

# Proficiency Testing Programs

## Participant Guide



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## 1. Participant Guide

The 'Participant Guide' is provided as a reference to enable participants to gain a thorough understanding of how LabSmart Services proficiency testing programs are conducted. This guide allows laboratories to maximise the benefits gained from participation.

## 2. Quality System

We have been providing a wide range of proficiency programs throughout Australia to the construction materials testing industry for many years. We provide both comprehensive and affordable programs. It is our aim, through the implementation of our quality system that we satisfy participants at every stage of a proficiency testing program.

Further details can be found on our website, [www.labsmartservices.com.au](http://www.labsmartservices.com.au)

## 3. Accreditation

LabSmart Services offers world class proficiency programs. As part of our internal quality assurance, we operate to a number of international standards. Our quality system is fully documented. All our proficiency testing programs are conducted so as to meet ISO/IEC 17043, Conformity assessment — General requirements for proficiency testing.

## 4. Scope

A range of proficiency testing programs are conducted covering the following construction materials:

- Concrete
- Soil
- Aggregate

Each material may have multiple programs offered involving different test methods. All programs are run on a regular basis depending on laboratory demand. A proficiency testing program schedule for the calendar year is available from our website. Additional details regarding the programs offered can also be found on the LabSmart Services website.

## 5. Confidentiality

All information including test results are treated confidentially. The proficiency testing report issued at the completion of a proficiency testing program does not identify either companies or individuals. Each participant is issued a unique identifying code during enrolment that is used in the report ensuring confidentiality of performance.

## 6. Robust Statistics

Statistics that reduce or eliminate the impact of outlier test results are referred to as "Robust Statistics". Examples of robust statistics are median and the interquartile range. Both these statistics are used in the statistical analysis of test results. A number of other statistics are calculated based on the median and interquartile range. As a consequence, these subsequent statistical calculations are also known as "Robust Statistics". More information regarding the statistics used can be found in Appendix A.

## 7. Conduct of Program

Proficiency testing programs involve a number of stages as shown below apart from the actual proficiency testing component. The remainder of the participant guide expands on each of these stages.



## Design

Proficiency Testing programs require considerable effort during all phases. The design and planning phases take place well before there are any participants. This is needed to ensure programs are technically well based and are conducted both in a manner that is helpful to participants and within appropriate timeframes. Prior to offering a program a number of planning and design steps are undertaken.

- Evaluate need for program based on feedback from industry and NATA.
- Determine program aim
- Determine statistics to be used
- Select test methods based on technical suitability
- Research availability of suitable materials
- Test possible materials
- Consider sample stability
- Consider sample homogeneity
- Assess quarantine requirements
- Select sample material based on availability, suitability and stability
- Determine sample processing and packaging requirements
- Design overall conduct of the program
- Develop program invitation, instructions and test log sheets
- Design technical report
- Plan the time frame needed to conduct each step of the program

For each program there is a minimum participation rate needed to ensure the program outcomes are meaningful. Also there are considerable costs associated with running a proficiency testing program that meets the requirements of ISO/IEC 17043. As a consequence, there is a minimum number of participants required for a program to be commercially viable. For these reasons programs cannot be offered for all tests.

However, should an organisation have a proficiency testing requirement not covered by LabSmart Services' existing schedule of programs we are happy to discuss new programs and advise other solutions.

### *Technical Advisors*

LabSmart Services has a panel of technical advisors that are carefully chosen for their expertise in testing construction materials. Advisors are usually NATA assessors and are either Technical or Laboratory Managers within their organisations. Technical advisors provide feedback about all aspects of the programs conducted. Where a technical advisor is associated with a program it is detailed in the program's technical report.

### *Test Selection*

Proficiency testing programs are run based on feedback received on the needs of the construction materials industry. Input is received from participant feedback and other industry contact.

Proficiency testing programs may consist of one or more materials and test combinations. The choice can depend on the availability of materials that display the necessary test characteristics, stability and homogeneity. The tests methods nominated need to have reasonably wide spread usage within the industry in order for the program to be statistically meaningful.

