EGA Pot Feed Systems Challenges and Solutions

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Abstract

Emirates Global Aluminium (EGA) adopted several pot feeding systems (PFS) through the past 44 years. Each system has its advantages and challenges. This paper explores the PFS installed in EGA to provide secondary alumina for production of standard purity (SP) metal, and the challenges with each system. The results of previous trials to overcome these challenges, and to optimize the feeding system to provide consistent feeding are presented. There are eight different PFS currently available in EGA. Each of these systems is categorized as continuous-filling system or time-based filling system. In this paper, all those systems will be compared on the basis of certain criteria and solutions to overcome some of their challenges.

Keywords: Pot feed systems, Consistent alumina feeding, Alumina silo level, Anode effect frequency.

1. Time Base PFS- Crane Filling System

The first pot feed system (PFS) is crane filling system which is time-based. It is one of the oldest types of PFS available in EGA. It works by having two discharge points at the bottom of the secondary silo, one to each potroom. Each discharge point is connected to A and B rooms through an air slide conveying system. The flow of material of the air slide is controlled by a rotary feeder that opens and closes automatically from the control room. Once the semi-rotary feeder opens, the fluidization of the air slide connecting it to the cranes in the potrooms, opens automatically and alumina is filled into the 30-tonne crane, which is shown in Figure 1. This PFS has good tolerance with respect to alumina property changes and relatively high reliability with low maintenance on the Fume Treatment Plant/Gas Treatment Centre (FTP/GTC) side. The crane filling system average availability is 99.93 %, as shown in Figure 2. Despite high availability of this system, it still has a lot of challenges. The major challenges and solutions are summarised in Table 1.

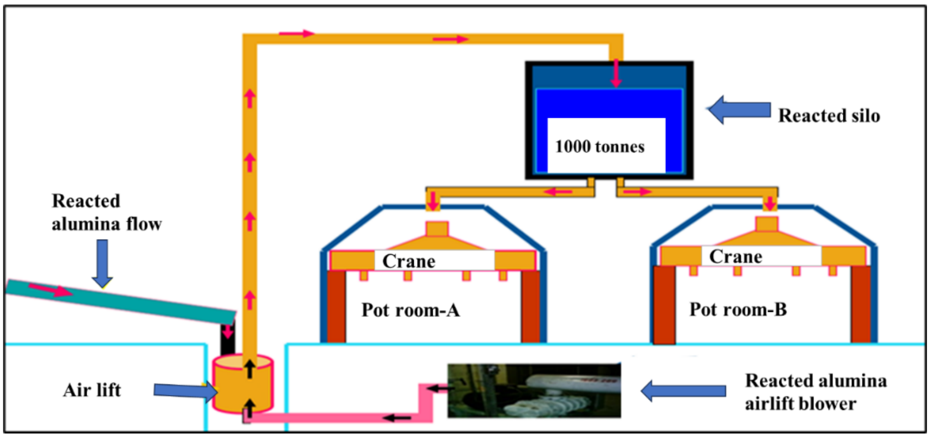

Figure 1. Crane filling general layout.

Table 1. Crane filling challenges and solutions.

Challenges	Solution /Improvement
One of the biggest challenges with this system, which has resulted in tripping the secondary conveying system followed by an unauthorized release of hydrogen fluoride (HF) to the environment, is the unavailability of the crane to supply alumina on time due to busy crane usage in other potline activities, such as anode changing.	To overcome crane unavailability, EGA has created a daily dashboard to identify if it caused by a supply and logistic issue, or by human behaviour in particular shifts, or by other reasons. Once this was put in place, the abnormal emissions reduced slightly as we have addressed the issues on time.
Inconsistent fine alumina discharge from the silo due to filling of cranes simultaneously in the same room.	Introduced an interlock in the system to avoid simultaneous filling.
High quantity of fine alumina discharge when the silo level is low.	Introduced an interlock in the system to restrict the crane filling if the silo is lower than 65 %. (silo capacity is 1000 t).
Mixing of alumina and anode cover recycled material (ACRM) as both silo discharges share the same air slide. Due to the increasing gap in the semi rotary feeder plates, ACRM seeped to the common airslide segment. Refer to Figure 3 for more details.	To solve the issue of alumina mixing with ACRM in the common air slide, the fluidization of the common air slide was adjusted and the semi rotary plats gap has been monitored and corrected quickly if an event takes place.

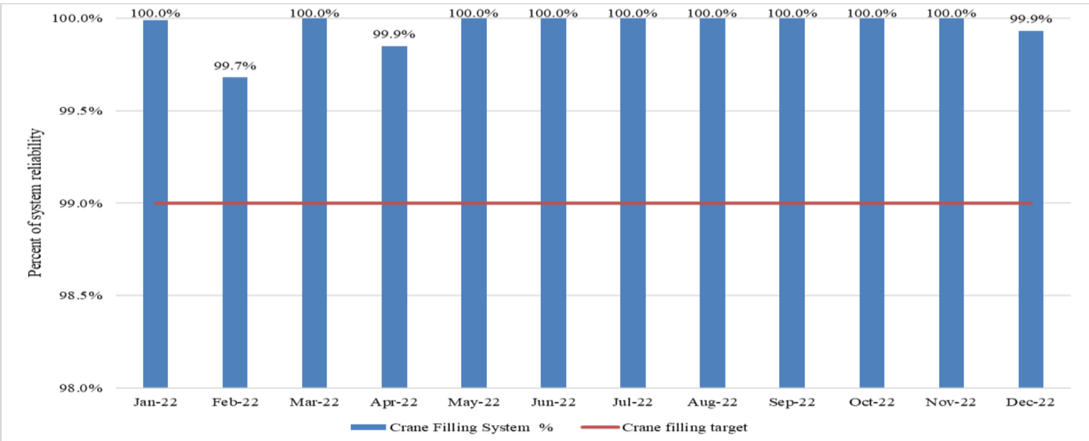

Figure 2. Crane filling system availability.

