ENVIRONMENTAL NOISE UPDATE AT AN ALUMINIUM SMELTER

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Abstract

A progressive noise mitigation programme has been implemented at Boyne Smelters Limited (BSL) over the last three years. Sixteen (16) new impellers were designed and retrofitted into the existing Gas Treatment Centre (GTC) fan casings. This retrofit was a challenge in its own right as the smelter is unable to be shut down and the retrofit had to occur with the plant running. Additionally, eight (8) new rectiformers, specified to be quieter than existing units, were purchased and installed to replace existing rectiformers on Reduction Lines 1 and 2 (L1 & L2). The latest works include the installation of trial noise mitigation schemes on the five (5) Reduction Line 3 (L3) rectiformers including a sound wall on one unit. The paper will outline the possible future paths that may be required to ensure that BSL continues to meet community expectations regarding noise emissions.

Introduction

Boyne Smelters Limited (BSL) has been producing primary aluminium since 1982 using Reduction Lines 1 and 2 (L1 & L2). In 1997, an expansion program with a new Reduction Line 3 (L3), initially increased production to a total of 490 000 tonnes/annum. Current production is around 540 000 tonnes/annum. As part of the 1997 expansion program, BSL planned to carry out some noise mitigation works to the reduction L1 and L2 Gas Treatment Centre (GTC) fans. There are four fans per GTC and two GTCs at each end (east and west) of L1 and L2. These fans produce low frequency, tonal noise that under certain meteorological conditions can be audible and impact adversely onto the neighbouring community.

The 1993 EIS for the L3 expansion set a $L_{Amax,adj,15minutes}$ noise objective of 42 dB(A).

Due to various constraints and technical hurdles, a number of noise mitigation initiatives that were proposed in 1998 (which included the installation of stack silencers) were not pursued. The main technical hurdle was the lack of available pressure drop within the system to allow for the stack silencers.

Starting in 2001, BSL undertook a complete reassessment of the noise emissions from the plant and mitigation program. The purpose of the paper is to present the projects that have been conducted to date.

Gas Treatment Centre Fan Noise

The noise emissions from the GTCs associated with L1 & L2 of BSL have been suspected to be the dominant noise source from the smelter for some time. A local area plan showing the locations of the GTCs and the local noise monitoring locations is presented in Figure 1.

The opportunity to ‘shut-down’ some or all of these fans is rare and in recent times, has only occurred three times. On 12 June 1992, all the fans (4 GTCs in total) on L1 and L2 were shut down. The October 1992 report [1] following the shut down indicated that there was a 5.6 dB(A) reduction in $L_{A10,15minutes}$ levels at position N1. Most of the reduction occurred in the 125, 250 and 500 Hz octave bands.

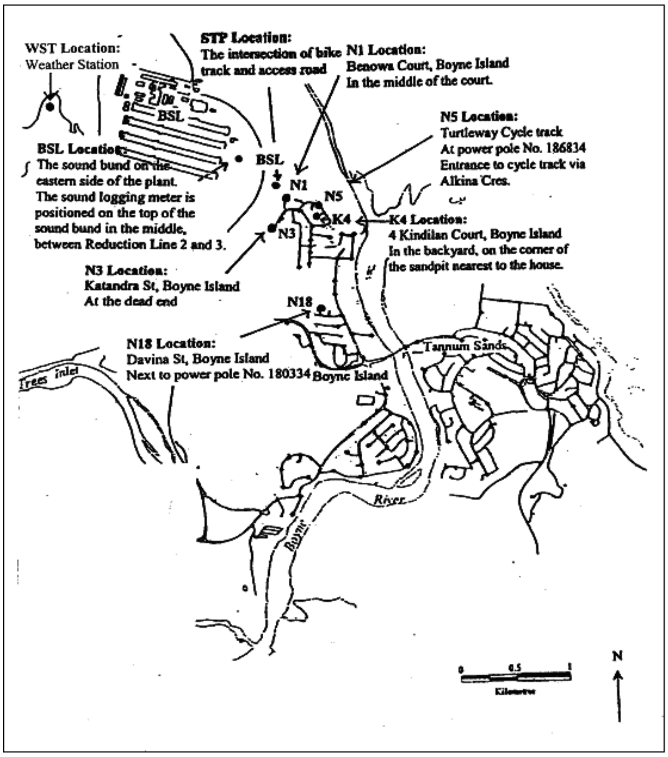

Figure 1 – Locality Plan

The effect of shutting down the GTCs can be simulated by comparing narrow band frequency spectra taken under “favourable” and adverse meteorological conditions as shown in Figure 2 [2]. Favourable conditions occur when noise from the smelter is directed away (or diminished) from sensitive receivers. Adverse conditions occur when noise from the smelter is directed towards (or enhanced) sensitive receivers.

