

Design intent to reality — commissioning of the Aguas Tenidas paste backfill plant, Spain

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Abstract

The Aguas Teñidas mine is located in the Huelva Province, Southern Spain, having been recommissioned by Minas de Aguas Teñidas SA (MATSA) in 2008 following a period of care and maintenance. The mine entered a period of pre-commercial commissioning production from late 2008 with full production achieved by the 4th quarter 2009. The adoption of paste backfill is a critical component of the mining operation and of the integrated approach to mine waste management adopted by MATSA (del Pozo, 2008).

Engineering of the paste backfill plant and underground distribution system (UDS) commenced in April 2007 with the undertaking of a basic engineering design by Golder Paste Technology Ltd. (Golder PasteTec), the scope of which involved the laboratory testing, development of the design intent, operating philosophy, equipment selection and plant layout. From this work, the detailed engineering and construction of the plant was by others and was ostensibly completed in May 2009 when commissioning began. The first trial stope pour was completed in July with full production underway by October 2009.

Significantly, the design, construction and commissioning support retained by MATSA was not continuous throughout the project with different engineering firms responsible for key aspects of the engineering and execution program. Since Golder PasteTec ‘bookended’ the project (early engineering and then commissioning) it is aware of the subtle differences from initial design intent set out at basic engineering, and the reality of that constructed, and this will be discussed in the paper.



Figure 1 Aguas Tenidas paste backfill plant, Spain

system (UDS) could be employed to the majority of stopes. At the paste backfill plant the thickened tailings are received in an agitated tank before transferring to vacuum disk filters. The filter cake from the filters then transfers via conveyor to an oversized continuous mixer. Previous Golder PasteTec material testing indicated a relatively low sensitivity of the tailings to water addition when prepared at a paste like consistency. As a result, Golder PasteTec considered continuous mixing to be a viable solution, however elected to oversize the mixer to increase the retention time and hence mixing duration. The adoption of continuous mixing was considered favourable with respect to capital outlay, reducing mechanical equipment (mixer and hoppers) and infrastructure.

MATSA also requested that the design accommodate the potential introduction of aggregate to the backfill. Again, Golder PasteTec material testing indicated substantial binder economies could be realised through the addition of aggregate, notably a slag aggregate from a nearby smelter. The design considered the introduction of the aggregate from drive over bins located adjacent to the plant. Aggregate would be fed into the plant via conveyor and discharged onto the filter cake conveyor. Weigh belt scales before and after the aggregate addition would record the differential feed weights enabling accurate dosing of the backfill constituent products in real time, thereby avoiding the batch process.

Binder addition follows a similar approach to the aggregate addition, with binder dosed via a weigh conveyor onto the filter cake conveyor. During mixing, the design considered the addition of a small amount of process water to enable final slump control. Water addition is again controlled in real time, with the mixer power draw monitored and calibrated to provide a measure of the material consistency within the mixer and hence the slump of the material. Overall, the mixer aims to prepare a slump within a 6 mm consistency tolerance.

From the mixer, the paste overflows into a gob hopper, which stores the backfill temporarily as it is sucked into one of two boreholes feeding the UDS. The gob hopper operation is critical to the reliability of the UDS as it acts to prevent the ingress of air into the system, which is designed to operate under vacuum. As such, the PLC controls the discharge valve in relation to the weights read by the load cells on the gob hopper to prevent the level of paste from falling to a low level whereby air may enter the system. An automated isolation valve at the top of the borehole will close should the gob hopper level fall below a critical level.

The UDS is designed using a cascade approach of inter-level boreholes and level piping. The system operates such that following initial start up the pipeline remains ostensibly full, thus preventing the free fall of material within boreholes, which can lead to excess hammer and elbow wear. The UDS design encompasses additional piping loops on key levels, which can be employed to increase the horizontal pipeline length when necessary to ensure the full line operating condition. A schematic of the UDS system is presented in Figure 3 below.

