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**Accuracy (trueness and precision)
of measurement methods and
results—**

**Part 1 : General principles and
definitions**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of International Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. By this establishment, **JIS Z 8402 : 1991** was withdrawn and replaced with this Standard. This Standard has been prepared based on the first edition of **ISO 5725-1** issued in 1994.

JIS Z 8402 : 1999 consists of the following six parts under the title "*Accuracy (trueness and precision) of measurement methods and results*".

- Part 1 : *General principles and definitions*
- Part 2 : *Basic method for the determination of repeatability and reproducibility of a standard measurement method*
- Part 3 : *Intermediate measures of the precision of a standard measurement method*
- Part 4 : *Basic methods for the determination of the trueness of a standard measurement method*
- Part 5 : *Alternative methods for the determination of the precision of a standard measurement method*
- Part 6 : *Use in practice of accuracy values*

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Accuracy (trueness and precision) of measurement methods and results— Part 1 : General principles and definitions

Introduction This Japanese Industrial Standard has been prepared based on ISO 5725-1 *Accuracy (trueness and precision) of measurement methods and results—Part 1 : General principles and definitions* issued in 1994 as the first edition and technical corrigendum 1 : 1998 without changing the technical contents.

The “Informative references” underlined with dots in this Standard show the matters not specified in the original International Standard.

0.1 JIS Z 8402 uses two terms “trueness” and “precision” to describe the accuracy of a measurement method. “Trueness” refers to the closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value. “Precision” refers to the closeness of agreement between test results.

0.2 The need to consider “precision” arises because tests performed on presumably identical materials in presumably identical circumstances do not, in general, yield identical results. This is attributed to unavoidable random errors inherent in every measurement procedure; the factors that influence the outcome of a measurement cannot all be completely controlled. In the practical interpretation of measurement data, this variability has to be taken into account. For instance, the difference between a test result and some specified value may be within the scope of unavoidable random errors, in which case a real deviation from such a specified value has not been established. Similarly, comparing test results from two batches of material will not indicate a fundamental quality difference if the difference between them can be attributed to the inherent variation in the measurement procedure.

0.3 Many different factors (apart from variations between supposedly identical specimens) may contribute to the variability of results from a measurement method, including:

- a) the operator;
- b) the equipment used;
- c) the calibration of the equipment;
- d) the environment (temperature, humidity, air pollution, etc.);
- e) the time elapsed between measurements.

The variability between measurements performed by different operators and/or with different equipment will usually be greater than the variability between measurements carried out within a short interval of time by a single operator using the same equipment.

0.4 The general term for variability between repeated measurements is precision. Two conditions of precision, termed repeatability and reproducibility conditions, have been found necessary and, for many practical cases, useful for describing the variability of a measurement method. Under repeatability conditions, factors a) to e) listed

above are considered constants and do not contribute to the variability, while under reproducibility conditions they vary and do contribute to the variability of the test results. Thus repeatability and reproducibility are the two extremes of precision, the first describing the minimum and the second the maximum variability in results. Other intermediate conditions between these two extreme conditions of precision are also conceivable, when one or more of factors a) to e) are allowed to vary, and are used in certain specified circumstances. Precision is normally expressed in terms of standard deviations.

0.5 The “trueness” of a measurement method is of interest when it is possible to conceive of a true value for the property being measured. Although, for some measurement methods, the true value cannot be known exactly, it may be possible to have an accepted reference value for the property being measured; for example, if suitable reference materials are available, or if the accepted reference value can be established by reference to another measurement method or by preparation of a known sample. The trueness of the measurement method can be investigated by comparing the accepted reference value with the level of the results given by the measurement method. Trueness is normally expressed in terms of bias. Bias can arise, for example, in chemical analysis if the measurement method fails to extract all of an element, or if the presence of one element interferes with the determination of another.

0.6 The general term accuracy is used in **JIS Z 8402** to refer to both trueness and precision.

The term “accuracy” was at one time used to cover only the one component now named trueness, but it became clear that to many persons it should imply the total displacement of a result from a reference value, due to random as well as systematic effects.

The term “bias” has been in use for statistical matters for a very long time, but because it caused certain philosophical objections among members of some professions (such as medical and legal practitioners), the positive aspect has been emphasized by the invention of the term trueness.