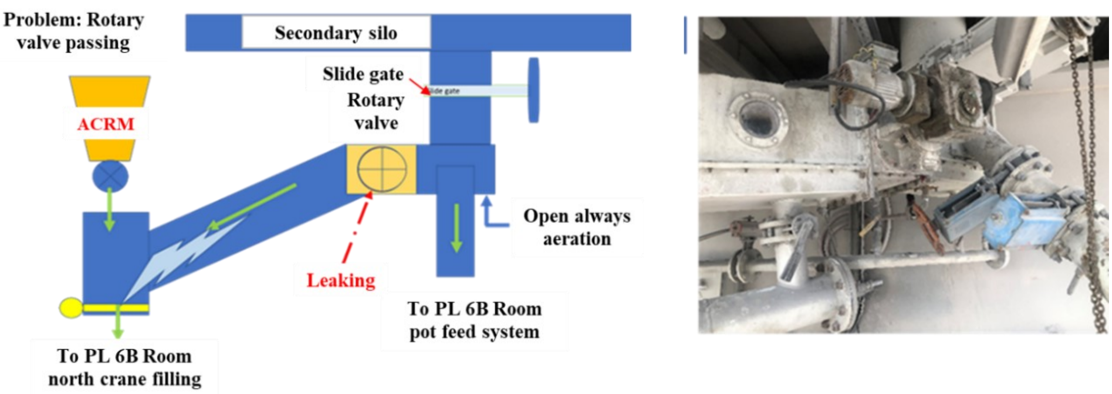

Figure 3. Crane filling system semi rotary feeder leaking ACRM.

2. Time Base PFS- Pressure Vessel

The Dense Phase System (DPS) is a conveying line consisting of a Pressurized Vessel (PV) under the secondary silo and pressurized conveying pipes (Figure 4). Every 4-6 hours the fluorinated alumina silo fills the PV. Once the 4-tonne PV is filled with alumina, the cone valve (conical type) closes, and the pressure starts building in the PV. Once the pressure reaches 440-450 kPa, the discharge valve opens, and the fluorinated alumina flows to feed reduction cells. Usually, each bin in a cell takes around 3-4 min to be full. This system copes very well with alumina property changes as it rarely causes an impact on anode effect frequency (AEF) due to low segregation. However, it comes at a small price as it requires relatively high maintenance and energy linked to the use of compressed air.

2.1 The Challenges Using a Pressure Vessel System

- This system uses a lot of compressed air.
- This system has the lowest reliability with 93.8 % availability in 2022 as shown in Figure 5.
- The DPS requires a lot of maintenance.
- There are pinch valve issues which allows for alumina to leak in the cells increasing the sludge and causing disturbance to the pot operation.
- A handicap is that the system had no alarms to identify these leakages.

2.2 Initiatives Taken to Enhance Control Over the Pressure Vessel System

- EGA has introduced an interlock to enhance the DFS. This interlock is triggered if the scheduled alumina filling to any cell exceeds 7 min. Once this interlock is triggered, the alumina conveying to those cells will be suspended and an alarm will be generated in the control room to inspect those cells. This reduced the issue of leakage inside the cells due to mechanical deviations.
- Moreover, the team has introduced a reporting system where the cell issues are categorized in 3 priorities based on the conveying time. This helped a lot in scheduling the maintenance work. In this reporting system, the team that manages the system highlights any holes in the conveying line or issues with the PVs themselves as top priority. This way, the system is kept controlled and optimized.

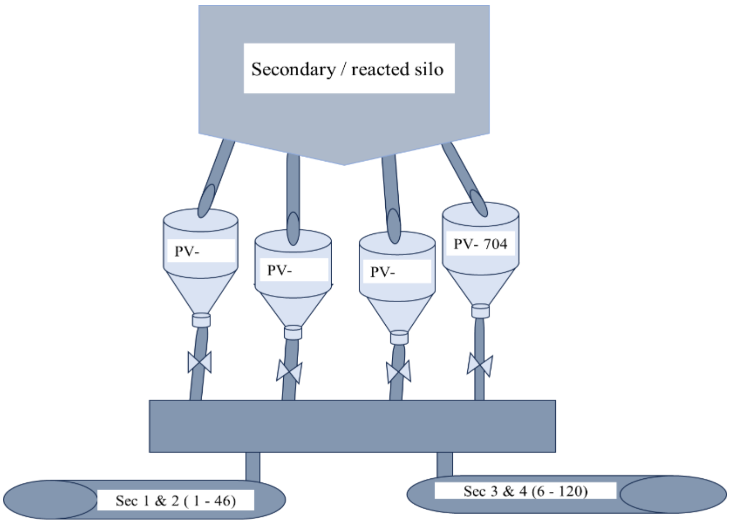

Figure 4.Time based PFS- Dense phase system (DPS.)