NATA also publishes the test areas and types of programs that they expect accredited laboratories to participate.

### *Subcontracting*

On occasion LabSmart Services may subcontract specific aspects of a proficiency program. Those aspects of a proficiency testing program that have been subcontracted will be acknowledged in the final proficiency testing program report.

At present pre-testing and homogeneity testing is occasionally subcontracted out. Laboratories that perform this work on our behalf must be NATA accredited and are usually well-regarded laboratories within the industry.

## **Invitation**

### *Program Evaluation*

Prior to participating in a proficiency testing program, laboratories are encouraged to evaluate their particular needs and evaluate the benefits of the proposed program. There is a range of publications available from our web site to assist with this process.

- About proficiency testing
- Benefits of proficiency testing
- Schedule of proficiency testing programs
- Proficiency Testing FAQ
- Specific program information sheets (fees, discounts, program details etc)
- Order/Application form
- Terms and conditions

### *Program Identification*

Each LabSmart Services proficiency program is identified by the program name plus the year and a unique program number.

For example, 'Plasticity 2020 (92)' indicates that the program covered plasticity testing. It was conducted in 2020 and was the 92<sup>nd</sup> program conducted.

### *Invitation to Participate*

Laboratories may apply for any of our programs online at any time. Prior to the commencement of a program contact is made with potential participants via e-mail and phone based on past participation and our client database. Invitations to participate are usually sent two weeks prior to the commencement of a program. To unsubscribe from future notifications please forward an e-mail detailing your request.

### *Program Coordinator*

Each program has a coordinator appointed who acts as the main contact and focal point for a program. The Program Coordinator for each program is shown on the program information sheet and testing instructions. The nominate person is happy to assist with any questions or issues associated with the program.

## **Enrolment**

### *Application*

Potential applicants are requested to complete an order form. The order form ensures that we have the current and correct contact details for each participant. Order forms are to be completed by a company representative with the appropriate level of authorisation within the organisation. The order form asks applicants to agree to the programs terms and conditions. Accredited and non-accredited laboratories may apply.

### *Notification of Enrolment*

Order forms are checked to ensure information supplied is legible and complete. A letter is forwarded via e-mail to the company representative indicating enrolment in the program. An invoice covering the fee for the program is also attached.

### *Statement of Participation*

On occasions participants may be required to provide to a third party a statement of participation. Generally, the e-mail notification of enrolment is sufficient evidence of having enrolled in a program. If additional confirmation is required, please contact LabSmart Services for a statement of participation.

### *Difficulties with continued participation*

If you have had a major equipment failure, fire, flood or other major difficulty please advise LabSmart Services as soon as possible for advice on the best course of action available. Please see the program terms and conditions for further information.

## Proficiency Testing

### *Sample*

Samples forwarded to participants are specially packed to ensure samples are not damaged or affected during transit. In some circumstances additional steps are taken by LabSmart Services to ensure samples comply with dangerous goods and quarantine regulations where required.

An e-mail is sent to participants that the samples have been dispatched. Samples are sent by Australia Post or by courier and are electronically tracked to ensure their safe arrival. Each proficiency program sample has included detailed instructions and a results log sheet. The sample results log asks the participant to record the condition of the sample(s) received.

It is very unusual for a sample to be either damaged or lost in transit. Should you receive a damaged sample please contact us so we can assess the likely impact it may have on the proficiency testing. If you believe a sample has been lost, please contact us immediately so a replacement can be arranged.

### *Sample Quality*

All samples sent to participants are of a high quality, appropriately packaged and labelled. Homogeneity testing is undertaken to ensure that samples sent to participants are representative of the sample population. Testing is conducted by an accredited laboratory and the results subject to statistical analysis and approval checks.

### *Performance of tests*

Where there are a range of tests to perform, you may choose to perform all tests or only those you wish to do. Follow the enclosed 'program instructions' and test method carefully. Participants are encouraged to pay attention to detail. If any matter is unclear or a question arises, please contact the program coordinator. Participants need to be aware that testing must not be discussed with other in-house participants or with those from other organisations until after the final report is issued.