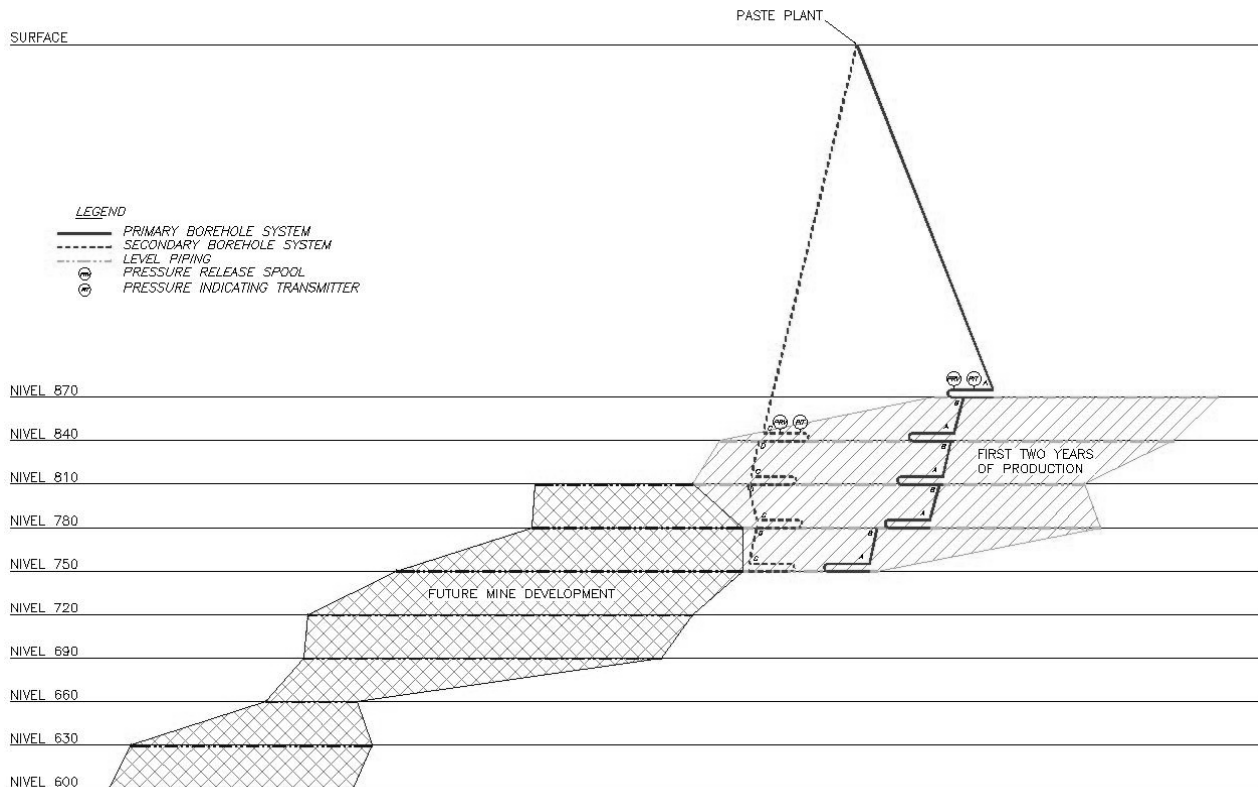


Figure 3 Schematic layout of the UDS System

3 Commissioning

Following construction, Golder PasteTec returned to the mine to support the commissioning programme, and the following sections describe the observations and modifications recommended during this work.

3.1 General

In general, the heart of the paste backfill process was constructed following the original Golder PasteTec Basic Engineering in that a continuous production system, based on vacuum disc filtration and gravity delivery underground is in place. Some modifications and substitutions to the equipment, process and layout had been made during detailed engineering and construction.

The size of the plant footprint had increased substantially from the Basic Engineering and there is plenty of room within the plant. This was in part due to future considerations for a paste pump, hydraulic unit and potential aggregate addition system, neither of which was developed.

The tailings thickening plant had been operating for four months prior to backfill commissioning and underflow densities of 75 wt% had been reported. The consistency of the underflow density had been fluctuating since the automation process had not been fully operational. Once commissioned, the thickening process should provide a steady underflow density. The mill has on occasion run Cu or Zn ore separately, which had also influenced the thickener performance.

It should be noted that having a true paste consistency from the deep bed thickener is critical to the tailings feed stream reaching the plant and ensuring reliable production of high quality fill.

3.2 Plant layout

During detailed design, the control room had been relocated to the top floor, overlooking the filters. In Golder PasteTec's experience the control room should typically place the operator near the mixer and final paste hopper to allow quick access for visibly inspecting the paste, collecting samples and for immediate

borehole flushing. Although the filters do require attention, much of the operator's time should be spent around the paste mixing and discharge operations. On that note, access around the plant and between the process circuits had become somewhat limited and additional stair towers and walkways were added to join the cement tower and slurry tanks with the rest of the plant.

