

ES ANALYTICAL is the global leader in rapid test technologies for determination of geochemical risk (acid, metals, salinity) for the mining industry. Building on extensive world-wide mine site experience and over 20 years of research and development, we offer a series of standard test suites designed specifically to address key questions for mine approvals and risk management.

STANDARD TEST SUITES 2015/16

STATIC GEOCHEMICAL TESTS

Our static suites include carefully selected analyses that provide the most useful and comprehensive characterisation for mine materials at the lowest cost. All suites include data validation by our professional geochemists.

Service	Inclusions	Units/LOR
STANDARD REACTIVE GEOCHEMISTRY [ST-01A]		
Sulphur speciation (Aherm 2004)	Total sulphur Sulphide sulphur (Cr-reducible) HCl-extractable sulphur KCl-extractable sulphur Net acid-soluble sulphur Total oxidisable sulphur Total actual acidity	0.01 wt% S 0.01 wt% S 0.02 wt% S 0.02 wt% S 0.01 wt% S 0.01 wt% S 2 mol/t H ⁺
Acid-base accounting (ABA) (AMIRA 2002)	Total sulphur Acid neutralisation capacity (ANC/NP) Maximum potential acidity (MPA/APP) Net acid producing potential (NAPP) ANC/MPA ratio (NPR)	0.01 wt% S 0.1 wt% CaCO ₃ kg H ₂ SO ₄ /t kg H ₂ SO ₄ /t —
Net acidity generation (NAG) (AMIRA 2002)	pH of oxidation (NAG _{pH}) NAG to pH 4.5 NAG to pH 7.0 NAG to pH 9.5 ³	— kg H ₂ SO ₄ /t kg H ₂ SO ₄ /t kg H ₂ SO ₄ /t
Other	Total carbon KCl leachate pH	0.02 wt% C —

Calculation of AMD/NMD/salinity risk category from static parameters

FULL GEOCHEMISTRY AND MINERALOGY [ST-03E]

Includes Suite ST-01	As above	
Major element chemistry by fused-disc XRF	Al Ca Cl Fe Mg Mn P K Na S Ti LOI	0.001–1 wt%
Metals by aqua regia digest and ICP-MS	Ag As Ba Bi Cd Co Cr Cu Mo Nb Ni Pb Sb Se Sn Te V W Zn Zr Trace: Be Ce Cs Ga Ge Hf In La Li Rb Sr Th Tl U Y	0.1–1 mg/kg
Mineralogy by quantitative XRD ¹	Quantitative mineralogy and validation	0.1 wt%
Other	Boron by aqua regia digest and ICP-AES Fluoride by fusion method Mercury by aqua regia digest and CV/FIMS	50 mg/kg 40 mg/kg 0.1 mg/kg

Acid buffering characteristic curve (ABCC)

LEACHABILITY

Bottle-roll leach test ² [LT-02]	24 h bottle-roll leach (1:1, deionised water) Leachate chemistry LC-01	
Oxidative leach test [LT-04]	Full hydrogen peroxide leach (NAG) Normalised (1:1) leachate chemistry LC-01	

LEACHATE CHEMISTRY [LC-01]

General parameters	pH, EC, acidity, alkalinity	
Major ions	Ca Mg Na K SO ₄ Cl F P	0.01–1 mg/L
Metals by ICP-MS	Ag Al As Bi B Cd Co Cr Cu Fe Mn Mo Ni Pb Sb Se Te Ti Sn U V Zn	0.0001–0.05 mg/L

KINETIC GEOCHEMICAL TESTS

Using proprietary OxCon oxygen consumption technology, ES ANALYTICAL is able to offer the world's fastest and most accurate kinetic test for determination of reactive sulphide oxidation rates (see over for more information).

