European Standards of Global Relevance — Implications for the Adoption of Paste Technology

J.A. Drielsma *European Association of Mining Industries (Euromines), Belgium*

M. Cambridge *Cantab Consulting Ltd, UK*

ABSTRACT

The European mining sector employs more than 200000 people. With a turnover of approximately A$ 22 billion, mining has the potential to become the backbone of the economy in many countries of central and eastern Europe. Despite recent trends there is active interest in mineral deposits, with ongoing exploration in Scandinavia and on the rim of Europe, and many new mining projects currently under development. Recent high-profile tailings spills, however, have resulted in increased regulatory demands for environmental protection across Europe, with the consequence that the European Commission initiated a new European Directive and a "Best Available Techniques" (BAT) document on the management of tailings and waste rock from the extractive industries. Between 2001 and 2003, the BAT document was completed in accordance with the principles of existing EU legislation for the development of BAT Reference documents (BREFs) for other sectors. The new Directive (published 11 April 2006) introduces a classification system for tailings management facilities and formally links financial guarantees, monitoring and reporting requirements to the detailed characterisation of the tailings. As during final drafting some open questions regarding waste characterisation methods remained unanswered the Directive calls for the development of European-wide standards to address the outstanding issues. Specific standards and guidance are now in preparation with the cooperation of the Member States and industry.

The most likely outcomes of the standardisation work are:

- *A European Static-Test Standard for prediction of acid mine drainage.*
- *A European Guideline on the characterisation of waste rock and tailings.*

The availability of these standards could in the future ease negotiations with local authorities for new permits and licenses providing that a flexible site-specific approach is adopted as intended by the Directive.

The impacts of this Directive are likely to be felt beyond the European Union due to the European Commission's stated ambition to demonstrate "global environmental leadership". The strong links between the European Centre for Norms (CEN) and the International Standards Organisation (ISO) are likely to result, therefore, in the new European requirements having a global impact on the industry.

This paper explains the status of the current regulatory and guidance framework, and explores how the BREF is being used prescriptively by some regulators and not as guidance, as intended. The example of paste technology is used to demonstrate how misinterpretation of the regulatory work could preclude the benefits of new and emerging technologies in an expanding European mining market place.

1 INTRODUCTION

The European mining sector currently employs more than 200000 people (European Commission, 2006) and, with significant exploration activity in Scandinavia and on the rim of Europe, mining has the potential to become the backbone of many economies in Central and Eastern Europe. The current turnover of the extractive industries in Europe is approximately A$ 22 billion (Lindvall and Drielsma, 2006) and is likely to increase as new European mining projects currently under development are brought on-stream. The successful development of these projects will depend on the interpretation and implementation of new EU Derectives, Best Available Techniques (BAT) and numerous standards.

Of particular significance to the minerals industry, between 2001 and 2003, BAT for the management of waste rock and tailings were developed in accordance with European Commission procedures for producing BAT Reference documents (BREFs) for other sectors (European Commission, 2004). In addition, with effect from 1st May 2006, a new EU Directive (Council of the European Union (EU), 2006) on the management of waste from the extractive industries was published and formally called for European-wide standards for waste characterisation. These standards are now in preparation with the cooperation of the EU Member States and industry. The likely outcomes of the work will be a European Static-Test Standard for prediction of acid mine drainage, and a European Guideline on the characterisation of waste rock and tailings referring to existing standards "approved" for use in the EU. The impact on the mining industry of these documents particularly with respect to the introduction of new and emerging technologies in Europe is currently uncertain.

2 BACKGROUND

Tailings management in most European countries is regulated by national mining laws. Though, traditionally, mineral planning policies and mine and quarry permitting are controlled by Member States of the European Union, the growing number of EU-wide environmental regulations has increasingly impacted on national legislation. National mining codes have, in many cases, been revised to take into account such regulations with mining companies in some EU Member States having had the design standards for hazardous waste landfills imposed upon tailings management facilities.

Two major tailings spills (Aznalcóllar, Spain in 1998 and Baia Mare, Romania in 2000) resulted in increased European regulatory demands for environmental protection in the sector. Shortly after the accident at Baia Mare, the European Commission published a "Communication on the Safe Operation of Mines". The communication announced two significant new regulatory actions:

- The development of a BREF on the management of tailings and waste rock.
- The development of a European Directive on the management of waste from the extractive industries.

During the following two years the BREF was developed in accordance with the "Seville process", a legal procedure for defining BAT for industrial installations within the energy, smelting, cement, glass, chemicals and pulp and paper sectors of the EU. The final version of the BREF was published in July 2004.

