Australian Government
Department of Industry, Science and Resources

National Measurement Institute

Proficiency Test Final Report AQA 25-02 MDMA/Methamphetamine

November 2025

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ACKNOWLEDGMENTS

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I would like to thank the management and staff of the participating laboratories for supporting the study. It is only through widespread participation that we can provide an effective service to laboratories.

The assistance of the following NMIA staff members in the planning, conduct and reporting of the study is acknowledged.

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SUMMARY

This report presents the results of proficiency study AQA 25-02 MDMA/Methamphetamine. The sample set consisted of two samples containing 3,4-methylenedioxymethamphetamine (MDMA) and two samples containing methamphetamine. A total of 34 laboratories received the samples, and 36 sets of results were reported. Two laboratories submitted two sets of results each, generated by different analysts.

Samples were prepared at the NMIA Sydney laboratory. Samples S1 and S2 were prepared from MDMA hydrochloride and Samples S3 and S4 were prepared from methamphetamine hydrochloride, all supplied by the Australian Federal Police.

The assigned values for Samples S1 and S4 were the robust averages of participants' results. The associated uncertainties were evaluated from the robust standard deviations of the participants' results. The consensus of participants' results in not traceable to any external reference, so although expressed in SI units, metrological traceability of these assigned values has not been established.

The assigned values for Samples S2 and S3 were the reference values as determined by quantitative nuclear magnetic resonance (qNMR) spectroscopy, with maleic acid (NMIA certified reference material (CRM) QNMR010) as the internal standard. The measurements of the reference values were made using qNMR and are traceable to the SI through Australian Standards for mass via balance calibration certificates and the purity of the NMIA maleic acid CRM QNMR010 (Batch No.: 10-Q-02).

The outcomes of the study were assessed against the aims as follows:

- *Assess participants' capabilities to measure MDMA and methamphetamine in samples typical of a routine seizure.*

Of 132 z-scores, 114 (86%) returned a z-score of $|z| \leq 2.0$, indicating an acceptable performance.

Of 132 E_n-scores, 106 (80%) returned a E_n-score of $|E_n| < 1.0$, indicating agreement of the participant's results with the assigned value within their respective expanded uncertainties.

Laboratories **3**, **4**, **6**, **7**, **12**, **13**, **15**, **16**, **19**, **21**, **29** and **34** returned acceptable z-scores and E_n-scores for all four samples.

- *Develop the practical application of measurement uncertainty, and provide participants with information that will assist uncertainty evaluations.*

Of 132 numeric results, 122 (92%) were reported with an associated measurement uncertainty. Participants used a variety of methods to evaluate their measurement uncertainty. These methods produced relative uncertainties ranging from 0.3% to 115% of the reported results.

- *Assess participants' ability to identify cutting agents commonly found in controlled drug preparation.*

Sample S1 was cut with niacinamide, Sample S2 was left uncut, Sample S3 was cut with caffeine and Sample S4 was cut with paracetamol.

Of the 36 sets of submitted results, 34 participants (94%) correctly reported on the identity of at least one cutting agent in the samples.

Laboratories **1**, **3**, **4**, **6**, **8**, **9**, **10**, **11**, **12**, **15**, **16**, **18**, **19**, **20**, **21**, **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, **31**, **33**, **34**, **35** and **36** correctly identified all cutting agents in this study.

- *Produce materials that can be used in method validation and as control samples.*

The samples produced for this study are homogeneous and are well characterised. Surplus of these samples is available for purchase and can be used for quality control and for method validation purposes.

1 INTRODUCTION

1.1 NMIA Proficiency Testing Program

The National Measurement Institute Australia (NMIA) is responsible for Australia's national measurement infrastructure, providing a range of services including a chemical proficiency testing program.

Proficiency testing (PT) is the 'evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons'.[1] NMIA PT studies target chemical testing in areas of high public significance such as trade, environment, law enforcement and food safety. NMIA offers studies in:

- controlled drug assay, drugs in wipes, and clandestine laboratory;
- per- and polyfluoroalkyl substances in soil, biosolid, water, biota, food, and consumables;
- hydrocarbons, phenols and other organic compounds in soil and water;
- pesticide residues in soil, water, fruit, vegetables, and herbs;
- metals in soil, water, food, filters, and paint;
- nutrients, anions and physical tests in water and soil; and
- chlorophyll a in water.

1.2 Study Aims

The aims of the study were to:

- assess participants' capabilities to measure 3,4-methylenedioxymethamphetamine (MDMA) and methamphetamine in samples typical of a routine seizure;
- develop the practical application of measurement uncertainty, and provide participants with information that will assist uncertainty evaluations;
- assess participants' ability to identify cutting agents commonly found in controlled drug preparation; and
- produce materials that can be used in method validation and as control samples.

The choice of the test method was left to the participating laboratories.

1.3 Study Conduct

The conduct of NMIA PT studies is described in the NMIA Study Protocol for Proficiency Testing.[2] The statistical methods used are described in the NMIA Chemical Proficiency Testing Statistical Manual.[3] These documents have been prepared with reference to ISO/IEC 17043 and The International Harmonized Protocol for the Proficiency Testing of Analytical Chemistry Laboratories.[1,4]

NMIA is accredited by the National Association of Testing Authorities, Australia (NATA) to ISO/IEC 17043 as a provider of proficiency testing schemes.[1] This study is within the scope of NMIA's accreditation.

2 STUDY INFORMATION

2.1 Study Timetable

The timetable of the study was:

Invitations sent	10/02/2025
Samples sent	23/04/2025
Results due	15/09/2025
Interim Report	16/09/2025
Preliminary Report	19/09/2025

Due to significant sample delivery delays to some international participants, the project timeline was extended.

2.2 Participation and Laboratory Code

Thirty-four laboratories registered to participate, with two laboratories requesting two sets of samples to be analysed independently by different analysts (total of 36 participants). Each participant was assigned a confidential laboratory code number for this study. All participants submitted results.

2.3 Test Material Specification

Four test samples were prepared in March 2025. Samples S1 and S2 contained MDMA hydrochloride, and Samples S3 and S4 contained methamphetamine hydrochloride. The starting materials were supplied by the Australian Federal Police.

Niacinamide, caffeine and paracetamol purchased from Sigma-Aldrich were used as cutting agents. Sample S1 was cut with niacinamide, Sample S2 was left uncut, Sample S3 was cut with caffeine, and Sample S4 was cut with paracetamol.

The MDMA and methamphetamine were ground and sieved through a 180 µm sieve. The cutting agents were processed similarly. Test samples were prepared by mixing a known mass of sieved drug with known amounts of sieved cutting agent in a tumbler overnight. Portions of 150 mg of each of the test samples were weighed into labelled glass vials.

Sample S1 was prepared to contain approximately 11.8% MDMA base (m/m).

Sample S2 contained approximately 77.0% MDMA base (m/m).

Sample S3 was prepared to contain approximately 59.5% methamphetamine base (m/m).

Sample S4 was prepared to contain approximately 31.9% methamphetamine base (m/m).

2.4 Test Sample Homogeneity and Stability

The preparation of homogeneous test samples is an important part of a PT study. Given the small (< 150 mg) test portions normally used for controlled substance analysis, the particle size must be sufficiently small and uniformly distributed to ensure minimal influence on analytical precision.

All samples were prepared using the same procedure as previous controlled drug PT studies, which has been demonstrated to produce sufficiently homogeneous samples. Therefore, a partial homogeneity test was conducted for Sample S1 only due to the low analyte level of the sample; the standard deviation for proficiency assessment has been increased accordingly for this sample. Results returned by the participants gave no reason to question the homogeneity of the other test samples.

To assess the stability of the samples, results returned by participants were compared to the dates of analysis (Section 6.7). The results gave no reason to question the samples' stability.

2.5 Sample Dispatch and Receipt

A set of four test samples, with each sample containing approximately 150 mg of test material, was dispatched to most participants on 23 April 2025. For some participants, dispatch was delayed due to public holidays and delays with receiving export permits.

The following items were also sent with the samples:

- a letter which included a description of the test samples and instructions for participants; and
- a form for participants to return to confirm the receipt and condition of the samples.

An Excel spreadsheet for the electronic reporting of results was emailed to participants.

2.6 Instructions to Participants

Participants were instructed as follows:

- Analyse each sample for the amount of drug by your routine test method. It is recommended to thoroughly mix the contents of each vial before taking a test portion for analysis.
- For each sample report % m/m drug as base. Report this figure as if reporting to a client.
- For each result report an evaluation of your expanded uncertainty as % m/m drug as base.
- Report the identity of cutting agents in all samples if this is within your normal scope of analysis.
- Give brief details of your:
    - basis of uncertainty evaluation (e.g. uncertainty budget, repeatability precision)
    - analytical method (e.g. sample treatment, instrument type, calibration method)
    - reference standard (e.g. source, purity)
- A results spreadsheet will be emailed to you. Please complete the results spreadsheet and return by email to jenny.xu@measurement.gov.au.
- Results are to be returned by 30 June 2025.

The results due date was later changed to 15 September 2025. This was to accommodate significant sample delivery delays to some international participants.

2.7 Interim Report and Preliminary Report

An Interim Report was emailed to all participants on 16 September 2025.

A Preliminary Report was emailed to all participants on 19 September 2025. This report included a summary of the results reported by participants, assigned values, performance coefficients of variation, z-scores and E_n-scores for each analyte in this study. No data from the Preliminary Report has been changed in the present Final Report.

3 PARTICIPANT LABORATORY INFORMATION

3.1 Test Methods Reported by Participants

Participants were requested to provide information about their test methods. Responses received are presented in Tables 1 and 2. Some responses may be modified so that the participant cannot be identified.

Table 1 Summary of Participants' Test Methods

Lab. Code	Analyte	Extraction Solvent	Internal Standard	Calib. Points	Technique	Detector	Column	Comments
1	All	Chloroform	Nortriptyline	1	GC	FID	HP5	
2*	Methamphetamine	Dissolution in acetonitrile/ water	Methoxyphenamine HCl	3	HPLC	DAD	Alltima C-18	
3	All	Acetonitrile/ Water 20:80	N/A	3	HPLC	DAD	Luna 2.5um C18(2)-HST 100 A (LC Column 100 X 3mm)	
4*	MDMA, Methamphetamine (S3)	water	none	1	UPLC	UV/Vis	C18 1.7 µm 2.1x100mm	
	Methamphetamine (S4)	BuCl	isopropylamphet	4	GC	FID	HP-1 12m x 0.2mm, 0.33µ film	
5	All	MeOH			LC	MS/MS	C18	MS
6	MDMA	Water	Phentermine	1	UPLC	DAD	Agilent Zorbax SB-C8	Wavelength: 215 nm
	Methamphetamine		N/A				Phenomenex Luna Omega PS C18	Wavelength: 215 nm
7	All	Methanol	Propylparaben	3	UPLC	PDA	ACQUITY C-18	
8	All	Ethanol	Propyl Paraben	7	UPLC	DAD	BEH Shield RP18	
9	All	Chloroform	Nortriptyline	1	GC	FID	ZB-5MS	
10	All	Methanol	Diazepam	6	GC	FID	128-5512 DB-5ms	
11	MDMA	acetonitrile/ water (80/20)	external standard	3	HPLC	DAD	C8	

Lab. Code	Analyte	Extraction Solvent	Internal Standard	Calib. Points	Technique	Detector	Column	Comments
12*	All	Deuterium oxide	Maleic acid		QNMR			Bruker AVIII 400 with BBO Prodigy cryoprobe
13	MDMA	Methanol	N/A	6	HPLC	DAD	Luna C-18	Wavelength: 258 nm
	Methamphetamine							Wavelength: 285 nm
14*	MDMA	D2O	Maleic Acid, DMS	3	QNMR	FT	N/A	Receiver Gain: 50.8, 40.3
	Methamphetamine	90:10 Water: Acetonitrile (0.1% TFA)	N/A	5	HPLC	PDA Detector	Xselect CSH C18 3.5µM, 4.6X100mm	Wavelength: 260 nm, resolution 4.8 nm
15*	MDMA	D2O	Maleic Acid		QNMR			60 MHz - 3 signals: 7.2 ppm – 6.3 ppm – 1.6 ppm
	Methamphetamine							60 MHz - 2 signals: 7.2 ppm (except for S4 due to an interference) – 1.2 ppm
16	MDMA	Water	Phentermine	1	UPLC	DAD	Agilent Zorbax SB-C8	Wavelength: 215 nm
	Methamphetamine		N/A				Phenomenex Luna Omega PS C18	
17*	All	Purified water	none	4	HPLC	DAD	Zorbax RX-SIL	
18	All	Methanol	2,4,6-trimethylpyridine	6	GC	FID	RTX-5-Amine	
19	All	Methanol	Strychnine	6	HPLC	DAD	Phenyl	
20	MDMA	Methanol	Selegilin	4	LC	UV	HSS C18 1.8 µm	Wavelength: 285 nm
	Methamphetamine							Wavelength: 257 nm
21	All	Methanol	X	5	HPLC	DAD	Aglient ZORBAX Eclipse Plus C18 4.6 x 250mm, 5um	Wavelength: 210 nm

Lab. Code	Analyte	Extraction Solvent	Internal Standard	Calib. Points	Technique	Detector	Column	Comments
22	All	Methanol	none	5	HPLC	DAD	Phenomenex C-18-XB	
23	MDMA	Eluent: Acetonitrile, ammonium acetate, diethylamine & water	None	4	HPLC	UV/Vis	LiChrospher 100-5 RP18 125 x 4.0mm	Wavelength: 285 nm
	Methamphetamine							Wavelength: 254 nm
24	All	Ethyl Acetate	Diphenylamine	5	GC	FID	HP1	
25	All	Chloroform	Nortriptyline	1	GC	FID	HP5	Split mode, Temperature programming Method
26	All	D2O	Maleic acid	NA	QNMR		NA	
27	MDMA	Water	N/A	7	HPLC	DAD	Luna 3um PFP(2) 100A 2x100mm	Wavelength: 214 nm
	Methamphetamine		ortho-methoxyphenamine	3	UPLC	PDA	BEH C18 1.7um 2.1x100mm	Wavelength: 254 nm
28	MDMA	Acetonitrile	/	4	HPLC	UV/Vis	PROTECOL C8 H 5UM 150 X 4.6MM	
29	All	MeOH:KOH buffer	methoxyphenamine	3	UPLC	PDA	Acquity UPLC BEH C18 1.7um	
30	MDMA	methanol	MDMA-D5	5	GC	MS	HP5MSUI	
	Methamphetamine		methamphetamine -D5					
31*	All	Isooctane	Dodecane	3	GC	FID	HP1 MS	
32*	MDMA	Methanol	N/A	4	HPLC	DAD	Hyper-Sil Gold C18 Selectivity HPLC columns (Thermofisher)	Wavelength: 205 nm
33*	MDMA	Phosphate buffer pH 3 /	none	3	HPLC	DAD	C18	Wavelength: 285 nm

Lab. Code	Analyte	Extraction Solvent	Internal Standard	Calib. Points	Technique	Detector	Column	Comments
		methanol (70/30)						
34*	MDMA, Methamphetamine (S4)	methanol	NO	1	HPLC	DAD	zorbax eclipse XDB 5 microns C-18 (4.6 mm x150 mm)	Wavelength: 230 nm
	Methamphetamine (S3)						zorbax eclipse C8 x 250 mm	
35	All	Methanol	none	5	HPLC	DAD	Agilent ZORBAX Eclipse Plus C18 4.6*250mm, 5um	Wavelength: 210 nm
36*	MDMA	Methanol	Methadone	5	GC	FID	Rxi-5ms	

*Additional information in Table 2.

