Paste 2019 – AJC Paterson, AB Fourie and D Reid (eds)

doi:10.36487/ACG_rep/1910_23_Wisdom

Maintaining high availability and low operational costs for filtered tailings facilities

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Abstract

High availability of filtration equipment is essential for reducing the capital cost on tailings filtration projects. At the same time, low operational costs are needed to maintain mine profitability. High availability, greater than 90%, and low operational costs can be achieved at the same time through good equipment design, good building layout, automation, and proper maintenance procedures.

Keywords: *availability, pressure filter, tailings*

1 Introduction

High availability of any equipment at a mine site is important to maintain production and profitability of the mine. Tailings systems availability is important because no mine wants the waste system to shut down the profit generating upstream operations. As tailings systems do not generate any money for the mine, historically they have been considered just a cost of doing business and as such, this part of the flow sheet can be overlooked compared to other parts of the mine. This view is changing now with the recent dam failures. Maintaining low costs are always important, but they are especially important for mines that incorporate pressure-filtered tailings as part of their flow sheet: automatic pressure filters will automatically destroy themselves if proper maintenance is not performed. Having the right equipment design, good building layout, good automation, and proper maintenance procedures can help achieve high availability for pressure-filtered tailings at an acceptable cost.

2 Equipment design

To maintain high availability, proper pressure filter equipment design is essential. This includes how the equipment is sized, performing cloth and plate maintenance outside of the operating filter requiring an open design for the filter, and access to filter components for easy maintenance.

2.1 Equipment sizing

Proper sizing of the dewatering equipment is vital for maintaining availability. Equipment that is undersized will be operating at excessive rates and without the proper downtime required for preventative maintenance. Sizing is typically done using bench scale filtration equipment and will give good results that have been proven to scale up to full sized filter production. It is important to properly test a complete range of tailings that are representative of the complete mine life. Using a blend of material as a typical tailings is not recommended. Figure 1 shows the laboratory scale test results for the corresponding operating envelope for a particular mine in South America. Note the variability in the filtration performance when all the test parameters were kept the same, such as feed pressure and cake thickness, etc.

