

# Scale Inhibition in Washers

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## ABSTRACT

Typical Bayer operations require the recovery of valuable caustic via a counter current decantation (CCD) circuit. A major issue with the initial CCD tank, commonly referred to as the first washer, is high rates of scale formation on the tank walls, rake mechanism, feed well and exit piping. This high scaling rate can result in reduced tank life, premature rake failure, increased flocculant consumption, and increased descale turnaround time, all of which ultimately result in a reduction in the efficiency of caustic recovery from the CCD circuit, its primary purpose.

As part of a suite of technologies aimed at improving the overall efficiency of Bayer process operations, Nalco Water has developed ScaleGuard™ technology to mitigate scale formation in the washers (and other) applications. At Hindalco's Muri Alumina refinery in India, a long-term trial of Nalco Water ScaleGuard technology has been completed. ScaleGuard was applied to the first washer for the purpose of extending the washer life and improving the overall efficiency of caustic recovery.

This paper describes how the ScaleGuard program was applied, how ScaleGuard performance was monitored, the benefits achieved as realized via the extended operational life of the washers, and the overall return on investment (ROI) which justifies the ongoing use of the ScaleGuard program.

## 1. INTRODUCTION

The scaling of process tanks, pipes and unit operations in contact with the Bayer process liquor are a consequence of the supersaturated solutions that are handled throughout the Bayer process. The International Alumina Institute (2010) in the update of the Alumina Technology Roadmap has a target to reduce the impact of scale of this type by 50% by the year 2020.

The unit operation of washing the mud residue to recover valuable caustic is typically carried out in a CCD circuit which is an area of rapid scale formation, especially in the first washer.

High alkalinity mud from the settler is mixed with a lower alkalinity wash water from a downstream washer which immediately raises the super saturation level of the combined flows in the first washer and promotes high rates of scale formation on the tank walls, pipes and rake mechanism. This leads onto to a very shortened life for the first washer as compared to both upstream (settlers) and downstream tanks (further washing stages).

Hindalco's Muri refinery was built in 1948 and was India's first alumina refinery. Over the years the Muri operation has gone through numerous expansions and now has a capacity of 450,000tpa, producing a blend of alumina and specialty hydrates. One of the most recent expansions at Muri involved the installation of four Deep Cone Washer vessels for the washing of the red mud.

The 1st washer operation was experiencing rapid scale formation and associated inefficiencies. The typical life of the 1st washer was limited to 180 days and turnaround time for descale was 60 days. The random shedding of scale by the washer, known as "scale events", occurred at typically 80 days into its operation and these "scale events" restricted the washer underflow which in turn greatly limited the washing efficiency of the 1st washer. The thickness of the scale laid down after 180 days of operation was typically 500mm.

Nalco Water, as part of the technical developments incorporating the HyClass™ chemistry range (Aboagye et al., 2012; Wang et al., 2013), has also released Nalco Water ScaleGuard technology (Aboagye et al., 2011; Kildea 2015); a new chemical and application program for reducing the scale deposition rate in high scaling rate environments.

This current paper describes how the Nalco ScaleGuard program was implemented on the 1st stage washer at Muri and outlines the ongoing benefits gained by the continued use of ScaleGuard.

## 2. METHOD

Nalco WaterScaleGuard chemical, together with the associated dosing and scale monitoring system, were set up alongside the 1st washer whilst in its final stages of descale.

When the 1st washer was brought back online the ScaleGuard was pumped via a simple chemical pump, diluted in-line with water and added into the top of the 1st washer at two locations.

A scale coupon, made of 40 x 200 x 3mm mild steel bar, was hung into the liquor, via stainless steel wire, at a point at a similar level with the 1st washer overflow pipe. The 2nd washer also had a scale coupon installed in a similar position for monitoring.

The mild steel scale coupons were regularly removed from the liquor and their weight recorded using a simple kitchen balance. The coupons were swapped out for a new coupon at intervals of typically two to three weeks or when there was a ScaleGuard dose change made.

Several ScaleGuard dosages were investigated over the life of the 1st washer, namely 5, 8, 9, 10 and 12ppm. Data for a zero-dose period was also obtained.

The setup of the ScaleGuard dosing and scale monitoring system is presented below (Figure 1).

