OVERLAND CONVEYOR NOISE: ENGINEERING TOOLS FOR NOISE REDUCTION

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ABSTRACT

Overland conveyors constitute one of the principal potential contributors to the noise footprint of mining developments, encroaching on human settlements. Design measures to reduce noise on existing conveyors, as well as noise modelling in environmental impact assessment (EIA) studies require an understanding of the key factors and the ability to quantify conveyor noise. Based on the author's experience in conveyor noise problem solving and noise modelling for purposes of environmental impact assessment, the focus of this paper is on field test experience and engineering planning and design tools, rather than controlled laboratory tests or detailed component level design considerations.

1. INTRODUCTION

1.1 ENVIRONMENTAL CONSEQUENCES OF CONVEYOR NOISE

Commonly employed in the mining industry as a mode of product transport, overland conveyors are typically routed through rural or semi-rural areas where it often causes noise disturbance, resulting in noise complaints from village or farm residents. This necessitates the consideration of conveyor noise in modelling and environmental impact assessments of new mining developments or expansions involving overland conveyors. Modelling of overland conveyor noise calls for field test data on actual conveyors and an understanding of the parameters controlling or affecting conveyor noise.

1.2 NOISE CHARACTERISTICS

Based purely on aural impression in the proximity of conveyors, the potential noise impact of an overland conveyor system may easily be underestimated. The physical extent of the noise footprint and levels on noise-sensitive receptors some distance away are magnified by operational, physical and acoustical characteristics.

Operational and Physical Aspects

As a linear source, an overland conveyor generates and emits noise over its entire physical length. With lengths often exceeding 30 km and with constant levels of continuous noise along the entire length, such conveyors almost inevitably traverse through, or pass nearby noise sensitive areas such as towns, villages or farmhouses. No matter how remote or scarcely populated an area is, it is almost impossible to align a long distance conveyor in such a way as to avoid the risk of noise impact on local communities.

Conveyors are typically routed through rural or semi-rural areas with relatively low background ambient noise levels. As such, these areas are more sensitive to intrusive noise.

Running for 24 hours per day, conveyors are audible over vast distances, especially at night when ambient levels in rural areas are typically of the order of 35 dBA.

Acoustic Characteristics of Conveyors

Conveyors are line sources characterised by a noise level which declines at a slow rate with distance (-3 dB compared to -6 dB per doubling of distance for a point source). As a consequence, given a line source and a point source producing the same levels at source (e.g. 3 m distance), the line source will produce higher noise levels at large distances. For example, on conveyor systems noise levels in the proximity of a transfer station are usually considerably higher than the corresponding levels at the conveyor. Notwithstanding, conveyor noise (due to a slower rate of decay) will overtake transfer station noise and dominate at larger distances from the line. Conveyor noise (sound power) is characteristically rich in low frequency content. An example in Figure 1 shows a spectrum measured at 1 m distance from a conveyor running on steel rolls at 4.5 m/s. Due to lower propagation losses, low frequency sound prevails over longer distances compared to high frequencies.

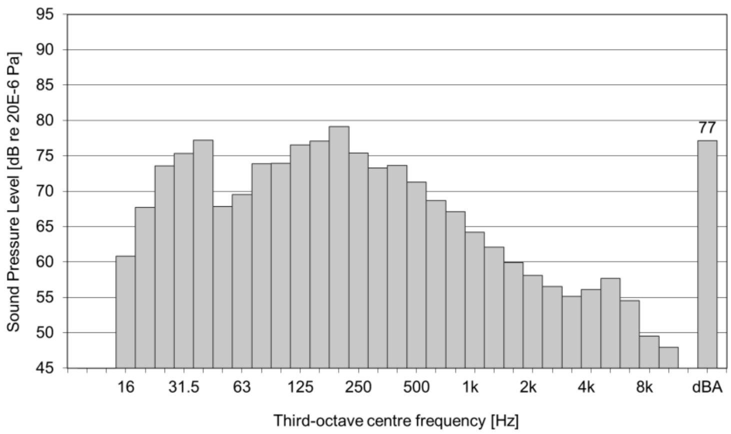

Figure 1. Example of noise spectrum measured at 1 m distance from a conveyor with steel rolls, running at 4.5 m/s

Belt and roll imperfections often generate an audible pulsation in the noise produced by a conveyor system.

Bearing failure produces very high levels of abnormal high-pitched noise. Only one defective bearing may ruin the performance of a long section of an otherwise quiet conveyor.

An auxiliary source of noise often cited as a nuisance in complaints relating to conveyors is the start-up alarm.