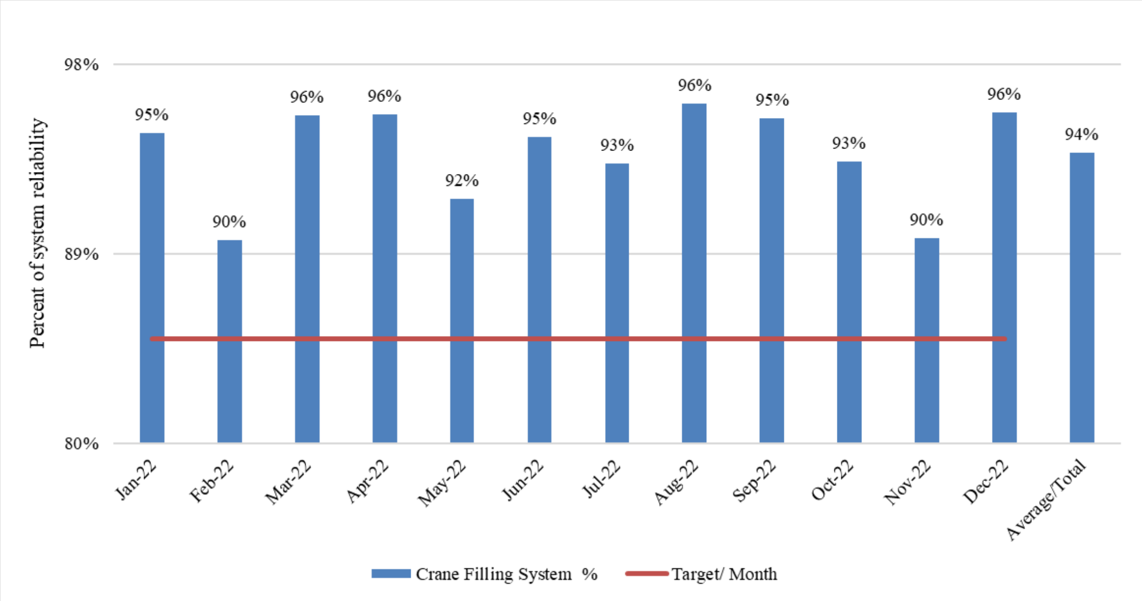

Figure 5. Dense phase system availability.

3. Time-Based PFS - Hybrid PFS

This system is a combination of pressurized vessel and fluidized system to make it a hybrid system, hence the naming convention. . This system consists of 1 PV with around 150 m of long piping that transports the alumina to a day-silo with a 6-tonne capacity. From the day silo the alumina is then shifted to the individual cells using fluidized air slides (See Figure 6). The working mechanism of this system is broken down into 3 steps:

Step 1:
- Once full cycle of filling from the PV to the cells takes around 1.5 hour assuming normal operation.
- The PV pressurize 2 tonnes of alumina and sends it to the bin (6-tonne capacity).
- The filling to bin will stop when it reaches 80 % of the full capacity.

Step 2:
- The feed is distributed to the wall bin (600 kg each) starting from Cell 273 and ending with Cell 277.

Step 3:
- The filling from the wall bin to the individual cells starts
- 12 min filling for the individual cell (10 min filling is ideal)
- Step 3 is repeated 4 times till the cell hoppers are full.

3.1 The Challenges of the Hybrid PFS System

- In case of a PV breakdown, there is no backup PV.
- There is no redundancy in conveying lines.
- In case of a prolonged breakdown for more than 5 hours, it will take more than 10 hours to fill all the cells.
- Access for maintenance crews for descaling of the pipes/diverters is very limited.

This system is moderately sensitive to alumina property changes. It has an availability rate of 99 % as shown in Figure 7.

3.2 Initiatives Taken to Enhance the Control Over the Hybrid Pot Feed System:

- Create an emergency protocol with actions to mitigate the system breaking down. This protocol includes actions to be taken by potline operation, maintenance team and FTP team, based each on 2, 4, and 8 hours (See Figure 8).
- Increase preventive maintenance to minimize breakdowns.
- Installation of a platform for better access for PV maintenance.

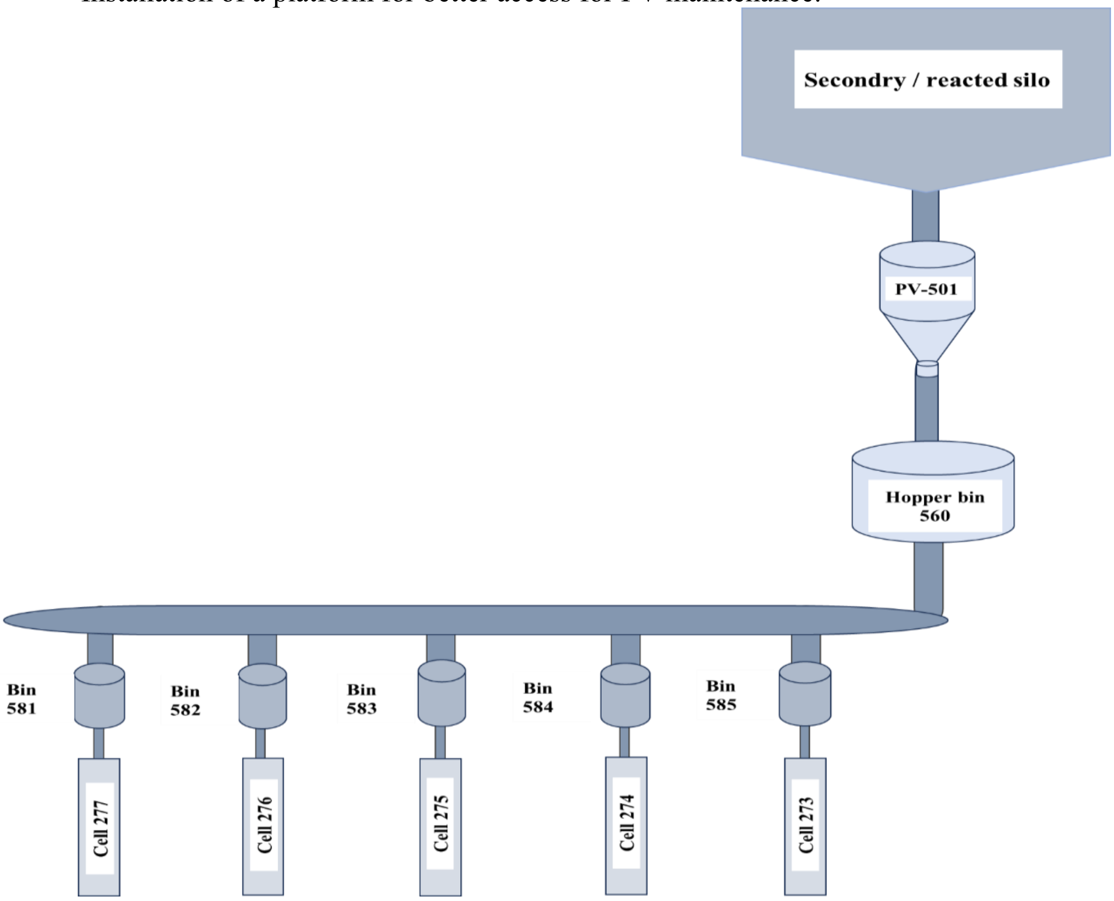

Figure 6. The conveying mechanism of hybrid PFS.

