

Australian Standard[®]

Coal preparation

Part 1: Higher rank coal—Float and sink testing

This Australian Standard was prepared by Committee MN/1, Coal and Coke. It was approved on behalf of the Council of Standards Australia on 30 September 1993 and published on 17 January 1994.

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Australasian Institute of Mining and Metallurgy
Australian Chamber of Commerce and Industry
Australian Coal Association
Australian Coal Industry Research Laboratories
Australian Coal Preparation Society
Australian Institute of Energy
Australian Mining Industry Council
Bureau of Steel Manufacturers of Australia
CSIRO, Division of Coal and Energy Technology
Department of Resource Industries, Queensland
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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 4156.1—1994

Coal preparation

Part 1: Higher rank coal—Float and sink testing

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NOTES

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PREFACE

This edition of this Standard was prepared by the Standards Australia Subcommittee on Coal Preparation, under the supervision of the Committee on Coal and Coke and the direction of the Multitechnics Standards Policy Board.

Adoption of the recommendations on presentation of results, which follow in part the tabular and graphic forms developed within ISO/TC 27/SC 1, Coal preparation— Terminology and performance, will aid in the exchange of information relating to the washability of higher rank coal, and in the assessment of the efficiency and performance of coal preparation plant.

This Standard formed the basis for preparation of ISO 7936:1992.

The term ‘normative’ has been used in this Standard to define the application of the Appendices to which it applies. A ‘normative’ appendix is an integral part of a Standard.

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FOREWORD

In commercial practice, coal cleaning is conducted largely by processes that take advantage of a relationship between particle ash percentage and particle relative density. However, coal particles contain not ash but mineral matter, and the general relationship is therefore only an approximation.

Float and sink testing is the standard laboratory method for determining, with respect to relative density, the washability characteristics of a wide range of coal samples, from bore core to mine production and coal preparation plant products. Data are derived for a number of different purposes and form the basis on which to—

- (a) establish limits theoretically attainable by density separations, often used as a reference base and in initial assessment of resource potential during exploration of coal deposits;
- (b) predict and compare results of simulated plant operations for various types and combinations of processing equipment, facilitating selection of optimum process arrangement;
- (c) design commercial coal preparation plant (in conjunction with appropriate non-density based washability data); and
- (d) examine products from operating plant for routine control purposes, or to assess separation performance critically against established criteria.

STANDARDS AUSTRALIA

Australian Standard

Coal preparation

Part 1: Higher rank coal—Float and sink testing

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard describes general practice used in determining the float and sink characteristics of higher rank coal (see AS 2096) and indicates procedures for deriving test samples. Methods for presenting the washability data obtained, and methods for establishing some conventional plant performance parameters, are included.

NOTE: For borehole samples, reference should be made to AS 2519, which sets out specific procedures and float and sink test schemes that have been developed for the various stages of an exploration program.

1.2 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

- 1038 Coal and coke—Analysis and testing
- 1038.20 Part 20: Higher rank coal—Hardgrove grindability index
- 2026 Density hydrometers
- 2096 Classification and coding systems for Australian coals
- 2162 Code of practice for the use of volumetric glassware
- 2418 Glossary of terms relating to solid mineral fuels
- 2519 Guide to the technical evaluation of higher rank coal deposits
- 2617 Guide for the taking of samples from hard coal seams *in situ*
- 2646 Sampling of solid mineral fuels
- 2646.6 Part 6: Hard coal—Preparation of samples
- 3881 Higher rank coal—Size analysis

ISO

- 7936 Hard coal—Determination and presentation of float and sink characteristics—General directions for apparatus and procedures

1.3 DEFINITIONS For the purpose of this Standard, the definitions given in AS 2418 apply.

1.4 ANALYSIS AND TESTING Where chemical analysis and testing are required, these shall be carried out in accordance with the various parts of AS 1038.

1.5 SAMPLING AND SAMPLE PREPARATION Samples for float and sink testing should be obtained and prepared according to the requirements of relevant Standards (AS 2519, AS 2617, AS 2646) and relevant sections of this Standard, as applicable.

