

## CALENDAR

- **National Western Mining Conference and Exhibition**  
February 7–9, 2006  
Grand Hyatt  
Denver, Colorado  
e-mail: colomine@coloradomining.org
  
- **INDABA 2006: Investing in African Mining Conference**  
February 7–9, 2006  
International Convention Centre,  
Convention Square  
Cape Town, South Africa  
e-mail: iiconf@iiconf.com
  
- **PDAC 2006**  
March 5–8, 2006  
Metro Toronto Convention Centre,  
North Building  
Toronto, Canada  
e-mail: lmcaldonald@pdac.ca  
Visit us at Booth 312
  
- **2006 SME Annual Meeting & Exhibit**  
March 27–29, 2006  
America's Center  
St. Louis, Missouri  
e-mail: sme@smenet.org  
Visit us at Booth 413
  
- **Asia Mining Congress 2006**  
March 27–31, 2006  
Grand Hyatt  
Singapore  
www.terrapinn.com/2006/asiamining
  
- **MiningWorld Russia 2006**  
April 25–28, 2006  
Crocus Expo - International  
Exhibition Centre  
Moscow, Russia  
e-mail: miningexplo@primexplor.ru

## Hang 'em Out to Dry

*We're going to hang out the washing on the Siegfried Line.*

This opening line from a World War I song strikes a cord with us at PAH. We like things dry, especially when it comes to geological, mining, and ore processing data. Well, maybe not in the metaphorical sense, but certainly in the literal sense.

Like the washing, which even though it has been on the line a while, is sometimes damp, we at PAH are required to process figures that vary in moisture content. While we generally prefer them dry, we are obliged to follow industry practice, and parts of the mining industry differ from others; some report wet, some mix both wet and dry, and in some there is no consistent practice. What is reported on wet- or dry-weight bases is often obscure and confusing.

### Wet-Weight and Dry-Weight Tonnages

We occasionally find ourselves confounded by the treatment of moisture content in relation to the weight of ore, waste, product, and tailings used by mining operations, consultants, and engineering groups. It is especially likely to be a problem in mines where the product is a major constituent of the ore, which includes iron, bauxite, coal, and most non-metallic products; in many of these mines dry-weight tonnages are seldom used.

At this point it is worth clarifying that moisture is usually defined by the loss of weight that occurs when the sample is dried at 105 °C for several hours. This temperature, slightly above the boiling point of water, is sufficient to drive off

superficial or absorbed water, without removing essential water of crystallization. It should not be confused with loss on ignition (LOI) which is conducted at much higher temperature and results in the loss of water of crystallization of hydrous materials such as clays, micas, and many oxide/hydroxide minerals. Heating to high temperatures (several hundred °C) may result in significant changes in mineralogy.

### Moisture Reporting Basis

In some instances, it is unclear whether the reported percentage moistures are on the basis of the wet weight or on the basis of the dry weight. This needs explanation; here is what they mean:



**Wet-basis moisture** is the moisture as a percentage of the combined dry material and the associated moisture.

**Dry-basis moisture** is the moisture as a percentage of the dry weight.



Illustrating this by example, suppose the wet and dry weights of a sample of rock are 150 grams and 100 grams respectively. The moistures can be reported as follows:

**Wet-basis moisture:** 33 percent (50 grams of water in 150 grams of wet rock)

**Dry-basis moisture:** 50 percent (50 grams of water in 100 grams of dry rock)

Both means of expression are acceptable, but wet-basis moisture is more commonly used in mining. In any case, the basis must be understood prior to undertaking any calculations using the moisture content.

Where the term *wet-weight tonnage* is used in this article it refers to the wet weight, i.e., the weight of the combination of dry material and associated moisture; as such, it is independent of the method of reporting the moisture content. However, determining the wet weight requires knowing and understanding how the moisture content is reported.

Where the term *dry-weight tonnage* is used in this article it refers to the dry weight, i.e., the weight of the dry fraction of the material. Though some products may be partially dried prior to shipping and sometimes referred to as 'dry' even though they contain some moisture, the phrase *dry-weight tonnage* used in this article refers to fully dried material (i.e., material with no remaining moisture at 105 °C).

## Metal/Product Content Reporting

The metal or product analysis of a material can be reported as a percentage of the dry weight or of the wet weight. Usually, if the quantity of material is given as dry-weight tonnage, the metal or product analysis is reported as a function of the dry weight; and if the quantity of material is given as wet-weight tonnage, the metal or product analysis of the material is reported as a function of the wet weight.

However, there are some instances when quantities are reported as wet-weight tonnages and the metal or product analyses are given on a dry-weight basis.

## Ore, Waste, and Products

In some mines, the moisture content of the ore and waste is significantly

different and it is sometimes unclear whether the quantities are wet-weight tonnages or dry-weight tonnages.