Table 2 Test Methods Additional Comments

Lab. Code	Analyte	Participant Comments
2	Methamphetamine	Linear regression
4	Methamphetamine (S4)	on GC due to paracetamol
12	All	Simultaneous observation of analyte and IS peaks in 1H NMR spectrum acquired using QNMR conditions.
14	MDMA	linearity check, run each quarter
15	All	Internal Standard used: Maleic Acid - Sigma Aldrich - 92816 – 99.93 % - BCC52148.
17	Methamphetamine	Only Methamphetamine analysis has an ISO 17025 accreditation
31	MDMA	400 uL of ammonium hydroxide is added per 10 mL of isooctane
	Methamphetamine	200 uL of ammonium hydroxide is added per 5 mL of isooctane
32	MDMA	MDMA Methodology: Number of calibration points reflective of purities encountered in live casework
33	Methamphetamine	Methamphetamine assays are not performed in the laboratory.
34	All	external standard
	Methamphetamine (S3)	Sample number 3 has been analysed using a different HPLC column (zorbax eclipse C8 x 250 mm), in order to separate caffeine and methamphetamine.
36	Methamphetamine	No method available for this analyte

3.2 Reported Basis of Participants' Measurement Uncertainty Evaluations

Participants were requested to provide information about their basis of measurement uncertainty (MU). Responses received are presented in Tables 3 and 4. Some responses may be modified so that the participant cannot be identified.

Table 3 Reported Basis of Uncertainty Evaluation

Lab. Code	Approach to Evaluating MU	Information Sources for MU Evaluation*		Guide Document for Evaluating MU
		Precision	Method Bias	
1	Top Down - precision and evaluations of the method and laboratory bias k = 3 (reported as 99.7)	Control samples - CRM	Instrument calibration Homogeneity of sample Masses and volumes Recoveries of SS	Eurachem/CITAC Guide
2	Bottom Up (ISO/GUM, fish bone/cause and effect diagram) Coverage factor not reported	Duplicate analysis	Instrument calibration Masses and volumes Matrix effects Recoveries of SS Standard purity	ISO/GUM
3	Top Down - precision and evaluations of the method and laboratory bias k = 2	Control samples - Retained sample	Recoveries of SS	ISO/GUM
4**	Standard deviation of replicate analyses multiplied by 2 or 3 k = 2			
5	Coverage factor not reported	Control samples Duplicate analysis	Instrument calibration Homogeneity of sample Masses and volumes Matrix effects Laboratory bias from PT studies Standard purity	ISO/GUM
6	Top Down - precision and evaluations of the method and laboratory bias k = 2	Control samples - SS Duplicate analysis	Laboratory bias from PT studies Recoveries of SS	Eurachem/CITAC Guide
7	Top Down - precision and evaluations of the method and laboratory bias k = 3	Control samples - CRM Duplicate analysis	Instrument calibration Homogeneity of sample Masses and volumes Standard purity	NATA GAG Estimating Measurement Uncertainty of chemical test results
8	Coverage factor not reported			
9	Top Down - precision and evaluations of the method and laboratory bias k = 3	Duplicate analysis	Matrix effects Standard purity	Eurachem/CITAC Guide
10	Evaluating Measurement Uncertainty by black box with pairs of values k = 2	Standard deviation from PT studies only		ISO/GUM Guide ENAC G 09 or ISO 21748

Lab. Code	Approach to Evaluating MU	Information Sources for MU Evaluation*		Guide Document for Evaluating MU
		Precision	Method Bias	
11	Top Down - reproducibility (standard deviation) from PT studies used directly Coverage factor not reported	Control samples - CRM Duplicate analysis	Instrument calibration	Eurachem/CITAC Guide
12	Bottom Up (ISO/GUM, fish bone/cause and effect diagram) Coverage factor not reported	Control samples - CRM Duplicate analysis	Instrument calibration Masses and volumes Standard purity	NATA GAG Estimating and Reporting Measurement Uncertainty of Chemical Test Results
13	Top Down - precision and evaluations of the method and laboratory bias k = 3	Standard deviation from PT studies only		Eurachem/CITAC Guide
		Control samples - RM / Ex PT Sample Duplicate analysis		
14	Coverage factor not reported			
15	Standard deviation of replicate analyses multiplied by 2 or 3 Coverage factor not reported	Control samples - RM / Ex PT Sample		ISO/GUM
16	Top Down - precision and evaluations of the method and laboratory bias k = 2	Control samples - SS Duplicate analysis	Laboratory bias from PT studies Recoveries of SS	Eurachem/CITAC Guide
17	Top Down - precision and evaluations of the method and laboratory bias k = 2	Standard deviation from PT studies only		Nordtest Report TR537
		Control samples - Sample from case	Laboratory bias from PT studies	
18	Top Down - precision and evaluations of the method and laboratory bias Coverage factor not reported	Standard deviation from PT studies only		ISO/GUM
19	Bottom Up (ISO/GUM, fish bone/cause and effect diagram) k = 2	Control samples - CRM Duplicate analysis	Instrument calibration Homogeneity of sample Masses and volumes Laboratory bias from PT studies	ISO/GUM
20	Top Down - precision and evaluations of the method and laboratory bias k = 1	Control samples - RM / Ex PT Sample Duplicate analysis		EA-04/16, 'EA guidelines on the expression of uncertainty in quantitative testing'
21**	Bottom Up (ISO/GUM, fish bone/cause and effect diagram) k = 2	Standard deviation from PT studies only		ISO/GUM
		Control samples - CRM Duplicate analysis	Homogeneity of sample Standard purity	

Lab. Code	Approach to Evaluating MU	Information Sources for MU Evaluation*		Guide Document for Evaluating MU
		Precision	Method Bias	
22	Standard deviation of replicate analyses multiplied by 2 or 3 k = 3	Control samples - RM / Ex PT Sample Duplicate analysis		
23	Uncertainty Budget Method Coverage factor not reported	Control samples - CRM Duplicate analysis	Instrument calibration Masses and volumes Standard purity	Internal SOP Document
24	Top Down - precision and evaluations of the method and laboratory bias Coverage factor not reported	Control samples - RM / Ex PT Sample	Standard purity	ISO/GUM
25	Top Down - precision and evaluations of the method and laboratory bias k = 3	Control samples - RM / Ex PT Sample	Instrument calibration Homogeneity of sample Standard purity	Eurachem/CITAC Guide
26	Top Down - precision and evaluations of the method and laboratory bias k = 2	Control samples - previously analysed real seizure samples Duplicate analysis	Homogeneity of sample Masses and volumes Matrix effects Standard purity	Nordtest Report TR537
27	Top Down - precision and evaluations of the method and laboratory bias k = 2	Control samples - In-house control, CRM-based QC Duplicate analysis	Instrument calibration Masses and volumes	ISO/GUM
28	Standard deviation of replicate analyses multiplied by 2 or 3 k = 2	Control samples - RM / Ex PT Sample	Laboratory bias from PT studies	
29	Top Down - precision and evaluations of the method and laboratory bias k = 2	Control samples - RM Duplicate analysis	Homogeneity of sample Standard purity	Eurachem/CITAC Guide
30	Coverage factor not reported			
31	Bottom Up (ISO/GUM, fish bone/cause and effect diagram) k = 2	Control samples - CRM Duplicate analysis	Instrument calibration Homogeneity of sample Masses and volumes Matrix effects Recoveries of SS Standard purity	Eurachem/CITAC Guide
32**	Top Down - precision and evaluations of the method and laboratory bias k = 2 (reported as 95)	Control samples - CRM Duplicate analysis	Instrument calibration Homogeneity of sample Masses and volumes Standard purity	ISO/GUM UKAS document M3003
33	Top Down - precision and evaluations of the method and laboratory bias Coverage factor not reported	Standard deviation from PT studies only		
34	Coverage factor not reported	Control samples - CRM Duplicate analysis	Instrument calibration Laboratory bias from PT studies	

Lab. Code	Approach to Evaluating MU	Information Sources for MU Evaluation*		Guide Document for Evaluating MU
		Precision	Method Bias	
35	Bottom Up (ISO/GUM, fish bone/cause and effect diagram) Coverage factor not reported			ISO/GUM
36	Standard deviation of replicate analyses multiplied by 2 or 3 k = 2	Duplicate analysis	Masses and volumes	ISO/GUM

*CRM = Certified Reference Material; RM = Reference Material; SS = Spiked Samples.
**Additional information in Table 4.

Table 4 Uncertainty Evaluation Additional Comments

Lab. Code	Participant Comments
4	2 x Standard deviation plus bias
21	ISO/GUM Type A evaluation (Expanded Uncertainty = k*s/sqrt(n))
32	Uncertainty has been calculated by creating uncertainty budgets using primary source data and data obtained from sources including certificates of analysis. Measurement of uncertainty calculated following principles listed in the UKAS document M3003. MoU expanded using K=2 for 95% coverage.

3.3 Details of Participants' Calibration Standards

Participants were requested to provide information about their calibration standards. Responses as received are presented in Table 5. Some responses may be modified so that the participant cannot be identified.

Table 5 Participant Calibration Standard

Lab. Code	MDMA		Methamphetamine	
	Reference Standard	Purity (%)	Reference Standard	Purity (%)
1	TRC	95	In house	99.8
2			Sigma-aldrich	99
3	Nmi	99.8	Merck	100
4	In house synthesis	99.7	In house synthesis	99.8
5	MDMA	98	Methamphetamine	98
6	Lipomed	99.8151 ± 0.0288	Lipomed	99.950 ± 0.05
7	NMI	99.8	NMI	99.8
8	NMIA	97.5	NMIA	99.8
9	TRC	95	In house	99.8±0.56
10	Lipomed HCl MDMA	83.7	Lipomed HCl Methamphetamine	79.5
11	LGC	83.8	N.A	N.A
12	NMI	98.8 ±0.12	NMI	98.8 ±0.12
13	NMI	99.8	In house	100
14	Cayman	99.65	Lipomed	99.95

Lab. Code	MDMA		Methamphetamine	
	Reference Standard	Purity (%)	Reference Standard	Purity (%)
15	nc	nc	nc	nc
16	Lipomed	99.8151 ± 0.0288	Lipomed	99.950 ± 0.05
17	Internal	100	Internal	100
18	Lipomed	99.8151	Lipomed	99.987
19	NMI	99.8	NMI	99.8
20				
21	NMIA	99.8±0.3	NMIA	99.8±0.3
22	Chiron	99.4	Chiron	99.5
23	Lipomed	99.95	NMIA	99.8
24	Lipomed	98.8	Lipomed	99.8
25	TRC	95	In-House	99.8
26	NA	NA	NA	NA
27	NMI	99.8	NMI	99.6
28	Lipomed	83.8		
29	NMI	99.8 +/- 0.3	NMI	99.8 +/- 0.3
30	LGC	>99.9	lipomed	>99.9
31	NMI	99.8 +/- 0.3	NMI	99.5 +/- 1.2
32	Sigma-Aldrich	99.9	N/A	N/A
33	lipomed	99.95		
34				
35	NMIA	99.8±0.3	NMIA	99.8±0.3
36	LGC	99.7		

3.4 Participants' Comments

Participants were invited to comment on the samples, the PT study in general and suggestions for future PT studies. Such feedback allows for the improvement of future studies. Participants' comments are presented in Table 6, along with the study coordinator's response where appropriate. Some responses may be modified so that the participant cannot be identified.

Table 6 Participants' Comments

Lab. Code	Participants' Comments	Study Coordinator's Response
36	Unable to perform purity testing on methamphetamine, introduction of amphetamine to the scheme would be highly beneficial	Thank you for your feedback. We have included amphetamine in previous PT studies and intend to include it in future studies, pending sourcing of material.

4 PRESENTATION OF RESULTS AND STATISTICAL ANALYSIS

4.1 Results Summary

Participant results are listed in Tables 7 to 10 with resultant summary statistics: robust average, median, mean, number of numeric results (N), maximum (Max), minimum (Min), robust standard deviation (Robust SD) and robust coefficient of variation (Robust CV). Bar charts of results and performance scores are presented in Figures 2 to 5.

An example chart with interpretation guide is shown in Figure 1.

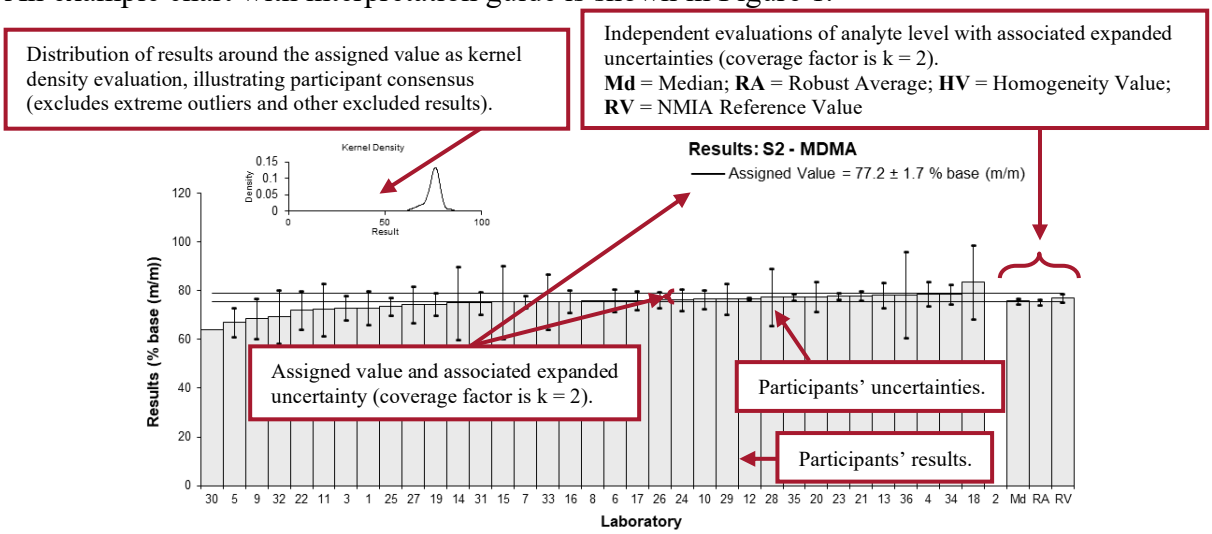


Figure 1 Guide to Presentation of Results

4.2 Outliers, Extreme Outliers and Other Excluded Results

Outliers were any result less than 50% and greater than 150% of the robust average and were removed prior to the calculation of the assigned values.[3,4] Extreme outliers (gross errors), such as those due to incorrect units, decimal placement errors, or results for a different proficiency test item, were also removed before the calculating statistics.[3]

4.3 Assigned Value

Assigned value is defined as the 'value attributed to a particular property or characteristic of a proficiency test item'.[1] In this PT study, the property is the % drug base (m/m) in the samples. Assigned values for Samples S1 and S4 were the robust averages of participants' results (after the removal of any outliers) and the expanded uncertainties were evaluated from the associated robust SDs (Appendix 2). Assigned values for Samples S2 and S3 in this study were reference values determined by quantitative nuclear magnetic resonance (qNMR) spectroscopy (Appendix 1).

4.4 Robust Average and Robust Between-Laboratory Coefficient of Variation

The robust averages and expanded MUs, and robust CVs (a measure of the variability of participants' results) were calculated as described in ISO 13528.[5]

4.5 Performance Coefficient of Variation (PCV)

The performance coefficient of variation (PCV) is a measure of the between-laboratory variation that in the judgement of the study coordinator would be expected from participants, given the levels of analytes present. The PCV is a value set by the study coordinator; it is not calculated from the participants' results. It is based on the mass fraction of the analytes in the study and experience from previous studies, and is also supported by mathematical models such as the Thompson-Horwitz equation.[6] By setting a fixed and realistic value for the PCV, a participant's performance does not depend on other participants' performances.

4.6 Standard Deviation for Proficiency Assessment

The standard deviation for proficiency assessment (SDPA, σ) is the product of the assigned value (X) and the PCV, as presented in Equation 1. This value is used for calculation of z-scores.

$$\sigma = X \times PCV \qquad \textit{Equation 1}$$

4.7 z-Score

For each participant's result, a z-score is calculated according to Equation 2.

$$z = \frac{(\chi - X)}{\sigma} \qquad \textit{Equation 2}$$

where:

z is z-score

χ is a participant's result

X is the assigned value

σ is the SDPA from Equation 1

For the absolute value of a z-score:

- $|z| \leq 2.0$ is acceptable;
- $2.0 < |z| < 3.0$ is questionable; and
- $|z| \geq 3.0$ is unacceptable.