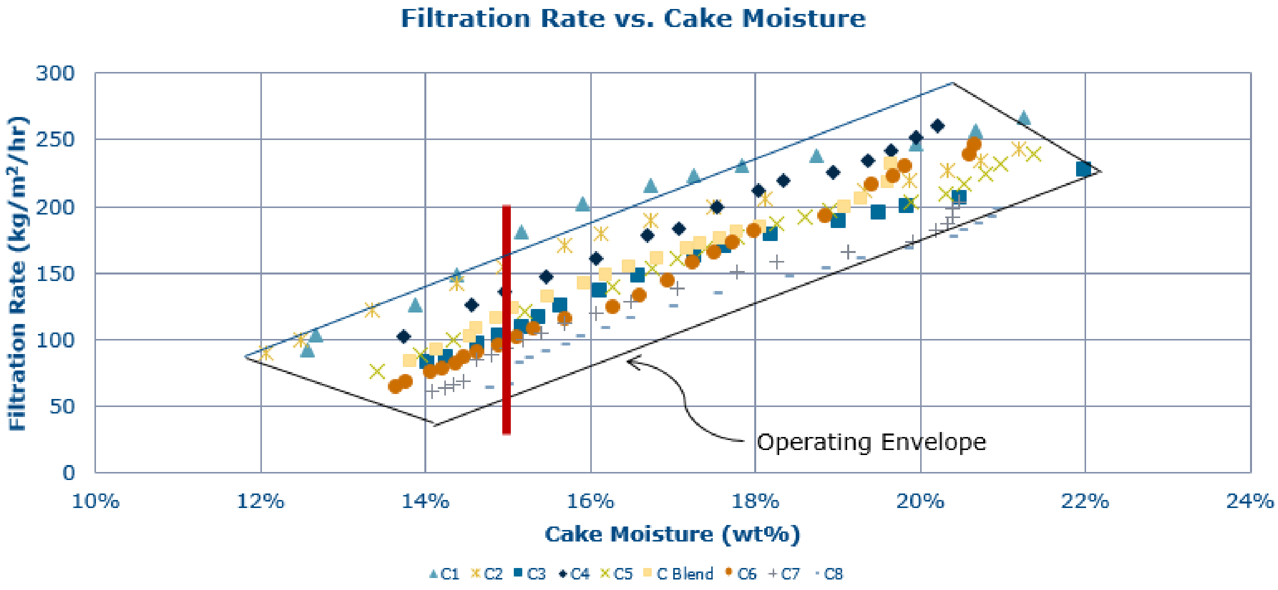

Figure 1 Pressure filter test results

At a given cake moisture of 15 wt%, which is typical for a filtered tailings project and is shown by a red line in Figure 1, there is a range of 50–160 kg/hr/m^2 variability in filtration rate. The blended sample is 100 kg/hr/m^2. It would not be uncommon for a filtration plant to be sized based on the blended sample; perhaps not ever even testing the other samples. This would mean that there are times the plant would be undersized by half. Without understanding the complete operational envelope, it would be very likely the filters would be undersized and there would be no time available for required maintenance. It is very tempting during the design phase of the project to use the best filtering material to save capital costs on the project. This again leads to the filters being undersized with no time available for required maintenance. Conversely, if the worst-case material is chosen and the design based on that, the capital and operating expenses may be too much for the project to bear and it may never proceed. It is best to understand the complete operating envelope and use ore blending and a good mine plan to mitigate the effects of the worst material.

2.2 Filter design to allow easy plate and cloth maintenance

Most of the maintenance on a pressure filter, approximately 80%, is associated with the filter cloth and filter plates. Along with the cloth on filter plates the wash bars, plate rollers, membranes (if required for operation), and the plates themselves require maintenance. Having the equipment designed such that the plates are easy to remove is essential for long-term maintenance and maintaining high availability.

Cloth life should be selected to minimise the number of unplanned cloth failures. The goal should be such that 99% of cloth changes are planned and 1% is unplanned. The challenge is to extend the cloth life to a point where the number of cloth failures start to increase significantly. Figure 2 shows the potential for any component to fail versus time (Riddel 2018). For filter cloths in a pressure filter, operating hours is equal to the number of cycles the filter cloth has been in operation. The point at which you want to change the filter cloth is shown by the red line, the potential failure line, in Figure 2. Operation past this line will give unplanned failures and can have a severe negative impact on availability. Proper selection of a filter cloth will achieve between 1,000 and 4,000 cycles of operation before reaching the potential failure line, depending on what type of tailings is being processed. The worst type of tailings for cloth life typically contain a significant portion of clay and clay sized particles. The more quartz type particles and larger particle size tailings will have a longer cloth life.

