NATIONAL PHYSICAL LABORATORY
Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222
NPL Management Ltd – Registered in England and Wales No 2937881

Certificate of Calibration

OZONE TRANSFER STANDARD

UKAS CALIBRATION 0478

FOR:	Dr Katie Read University of York National Centre for Atmospheric Science (NCAS) Department of Chemistry Heslington York, YO10 5DD United Kingdom
DESCRIPTION:	Calibration of Ozone Transfer Standard
IDENTIFICATION:	TE 49i-PS S/N 0703820527 Certified response of TE 49i-PS: TE 49i-PS nmol mol^{-1} = 0.998 SRP20 nmol mol^{-1} + 0.5 nmol mol^{-1} Uncertainty at amount fractions greater than 100 nmol mol^{-1} = 3% of value. Uncertainty at amount fractions between 0 and 100 nmol mol^{-1} = 3 nmol mol^{-1}.
DATE(S) OF CALIBRATION:	2nd July 2024
UNCERTAINTIES:	The reported uncertainties are based on a standard uncertainty multiplied by a coverage factor, k = 2, providing a level of coverage probability of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

Reference: UniYork2024040280July24

Date of Issue: 11 July 2024 **Signed:** David Butterfield **(Authorised Signatory)**

Checked by: DMB **Name:** D M Butterfield **on behalf of NPLML**

1. MEASUREMENT PROCEDURE

The National Physical Laboratory (NPL) has calibrated an ozone transfer standard. The traceable NPL calibration standard used was NIST Standard Reference Photometer SRP 20, quality assured and controlled by independent audit procedures. The calibration performed relates the transfer standard to the ozone amount fractions determined by the SRP. The ozone cross-section used in the SRP software, and hence the value to which the results of these calibrations are traceable, is that given by Hearn, 1961, i.e. 1.147×10^{-17} cm^2 $molecule^{-1}$.

The transfer standard was calibrated, having first conditioned the sample lines at an amount fraction of approximately 501 nmol mol^{-1} of ozone for over an hour.

One calibration run was carried out, each covering ten ozone amount fractions in the range zero to 500 nmol mol^{-1}. Each constituent data point consisted of ten determinations of ozone amount fraction measured by both the SRP and the transfer standard. The data were combined to produce linear regressions in the form:

Transfer standard output in nmol mol^{-1} = **m** SRP20 reading in nmol mol^{-1} + **c**,

where: **m** is the gradient determined as the ratio of the transfer standard reading for ozone in nmol mol^{-1} to the SRP reading for ozone in nmol mol^{-1}

c is the zero-intercept expressed in nmol mol^{-1}.

The mean values for **m** and **c**, over the ten calibration runs, were calculated and are shown below.

During these tests, the ozone "slope", i.e. the transfer standard' "span" setting, was set to 1.011.

2. RESULTS

The results of the calibration are given in the following table. The data have been arranged in numerical order, and do not reflect the sequence in which the calibration was carried out.

SRP 20 value (nmol mol^{-1})	Mean TE 49i-PS (nmol mol^{-1})	Mean TE 49i-PS (pphm)	Standard deviation of TE 49i-PS (nmol mol^{-1})
0.2	0.6	0.06	0.3
4.0	4.7	0.47	0.7
21.1	21.5	2.15	0.1
63.8	64.3	6.43	3.4
144.5	144.6	14.46	0.7
221.2	221.3	22.13	0.7
301.4	300.7	30.07	1.5
372.9	373.1	37.31	2.6
437.3	436.8	43.68	0.8
500.3	499.7	49.97	0.5

The results of the calibration were as follows:

TE 49i-PS nmol mol^{-1} = 0.998 SRP20 nmol mol^{-1} + 0.5 nmol mol^{-1}

In units of pphm, parts per hundred million, the equation becomes: TE 49i-PS pphm = 0.998 SRP20 pphm + 0.05 pphm

The above equation is only valid in the amount fraction range 0 to 500 nmol mol^{-1}.

The standard error of the residuals of the linear regressions was 0.3 nmol mol^{-1}.

The uncertainty in the values predicted by this equation is 3.0% at amount fractions greater than 100 nmol mol^{-1}, and 3 nmol mol^{-1} at amount fractions between 0 and 100 nmol mol^{-1}.

The above overall uncertainties contain components arising from:

- Uncertainty in the ozone absorption cross section

- Purity of the air supply used in the calibration
- Non-linearity in the analytical instrumentation
- Bias in the primary standard used, based on the results of international intercomparisons

The overall uncertainty has been determined according to the Guide to the expression of Uncertainty in Measurement published by the International Organisation for Standardisation in association with the Comité International des Poids et Mesures (CIPM). The uncertainties consist of CIPM classification type A uncertainties, evaluated by statistical methods, combined with CIPM classification type B uncertainties, evaluated by other means.

3. VALIDITY

No tests were carried out on the long-term stability of the transfer standard. It is our experience that ozone photometers operating on the UV absorption principle are likely to remain stable for periods of up to 6 months.