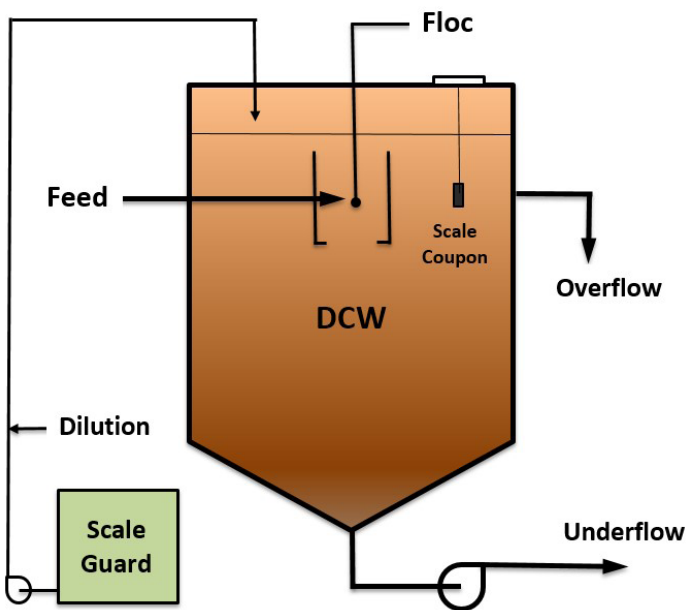


Figure 1. Schematic of ScaleGuard dosing and scale monitoring.

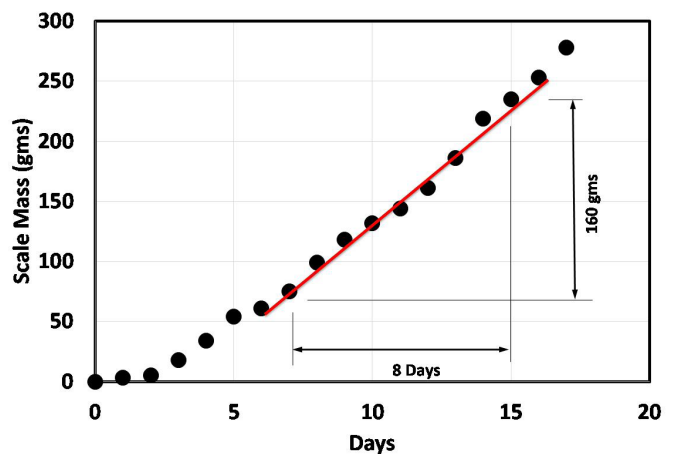
## 3. RESULTS AND DISCUSSION

The ScaleGuard trial was started on a newly descaled 1st washer and the success criteria of the trial were agreed.

- No “scale event” to occur in the first 100 days of operation
- The 1<sup>st</sup> washer life to be extended to more than 200 days
- The scale thickness to be less than 300mm at 1<sup>st</sup> washer duty end
- De-scale time to be reduced from the usual 60 days

However, a new washer (a fifth vessel) was being constructed over the same period of time and this newly constructed washer became the new 1st washer after the original trial operation had been running for 130 days. The original vessel used as the 1st washer was then put into 2nd washer duty (became a second washer). The ScaleGuard dosing system and scale coupons were moved to accommodate this operational change.

The scaling rate was determined by the slope of a line plotted from mass of scale deposited over time. Note that in all instances the data associated with the first few days of coupon immersion in the liquor was ignored because this data exhibited a very slow scaling rate which was assumed to be brought about by nucleation of the first gibbsite nuclei (St-Jean et al., 2011) and as such was not representative of overall rate of deposition. After this initial induction period, scaling rate (kg/m<sup>2</sup>/day) then become relatively steady and was determined in the linear portion of the scaling rate curves produced. An example of this calculation method is given below (Figure 2).



$$\text{Scale Growth Rate} = \frac{235 - 75}{15 - 7} = 0.02 \text{ kg/day.}$$

$$\text{Surface Area of Scale Coupon} = 0.0185 \text{ m}^2.$$

$$\text{Scale Growth Rate} = 0.02/0.0185 = \mathbf{1.08 \text{ kg/m}^2/\text{day.}}$$

Figure 2. Example of how scaling rate has been calculated.

As previously mentioned, the amount of ScaleGuard added to the 1st washer was varied to determine relative performance over a range of doses. However, it quickly became apparent that the ideal ScaleGuard dose for the Muri 1<sup>st</sup> washer application was around 10ppm and therefore this is where most of the data has been collected.

The scaling rate, as calculated above, versus ScaleGuard dose (ppm) is presented in Figure 3, for each individual scale coupon placed into either of the two 1st washers treated.

There is a clear dose response evident with optimum performance at or around the dose of 10ppm. It is also clear that at a given dose there is also some variability which is most likely dependent upon the operating condition of the washer tank and varying mud and liquor conditions for the duration of time of coupon immersion.