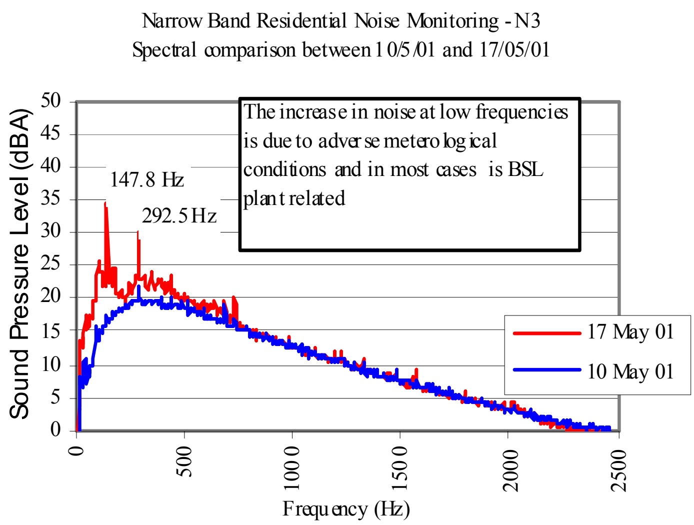

Figure 2 – Spectral comparison at Position N3 - 10/05/01 and 17/05/01 measurements

In 2001 there were two partial shut downs where one GTC was shut down. GTC 2B (southwestern L1/L2 GTC) and GTC 2A (southeastern L1/L2 GTC) were shut down for around 3 hours on 26 October 2001 and 1 November 2001 respectively. Measurements were taken in the community and at the GTC stacks.

In the subsequent report [3], it was concluded that shutting down one GTC reduced overall L_{Aeq} noise levels at the GTC stack by 1.4 to 2.9 dB(A) depending on the measurement location (maximum expected could be argued to be 3 dB(A) since there are two GTC per stack). There was little or no difference in community noise levels when GTC 2B was shut down but a difference of 3.6 to 7.3 dB(A) in the L_{A10} and L_{A90} levels at community locations when GTC 2A was shut down. The reduction in noise levels was principally achieved between the 63 and 630 Hz ⅓ octave bands. The report went on to argue that the effective reduction in the community from the shut down of one southeastern GTC should be considered to be 3 dB(A) and that a 5 to 6 dB(A) reduction was achievable at community locations with the treatment of both GTC 2A & 2B.

QLD EPA Noise Objective

In February 2002, negotiations between BSL and the Queensland Environmental Protection Agency culminated in an agreed noise objective for the BSL Operations, as follows:-

BSL plant noise emissions expressed as $L_{Amax,adj,15minutes}$ at the community locations N1, N3, N5, K4 and N18 are to be less than or equal to 42 dB(A) over any 24 hour period for 90% of the year. Instantaneous BSL plant noise emissions expressed as L_{Amax} at the same community locations are to be less than or equal to 55 dB(A) over any 24 hour period for 90% of the year.

Where $L_{Amax,adj,15minutes}$ is the adjusted average maximum A-weighted sound pressure level and L_{Amax} is the maximum instantaneous A-weighted sound pressure level.

Long Term Environmental Noise Study

In August 2001, two environmental noise loggers were installed in the Boyne Island/Tannum Sands area, as follows:-

- Location K4 - a location where attended noise monitoring has taken place for some years and which is relatively close to the BSL plant; and,
- 18 Neptune Street, Tannum Sands – a location remote from the BSL plant but still representative of a community location similar to that at K4.

The data was collected for three (3) months and compared to weather data collected at two locations, as follows:-

- Radar Hill – Bureau of Meteorology (BOM) weather station
- BSL – BSL weather station

The February 2002 study [4] contained various statistical analyses and of interest were the 3D surfaces (noise level, wind speed and wind direction) obtained for the night time $L_{A90,15minutes}$ period as shown in Figures 3 and 4.

The long term noise monitoring project concluded that, with respect to the BSL noise objective, BSL operations have the potential to adversely impact on the local community under a number of weather conditions, such as most calm conditions, and low to medium wind speeds (less than 5 m/s) from about 202.5° (SSW) to 315° (NW). The noise impact under adverse meteorological conditions show that the noise levels at K4 can be 6 to 10 dB(A) above those at 18 Neptune Street. These results are consistent with attended community measurements. At the time of the study, BSL operations were shown to adversely impact on the nearest Boyne Island community around 25% of the time. There appeared to be little seasonal variation, apart from some noise increase occurring in the evening and nighttime, as monitoring progressed from late winter into early summer. It is likely that this variation is attributable to increased insect, frog or bird activity in the spring and summer months.