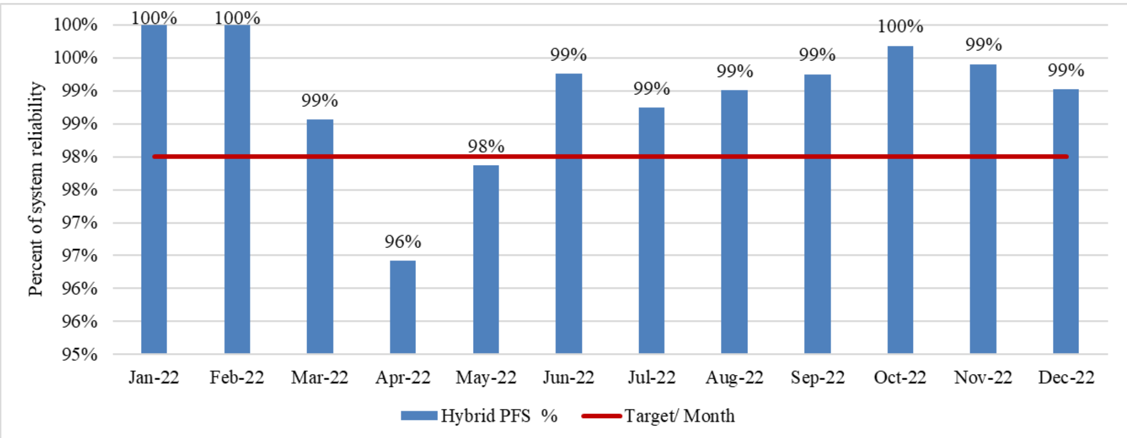

Figure 7. Hybrid PFS availability.

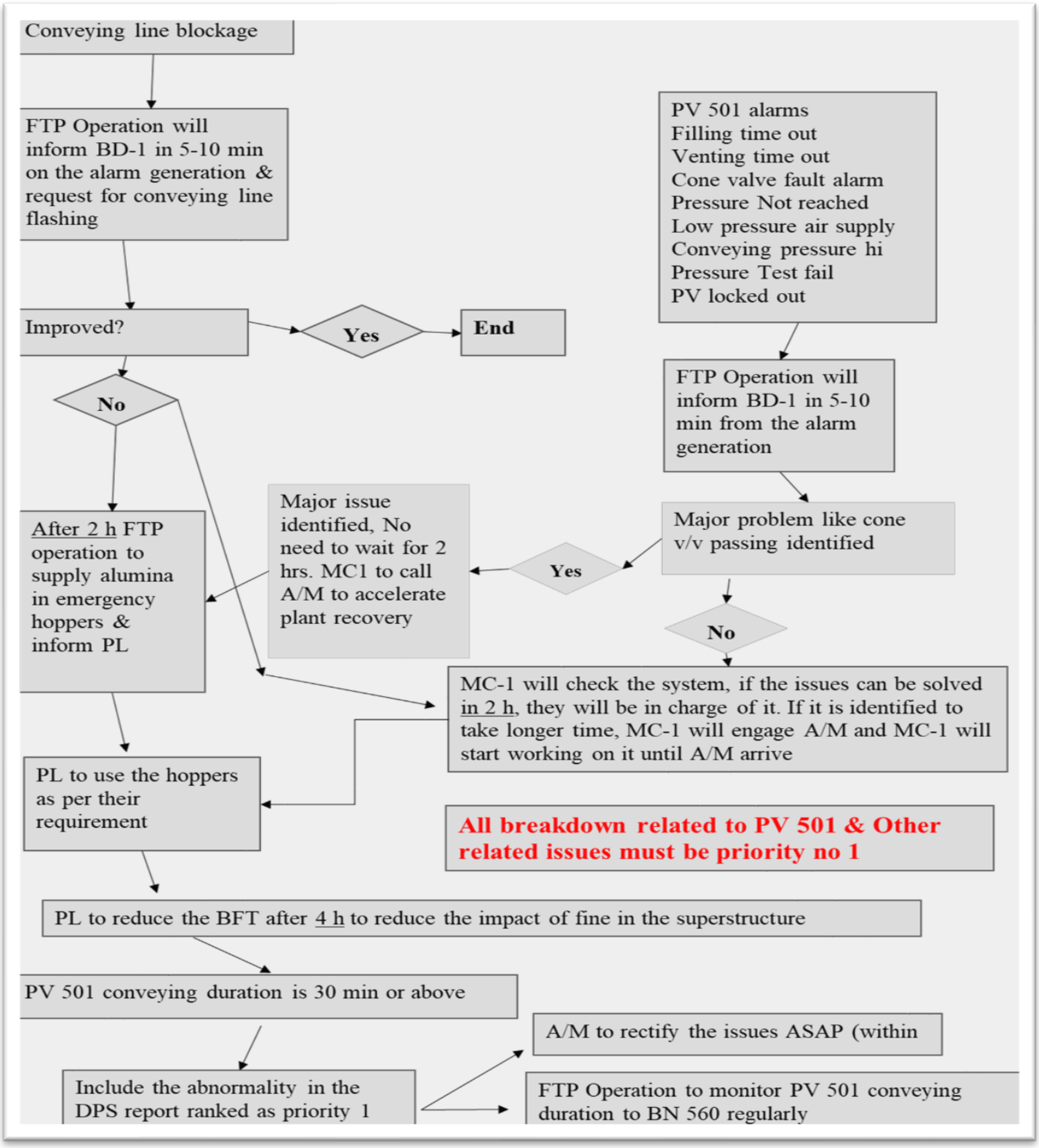

Figure 8. Eagle PFS emergency protocol.