1 Scope

1.1 The purpose of **JIS Z 8402** is as follows:

- a) to outline the general principles to be understood when assessing accuracy (trueness and precision) of measurement methods and results, and in applications, and to establish practical estimations of the various measures by experiment (Part 1 of this Standard);
- b) to provide a basic method for estimating the two extreme measures of the precision of measurement methods by experiment (Part 2 of this Standard);
- c) to provide a procedure for obtaining intermediate measures of precision, giving the circumstances in which they apply and methods for estimating them (Part 3 of this Standard);
- d) to provide basic methods for the determination of the trueness of a measurement method (Part 4 of this Standard);

- e) to provide some alternatives to the basic methods, given in Part 2 and Part 4, for determining the precision and trueness of measurement methods for use under certain circumstances (Part 5 of this Standard);
- f) to present some practical applications of these measures of trueness and precision (Part 6 of this Standard).

1.2 This part of this Standard is concerned exclusively with measurement methods which yield measurements on a continuous scale and give a single value as the test result, although this single value may be the outcome of a calculation from a set of observations.

It defines values which describe, in quantitative terms, the ability of a measurement method to give a correct result (trueness) or to replicate a given result (precision). Thus there is an implication that exactly the same thing is being measured, in exactly the same way, and that the measurement process is under control.

This part of this Standard may be applied to a very wide range of materials, including liquids, powders and solid objects, manufactured or naturally occurring, provided that due consideration is given to any heterogeneity of the material.

2 Normative references

The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect is given to these referred standards, only the edition of indicated year constitutes the provision of this Standard but the revision and amendment made thereafter are not applied. The normative references without the indication of the year of coming into effect apply limiting only to the most recent edition (including the amendment).

JIS Z 8101-1 *Statistics—Vocabulary and symbols—Part 1 : Probability and general statistical terms*

JIS Z 8101-2 *Statistics—Vocabulary and symbols—Part 2 : Statistical quality control terms*

JIS Z 8402-2 : 1999 *Accuracy (trueness and precision) of measurement methods and results—Part 2 : Basic method for the determination of repeatability and reproducibility of a standard measurement method*

JIS Z 8402-3 : 1999 *Accuracy (trueness and precision) of measurement methods and results—Part 3 : Intermediate measures of the precision of a standard measurement method*

JIS Z 8402-4 : 1999 *Accuracy (trueness and precision) of measurement methods and results—Part 4 : Basic methods for the determination of the trueness of a standard measurement method*

3 Definitions

For the purposes of this Standard, the following definitions apply.

Some definitions are taken from **JIS Z 8101**.

The symbols used in this Standard are given in Annex A.

Informative reference : This Standard used a term “test method” for “method for measurement” and a term “test result” for “result of measurement” at the stage of draft proposal. Later (1985) on, by a suggestion that the term of “test” is indistinguishable from “statistical test”, the test method and the test result were changed to measurement method and measurement result respectively. In the wake of that change, part of the title of this Standard was revised to “measurement methods and results”. The change however was not fully accomplished in the body of this Standard remaining, for example, the terms of test result and level of test.

3.1 observed value The value of a characteristic obtained as the result of a single observation.

[JIS Z 8101-1]

3.2 test result The value of a characteristic obtained by carrying out a specified test method.

Note 1 The test method should specify that one or a number of individual observations be made, and their average or another appropriate function (such as the median or the standard deviation) be reported as the test result. It may also require standard corrections to be applied, such as correction of gas volumes to standard temperature and pressure. Thus a test result can be a result calculated from several observed values. In the simple case, the test result is the observed value itself.

[JIS Z 8101-2]

3.3 level of the test in a precision experiment The general average of the test results from all laboratories for one particular material or specimen tested.

3.4 cell in a precision experiment The test results at a single level obtained by one laboratory.

3.5 accepted reference value A value that serves as an agreed-upon reference for comparison, and which is derived as:

- a) a theoretical or established value, based on scientific principles;
- b) an assigned or certified value, based on experimental work of some national or international organization;
- c) a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group;
- d) when a), b) and c) are not available, the expectation of the (measurable) quantity, i.e. the mean of a specified population of measurements.

[JIS Z 8101-2]

3.6 accuracy The closeness of agreement between a test result and the accepted reference value.

Note 2 The term accuracy, when applied to a set of test results, involves a combination of random components and a common systematic error or bias component.

[JIS Z 8101-2]

3.7 trueness The closeness of agreement between the average value obtained from a large series of test results and an accepted reference value.

Notes 3 The measure of trueness is usually expressed in terms of bias.

4 Trueness has been referred to as "accuracy of the mean". This usage is not recommended.

[JIS Z 8101-2]

Informative reference : "The average value obtained from a large series of test results" means the expectation of the test results.

3.8 bias The difference between the expectation of the test results and an accepted reference value.

Note 5 Bias is the total systematic error as contrasted to random error. There may be one or more systematic error components contributing to the bias. A larger systematic difference from the accepted reference value is reflected by a larger bias value.

