaller than the expanded uncertainty U (k=2) of the measurement result with the largest uncertainty. The uncertainties of both measurement results must be approximately equal.

b. *Comparison of a measurement result with the gravimetric value of the PSM.*
In this situation, the approach that will be used in the International Committee of Weights and Measures (CIPM) Mutual Recognition Agreements (MRAs) will be applied and the difference between the gravimetric and analyzed values will be compared to the combined uncertainties of the gravimetric and analyzed values. Both possibilities, gravimetric value from NIST and analyzed value from NPL, and gravimetric value from NPL and analyzed value from NIST, must be investigated.
Both of the following criteria must be met:

- $| x_{grav,NIST} - x_{anal\ NPL} | \leq \sqrt{(U^2_{grav,NIST} + U^2_{anal,NPL})}$ and

- $| x_{grav,NPL} - x_{anal,NIST} | \leq \sqrt{(U^2_{grav,NPL} + U^2_{anal,NIST})}$.

* The maximum allowable difference between the institute's analyzed values, or the measurement result and the gravimetric value for each PSM, is listed in Table 1.

* For each successful bilateral comparison, a short report will be drafted that may be distributed within Inter-American Metrology System (SIM), European Association of Metrology Institutes (EURAMET) or other Regional Metrology Organizations (RMOs), and used as supporting evidence for Calibration and Measurement Capabilities (CMCs).

* A list of Primary Standard Gas Mixtures declared to be equivalent will be listed in Annex 1 of the DoE. Included in the DoE shall be an expiration date at which time the declaration shall no longer be in effect. The DoE shall be reassessed on a biennial basis; a new DoE will be scheduled to become in force on July 1 of every even year, which will include an updated Annex 1 listing.

* Each party will inform the other about errors, additional uncertainty or any other problems associated with standards supplied and/or received. Each party will inform the other of any anticipated circumstances that might adversely affect the production and/or quality of PSMs.

* When problems occur between comparison exercises that might affect the integrity of the PSMs from either institute, they will be investigated, and corrective measures taken as necessary. Subsequently, both parties must agree upon statements regarding equivalence.

To further develop and/or to extend PSM ranges, NIST and NPL will conduct exploratory comparisons, as listed in Table 2, to start underlining new, future BIPM CMC Claims. For each of these comparisons a NIST-NPL report will be drafted.

The term for the present Memorandum of Cooperation is January 1, 2019 through December 31, 2026. However, either party may terminate its involvement with a written notification that is submitted 90-days in advance to the other party. Activities contemplated by this Agreement are subject to the availability of funds and other necessary resources to the Parties. No funds are obligated by this Agreement. This Agreement is a statement of intent to cooperate as outlined and does not create legally binding duties or obligations and shall not serve as the basis for any legal claim.

NIST is authorized under its statutory authority to enter into this Agreement and to conduct the activities referenced herein. This Agreement is entered into under the terms of sections 272(b) (9) & (c) (5), and of title 15 of the U.S. Code.

Table 1 PSMs to be compared.

Component	Amount Fraction (mol/mol)	Maximum allowable difference	Frequency of reassessment (years)
CO_2 in N_2 or air	$10 \cdot 10^{-6}$ to $20 \cdot 10^{-2}$	0.3 % relative	3
CO in N_2 or air	$1 \cdot 10^{-6}$ to $10 \cdot 10^{-2}$	0.3 % relative	3
CO in N_2 or air	$1 \cdot 10^{-7}$ to $1 \cdot 10^{-6}$	2.0 % relative	3
ethanol in N_2 or air	$50 \cdot 10^{-6}$ to $1000 \cdot 10^{-6}$	0.5 % relative	3
O_2 in N_2	$10 \cdot 10^{-6}$ to $25 \cdot 10^{-2}$	0.2 % relative	3
propane in N_2 or air	$1 \cdot 10^{-6}$ to $1 \cdot 10^{-2}$	0.3 % relative	3
NO in N_2	$10 \cdot 10^{-6}$ to $1 \cdot 10^{-2}$	0.5 % relative	3
NO in N_2	$0.4 \cdot 10^{-6}$ to $10 \cdot 10^{-2}$	1.0 % relative	3
NO_2 in N_2 or air	$10 \cdot 10^{-6}$ to $1 \cdot 10^{-2}$	0.5 % relative	3
SO_2 in N_2 or air	$10 \cdot 10^{-6}$ to $1 \cdot 10^{-2}$	0.5 % relative	3
SO_2 in N_2 or air	$0.4 \cdot 10^{-6}$ to $10 \cdot 10^{-6}$	2.0 % relative	3
H_2S in N_2	$1 \cdot 10^{-6}$ to $1000 \cdot 10^{-6}$	1.0 % relative	3
CH_4 in N_2 or air	$1.7 \cdot 10^{-6}$ to $10 \cdot 10^{-2}$	0.2 % relative	3
VOCs (ethane, propane, i-butane, n-butane, n-pentane, n-hexane, n-heptane, benzene, toluene, ethylbenzene, o-xylene) in N_2	$1 \cdot 10^{-9}$ to $1 \cdot 10^{-6}$	2.0 % relative	3
VOC terpenes (limonene, α-pinene, 1,8-cineole and 3-carene)	$1 \cdot 10^{-9}$ to $1 \cdot 10^{-6}$	0.5 % relative	3
Stack gas (NO, CO, CO_2, C_3H_8, SO_2) in N_2	Typical	3.0 % relative	3

Table 2 Exploratory comparisons.

Component	Amount Fraction (mol/mol)	Measurement capability	Year	Initiator
HCHO in N_2	2×10^{-6}	Gravimetric	2020	NPL
HCL in N_2	10×10^{-6}	Gravimetric	2020	NPL
N_2O in N_2 or air	$0.3 \cdot 10^{-6}$ to $1000 \cdot 10^{-6}$	Gravimetric	2019	NPL
NH_3 in N_2	$10 \cdot 10^{-6}$ to $300 \cdot 10^{-6}$	Gravimetric	2019	NPL

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for CAG 21 Dec 18

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