'Log sheets' on which to record the test results and other details are provided with each sample. Care needs to be exercised to ensure results are legible, complete, in the correct physical units and correct number of decimal places.

The timeframe within which testing is to be completed and the results returned is detailed on the forms supplied. Usually, two to three weeks is allowed. Testing should be commenced on receipt of the sample so that results can be returned by the date shown on the instruction sheet.

### *Program Amendments*

Sometimes an issue arises regarding the use of equipment or interpretation of the test method etc. that was unforeseen during the planning stages of the program. Matters that affect the proficiency testing outcome are resolved by the program coordinator and all affected laboratories contacted in regards to the appropriate course of action.

### *Reuse of Test Sample*

Reusing material from a program is not recommended as it can cause misleading test results. Sufficient material is provided to meet the testing requirements of each proficiency program. Should you require additional material or need another sample please contact us for assistance.

### *Submission of Test Results*

'Log sheets' on which to record the test results and other details are provided with each sample.

Testing should be completed in time to allow an organisation's supervisor to check and approve the test results. Supervisors should ensure that the results log is fully completed, legible, to the correct decimal places (with the decimal place in the right position) and expressed in the correct physical units.

Once a supervisor is satisfied with the participant's results log it should be approved by the supervisor and submitted by the due date or earlier. Authorisation by the supervisor also acknowledges that confidentiality regarding the testing has been maintained.

Participants who have not submitted test results by the date shown on the instructions are usually sent a reminder or contacted. For test results submitted after the due date it will depend on how far the data analysis has progressed as to whether the results can be included in the final report.

### *Completion of Testing*

Following completion of testing it is strongly recommended that packaging, instructions, any unused test portions and the material tested be retained until the technical report is issued. Retainment of this material may aid in the resolution of any outliers.

## **Evaluation of Results**

### *Program Aim*

The program aim determines how the program is to be conducted and the assessment technique to be used to measure performance. Programs employ a 'consensus' process where **robust statistics** are used to measure an individual's performance against all other participants. Program aims may be broader and encompass more than one performance measure. More detailed information regarding a particular program's aim can be found in program information sheets located on the web site.

### *Check of Results*

Each participant's set of results undergoes rigorous checking prior to statistical analysis. This is done to ensure that the test results do not adversely affect the quality of the statistical analysis. It may be necessary at times to contact participants to clarify some aspect relating to their submitted results log. The checking process ensures fewer results are rejected from statistical analysis and therefore a much better outcome for participants. Only results considered satisfactory are used in the statistical analysis. More detail can be found in Appendix A.

### *Statistical Analysis*

Test results are checked for aspects that may impact on the statistical analysis such as normality and bimodal behaviour. **Robust statistics** are used to assess each participant's performance. The statistical data derived is further checked for trends, abnormal data grouping or bias. Such affects may arise from variations in testing practice, equipment, test methods or test settings used. More detailed explanation of the statistics used may be found in **Appendix A**.



## Assessment

Assessment of 'test performance' is undertaken by calculating z-scores with either statistical (consensus) or set performance limits. Participants with a result outside the limits are identified as having obtained an 'outlier' and will need to investigate their performance. Participants with a result close to being considered an outlier are recommended that they review their performance (Z-score  $\pm 2.75$ ). Those remaining participants represent the majority of participant's where performance has been considered satisfactory. Other aspects of a program such as adherence to test methods and accuracy of calculations etc. may sometimes form part of the assessment. The assessment process used is detailed in the final report.

Detailed information is collected from participants in the program to allow technical comment in regard to addressing outliers or improving performance. The program outcomes are detailed in a technical report published at the end of the program.

The technical report may also contain qualitative feedback e.g.