The new Directive (Council of the European Union, 2006) on the management of wastes from the extractive industries was finally approved in April 2006 after extended negotiations. The legislative process culminated in the European Parliament choosing not to endorse the recommendations of its Environmental Committee and having to bargain with the Ministers responsible for mining in each of the EU Member States to ensure the adoption of the Directive before the deadline.

3 THE REFERENCE DOCUMENT ON BEST AVAILABLE TECHNIQUES (BAT) FOR MANAGEMENT OF TAILINGS AND WASTE ROCK IN MINING ACTIVITIES

The objective of the BREF is to contribute to the knowledge of measures available for the prevention of future accidents from tailings and waste rock disposal, and to provide technical support for regulators, permitters and developers. This document is intended to accompany the new EU Directive and, like the

BREFs for other industrial sectors, to be used to guide regulators and companies in developing and permitting their processes. All reference documents on BAT produced by the "Seville process" are legally recognised as being neither prescriptive nor exhaustive.

The BREF for the management of tailings and waste rock was produced by a small drafting group which relied on contributions from industry, Member States and Non-Government Organisations for a review of current practice and technology. The resulting document is therefore only as comprehensive as the range of data received. It presents quite a narrow view of the benefits and drawbacks of some technologies, and is therefore only applicable for use as background information when developing or permitting a mining project. The BREF is, however, an extensive text on mining and processing techniques as they relate to tailings and waste rock management, and is probably unique in its coverage. The document is therefore considered to be generally satisfactory in content by the European Commission, governmental experts, Non-Government Organisations and industry. It is widely considered to represent sound guidance on the range of techniques that may be considered to be good practice, and is a significant advance for all concerned in the industry.

However, it is recognised that technological developments in the mining industry are often implemented over a longer time scale than in other sectors, due to the high investments and the long life-span of the operations. Further, it is evident that new EU Member States (including Poland, Slovakia, Hungary, Romania and Bulgaria) are currently embarking on modernisation, closure and restructuring and will need more time to implement new technologies. So, despite some calls within the industry to improve the wording of the BREF through an early revision, any update is unlikely to take place for some time.

4 DIRECTIVE 2006/21/EC ON MANAGEMENT OF WASTES FROM THE EXTRACTIVE INDUSTRIES

The new Directive on the management of waste from the extractive industries establishes a stand-alone regulatory instrument for tailings and waste rock management, thereby separating the mining industry from the body of EU law which deals with domestic and industrial waste, municipal and hazardous waste landfills. The overall aim of the Directive is to prevent major accidents and minimise the risks associated with tailings and waste rock disposal. It requires mining companies to prevent or reduce effects on human health and the environment by compliance with the conditions of an operating permit and, specifically, through the preparation of waste management, emergency and closure plans. The Directive confirms the central role of the BREF document in that it requires planning, permitting and closure conditions for tailings management facilities to be based on BAT. Importantly, Member States are also required to ensure that responsible Ministries are informed of developments in BAT - recognition of the dynamic nature of the BAT concept in EU law.

The Directive, which was finally adopted on 11 April 2006, will have a major impact on the management of tailings since it links pre-development characterisation of the waste material with the requirements for financial guarantees, monitoring and reporting. In addition as of 1st May 2008, all new mines will be required to provide a financial guarantee "or equivalent" to cover rehabilitation of the land affected by the tailings management facility.

5 TECHNICAL GUIDANCE TO THE DIRECTIVE

During the final drafting of the Directive, a number of open questions regarding waste characterisation methods were identified. Accordingly, the Directive stipulates that the European Commission, assisted by a group of national experts from the EU Member States, is to provide technical guidance on outstanding issues by 1st May 2008.

One key area identified for such technical guidance is waste characterisation and the prediction of acid generation behaviour. At the suggestion of the European mining industry, a technical committee of the Centre for European Norms (CEN) has been established and the European Commission has granted it an official mandate to compile the necessary guidance. The CEN hosted an international workshop on acid generation behaviour in Brussels on 4th and 5th May 2006 to bring together the mining industry's experts on acid rock drainage (ARD) and to receive their views on future standardisation. The CEN is currently preparing the necessary guidance with the aid of regulators and industry. Whilst the resulting technical

standard will not be legally binding, it is likely that any future departure from the guidelines might result in significant delays in permitting and in additional operating costs for mining companies.

5.1 Outcomes of an International Workshop on Acid Generation Behaviour

5.1.1 Static Testing

Delegates of the international workshop concluded that it would be relatively straightforward to develop a new European Norm on static testing for acid base accounting. A number of standard procedures are available which can accommodate differences in mineralogy and legal context (e.g. waste management planning, operational control and compliance), and it was agreed that existing international procedures were appropriate for adoption in the guidance documentation.