4. Continuous PFS - System A

The first of three similar systems is based on blower fluidization. It consists of a conveying line that has a fluidization pad at its bottom (See Figure 9 and 10). This pad requires air to fluidize the material from the Moller type discharge of the secondary silo to move it to the product pipe which is the horizontal pipe connected to the potline roof (fluid flow pressure). One of the advantages of this system is that every cell has a level sensor that indicates the alumina level in the bin of the cell. This system operates very smoothly under normal conditions. It has a reliability of 98.5 % (See Figure 11).

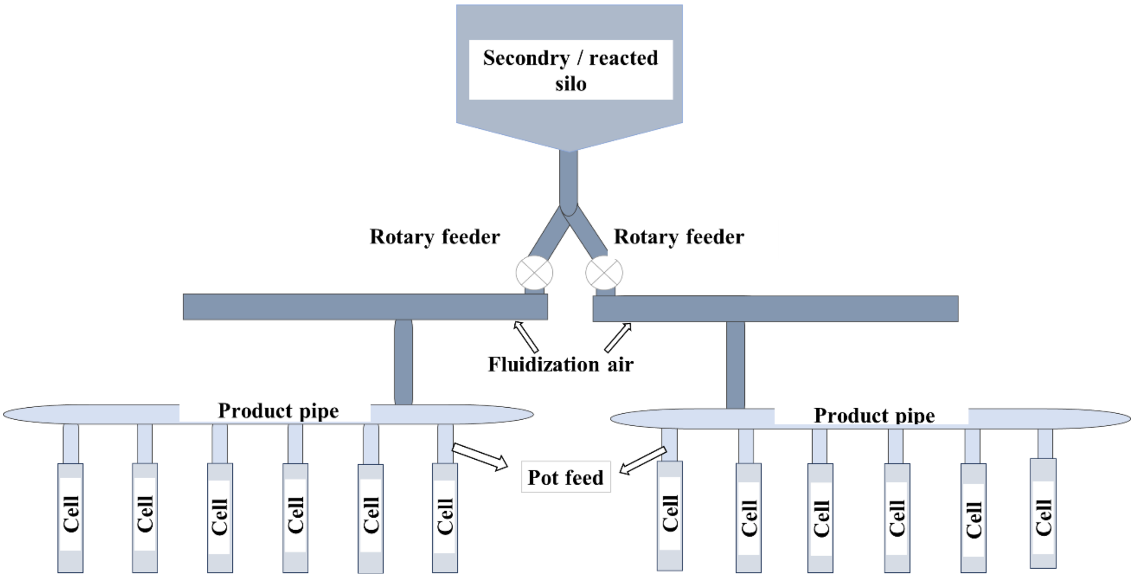

Figure 9.Continuous PFS A.

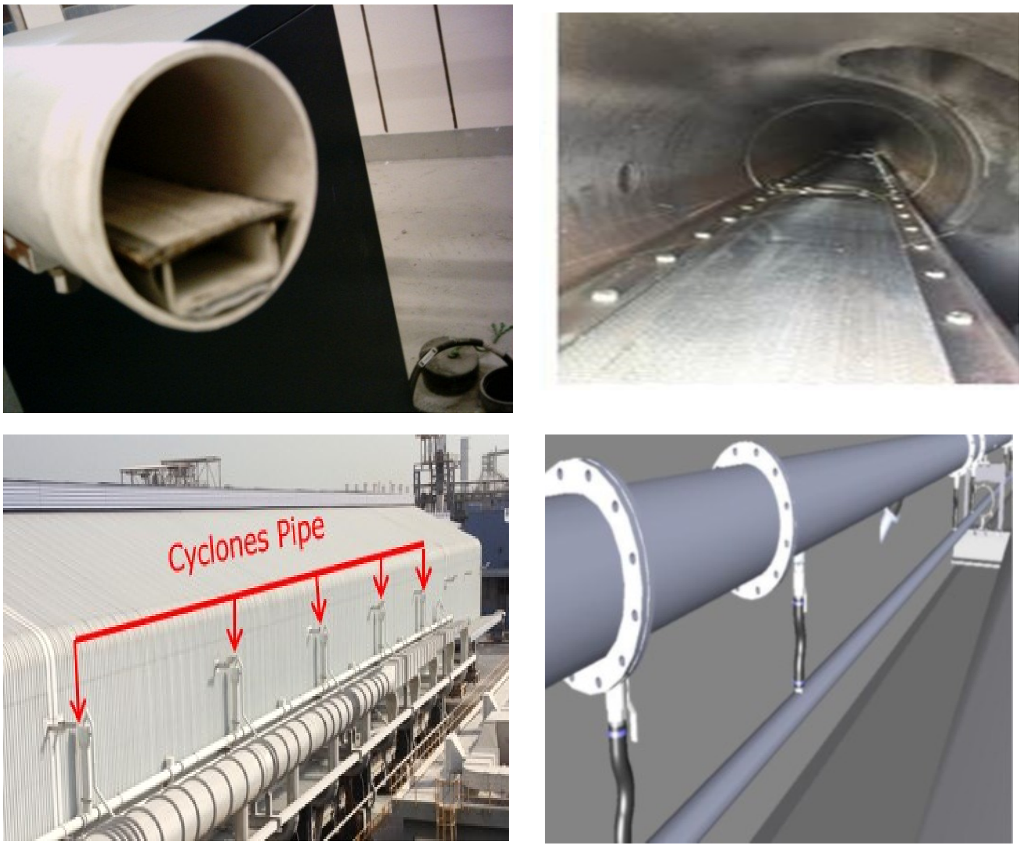

Figure 10. PFS system A conveying line and cyclone pipe.