- Accuracy of calculations performed
- Accuracy in completing result log sheets
- Type and accuracy of equipment used
- Techniques used
- Aspects of test performance
- Quality of submitted information e.g. graphs

This additional information may form part of the assessment process or used to assist all participants to improve and benchmark other aspects of the test process against other participants.

## Test Methods

The effect of different methodology within a test method as well as the impact of equivalent test methods is also assessed and reported. Where appropriate these results may be separated from the main group and assessed independently.

## Reports

### Z-score Summary

A summary of the statistics for each program is forwarded to each participant once the majority of results have been received. This is usually two to four weeks after the due date for return of participant results. It provides early feedback on participant performance. These may also be forwarded to NATA as an early indication of performance. The summary is superseded by the final program report.

### Participant Summary

A non-NATA endorsed summary of individual performance is available on request after the close date for return of results. Early feedback is sometimes needed by participants to help with a NATA assessment, staff training or some other urgent need. Individual performance summaries detail the participant's z-scores and other statistics for each test and some limited feedback on performance and are subject to change.

An endorsed participant summary may be requested after the final program report has been issued as a consolidation of results for organisations that have entered multiple participants and laboratories.

### *Proficiency Testing Report*

A proficiency testing report is provided to each participant (or group of participants where appropriate) that sets out how the program was conducted, the consensus outcomes as well as assessment of individual performances.

Due to the large amount of data that proficiency programs often generate reports are issued 4 to 8 weeks after the date set for returning results. Reports are prepared by our experienced staff in conjunction with the technical advisor for the program. Each report contains the following information where applicable:

- Aim of the program
- Scope of tests covered
- Tabulated results from each participant
- Tabulated statistics for each test
- Charts and graphs to assist in understanding the program statistics
- Summary of overall performance
- Identification and discussion of outliers
- Technical feedback on testing
- Technical review of test performance and submitted results
- Details regarding program design, sample preparation and homogeneity testing.
- Instructions and log sheet used for the program

Detailed explanation of the statistics used in reports and the charts and graphs used can be found in Appendix A.

### *Supplementary Reports*

Supplementary reports are provided to satisfy:

- Organisations that require more tailored report to suit their particular circumstances
- Laboratories with outliers that have completed additional proficiency testing and wish for the results to be compared to the original program
- Organisations that are seeking accreditation but have missed a program and require a sample from a previous program and comparison to the past program
- Depending on circumstances, participants that have missed inclusion in the final report may be eligible for a supplementary report that statistically evaluates their results

If you fit into one of the above or have something else in mind, please feel free to discuss your particular needs with our staff. In some cases, a fee may be levied to cover report preparation costs.

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## Follow-up by Participant

### *Participant Review*

Reading the proficiency testing report and reviewing the outcome is an important part of the program. Proficiency testing reports contain information that usually can be used by all participants to either better understand testing practices or assist with improving testing performance.

Those participants with an outlier will need to investigate their test results to determine the reason for such an outcome and if possible, put in place corrective action.

The proficiency report may recommend that some participants should review their performance in the program. At other times aspects of testing practice may have been identified as being unusual in some way. In either case while it is not considered mandatory for these matters to be addressed it does present an opportunity for the participant or laboratory for improvement.

### *Help with outliers*

The proficiency testing report often has technical information regarding testing and feedback regarding performance which may assist in investigating outliers. The program coordinator may also be able to give additional feedback, particularly about the severity or significance of the outlier. Examining the material that was tested and saved may also be useful. Looking at the paperwork supplied may clear up any misunderstandings the operator had during testing.

Extra samples are kept after every program. Participants with outliers are able to request additional samples to help with investigating outliers. Storage and handling fees may apply.

### *Have a query?*

Please contact the program coordinator should you have any questions regarding the program, the statistics used or the proficiency testing report.

### *Additional samples*

Some areas of material testing will have more than one program running covering different tests. For most programs extra samples are stored after each program to assist laboratories that may require them for the following purpose:

- Confirm corrective action taken following an outlier in the program
- To assist in gaining accreditation for a new test
- Confirm corrective action taken from a NATA audit involving staff competency or testing
- Staff training
- Have missed a program
- Resolution of differences in test outcomes amongst a group of laboratories

Contact us should you require a sample outside of scheduled proficiency testing programs. For all samples supplied a supplementary report plus the technical report for the program is provided.

