Report No. 1071

Gas Flow Meter

Proficiency Testing Program

Round One

March 2018

ACKNOWLEDGMENTS

PTA wishes to gratefully acknowledge the technical assistance that was provided for this program by Dr Khaled Chahine, National Measurement Institute, Australia. This assistance included preparation and input into the design of the program, technical advice, calibration of the gas flow meter, analysis of the results and discussion in the final report.

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CONTENTS

1. Foreword

This report summarises the results of an interlaboratory comparison on a rotary gas flow meter by laboratories.

The exercise was conducted from March 2017 to February 2018 by Proficiency Testing Australia (PTA). The Program Coordinator was Dr M Li. This report was authorised by Mr P. Briggs, PTA General Manager.

The main aim of the program was to assess laboratories' abilities to competently perform the prescribed calibration. Interlaboratory comparison provides objective evidence that laboratories are competent and that they can achieve the level of accuracy for which they have nominated. It also provides a means for improving the quality and performance of laboratories.

2. Program Features and Design

Each laboratory was randomly allocated a unique code number for the program to ensure confidentiality of results. Reference to each laboratory in this report is by code number only.

Laboratories were provided with the "Instructions to Participants" and "Results Sheet" (refer Appendix B).

Participants were provided with one Instromet with S/No: 20300089-2003.

Four laboratories from Australia and one laboratory from New Zealand participated in the program, with all laboratories submitting results.

Results as reported by participants with corresponding summary statistics are presented in Appendix A for each testing point for each laboratory.

3. Reporting by Participants

Laboratories were asked to report their test results on a proforma "Results Sheet" (refer Appendix B). The participating laboratories were asked to report uncertainties at 95% confidence levels.

4. Reference Values

The reference values for the rotary gas flow meter were based on the calibration results provided by the National Measurement Institute (NMI), Australia.

5. Summary of Results

A summary of the results returned by the participating laboratories, compared to the reference values, appears in Appendix A in the tables.

In accordance with international practice, measurement performance has been assessed on the basis of an E_n ratio for each measurement. The E_n ratios are calculated using a standard statistical technique for comparing values and are derived from the following expression:

$$E_n = \frac{Lab - Ref}{\sqrt{(U_{Lab})^2 + (U_{Ref})^2}}$$

where *Ref* is the values measured by NMI, U_{Lab} is the laboratory's reported uncertainty of measurement at a 95% confidence level, and U_{Ref} is the uncertainty associated with the Ref at a 95% confidence level. U_{Ref} is estimated from the uncertainty associated with the NMI measurement results.

6. PTA and Technical Advisor Comments

The majority of the results of the participating laboratories are consistent with each other and with the reference values. The table of E_n ratios in Appendix A show good agreement amongst all laboratories.

The variation between laboratories seems random, with a good spread of positive E_n ratios, which indicates that the reference artefact does not contain any significant bias. Only one testing point's $|E_n|$ ratio is greater than 1.0, and it confirms the lack of bias in the reference instrument.

From the five sets of reported results, 80% (4 sets of results) were considered satisfactory i.e. $| E_n | < 1.0$.

Only one testing point of results from laboratory code 5 generated an $| E_n |$ ratio greater than 1.0. It is recommended that value of $| En | \geq 1.0$ is investigated and that corrective actions are taken by the laboratory concerned.

The overall performance by the participating laboratories is acceptable and within expectations. Measurement uncertainties stated by all laboraties are within acceptable range.

The interlaboratory comparison results may provide evidence to support the level of competency that the participating laboratories can achieve in gas flow meter measurements.

As this program is the first proficiency test for gas flow meter measurement there is no previous data available for comparison. No variation between test methods was observed. No variation between estimates of uncertainty was observed. Results obtained justify claimed uncertainty by all laboratories.

7. Reference

[1] *Guide to Proficiency Testing Australia (2016).* (This document can be found on the PTA website, www.pta.asn.au).

