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Scale Formation Control on Lead Washers

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ABSTRACT

Scale formation is one of the most critical challenges to control the mud settling performance in a lead washer and to extend the vessel life. The first impacts refinery throughput and operational costs, with high flocculent usage and poor caustic recovery. The second is directly related to maintenance costs. Rio Tinto Yarwun alumina refinery has been working to improve the performance of its lead washers through a series of improvement projects with successful results. In order to address the scale formation issue, the Nalco Water ScaleGuard™ program was trialled in the plant with promising results. This paper describes the method applied for the plant trial and its results.

1. INTRODUCTION

Alumina refineries are capital intensive processing plants, due to high raw material and maintenance costs. Part of the latter expenditure comes from equipment turnarounds, where maintenance and cleaning activities take place, resetting pipes, valves, pumps and vessels, like precipitators, digesters and settlers in preparation for another cycle in service. The maintenance of these vessels also requires high risk work including high pressure water blasting methods which have contributed to fatalities in the industry.

The mud washing area has a number of counter current washers, typically called washers, which the primary function is to recover caustic and alumina from the residue before its final disposal. The washers experience alumina scaling deposition on walls, feedwell and rake mechanisms. Lead washers are the most severely impacted vessels by alumina deposition due to the high scaling rates during service. Turnaround processes on these vessels are significantly impacted by the thickness and hardness of the scale, especially on the internal tank walls.

At Rio Tinto Yarwun alumina refinery many improvements have been implemented in order to minimise the scale formation in the lead Washers. One of these initiatives is the Nalco Water ScaleGuard program. This paper describes the method applied for the plant trial and its results.

2. METHOD

On site laboratory test work was conducted using ScaleGuard to determine the performance of the product to inhibit alumina reversion in the lead washer overflow stream. The observed positive performance of the product led to a plant trial on one of the lead Washers at Yarwun using addition rates from 6 to 10ppm.

Baseline data collection and scale deposition rate monitoring was carried out during two periods before and after the trials when product was not dosed to the vessel (blanks).

The scale deposition rate in the field trials was measured by two methods:

a) Deposition on steel coupons suspended in the clear liquor zone of one of the lead Washers during each test

b) Deposition inside a 500mm piece of 25mm diameter steel pipe through which the overflow of that vessel was continuously flowing at a constant rate during each test.

Figure 1. Side stream overflow pipe arrangement

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For each control and trial dose rate, a new coupon and side stream overflow pipe were installed.

The criterion for success was to achieve a 60% reduction in scale growth at a ScaleGuard dose rate of 6ppm +/- 20%.

3. RESULTS AND DISCUSSION

3.1 SCALE COUPONS

The mass and thickness of scale growth on coupons placed in the lead washer during each phase of the trial were taken at frequent intervals.

Figure 2 outlines the mass of scale vs time in the lead Washer coupons at the various trial conditions.

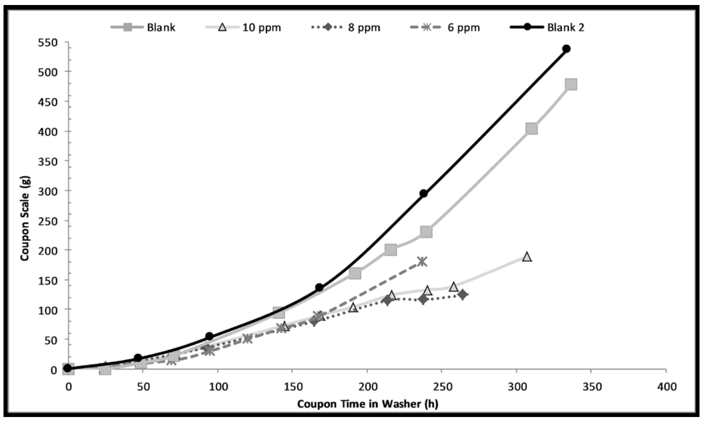

Figure 2. Coupon Scale Growth vs Time

While the impact of the ScaleGuard dosing on the coupons results are evident, it should be noted that the location of the coupon inside the tank was limited to existing hatches on the tank roof. No work was conducted to determine if dosing location relative to coupon position was optimum to give the best results from scale coupons.