### *Feedback*

LabSmart Services is interested in your views and comments as this allows us to improve our service. A survey is enclosed with the technical report sent to all participants in each proficiency program this is also anonymous. Feedback is welcome at any time. Ring or email us with your thoughts. Please see our website for contact details.

### *Corrections to proficiency testing reports*

Although all proficiency testing reports are checked thoroughly occasionally there is an omission or an error. Please contact us with your concerns.

If the correction is technically warranted and affects the majority of participants, then a revised report is reissued to all participants. If the correction affects only one or two participants, then a correction sheet or a revised report may be forwarded to those individuals affected. Generally spelling and grammatical oversights are not corrected unless technically warranted. Feedback regarding our reports is always welcome.

### *Appeals*

Participants with a concern regarding the performance assessment of their test results are strongly encouraged to contact the program coordinator as soon as possible. Often matters once raised can be resolved quickly.

If the matter is not resolved a participant may appeal the assessment of their test results. An appeal may be lodged by E-mail to the General Manager, LabSmart Services outlining your concerns. We will endeavour to resolve participant appeals as soon as possible. Please see our terms and conditions for further details.

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## Appendix A Statistical Analysis

### *General*

The following outlines the statistical process used for analysis of participant's results. The statistics used may however be modified where necessary in order to apply the most appropriate statistical analysis. The report on the proficiency program will indicate if a different approach was required.

Knowledge of robust statistics is not required in order to follow the mathematics used to analysis participant's results. Organisations that wish to run similar programs will need additional statistical knowledge to what is presented in this appendix. LabSmart Services can supply training should this be required.

To obtain the most from proficiency program reports an understanding of how to interpret the statistical analysis is useful. There are publications on our website that can assist.

### *Robust Statistics*

Statistics that eliminate the impact of outlier test results are referred to as "Robust Statistics". We calculate the median and the inter-quartile range. Both these statistics are used in the statistical analysis of test results. A number of other statistics are also calculated based on the median and inter-quartile range. As a consequence, these subsequent statistical calculations are also known as "**Robust Statistics**".

### *Evaluation of Performance*

Staff and technical advisors assess the Z-scores obtained for a program to make sure it is relevant. Most times z-score match industry expectations.

The z-scores are used as a measure of performance enabling the evaluation of one participant against another participant in the program.

### *Technical Feedback*

Technical feedback may also be given in relation to the use of test methods, equipment used or other issues identified with test methodology.

Other feedback may also be given such as accuracy in completing log sheets and quality of information submitted etc.

### *Types of samples*

#### Single sample

Most programs involve a single sample on which a number of tests are performed.

#### Multiple samples

Some programs involve two samples on which each has the same set of tests performed. The statistics applied is the same as for single sample case.

### Paired samples

The samples supplied may be the same material from the same batch. These would be expected to give similar results.

Alternately the samples may be of different materials with slightly varying properties. In this case the results should be different.

Paired samples are used when the assessment of between-laboratories and within-laboratory variation is of interest.

### *Check of submitted results*

Each participant's results undergo the following checks prior to statistical analysis.

- Participants particulars are correct i.e. code/company etc.
- Compliance with program instructions
- Results legible
- Results log sheet fully completed
- Results reported to the correct physical units
- Results reported to the nominated number of decimal places
- Results reported are feasible
- Results reported have not been mixed up (involving multiple samples or measurements)
- Possible transcription errors
- Results correct but recorded in the wrong part of the log sheet

Depending on the outcome of the check and the information available the following may occur:

- Participant contacted for further clarification
- Result corrected
- Result rejected from further analysis
- Result recalculated and corrected

Those reviewed results considered satisfactory are used in the statistical analysis. Where a result has been significantly amended it is flagged in the proficiency testing report. Minor corrections such as decimal place etc are not flag but usually comment is made regarding overall performance by laboratories.