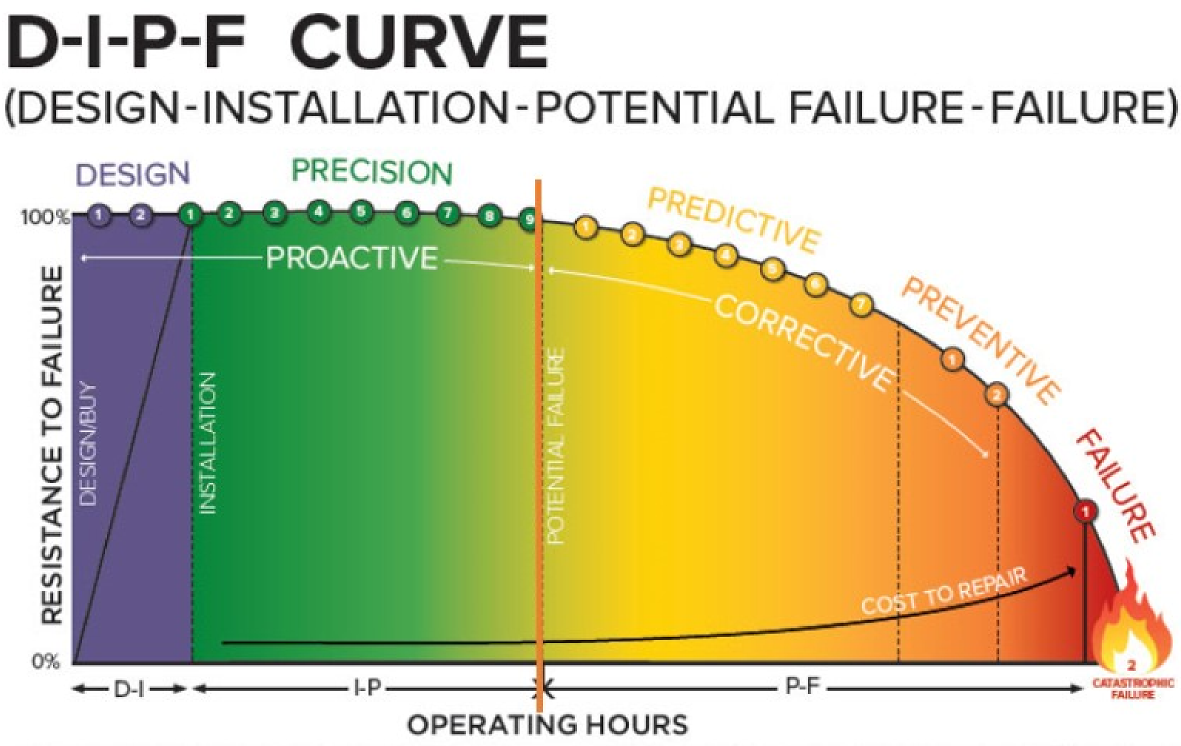

Figure 2 **Failure curve**

Unplanned cloth failures have significant flow-on effects to filter availability, as follows:

- Failure of a cloth leads to solids behind the cloth.
- These solids then pass through the filtrate ports in the plate (path of least resistance) and then build-up behind the adjacent cloth on the other side of the plate.
- The build-up of solids also causes the plates to become deformed when the solids build-up on the sealing surface and the plate pack is closed.
- This then leads to premature slurry leakage at the sealing surface, failure of the adjacent plate and failure of the cloth.

In this way, an unplanned cloth failure propagates throughout the plate pack causing the whole filter to have cloth failures.

At the potential failure cycle count for the cloth it is best to remove the filter plate, or set of plates, from the filter to perform the required cloth maintenance. This requires the proper filter design allowing quick and easy removal of filter plates. It is possible to remove a set of up to 20 plates at a time to reduce lifting and removal times.

As soon as the dirty filter plates are put into the maintenance rack, new clean plates are lifted into the filter allowing the filter to operate while the dirty plates are maintained (Figure 3). As the cloth and plate maintenance is performed outside the filter, while the filter is operating, high availability of the filter is maintained. The total downtime to remove a set of plates and reinstall a set of plates has been measured in an operating filter to be 10 minutes.

Figure 3 Plate and cloth installation on FLSmidth filter

The removed filter plates are put into a maintenance rack (Figure 4).

Figure 4 Filter plate maintenance rack

Filter plates in the maintenance rack have access to change the filter cloth, as opposed to in-filter cloth changing (Figure 5).

Figure 5 In filter cloth and plate maintenance

While the plates are in the maintenance rack, the other items on the filter plate can also be maintained such as the wash bars, plate links (Figure 6), plate wheels (Figure 7), and the plate itself (Figure 8) can be washed and repaired as needed. The filter operator can perform this cloth and plate maintenance as part of their duties.

Figure 6 Filter plate links

Figure 7 Filter plate support wheel

Figure 8 Dirty filter plate grid

3 Building layout

Building layout is important to allow access to filter components, ensure there is adequate space available for cloth and plate maintenance, and consideration for environmental factors.

3.1 Valve access

Besides the filter cloth and plate maintenance, maintenance of other components of a pressure filter are required. These items include slurry valves, instruments, and hydraulic cylinders. Valves, particularly the pinch valves, require occasional inspection and maintenance. The positioning of these valves should be carefully considered where they are accessible and can be easily maintained with sufficient space to allow removal and installation. Every pinch valve should have a flexible connection (bellows) as an interface with the rigid piping system or a removable angled spool where a bellows is not practical or possible. A lifting point must be provided above every valve with sufficient headroom to allow easy extraction. The valves are bulky, heavy and cannot be easily manoeuvred (Figure 9).