APPENDIX A

Summary of Reported Results

Summary of Reported Results LAB1

Flow Rate (Transfer Standard)	Absolute Pressure (Inlet)	Temperature (Inlet)	Relative Humidity	Pressure Loss	$Error_{Lab}$ (Transfer Standard)	U_{Lab} (k=2)	$Error_{NMI}$ (Transfer Standard)	U_{NMI}	**E_n**
m³/hr	(Pa)	(°C)	(%)	(Pa)	(%)	(%)	(%)	(%)	
0.6	102095	19.41	59	3	-0.30	0.17	-0.34	0.17	0.17
1.8	102117	19.38	59	3	-0.13	0.16	-0.06	0.17	0.29
6.0	102127	19.30	60	7	-0.10	0.15	0.01	0.17	0.50
9.0	102141	19.31	61	11	-0.09	0.13	0.02	0.17	0.51
13.0	102156	19.30	62	16	-0.09	0.13	0.02	0.17	0.51
17.0	102162	19.30	62	22	-0.08	0.13	0.02	0.17	0.47
25.0	102181	19.32	62	39	-0.08	0.12	0.02	0.17	0.48
33.0	102181	19.27	62	61	-0.09	0.13	0.02	0.17	0.52
42.0	102206	19.40	62	92	-0.08	0.13	0.02	0.17	0.47
50.0	102182	19.43	61	129	-0.13	0.14	0.02	0.17	0.68
60.0	102160	19.36	63	176	-0.12	0.14	0.02	0.17	0.64
65.0	102130	19.29	63	207	-0.09	0.14	0.02	0.17	0.50

Notes: 1. Reference Laboratory: National Measurement Institute (NMI), Australia.

2. Uncertainties of measurement are at a 95% confidence level.

3. $$E_n = \frac{\text{LAB - REF}}{\sqrt{(U_{LAB}^2 + U_{REF}^2)}}$$ Values of $|E_n| \geq 1.0$ require investigation.

4. E_n ratios are based on laboratory's reported uncertainties and calibration data from NMI.

5. Confidentiality: Refer to Guide to Proficiency Testing Australia (2016).

Summary of Reported Results LAB2

Flow Rate (Transfer Standard)	Absolute Pressure (Inlet)	Temperature (Inlet)	Relative Humidity	Pressure Loss	$Error_{Lab}$ (Transfer Standard)	U_{Lab} (k=2)	$Error_{NMI}$ (Transfer Standard)	U_{NMI}	$\mathbf{E_n}$
m³/hr	(Pa)	(°C)	(%)	(Pa)	(%)	(%)	(%)	(%)	
1.2	101490	22.16	31.7	1	-0.25	0.30	-0.13	0.17	0.34
2.0	101490	22.09	31.7	2	-0.10	0.30	-0.05	0.17	0.15
6.0	101490	21.92	31.7	9	-0.24	0.30	0.01	0.17	0.73
9.0	101490	21.65	31.7	9	-0.10	0.30	0.02	0.17	0.34
13.0	101490	21.70	31.7	12	-0.09	0.30	0.02	0.17	0.32
17.0	101490	21.77	31.7	18	-0.11	0.30	0.02	0.17	0.38
25.0	101510	22.38	30.9	37	-0.18	0.30	0.02	0.17	0.58
33.0	101510	22.19	30.9	56	-0.10	0.30	0.02	0.17	0.35
42.0	101510	22.18	30.9	87	-0.15	0.30	0.02	0.17	0.49
50.0	101510	22.19	30.9	122	-0.13	0.30	0.02	0.17	0.44
60.0	101510	22.20	30.9	170	-0.10	0.30	0.02	0.17	0.35
65.0	101510	22.39	30.9	197	-0.09	0.30	0.02	0.17	0.32

Notes: **1.** Reference Laboratory: National Measurement Institute (NMI), Australia.

2. Uncertainties of measurement are at a 95% confidence level.

3. $$E_n = \frac{\text{LAB - REF}}{\sqrt{(U_{LAB}^2 + U_{REF}^2)}}$$ Values of $|E_n| \geq 1.0$ require investigation.