4.8 E_n-Score

The E_n-score is complementary to the z-score in assessment of laboratory performance. The E_n-score includes measurement uncertainty and is calculated according to Equation 3.

$$E_n = \frac{(\chi - X)}{\sqrt{U_\chi{}^2 + U_X{}^2}} \qquad \textit{Equation 3}$$

where:

E_n is E_n-score

χ is a participant's result

X is the assigned value

U_χ is the expanded uncertainty of the participant's result

U_X is the expanded uncertainty of the assigned value

For the absolute value of an E_n-score:

- $|E_n| < 1.0$ is acceptable; and
- $|E_n| \geq 1.0$ is unacceptable.

4.9 Traceability and Measurement Uncertainty

Laboratories accredited to ISO/IEC 17025 must establish and demonstrate the traceability and measurement uncertainty associated with their test results.[7] Guidelines for quantifying uncertainty in analytical measurement are described in the Eurachem/CITAC Guide.[8]

5 TABLES AND FIGURES

Table 7

Sample Details

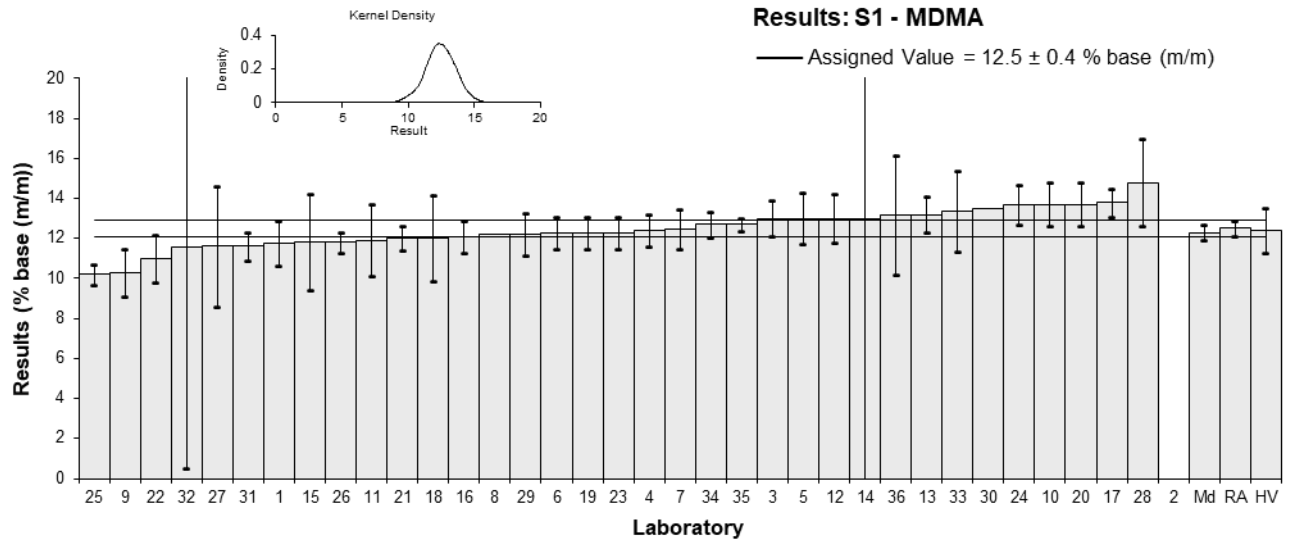
Sample No.	S1
Matrix	Powder
Analyte	MDMA
Unit	% base (m/m)

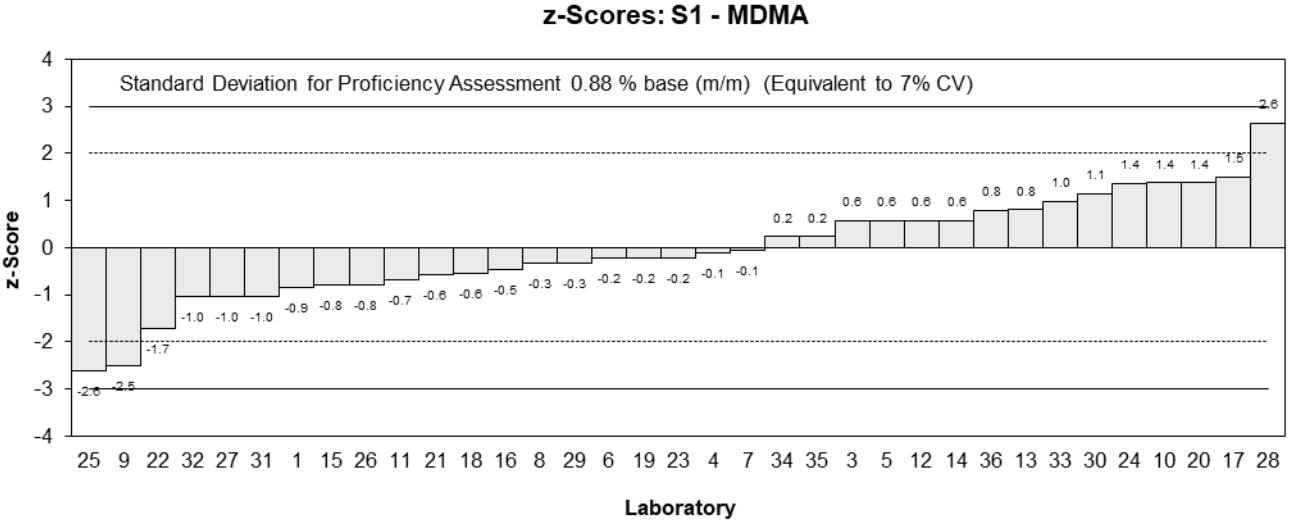
Participant Results

Lab. Code	Result	Uncertainty	z	E_n
1	11.75	1.13	-0.86	-0.63
2	NR	NR		
3	13	0.9022	0.57	0.51
4	12.4	0.8	-0.11	-0.11
5	13	1.3	0.57	0.37
6	12.3	0.8	-0.23	-0.22
7	12.45	1	-0.06	-0.05
8	12.2	NR	-0.34	-0.75
9	10.3	1.2	-2.51	-1.74
10	13.7	1.1	1.37	1.03
11	11.9	1.8	-0.69	-0.33
12	13	1.2	0.57	0.40
13	13.2	0.9	0.80	0.71
14	13	15	0.57	0.03
15	11.8	2.4	-0.80	-0.29
16	12.1	0.8	-0.46	-0.45
17	13.8	0.7	1.49	1.61
18	12.01	2.16	-0.56	-0.22
19	12.3	0.8	-0.23	-0.22
20	13.7	1.1	1.37	1.03
21	12.0	0.6	-0.57	-0.69
22	11	1.2	-1.71	-1.19
23	12.3	0.8	-0.23	-0.22
24	13.68	1	1.35	1.10
25	10.2	0.5	-2.63	-3.59
26	11.8	0.5	-0.80	-1.09
27	11.6	3	-1.03	-0.30
28	14.8	2.2	2.63	1.03
29	12.21	1.04	-0.33	-0.26
30	13.5	NR	1.14	2.50
31	11.6	0.7	-1.03	-1.12
32	11.59	11.08	-1.04	-0.08
33	13.35	2	0.97	0.42
34	12.7	0.63	0.23	0.27
35	12.7	0.3	0.23	0.40
36	13.18	2.98	0.78	0.23

Statistics

Assigned Value	12.5	0.4
Homogeneity Value	12.4	1.1
Robust Average	12.5	0.4
Median	12.3	0.4
Mean	12.5	
N	35	
Max	14.8	
Min	10.2	
Robust SD	0.93	
Robust CV	7.5%	


Results: S1 - MDMA
Assigned Value = 12.5 ± 0.4 % base (m/m)
Kernel Density
Density
Result
Results (% base (m/m))
Laboratory
25 9 22 32 27 31 1 15 26 11 21 18 16 8 29 6 19 23 4 7 34 35 3 5 12 14 36 13 33 30 24 10 20 17 28 2 Md RA HV


z-Scores: S1 - MDMA
Standard Deviation for Proficiency Assessment 0.88 % base (m/m) (Equivalent to 7% CV)
z-Score
Laboratory
25 9 22 32 27 31 1 15 26 11 21 18 16 8 29 6 19 23 4 7 34 35 3 5 12 14 36 13 33 30 24 10 20 17 28

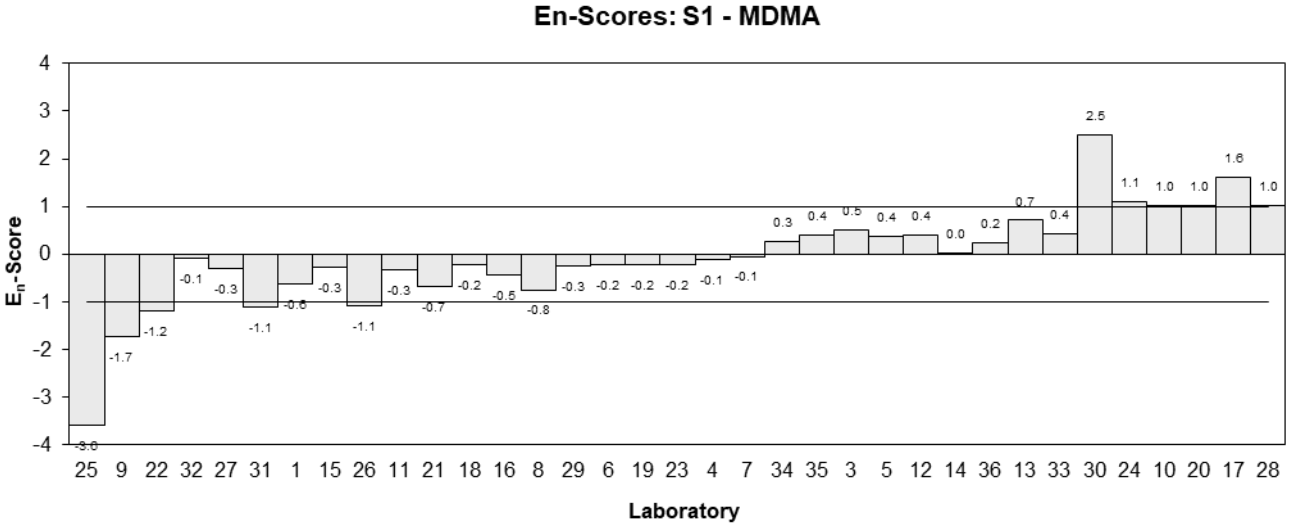

En-Scores: S1 - MDMA
En-Score
Laboratory
25 9 22 32 27 31 1 15 26 11 21 18 16 8 29 6 19 23 4 7 34 35 3 5 12 14 36 13 33 30 24 10 20 17 28

Figure 2

Table 8

Sample Details

Sample No.	S2
Matrix	Powder
Analyte	MDMA
Unit	% base (m/m)

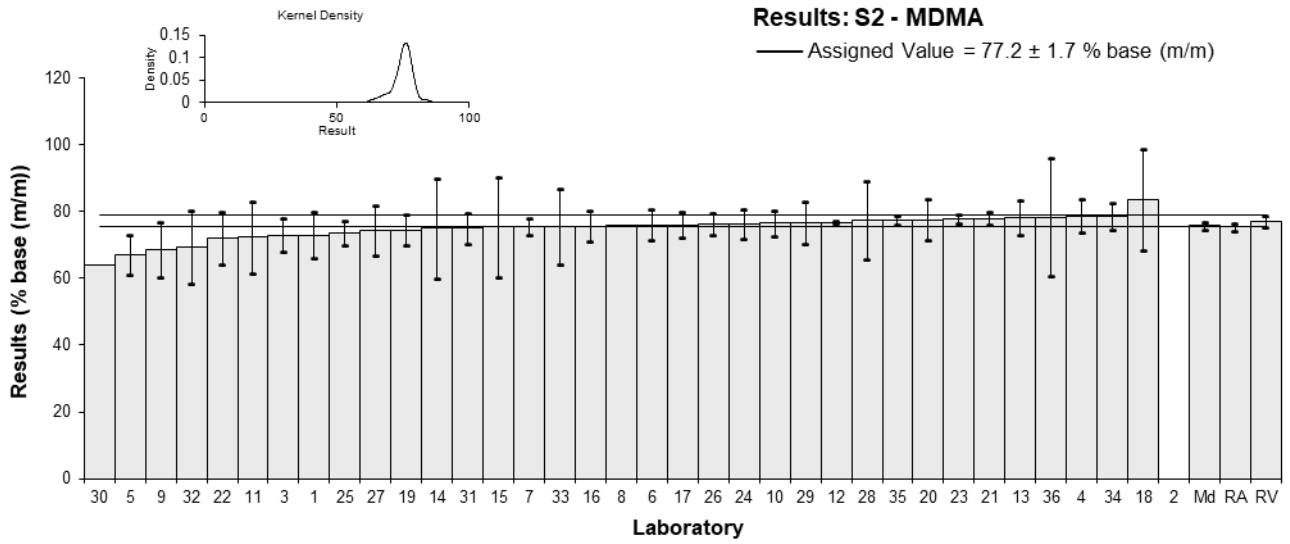
Participant Results

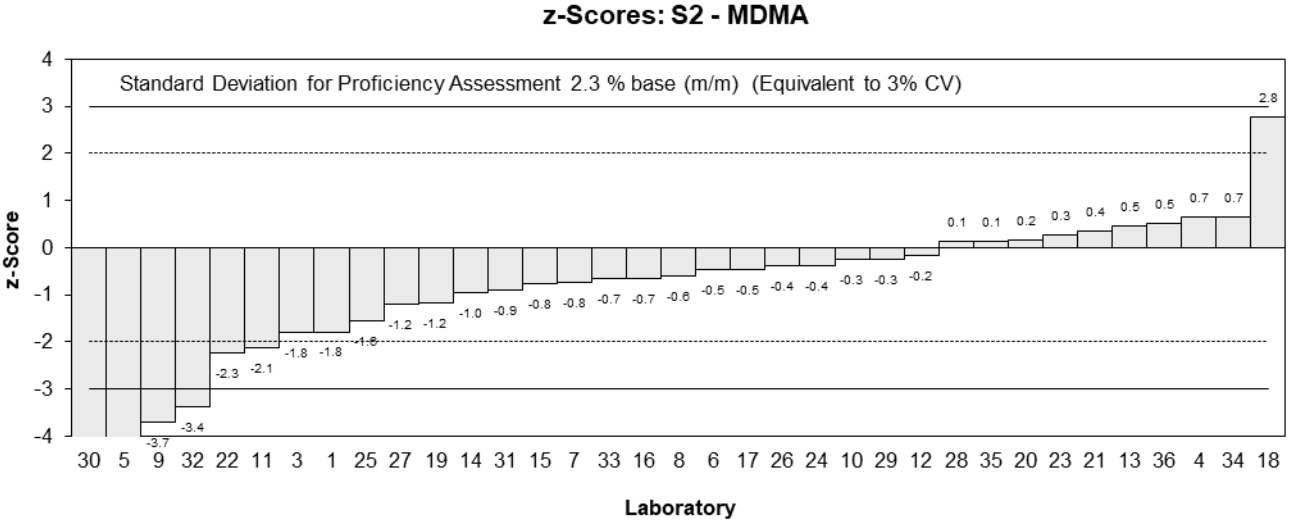
Lab. Code	Result	Uncertainty	z	E_n
1	73.05	7.07	-1.79	-0.57
2	NR	NR		
3	73	5.0662	-1.81	-0.79
4	78.7	5.0	0.65	0.28
5	67	6	-4.40	-1.64
6	76.1	4.6	-0.47	-0.22
7	75.47	2.4	-0.75	-0.59
8	75.8	NR	-0.60	-0.82
9	68.6	8.2	-3.71	-1.03
10	76.6	3.8	-0.26	-0.14
11	72.3	10.9	-2.12	-0.44
12	76.8	0.39	-0.17	-0.23
13	78.3	5.3	0.47	0.20
14	75	15	-0.95	-0.15
15	75.4	15.1	-0.78	-0.12
16	75.7	4.6	-0.65	-0.31
17	76.1	3.8	-0.47	-0.26
18	83.63	15.05	2.78	0.42
19	74.5	4.6	-1.17	-0.55
20	77.6	6.2	0.17	0.06
21	78.0	1.9	0.35	0.31
22	72	7.9	-2.25	-0.64
23	77.8	1.4	0.26	0.27
24	76.32	4.6	-0.38	-0.18
25	73.6	3.6	-1.55	-0.90
26	76.3	3.3	-0.39	-0.24
27	74.4	7.44	-1.21	-0.37
28	77.5	11.6	0.13	0.03
29	76.60	6.40	-0.26	-0.09
30	64.2	NR	-5.61	-7.65
31	75.1	4.6	-0.91	-0.43
32	69.37	11.08	-3.38	-0.70
33	75.69	11.35	-0.65	-0.13
34	78.7	3.93	0.65	0.35
35	77.5	1.4	0.13	0.14
36	78.39	17.78	0.51	0.07

Statistics

Assigned Value	77.2	1.7
Reference Value	77.2	1.7
Robust Average	75.5	1.1
Median	75.8	1.1
Mean	75.2	
N	35	
Max	83.63	
Min	64.2	
Robust SD	2.6	
Robust CV	3.5%	

Assigned value is the reference value as determined by qNMR spectroscopy.


