

Alternative tailing disposal - fact and fiction

Andrew Watson notes that despite technological advances in mineral processing, mining companies still face challenges in how to best manage tailing materials. He aims to help readers separate fact from fiction and provides high-level guidance on when to use individual technologies

Alternative Tailing Disposal (ATD) has been viewed as the 'silver bullet' that will address all tailing management issues, especially water issues. Yet misconceptions abound. The various tailing disposal types are defined as follows:

Filtered tailing disposal: Tailing materials are dewatered to a >85% solids by weight (defined as weight of solids divided by weight of solids plus weight of water) using filters aided by a vacuum or confining pressure. The materials are transported by conveyor or trucked to deposal areas where they are handled by earthmoving equipment.

Paste disposal: Produced in specialised paste thickeners, or ultra-high-density thickeners and transported by positive displacement pumps, paste is best used for backfill in underground workings, where transport and placement is aided by gravity. Paste is generally discharged with 70-85% solids by weight.

Thickened tailing disposal: Tailing materials are 'thickened' through the use of high-density or deep-cone thickeners to about 65-72% solids by weight. This creates a structurally stable tailing that can be deposited at an impoundment site with little segregation and releases very small amounts of reclaim water.

Conventional tailing disposal: Tailing materials are dewatered in conventional thickeners to about 30-55% by weight and transported as a slurry to the repository. Tailing particles typically segregate during deposition and the deposits release significant amounts of water for recovery in reclaim water ponds. Conventional disposal involves the use of dams, embankments or surface impoundments and may use either cycloning or spigoting for deposition.

ATD: a silver bullet?

Mining ever lower grades of ore has resulted in increased water use per unit of production; in some cases availability of water is one of the greatest constraints on mine development. By optimising water recovery, ATD technologies promise to reduce water use at mines. ATD



Aerial view of the original Balen TSF in Belgium (see box)

technologies also promise a smaller footprint, reduced environmental impact and risks.

So why isn't everyone doing it? Despite the advantages, there are a number of factors that determine whether an ATD technology is suitable. Some of the factors that limit the use of ATD technologies include:

- **Energy supply:** ATD methods use more energy than conventional disposal methods, and thus require an inexpensive energy supply to dewater and transport the filtered, thickened or paste tailing materials
- **Climate:** although ATD methods have been implemented in wet climates, their successful implementation is aided by a dry climate
- **Production rates:** filtered and paste technologies are unproven at mines with moderate to high production rates. Thickened technologies are sometimes used at mines with moderate production rates. Conventional tailing deposition is the only proven technology at mines with high production rates
- **Project economics:**

mining companies must weigh carefully the tradeoffs that come with using an ATD method—reduced footprint and less water used come at the expense of higher operational costs. Many mines cannot support the extra costs

- **Operational predictability:** maintaining uniform deposition slopes on paste and thickened deposal facilities has proven to be a challenge because of changes in ore characteristics, tailing gradations and percent solids. For the filtered technology, co-ordination of the material handling, spreading and compaction with a high



Tailing materials at Balen are handled by earthmoving equipment after deposition

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production rate are not simple tasks

- **Topography:** some ATD technologies lend themselves toward flat topographies and are usually not feasible at sites with even moderately steep terrain. Filtered tailing disposal is possible in a variety of terrains, accounting for stability, operational and closure requirements
- **Seismicity:** concerns about dynamic stability of slopes constructed with ATD technologies may negate many of the perceived benefits
- **Water:** the filtered technology saves significant amounts of water and paste technology saves water, although not as

much. Water saved by thickened deposition is only marginally better than conventional disposal.

Filtered tailing disposal

The advantages of filtered tailing disposal are most apparent for sites in arid, highly seismic or cold regions, or where space is limited. Although generally more expensive per tonne of tailing than conventional disposal, filtering costs can be offset by improved storage efficiency and a smaller environmental footprint. The costs of moving tailing materials to the impoundment, are generally higher than

conventional slurry transport. Being unsaturated, stacks are susceptible to oxidation. In addition, although overall water losses are minor, provisions must still be made for controlling seepage to the ground water. Although dust generation is an issue for most filtered tailing facilities, it can be managed by operating on small areas at a time. Site specific testing and analyses are required to characterise the dynamic performance and specific requirements for 'dry stacks'.

Recommended for use: at mines with severe lack of water, where space is limited, or where meeting environmental regulations

Filtered tailing solutions in action

MWH, a global environmental engineering consultancy, has two successful filtered tailing disposal projects that show the advantages of this technology—also known as mechanical dewatering—for tailing and sediment disposal. Both projects optimise storage space and conserve water while decreasing potential environmental impacts.



The Balen TSF today

At the Balen zinc processing facility in northwest Belgium, tailing materials were stored in a 30 ha tailing storage facility (TSF) which was nearing its capacity. By investigating ways to lengthen the lifetime of the existing TSF and through the conceptual and detailed design of a filtered tailing process, MWH was able to increase the tailing pond lifetime from six-and-a-half to 22 years, while dramatically reducing the environmental impacts and safety risks at the site.