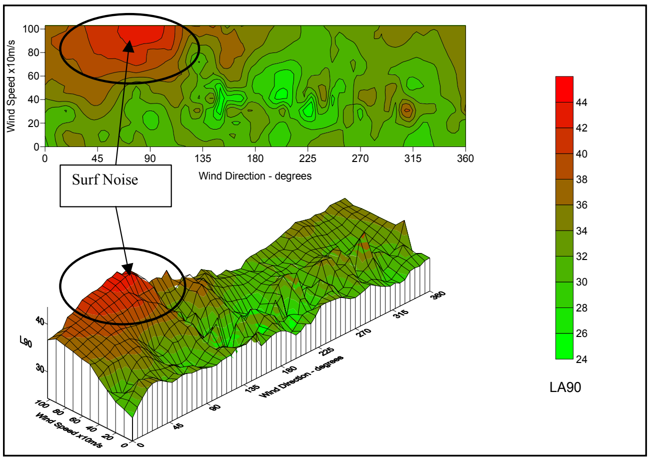

Figure 3 – Long Term Noise Monitoring at 18 Neptune St, Tannum Sands

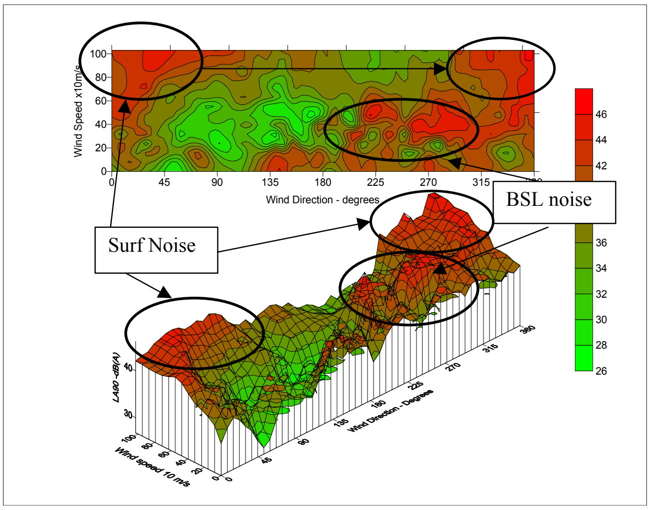

Figure 4 – Long Term Noise Monitoring at Location K4

GTC Impeller Design Study

In late 2001, Howden Australia was commissioned by BSL to undertake ¼ scaled model fan noise and performance testing of (a) the existing GTC fan design (Flakt design) and (b) two configurations of the proposed new impeller. The March 2002 report [5] found that the Flakt impeller was performing below the original predicted performance by approximately 5% on volume, 10% on pressure and 15% on efficiency. The tests showed that replacing the Flakt impeller with a new impeller would allow the original specified performance to be obtained, but that the power consumed, with three fans operating would be close to the motor capacity. Further, the new impeller model showed an overall noise reduction of just under 10 dB(A). Figure 5 shows the ⅓ octave band noise results of the scaled testing.

The advantages of the new impeller design were therefore the ability to provide additional flow and pressure, as well as reduced noise levels. Thus in terms of noise, there were two advantages, reduced noise levels and the ability to design and install stack silencers should they be required.