SECTION 2 DERIVATION OF TEST SAMPLES

2.1 SCOPE OF SECTION This Section describes sampling procedures relevant to float and sink testing.

2.2 SAMPLING

2.2.1 General Sampling and sample reduction shall be carried out as described in AS 2646, where applicable.

NOTES:

- 1 It is recommended that pilot testing, as described in Clause 3.3.3, be carried out wherever possible to ensure that the sample is adequate for its intended purpose.
- 2 It is assumed that square-mesh particle sizes are used; if wedge-wire sizes are used, this fact should be reported.

2.2.2 Size of sample

2.2.2.1 Bulk sample The size of the sample to be taken for any given purpose will determine to a large extent the accuracy of the test. In turn, the sample size will be governed by the purpose for which the test is being carried out (see Foreword). The mass of the bulk sample should be sufficient to contain the minimum quantities in each screen fraction as listed in Table 2.1. Table 2.1 is for guidance only, for use with an unknown sample, and the mass of the recommended sample may have to be substantially increased. As a general rule, the number of discrete particles in any size fraction should be not less than 2000.

Because some coals give low yields in the middle fractions of relative density, there may be insufficient sample for analytical requirements, minimum requirements being that there be not less than 20 g and not less than 10 particles in each relative density fraction.

NOTE: If these requirements cannot be met, this fact should be noted in the reporting of results. This is particularly relevant to float and sink testing of small bore core samples.

When a bulk sample is being taken, it is better to over-sample than to have insufficient material. For testing on the top sizes shown in Table 2.1, the bulk sample may have to be of the order of 20 t, and for other sizes the amounts should be reduced *pro rata* according to the reduction in size.

A method for the determination of the required mass of the bulk sample is given in Appendix A.

2.2.2.2 Coal from a preparation plant To check the operation of a coal preparation plant, the sampling procedures described in AS 2646 should be followed. The minimum quantities for each sample in Table 2.1 should ensure that adequate amounts of misplaced materials are available.

NOTE: If a mass balance of the coal preparation plant is to be carried out, it is necessary that the mass of the raw coal input and all the products of the plant be taken before drying, after which the mass balance may be calculated on the basis of dry coal.

In the sampling of pulp, the quantity of the (dried) solids should comply with Table 2.1. Samples shall be taken at regular intervals over the full width of the pulp stream either manually or by mechanical means using a sampling device having a capacity equal to at least twice that of the sample being taken. Care should be exercised so that none of the sample is lost by splashing. The gross sample thus obtained should be de-watered by filtration and air dried before being subsampled.

TABLE 2.1
RECOMMENDED MASS OF COAL SAMPLE FOR
A GIVEN PARTICLE SIZE FRACTION

Nominal particle size fraction (see Note) mm	Recommended mass, kg				
	Raw coal	Coal preparation plant products			
		Comprehensive test		Control test	
		Clean coal	Discard	Clean coal	Discard
–125 +63	2 000	2 000	4 000	1 000	2 000
–63 +31.5	250	250	500	125	250
–31.5 +16.0	30	30	60	15	30
–16.0 +8.0	10	10	20	5	10
–8.0 +4.0	5	5	10	2.5	5
–4.0 +2.0	2.5	2.5	5	1.2	2.5
–2.0 +0.5	1.2	1.2	2.5	0.8	1.2
–0.5	0.8	0.8	1.2	0.4	0.8

NOTE: The particle sizes shown in Table 2.1 may be supplemented or replaced by other particle sizes or gauges in accordance with personal preference, provided that—

- (a) the number of discrete particles in any size fraction is not less than 2000;
- (b) the number of particles within each relative density fraction is not less than 10; and
- (c) the mass contained in any relative density fraction is not less than 20 g.

2.2.2.3 Control tests As the results of successive tests can be averaged, the minimum recommended quantities can frequently be reduced to approximately one-half of those required for comprehensive testing.

2.2.3 Sampling points for raw coal There is no universally recognized location at which raw coal should be sampled, because much depends on the local layout and facilities. In the case of run-of-mine coal, where both the size distribution and the ash level as mined may vary during a shift as well as from day to day, it is recommended that suitable increments be taken to cover this variation. The number and mass of increments should be chosen to give a bulk sample that will yield a screened fraction not less than that given in Table 2.1, as appropriate.

