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NOISE CONTROL AT GAS-FIRED COMPRESSOR STATIONS

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ABSTRACT

Three new gas compressor stations needed noise assessments as part of the planning approval process. ENM and SoundPLAN proprietary noise models were used to predict noise levels at distances up to 1600m. The validity of noise source data and the contribution of acoustical lagging were significant issues. The results from commissioning noise surveys have been used to compare the excess attenuation under calm conditions with that predicted by the two noise models. Experience at site has indicated that vibration isolation of gas piping is desirable for maximum performance and that venting noise is significant.

1. INTRODUCTION

Following the disastrous explosion at Esso Longford near Sale in Victoria in 1998, gas supplies to Melbourne for the 1999 Winter were seriously threatened.

In order to provide security of gas supply from other sources, the Victorian Government authorized the simultaneous construction of the Moomba-Melbourne Augmentation Project (MMAP) and the South West Pipeline Project (SWPP).

This paper is concerned with the noise control issues at the three compressor stations that formed part of the MMAP. These stations were located at Bulla Park and Young in New South Wales and at Springhurst, near Wangaratta in Victoria.

2. NOISE MODELLING

As part of the development approval process, noise assessment was required for all three compressor stations. Whilst Springhurst was a greenfield site, both Bulla Park and Young were existing compressor station sites. The gas turbines were Solar Turbines models and duties as follows.

Table 1
Compressor operating duties

	Bulla Park	Young	Springhurst
Turbine Model	Solar Mars 100	Solar Centaur 50	Solar Centaur 50
Power, MW	11.2	4.3	4.3
Inlet pressure, MPa	4.2	4.4	3.2
Discharge pressure, MPa	6.3	8.6	7.5
Discharge pipe dia, m	0.76	0.3	0.45
Flow ksm^3/hr	519	120	90

Following conventional practice, the individual noise sources at each station were entered into the modelling package, along with ground contour details, source directivities, and receiver locations.

The noise modelling packages used were ENM and SoundPLAN. Typically there were only 15-20 noise sources per site, making the noise modelling fairly straight forward. This was fortuitous, as the timescale for the project was extremely short. The entire project time line was only 7-8 months from ordering to start-up of the turbines.

The noise sources and the overall sound power levels for the Springhurst site are given in Table 2.

Table 2
Source sound power summary

Item	Lw dB(A)	Notes
Exhaust	110	Standard silencer type 17A1
Air inlet	85	With filters and inlet silencer
Compressor	110	Solar Turbines
Acoustic enclosure	112	85dB(A) and close fitting
Process gas cooler	85	Jord
Air compressor	76	
Generator	102	Cat diesel engine
Inlet piping	116-124	Lagged – see text
Discharge piping (before cooler)	118-124	Lagged – see text
Discharge piping (after cooler)	113-119	Lagged – see text
Blowdown vent	86	Vent silencer fitted
Bypass valve	87	No Whisper Trim