The rate at which scale grew on the various coupons is illustrated in Figure 3. Interestingly the growth rate on the untreated coupons continued over time, while there is a plateau observed in both the 10ppm and 8ppm trial data at around 0.55 – 0.6 g/h. This suggests the benefit of ScaleGuard treatment for these tests would increase with time and the success criteria met, if the trials continued on trend for a longer period.

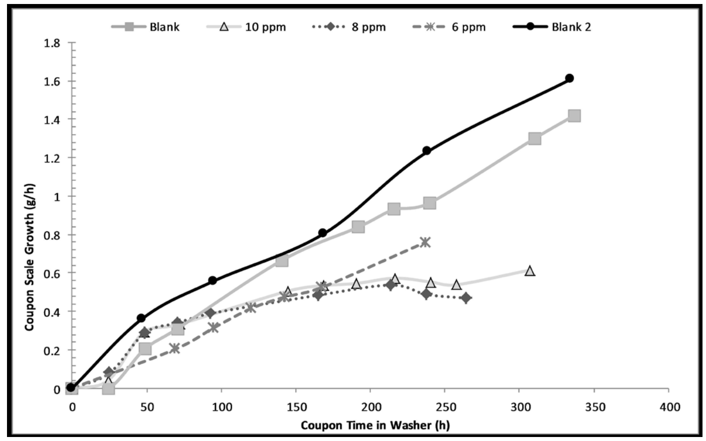

Figure 3. Coupon Scale Growth Rates

ScaleGuard dosing was interrupted on two occasions during the trials, due to two pump trips.

During the 8ppm phase, a 7h dosing outage was discovered on 21/1/16 (Between 67 – 74h).

During the 6 ppm trial a 21h outage occurred between 124 – 145h. Both were the result of power failure on the dosing unit.

It is unclear the impact these outages had on the respective coupon results, however both appear to coincide with increases in the scaling rate noted in the overflow pipe measurements (See 3.2 below).

Figure 4 shows a photograph of the scale coupons following each trial phase. Although there are some differences in the trial phase durations, the contrast between treated and untreated is significant.

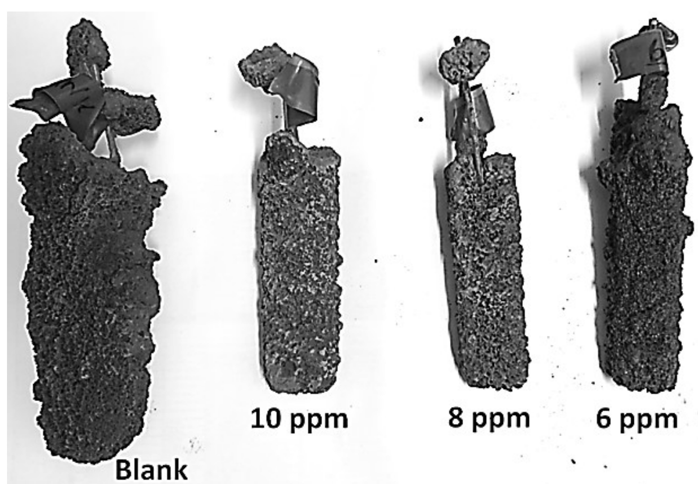

Figure 4. Scale coupons following each trial

3.2 OVERFLOW PIPE SCALE RESULTS

In addition to scale measurement via coupons, the performance of ScaleGuard was measured in a side stream of the washer overflow. For this, a continuous flow of 40L/min was diverted and passed through a 500mm long section of 25mm diameter steel pipe. This flow was checked and regulated daily to ensure the velocities in the pipe for each test were the same.

The target velocity was set to being similar to that in the washer overflow line during normal operation.

The scale deposition was measured through changes in the mass of the pipe at various stages through each trial phase. The results are shown in Figure 5 below.

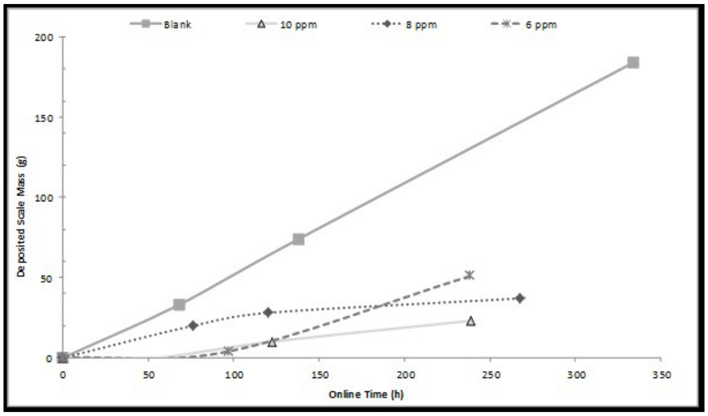

Figure 5. Overflow pipe scale growth

Figure 5 outlines the reduction in scale deposition on the overflow pipes compared with the untreated blank.