Suggested sampling points are as follows:

- (a) A strip sample from a newly opened mine, a trial shaft, or other appropriate locations (as described in AS 2617).
- (b) At the output end of a continuous miner or mechanical loader operating at the work face, so that the sample represents the full height of the seam being worked.
- (c) From the main output conveyor belt or district conveyor belt (as described in AS 2646).
- (d) At the feed to a coal preparation plant, after primary crushing (as described in AS 2646).
- (e) Overflow weirs and launder discharges (in the case of pulp samples).

2.3 SAMPLE PREPARATION The gross sample should be spread out on an impervious base, preferably under shelter, and allowed to dry sufficiently for screening. It should then be screened on sieves having a suitable range of apertures. Oversize material may be broken by hand, drop shatter or machine according to the top size required (in the process, the relevant part of the crushing circuit should be simulated if possible).

The quantity of material passing through the 8 mm screen is usually in excess of requirements, but can be reduced by a sample splitter. Further screening may then be carried out on the subsample with other screens as required.

If information on intermediate sizes is required, the appropriate screens may be included, or the yield may be calculated on a cumulative basis.

The screening process may be preceded by treatment of the sample (such as that described in Appendix B) designed to simulate the particular breakdown that may occur in a coal preparation plant.

SECTION 3 GENERAL FLOAT AND SINK TEST PRACTICE

3.1 SCOPE OF SECTION This Section describes the basic elements involved in performing float and sink analysis on prepared samples. It is broadly applicable to any test purpose that requires higher rank coal samples to be partitioned on the basis of differences in relative density.

Float and sink analysis is the division of a sample into relative density fractions having defined limits, the proportions of the fractions being expressed as mass percentages of the total sample, commonly with an indication of the ash percentage (and other characteristics, if required) of each fraction.

3.2 SEPARATING MEDIA, APPARATUS AND HYDROMETERS

3.2.1 Separating media The medium to be used for a separation is determined by the relative density required and is generally prepared from a mixture of organic liquids (see Notes 1 and 2).

The properties of organic liquids, which are generally used, are listed in Table 3.1 (see Note 3).

Where relative densities of 1.6 and less are required, a mixture of perchloroethylene and white spirit may be used; where relative densities in the range of 1.6 to 2.9 are required, sym-tetrabromoethane or bromoform mixed with perchloroethylene is satisfactory.

Organic liquids are costly, but are preferred to alternative media because of low viscosity, ease of use and the fact that they are inert towards shales; the products of the separation are easier to deal with, and prolonged washing and drying times are unnecessary, owing to the generally high volatility of these liquids (see Note 4). Organic liquids should be used sparingly, and it is recommended that liquid recovery be practised, particularly by drainage, after removal of the sample from the separation tank.

WARNING: PARTICULAR ATTENTION IS DRAWN TO THE FACT THAT VAPOURS FROM THESE LIQUIDS ARE TOXIC AND PRESENT A DANGER TO HEALTH; HENCE ADEQUATE VENTILATION, PREFERABLY DOWN-DRAUGHT, IS ESSENTIAL. IF A DOWN-DRAUGHT BENCH IS NOT AVAILABLE, IT IS ESSENTIAL TO CONDUCT TESTS USING ORGANIC LIQUIDS OUT OF DOORS, OR ALTERNATIVELY IN AN OPEN-SIDED BUILDING (SEE NOTE 5). USE OF SUITABLE PROTECTION TO AVOID CONTACT WITH SKIN AND EYES IS RECOMMENDED. IF CONTACT IS MADE WITH THE SKIN OR EYES, THE LIQUID SHOULD BE WASHED OFF WITH COPIOUS QUANTITIES OF COLD WATER. MEDICAL ADVICE SHOULD ALSO BE SOUGHT. WORK AND STORAGE AREAS SHOULD DISPLAY 'INFLAMMABLE SUBSTANCE' AND 'NO SMOKING' SIGNS. AS THE USE OF SOME ORGANIC LIQUIDS IS GOVERNED BY SAFETY REGULATIONS, THE USER IS URGED TO ENSURE COMPLIANCE WITH THE RELEVANT STATUTORY REGULATIONS.