3. NOISE SOURCE DATA

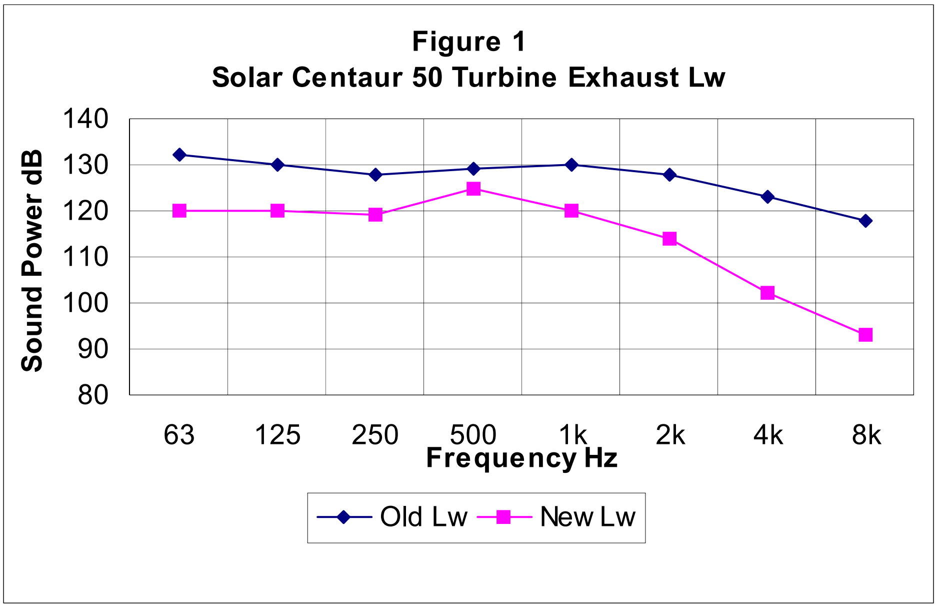
Exhaust noise

To our surprise, Solar's noise data had changed from that used on a previous project [1]. A review of this data indicated that the unsilenced exhaust noise had apparently decreased from Lw 135dB(A) to Lw 125dB(A). There was no corresponding change in the silenced enclosure breakout noise data or the turbine air inlet noise data, both of which would be expected to change if the power rating (and hence noise) of the turbine had changed significantly. The new test data (Solar Ref SPNP/898/M4) had been tested to ISO 10494 but we could not draw any explanation from Solar as to the reasons for the variation [2].

Interestingly what had changed were the exhaust silencer insertion losses, typically reduced by 5-10dB. This resulted in similar overall silenced exhaust levels for versions of the same turbine. The old Solar data had been used on previous Marshall Day Acoustics projects with confidence and Solar could certainly test unsilenced turbines.

Perhaps the real reasons reflected Solar's recognition of the true performance of their exhaust silencers, which had caused headaches in the past for silencer vendors in trying to meet their onerous IL performance requirements.

The old and new unsilenced exhaust sound power data for the Solar Centaur 50 turbine is presented in Figure 1.



Pipe noise

As the total length of above ground piping at a compressor station can often exceed several hundred metres, the radiated pipe noise is a significant contributor to overall noise levels, particularly when stringent noise criteria are involved.

Consequently, the study of pipe noise took considerable effort. It is usually very difficult to obtain good measurement of pipe noise alone, due to the influence of other noise sources, notably valves, compressors and the turbine itself (especially the inlet which has a significant high frequency component).

In this instance, we were unable to conduct measurements at an existing compressor station operating at the same duty, so data from Marshall Day Acoustics' files were reviewed. The following reliable information was available:

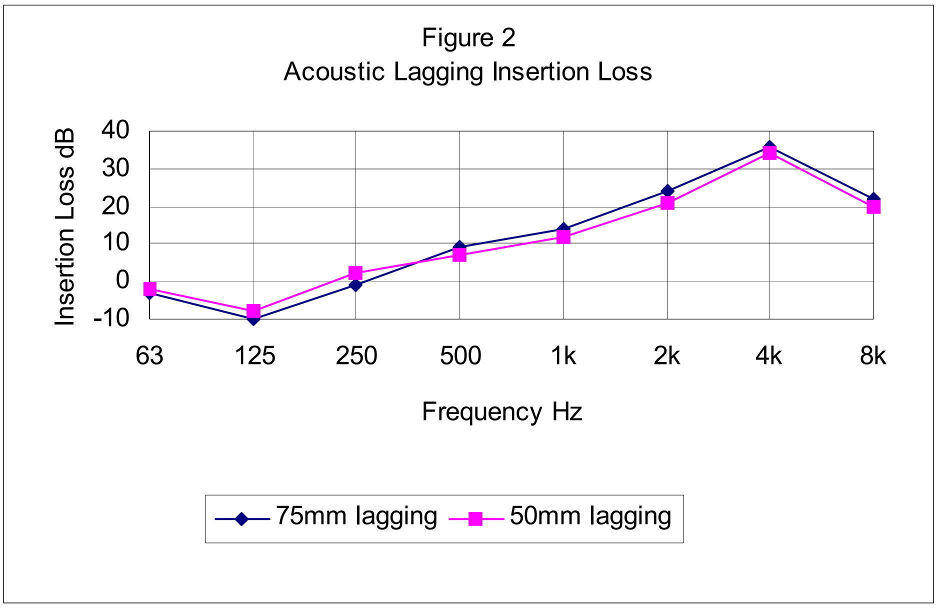
Table 3
Pipe noise data Lp at 1m, dB(A)

Site	Compressor	Inlet	Discharge	Notes
Bulla Park, NSW	Dresser Rand	97	102	Unlagged
Gooding, Vic	Solar Centaur	N/a	76	Lagged
Enneabba, WA	Solar Mars	89	90	Unlagged

Using the method described in Bies and Hansen [3], the measured versus predicted noise levels were compared for the case of the Dresser Rand DR990 units at Bulla Park.