5.1.2 Kinetic Testing

On the subject of kinetic testing for the prediction of acid generation potential, the ARD practitioners had the following key messages for the CEN:

- Kinetic testing can give valuable additional information even when static testing indicates a clear ARD potential.
- Due to variations in mineralogy, climate, practicalities, and the different nature of waste rock and tailings, it will be very difficult to develop one single European Norm for kinetic testing.
- Results from kinetic testing are qualitative rather than quantitative, but provide a better prediction of whether a specific waste will produce ARD and an indication of the timescale to onset of ARD.
- Kinetic testing cannot predict leachate quality, but gives a good indication of which metals may be of concern.
- The kinetics of acid-producing and buffering reactions within waste rock and tailings are not truly "intrinsic" properties of the waste material. The use of laboratory-scale parametric tests at the expense of common kinetic testing methods will therefore lead to incorrect predictions of acid generation behaviour.
- The potential replacement of internationally applied kinetic tests for the characterisation of waste rock and tailings by existing European column test norms will need to be clearly demonstrated.
- Good mineralogical information about the waste is essential to be able to choose the best procedure and to interpret the results correctly.

5.2 A European Static-Test Norm for Prediction of Acid Mine Drainage

Recognising that drawing conclusions from laboratory acid base accounting data (ABA) on acid generation behaviour in the field requires significant experience, the CEN is preparing to base the new European Norm on the modified ABA method of Lawrence and Wang (1997). The CEN recognises this to be an appropriate method because it takes into consideration the slower reaction time of some buffering minerals.

There remains some concern, however, about the reliability of the "fizz test" and the modification of the test to suit different waste materials. The fizz rating (an empirically-based method for gauging the most efficient amount of acid to add to lower the pH to between 2.0 and 2.5 prior to back-titration) can be confirmed by cross-checking the resulting Neutralisation Potential (NP). If the resulting NP is beyond the required range, the test needs to be repeated with a corrected fizz rating. Within the CEN, the empirical element of the fizz test is seen as being a weakness of the Lawrence and Wang method, with only limited faith being shown in the cross-checks that are possible as part of the procedure. The CEN is therefore recommending the use of total carbonate content analysis as an alternative to the fizz rating.

In summary, the new European Norm for static testing is likely to include:

- Calculation of acid generation potential (AP) from Total and/or Sulphide-Sulphur content.

- Acid Base Accounting using Lawrence and Wang (1996) with analysis of total carbonate content to estimate the amount of acid required to reach pH 2.0-2.5.
- Calculation of NP Ratio (NPR = NP/AP) and Net NP (NNP = NP-AP).

There are some open questions in this stepwise procedure, which the CEN is concentrating on resolving in time to meet the requirements of the European Commission.

5.3 A European Guideline on the Characterisation of Waste Rock and Tailings

The CEN will also develop a general guidance that is broad enough to describe the characterisation of both benign waste from aggregate quarries and potentially acid generating tailings with significant metal content. The guideline is planned to cover all significant aspects of predicting acid generation behaviour, including planning, interpretation and reporting, and will make reference to other relevant European Norms, publicly available guidelines and standards from other jurisdictions.

A draft list of topics to be covered by the guideline includes (Lindahl, 2006):

- Defining the objectives of a study.
- Information requirements (e.g. emphasising the need for a good mineralogical assessment).
- Planning.
- Sampling.
- Sample treatment.
- Static tests (with reference to the new European Norm under development).
- Interpretation of static test data.
- Kinetic tests (with reference to existing international guidelines and standards).
- Metal leaching.
- Description of different waste categories and management scenarios.
- Interpretation and conclusions.

6 IMPACTS ON PASTE TECHNOLOGY IN EUROPE

6.1 European Experience

Despite a lack of coverage in the BREF, paste technology has been under consideration at an increasing number of European mining sites over the past ten years. Though the applications remain principally related to the use of paste backfill in underground operations, there is also increasing interest in paste technology for surface disposal of tailings.

6.1.1 Backfill

The BREF includes a brief review of the advantages and disadvantages of paste filling underground, but provides no comment on the use of potentially acid generating tailings for backfilling. The document recognises paste backfilling as BAT where there is a need for competent backfill, the tailings are very fine and it is "desirable or costly to keep water out of the mine". Against this background, paste backfill is being extensively used at underground operations throughout Europe.

