Pipeline Blowdown Noise Levels

James Boland[1], Henrik Malker[2], Benjamin Hinze[3]

[1]SLR Consulting, Acoustics and Vibration, Brisbane, Australia
[2]Atkins Global, Acoustics, London, United Kingdom
[3]SLR Consulting, Acoustics and Vibration, Brisbane, Australia

ABSTRACT

SLR Consulting Australia Pty Ltd (SLR) was engaged to model and measure environmental noise emission levels from gas pipeline blowdown events. Noise measurements taken during the events showed the noise to be broadband, generally steady-state, and to also have a determined source sound power level (SWL) of 168 dBA. The measured SWL matched theoretical predictions using jet noise equations for supersonic jets, especially at the initial stages of the blowdown with the highest pressure differentials. Far field measurements were also taken at multiple locations with a source noise level reaching 88 dB, (LAmax) measured at a location 2.6 km from the source.

The opportunity to measure such a loud environmental noise event allowed for an investigation into the application of the CONCAWE algorithm in SoundPLAN with regard to noise predictions over large distances from the source, as is commonly required in the context of noise modelling for the gas industry. The results of the investigation into large distance CONCAWE based predictions are discussed.

1. INTRODUCTION

An 80 km long section of gas pipeline was to be cleared of methane gas through a blowdown (venting) process, to allow for a planned hot work maintenance activity. The gas in the pipeline was at an operating pressure of approximately 13,000 kPag. There was one blowdown vent at each end of the pipeline and both vents were opened at the same time.

SLR was engaged to model and monitor noise emission levels from the blowdown. The initial prediction of the noise emission level was undertaken using a spreadsheet model “Worksheet” that was developed by Nelson to complement the NASA Reduced-Noise Gas Flow Design Guide (Nelson 1999). The Worksheet provided a predicted sound power level (SWL). The spreadsheet model predicted an initial SWL of 168 dBA and the prediction spectra was considered to be broadband, with no expected tonality. The noise level from the blowdown was expected to be generally steady-state for two (2) hours after the blowdown commenced. The predicted SWL was then used in a SoundPLAN environmental noise model to assess the noise impact at the surrounding noise sensitive receivers. Noise measurements were then undertaken during the blowdown to verify the environmental noise model.

The CONCAWE noise propagation modelling method was originally intended for use out to a distance of 1 km from an industrial facility noise source. At distances greater than 1 km it was reasoned that noise contribution from such sources would not be significant when compared with the existing background noise environment. The coal seam gas industry operates in regions where there are very low background noise levels and often involves plant items that operate 24 hours a day. As such, it is not uncommon for industrial noise emissions at night-time to be clearly audible at receiver locations at distances greater than 1 km from the source. The CONCAWE noise propagation modelling algorithms are based on a study of noise emission from oil industry infrastructure, undertaken in the 1980s, which describes modelling at distances of greater than 1 km as a limitation of the model.

This paper outlines the results of a comparison of measured noise levels with noise level predictions obtained using the CONCAWE algorithm within SoundPLAN at distances of up to 7 km.

2. CONCAWE

CONCAWE (The Conservation of Clean Air and Water) is an oil industry study group that was established in 1963 to carry out research into environmental issues relevant to the oil industry. The CONCAWE noise propagation modelling method is based on the results of a study undertaken by Acoustic Technology Limited, on behalf of CONCAWE, into the propagation of noise emission from oil industry infrastructure. The CONCAWE noise model has since been widely adopted and is made available within the SoundPLAN noise modelling software.

3. BLOWDOWN INFRASTRUCTURE DETAILS

The section of gas pipeline for the blowdown was an 80 km long buried steel pipeline of 600 mm diameter. The blowdown vent outlets valves were 183 mm diameter and mounted in a 250mm ID steel riser pipe that extended to 3.0 m above the ground. There was one identical vent at each end of the pipeline section and each vent was planned to be opened at exactly the same time. The vents were located in a rural area with the nearest residential receivers located at an offset distance of approximately 3 km from the nearest point to one of the vents. The blowdown vent arrangement was the same at each end of the pipeline and is shown below in **Figure 1**.

Figure 1 Blowdown valve arrangement

Figure 2 below shows a photograph of the blowdown approximately fifteen minutes after it commenced. The photograph was taken at 250 m from the vent shown in **Figure 1**. The gas plume was estimated to have been approximately 40 m high.