The disc filter floor and the conveyor floor had been constructed of steel grating. Golder PasteTec typically uses a concrete slab (with curbs) on the disc filter floor to keep the wash down within the upper floor. As a minimum, the conveyor floor should be concrete to contain the spillage from the filter cake belt that normally occurs. As expected, the new building and paste equipment quickly became covered in tailings soon after start-up.

There was no screen constructed on the final holding hopper. A standard 75 mm square steel grate is always required within the gob hopper as the last line of protection for the borehole. This screen is critical to filter the mixer discharge so that collection of any cement chunks, broken mixer paddles, pieces of liner and other foreign objects happens prior to material entering the borehole. The area around the mixer was redesigned to allow better visibility into the gob hopper and to promote cleaning after each pour. A toe plate around the opening was recommended to prevent accidental kicking of material into the final hopper.

During construction, the curing room for the paste backfill cylinders had been re-located directly above the electrical room. Placing running water and constant moisture directly above the electrical room posed a risk to the plant and created a hazard. Significant moisture barriers had to be applied to protect the integrity of the electrical room and the curing room was in fact moved later after an unfortunate incident with flooding.

3.3 Process

The filtration system performed as designed during commissioning with densities exceeding 80 wt% solids. The continuous mixer re-pulped the cake sufficiently and generated a homogenous and steady mix.

The chosen cement feed system did not perform well at start up. The impact flow meter was therefore removed due to inconsistent performance. In the Basic Engineering, Golder PasteTec had recommended a rotary valve, weigh belt and screw conveyor combination that has worked reliably at other operations. The weigh belt measures the mass flow and a loop between the weigh belt and the rotary valve that will speed up the rotary valve (or slow it down) to obtain the set point mass flow on the weigh belt. Both the screw conveyor and the weigh belt can be either variable speed or set speed. Variable speed allows instantaneous reaction to the mass flow of tailings that is reaching the mixer, i.e. as soon as the tailings weigh belt knows that it is feeding X t/hr, the PLC will tell the weigh belt to add Y t/hr and the vfd's on the rotary valve, weigh belt and screw conveyor will all speed up to provide that Y t/hr throughput. The important factor is the time it takes for the cement to go from the rotary valve to the mixer and the time for the tailings to get from the weigh scale to the mixer. The idea is that when the tailings cross the weigh scale, the cement content that corresponds to that instantaneous weight should enter the mixer at the same time as the tailings do.

The 200 mm diameter paste backfill line that connected the gob hopper to the borehole collar did not reflect the original Basic Engineering design. Modifications to the design had been made to include a breather line running from the borehole collar back up over and into the gob hopper. This revision posed a plugging risk to the UDS and it was agreed that this addition be removed. In fact, much of the discharge piping was replaced during commissioning to provide a more robust system that was nearly self-cleaning, fulfilling one of the most important factors in paste plant design, the consideration of what happens once the plant is shutdown — how can it be cleaned safely?



Figure 4 Gob hopper discharge before and after modifications

3.4 Underground distribution system (UDS)

The underground paste line was installed by a subcontractor (Clarcon) and was done to a professional grade. Some minor grouting of down hole plates required completion during commissioning. The grout serves two purposes: providing stability and rigidity to the plate and prevents water from accumulating around the top of the casing that could lead to corrosion or leakage.

The UDS was flushed repeatedly and pressure tested successfully using water and compressed air; Figure 5 below illustrates a manual pressure gauge used in the testing.



Figure 5 Pressure testing the UDS

The first test stop was poured successfully on 15 July with 6 wt% cement and a 190 mm slump. Production pouring began in late fall 2009 and continues. A return visit is planned to follow up on recommendations and continue ‘tweaking’ the plant performance.

4 Conclusions

In conclusion, the Aguas Tenidas mine backfill plant is meeting the original design intent, that being the continuous production of a consistent and reliable backfill product. At the time of commissioning, the plant was approaching design-operating parameters and further improvement is expected as the operator become familiar with the plant operation. It is, however, clear that opportunities to avoid delay, and mitigate the need for retrospective modifications, were missed by not ensuring continuity in the design intent from conception through to execution.

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