4. E_n ratios are based on laboratory's reported uncertainties and calibration data from NMI.

5. Confidentiality: Refer to Guide to Proficiency Testing Australia (2016).

Summary of Reported Results LAB3

Flow Rate (Transfer Standard)	Absolute Pressure (Inlet)	Temperature (Inlet)	Relative Humidity	Pressure Loss	$Error_{Lab}$ (Transfer Standard)	U_{Lab} (k=2)	$Error_{NMI}$ (Transfer Standard)	U_{NMI}	**E_n**
m³/hr	(Pa)	(°C)	(%)	(Pa)	(%)	(%)	(%)	(%)	
0.5	101205	22.8	48.3	2	-0.63	0.25	-0.41	0.17	0.74
1	101190	22.8	47.9	2	-0.36	0.25	-0.18	0.17	0.61
2	101178	22.8	47.7	2	-0.18	0.25	-0.05	0.17	0.43
3	101187	22.8	48.4	5	-0.11	0.25	-0.02	0.17	0.31
4	101194	22.8	48.5	5	-0.04	0.25	0.00	0.17	0.13
5	101151	22.5	48.1	4	0.00	0.25	0.01	0.17	0.03
6	101141	22.6	48.3	6	-0.02	0.25	0.01	0.17	0.11
7	101201	22.6	48.5	9	-0.02	0.25	0.02	0.17	0.12
8	101213	22.6	48.7	11	-0.03	0.25	0.02	0.17	0.16
9	101220	22.6	48.5	12	-0.03	0.25	0.02	0.17	0.16

Notes: 1. Reference Laboratory: National Measurement Institute (NMI), Australia.

2. Uncertainties of measurement are at a 95% confidence level.

3. $$E_n = \frac{LAB - REF}{\sqrt{(U_{LAB}^2 + U_{REF}^2)}}$$ Values of $|E_n| \geq 1.0$ require investigation.

4. E_n ratios are based on laboratory's reported uncertainties and calibration data from NMI.

5. Confidentiality: Refer to Guide to Proficiency Testing Australia (2016).

Summary of Reported Results LAB4

Flow Rate (Transfer Standard)	Absolute Pressure (Inlet)	Temperature (Inlet)	Relative Humidity	Pressure Loss	$Error_{Lab}$ (Transfer Standard)	U_{Lab} (k=2)	$Error_{NMI}$ (Transfer Standard)	U_{NMI}	**E_n**
m³/hr	(Pa)	(°C)	(%)	(Pa)	(%)	(%)	(%)	(%)	
6.0	100192	22.50	42.03	12	-0.12	0.25	0.01	0.17	0.44
9.0	100192	22.48	42.04	12	-0.11	0.25	0.02	0.17	0.43
13.0	100193	22.51	42.04	13	-0.10	0.25	0.02	0.17	0.40
17.0	100193	22.49	42.07	18	-0.17	0.25	0.02	0.17	0.63
25.0	101493	21.21	44.13	32	-0.04	0.25	0.02	0.17	0.20
33.0	101492	21.19	44.12	49	-0.10	0.25	0.02	0.17	0.40
42.0	101489	21.17	44.13	74	-0.09	0.25	0.02	0.17	0.36
50.0	101487	21.16	44.12	100	-0.10	0.25	0.02	0.17	0.40
60.0	101487	21.18	44.10	138	-0.08	0.25	0.02	0.17	0.33
65.0	101487	21.18	44.10	158	0.04	0.25	0.02	0.17	0.07

Notes: 1. Reference Laboratory: National Measurement Institute (NMI), Australia.

2. Uncertainties of measurement are at a 95% confidence level.

3. $$E_n = \frac{LAB - REF}{\sqrt{(U_{LAB}^2 + U_{REF}^2)}}$$ Values of $|E_n| \geq 1.0$ require investigation.