Kernel Density
Density
Result
Results: S2 - MDMA
Assigned Value = 77.2 ± 1.7 % base (m/m)
Results (% base (m/m))
Laboratory
30 5 9 32 22 11 3 1 25 27 19 14 31 15 7 33 16 8 6 17 26 24 10 29 12 28 35 20 23 21 13 36 4 34 18 2 Md RA RV


z-Scores: S2 - MDMA
Standard Deviation for Proficiency Assessment 2.3 % base (m/m) (Equivalent to 3% CV)
z-Score
Laboratory
30 5 9 32 22 11 3 1 25 27 19 14 31 15 7 33 16 8 6 17 26 24 10 29 12 28 35 20 23 21 13 36 4 34 18

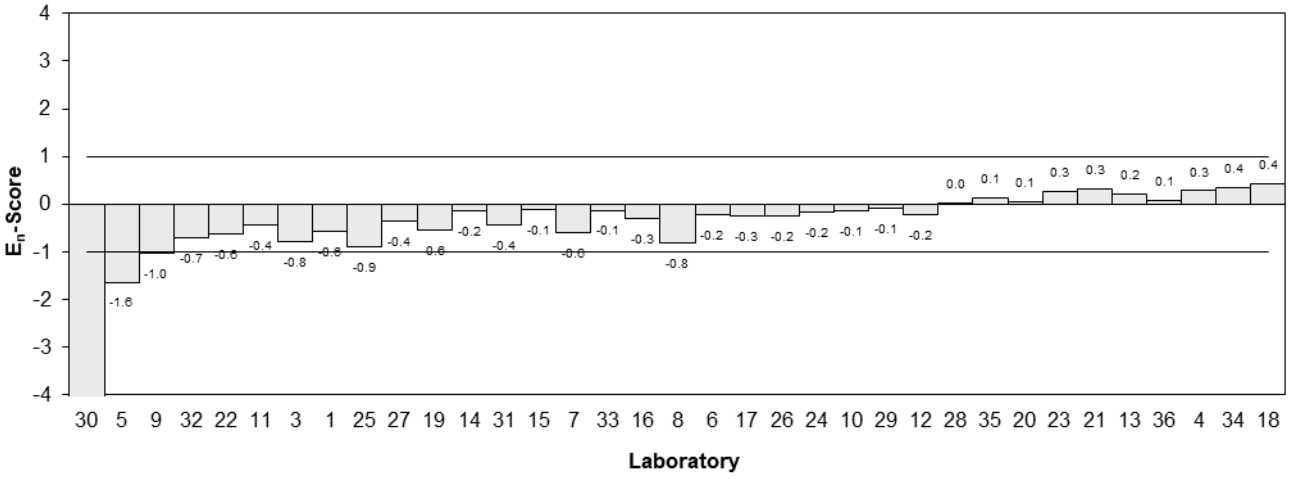

En-Scores: S2 - MDMA
En-Score
Laboratory
30 5 9 32 22 11 3 1 25 27 19 14 31 15 7 33 16 8 6 17 26 24 10 29 12 28 35 20 23 21 13 36 4 34 18

Figure 3

Table 9

Sample Details

Sample No.	S3
Matrix	Powder
Analyte	Methamphetamine
Unit	% base (m/m)

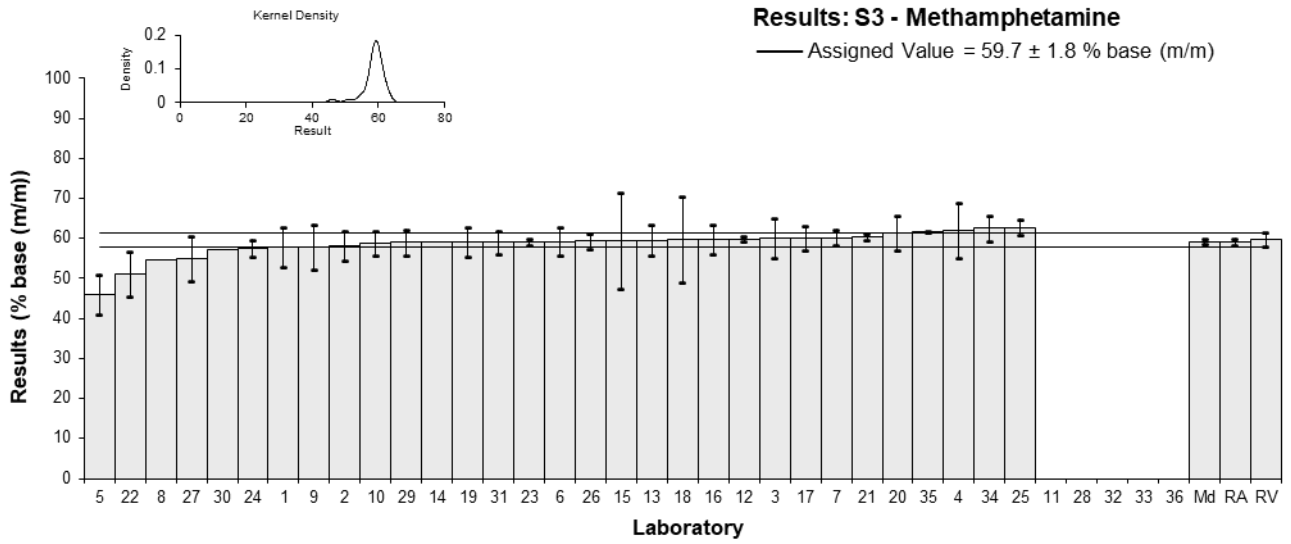
Participant Results

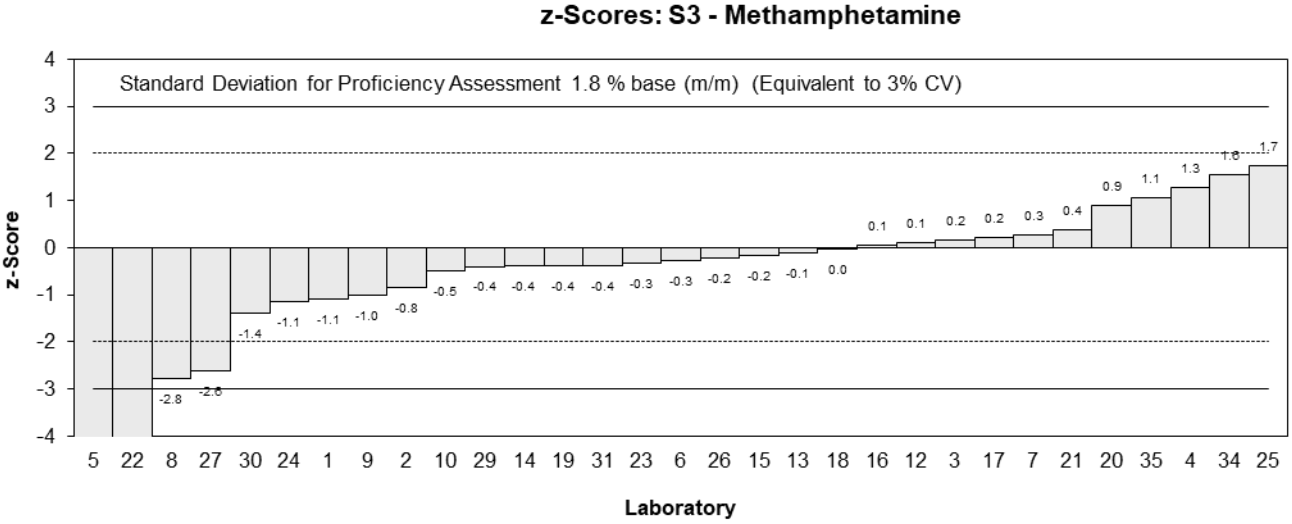
Lab. Code	Result	Uncertainty	z	E_n
1	57.74	5.03	-1.09	-0.37
2	58.2	3.8	-0.84	-0.36
3	60	4.932	0.17	0.06
4	62.0	7.0	1.28	0.32
5	46	5	-7.65	-2.58
6	59.2	3.6	-0.28	-0.12
7	60.21	2	0.28	0.19
8	54.7	NR	-2.79	-2.78
9	57.9	5.7	-1.01	-0.30
10	58.8	2.9	-0.50	-0.26
11	NR	NR		
12	59.9	0.65	0.11	0.10
13	59.5	3.9	-0.11	-0.05
14	59	NR	-0.39	-0.39
15	59.4	11.9	-0.17	-0.02
16	59.8	3.6	0.06	0.02
17	60.1	3	0.22	0.11
18	59.65	10.7	-0.03	0.00
19	59.0	3.7	-0.39	-0.17
20	61.3	4.3	0.89	0.34
21	60.4	0.8	0.39	0.36
22	51	5.6	-4.86	-1.48
23	59.1	0.8	-0.34	-0.30
24	57.65	2.1	-1.14	-0.74
25	62.8	2.0	1.73	1.15
26	59.3	1.8	-0.22	-0.16
27	55	5.5	-2.62	-0.81
28	NR	NR		
29	58.99	3.23	-0.40	-0.19
30	57.2	NR	-1.40	-1.39
31	59	3	-0.39	-0.20
32	NR	NR		
33	NR	NR		
34	62.5	3.12	1.56	0.78
35	61.6	0.2	1.06	1.05
36	NR	NR		

Statistics

Assigned Value	59.7	1.8
Reference Value	59.7	1.8
Robust Average	59.2	0.8
Median	59.2	0.7
Mean	58.6	
N	31	
Max	62.8	
Min	46	
Robust SD	1.9	
Robust CV	3.2%	

Assigned value is the reference value as determined by qNMR spectroscopy.


Kernel Density
Density
Result
Results: S3 - Methamphetamine
Assigned Value = 59.7 ± 1.8 % base (m/m)
Results (% base (m/m))
Laboratory
5 22 8 27 30 24 1 9 2 10 29 14 19 31 23 6 26 15 13 18 16 12 3 17 7 21 20 35 4 34 25 11 28 32 33 36 Md RA RV


z-Scores: S3 - Methamphetamine
Standard Deviation for Proficiency Assessment 1.8 % base (m/m) (Equivalent to 3% CV)
z-Score
Laboratory
5 22 8 27 30 24 1 9 2 10 29 14 19 31 23 6 26 15 13 18 16 12 3 17 7 21 20 35 4 34 25

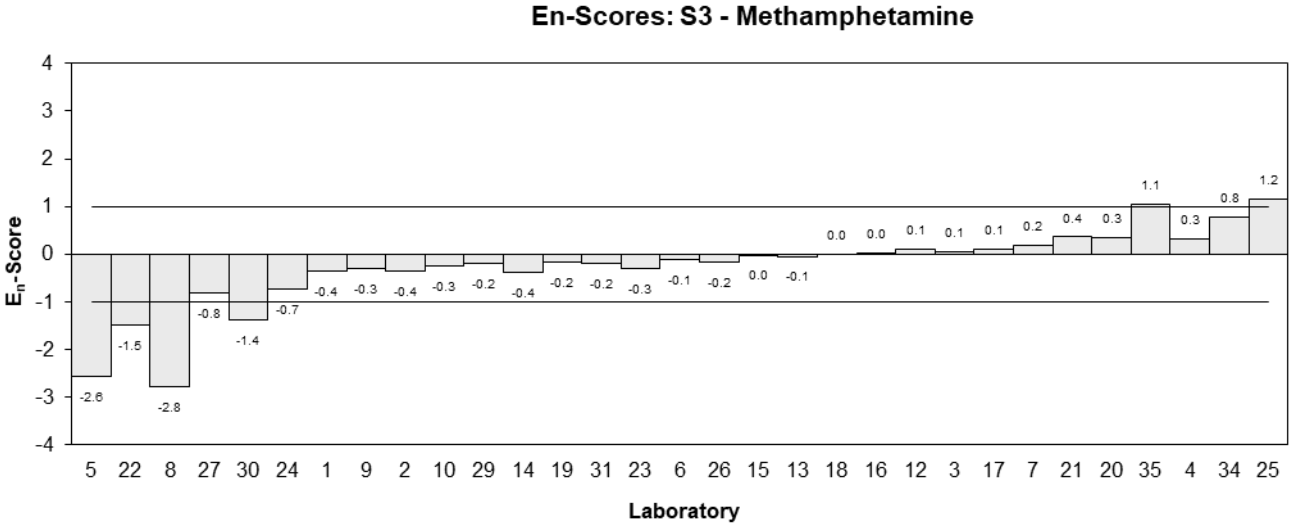

En-Scores: S3 - Methamphetamine
En-Score
Laboratory
5 22 8 27 30 24 1 9 2 10 29 14 19 31 23 6 26 15 13 18 16 12 3 17 7 21 20 35 4 34 25

Figure 4

Table 10

Sample Details

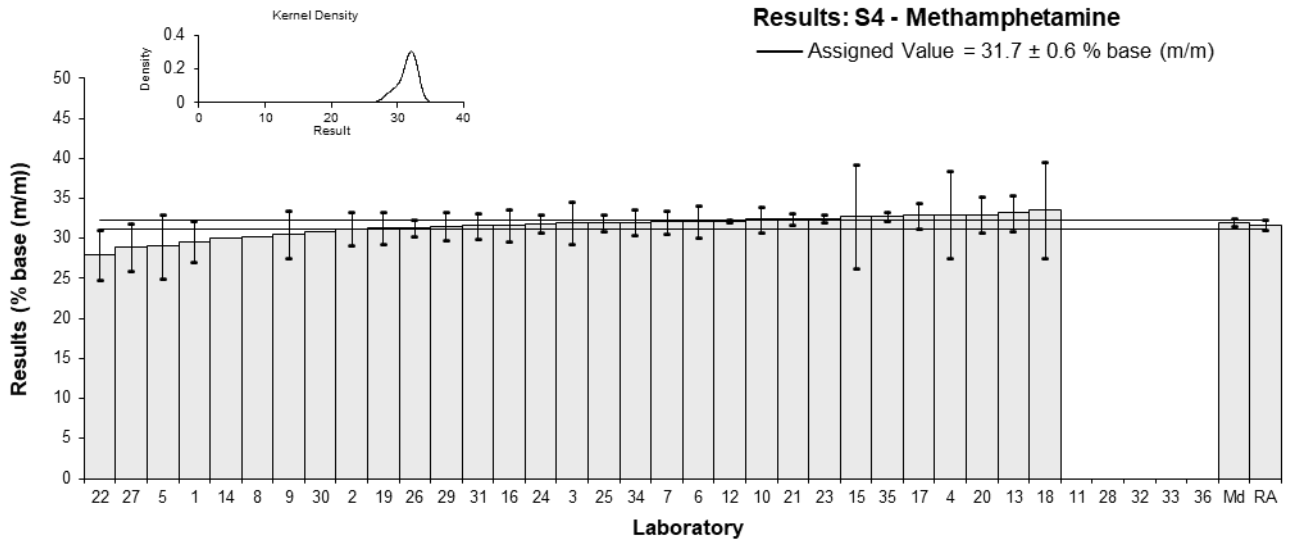
Sample No.	S4
Matrix	Powder
Analyte	Methamphetamine
Unit	% base (m/m)