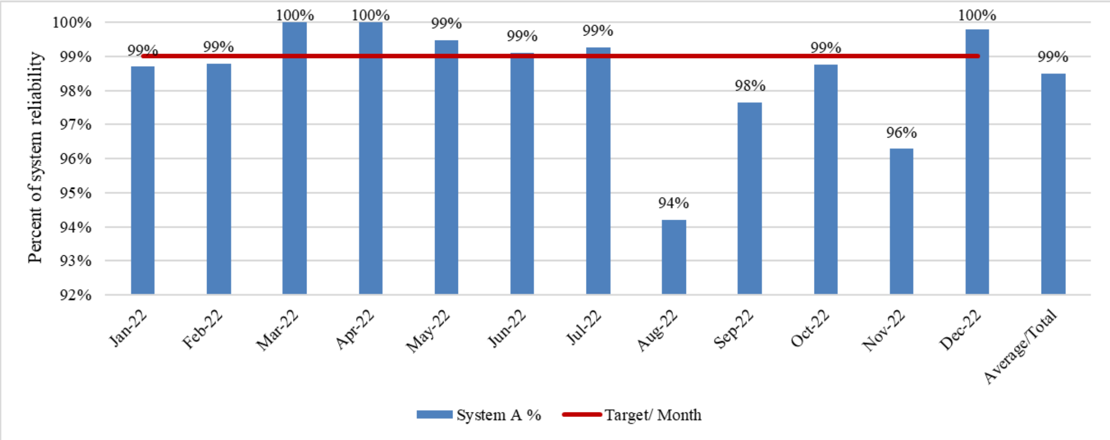

Figure 11. Continuous PFS A availability.

4.1 The Challenges with This System Are:

- It is sensitive to alumina properties changes, which is the biggest challenge in this system.
- Moreover, the fine materials used to be recycled through the cyclone back to FTP/ GTC.
- Alumina segregation can take place across the feeding system.

4.2 To Mitigate These Challenges the Following Is Implemented:

- Flush the system once a day each for 2 hours; the recovery time is 30 min.
- Develop emergency protocol for PFS – System A (Figure 12).
- The cyclones pipe was modified to reduce the velocity and minimize fine alumina venting back to the FTP/GTC Fume Duct.
- Optimize the fluidization pressure across the airslide to minimise the segregation.