This was an outstanding measurement condition as the influence from external sources was minimal. The turbine and compressor were both located inside a building and owing to the remote site, the pipe was unlagged allowing precise pipe noise measurements. The method in Bies and Hansen appeared to predict absolute noise levels rather poorly, but was considered useful for adjusting the site measurements under alternative operating conditions. This enabled the pipe noise Lw to be determined for each station.

Unsurprisingly, pipe lagging was required at all three sites. Information from HGC in Canada [4] provided excellent information on pipe lagging acoustic performance.



Two alternative lagging options were developed, one nominally 50m thick and with a 5kg/m^2 wrap and the other nominally 75mm thick with a 6kg/m^2 wrap. The densities of the 50mm Rockwool insulation were 65kg/m^3 and the 75mm Rockwool lining was 80kg/m^3. The insertion loss of these lagging alternatives are given in
Figure 2.

4. MODELLING RESULTS

Each compressor station scenario differed in certain ways and similar noise levels could not be expected at the same distance from each. At Springhurst, the client required the EPA criterion (of 36dB(A)) to be met at 550m; this allowed for an easement boundary, where cattle could graze but no future residential development could take place. Typically the nearest residence was a distance of 800-1500m from each compressor.

The results of the modelling for the case of neutral weather conditions are given in Table 4. Generally, there was good agreement at distances over 1km, but in the 500-800m range the results from both prediction models varied .

Table 4
Noise modelling results

Site	Criterion	L_1 predicted level			L_2 predicted level		
		ENM	**SoundPLAN**	**Dist.**	**ENM**	**SoundPLAN**	**Dist.**
Springhurst	L_{eq} 36dB(A)	47	35	550m	26	27	1520m
Young	L_{10} 35dB(A)	36	32	800m	17	19	1590m
Bulla Park	L_{10} 33dB(A)	n/a	33	1000m	29	24	1320m

It was apparent from the program printouts that the differences were due to excess attenuation, ie that due to air absorption and ground effects. SoundPLAN uses the CONCAWE [5] algorithm whilst the ENM algorithm is described by Tonin [6]. The differences that arose are discussed in Section 5 of this paper.

This project gave a good opportunity to study excess attenuation, as EPA compliance required the background noise levels before operation of the turbine compressors to be measured, as well as the noise levels following commissioning. At Bulla Park for instance, the daytime noise level during calm conditions was 19dB(A).

5. MODELLING COMPARISON

At Springhurst (and probably at Young) where commissioning noise tests have been conducted, noise levels exceeded the design criteria by 3-4dB(A). This was due to a number of factors:

- exhaust noise exceeding design by 2-3dB(A)
- enclosure breakout exceeding guarantee by 5dB(A)
- pipe noise radiating from support structures.

The commissioning measurements at Bulla Park, showed that whilst the EPA criterion was met, the predicted noise level of less than 24B(A) under calm conditions equalled the derived value.

As at Springhurst, the turbine enclosure breakout noise exceeded the design value in this case by 17dB(A). Rework to the enclosures at Young and Springhurst was not complex and primarily consisted of:

- grouting the gap between the turbine skid and concrete slab
- correct sealing between the enclosure wall panels and the skid
- replacing damaged door gaskets
- correctly sealing compressor inlet and discharge pipe penetrations
- sealing other penetrations eg cables, bolts.

Table 5
Noise measurement results

Site	Distance	Measured noise levels	Prediction SoundPLAN	Condition
Springhurst	550m	40dB(A)	35dB(A)	Calm
Springhurst	1520m	<30dB(A)	27dB(A)	Calm
Young	800m	40 dB(A)	32 dB(A)	Tail wind
Bulla Park	1320m	25*dB(A)	24dB(A)	Occ N/E wind

* This is an estimate derived from measurements at 660m where the turbine/compressor was audible.