Sometimes one material is measured on one basis and others on another. PAH recently encountered a project where the ore quantities were given as dry-weight tonnages and the waste quantities as wet-weight tonnages. In this instance the moisture content of the ore was about 8 percent and the moisture content of the waste was about 35 percent, so presenting the weight of waste as wet-weight tonnage made sense in that it gave a better measure of the mining requirements of the waste. The critical matter in understanding these figures is that the quantity basis be clearly and frequently stated, particularly where different bases are used for different materials.

In addition to reserve and production quantities, in-situ densities and strip ratios can also be confusing when different materials are stated on different bases.

## Reserves, Production, and Planning

Further confusion occurs when different bases are used for reserves, production reporting, and mine planning. Sometimes the base of quantity reporting changes over the life of the property, adding further confusion.

## Product

Although base and precious metal mines nearly always report quantities as dry-weight tonnages, flotation concentrate quantities are usually stated in both dry-weight and wet-weight tonnages. Dry-weight tonnage is used for production reporting in order to allow metallurgical balance calculations in the plant and the wet-weight tonnage is used for shipping.

For bulk products which include minimal processing, it is usually the practice to report the reserve quantities as wet-weight tonnages basis at a moisture content common for the

product, a moisture content that may be different from the in-situ moisture or the actual moisture of shipped product from that specific mine.

Some mines, particularly non-metallic operations, can have the same product in different physical form that may have different moisture contents, e.g., kaolin can be in the form of dry powder, dry pellets, and slurry, yet for reserves, production reporting, or planning, may use some fixed moisture content, usually that of the principal product.

## Possibilities for Confusion

Summarizing the possibilities of confusion we can have differences in the following areas, in both quantities and in analyses of metal or product of the materials.

- ◆ Reserves
  - Ore (*possibly several types, such as oxide vs. sulfide, upgradable vs. direct-to-plant, etc.*)
  - Waste
  - In-situ densities
  - Strip ratio
- ◆ Mine production
  - Ore
  - Stockpiled low-grade
  - Waste
- ◆ Mine Inventories
  - Ore stockpiles
  - Waste dumps
- ◆ Plant production
  - Ore
  - Leach heaps
  - Concentrate/product
  - Tailings
- ◆ Plant Inventories
  - Crushed ore stockpiles
  - Concentrate/product stockpiles

These items can be reported in the following forms:

**Dry-weight tonnage** (in some industries referred to as 'moisture-free')

**Wet-weight tonnage**  
Actual

Some standard (fixed) moisture content

## Common Industry Practice

### Base and Precious Metals

- ◆ Everything is usually reported on dry-weight tonnages, including in-situ densities and strip ratios. The strip ratio is usually expressed as waste tonnage to ore tonnage.
- ◆ Moisture content of the ore usually ranges from 3 to 6 percent and the moisture content of the waste is about the same as the ore.
- ◆ Metal content is reported on dry-weight basis.
- ◆ Concentrate quantities are usually stated as both dry-weight and wet-weight tonnages.

### Coal

- ◆ Everything is usually reported as wet-weight tonnage or basis, including in-situ densities. Waste is normally reported on a volume basis; accordingly, strip ratios are reported as volume per wet-weight tonnage of coal.
- ◆ Coal moisture content commonly ranges from 1.5 to 30 percent; lignite may contain as much as 40 percent moisture.
- ◆ Reserve quantities are normally stated in terms of wet-weight tonnages of product; accordingly, if a mine produces both raw and processed coal, the reserves are stated in terms of the combined product. In some cases, particularly western U.S. coal, the product is direct shipped without any intermediate processing. Sometimes the product is all processed, as is the case for much eastern U.S. coal; sometimes part is shipped raw and part is processed. The moisture content of raw and processed material is usually different, with the latter usually having about one

percent higher moisture.

- ◆ While product quantity is usually reported as wet-weight tonnage and the analyses of valuable constituents and contaminants normally as a percentage of the wet weight, there are some other terms and bases used, the principal of which are as follows:
  - As received (same as wet-weight basis)
  - Air-dried (though it might contain as much as 30 percent moisture)
  - Moisture-free (principally applied to metallurgical [coking] coal)
  - Ash-free/moisture-free (AFMF) (sometimes used by utilities)

### Bauxite

- ◆ The reporting for bauxite is not consistent. For some mines everything is reported on a dry basis and others on a wet basis.
- ◆ Where reporting is on a wet basis, in-situ densities are also reported on a wet basis. The waste, in such instances, is normally reported on a volume basis; accordingly, strip ratios are reported as volume per wet-weight tonnage of bauxite.
- ◆ In-situ bauxite moisture content commonly ranges from 10 to 15 percent. The moisture content of processed bauxite material is usually about two percent higher than that of the in-situ material.
- ◆ Reserve quantities can be stated as either dry-weight or wet-weight tonnages. In the latter case, they are normally stated in terms of wet-basis tonnage of product at the moisture content of the processed (washed) product.
- ◆ Some bauxite is dried prior to shipping. Dried material will typically have moisture content of about 5 percent. Reserves, however, where they are stated as wet-weight tonnages are normally stated in terms of wet, washed, un-dried product.