A paste backfill plant can provide an appropriate process for controlling the quality of the material used for the support of mining cavities, enabling maximised recovery of ore and at the same time minimising the need for imported material for backfilling. The industry in Europe has recognised the dual advantages of paste backfilling techniques of improving extraction ratios whilst reducing the need for surface disposal, thus meeting the principal rationale of the Directive, i.e. to reduce the risks arising from disposal of tailings. In

particular, the Irish lead zinc operations have adopted paste backfill systems for their shallow extraction operations. Though the Irish ore bodies contain significant sulphide minerals and have an acid generation potential, the resulting paste backfill and the limestone host rock have been shown to provide sufficient buffering capacity to mitigate any long-term environmental impacts arising from acid generation. At the same time the increased extraction ratios, coupled with lower implicit operating costs, have enabled the Irish mines to maintain their competitiveness. The technologies developed on these sites have been approved by both mining and environmental licensing authorities, and paste backfill has been accepted as an appropriate technology for underground extraction.

6.1.2 Surface Tailings Disposal

Paste technology for surface tailings disposal has also proved to be of increasing interest in Europe, following the recent incidents at Aznalcóllar and Baia Mare. One particular benefit linked to paste technology is that the total tailings can be used, without the need for the removal of the fines content. The residual quantity for deposition elsewhere is thus easier to manage, particularly with respect to the risk of dusting. The management of tailings in dewatered or thickened form also enables steeper angles compared with conventional hydraulic deposition on beaches, thus increasing storage capacity without the need to raise the impoundment structure. However, the BREF identifies that this results in the development of an unsaturated deposit, introducing the risk of oxygen inflow, oxidation of sulphides and the possible generation of ARD.

Though few projects in Europe are currently employing paste technology for surface disposal of tailings, a number of studies are in hand. The potential for improving both operating and closure costs at tailings management facilities by staged disposal and rehabilitation is being investigated at a number of sites. The adoption of paste disposal in some cases is recognised as having significant advantages for early rehabilitation and for reduced closure costs, though not necessarily for reduced capping requirements. The benefits of staged reclamation funded from operating revenue and not out of the closure fund is seen as possibly advantageous under the Directive as it could reduce requirements for financial guarantee in the early stages of mine-life to the benefit of both operating and developing mine projects in Europe.

The Aughinish aluminium refinery in southern Ireland has been using paste tailings deposition for a number of years. The technology has proved successful in terms of regulatory approval and achieving efficient disposal, and though there remain questions regarding rehabilitation, water control and peripheral stability the long-term prognosis is good.

6.2 Future Impacts

It is significant that the mining industry in Europe is now regulated separately from the body of EU law that deals with domestic and industrial waste, municipal and hazardous waste landfills. Under this body of law, co-disposal of non-hazardous and hazardous wastes (or of liquid and solid wastes) is prohibited, which has posed considerable difficulties for the implementation of mining best-practice over the past decade. There is no such prohibition within the new Directive, and the BREF allows the necessary pragmatic, case-by-case approach based on achieving a satisfactory environmental outcome.

6.2.1 Application of the BREF

One major challenge facing the European mining industry is the permitting of new and emerging technologies (Cambridge, 2003). Though thickened tailings can hardly be considered new technology, the use of paste techniques is so defined in the BREF. The BREF reviewed paste technology in brief detail only, providing a single page on paste backfill and some two pages on surface tailings disposal. The limited coverage of this technology has the potential to restrict its application in Europe, not because it is inappropriate, but as a result of an overly restrictive interpretation of the BREF.

The BREF states that paste techniques are not applicable where the waste contains less than 15% <20μm or if the tailings have an acid generating potential. However, the latter statement contains a caveat that “the case for thickened tailings inhibiting oxidation has yet to be proved on an industrial scale”. Of particular concern is the interpretation in the BREF, which appears to conclude that paste technology is not appropriate for tailings with an acid generation potential and that saturation is the only secure method of disposal. This

contrasts with the lack of any comment on whether paste backfilling of acid-generating tailings is appropriate.

Since July 2004, various EU authorities have interpreted the BREF prescriptively and without consideration of the safety or environmental consequences. Therefore, despite the potential benefits, as evidenced by research currently being undertaken at a number of pilot scale trials throughout the EU, e.g. at Neves Corvo in Portugal (Verburg et al., 2006), the strict adherence to the BREF wording for potentially acid-generating tailings is seen as a significant hurdle to the permitting of future surface disposal of tailings as paste.

To fully understand the EU regulatory context, one should recognise the tension that is developing between the industry's attempts to build on research into paste technology and implement new technologies on the one hand; and in some cases the EU Member State authorities' inability to immediately follow suit (in the context of current privatisation, closure and restructuring efforts) on the other. The BREF represents a snapshot of BAT, which necessarily lags behind the industry's innovative project plans and this could lead to lengthy permitting and regulatory negotiations between updates of the BREF.