Figure 2 Western Blowdown Vent

4. NOISE MEASUREMENT METHODOLOGY

Unattended noise loggers were installed the day before the blowdown at a mix of locations that included sensitive receiver locations and other intermittent locations of interest, purposely selected to gather data to inform this study. During the initial stage of the blowdown, operator attended measurements were undertaken close to one of the vents and then at increasingly larger offset distances as time allowed.

4.1 Equipment

Unattended noise monitoring was undertaken using SVAN 957 and ARL EL-316 noise loggers. Operator attended measurements were undertaken with a B&K 2250 Sound Level Meter. The equipment all held current calibration certificates and no significant drifts were detected during any of the routine field calibrations.

5. NOISE MEASUREMENT RESULTS

The results of the unattended and attended noise measurements collected during the initial stages of the blowdown are shown below in **Table 1**. The weather conditions recorded during the measurement period are presented in **Section 6.2**.

Table 1 Measured Noise Levels

Location	Distance to source *(m)*	dB *(LAeq,1 min)*
E1	100	120
E2	1,850	65
E3	2,640	82
E4	5,990	65
E5	5,670	61
W1	100	121
W2	340	105
W3	2,980	67
W4	4,670	64
W5	5,960	56[1]
W6	7,240	47[1]
W7	2,200	74
W8	3,180	70
W9	4,370	60

Note 1 The shaded levels are estimates only as the data was collected approximately two (2) hours after the start of the blowdown. The estimated levels presented were derived by factoring the measured noise levels according to the expected drop in SWL over time.

The relatively low measured level at Location E2 is considered to be caused by screening from a large section of lightly wooded forest between the vent and the monitoring location. Further detail is contained in **Section 6.1** and **Section 7.2**.

The measurement data was plotted as a function of distance from the vent as presented below in **Figure 3**. Note - the environmental conditions such as ground cover and terrain variability have not been accounted for in this graph. A logarithmic line of best fit has been added for interest.

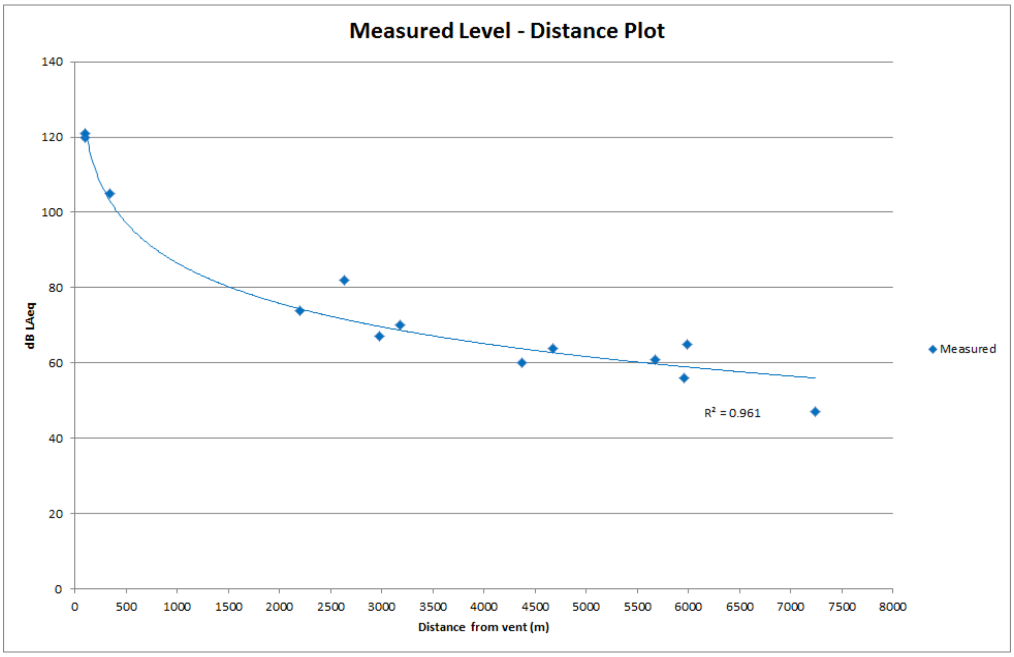

Figure 3 Measured Level – Distance Plot

A measured sound pressure level spectrum at location W1 (100 m from the western vent) is presented below in **Figure** 4.

