

Australian Standard™

Guide to the sampling of particulate materials

Part 4: Checking for bias



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Guide to the sampling of particulate materials

Part 4: Checking for bias

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PREFACE

This Guide was prepared by Standards Australia Committee MN-010, Sampling of Minerals as a basis for preparing Standards for the sampling of a range of minerals from moving streams and stationary situations.

This Guide is Part 4 of the AS 4433 series for the sampling of particulate materials, to be used for the preparation of sampling Standards for a number of mineral commodities. Other Standards in the series are as follows:

Part 1: Sampling procedures

Part 2: Preparation of samples

Part 3: Estimating sampling precision

Part 5: Sampling of slurries

Part 6: Inspection of mechanical sampling systems

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STANDARDS AUSTRALIA

Australian Standard

Guide to the sampling of particulate materials

Part 4: Checking for bias

1 SCOPE

This Guide sets out methods for checking mechanical sampling systems for bias. It covers primary sampling of particulate materials and subsequent sample preparation, whether manual methods or mechanical devices are employed. Bias testing involves an initial system check, comparison of routine sampling with a reference method, and ongoing system checks to confirm conformance. This is referred to as testing 'relative bias' if there is not a strong reason for expecting the alternative set of sampling procedures to be much more reliable than the routine sampling procedures.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- | | |
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| 4264 | Coal and coke—Sampling |
| 4264.4 | Part 4: Determination of precision and bias |
| 4433 | Guide to the sampling of particulate materials |
| 4433.1 | Part 1: Sampling procedures |
| 4433.2 | Part 2: Preparation of samples |
| 4433.6 | Part 6: Inspection of mechanical sampling systems |

ISO

- | | |
|-------|---|
| 3086 | Iron ores—Experimental methods for checking the bias of sampling |
| 12745 | Copper, lead and zinc ores and concentrates—Precision and bias of mass measurement techniques |
| 13292 | Copper, lead and zinc sulfide concentrates—Experimental methods for checking the bias of sampling |

3 DEFINITIONS

For definitions relevant to this Standard refer to AS 4433.1 and AS 4433.2.

4 FUNDAMENTALS OF BIAS

4.1 Bias

Bias is a tendency for estimates of a characteristic to be persistently higher or persistently lower than a reference value. The persistence of a bias is often not made clear. A bias is likely to remain approximately consistent only while moisture content, particle size distribution, material source or other aspects of the material or sampling system remain approximately constant.

Bias is sometimes viewed as a difference between the average of estimates of a characteristic and the reference value. If such a difference could be relied upon to not change, it would be sensible to estimate the bias and to compensate for it by numerically adjusting subsequent measurements. This view of the nature of a bias and way of coping with bias is not recommended because the persistence of a bias cannot be relied upon.

4.2 Relative bias

Relative bias is a tendency for one set of estimates of a characteristic to be persistently higher or persistently lower than another set of estimates.

4.3 Tolerable bias

Tolerable bias is an amount of bias that may be tolerated in some aspect of a sampling and testing system. In practice, many aspects of sampling and testing systems may be slightly biased with the biases varying from time to time, between operators or with the material being sampled and tested. A judgement has to be made about the sizes of biases that will be tolerated because they are commercially unimportant, because they are too difficult to detect and eliminate, or after considering both of these issues. It is recommended that the following possible sources of bias be considered when making such judgements, because there is little point to reducing one source of bias when there are other, more economically important sources of bias:

- (a) It is generally not possible to completely eliminate biases from the measurement of mass, moisture content and sizing. Yet all of these affect the assessed economic value of a lot.
- (b) Small biases in testing procedures can occur.
- (c) Small biases can occur in primary sampling, secondary sampling, sample preparation and in the taking of samples for testing.

5 PROCEDURE FOR CHECKING FOR BIAS

5.1 General

The procedure for checking for bias is as follows:

- (a) A *system check* is initially carried out to ensure that sampling equipment and procedures are in order.
- (b) *Bias testing* is then conducted, where the sampling procedures are compared with the results of an alternative which is considered to be much more reliable. A bias test can only determine the average bias for the period (and for the other conditions) over which data were collected.
- (c) *Subsequent system checks* are carried out on an ongoing basis to confirm continued conformance of the sampling system.

5.2 Basis of procedure

The most important reason for checking a sampling procedure for bias is to seek assurance that any bias in the results is tolerable.

The disadvantage of bias tests is that they can only provide circumstantial evidence. They may show that there was no bias at some particular times under particular conditions, but this does not necessarily justify the prediction that there will be no bias in the future. For instance, consider a primary sample cutter used for sampling ore which a company with a processing plant purchases from mines that do not have their own processing plants. If the cutter has a 80 mm aperture and was found to have no significant bias based on extensive bias testing with ores up to 25 mm nominal top size, then it would not be confidently predicted that there would be no bias when sampling ore of 40 mm nominal top size.

