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Table 1 Certified property values

Element	mg/kg, d		
Antimony (Sb)	0.188	+/-	0.010
Cobalt (Co)	3.60	+/-	0.17
Lead (Pb)	5.46	+/-	0.15
Manganese (Mn)	53.4	+/-	1.0
Nickel (Ni)	8.80	+/-	0.26
Selenium (Se)	0.307	+/-	0.008
Strontium (Sr)	181	+/-	7
Vanadium (V)	23.1	+/-	1.1

Values are expressed as robust mean +/- expanded uncertainty (U). Property values are the best estimate of the true value and are an unweighted robust mean value of an accepted dataset obtained from an interlaboratory study using ISO/IEC 17025 accredited laboratories, each of whom tested a minimum of five unique samples.

Table 2 Non-certified property values

Parameter	%, d		
Ash	9.32	+/-	0.06
Sulfur (S)	0.343	+/-	0.008
Chlorine (Cl)	0.0311	+/-	0.0009
Phosphorus (P)	0.1135	+/-	0.0015
Element	mg/kg, d		
Arsenic (As)	0.302	+/-	0.072
Barium (Ba)	46.3	+/-	2.4
Boron (B)	3.47	+/-	0.52
Cadmium (Cd)	0.024	+/-	0.004
Chromium (Cr)	(12.4)		
Copper (Cu)	13.5	+/-	0.6
Fluorine (F)	176	+/-	4
Lithium (Li)	(34.2)		
Mercury (Hg)	0.041	+/-	0.002
Molybdenum (Mo)	(0.410)		
Zinc (Zn)	7.93	+/-	0.53

The standard test methods used are detailed in section 4. Where more than one test method was used, significant biases between methods were not observed.

Expanded uncertainty (U) is a robust value estimated on the likely range of the true value of each parameter, including estimation of the uncertainty due to characterisation and heterogeneity, and is calculated from $1.25 \times s^* / \sqrt{n} \times k$ where k is a coverage factor of 2 corresponding to a level of confidence of approximately 95%.

Values in parentheses () indicate an informational value.

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Report Number: ACIRS-M2-2018-CoA-rev03
Previous ACIRS-M RM: This sample is the first in the series



Accredited for compliance with ISO 17034
Accreditation Number 21027

*NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

1. PURPOSE

This reference material is a higher rank bituminous coal. The certified values for specified trace elements (Table 1) are traceable to SI units and are suitable for calibration purposes. All non-certified values (Table 2) are intended to be used for quality control purposes for the analysis of similar coals. Informational values are provided for reference only.

2. DESCRIPTION OF THE SAMPLE AND PREPARATION

ACIRS-M2-2018 comprises a sealed jar containing 50 g (minimum) of coal at a nominal top size of 212 μm . This sample was prepared from a 25 kg bulk sample of a higher rank bituminous coal sourced from the Queensland, Bowen Basin in 2017 at -50 mm top size.

The material was air-dried and then crushed in a swing hammer mill to a nominal top size of 2.36 mm. The material was then repeatedly mixed by rotary sample division (RSD) until lots of approximately 0.5 kg were obtained which were then air dried and milled to a nominal top size of 212 μm . This pulverised material was further divided by RSD until representative 50 g samples were obtained. Each sample was then placed into sealed amber glass jars.

3. INSTRUCTIONS FOR HANDLING AND USE

Before each use, the bottle **must** be thoroughly mixed by end-over-end rotation to re-homogenise the coal sample.

To minimise the risk of compositional changes due to oxidation, store in a cool, dark place in the original container with lid tightly sealed. ACIRS cannot be held responsible for any changes that occur after the sample bottle has been opened.

The minimum sample intake for ACIRS-M2-2018 is established in accordance with the standard test methods listed in section 4. Corrections to dry basis values should be in accordance with ISO 1170 or equivalent.

4. HOMOGENEITY ASSESSMENT AND CHARACTERISATION

Homogeneity of the batch was confirmed by comparison of the dry ash value of each sample against the ash repeatability criteria of ISO 1171. Satisfactory sample homogeneity for this coal was established after evaluation in accordance with ISO 33405:2024.

ACIRS-M2-2018 was originally certified from the outcomes of ACARP research project C25044 during 2017-18. Further testing was conducted in 2025 through an independent interlaboratory study conducted by ACIRS. The accepted characterisation dataset included testing by analytical methods in Table 3.