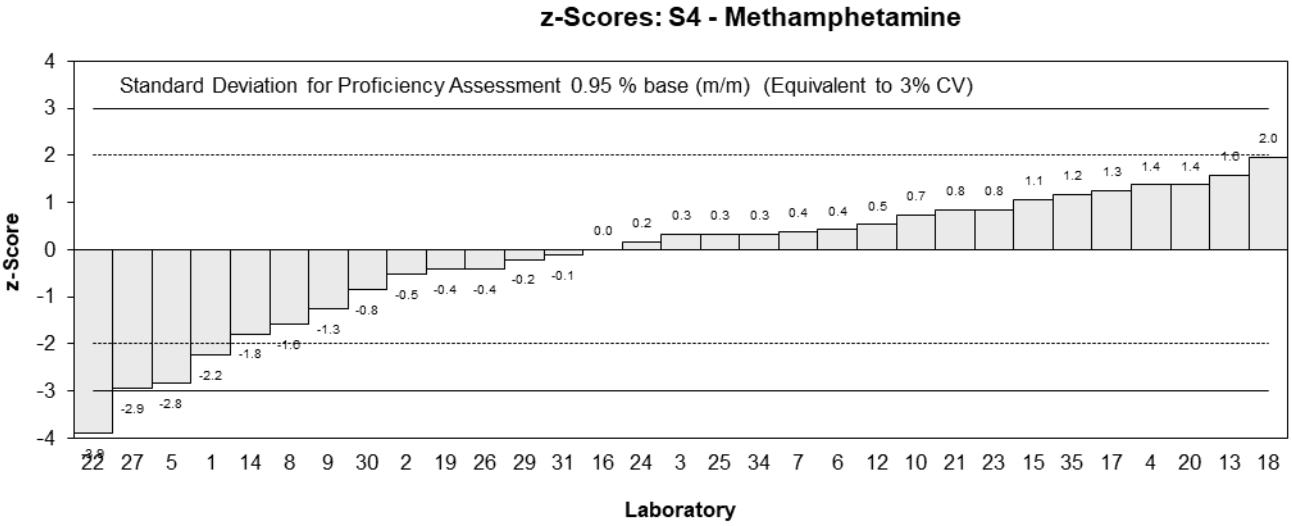
Participant Results

Lab. Code	Result	Uncertainty	z	E_n
1	29.57	2.57	-2.24	-0.81
2	31.2	2.1	-0.53	-0.23
3	32	2.6304	0.32	0.11
4	33.0	5.4	1.37	0.24
5	29	4	-2.84	-0.67
6	32.1	2.0	0.42	0.19
7	32.05	1.4	0.37	0.23
8	30.2	NR	-1.58	-2.50
9	30.5	3	-1.26	-0.39
10	32.4	1.6	0.74	0.41
11	NR	NR		
12	32.2	0.17	0.53	0.80
13	33.2	2.2	1.58	0.66
14	30	NR	-1.79	-2.83
15	32.7	6.5	1.05	0.15
16	31.7	2.0	0.00	0.00
17	32.9	1.6	1.26	0.70
18	33.56	6.04	1.96	0.31
19	31.3	2.0	-0.42	-0.19
20	33	2.3	1.37	0.55
21	32.5	0.7	0.84	0.87
22	28	3.1	-3.89	-1.17
23	32.5	0.5	0.84	1.02
24	31.84	1.1	0.15	0.11
25	32.0	1.0	0.32	0.26
26	31.3	1.0	-0.42	-0.34
27	28.9	3	-2.94	-0.92
28	NR	NR		
29	31.50	1.75	-0.21	-0.11
30	30.9	NR	-0.84	-1.33
31	31.6	1.6	-0.11	-0.06
32	NR	NR		
33	NR	NR		
34	32	1.6	0.32	0.18
35	32.8	0.6	1.16	1.30
36	NR	NR		

Statistics

Assigned Value	31.7	0.6
Robust Average	31.7	0.6
Median	32.0	0.5
Mean	31.6	
N	31	
Max	33.56	
Min	28	
Robust SD	1.3	
Robust CV	4%	


Kernel Density
Density
Result
Results: S4 - Methamphetamine
Assigned Value = 31.7 ± 0.6 % base (m/m)
Results (% base (m/m))
Laboratory
22 27 5 1 14 8 9 30 2 19 26 29 31 16 24 3 25 34 7 6 12 10 21 23 15 35 17 4 20 13 18 11 28 32 33 36 Md RA


z-Scores: S4 - Methamphetamine
Standard Deviation for Proficiency Assessment 0.95 % base (m/m) (Equivalent to 3% CV)
z-Score
Laboratory
22 27 5 1 14 8 9 30 2 19 26 29 31 16 24 3 25 34 7 6 12 10 21 23 15 35 17 4 20 13 18

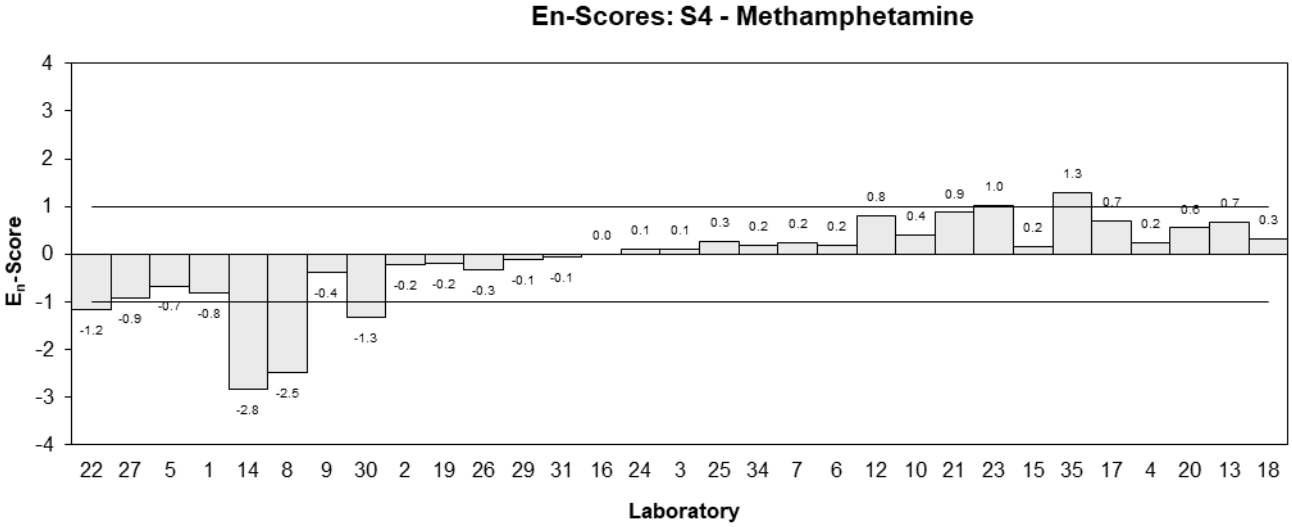

En-Scores: S4 - Methamphetamine
En-Score
Laboratory
22 27 5 1 14 8 9 30 2 19 26 29 31 16 24 3 25 34 7 6 12 10 21 23 15 35 17 4 20 13 18

Figure 5

Table 11 Participants' Identification of Cutting Agents*

Lab. Code	Cutting Agents			
	S1	S2	S3	S4
Preparation	Niacinamide	-	Caffeine	Paracetamol
1	Niacinamide		Caffeine	Acetaminophen
2			Caffeine	Paracetamol
3	Niacinamide	N/A	Caffeine	Paracetamol
4	nicotinamide		caffeine	paracetamol
5			caffeine	paracetamol
6	Nicotinamide	Nil	Caffeine	Paracetamol
7			caffeine	
8	Niacinamide	/	Caffeine	Acetaminophen
9	Niacinamide		Caffeine	Acetaminophen
10	NIACINAMIDE		CAFFEINE	ACETAMINOPHEN
11	Nicotinamide	/	Caffeine	Acetaminophen
12	niacinamide	uncut	caffeine	paracetamol
13				
14	N/A	N/A	Caffeine	N/A
15	Nicotinamide	x	Caffeine	Paracetamol
16	Nicotinamide	Nil	Caffeine	Paracetamol
17	Nicotinamide		Caffeine	
18	Nicotinamide		Caffeine	Acetaminophen
19	Nicotinamide		Caffeine	Paracetamol
20	Nicotinamide	N/A	Caffeine	Paracetamol
21	Niacinamide		Caffeine	Acetaminophen
22			Caffeine	Acetaminophen
23	Nicotinamide	N/A	Caffeine	Paracetamol
24	Nicotinamide		Caffeine (23.31 m%)	Paracetamol
25	Niacinamide		caffeine	acetaminophen
26	Nicotinamide		caffeine, dimethylsulfone	paracetamol
27	Nicotinamide	N/A	Caffeine	Paracetamol
28	Nicotinamide	/	Caffeine	Paracetamol
29	nicotinamide		caffeine	paracetamol
30	nicotinamide		caffeine	paracetamol
31	Nicotinamide	None	Caffeine	Paracetamol
32	N/A	N/A	N/A	N/A
33	niacinamide		caffeine	paracetamol

Lab. Code	Cutting Agents			
	S1	S2	S3	S4
34	niacinamide		caffeine	acetaminophen
35	Niacinamide		Caffeine	Acetaminophen
36	Nicotinamide		Caffeine	Paracetamol

*Some responses may be modified so that the participant cannot be identified.

6 DISCUSSION OF RESULTS

6.1 Assigned Value

The assigned values for Samples S1 and S4 were the robust averages of participants' results. The robust averages and associated expanded uncertainties were calculated using the procedure described in ISO 13528.[5] The calculation of the expanded uncertainty for a robust average is presented in Appendix 2.

The reference values obtained using qNMR spectroscopy were used as the assigned values for Samples S2 and S3. Maleic acid (NMIA CRM QNMR010) was used as the internal standard. The uncertainty of the reference value was evaluated in accordance with the ISO GUM.[9] Additional details are given in Appendix 1.

Traceability: The consensus of participants' results in not traceable to any external reference, so although expressed in SI units, metrological traceability has not been established.

The measurements of the reference values were made using qNMR and are traceable to the SI through Australian Standards for mass via balance calibration certificates and the purity of the NMIA maleic acid CRM (QNMR010, Batch No.: 10-Q-02).

6.2 Measurement Uncertainty Reported by Participants

Participants were asked to report an evaluation of the expanded MU associated with their results, and the basis of this uncertainty evaluation. It is a requirement of ISO/IEC 17025 that laboratories have procedures to evaluate the uncertainty of chemical measurements and to report this uncertainty in specific circumstances, including when the client's instruction so requires.[7]

Of 132 numeric results, 122 (92%) were reported with an associated expanded uncertainty. Participants used a wide variety of procedures to evaluate their reported uncertainties (Tables 3 and 4). Two participants reported using the NATA GAG Estimating and Reporting MU as their guide; this document has been officially removed from the NATA website and is considered obsolete.[10]

Laboratory **14** reported uncertainties for Samples S1 and S2 MDMA, however did not report uncertainties for Samples S3 and S4 methamphetamine; this participant reported that they were not accredited to ISO/IEC 17025. Laboratories **8** and **30** did not report uncertainties for any of their results; both these participants reported that they were not accredited to ISO/IEC 17025.

For this PT study, participants were instructed to report uncertainties as % drug as base (m/m). Laboratory **14** reported uncertainties for both Samples S1 and S2 as '15', resulting in one of their uncertainties being 115% of the result. Laboratory **32** reported their uncertainties for both Samples S1 and S2 as '11.08', resulting in one of their uncertainties being 96% of the result. These participants may have reported relative uncertainties instead.

Laboratory **35** reported very small relative uncertainties, with one uncertainty being only 0.3% of the result; their other uncertainties were around 2% of the reported result.

The magnitudes of the other reported uncertainties were within the range 1% to 26% relative to the reported result. In general, an expanded uncertainty of less than 3% relative may be unrealistically small for a routine measurement, while an expanded uncertainty of over 10% relative may be too large to be fit for purpose. Of the 122 expanded MUs reported, 13 were less than 3% relative, while 32 were greater than 10% relative.

Participants were also requested to report the coverage factor associated with their uncertainties (Table 3). Of the participants reporting coverage factors, most reported k = 2 at

approximately 95% confidence level (15 participants). Six participants reported k = 3 at approximately 99% confidence level. One participant, Laboratory **20**, reported k = 1 at approximately 68% confidence level; therefore, this participant's uncertainties were reported as standard uncertainty rather than expanded uncertainty as requested for this PT study.

Uncertainties associated with results returning an acceptable *z*-score but an unacceptable E_n-score may have been undervalued.

In some cases, results were reported with an inappropriate number of significant figures. Including too many significant figures may inaccurately reflect the precision of measurements. The recommended format is to write the uncertainty to no more than two significant figures and then to write the result with the corresponding number of decimal places. For example, instead of 29.57 ± 2.57%, it is recommended to report 29.6 ± 2.6%.[8]

6.3 z-Score

The *z*-score compares the participants' deviation from the assigned value with the standard deviation for proficiency assessment (SDPA).

The SPDA defines acceptable performance in a proficiency test. Unlike the standard deviation based on between-laboratory CV, setting the SDPA as a realistic set value enables *z*-scores to be used as fixed reference value points for assessment of laboratory performance, independent of group performance.

The between-laboratory CV predicted by the Thompson-Horwitz equation,[6] between-laboratory CV from reported results in this study, and the SDPA (as PCV) are presented for comparison in Table 12.

SDPAs equivalent to 3% were used to calculate *z*-scores for Samples S2, S3 and S4. Sample S1 was a low-level sample, close to the lower end of participants' analytical range; a SDPA equivalent to 7% PCV was used to calculate the *z*-scores for this sample.

Table 12 Thompson/Horwitz CV, Between-Laboratory CV and SDPA (as PCV)

Sample	Analyte	Assigned Value (% base (m/m))	Thompson-Horwitz CV (%)	Between-Laboratory CV* (%)	SDPA (as PCV) (%)
S1	MDMA	12.5	2.7	7.5	7
S2	MDMA	77.2	1.1	3.5	3
S3	Methamphetamine	59.7	1.3	3.2	3
S4	Methamphetamine	31.7	1.8	4.0	3

*Robust between-laboratory CV with outliers removed, if applicable.

Of 132 results for which *z*-scores were calculated, 114 (86%) returned a *z*-score of $|z| \leq 2.0$, indicating an acceptable performance.

Laboratories **2**, **3**, **4**, **6**, **7**, **10**, **12**, **13**, **14**, **15**, **16**, **17**, **19**, **20**, **21**, **23**, **24**, **26**, **29**, **31**, **33**, **34**, **35** and **36** returned acceptable z-scores for all reported numeric results.

Twelve participants returned at least one questionable or unacceptable *z*-score.

Laboratory **9** returned questionable or unacceptable *z*-scores for both MDMA samples (negatively biased).

Three participants returned questionable or unacceptable *z*-scores for both methamphetamine samples (all negatively biased): Laboratories **5**, **22** and **27**. These participants should review their methodology to identify the source of this negative bias.

The dispersal of participants' *z*-scores is presented graphically in Figure 6.