(a) (b)

Figure 9 Filter feed pinch valves (a) Inaccessible location; (b) Sleeve change with pipe support

3.2 Follower head access

There are two heads on a pressure filter; one at each end of the plate stack. One of them moves and the other is stationary. These heads contain the high pressures generated in filtration. The follower, which is the moving head which on a pressure filter, should be equipped with a walkway (or walkways) and hand-railings to enable routine unrestricted access for the purpose of installation, set up and maintenance. An access ladder or stairway to the crosshead, possibly at the home position, should be incorporated into the floorplan (Figure 10).

(a) (b)

Figure 10 Filter follower: (a) Top of follower; (b) Back of follower

3.3 Underside of filter access

Access to the drip tray components, particularly the hydraulic cylinders and instrumentation components can be challenging, as it will be located under the floor of the filter (Figure 11). A walkway offering access to these areas is a critical item to avoid delays for installation, inspection or repair activities.

Figure 11 Underside of filter

3.4 Area for plate and cloth maintenance

Sufficient area is required for plate and cloth maintenance. The area should consist of a dirty maintenance rack and a clean ready rack. The maintenance rack should contain enough space to hold approximately 10% of the total number of filter plates installed. This area needs to be contained and drained so that the plates can be washed as needed. A 5 m length of rack needs to be available such that plates can be spread apart and maintained before being put in to the clean rack (Figure 12). The clean rack should also contain enough space to hold approximately 10% of the total number of filter plates installed. The rack should have a lower access for maintenance on the lower part of the plate, and an upper walkway to access the top of the plate.

Figure 12 Plate maintenance area

3.5 Site environmental considerations

It is important that the filter press system be protected from the environment. At a minimum, a roof over the filters must be provided to protect the filters from precipitation and sunlight. Sunlight UV radiation is harmful to the polypropylene filter plates and some of the rubber components used on the filter. Precipitation can make the filter inoperable, especially in cold climates (Figure 13). If the filter operates in a cold climate without a complete building heat, tracing of all water lines must be used. Depending on wind speeds, walls of the building may need to be provided to allow crane operation for maintenance. Wind speeds in excess of 10 km/h will make use of the maintenance cranes difficult if not impossible.

Figure 13 Open air filter in cold weather

4 Automation

The most beneficial automation for maintaining high availability on a pressure filter is focussed on the filter cloth. As indicated before, 80% of the maintenance on a pressure filter revolves around the operation and replacement of the filter cloth. It is very beneficial to know when a cloth has failed, track how long that cloth was in operation and where it failed.

4.1 Single plate turbidity sensing

Turbidity sensors can be used on the combined discharge filtrate flow from a filter press to know if and when a filter cloth has failed. As a filter may have up to 200 plates, it is more beneficial to know which filter cloth has failed. Turbidity sensing modules can be installed into a filter plate in order to detect damages in the filter cloth. High turbidity during certain portions of the filtration cycle indicates that a cloth failure has occurred and that the respective cloth needs to be replaced. Figure 14 shows how the product is installed in a filter plate.