### *Distribution*

The results from the proficiency programs are expected to follow the normal distributed. Results are checked to see that the results follow approximately the normal distribution. The results are compared with homogeneity data and checked for other influences such as test methods used, equipment, sample preparation etc.

### *Statistics*

For each test in a proficiency program there is a table in the proficiency testing report that details the result and z-score for each participant. A number of other statistics are also calculated. Information as to how these statistics are determined is detailed below. Examples of how proficiency statistics are reported are shown as well as charts and graphs used as aids in understanding the proficiency testing outcomes.

Number of results

The number (N) of valid test results.

Median

The median is the central value of a group of results that have been sorted from lowest to highest.

N=6 (Even)

X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	Median = $[X_3+X_4]/2$
2	2	7	14	20	24	10.5

N=5 (Odd)

X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>		Median = X <sub>3</sub>
2	7	8	13	22		8

Quartiles

The test results are split into quarters based on the value of each result and frequency. The values of Q are the upper value for that quarter section. Sometimes it is necessary to interpolate a Q value.

		<b>Median</b>			
Q1	Q2	Q3	Q4		
25%	25%	25%	25%		
		50%			
		IQR			

There is more than one approach to calculating quartiles. Our programs use the (n-1) approach as applied by the excel function, 'quartiles' or 'quartiles.inc'. The *Inter-Quartile Range*, **IQR** is where 50% of the results lie. It is found by subtracting the first quartile from the third quartile i.e.  $IQR = Q3 - Q1$ . The inter-quartile range is an important part of calculating robust statistics.

Standard Deviation (SD) – (Normalised IQR)

The standard deviation is useful in analysing the test outcomes and is widely understood. Quartiles however do not correspond to standard deviation and the normal distribution. It is necessary to transform (normalise) the IQR so that the normalised IQR (N-IQR) is approximately  $\pm 1$  SD.

The conversion value used is 0.7413. The semi-IQR is derived by dividing by 2. From the normal unit table, the z value corresponding to 25% is 0.6754. The semi-IQR is divided by 0.6745. The conversion value  $0.7413 = 0.5 / 0.6745$ .

$$IQR \times 0.7413 = N-IQR \approx 1 \text{ SD}$$

Coefficient of variation

The coefficient of variation (CV) allows the variation relative to the median to be compared across different test methods and samples as well as homogeneity data. It needs to be used cautiously as it is not always indicative across programs.

Coefficient variation (%) = ( N-IQR / Median ) x 100

Or Coefficient variation (%) = ( SD / Average ) x 100

Useful comparisons are only possible when the median value of the data sets is of a similar magnitude. In drawing valid conclusions from calculated 'coefficient of variation' values technical knowledge of the testing methodology and sample behaviour is also needed.

For example, different soil types can make the determination of the Liquid Limit either very consistent (low CV) for one program or quite variable (high CV) for another program. Comparing just the CV alone could yield incorrect conclusions about the two programs without knowledge of the type of material tested in each program.

### Range

The range provides a measure of the spread in results. It is obtained by subtracting the lowest value (*minimum*) from the highest value (*maximum*) in the data set. This calculation includes outliers unless otherwise indicated in the report.

### Consensus value

The median value is used as the "consensus value" (also known as the "assigned value") unless otherwise specified. It is the assigned value against which all participants are compared.

### Uncertainty of the assigned value

An estimate of the standard measurement uncertainty of the median can be determined from:

$$\mu_{(\text{Median})} = [ \text{N-IQR} / \text{SQRT}(\text{N}) ] \times 1.25$$

The standard measurement uncertainty of the median is used to determine if the derived consensus value is suitable for use in the program. The program report will indicate if the standard uncertainty of the median is unsuitable.

The standard measurement uncertainty of the median should not be confused with the standard or expanded measurement uncertainty associated with the test.