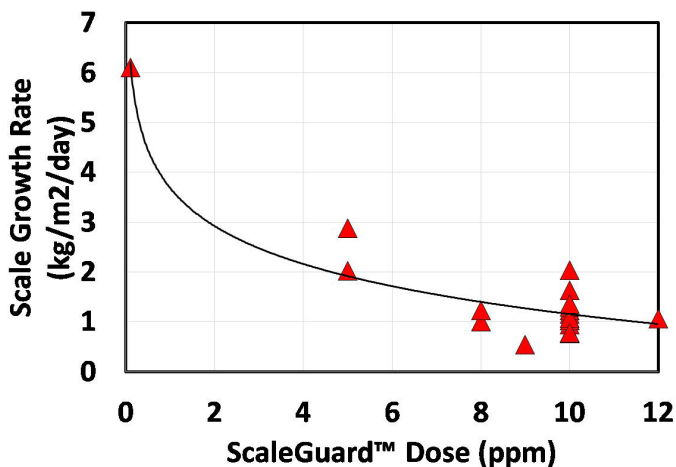


Figure 3. Scaling Rate versus ScaleGuard dose.

The new 1st washer operated for 197 days without incurring any “scale event” and was halted in its operation by premature rake failure caused by a mechanical issue with the rake drive mechanism.

The final thickness of scale after the 197 days of steady operation was determined by site personnel to average around 300mm.

Based on coupon data a 10ppm addition rate has resulted in a 60 - 80% reduction in scale formed whereas based on the actual scale deposited on the wall of the tank itself the reduction in scale formed is more like around 40%.

Photographs of both the untreated and treated scale that has formed on the coupons are presented in Figures 4 and 5. Visual inspection and interpretation of the two scales formed on the coupons suggests that when ScaleGuard is in use, the scale appears to be less porous or less open with fissures than the scale formed without ScaleGuard. The scale formed when ScaleGuard is in use

appears to be denser or more bound together.

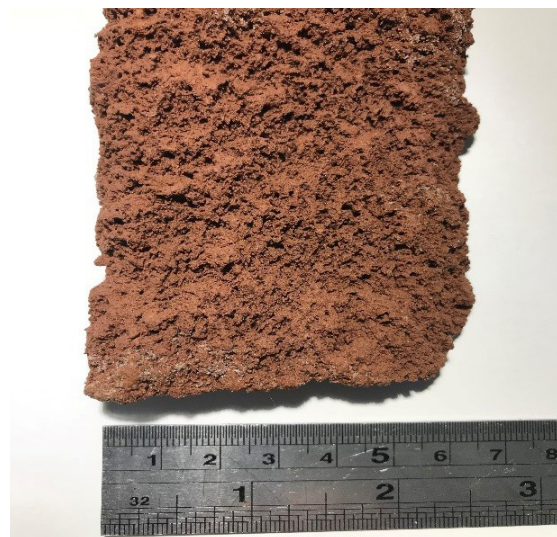


Figure 4. Untreated Scale after 2 days.



Figure 5. Treated Scale after 15 days.

The previously used and treated 1st washer was returned to 1st washer duty. This particular washer was in duty as a 1st washer for a total of 200 days and as a 2nd washer for 197 days, a total of 397 days before being taken offline for descale. The ScaleGuard treatment was only applied when this washer was utilised as 1st washer. This washer has not incurred any “scale events” throughout its entire combined duties.

Figure 6 shows the thickness of the scale on the wall of the treated 1st washer. This scale is typically 40% lower in thickness than that experienced with untreated duty.



Figure 6. Wall Scale of the 1st Washer.

#### 4. RETURN ON INVESTMENT (ROI)

The addition of Nalco Water ScaleGuard to the liquor zone of a 1st washer has provided a significant reduction in scale growth.

The return on investment for the treatment program will be a combination of the following benefits;

1. Extended 1st washer life.
2. No “scale events” leading onto improved U/F density and caustic recovery.
3. Improved vessel hydraulics resulting in maintained washing efficiency and reduced flocculant demand.
4. Shorter descale time leading onto quicker turnaround time and ongoing caustic recovery.
5. Although not measured in this instance there is expected to be a reduction in liquor reversion via increased liquor stability.

#### 5. CONCLUSIONS

The use of Nalco Water ScaleGuard to lower the amount of scale growth in 1st washers has been proven.

The ScaleGuard program allowed Muri operations to run their 1st washer over an extended period without incurring any “scale events.”

The time to descale this 1st washer was also monitored and descale time was determined to be a total of 48 days. This is a reduction in descale time of 12 days, or 20%, over previous descale times for a first washer of typically 60 days.

Scale deposition onto the walls of the 1st washer was reduced by 40% compared to historical data from previous 1st washer campaigns.

Descalation time was reduced by 20% given that the volume of scale required to be removed is significantly less.

Reversion induced alumina loss is expected to be reduced with the use of ScaleGuard.

#### 6. REFERENCES

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