Empty conveyors are noisier (typically 2 dB) than conveyors running with load.

2. CONVEYOR NOISE GENERATING MECHANISMS

Conveyor noise is generated and affected by a number of mechanisms. In belt-roll interaction, noise is produced by the belt impacting radially on the roll, by belt and roll linear movement at the contact point and by belt drive friction noise. Noise is also produced individually by rotating rolls and by the moving belt. Roller noise is produced by stress and strain in the roll shell by the bearings, the seals, the axis and supports. Belt noise is produced by belt movement, by dynamic belt stress and strain and by structure-borne propagation along the belt of noise originating at the belt-roll interface. In all the above, the level of noise generated is amplified and modulated by roll and belt imperfections.

Secondary noise is produced by excitation of the supporting structure and by structure-borne transfer to the canopy and any steel cladding where large surfaces are capable of emitting the energy as air-borne noise.

3. ACOUSTIC ENGINEER’S TOOLS AND OPTIONS FOR CONVEYOR NOISE CONTROL

Acoustic engineers engaged in noise problem solving and in predictive EIA noise studies have to work within project budget constraints, existing infrastructure and layouts, or future process layouts designed to optimise production. Moreover, in considering solutions for conveyor noise problem solving or mitigation of conveyor noise in future developments, the engineer seldom has the luxury of conducting any research or experiments. The task has to be performed by designs employing proven technologies available from suppliers. Within such constraints, the engineer nonetheless still has several planning and design options to consider in devising practically viable measures for problem solving or mitigation. The best solution and combination of measures employed are different in each application, depending on operational constraints, the nature and distance of noise-sensitive receptors, topography and various other considerations.

3.1 CONVEYOR SPEED

Conveyor speed is normally determined by operational requirements, but in assessing the noise impact of a future installation, the acoustic engineer should take cognisance of the increase in noise coupled to the increase in speed. Figure 2 shows the result of field tests conducted on a loaded conveyor running on standard steel rolls at different speeds. Rolls were spaced 1.8 m apart and the conveyor had no canopy. With the objective of obtaining data required for the derivation of noise emission (sound power levels), sound pressure level spectra and dBA levels were measured at a distance of 3 m from the edge of the conveyor, and an average level obtained by scanning along a 50 m long trajectory parallel to the line.

In this particular case, noise levels increased by a very substantial 10 dB per doubling of speed in the range 2–6 m/s.

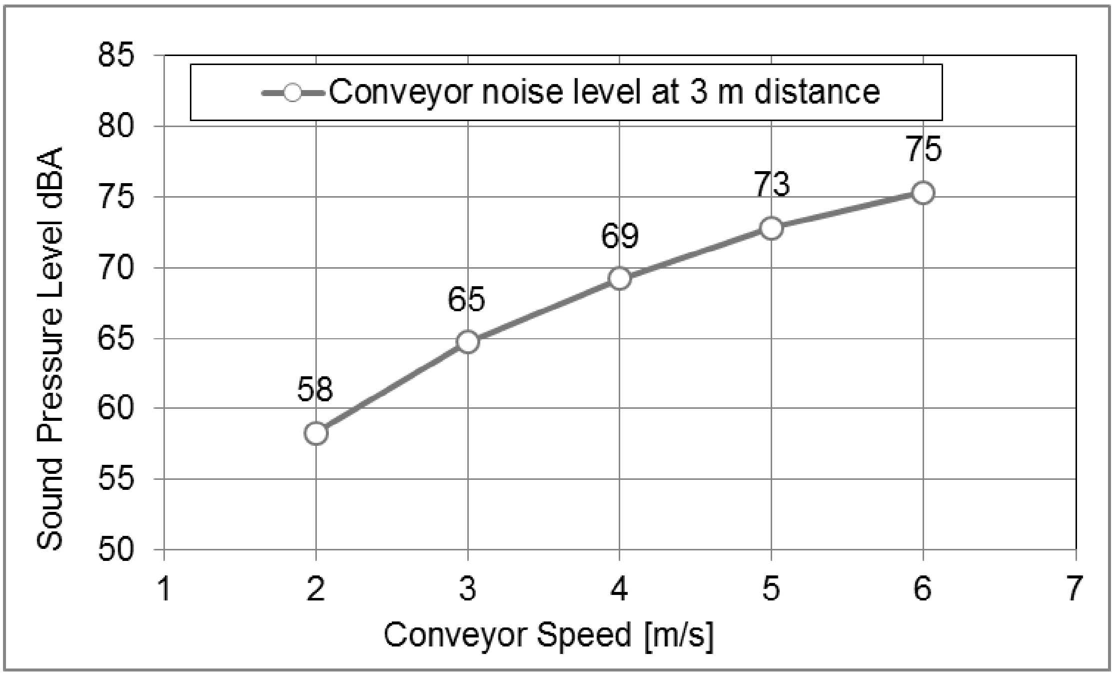

Figure 2. Field tests of conveyor noise as a function of speed. Standard steel rolls spaced 1.8 m; no canopy. Noise levels averaged over a 50 m length of line at 3 m distance