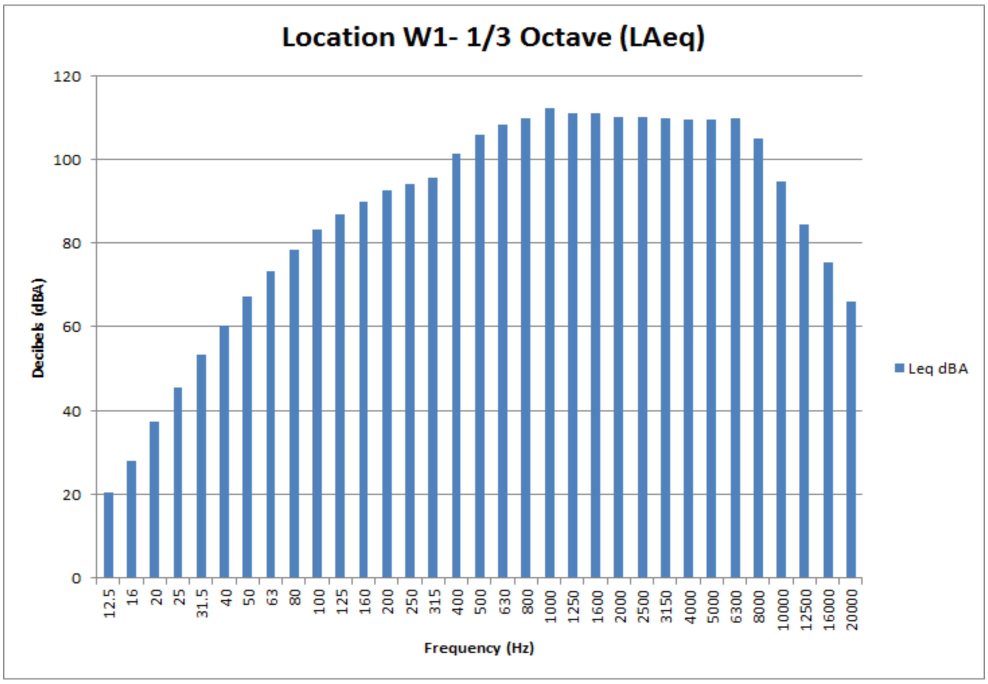

Figure 4 Measured Third Octave Band Spectrum

The determined sound power level (SWL) based on this measurement correlated well with the predicted SWL at the early stages of the blowdown when the pressure differential was highest. It can be seen in **Figure 5** that when the measured pipeline pressure dropped below 5000 kPag that the measured levels diverge below the predicted levels. This anomaly is expected to have been due to limitations of the Worksheet model. A discussion of opportunities for further research into the Worksheet calculation algorithms is included at the end of this paper.