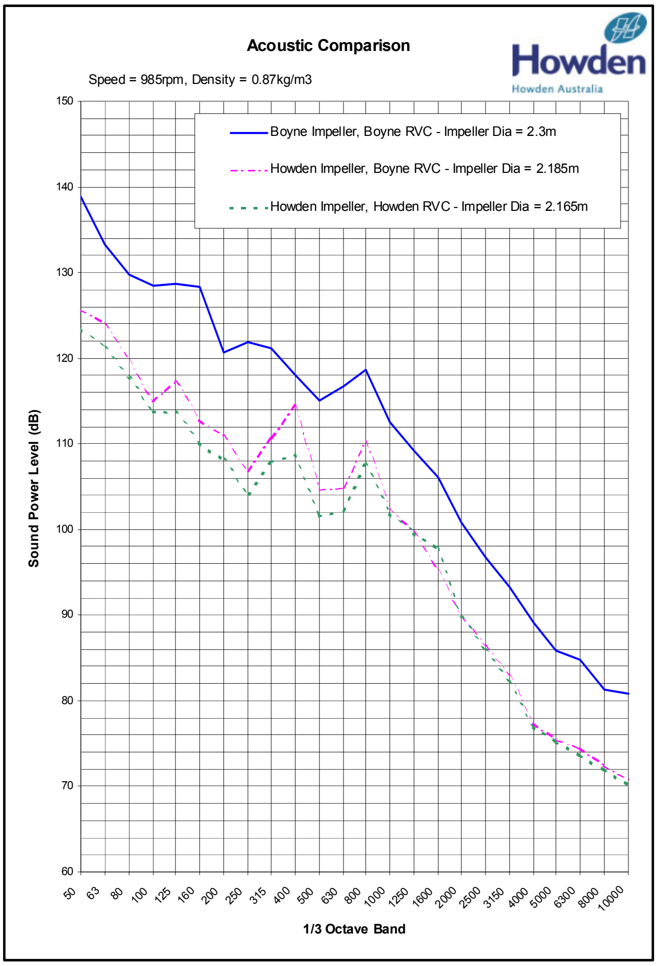

Figure 5 – Noise Comparison of Different Impeller Designs (¼ Model Test)

Post Installation of modified Impellers

In 2002, the eastern L1 and L2 GTC impellers were replaced with the new impeller. Impellers had to be installed one at a time and with the inability to shut down the smelting process, operations continued with 3 out of 4 fans running at full capacity.

Stack noise testing [6] to ISO10494 [7] before and after the installation of the new impellers on the eastern GTC stacks showed the following:-

- Significant reductions (5 to 10 dB(A)) in broad band energy from 250 Hz to 2.5 kHz;
- A 6 dB(A) overall reduction in sound power level at the stack outlets;
- An increase of up to 5 dB(A) in the 200 Hz ⅓ octave band due to the change in Blade Pass Frequency (BPF) of the fans; and,
- A reduction in BPF harmonics generated by the new impellers as compared to the previous impellers.

Figure 6 presents the change in narrowband frequency noise spectra at one position on an eastern GTC stack.

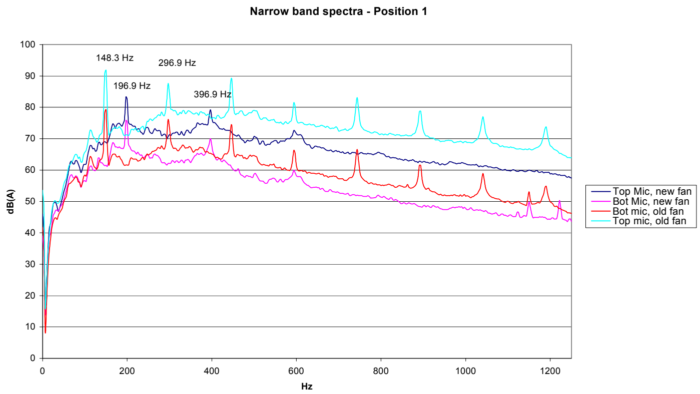

Figure 6 – Narrow band spectrum for Position 1 (modified and original impellers)

Further community noise measurements showed that the influence of the western GTC fans on the community noise remained significant. Given the successful noise reduction at the eastern GTC fans, the decision was made to retrofit the modified impellers on the western GTC fans as well. This work was finalised in early 2004.

Community noise surveys are being undertaken to assess the effect of the change in the GTC fans and to determine if additional noise reductions are necessary. It is expected that this assessment will be completed by the end of 2004.

Rectiformers

Other noise sources with the potential for adverse impact on the community include the rectiformers for L1, L2 and L3. In 2000, BSL initiated a $80 million replacement program for the L1 and L2 rectiformers. Following an assessment study [8], BSL requested a $400,000 design improvement for reduced noise levels from the new Fuji rectiformers. A subsequent study [9] showed that the new L1 and L2 rectiformers do not have the potential to adversely impact on community noise levels or character.

The L3 rectiformers have an adverse impact on some community locations in terms of noise levels and character. A current study is ongoing [10], with the assessment of a trial 4.5 m noise wall and a design investigation into noise absorption lining of the enclosure.

The L3 rectiformers are located on the northern side of the L3 reduction line. They are located within concrete enclosures with an open frontage that is in the general direction of sensitive receivers. 50 Hz and harmonic tones are detectable at these receivers, as shown in Figure 7. A previous study [8] has shown that there is a strong likelihood of reinforcement (standing waves) of 50 Hz and other harmonics within the existing enclosure.