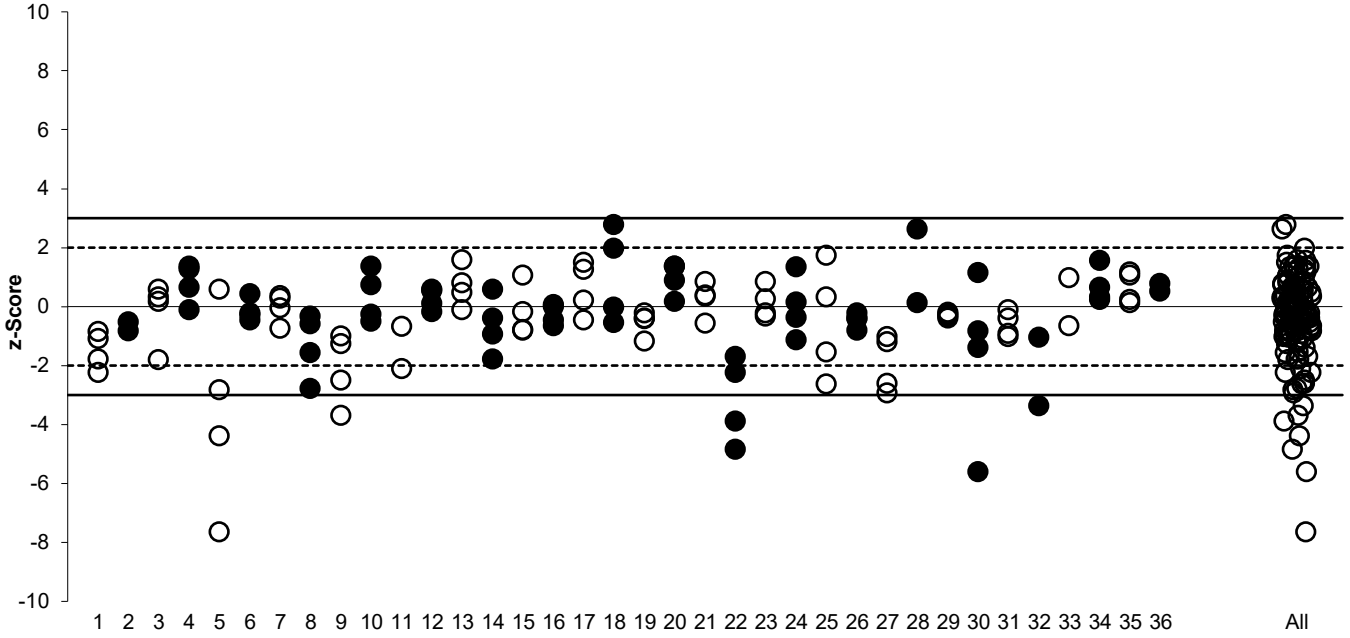
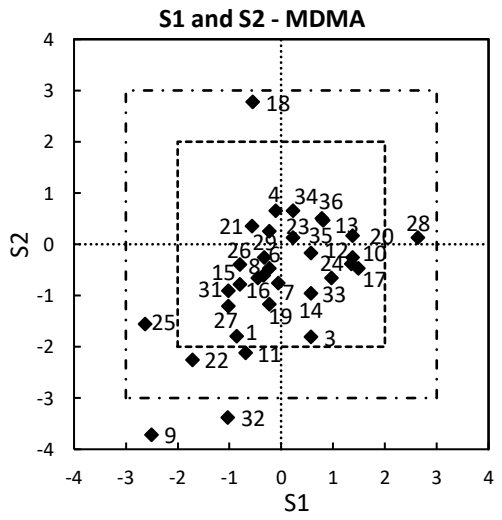


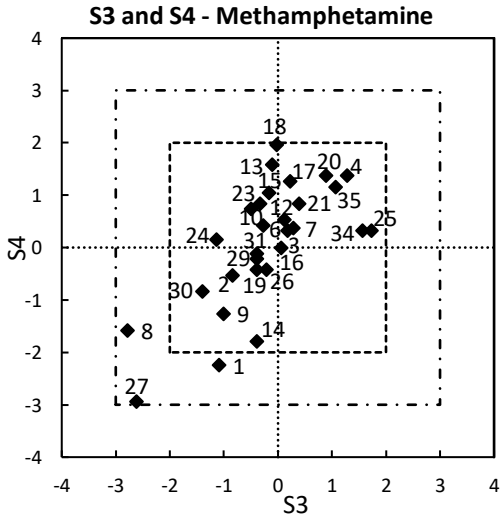
Figure 6 *z*-Score Dispersal by Laboratory

Scatter plots of *z*-scores for MDMA in Samples S1 and S2, and methamphetamine in Samples S3 and S4, are presented in Figures 7 and 8 respectively. Scores are predominantly in the upper right and lower left quadrants, indicating that laboratory bias is the major contributor to the variability of results. Points close to the diagonal axis demonstrate excellent repeatability, while points close to the zero demonstrate excellent repeatability and accuracy.



Laboratories **5** and **30** are off-scale.

Figure 7 *z*-Score Scatter Plot – MDMA



Laboratories **5** and **22** are off-scale.

Figure 8 *z*-Score Scatter Plot – Methamphetamine

6.4 E_n-Score

E_n-scores can be interpreted in conjunction with *z*-scores. The E_n-score indicates how closely a result agrees with the assigned value considering the respective uncertainties. An unacceptable E_n-score can either be caused by inappropriate measurement, an inappropriate evaluation of measurement uncertainty, or both. Where a participant did not report an expanded uncertainty with a result, an expanded uncertainty of zero (0) was used to calculate the E_n-score.

Of 132 results for which E_n-scores were calculated, 106 (80%) returned an E_n-score of $|E_n| < 1.0$, indicating agreement of the participant's result with the assigned value within their respective expanded uncertainties.

Laboratories **1**, **2**, **3**, **4**, **6**, **7**, **11**, **12**, **13**, **15**, **16**, **18**, **19**, **21**, **27**, **29**, **32**, **33**, **34** and **36** returned acceptable E_n-scores for all reported numeric results.

Sixteen participants returned at least one unacceptable E_n-score.

Laboratory **30** returned unacceptable E_n-scores for all samples. They did not report any uncertainties. Three of this participant's results returned acceptable *z*-scores, and these results likely would have returned acceptable E_n-scores if realistic and fit-for-purpose uncertainties were reported.

The dispersal of participants' E_n-scores is presented graphically in Figure 9.

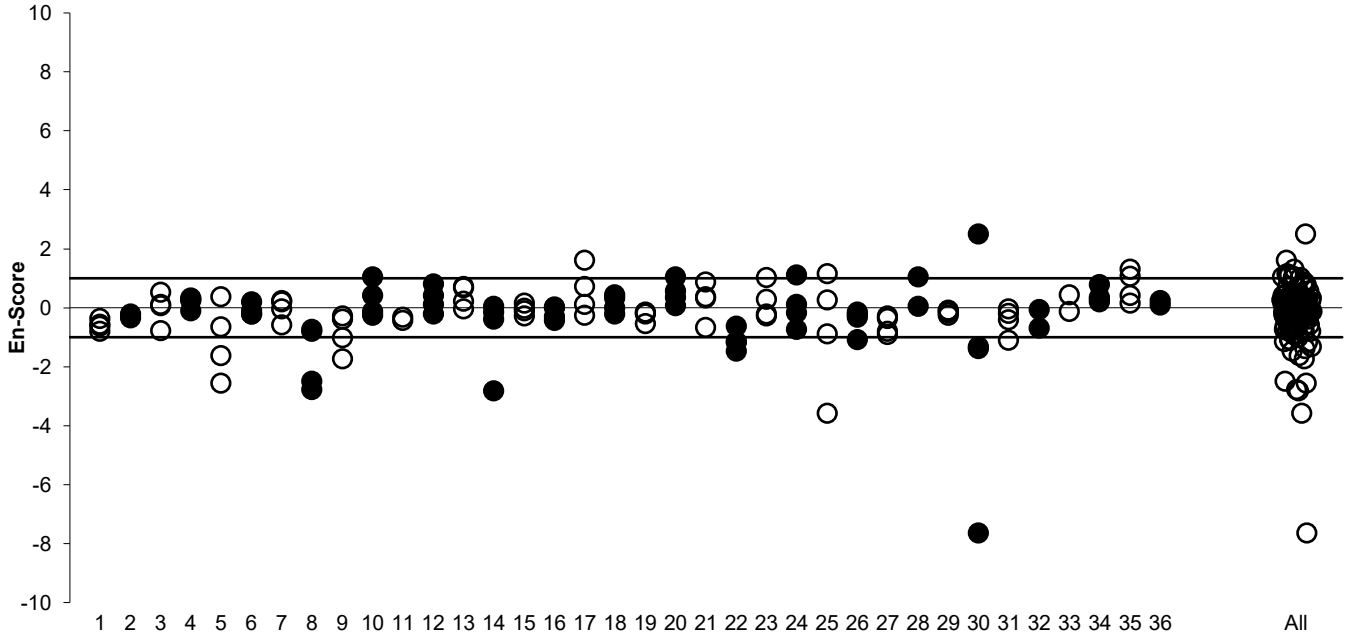


Figure 9 E_n-Score Dispersal by Laboratory

6.5 Identification of Cutting Agents

Sample S1 was prepared by adding niacinamide to MDMA hydrochloride. Sample S2 was left uncut. Samples S3 and S4 were prepared by adding caffeine and paracetamol respectively to methamphetamine hydrochloride.

Participants were requested to identify the cutting agents in the samples if part of their routine analysis, and the results reported are presented in Table 11. In general, the identification of the cutting agents in this study was not challenging for participants.

Thirty-four participants (94%) reported on the identity of at least one cutting agent in the samples.

Twenty-eight participants (78%) correctly identified all cutting agents in this study (Laboratories **1**, **3**, **4**, **6**, **8**, **9**, **10**, **11**, **12**, **15**, **16**, **18**, **19**, **20**, **21**, **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, **31**, **33**, **34**, **35** and **36**).

For Sample S1, 29 participants correctly identified niacinamide as the cutting agent (Laboratories **1**, **3**, **4**, **6**, **8**, **9**, **10**, **11**, **12**, **15**, **16**, **17**, **18**, **19**, **20**, **21**, **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, **31**, **33**, **34**, **35** and **36**).

For Sample S3, 34 participants correctly identified caffeine as the cutting agent (Laboratories **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **10**, **11**, **12**, **14**, **15**, **16**, **17**, **18**, **19**, **20**, **21**, **22**, **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, **31**, **33**, **34**, **35** and **36**). Laboratory **26** additionally reported dimethyl sulfone; this may have been a small impurity in the original methylamphetamine matrix.

For Sample S4, 31 participants correctly identified paracetamol as the cutting agent (Laboratories **1**, **2**, **3**, **4**, **5**, **6**, **8**, **9**, **10**, **11**, **12**, **15**, **16**, **18**, **19**, **20**, **21**, **22**, **23**, **24**, **25**, **26**, **27**, **28**, **29**, **30**, **31**, **33**, **34**, **35** and **36**).

6.6 Participants' Analytical Methods

Participants were requested to analyse the samples using their routine test methods and to report a single result for each sample as they would normally report to a client. Results reported in this way reflect the true variability of results reported to laboratory clients. The method descriptions provided by participants are presented in Tables 1 and 2.

Plots of the *z*-scores versus various parameters are presented in Figures 10 to 13. A variety of sample masses, calibration standard sources, and extraction solvents were used by participants in this study.

Instrumental techniques employed by participants for the analysis of MDMA and methamphetamine samples in this study included gas chromatography (GC) coupled with flame ionisation detection (FID) or mass spectrometry (MS); liquid chromatography (LC) including high performance liquid chromatography (HPLC) or ultra performance liquid chromatography (UPLC) as reported by participants, coupled with diode array detection/photodiode array detection (DAD/PDA), UV-Vis, or tandem mass spectrometry (MS/MS); and quantitative nuclear magnetic resonance (qNMR) spectroscopy. LC-DAD/PDA was the most common measurement instrument employed by participants for both MDMA and methamphetamine.

Laboratory **5** reported using LC-MS/MS for all samples and returned negatively biased questionable or unacceptable *z*-scores for three of their reported results.

The measurement of MDMA in Sample S1 posed a greater analytical challenge for participants than the measurement of MDMA in Sample S2 and methamphetamine in Samples S3 and S4. This is likely due to its low-level % base (m/m) value, close to the lower end of participants' analytical range. The between-laboratory CV for Sample S1 was 7.5%, around double that observed for the other samples (3.5%, 3.2% and 4.0% in Samples S2, S3 and S4 respectively). However, there was no significant trend observed with respect to methodology used for this sample.