- ◆ Analyses are usually reported on a dry-weight basis, which is sometimes referred to as 'moisture-free' bases.

### Iron Ore

- ◆ Like bauxite, reporting for iron ore is also inconsistent. Again, where reporting is on a wet-weight basis, in-place densities and strip ratios are also reported on a wet-weight basis.
- ◆ In-situ moisture content of the ore is generally in the range of 2 to 8 percent.
- ◆ Reserve quantities can be stated as either dry-weight or wet-weight tonnages, usually in terms of the weight of in-situ unprocessed ore, which is the same as the product where the ore is shipped directly.
- ◆ Analyses can be on either a dry-weight or wet-weight basis.
- ◆ The product can occur in a variety of forms, the principal of which are listed below:
  - Lump
  - Fines
  - Pellets
- ◆ Sometimes the phrase 'natural basis' is used to indicate wet-weight basis.
- ◆ With iron mines primarily direct shipping product it is understandable that wet-weight basis quantities are commonly used. However, iron-ore processing plants producing pellets or other intermediate products usually report quantities as dry-weight tonnages and, in addition, the analyses for both feedstock and product. PAH recently encountered a situation where a misunderstanding occurred between a mine and a planned pelletizing plant, the mine agreeing to supply a certain quantity of iron ore believing it was on a wet-weight tonnage and the pelletizing plant believing it was on a dry-weight tonnage.

## **Kaolin**

- ◆ The reporting basis for kaolin varies from mine to mine and also even within the operations.
- ◆ In-situ moisture content of the material is generally about 20 percent.
- ◆ Reserve quantities are normally stated on dry-weight-basis weights, usually in terms of the weight of in-situ unprocessed material. Analyses are usually stated in terms of the brightness and grit content of processed (degritted and bleached) material even though related quantity figures may be unprocessed.
- ◆ While kaolin reserves are usually stated on an in-situ dry-weight basis, mining is often reported on a volumetric basis and sometimes on a wet-weight basis at the moisture content of the material; plant operations are reported either on a dry-weight basis or on a wet-weight basis at a fixed moisture content of the principal product.
- ◆ The product can occur in a variety of forms, the principal of which are listed below:
  - Extruded pellets (about 6% moisture)
  - Powder (about 6% moisture)
  - Slurry (about 28% moisture)

## **Potash**

- ◆ Potash reserves are normally stated in terms of wet tonnes of ore,

though 'wet' in the context of potash ore is minimal since potash typically only contains about 1.5 percent moisture. Analyses are normally presented on a dry-weight basis. Neither wet-weight basis nor dry-weight basis is normally stated for potash, perhaps since it makes little difference to the figures and the range of accuracy of reserve figures is much higher than inclusion or exclusion of moisture.

- ◆ Potash product is even drier than the ore, usually containing less than 0.5 percent moisture. As for reserves product quantities and analyses do not specify wet-basis or dry-basis, and again, it is essentially irrelevant, in this case since the product is very close to being totally dry.
- ◆ Figures for other evaporites, such as salt and soda ash, are similarly stated.

## **Mineral Sands**

- ◆ For mineral sands, the reserves are usually reported as dry-weight tonnages, and in-situ densities are also on a dry-weight basis. For most heavy mineral sands stripping is minimal and the strip ratio is usually expressed in terms of volume per dry-weight tonnage of ore.
- ◆ Mineral sand moisture content can vary seasonally, and is generally in the range of 4 to 18 percent.
- ◆ Metal content of the ore is reported on a dry-weight basis.

- ◆ Products are normally stated as dry-weight tonnages, together with dry-weight basis analyses.

## **CONCLUSION**

To avoid confusion, PAH recommends that where values are given in any other form than dry-weight basis, the basis should be specified, together with the actual or approximate moisture content and, where the basis includes processing of any kind, this should also be stated. Where quantities and analyses are given on differing bases, then the bases for both quantities and analyses should be stated. An example of such a value is shown below for a lateritic nickel ore plant feed stream:

Quantity: 1,000,000 wet tonnes of screened product at 30% moisture content

Analysis: 2.0 percent nickel in dry, screened product

In tables, the specification of units can become laborious and repetitive. In such instance footnotes can help keep table headings from becoming too cluttered.

Without clearly specifying the basis of reported figures, who knows what they mean? Perhaps Bob Dylan said it best:

*The answer, my friend, is blowing in the wind.*

This month's article was provided by Richard Addison, P.E., Principal Process Engineer, a laundry expert, and aficionado of obscure ballads, dry wines, and moist cake. dick.addison@pincock.com



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