6. EXCESS ATTENUATION

The major differences between the results obtained from the ENM and SoundPLAN models was in the value of the excess attenuation, being primarily air and ground attenuation losses.

As both Springhurst and Bulla Park were low ambient noise level environments and the turbines could be run in the absence of other noise sources, data from these two sites was studied in detail.

A noise measurement at 60m from each site allow the plant sound power to be determined. This can be used to determine the excess attenuation by comparison with the measured noise level at a given distance, when corrected for background noise effects.

The excess attenuation is given in Table 6 in dB(A) and is plotted in octave bands in Figure 3.

Table 6
Excess attenuation dB – calm conditions

Distance	ENM	SoundPLAN	Measured
550m	5	10	10
700m	9	11	7*
1320m	10	14	12

Probably influenced by background

Reference to Figure 3 shows that the results vary according to frequency. In rural situations MDA tends to use a grass cover of 50% to account for the Australian grasses in rural situations, rather than a value of 90-100% which would normally be assumed for "European" grass between the source and nearest receiver.

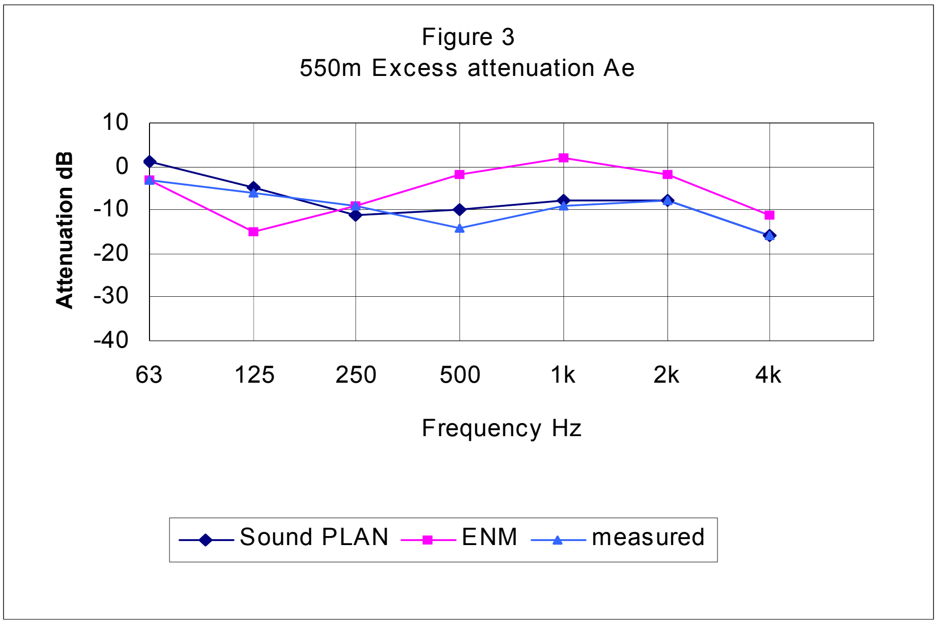
Further work is required to validate the results, as over large distances, and with lower source noise levels, estimates of the excess attenuation at mid frequencies become increasingly difficult and more widely variable.

7. FURTHER CONSIDERATIONS

One of the problems in being engaged for noise assessment purposes only is that practical noise control at the site is often inadvertently overlooked by the client. In this project these were:

Pipe noise leakage

The inlet and discharge piping to the compressor was treated in accordance with the recommendations but an oversight derated its effectiveness. In all cases, the pipe was laid directly on the pipe supports and then lagged. With heavy pipe, including valves and flanges, pipe supports were frequent, often at spacings of 2-3m, especially when both inlet and discharge were supported by a single frame. The pipes were not well isolated from the supports and the pipe vibration was transmitted to the frame via the uninsulated section of pipe. This resulted in significant vibration sufficient to radiate noise.