6.2.2 Application of the new Directive

The new Directive requires financial guarantees to ensure that all obligations defined in the waste management permit are fulfilled, particularly those relating to closure and post-closure of the waste facility. The need to adapt the financial guarantees to the size of the disposal/tailings facility represents an economic incentive to keep the footprint of the storage area to a minimum by increasing the efficiency of disposal and by undertaking staged rehabilitation during operation wherever possible. Large financial guarantees impose significant pre-start-up investment burdens which may mitigate the adoption of more expensive technology options in Europe unless authorities are convinced of the long term environmental benefits.

This has important implications for the cost/benefit considerations related to the implementation of new technologies in Europe. Under the Directive, continued mining operation or project development in Europe will incur higher capital investment during mine life, reducing available funding for further innovations, as well as for exploration, extension and development. Changes to the financial guarantee instruments in a number of Member States have already caused some operators to sell their existing mines in favour of other investment opportunities outside the EU. For the less profitable and new mine projects there may be a significant disincentive to continued operating.

6.2.3 Application of the new technical guidance

The development of the technical guidance to the new Directive will provide authorities within the EU Member States with a clearer definition of "acid generating potential" and it is hoped that the improved understanding will ease negotiations between developers and local authorities. The risk remains that some authorities will feel more comfortable using the technical guidance as a rigid classification of wastes and will limit those for which new and emerging technologies can be applied. The CEN is fundamental to this process and will continue to work on the general guideline during 2007. During this period of development the industry would be well advised to follow progress closely and to provide input where appropriate.

CONCLUSIONS

Paste technology has been adopted by the European mining industry and, despite some teething problems, the potential long-term benefits have now proven to be significant for backfilling underground. Though a number of projects are currently employing surface paste disposal technologies, their implementation pre-dates the final version of the BREF, the finalisation of the new Directive and the development of its technical guidance.

The permitting of surface paste disposal in Europe currently has a significant hurdle to overcome as the wording of the BREF is being interpreted prescriptively by a number of EU Member States. The mining industry needs to continue to undertake pilot trials and associated monitoring to develop the case for paste disposal, such that when the BREF is next updated the text can be modified to include a more elaborate description of the benefits of this technology as an alternative.

If the European mining industry is to remain competitive, technologies will have to be adopted to facilitate tailings management that secures the best possible environmental protection and reduces long-term risk in an economic manner. The adoption of some new technologies will result in sustainable long-term environmental gain and should thus encourage Member States to make realistic assessments of financial guarantees which encourage new mineral investments.

However, if the technical guidance to the Directive is used as a rigid classification of waste it may establish further disincentives to the application of emerging technologies, such as paste disposal of tailings.

The impact of the new regulatory framework is likely to extend beyond the borders of the EU, due to Europe's ambition to demonstrate "global environmental leadership" and the financial community's willingness to adopt similar requirements themselves. Strong links between the European Centre for Norms (CEN) and the International Standards Organisation (ISO) are likely to be the vehicle by which new European requirements impact the industry globally.

REFERENCES

Cambridge, M. (2003) The Future of Tailings Disposal in Europe, Minerals and Energy, Vol. 8, No.4, 2003.

Council of the European Union (2006) Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from the extractive industries and amending Directive 2004/35/EC : OJ L 102/06, April 11, 2006.

European Commission (2004) Reference Document on Best Available Techniques for Management of Tailings and Waste rock in Mining Activities, Seville.

European Commission (2006) EU Non-Energy Extractive Industry — Sustainable Development Indicators 2001-2003, Luxembourg: Office for Official Publications of the European Communities, ISBN 92-79-00380-1.

Lawrence, R.W. and Wang, Y. (1997) Determination of Neutralization Potential in the Prediction of Acid Rock Drainage. Proc. 4th International Conference on Acid Rock Drainage, Vancouver, BC, pp. 449-464.

Lindahl, L-Å. (2006) Discussion paper presented to the Centre for European Norms, Technical Committee 292, Working Group 8 on the characterisation of wastes from the extractive industry, Paris, October 2006.

Lindvall, M. and Drielsma, J. (2006) Tailings Management in Europe – An Industry Perspective. 9th International Seminar on Paste and Thickened Tailings, Australian Centre for Geomechanics, Limerick, April 2006, pp. 81-91.

Verburg, R., Ross, C., Dillon, M., Newman, P. and Fordham, M. (2006) Surface Paste Disposal of High Sulfide Tailings – Geochemical and Geotechnical testing: 9th International Seminar on Paste and Thickened Tailings, Australian Centre for Geomechanics, Limerick, April 2006, pp. 131-145.