The valves used to regulate the flow for the side stream needed minimal or no adjustment through the course of the dosed trials however the blank struggled to maintain flow and the valves quickly became difficult to operate (and eventually seized) due to scaling.

It was for this reason that the entire system had to be replaced before the first of the dosed trials, i.e. seized up before the first 2 weeks. By contrast, no parts required replacement for the entire time ScaleGuard was added at various doses i.e. over 4 weeks of continuous use.

It was intended to do another blank scale pipe measurement along with the last blank coupon test. This was to start approximately 1 week after ScaleGuard dosing had ended. However, by then it was again found that the regulating valves had seized, and the line restricted due to scale formation.

These observations provide further qualitative evidence that the ScaleGuard was effective at inhibiting scale deposition in the downstream pipework.

Interestingly, the scaling rate change (gradient shift) in the trends in Figure 5 above for both the 8 and 6 ppm trials coincide with the interruption in chemical dosing in each phase outlined in section 3.1. In each case, the interruption coincided with an increase in measured deposition. That is before (and just after) the first measurement in the 8ppm trial and for 21 h in between the second and last measurement in the 6ppm trial.

Given the infrequent measurements of the pipe mass during each trial it is difficult to draw clear conclusions as to what influence the dosing interruptions had on total scale deposition.

Figures 6a to 9b show a view looking inside each pipe (from both ends). This provides some insight as to the differing appearance and amount of deposition.