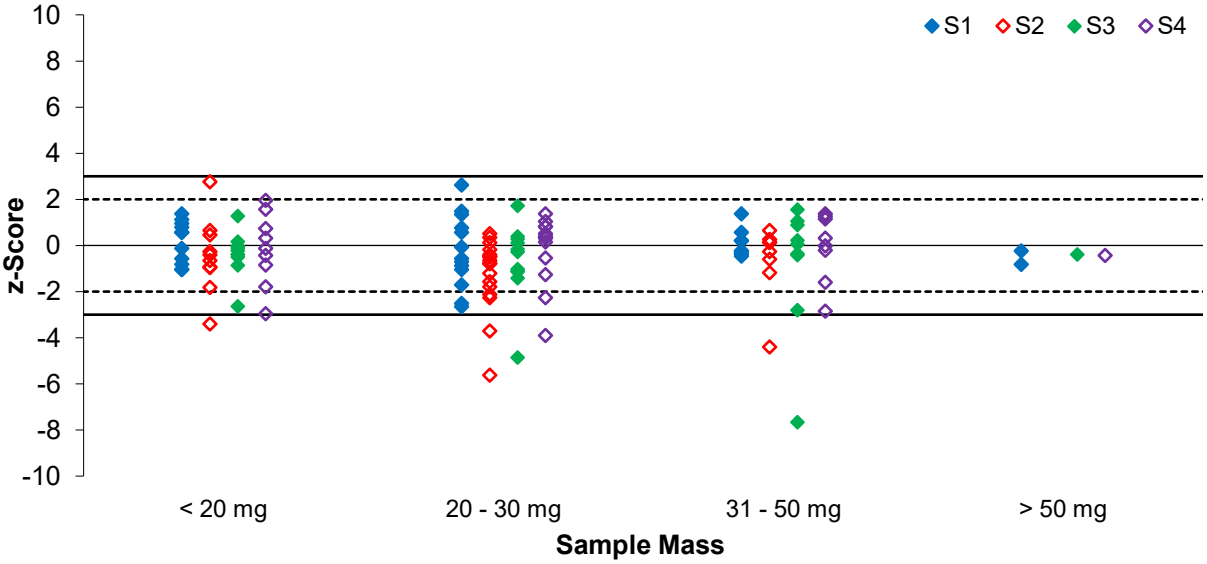


Figure 10 *z*-Score vs Sample Mass Used for Analysis

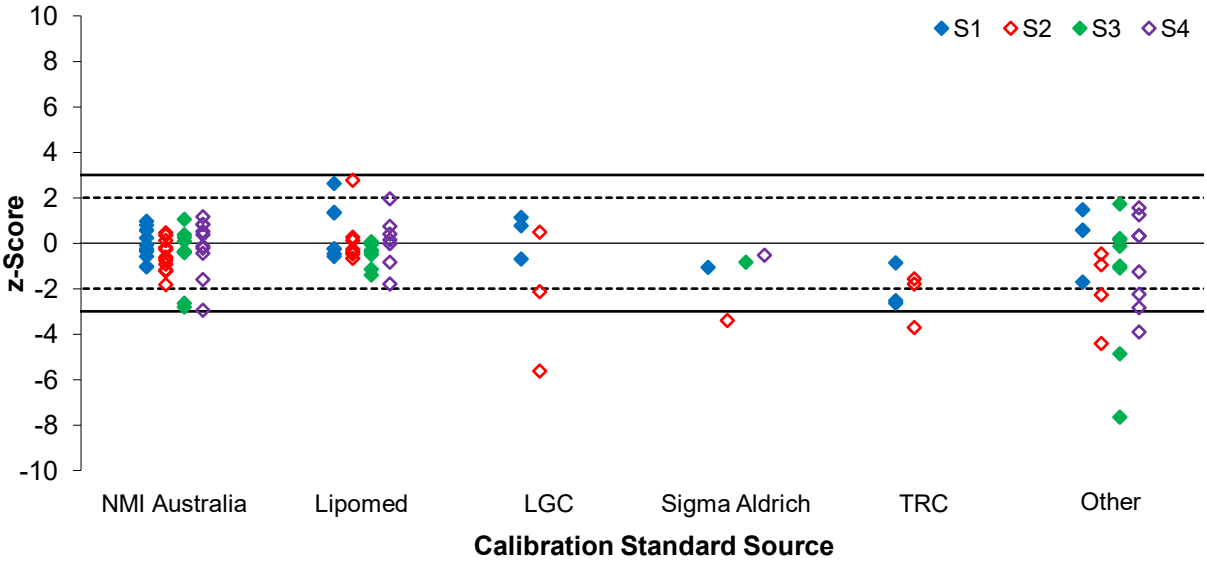


Figure 11 *z*-Score vs Calibration Standard Source

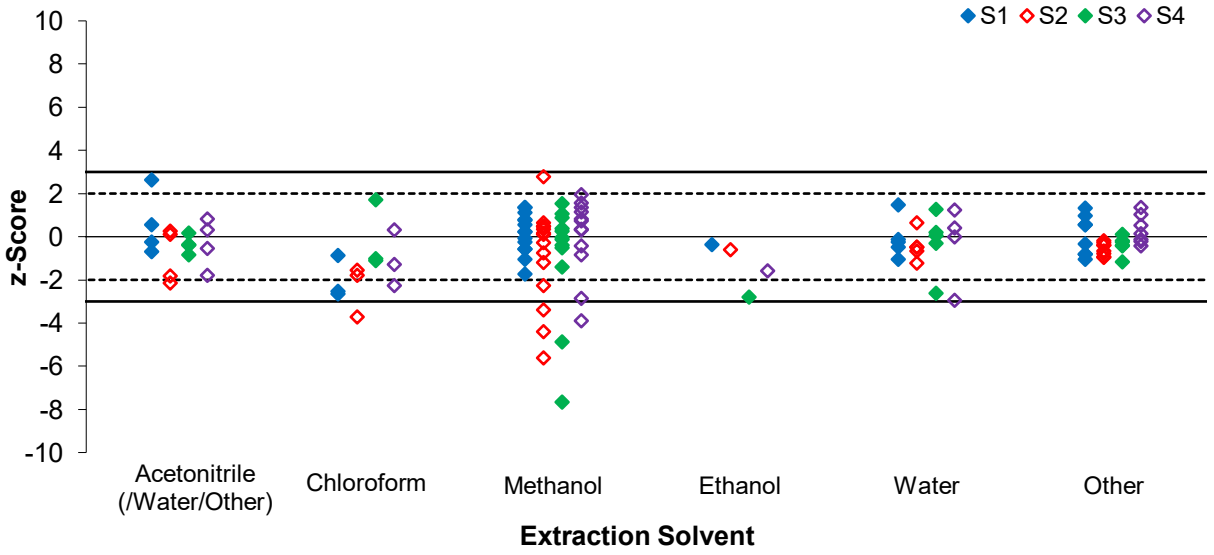


Figure 12 *z*-Score vs Extraction Solvent

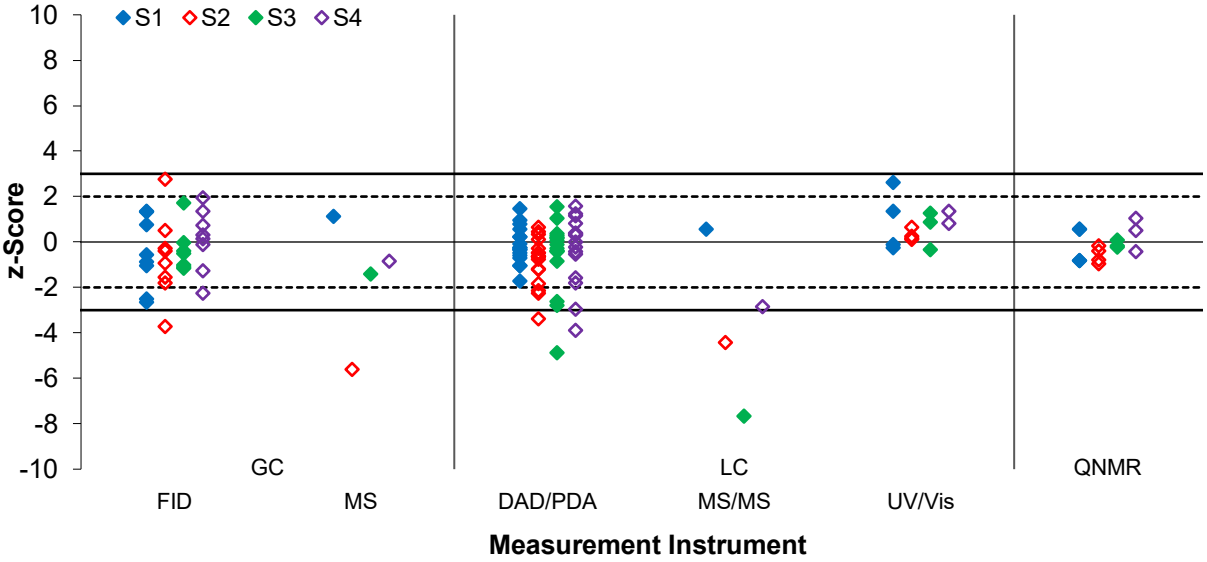


Figure 13 *z*-Score vs Measurement Instrument

6.7 Comparison of Results and Date of Analysis

As there were delays with sample delivery to some international participants, the samples were analysed by participants over approximately 4 months. No trend was found between when the samples were analysed and the results obtained (Figure 14).

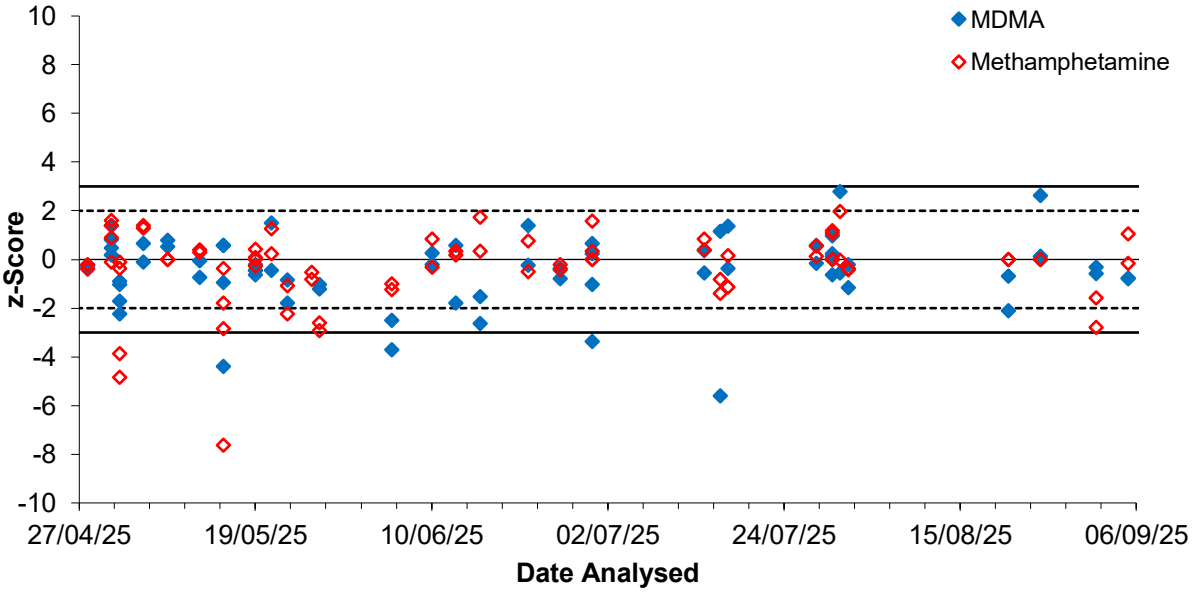
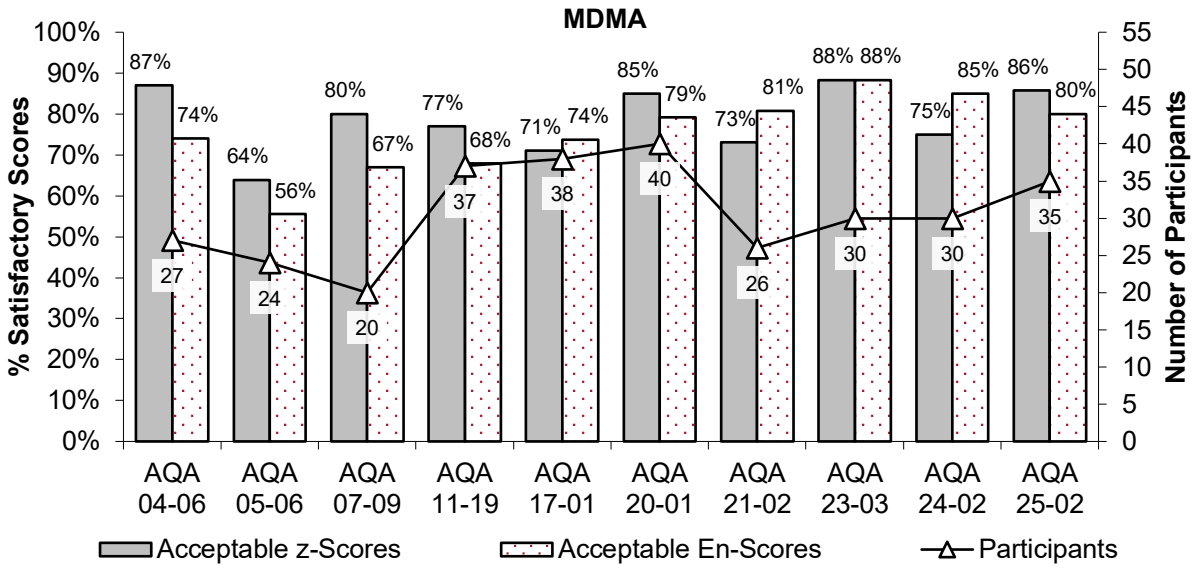


Figure 14 *z*-Score vs Sample Analysis Date

6.8 Comparison with Previous PT Studies

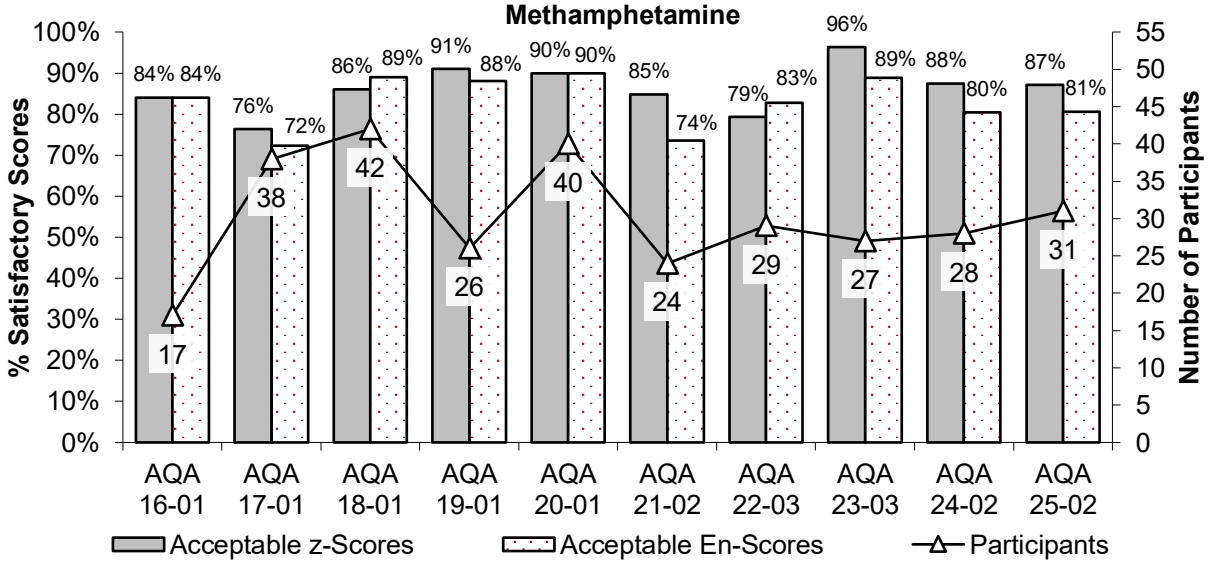
A summary of the acceptable performance, presented as a percentage of the total number of scores, obtained by PT study participants for MDMA from 2004 – 2025 (last ten studies with MDMA) is presented in Figure 15. The average proportion of acceptable *z*-scores and E_n-scores over this period is 79% and 75% respectively.



One sample in AQA 25-02 was scored using 7% PCV; all other samples included in this chart were scored using 3% PCV.

Figure 15 Summary of Participants' Performance in NMIA MDMA PT Studies

A summary of the acceptable performance, presented as a percentage of the total number of scores, obtained by PT study participants for methamphetamine from 2016 – 2025 (last ten studies with methamphetamine) is presented in Figure 16. The average proportion of acceptable *z*-scores and E_n-scores over this period is 86% and 83% respectively. Overall, participants' performance with methamphetamine quantitation has been better than for MDMA.



One sample in AQA 23-03 was scored using 5% PCV; all other samples included in this chart were scored using 3% PCV.

Figure 16 Summary of Participants' Performance in NMIA Methamphetamine PT Studies

A number of participants have consistently participated in NMIA MDMA and methamphetamine PT studies, and individual performance history reports are emailed to each participant at the end of every PT study. The consideration of *z*-scores for an analyte over time provides much more useful information than a single *z*-score. Over time, laboratories should expect at least 95% of their scores to lie within the range $|z| \leq 2.0$. Scores in the range $2.0 < |z| < 3.0$ can occasionally occur, however, these should be interpreted in conjunction

with the other scores obtained by that laboratory. For example, a trend of *z*-scores on one side of the zero line is an indication of method or laboratory bias.

A summary of individual laboratory's performances over the last seven NMIA MDMA PT studies is presented in Figures 17 and 18 for Australian and international laboratories respectively. Four Australian and three international laboratories have achieved acceptable *z*-scores across all MDMA samples in PT studies participated in over this period.