NOTES:

- 1 If it is desired to use inorganic solutions or aqueous suspensions for the purpose, reference should be made to ISO 7936.
- 2 Despite thorough drying after float and sink testing, some component of organic liquids may remain and influence particular subsequent analyses and tests, e.g. chlorine, fly-ash precipitability.
- 3 New liquids developed should be assessed to establish whether use could change relevant properties of coal being tested.

- 4 To accelerate drying and to minimize contamination, float and sink fractions that have been separated by mixtures containing the high relative density halogenated organic compounds (particularly sym-tetrabromoethane which has an extremely low vapour pressure), should be rinsed with a more rapidly evaporating compatible organic liquid.
- 5 Where tests are conducted in exposed situations, samples should be protected from airborne contaminants and wind loss.

TABLE 3.1
PHYSICAL PROPERTIES OF ORGANIC LIQUIDS USED IN
FLOAT AND SINK ANALYSIS

Organic liquid	Relative density	Distillation range or boiling point, °C at 100 kPa	Viscosity at 20°C	Vapour pressure at 20°C kPa	Flammable
White spirit	0.77	30 to 200	—	—	Yes
Bromoform (tribromomethane)	2.79	150.0	2.152 (15°C)	0.60	No
Sym-tetrabromoethane (acetylene tetrabromide)	2.96	239	12.0	0.01	No
Tetrachloroethylene (perchloroethylene)	1.61	120.8	1.0	1.83	No

NOTES:

- 1 Particular attention is drawn to the fact that many solvent vapours present a serious health hazard and hence adequate ventilation, preferably down-draught, is essential.
- 2 As the use of some organic liquids is governed by safety regulations, the user is urged to ensure compliance with the relevant statutory regulations.
- 3 Tetrabromoethane has an extremely low vapour pressure and therefore it is essential that it be rinsed from the sample by a more rapidly evaporating solvent.
- 4 Bromoform is generally not recommended, because of its higher volatility and greater toxicity compared with tetrabromoethane.

3.2.2 Apparatus The principal criteria for a satisfactory testing apparatus are that it be unaffected by the test media, reasonably robust, suitable for the purpose, convenient and safe to use. For the most part, quite simple equipment is applicable. A variety of apparatus is used, depending primarily on the particle size distribution of samples being processed.

Typical separating vessels for the coarser size fractions are shown in Figure 3.1 (–250 mm +8 mm), and Figure 3.2 (–11.2 mm +0.5 mm). Basically, the equipment consists of a rectangular or cylindrical tank having an inner mesh basket (or tank having mesh base). The arrangement provides a convenient means of recovering floats and sinks separately; floats are skimmed off the surface of the liquid using a mesh scoop of suitable aperture, and sinks are recovered by raising the inner basket which is then supported above the tank to allow liquid to drain. Baskets should be fitted with suitable lifting handles. They should have inserts having mesh apertures suitable to contain all particles within the basket.

Figure 3.3 shows a typical arrangement of a series of such tanks, as may be set up in a laboratory situation.

NOTE: Mechanical handling is recommended where large quantities are to be treated. The larger facilities may be serviced by a small overhead crane.

Two types of separating vessels that have been found suitable for the finer size fractions are shown in Figure 3.4 ($-2\text{ mm} +0.5\text{ mm}$), and Figure 3.5 (-0.5 mm). For Figure 3.4, the sinks are recovered by inserting the stopper and physically parting the two halves of the apparatus, filtering the contents of each half into the corresponding product. For Figure 3.5, sinks are removed first through the outlet valve followed separately by the floats through the same valve.

To minimize evaporation, all media containers should be fitted with lids when not in use.

Additional items that are needed are buckets, shovels, mesh scoops, balances, drying trays, fan, air-swept drying cabinet, filter apparatus and hydrometers and labels.

3.2.3 Hydrometers Maintaining the required relative densities of the media is a critical aspect of the test and requires monitoring and control throughout the whole float and sink operation. Recommendations on the types of hydrometers suitable for this purpose and requirements for use are listed below:

- (a) Types M100 or M50 having scale subdivisions less than or equal to 0.002 are recommended.
- (b) Certified reference or working hydrometers are both permissible.
- (c) Before initial use, working hydrometers should be calibrated by reference to certified reference hydrometers or by the mass method. These methods are described in Appendix C.

It is considered preferable to reject rather than apply a correction to a working hydrometer that is out of tolerance.