Table 3 Analysis Methods

Parameter	Analysis Method	Number of Results
Ash, % d	ISO 1171 (9), AS 1038.3 (6), ISO 17246 (3)	18
Total Sulfur, % d	ISO 19579 (15), ASTM D4239-26 (5)	20
Phosphorus, % d	ISO 13605 (10), ASTM D6349-21 (10)	20
Chlorine, % d	ISO 18806 (15), ASTM D6721-24 (5)	20
Fluorine, mg/kg d	ISO 11724 (10), AS 1038.10.4 (6)	16
Antimony, mg/kg d	ASTM D6357-21b (10), In-house method (9)	19
Arsenic, mg/kg d	ISO 11723 (5), ASTM D6357-21b (4), In-house method (10)	19
Barium, mg/kg d	ISO 13605 (5), ASTM D6349-21 (10)	15
Boron, mg/kg d	AS 1038.10.3 (10), ASTM D8213-18 (5), In-house method (10)	25
Chromium, mg/kg d	ASTM D6357-21b (10), In-house method (15)	25
Cadmium, mg/kg d	ASTM D6357-21b (10), In-house method (15)	25
Cobalt, mg/kg d	ASTM D6357-21b (10), In-house method (15)	25
Copper, mg/kg d	ASTM D6357-21b (9), In-house method (15)	24
Lead, mg/kg d	ASTM D6357-21b (10), In-house method (15)	25
Lithium, mg/kg d	ASTM D6357-21b (5), In-house method (10)	15
Manganese, mg/kg d	ISO 13605 (5), ASTM D6357-21b (9), In-house method (10)	24
Mercury, mg/kg d	ASTM D6722	11
Molybdenum, mg/kg d	ASTM D6357-21b (14), In-house method (5)	19
Nickel, mg/kg d	ASTM D6357-21b (10), In-house method (15)	25
Selenium, mg/kg d	ISO 11723 (5), ASTM D4606-21 (5), In-house method (5)	15
Strontium, mg/kg d	ISO 13605 (5), ASTM D6349-21 (10), In-house method (5)	20
Vanadium, mg/kg d	ASTM D6357-21b (9), In-house method (15)	24
Zinc, mg/kg d	ASTM D6357-21b (14), In-house method (10)	24

Results were evaluated for technical competency before inclusion in the characterisation dataset, e.g., by meeting standard method precision limits and by outlier identification. Robust statistical techniques were then used in the characterisation process in accordance with the guidelines of:

- IUPAC, 2006 International Harmonized Protocol for the Proficiency Testing of Analytical Chemical Laboratories
- ISO 13528:2022, Statistical methods for use in proficiency testing by interlaboratory comparison, and
- ISO 33405:2024 Reference Materials – Approaches for characterization and assessment of homogeneity and stability

5. METROLOGICAL TRACEABILITY

Property values are operationally defined by methods listed in section 4 using only results from laboratories accredited to ISO/IEC 17025. Certified values in Table 1 include metrological traceability with primary (NMI) reference standard NIST SRM 1635a.

6. PERIOD OF VALIDITY

Property values are considered stable until June 2036. The stability of assigned property values and informational values will be monitored by ACIRS, and it is the responsibility of the user to obtain the most recent documentation for this reference material available at www.acirs.com.au/products/.

7. HEALTH AND SAFETY

Samples shall be handled in accordance with the Safety Data Sheet available from www.acirs.com.au/products/.

8. LEGAL NOTICE

To the extent permitted by law, ACIRS disclaims all warranties whether expressed or implied regarding merchantability, non-infringement, or fitness for a particular purpose. In no event will ACIRS be liable for incidental damage or consequential loss arising from the use of this product.

Where the product does not conform to assigned property values or informational values, giving due consideration to the stated uncertainties and accepted tolerances, the total liability of ACIRS shall be limited at ACIRS' absolute discretion to either replacement of the product or refund of the purchase price.

9. REVISION HISTORY

Document Number	Summary	Date
CR-M2-2018-rev0	- Original (rev0)	01/06/2018
ACIRS-M2-2018-CoA-rev01	- Updated Table 1 & Notes: added P, updated Se from indicative to certified value, removed Cd, n laboratories transferred to section 4 - Added section 1 (Introduction) & section 5 (Traceability), updated section 3 (Handling & Use) & section 4 (Characterisation) - Period of validity extended to February 2025 - Formatting, minor editorial corrections	21/03/2023
ACIRS-M2-2018-CoA-rev02	- Added Table 2: Cl and Cd as informational values - Period of validity extended to February 2028 - Formatting, minor editorial corrections	28/02/2025
ACIRS-M2-2018-CoA-rev03	- Updated Phosphorus value with improved characterisation dataset - Added 15 trace element property values - Period of validity extended to June 2036 - Formatting, minor editorial corrections	30/06/2026

10. AUTHORISATION

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