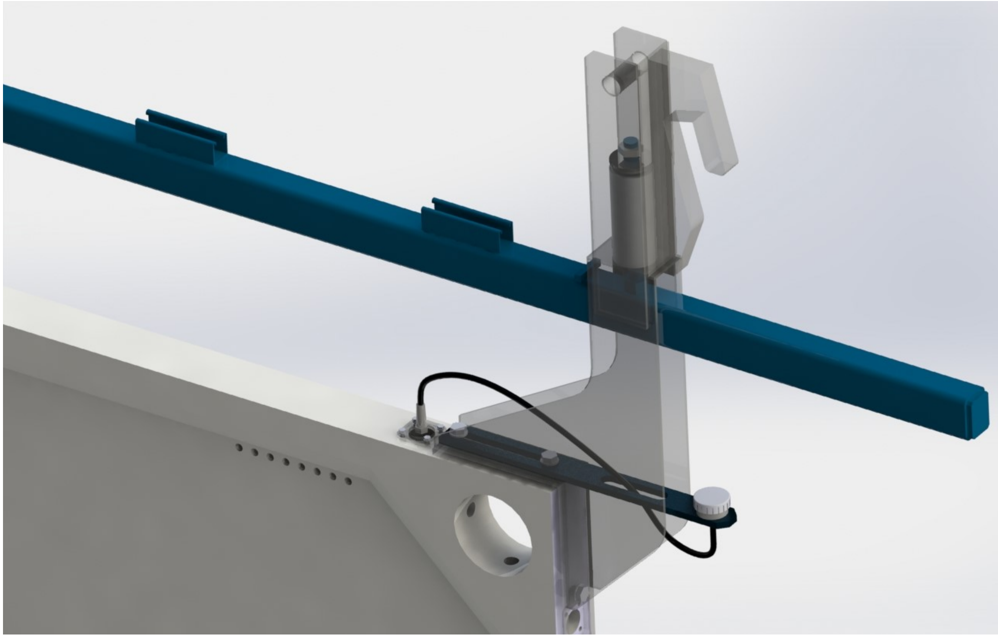

Figure 14 FLSmidth IntelliPlate™ installation

4.2 Filter cloth failure tracking

When a filter cloth has failed, it is very beneficial to log where the cloth failed and why it failed. Thoryx Consultants Inc. has developed a proprietary web-based software package that allows a maintenance person to log this information when the cloth is changed (Blanchet 2018). The information is logged using a mobile device. The use of this software enables understanding of cloth performance in the operating filters. It allows targeted cloth improvements based on failure modes, predictive maintenance and inventory control, and improved availability and production.

5 Maintenance procedures

Good maintenance procedures ensure the pressure filter system is operating at peak efficiency. These procedures include the following:

- Daily walk-arounds, inspections, tightening bolts and other preventative maintenance. Some of this is completed as the filter is running (greasing, etc.).
- Plate pack change-outs on a scheduled cycle count, as described previously.
- Plate and cloth maintenance outside the filter. This process takes on average 9–10 minutes per plate. Work includes:
  - Wash down cloth.
  - Unbolt cloth attachment.
  - Lift and remove cloth from upper platform.
  - Inspect and replace plate rollers, as required.
  - Inspect and replace cloth sprays, as required.
  - Wash down plate sealing surfaces and grid surfaces.
  - Hang new cloth from upper platform.
  - Secure cloth.
  - Slide to ready rack.

- 10-hour shutdown every two weeks. Work includes:
  - Maintenance.
  - More significant maintenance to the shaker system.
  - Valve/seal replacements.
  - Feed pump maintenance.
  - Pipe replacements.
  - Hose replacements.

6 Operational costs

6.1 Personnel

It is good practice to have one operator for every two filters. As the filters will operate 24 hours a day, 7 days a week, the operators need to be staffed accordingly. Maintenance personnel can be limited to one full-time maintenance person for every two filters, but they need to be available only during day shift during the workweek. Emergency maintenance personnel from the general mine maintenance pool can be trained for off shift emergencies.

6.2 Operating expenses

Annual costs for a potential multi-filter installation in South America during a pre-feasibility study were analysed using the principals presented in this paper. Included in the annual operational costs were the thickener which feeds the filter installation, four filters and all the manpower and spares and consumables required for operation of the thickener and filters. The results are presented in Table 1.

Table 1 South American filtered tailings operating costs

Cost	Value
Total direct labour cost/year	14%
Total power consumption/year	28%
Total cloth cost/year	36%
Total thickener flocculant cost/year	14%
Spares and consumables cost/year	7%
Total operating cost (USD/tonne)	0.75

7 Conclusion

Tailings filtration facilities that use the design and practices described in this paper have been documented to achieve 90% availability. This allows for fewer filters to be installed which reduces capital costs of the installation. Operational costs have been shown to be less than US 0.80/t of tailings dewatered allowing for filtered tailings to be a competitive solution for many mines.

References

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