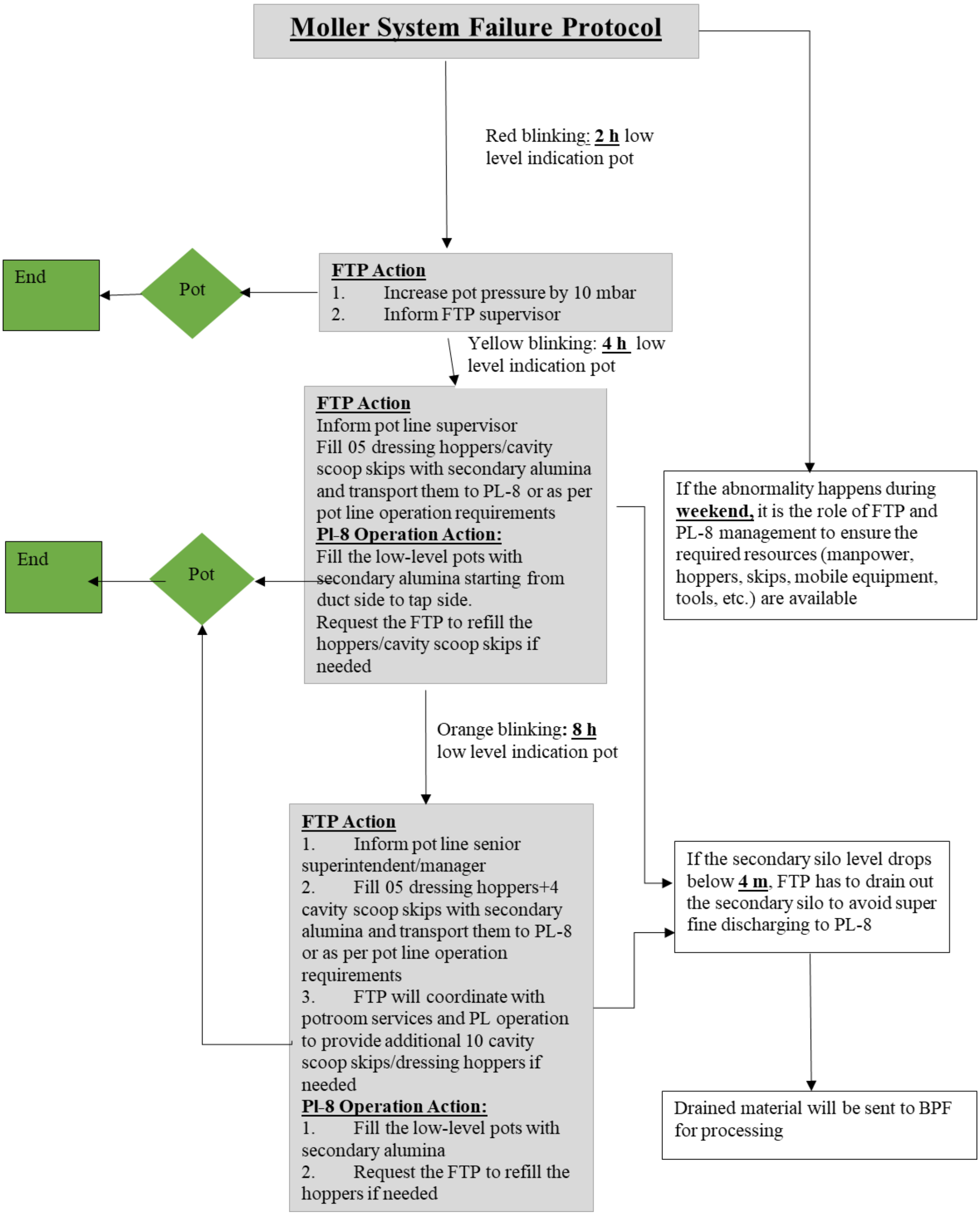

Figure 12. Continues PFS emergency protocol.

5. Continuous PFS - System B

This system is a robust system very similar in concept to System A with a recorded availability of 99 % (Figure 14). The main differences in this system are the design of the fluidization pad, and the fact that there are no level sensors of alumina in the individual cells. In this system the level sensors are installed at the end of the distribution air slide (the horizontal air slide next to the potroom roofs that transport alumina to potlines) as shown in Figure 13.

5.1 The Challenges With This System Are:

This system is very robust despite the issues during commissioning such as:

- Individual cell's flexible detaching
- Elongation of the flexibles leading to material stagnation, etc.
- Alumina Segregation across the airslide.
- Foreign material accumulation in the airslide.

After solving all the commission issues, the system performance has steady performance despite accumulation of fines in the system over time.

5.2 Additional Actions EGA Team Introduced to Prevent Accumulation of Fines:

- Flushing the system twice a day each for 4.5 hours. Trials showed that this is an optimum duration. The recovery time of this system is 4-5 hours. In EGA's Al Taweelah operations there the GTC the flushing takes place 3-4 times per day with a logic of high-level sensor activation on distribution airslide.
- Introducing an interlock to ensure that both sections connected to the same FTP (in Jebal Ali operations the GTCs are called FTPs) have high level indication within 30 min prior to initiating the flushing. This is to ensure an optimum distribution of fines from the discharge of the secondary silo to the cell feed system.
- Optimize the discharge of the secondary silo level depending on number of cells connected in each room

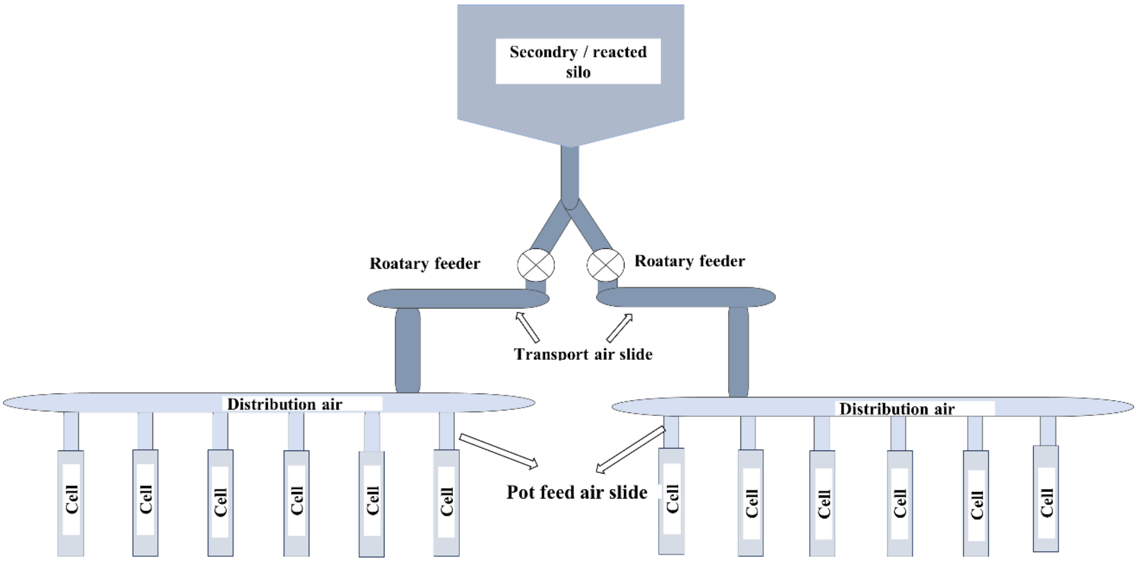

Figure 13. Continuous PFS B.

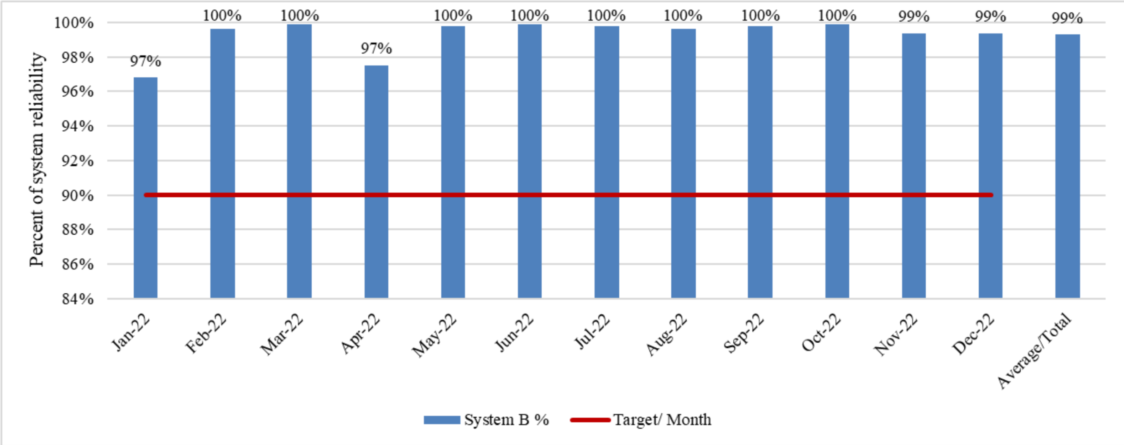

Figure 14. Continuous PFS - System B.