4. E_n ratios are based on laboratory's reported uncertainties and calibration data from NMI.

5. Confidentiality: Refer to Guide to Proficiency Testing Australia (2016).

Summary of Reported Results LAB5

Flow Rate (Transfer Standard)	Absolute Pressure (Inlet)	Temperature (Inlet)	Relative Humidity	Pressure Loss	$Error_{Lab}$ (Transfer Standard)	U_{Lab} (k=2)	$Error_{NMI}$ (Transfer Standard)	U_{NMI}	**E_n**
m³/hr	(Pa)	(°C)	(%)	(Pa)	(%)	(%)	(%)	(%)	
0.5	101.88	20.93	57.54	0	-0.77	0.23	-0.41	0.17	1.27
2.0	101.85	20.67	57.73	0	-0.25	0.23	-0.05	0.17	0.70
6.0	101.88	20.67	57.7	0.72	-0.18	0.23	0.01	0.17	0.68
9.0	101.88	20.7	57.74	4.24	0.04	0.23	0.02	0.17	0.07
13.0	101.85	20.6	57.85	10.88	-0.04	0.23	0.02	0.17	0.21
17.0	101.86	20.64	57.76	18.66	0.02	0.23	0.02	0.17	0.00
25.0	101.88	20.9	57.55	35.99	0.06	0.23	0.02	0.17	0.14
33.0	101.86	20.49	57.84	59.6	-0.01	0.21	0.02	0.17	0.11
42.0	101.89	20.77	57.67	92.09	0.03	0.21	0.02	0.17	0.04
50.0	101.89	20.89	57.58	127.01	0.08	0.21	0.02	0.17	0.22
60.0	101.84	20.53	57.74	176.87	0.03	0.21	0.02	0.17	0.04
65.0	101.88	20.74	57.69	208.73	0.02	0.17	0.02	0.17	0.00

Notes: 1. Reference Laboratory: National Measurement Institute (NMI), Australia.

2. Uncertainties of measurement are at a 95% confidence level.

3. $$E_n = \frac{\text{LAB - REF}}{\sqrt{(U_{LAB}^2 + U_{REF}^2)}}$$ Values of $|E_n| \geq 1.0$ require investigation.

4. E_n ratios are based on laboratory's reported uncertainties and calibration data from NMI.

5. Confidentiality: Refer to Guide to Proficiency Testing Australia (2016).

APPENDIX B

Instructions to Participants

GAS METER

PROFICIENCY TESTING PROGRAM

INSTRUCTIONS TO LABORATORIES

EQUIPMENT

A rotary gas flowmeter with the following details:

Make : Instromet
Model : IRM-A-DUO G40
Range : 0.5 to 65 $m^3\ h^{-1}$
Pulsation : 8583.13 pulses m^{-3}
Serial No : 20300089-2003

MEASUREMENT TO BE CARRIED OUT

Consider this as a job for a normal customer. Use techniques and equipment that will allow you to report your measurements and uncertainties to your best measurement capabilities.

Please do NOT adjust any settings, dismantle or attempt any maintenance or rectification.

The meter should be run for a period of ½ hour before any measurement commences. Use a flowrate between 10-50 $m^3\ h^{-1}$.

IMPORTANT: Special care is required to avoid any over-revving of the flowmeter as this may cause damage to the instrument.

Error of the meter is the value which shows the relationship in percentage terms of the difference between the volume indicated by the transfer standard and the volume which is measured by the participating laboratory using their primary standards for gas flow.

$$E = \frac{(V_t - V_s)}{V_s} \quad (\%) \quad (1)$$

where

E is the error of the transfer standard
V_t is the indicated volume by the transfer standard (m^3)
V_s is the volume which is rated by the primary standard of gas flow rate at the inlet of the meter (Use the meter's pressure port labelled Pr)

Measurements to be conducted at <u>any</u> flowrates between 0.5 and 65 $m^3\ h^{-1}$ at the inlet conditions of the meter. The pressure drop across the meter is also to be recorded at each flowrate. The flowrate, absolute pressure, temperature, relative humidity, pressure loss across inlet/outlet of meter and %Error in addition to the expended uncertainties at 95% confidence limit are to be recorded and reported as shown in the example given Table 1.

Table 1. Sample of measurement results on Instromet rotary gas meter.

Flow rate of the transfer standard at inlet conditions) (m^3 h^{-1})	Absolute pressure at inlet conditions (Pa)	Temperature at inlet conditions (°C)	Relative Humidity (%)	Pressure loss (Pa)	Error of the transfer standard (%)	Expanded uncertainty of measurement *U* (*k*=2) (%)
0.5						
2.0						
6.0						
9.0						
13.0						
17.0						
25.0						
33.0						
42.0						
50.0						
60.0						
65.0						

DOCUMENTS TO BE SUBMITTED

Within **two weeks** of receipt of the artefact, the participant is requested to return the artefact and results sheet to:

Dr Michael Li
Proficiency Testing Australia
7 Leeds St, Rhodes NSW 2138
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FINAL REPORT

A final report will be issued at the end of the program with each laboratory only identified by a **confidential code number.**

GENERAL INFORMATION

For general information, please contact Dr Michael Li, PTA,

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End of Report