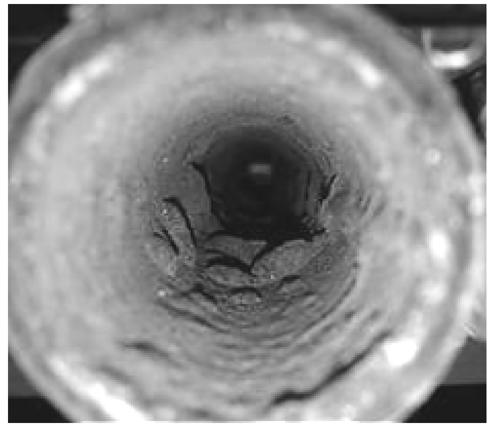

Figure 6a. Pipe – Blank – Inlet view

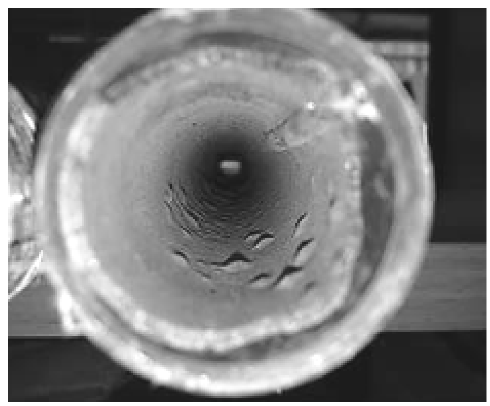

Figure 6b. Pipe – Blank – Outlet view

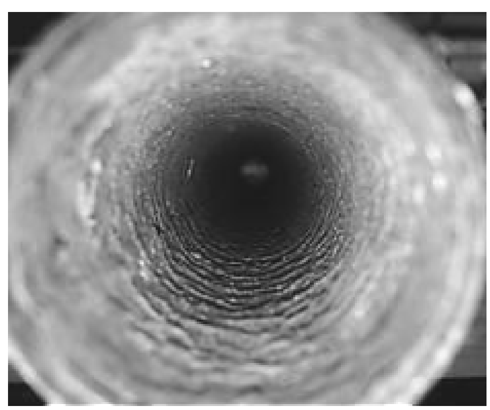

Figure 7a. Pipe – 10 ppm – Inlet view

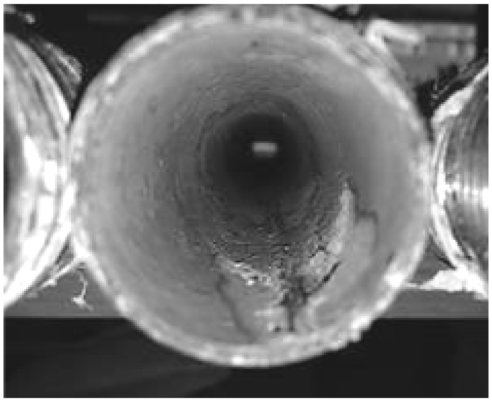

Figure 7b. Pipe – 10 ppm – Outlet view

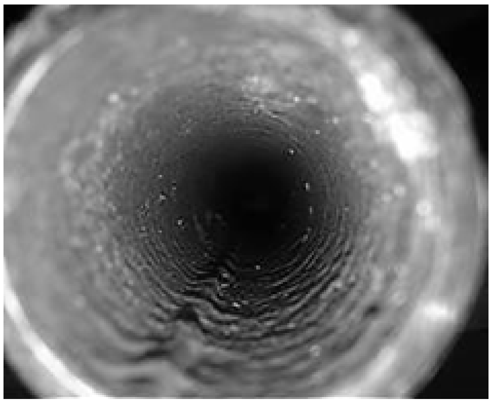

Figure 8a. Pipe – 8 ppm – Inlet view

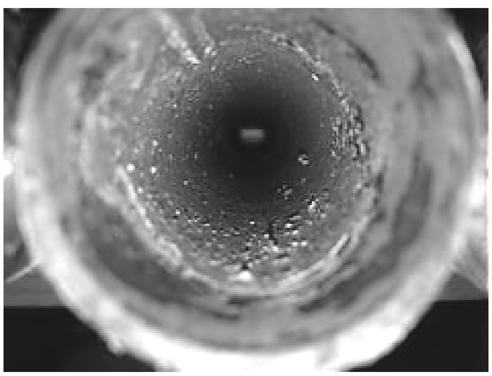

Figure 8b. Pipe – 8 ppm – Outlet view

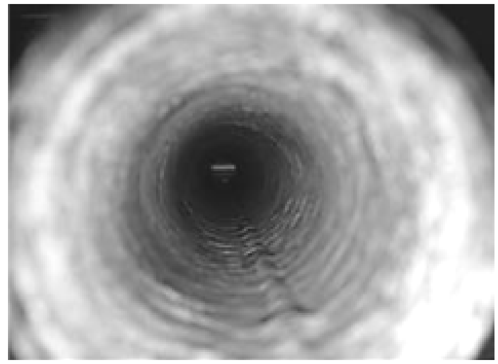

Figure 9a. Pipe – 6 ppm – Inlet view

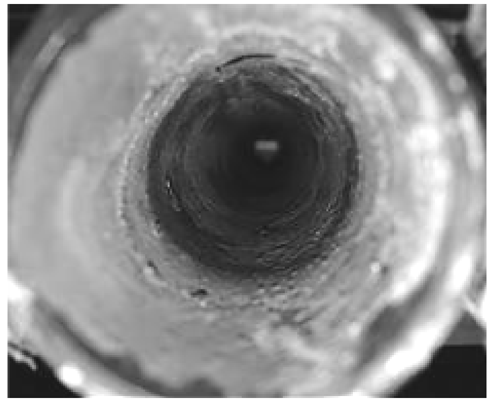

Figure 9b. Pipe – 6 ppm – Outlet view

4. CONCLUSION

- Nalco Water ScaleGuard was successful at inhibiting scale formation on both scale coupons in the tank and in the overflow piping system.
- The pre-trial success criteria of 60% scale reduction at 6ppm +/- 20% was met as measured by the side stream overflow pipe. An apparent scale inhibition vs ScaleGuard dose was observed during the various trial phases. This needs to be confirmed in further trials.
- Scale reduction measured by the in-tank coupons was between 30 – 60% on a mass basis for doses between 6 – 10 ppm. The results for the 8ppm and 10ppm trials were very similar (with 8ppm being slightly better than the 10ppm test) via this measurement technique. This differed to the overflow pipe results, suggesting in-efficient product mixing or other factors (e.g. vessel interface control) may have influenced the coupon results.

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