In contrast, system checks look at the sampling procedure and equipment, rather than at particular samples, and therefore provide structural evidence that the sampling system does not allow bias to occur. This provides a reasonable basis for expecting that the sampling bias will not be excessively large in the future. This is the case particularly if the system checks are very conservative ones. For instance, a stopped-belt sampling procedure that takes ore off a very substantial length of a belt is generally considered unlikely to be biased.

One disadvantage of system checks is that the knowledge of the conditions required for unbiased sampling is somewhat uncertain. For instance, two commonly accepted rules due to Pierre Gy* are the following:

- (a) The minimum cutter width, W_0 , must be the larger of 10 mm and three times the nominal top size of the particles being sampled; and
- (b) The cutter speed V (in metres per second) must not exceed $V_0 = 0.3 (1 + W/W_0)$; where W is the actual cutter width.

These rules are based on Gy's experience and on some test work done with calcined bauxite. They do not consider the 'bounciness' of the particles, the typical velocity of particles when they hit the cutter blades, the inclination of the cutter blades, or the ore flow rate. Unless a sampling procedure is very conservative, it is common for bias tests to be conducted, at least at the time of installation.

An advantage of bias tests over system checks is that they are a direct way of checking the issue of primary interest. Suppose that a sample cutter does not always move at constant speed. A system check may fail to detect such an intermittent fault. However, a series of bias checks is likely to detect it.

Another disadvantage of bias tests is that they are very expensive. In some situations, bias tests are unrealistic or impractical.

In this Guide, it is suggested that system checks should be conducted regularly and that they should form the major line of protection against bias in sampling procedures. The reasons for this preference are as follows:

- (i) System checks can be done frequently at reasonable cost. This allows problems to be picked up more quickly than if the same cost were incurred by conducting bias tests less frequently.
- (ii) Bias tests can only ever provide circumstantial evidence that there was no detectable bias at the time the bias test or check of extraction ratio was carried out. There may be a bias for sampling of slightly different materials or under other conditions.
- (iii) If the components of a system check are not satisfied, then it is known precisely how to go about rectifying the problem. In contrast, if a bias test shows that there is bias, this information is not sufficient to indicate that the problem needs to be rectified or how to rectify it.

Bias tests should always be preceded by a thorough system check. If the system check shows that some aspect of the sampling system is not operating correctly, then the sampling system should generally be fixed so that it satisfies the system check before a bias test is conducted.

* See, for instance, GY, P.M. *Sampling of heterogeneous and dynamic materials systems: theories of heterogeneity, sampling and homogenizing*. 1992. Elsevier.

6 SYSTEM CHECKS

The basic requirement for unbiased sampling is that all particles have an equal chance of being sampled. System checking amounts to checking that this general principle is satisfied. In particular, it is necessary to check that large particles have as large a chance of being sampled as small particles, despite being more likely to hit cutter blades.

For general principles of system checking, refer to AS 4433.1.

For guidance on detailed system checking procedures, refer to AS 4433.6.

7 PRINCIPLES OF BIAS TESTING AGAINST A REFERENCE METHOD

7.1 General

A sampling method intended for routine use can be bias tested against a reference method. The reference method is assumed to be unbiased and should generally be of greater precision than the method being checked, so that the amount of bias-testing effort can be minimized.

In some circumstances, it is difficult to find a reference method that is reliably unbiased. For instance, no current method for determining moisture is perfect. In such circumstances, any statements about bias should be qualified by saying what method has been used for comparison. (See Clause 8).

One commonly-used reference method is stopped-belt sampling, where the belt which is stopped may be a diverter belt. This is used for checking the bias of mechanical sample cutters.

Another commonly-used reference method is careful sample preparation by an expert, where the method to be checked is routine sample preparation procedures. In a case like this, the difference between the two methods would usually be described as ‘relative bias’ rather than as ‘bias’, reflecting the fact that the benchmark is not known to be absolutely correct.

7.2 Context of bias testing

One aspect of the context is the part of the sampling system that is being bias tested. It could be just the primary cutter. It could also be a secondary cutter, some component of the sample preparation system, or that a substantial portion of the sampling and sample preparation system needs to be tested for bias in a single step. Bias testing of the primary cutter is usually the hardest step, because it causes most interference with routine operations and deals with the largest quantities of material.

Another aspect of the context is that bias testing for moisture loss and sizing must be carried out when the sampling system is operating in a typical mode, so that the moisture losses and size degradation are typical of routine operations. Chemical quality characteristics are more robust to atypical operating procedures such as stopping and starting of belts and other parts of the materials-handling system.

Major checks of bias are likely to be conducted at the following times:

- (a) Commissioning of a new mechanical sampling system.
- (b) Alteration to the mechanical sampling system.
- (c) Alteration to sampling procedures.
- (d) Sampling of new materials.