Figure 7 presents the variability in the noise spectra for various locations within a rectiformer (RF33) bay. At the rear of the rectiformer there is more high frequency content which controls the overall noise levels. However, at low frequencies the distribution is more uniform and the presence of standing waves is confirmed by noise mapping of ⅓ octaves (Figure 8).

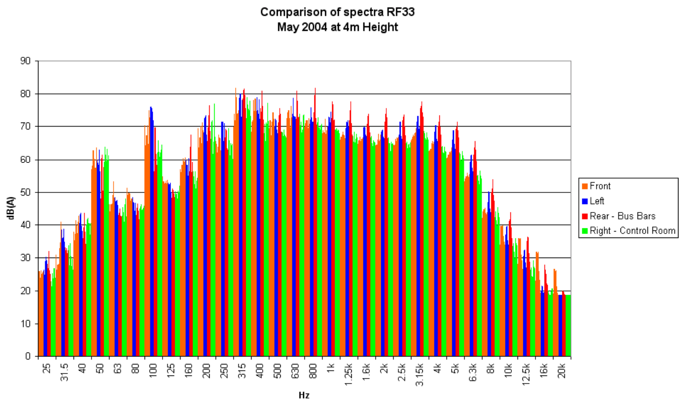

Figure 7 – Third octave spectra comparison at various rectiformer (RF33) locations

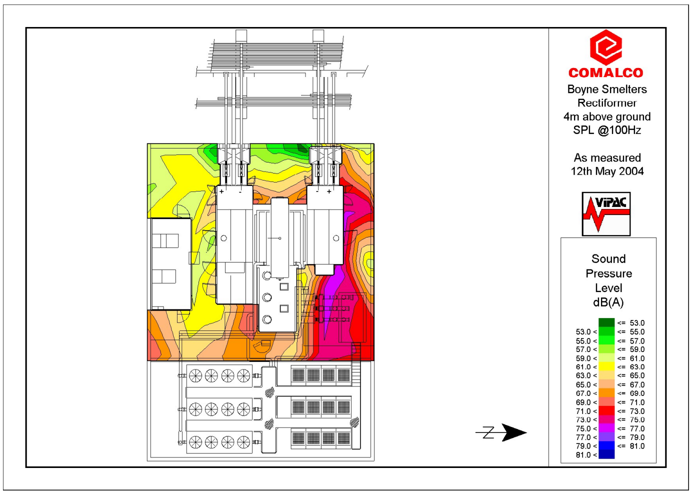

Figure 8 – 100 Hz contour map for rectiformer (RF33) at height of 4m

The 4.5m wall has been designed to provide shielding to sensitive receivers but also has the effect of directing the noise upwards given that the enclosure becomes effectively four-sided. The additional wall also has some effects on the standing wave environment. Figure 9 shows the effect of the wall on the overall noise levels within the enclosure for RF33.

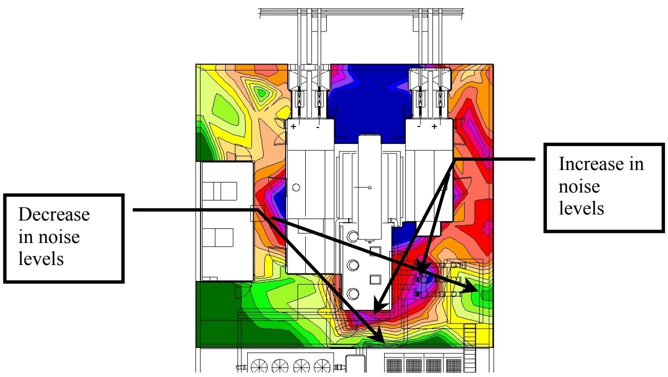

Figure 9 – 100 Hz contour map for rectiformer (RF33) at height of 4m

It is expected that under neutral meteorological conditions, the noise impact of the L3 rectiformers would be reduced. There is however the risk that under "adverse" meteorological conditions the noise impact of the L3 rectiformers would remain. An ongoing study is looking at using an absorptive lining within the enclosure to reduce the "reverberant" noise levels and "detune" the geometric reinforcement (standing waves). This design study is expected to be completed by the end of 2004.

Conclusions

This paper has demonstrated the ongoing efforts by BSL to reduce environmental noise impacts. The complexity of some of the noise mechanisms has required sophisticated analysis techniques to develop a mitigation strategy. Already there is anecdotal evidence that suggests that there has been a reduction of impact at the community sensitive receivers. Additional noise monitoring over the winter months will allow the assessment of that reduction.

References

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[6] Vipac Engineers and Scientists Ltd, "Noise Assessment – Post New Fans Eastern GTC's", Report No. 746000_TRP_002089_BB, August 2003.

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