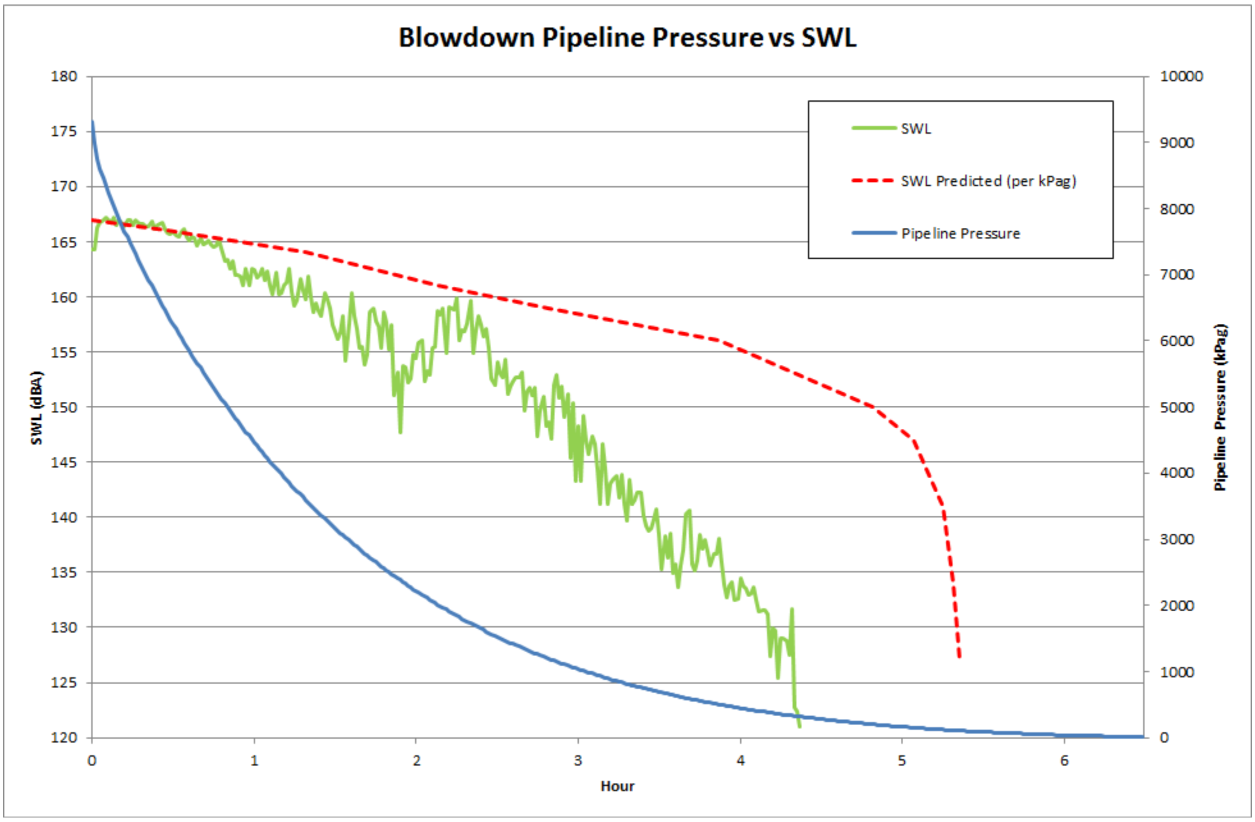

Figure 5 Blowdown Pipeline Pressure vs SWL

6. NOISE MODELLING METHODOLOGY

Noise modelling for the blowdown was undertaken using SoundPLAN (v7.4). The model included the terrain contours, ground cover, meteorological conditions, sources and receiver locations.

6.1 Ground conditions

The ground surface within the study areas varied between open grassland and some sections of lightly wooded forest. There were no significant water bodies within the calculation areas. The photograph in **Figure 6** shows the typical open grassland that was most common between the western vent and the adjacent monitoring locations. Similar ground cover existed between the eastern vent and the monitoring locations to the north-west of that vent.

Figure 6 Ground Conditions – Typical Open Grassland (Location W3)

There was a section of lightly wooded forest between the eastern vent and the Monitoring Location E2 as shown in the aerial image contained in **Figure 7**.

Image source : Google Earth

Figure 7 Ground Conditions – Location E2

The photograph in **Figure 8** shows the typical ground cover and foliage conditions in the lightly wooded forest area between the vent and Location E2.

Figure 8 Ground Conditions - Typical Lightly Wooded Forest (Location E2)

The ground condition parameters were entered to SoundPLAN as Ground Absorption object types and the parameters adjusted according to the observations made during the site visit. The areas of lightly wooded forest (as shown in **Figure 7** and **Figure 8**) were entered into SoundPLAN as a Volume Attenuation Area object type with, an effective height of 7 m.

6.2 Meteorological conditions

The weather conditions during the blowdown event were monitored using a Vantage Vue portable weather station set up at 2.0 m above ground level. The weather station was located adjacent to Monitoring Location W4, at a distance of approximately 4 km from one of the vents. Weather data from during the eastern blowdown were taken from the closest Bureau of Meteorology (BOM) weather station approximately 30 km away. It should be noted that the east and west blowdown vents were approximately 80 km apart. The weather conditions that were used as input to SoundPLAN, through the CONCAWE input fields, as presented below in **Table 2**.