RAPID OXYGEN CONSUMPTION CELL TEST [KT-01]

Oxygen consumption cell test using OxCon technology	4–8 week oxidation cell test under site-specific conditions (temperature, humidity, moisture content, compaction, solar radiation) to determine the rate of reactive sulphide oxidation (sulphide half-life) and 'lag time' to onset of acid conditions.
Includes	Full geochemistry and mineralogy (ST-03E) Leachability (LT-02, LT-04) Full report and calculation of AMD/NMD/salinity risk potential

EXTENDED LEACHABILITY TESTS (CONVENTIONAL KINETIC TESTS)

Column leach [KT-05]	Extended duration leach test for determining element mobility and acidity/salinity release rates. Typically 12–24 months with weekly/monthly leachate analyses (LC-01).
Humidity cell [KT-07]	Extended duration leach test under accelerated oxidation conditions for determining element mobility and acidity/salinity release rates. Typically 12 months.

FULL-SCALE GEOCHEMICAL STABILITY AND COVER DESIGN TESTS

Our full-scale laboratory tests directly determine the rate of sulphide oxidation in a vertical bulk section (1–5 m) of mineral waste, with or without cover materials, for low-cost cover design validation (see over for more information).

OXYGEN PENETRATION TEST [OPT-02]

Oxygen penetration/diffusion/flux test using OxCon technology	Measurement of depth of oxygen diffusion and oxygen flux into reactive sulphidic materials under site-specific conditions (temperature, humidity, moisture content, compaction, solar radiation) to determine the depth of the reactive zone using actual materials, including cover materials. Typically conducted using a 1–5 m packed column (150–250 mm diameter, 20–400 kg).
Includes	Rapid oxygen consumption cell test (KT-01) and suite inclusions.

WATER TREATMENT TESTS

Our laboratory 'treatability' trials for contaminated water help optimise treatment requirements and costs, and provide certainty of treated water quality.

WATER TREATMENT TEST [WT-01]

Bench-scale water treatment simulation	Dosing of contaminated water with selected reagents (neutralising agents, flocculants, adsorbants) to prescribed endpoints to determine treatment requirements (reagent, dosing method, interferences, total reagent mass). Includes
Includes	Treated water chemistry (LC-01) TREATSIM geochemical validation and modelling of treatment requirements

Pricing is determined by many factors, such as the number of samples, the kinetic test conditions to be tested, and the selection of treatment reagents. For the best pricing please contact ES ANALYTICAL on

T +61 3 9810 7527
E lab@esanalytical.com

All static tests are conducted by NATA-accredited laboratories using applicable standard methods except where noted. All kinetic testwork is conducted in-house by ES ANALYTICAL.

¹ Conducted by a specialist mineralogical laboratory. ² Conducted in-house. ³ Specific test developed by ES ANALYTICAL for net-neutral materials. LOR = limit of reporting (detection limit).

ES ANALYTICAL specialises in the latest rapid test technologies for determination of AMD/ARD* risk under simulated site conditions.

Knowing with certainty the AMD risk of mine materials has never been more important. Stricter regulations and community scrutiny mean that missteps in the management of environmental impacts can have severe consequences for mine operations.

Material assessments for AMD risk can be expensive and some of the key kinetic tests are expensive and can take years to complete. Not only that, the results are often unclear and give little management guidance. At ES ANALYTICAL, we spend a lot of time thinking of ways to do this better, and developing tests with real management significance.

WHAT'S NEW

Based on many years of research and development, we can now provide a kinetic test based on proprietary OxCON oxygen consumption cell technology that gives comprehensive, accurate, management-ready results in as little as 4 weeks at a fraction of the cost of other methods.

Oxygen consumption cell tests are quickly becoming the new standard for kinetic geochemical testwork. Not all oxygen consumption tests are the same, however. Only ES ANALYTICAL's OxCON test provides the accuracy, reliability and complete reporting that permit use of the results in a range of management activities.

OxCON technology is also used in our oxygen penetration tests, which directly test the depth of oxidation, oxygen flux and the effectiveness of cover materials at *full scale, under site-simulating conditions*. No more modelling, no more uncertainty. That's how it should be.

With results in weeks, not years, and clear metrics that you can use directly to make management decisions, it has never been easier, cheaper or quicker to de-risk and tick off that management or approvals checklist.