The installation of an isolation pad between the pipe and frame would have eliminated this problem but practical difficulties prevented them being installed. As the pipe contacts the frame at a line, the point loads are significant. In order to provide adequate isolation, the required pad loading (estimated by Embleton's at 100kPa) necessitated a pad of size 400 x 100mm. Hence each pipe would have required a saddle and load plate to ensure the load was uniformly distributed at each connection point, and proper isolation was achieved. Trials at site indicated that even the most rudimentary isolation system gave reductions of 5-10dB. As most vibration energy was centred around 2-3kHz, at which frequency steel structures radiate sound very efficiently, the benefit of isolation would have been significant.

This form of pipe isolation has been suggested for another compressor project currently under construction for Esso at Longford, Victoria. The cost is estimated at $60 each per pipe support.

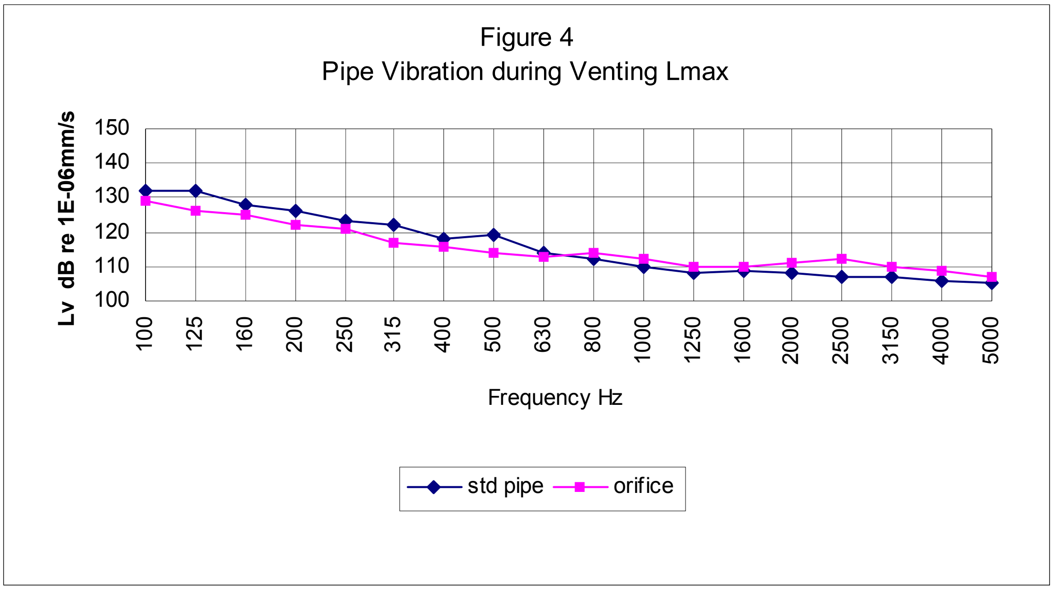
Vibration measurements on the surface of the lagged pipe confirmed that the sound radiation from the pipes was negligible and that the acoustic lagging had performed satisfactorily, although the overall result was limited by flanking at the pipe support.

Vent noise

One noise source that had not been considered in the initial modelling was the emergency blowdown system. Consisting of 80m of unlagged 350dia pipe discharging into an attenuated blowdown vessel. However, its use is infrequent.

Assessed on a sleep disturbance basis, the noise level from the vent only needed to be 105dB(A) but was guaranteed by the silencer vendor to be 75dB(A) at 1m. Our concerns were raised when the local farmer commented that during one blowdown he could hear the venting when operating his tractor and wearing earmuffs. The venting was audible above the tractor diesel engine at a distance of 300-400m.

Subsequent measurements indicated that the noise level at 30m from the blowdown vessel was as high as 106-114dB(A). This was not due solely to the vent outlet but the breakout from the 80m of unlagged vent pipe. Vibration measurements on the discharge of this pipe indicated unprecedented broadband vibration levels on the case of a process pipe. Maximum vibration levels are presented in Figure 3 below. At 3m from the pipe the noise was measured at L_{max} 108dB(A).



8. ACKNOWLEDGEMENTS

This technical information was supplied with kind permission of Transmission Pipelines Authority now GPU GasNet, Worley Australia and Solar Turbines Australia.

9. REFERENCES

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