Table 2 Meteorological parameters

Parameter	East	West
Temperature, *(^oC)*	16	15
Air pressure, (mbar)	1031.5	1025.3
Humidity, (%)	70	77
Wind Speed, (m/s*)*	1.5	0.4
Wind Direction	E	ENE
Pasquill Stability Class	F	D

6.3 Modelled source

The gas vents were modelled as spherically propagating point sources situated 20 m above the terrain. The source height was determined to be the approximate average height of the gas jet. The SWL of the source was determined based on a measured value at a known distance of 100 m from the source. The source SWL spectrum used in the modelling is shown in **Table 3**.

Table 3 Model Source Input

Octave Band *(Hz)*	63	125	250	500	1000	2000	4000	8000	16000	Overall
SWL (dBA)	125	136	147	158	163	164	159	151	135	168

6.4 Modelled receivers

All receiver locations were free field and set at 1.5 m above the terrain. Note - Images that display the geographical locations of the sources and receivers have been purposely omitted.

7. NOISE MODELLING RESULTS

7.1 Overall Results

In **Figure 9** below, the noise modelling results are compared graphically with the noise levels measured during the blowdown event.

Figure 9 Level – Distance Plot

It can be seen from the results in **Figure 9** that the model over predicted the noise levels with increasing deviation as the distance from the source increased. Note - The data from Location E2 has been excluded from the graph in **Figure 9**, as the physical path properties between the source and receiver location was significantly different from that of all the other monitoring locations.

7.2 Location E2

Location E2 was the only receiver location affected by the areas of lightly wooded forest and was selected for the purpose of collecting data relating to the attenuation of noise passing through a lightly wooded forest. The User Defined attenuation spectrum for foliage was applied, within SoundPLAN, to the areas of lightly wooded forest which resulted in the model over predicting the received noise level by 10 dB. Increasing the amount of attenuation by means of adjusting the User Defined attenuation spectrum resulted in only small changes to the predicted receiver level at location E2. Keeping the default spectrum attenuation setting and adjusting the effective height of the trees to 40 m resulted in an exact correlation with the measured data. However, the actual effective height of the trees was observed to be approximately 7 m. There is scope for some further study in this area, as discussed at the end of this paper.

8. CONCLUSION

The high predicted broadband type SWL, and the fact that the source was expected to be generally steady-state for at least two hours, presented SLR with the opportunity to investigate the application of the CONCAWE algorithm with respect to noise propagation predictions over large distances. A comparison of the measured levels with the predicted levels has indicated that, in this instance, SoundPLAN over predicted the noise levels with increasing deviation as the distance from the source increases. However with the correct weather data and ground condition inputs a correlation of ±2dB is still achieved at a distance of up to 2.5 km. At a distance of 7.0 km a prediction correlation of ±3 dB was achieved.

FURTHER AREAS OF STUDY

1. Predictions obtained with the “Worksheet” calculator that compliments the NASA Reduced-Noise Gas Flow Design Guide seemed to be consistent with the measured data at high pressure differentials during the initial stages of the blowdown. The Worksheet started to over predict as the blowdown proceeded and the pressure differential decreased. There was a noticeable divergence in the data sets as the pressure differential dropped below 5000 kPag. Further study is planned to better understand what caused this divergence and possibly to use the measured data to refine the calculation algorithm provided in the Worksheet.
2. It was noticed during the modelling exercise that varying the ground conditions and environmental parameters had a significant effect on the modelling results as the distance from the source increased to beyond 4 km. Further study is planned based on empirical methods in order to better understand the significance of this behavior.
3. The default User Defined attenuation spectrum provided in the modelling software did not provide enough attenuation to enable correlation with the measured noise level at the receiver location E2. The receiver location was selected intentionally for the purpose of collecting data relating to the attenuation of noise through areas of forest, as the gas industry infrastructure is often situated within areas that contain significant sections of this type of ground cover. The model was unable to accurately predict the noise level at this location. Further study is planned, based on a literature review and possibly using empirical methods, to better understand the actual attenuation provided by areas of forest and to also learn more about the behavior of the modelling software in this context.

REFERENCES

CJ Manning, Acoustic Technology Limited (Ref AT931), 1981, *The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighbouring Communities – Part 1*, Report 4/81, CONCAWE, The Hague.

Nelson, David A, 1999, *NASA Glenn Research Centre – Reduced-Noise Gas Flow Design Guide*, Nelson Acoustical Engineering Inc.