3.2 ROLL TYPE

Roll properties found to have a significant effect on overall conveyor noise are roundness imperfections and the type of roll shell material. Table 1 shows the results of field tests conducted on a fully operational overland conveyor running on four different roll types at the same time: standard steel; machined (rounded) steel; and two HPDE roll types from different suppliers. A set of each roll type was installed on consecutive 100 m long sections of line. Idler spacing was 1.8 m and the conveyor without canopy was running with load at a constant 6.5 m/s. Noise levels for each roll type were determined by averaging the sound pressure level at a constant distance of 1 m from a 50 m segment of line centred around the midpoint of the relevant 100 m section. In this way, the results of each roll type were not influenced by noise from adjacent sections equipped with other roll types.

Noise levels produced by the line section fitted with rounded steel rolls were 9 dB lower than the corresponding levels produced by standard steel rolls. In terms of environmental noise impact, this is a substantial reduction, considering that a 9 dB reduction in sound power would shrink the noise footprint of a conveyor by a factor of eight. For example, by not taking atmospheric and ground cover losses into account, a conveyor producing a certain noise level at a distance of 1 000 m when running on standard steel rolls would produce the same level at 125 m if the rolls were replaced with rounded (machined) steel rolls. With HPDE rolls the reductions were even greater, with Type A and Type B rolls producing 15 dB and 21 dB less noise respectively, compared to the standard steel rolls tested in this case.

Idler	Noise level At 1 m [dBA]	Advantage Noise level relative to standard steel roll [dB]
Steel Standard	91	0 dB (Reference)
Steel Rounded	82	- 9 dB
HPDE Type A	75	- 15 dB
HPDE Type B	70	- 21 dB

Table 1. Noise levels measured at 1 m distance from a conveyor fitted with different roll types on 100 m sections of line. Conveyor speed 6.5 m/s

3.3. CONVEYOR HOUSING

3.3.1 Conventional Housing

The noise emission characteristics of overland conveyors are affected by the type of housing. Conventional partially open housings or canopies do not reduce the overall sound power, but they do modify the radiation pattern, for instance, the directional spread of noise. Conveyor directivity is relevant in solving noise problems in EIA modelling of conveyors and in considering measures to mitigate conveyor noise impact in new developments. Based on the results of numerous field tests, Figure 3 illustrates the effects of the most common configurations on a conveyor's radiation characteristics. With an open conveyor (no canopy) as reference (0 dB), the tendencies are found to be as follows:

Doghouse Canopy
A conventional doghouse canopy, open at the front, screened at the top and at the back with steel cladding, usually with a gap at the bottom, collects and projects most of the noise towards the open side. This causes the noise level on the open side to rise by 2–3 dB, relative to an open conveyor. On the opposite (partially screened) side, the level is typically reduced by 4 dB.

Flat Roof Canopy
A flat roof canopy (both sides open) typically elevates the noise level on either side by 1–2 dB relative to an open conveyor.

i. Improving Canopy Noise Screening
Noise reduction on conveyor lines with conventional canopy designs is restricted by a fundamental flaw, that is, the structural integration of the canopy with the conveyor supporting framework. Because it is intimately coupled to the primary source of noise, structure-borne conveyor noise and vibration are transferred to the large canopy surfaces acting as efficient radiators of air-borne sound.

When considering possible improvement of the noise screening provided by the housing, the first step would be to completely detach the housing from the conveyor support framework. A doghouse canopy, for example, may still be left open on the maintenance side, but should be supported on an independent frame. On the rear side, the gap at the bottom should be reduced to the minimum required for water drainage. Once detached in this way, the noise screening performance may be improved by interior acoustic lining of the canopy.