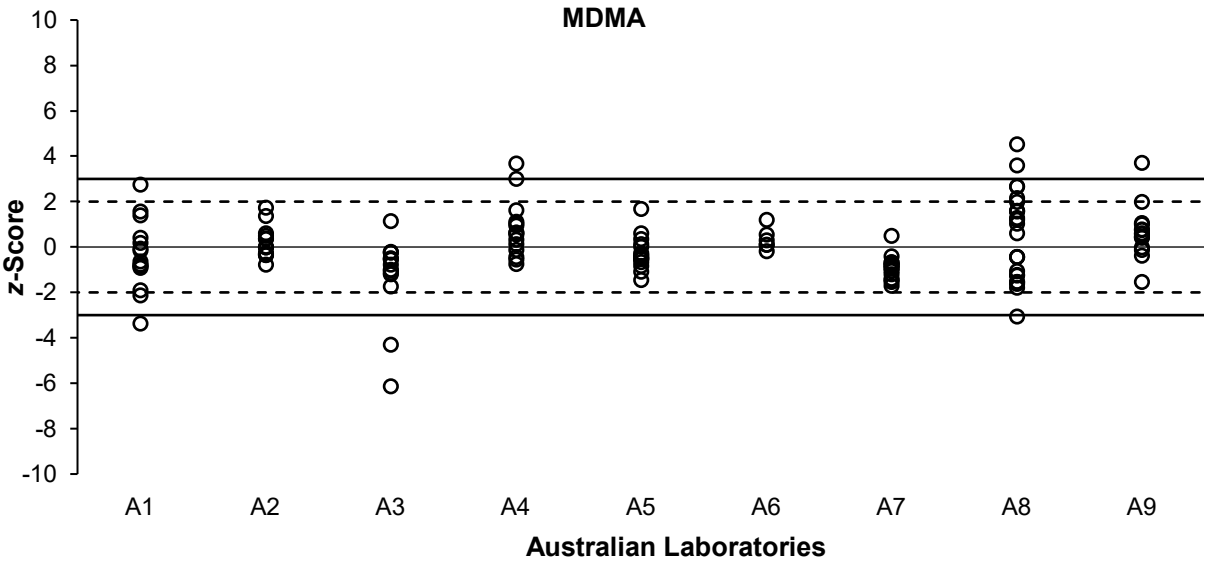
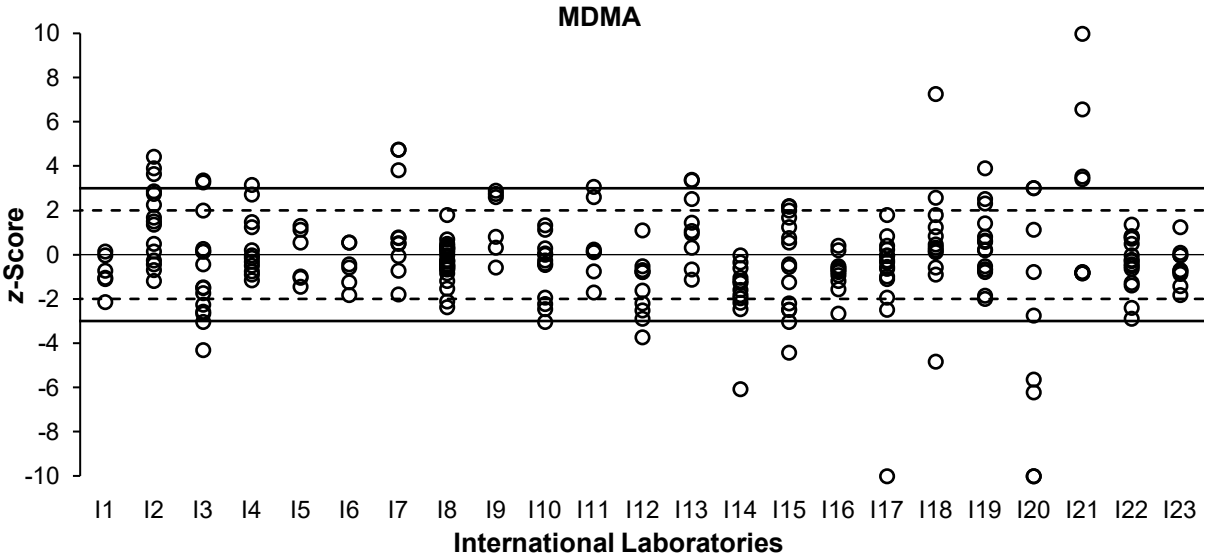


Figure 17 Summary of Australian Participants' *z*-Scores in NMIA MDMA PT Studies



z-Scores greater than 10.0 or less than -10.0 have been plotted at 10.0 or -10.0 respectively.

Figure 18 Summary of International Participants' *z*-Scores in NMIA MDMA PT Studies

A summary of individual laboratory's performances over the last ten NMIA methamphetamine PT studies is presented in Figures 19 and 20 for Australian and international laboratories respectively (laboratory identifiers may not be the same as for Figures 17 and 18). Five Australian and six international laboratories have achieved acceptable *z*-scores across all methamphetamine samples in PT studies participated in over this period.

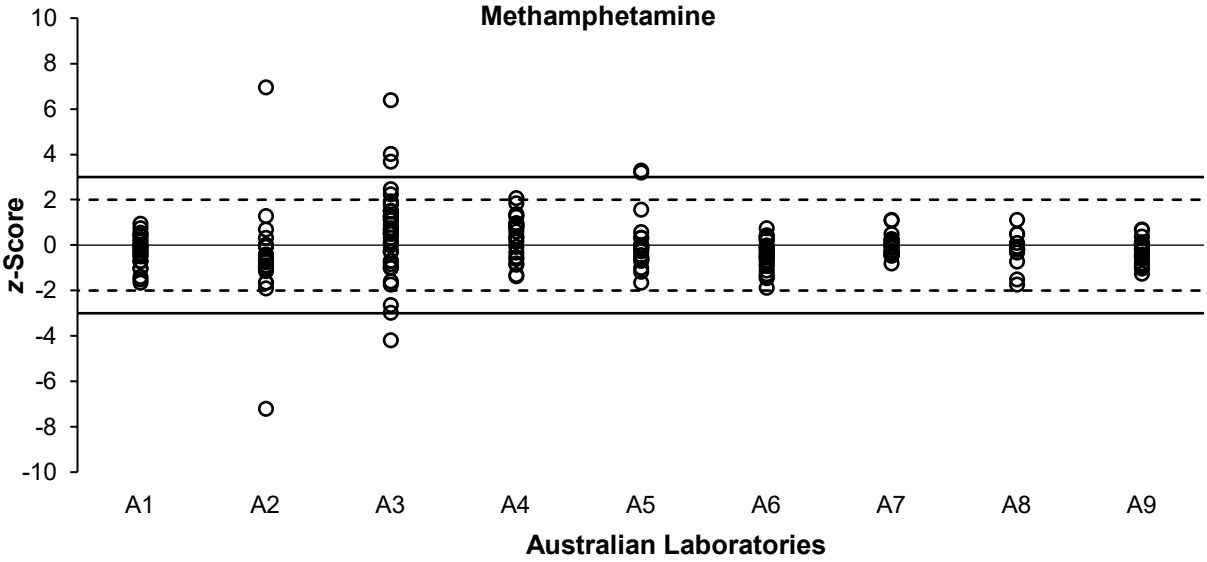


Figure 19 Summary of Australian Participants' *z*-Scores in NMIA Methamphetamine PT Studies

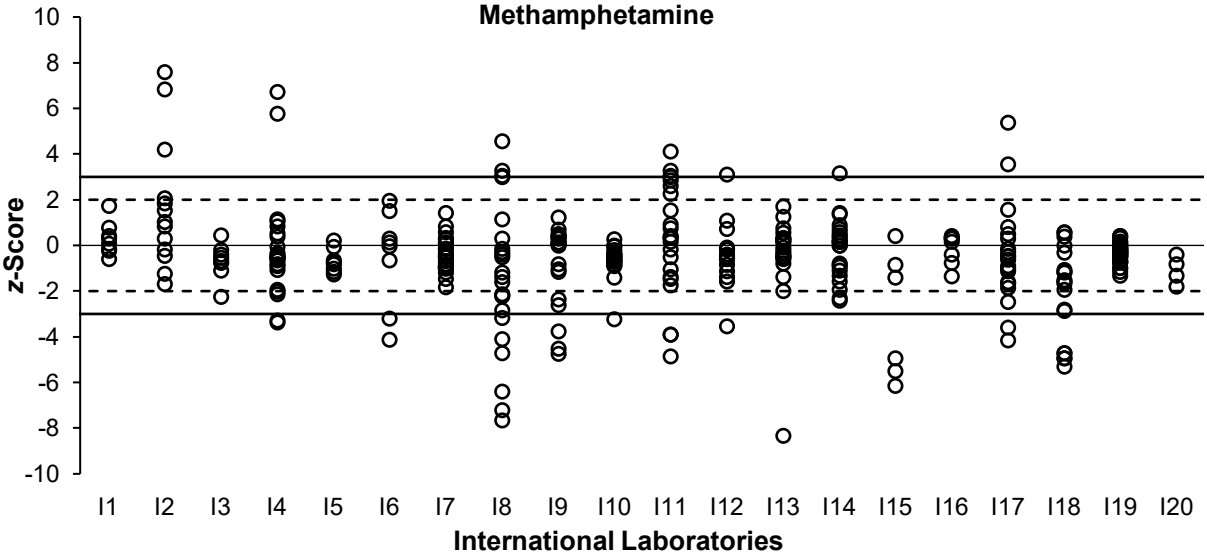


Figure 20 Summary of International Participants' *z*-Scores in NMIA Methamphetamine PT Studies

7 REFERENCES

Please note that for all undated references, the latest edition of the referenced document (including any amendments) applies.

[1] ISO/IEC 17043, *Conformity assessment — General requirements for the competence of proficiency testing providers*.

[2] Commonwealth of Australia, Department of Industry, Science and Resources, NMIA, 2025, *Study Protocol for Proficiency Testing*, viewed October 2025, <https://www.industry.gov.au/sites/default/files/2020-10/cpt_study_protocol.pdf>.

[3] Commonwealth of Australia, Department of Industry, Science and Resources, NMIA, 2025*, Chemical Proficiency Testing Statistical Manual*, viewed October 2025, <https://www.industry.gov.au/sites/default/files/2019-07/cpt_statistical_manual.pdf>.

[4] Thompson, M., Ellison, S.L.R. and Wood, R., 2006, 'The International Harmonized Protocol for the Proficiency Testing of Analytical Chemistry Laboratories', *Pure Appl. Chem.,* vol. 78, pp. 145-196.

[5] ISO 13528, *Statistical methods for use in proficiency testing by interlaboratory comparison*.

[6] Thompson, M., 2000, 'Recent trends in inter-laboratory precision at ppb and sub-ppb concentrations in relation to fitness for purpose criteria in proficiency testing', *Analyst*, vol. 125, pp. 385-386.

[7] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories.*

[8] Eurachem/CITAC Guide CG 4, QUAM:2012.P1, *Quantifying Uncertainty in Analytical Measurement*, 3rd edition, viewed October 2025, <http://www.eurachem.org/images/stories/Guides/pdf/QUAM2012_P1.pdf>.

[9] ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*.

[10] NATA, 2020, *Update to Measurement Uncertainty resources*, viewed October 2025, <https://nata.com.au/news/update-to-measurement-uncertainty-resources/>

APPENDIX 1 HOMOGENEITY TESTING AND REFERENCE VALUES

Three sample vials from each of Samples S1, S2 and S4 were analysed in duplicate under repeatability conditions and in random order. Measurements were made using qNMR spectroscopy with maleic acid as the internal standard. The data supplied with the material is shown in Table 13 and is traceable to the SI unit for mass, the kilogram (kg). The internal standard solution was prepared gravimetrically in D_2O.

Table 13 Maleic Acid CRM Details

Supplier	Catalogue No.	Batch No.	Purity (95% confidence)
NMIA, Chemical Reference Materials	QNMR010	10-Q-02	98.8 ± 0.12%

Samples were prepared gravimetrically, by accurately weighing approximately 20 mg of sample and dissolving this in 900 µL of internal standard solution which was also accurately weighed. Samples were analysed on a Bruker Ascend 500 MHz NMR spectrometer, using a qNMR relaxation time of 25 s. The mass fraction of MDMA and methamphetamine was determined from the NMR response at around 1.34 ppm and 1.25 ppm respectively.

The average of the mass fractions determined for the different vials of Sample S1 was used as the homogeneity value. The averages of the mass fractions determined for the different vials of Samples S2 and S3 (Tables 14 and 15) were used as the reference values and the assigned values. The standard uncertainties were evaluated in accordance with the ISO GUM,[9] by combining standard uncertainty terms for method precision, sample homogeneity, weighing of sample, preparation and addition of standard solution, the very small uncertainties in molecular weights, an evaluation of potential interference bias made by comparing the results from different NMR signals, and the between-batch variation. A coverage factor, k, was calculated using effective degrees of freedom derived from the Welch-Satterthwaite equation.

The measured reference values for Samples S2 and S3 were in agreement with the robust averages of participants' results, within their respective associated uncertainties.

Table 14 Reference Value for Sample S2

Vial No.	MDMA (% base (m/m))	
	Replicate 1	Replicate 2
219	77.2	77.2
227	77.3	77.3
248	77.2	77.1
Average	77.2	
CV	0.11%	

Sample S2 Reference Value: 77.2 ± 1.7 % MDMA base (m/m)

The uncertainty is an expanded uncertainty at 95% confidence level (k = 2.1).[9]

Table 15 Reference Value for Sample S3

Vial No.	Methamphetamine (% base (m/m))	
	Replicate 1	Replicate 2
301	59.4	59.8
329	60.0	59.9
334	59.5	59.3
Average	59.7	
CV	0.51%	

Sample S3 Reference Value: 59.7 ± 1.8% methamphetamine base (m/m)

The uncertainty is an expanded uncertainty at 95% confidence level (k = 2.1).[9]

APPENDIX 2 ROBUST AVERAGE AND ASSOCIATED UNCERTAINTY, z-SCORE AND E_n-SCORE CALCULATIONS

A2.1 Robust Average and Associated Uncertainty

When the robust average is calculated using the procedure described in ISO 13528,[5] the uncertainty is evaluated as:

$$u_{rob\ av} = \frac{1.25 \times S_{rob\ av}}{\sqrt{p}} \quad \textit{Equation 4}$$

where:

$u_{rob\ av}$ is the standard uncertainty of the robust average

$S_{rob\ av}$ is the standard deviation of the robust average

p is the number of results

The expanded uncertainty ($U_{rob\ av}$) is the standard uncertainty multiplied by a coverage factor of 2 at approximately 95% confidence level.

A worked example is set out below in Table 16.

Table 16 Uncertainty of Robust Average of MDMA in Sample S1

No. results (p)	35
Robust Average	12.48% base (m/m)
$S_{rob\ average}$	0.93% base (m/m)
$u_{rob\ average}$	0.20% base (m/m)
k	2
$U_{rob\ average}$	0.40% base (m/m)

Therefore, the robust average for Sample S1 MDMA is 12.5 ± 0.4% base (m/m).

A2.2 z-Score and E_n-Score Calculations

For each participant's result, a z-score and E_n-score are calculated according to Equations 2 and 3 respectively (Section 4).

A worked example is set out below in Table 17.

Table 17 z-Score and E_n-Score for Sample S1 MDMA Result Reported by Laboratory 4

Participant Result (% base (m/m))	Assigned Value (% base (m/m))	SDPA	z-Score	E_n-Score
12.4 ± 0.8	12.5 ± 0.4	7% as PCV, or: 0.07 × 12.5 = 0.875% base (m/m)	$z = \frac{12.4 - 12.5}{0.875} = -0.11$	$E_n = \frac{12.4 - 12.5}{\sqrt{0.8^2 + 0.4^2}} = -0.11$

APPENDIX 3 ACRONYMS AND ABBREVIATIONS

CITAC	Cooperation on International Traceability in Analytical Chemistry
CRM	Certified Reference Material
CV	Coefficient of Variation
DAD	Diode Array Detection
EA	European Accreditation
FID	Flame Ionisation Detection
GAG	General Accreditation Guidance (NATA)
GC	Gas Chromatography
GUM	Guide to the expression of Uncertainty in Measurement
HPLC	High Performance Liquid Chromatography
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
k	Coverage factor
Max	Maximum
Md	Median
MDMA	3,4-Methylenedioxymethamphetamine
Min	Minimum
MS	Mass Spectrometry
MS/MS	Tandem Mass Spectrometry
MU	Measurement Uncertainty
N	Number of numeric results
NATA	National Association of Testing Authorities, Australia
NMIA	National Measurement Institute Australia
NMR	Nuclear Magnetic Resonance
NR	Not Reported
PCV	Performance Coefficient of Variation
PDA	Photodiode Array
PT	Proficiency Testing
qNMR	Quantitative NMR
RA	Robust Average
RM	Reference Material
RV	Reference Value
SD	Standard Deviation
SDPA	Standard Deviation for Proficiency Assessment
SI	International System of Units
SS	Spiked Samples
UPLC	Ultra Performance Liquid Chromatography
UV/Vis	Ultraviolet/Visible spectroscopy

END OF REPORT