The rejection limit is 0.003 relative density units.

- (d) Under normal working conditions, there is no need to apply temperature, meniscus or surface tension corrections.
- (e) Readings on the hydrometer stem should correspond to the bottom of the meniscus.

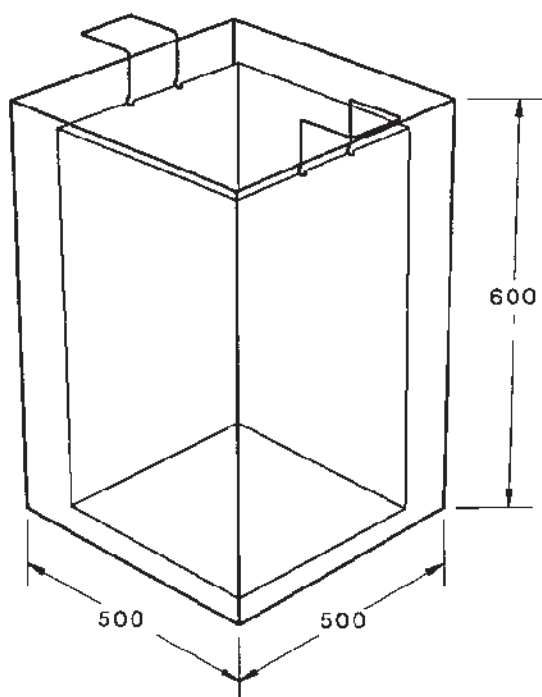
3.3 BASIC FLOAT AND SINK TEST PROCEDURES

3.3.1 Relative densities of test media The range and number of relative density separations to be made are generally not fixed, and may vary with the purpose of the test and individual requirements. For example, routine plant control tests may require use of as few as one separation density at the nominal plant cut-point density, as a guide to the level of misplaced material. Comprehensive testing of raw coals or plant products, where assessment of economics, plant design or plant performance is under investigation, may require eight or more separations, whereas the evaluation of bore cores during preliminary exploration may be achieved with fewer separating densities. However, the abbreviated washabilities may be of limited use in later evaluations and this practice may be false economy.

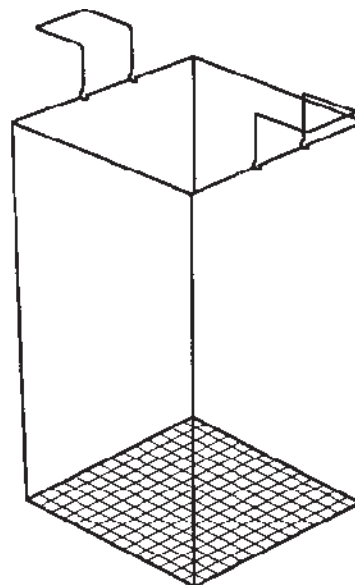
Where actual requirements are uncertain, the most suitable relative densities may have to be determined by trial and error, adjustments by way of extra separation being made *before* crushing the preliminary float or sink fractions for analysis.

Consideration should be given to developing a data base that is consistent in terms of the number of relative density cut-points prescribed for washability analysis. This will facilitate blending of washability analyses for reserve calculations and ensure that all of the data can be used.

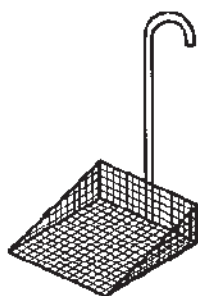
The more comprehensive tests could include relative densities of 1.30, 1.40, 1.50, 1.60, 1.70, 1.80 and 2.00. Additional separations between these levels at selected sections of the range are often considered necessary for accurate interpolation of data, e.g. for raw coal samples where cumulative ash is increasing rapidly in relation to cumulative yield, or for plant performance test samples in the vicinity of the plant separating density. Similarly, separations outside the above range may be required where interpretation is needed at extremely high or extremely low relative density.



(a) Tank having inner liner



(b) Inner liner having wire-mesh bottom only



(c) Wire-mesh strainer

DIMENSIONS IN MILLIMETRES

FIGURE 3.1 SUITABLE FLOAT AND SINK APPARATUS FOR SEPARATION OF $-250\text{ mm} +8\text{ mm}$ COAL FRACTIONS