[JIS Z 8101-2]

Informative reference : If a sign of plus or minus is taken as a problem, "the value obtained by subtracting the accepted reference value from expectation of the test results is taken as bias."

3.9 laboratory bias The difference between the expectation of the test results from a particular laboratory and an accepted reference value.

3.10 bias of the measurement method The difference between the expectation of test results obtained from all laboratories using that method and an accepted reference value.

Note 6 One example of this in operation would be where a method purporting to measure the sulfur content of a compound consistently fails to extract all the sulfur, giving a negative bias to the measurement method. The bias of the measurement method is measured by the displacement of the average of results from a large number of different laboratories all using the same method. The bias of a measurement method may be different at different levels.

3.11 laboratory component of bias The difference between the laboratory bias and the bias of the measurement method.

Notes 7 The laboratory component of bias is specific to a given laboratory and the conditions of measurement within the laboratory, and also it may be different at different levels of the test.

- 8 The laboratory component of bias is relative to the overall average result, not the true or reference value.

3.12 precision The closeness of agreement between independent test results obtained under stipulated conditions.

Notes 9 Precision depends only on the distribution of random errors and does not relate to the true value or the specified value.

- 10 The measure of precision is usually expressed in terms of imprecision and computed as a standard deviation of the test results. Less precision is reflected by a larger standard deviation.

- 11 "Independent test results" means results obtained in a manner not influenced by any previous result on the same or similar test object. Quantitative measures of precision depend critically on the stipulated conditions. Repeatability and reproducibility conditions are particular sets of extreme conditions.

[JIS Z 8101-2]

Informative reference : "Independent test results" are given in a "specific condition" as the measurement results of the identical test items.

3.13 repeatability Precision under repeatability conditions.

[JIS Z 8101-2]

3.14 repeatability conditions Conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time.

[JIS Z 8101-2]

3.15 repeatability standard deviation The standard deviation of test results obtained under repeatability conditions.

Notes 12 It is a measure of dispersion of the distribution of test results under repeatability conditions.

- 13 Similarly "repeatability variance" and "repeatability coefficient of variation" could be defined and used as measures of the dispersion of test results under repeatability conditions.

[JIS Z 8101-2]

3.16 repeatability limit The value less than or equal to which the absolute difference between two test results obtained under repeatability conditions may be expected to be with a probability of 95 %.

Note 14 The symbol used is r .

[JIS Z 8101-2]

Informative reference : "Repeatability" in 3.13, "repeatability standard deviation" in 3.15 and "repeatability limit" in 3.16 represent respectively concept, scale and limit used for a standard of comparison, to be used in properly separated senses.

3.17 reproducibility Precision under reproducibility conditions.

[JIS Z 8101-2]

3.18 reproducibility conditions Conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment.

[JIS Z 8101-2]

3.19 reproducibility standard deviation The standard deviation of test results obtained under reproducibility conditions.

Notes 15 It is a measure of the dispersion of the distribution of test results under reproducibility conditions.

16 Similarly "reproducibility variance" and "reproducibility coefficient of variation" could be defined and used as measures of the dispersion of test results under reproducibility conditions.

[JIS Z 8101-2]

3.20 reproducibility limit The value less than or equal to which the absolute difference between two test results obtained under reproducibility conditions may be expected to be with a probability of 95 %.

Note 17 The symbol used is R .

[JIS Z 8101-2]

Informative reference : "Reproducibility" in 3.17, "reproducibility standard deviation" in 3.19 and "reproducibility limit" in 3.20 represent the concept, scale and limit used for a standard of comparison respectively to be used in properly separated senses.

3.21 outlier A member of a set of values which is inconsistent with the other members of that set.

Note 18 Part 2 of this Standard specifies the statistical tests and the significance level to be used to identify outliers in trueness and precision experiments.

3.22 collaborative assessment experiment An interlaboratory experiment in which the performance of each laboratory is assessed using the same standard measurement method on identical material.

Informative reference : The identical test items are specified in 4.3.

Notes 19 The definitions given in 3.16 and 3.20 apply to results that vary on a continuous scale. If the test result is discrete or rounded off, the repeatability limit and the reproducibility limit as defined above are each the minimum value equal to or below which the absolute difference between two single test results is expected to lie with a probability of not less than 95 %.

20 The definitions given in 3.8 to 3.11, 3.15, 3.16, 3.19 and 3.20 refer to theoretical values which in reality remain unknown. The values for reproducibility and repeatability standard deviations and bias actually determined by experiment (as described in Part 2 and Part 4