REAL-WORLD CONDITIONS

To be relevant, the conditions of the test must reflect site conditions. ES ANALYTICAL runs all of its OxCON tests under conditions that match each site's environmental profile. Temperature, humidity, moisture, compaction and solar radiation are key parameters that can profoundly affect the results of kinetic geochemical tests. Need to know how the material behaviour would change by increasing moisture or adding a cover? Test it. Our rapid kinetic tests allow multiple parameters to be varied and tested within just a few weeks.

SIMPLIFYING TEST SELECTION

We know that selecting the most appropriate suite of tests for your analysis program is critical but often challenging. That's why we developed standard test suites that cover the key geochemical parameters at different levels of detail, and bundled the analyses together to give you the absolute best price.

MAKE TESTING ROUTINE

ES ANALYTICAL's test suites allow mine managers to de-risk permitting and closure planning and provide real certainty around downstream risks and how they should be managed. Each test has the potential to save millions of dollars by optimising material handling and management, so make it routine:

- » Mine approvals, extensions and regulatory compliance
- » Engineering design validation
- » Closure and rehabilitation
- » Design and costing
- » Water treatment costing and equipment requirements
- » Stockpile metal loss / metallurgy

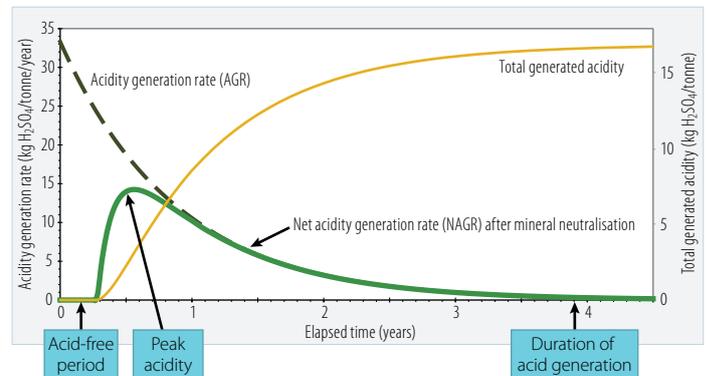
OUR MOST POPULAR TESTS EXPLAINED

OxCON Rapid Oxygen Consumption Cell Tests

Our most popular suite, this test determines the intrinsic rate of oxidation for sulphidic materials by direct measurement of oxygen consumption by the material over time. In combination with the detailed mineralogy and geochemistry of the sample, this 'snapshot' taken over 2–6 weeks tells us how much acidity will be generated over the reactive lifetime of the material, and how long the acid neutralisation capacity of the sample will be able to neutralise the generated acidity.

This information is pulled together in a graphical output that puts key management metrics at your fingertips, clearly showing the acid-free 'lag' period before the onset of acid conditions for acid-forming samples, the timing and magnitude of peak acidity, and the longevity of acid generation (see below).

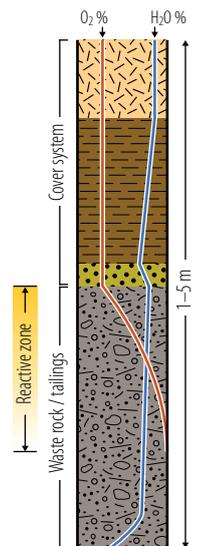
The oxidation rate is reported as a reactive sulphide 'half-life' (as well as in various conventional units), which allows the result to be applied directly to bulk average materials—a result with direct management utility.



OxCON Oxygen Penetration Tests

The intrinsic oxidation rate is only part of the story, however. Our full-scale OPT columns allow entire vertical sections of up to 5 m or more of waste material, with or without full-scale cover systems, to be tested in the laboratory under simulated field conditions. This determines the thickness of the 'reactive zone', from which actual dump-scale acidity generation rates can be calculated.

Using the OPT column it is possible for the first time to directly test the geochemical performance of proposed closure strategies such as covers for waste rock dumps and tailings storage facilities, replacing or augmenting conventional modelling approaches such as VADOSE/W. As better covers result in thinner reactive zones, the relative performance of different strategies can be compared directly under carefully controlled conditions, and the thickness, compaction and target moisture content of each cover component can be optimised to minimise cost and maximise long-term geochemical stability—with significant opportunities for cost savings in construction.



*Acid and metalliferous drainage (AMD) or acid rock drainage (ARD)