6. Continuous PFS - System C

PFS - System C has continuous supply of alumina to the pots. It consists of alumina conveying pipes with fluidization pad (Figure 15). The fluidization pressure required to fluidize alumina supplied to 120 pots is more efficient than the other pot feed systems. This is due to the unique design of the distribution air slide segment which allows better fluidization of the air. This is regarded as very efficient in terms of the design of the blower needed to fluidize the alumina to the cells. The system did not have any serious issues during commissioning. The performance of the system is very stable that is attributed to the supplier who was flexible to consider redesigning the system during design reviews with feedback from the end user. Since the system is relatively new there are no issues to report and no further actions actions to enhance the system are needed at the moment.

6.1 The Challenges with This System Are:

- Alumina seepage in individual pot airslide chamber during commission.
- Minor alumina segregation across the system.

6.2 Actions Introduced to Prevent Accumulation of Fines:

- Enhance the flashing time from 1.5 hours to 3.5 hours.
- Increase the flashing frequency from once to two a day.

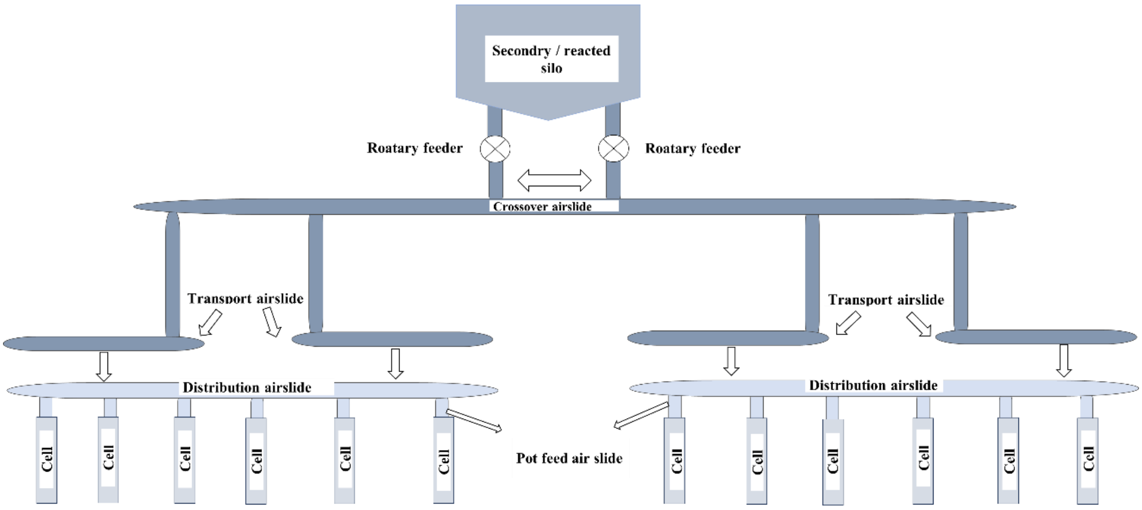

Figure 15. Continuous PFS - System C.

7. Summary

This paper discussed all different PFS systems that EGA has been using throughout the last 40 years. These systems are compared in terms of their resistance to alumina properties change, breakdowns and performance consistency. Based on the previous criteria, the reliability of the different PFS is compared in Figure 16.

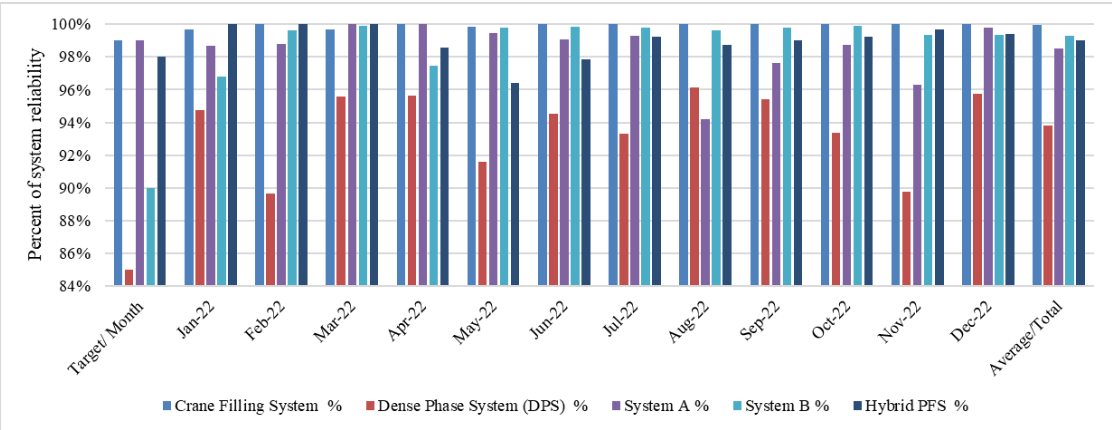

Figure 16. EGA PFS reliability.

8. Conclusions

Based on the presented data, it should be noted that, in general terms, the reliability of the continuous pot feeding systems is higher than the time-based pot feeding systems. Besides the crane filling system, PFS -System C is the most efficient in compressed air consumption and it had only minor issues during commissioning when compared to the other systems. Moreover, PFS - System C is found to be more robust to cope with changes in alumina properties. All-in-all, there are many improvements opportunities that can be adopted in the varies pot feed systems in order to further enhance the efficiency and its reliability.