### Z-scores (Single sample)

Robust z-scores (Z) are calculated for each test and participant using the following:

$$Z = [\text{Participant Result} - \text{Median}] / \text{N-IQR}$$

### Industry Assigned Value

An "industry assigned value" rather than the N-IQR may be more applicable in some circumstances. This generally occurs where there is an abnormally large or very small variation (N-IQR) exhibited by the test result data. As a consequence, there are often either too many outliers or none detected at all.

The assigned value in this instance is determined in conjunction with the technical advisor for the program. Industry expectations with respect to the variation expected for a particular test and N-IQRs from previous programs are used in determining the assigned value to be used. This 'target value' is expressed as a standard deviation. The target SD is substituted for the N-IQR value in the z-score formula above.



Z-scores (Paired Samples)

Some proficiency program participants receive two (i.e. paired) samples e.g. concrete cylinders. For this type of program, a “Between laboratories” z-score and a “Within laboratory” z-score is calculated. The between laboratories z-score measures the variation between laboratories (participants). The within laboratory is comparing the variation in test results obtained for the two samples against the variations obtained by the other laboratories (participants) in the program.

To calculate these z-scores the standardised sum (SS) and standardised difference (SD) must be determined. It is calculated using the test result from one sample (A) and the test result from the other sample (B) for each participant.

$$SS = (A+B) / \sqrt{2} \text{ and}$$

If median (A) > median (B) then  $SD = (A-B) / \sqrt{2}$  or

If median (A) < median (B) then  $SD = (B-A) / \sqrt{2}$

For each set of standardised results, the median and N-IQR is calculated. This is shown as median (SS), N-IQR (SS), median (SD) and N-IQR (SD). These are used to calculate the ‘between laboratories’ and ‘within laboratory’ z-score for each participant.

‘Between laboratories’ z-score =  $[SS - \text{median (SS)}] / \text{N-IQR (SS)}$

‘Within laboratory’ z-score =  $[SD - \text{median (SD)}] / \text{N-IQR (SD)}$

Outliers

The z-scores (Z) are used as a performance measure with respect to other participants in the program.

**Z-score range**

-3	-2	-1	0	1	2	3
Weaker	Weak Consensus	Strong Consensus		Weak Consensus	Weaker	
Review	Satisfactory				Review	

| Z | greater than 3 indicates an outlier in the program and the cause(s) for the unsatisfactory performance needs to be investigated. Outliers are highlighted in proficiency testing reports by #.

| Z | between 2 and 3 indicates a questionable performance particularly the closer to 3 the performance outcome. It is recommended that those participants above 2 should review their results. Those greater 2.75 should consider investigating the reason for the low performance outcome.

| Z | less than 2 indicates a satisfactory performance.

| | is the absolute value i.e. positive value

*Presentation of proficiency testing information*Example 1 – Single Sample

The proficiency testing report tabulates the statistics for single samples as shown in example 1.

Example 2 – Paired Samples

The proficiency testing report tabulates the statistics for paired samples as shown in example 2.

Example 3 - Z-score bar graph

This shows the z-score for each participant in z-score order. This allows outliers to be readily seen as well as allow each participant to see where their result lies with respect to other participants. The z-score scale allows each participant to see approximate z-scores. The bar graph also readily shows whether a participant was lower or higher than the median (i.e. z-score 0).

**Example 1 – Z-scores for a single sample**

Code	Test Result %	Z Score	Code	Test Result %	Z Score
L3	42	1.82	T6	38	0.61
M7	40	1.21	Y3	36	0.00
V3	40	1.21	K2	42	1.82
R4	43	2.12	D7	38	0.61
Z3	35	-0.30	W9	35	-0.30
N3	32	-1.21	Z5	36	0.00
K4	34	-0.61	Q2	35	-0.30
V6	39	0.91	L2	32.3	-1.12
U7	31	-1.52	C5	35	-0.30
F3	45	2.73	J2	37	0.30
R3	35	-0.30	D9	38.00	0.61
N2	36	0.00	V9	42.00	1.82
Q6	38.3	0.70	S9	40.00	1.21
C3	36	0.00	Y6	36.00	0.00
Y4	34	-0.61	P5	32.00	-1.21
C4	34	-0.61	T5	37.34	0.41
K9	39	0.91	U5	36.00	0.00
B2	34	-0.61	G7	37.00	0.30
J3	36	0.00	W7	35.40	-0.18
X2	37	0.30			
B6	33	-0.91			
B8	29	-2.12			
T8	35	-0.30			
C2	39.9	1.18			
Y8	38	0.61			
F6	43	2.12			
T9	41	1.52			
L7	41	1.52			