The dewatering plant, which has been operating since 2007, uses a series of horizontal, membrane filter presses. The filtering process results in a dewatered tailing material with a 65% solid content (35% water content) which has geotechnical characteristics that allow it to be stockpiled and compacted. Compaction helps minimise environmental risks due to the low permeability of the compacted material ($k < 10^{-9}$ m/s).

Disposal of sediments at ports and rivers are analogous to the tailing disposal issues faced by miners. For cargo gateways to remain navigable and safe for large vessels, the Port of Antwerp must regularly dredge and dispose of harbor sediments. At this site, MWH designed and is currently overseeing the construction of a large scale sediment dewatering plant. Scheduled for completion in October 2010, the plant

will treat 2.6 million m³ of sediments annually. The disposal facility will have a smaller footprint than the lagoons that are currently used, providing much needed relief to the lack of space at the port.

The process is as follows: the port's sediments will be dredged so that contaminated sediments are pumped ashore to control environmental risks. Sand will be separated and stockpiled for re-use.

After thickening and conditioning, the remaining sediments will be mechanically dewatered in membrane chamber filter presses, until a 65% solid content (35% water content) is achieved. Twelve chamber filter presses will be used to dewater the sediments; the resulting filter cakes will be transported via conveyor belts to a nearby storage facility. The filtrate will be treated to remove heavy metals, organics and nitrogen so it is suitable for re-use.



A series of filter presses dewater the tailing materials

The filter cakes will be placed in an existing sediment pond containing hydraulically placed dredged sediments. In order to prevent the filter cake material from displacing the dredged sediments, they will be placed in thin layers over a separation geotextile. Vertical drains will be installed in the underlying silt prior to sealing these layers to accelerate the consolidation process and to provide more stability and safety during construction.

Processing details for both the Balen and the Port of Antwerp projects can be viewed in a short (10 minute) video, www.mwhglobal.com/MWHglobal/tailing_video.html

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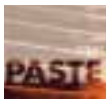
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Dewatered tailing materials from Balen are trucked to disposal areas



through the use of a conventional tailing disposal is difficult. Other important considerations are small to moderate production rates and inexpensive energy supply.

See the box for detailed information on two projects that demonstrate the successful use of the filtered tailing process.

Paste disposal

Paste disposal has been successfully used as underground backfill for many years. Surface

paste disposal is relatively new and its application is limited. Due to the high percent solids of the paste and high viscosity, the paste flows follow the 'plug flow' concept. This requires the materials to have a minimum of 15% particles smaller than 2 micron. Producing and transporting paste is relatively expensive due to the high capital and operating cost of paste thickeners and pumps.

Recommended for use: at mines with low production rates with water and space constraints as well as inexpensive energy. Paste is best used to backfill underground workings. It is not recommended for moderate to high production mines or with coarse tailing materials.

Thickened tailing disposal

The main advantage of the thickened disposal is the requirement for a smaller, if any

embankment. This advantage can only be achieved if the topography is flat. When the slope of the natural terrain is steeper than the deposition angle, the advantages of thickened disposal over conventional deposition disappear rapidly. High-density thickened tailing materials do not segregate and the beach slope remains fairly uniform. High solids content can form a larger angle of inclination because of the increased shear yield stress. However, success in achieving slope angles of greater than 2 to 3% has been limited.

In addition to higher costs associated with transporting the thickened tailing, more frequent clearing of

delivery pipelines may be required, as well as precise control of deposition layer thickness. For this technology to be effective, operators must maximise air drying and consolidation. The stability of the deposits under seismic loading conditions must be evaluated to be certain that the thickened deposits are not susceptible to liquefaction. Water savings compared to conventional tailing disposal are relatively small.

Recommended for use: at mines with small to moderate production rates where disposal areas are spacious and almost flat. This method can also be suitable for areas with weak foundation materials, which preclude the development of an embankment. Thickened disposal may not be feasible in areas with heavy precipitation, low temperatures and little sun to enhance evaporation.

The conventional approach

Conventional tailing disposal is widely used and remains one of the least expensive methods of disposal. It uses dams and embankments to form Tailing Storage Facilities (TSF) where the tailing can settle from suspension to a deposit that is stable. Selection of the embankment type must be based on the specific characteristics of each mine, mill, tailing grind, climate, seismicity and topography and other factors. Conventional storage falls short in the face of space constraints. Some facilities that use cyclone tailing sand to construct the tailing embankment have been found to consume less water than thickened deposits. Environmental concerns regarding impacts to groundwater must be carefully addressed.

Recommended for use: at any production rate, but in particular at high production mines where the mine's topography lends itself to storage of the tailing in surface impoundments. Environmental concerns related to TSFs can be minimised by favourable site geologic conditions and engineered controls or by lining the impoundment.

In summary, of the various tailing disposal methods, conventional tailing disposal through surface impoundments remains common and inexpensive. ATD methods promise to conserve water, minimise space requirements and reduce environmental impacts, but these promises must be analysed in detail before deciding on a specific ATD method. While the industry has seen some success, the use of ATD methods at high production mines remains unproven. It is important to separate fact from fiction when selecting tailing disposal methods: the 'silver bullet' has yet to be found! **IM**

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