<b>Statistic</b>	<b>Value</b>
Number of results	<b>47</b>
Median	<b>36.0</b>
First Quartile	<b>35.0</b>
Third Quartile	<b>39.5</b>
IQR	<b>4.5</b>
Normalised IQR	<b>3.3</b>
CV (%)	<b>9.2</b>
Minimum	<b>29</b>
Maximum	<b>45</b>
Range	<b>16</b>

**Note:** A # indicates an outlier where the z-score obtained is either greater than 3 or less than -3. Codes for all participants are shown. The results column shows a blank entry for those participants that did not submit results for this test. Minimum, Maximum and Range are calculated with outliers excluded.

Example 2 – Z-scores for paired samples

Code	Test Results		Z Score	
	Sample A	Sample B	Between Laboratories	Within Laboratory
E2	49.6	49.8	1.5	-0.14
D8	45.1	44.8	-0.75	0.21
M7	42.0	42.5	-2.05	-0.35
A8	41.6	41.3	-2.43	0.21
K8	45.1	47.5	-0.10	-1.70
Z5	48.1	51.0	1.47	-2.06
F5	43.2	48.1	-0.41	-3.48 #
E5	46.7	47.2	0.22	-0.35
Y9	48.1	47.1	0.53	0.71
J9	43.5	47.0	-0.60	-2.48
O9	46.5	46.5	0.00	0.00
Q6	47.1	41.0	-1.18	4.33 #
U4	43.2	45.1	-1.13	-1.35
P7	43.8	45.1	-0.99	-0.92
S7	46.4	46.6	0.00	-0.14
O6	42.2	43.2	-1.83	-0.71
H5	47.6	46.8	0.34	0.57
C7	48.3	44.3	-0.10	2.84
W4	47.3	46.0	0.07	0.92
S3	47.4	48.2	0.63	-0.57
V1	42.9	49.9	-0.05	-4.97 #
M1	47.4	44.7	-0.22	1.92
K3	40.2	40.1	-3.06 #	0.07
X3	47.0	46.9	0.22	0.07
R1	47.2	46.7	0.22	0.35
J1	47.6	46.2	0.19	0.99
C2	44.2	44.3	-1.08	-0.07
H8	47.2	45.2	-0.14	1.42
F8	45.5	48.9	0.34	-2.41

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Code	Test Results		Z Score	
	Sample A	Sample B	Between Laboratories	Within Laboratory
O1	47	48	0.51	-0.35
H9	50	47	1.04	1.92
S2	50	47	0.94	1.77
C8	41	43	-2.22	-0.85
W9	47	47	0.12	-0.35
C4	50	50	1.69	-0.43
A2	48	48	0.67	-0.14
Z9	45	44	-0.94	0.35
K5	49	49	1.08	-0.35
L8	49	47	0.60	1.06
N7	47	45	-0.22	1.06
X7	49	47	0.60	1.06
E3	51	49	1.64	1.42
C5	48	45	-0.19	1.99
G5	46	45	-0.51	0.78
W1	50	50	1.54	-0.14

Sample A	Sample B	Statistic
53	53	Number of results
47.0	46.8	Median
2.2	2.4	Normalised IQR
4.7	5.2	CV (%)
40	40	Minimum
51	51	Maximum
11	11	Range

Note: A # indicates an outlier where the z-score obtained is either greater than 3 or less than -3.

**Example 3 – Z-score bar graph**