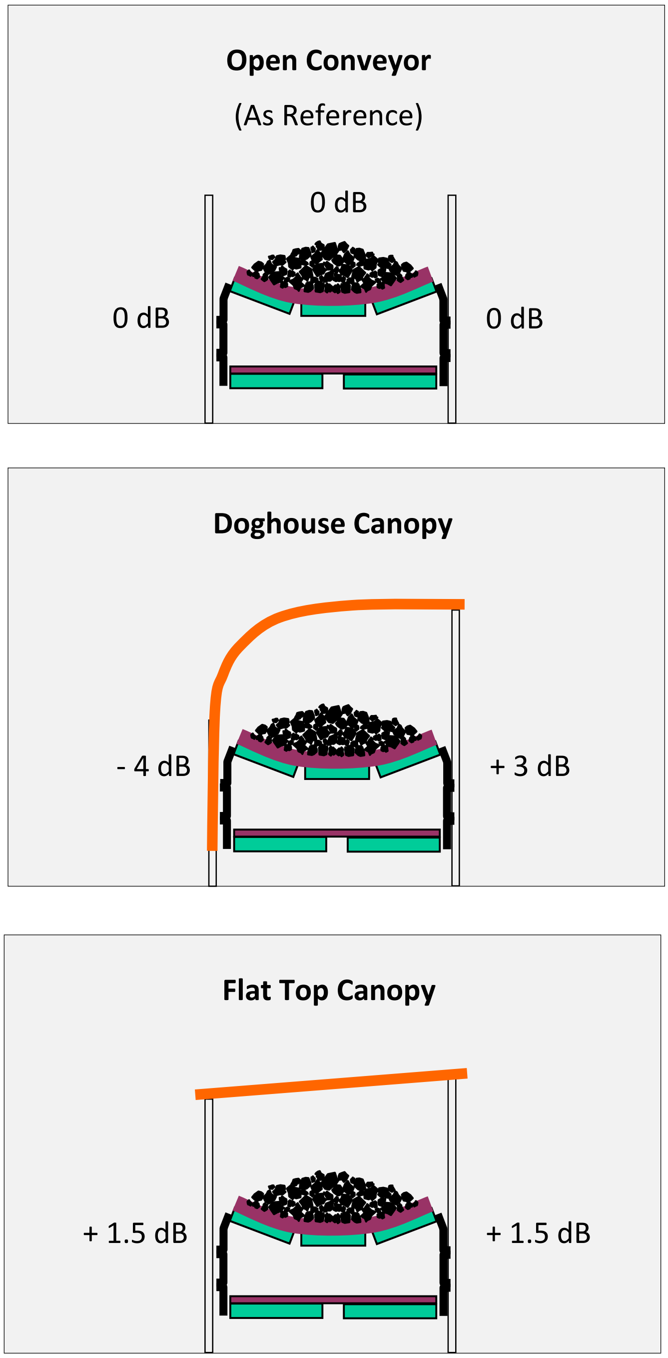

Figure 3. Typical directional characteristics of conventional conveyor canopies

A. NOISE SCREENING

If a conveyor is routed too close to a noise sensitive area, adjustment of the parameters discussed in the previous sections may not provide the required noise reduction. In such cases the construction of noise barriers may be considered. A noise barrier may consist of a berm, a wall, or a combination of the two, as illustrated by example for a particular case in Figure 4. In this case, the use of quiet rolls and other measures would not reduce conveyor noise below the 30 dBA night-time limit in a rural village bordering on the conveyor route. In addition to using low noise HPDE rolls, a noise barrier with a height of 3.5 m would be required. The minimum length of the barrier in this particular case, as determined by noise modelling, had to be approximately 1.6 km. It was located such as to overlap the extremities of the village by 300 m on each end.

If a combination of a berm and a wall is used, the heights of the individual components are not important, as long as the overall height is equal to the design height, in this case 3.5 m. The effective height and distance of the noise screen are determined by the distance of the noise receptor from the conveyor and by the height above ground level of the horizon point, regardless of the shape of the berm. The horizon point is defined by the line-of-sight from the top of the conveyor, looking in the direction of the noise-sensitive area. With respect to attenuation, the width of the berm is unimportant. Any self-supporting structure, as long as it is solid with no openings, will be more than thick enough for acoustical purposes.

Although the use of a berm as part of the barrier is not a precondition, it should be noted that a berm does have certain advantages over a vertical wall in that firstly, it provides a small degree of absorption. More importantly, the sloped face on the side of the conveyor reflects conveyor noise skywards, rather than horizontally. This is important if there is a noise sensitive area on the opposite side of the conveyor as well. In that case, a barrier face with a gentle slope on the conveyor side is better than a steep upward slope.

For all practical purposes, the required thickness of a brick wall is determined by structural, safety and security considerations. For acoustical purposes, a single (110 mm) brick wall is more than adequate. The barrier must have no gaps and all joints must be airtight.

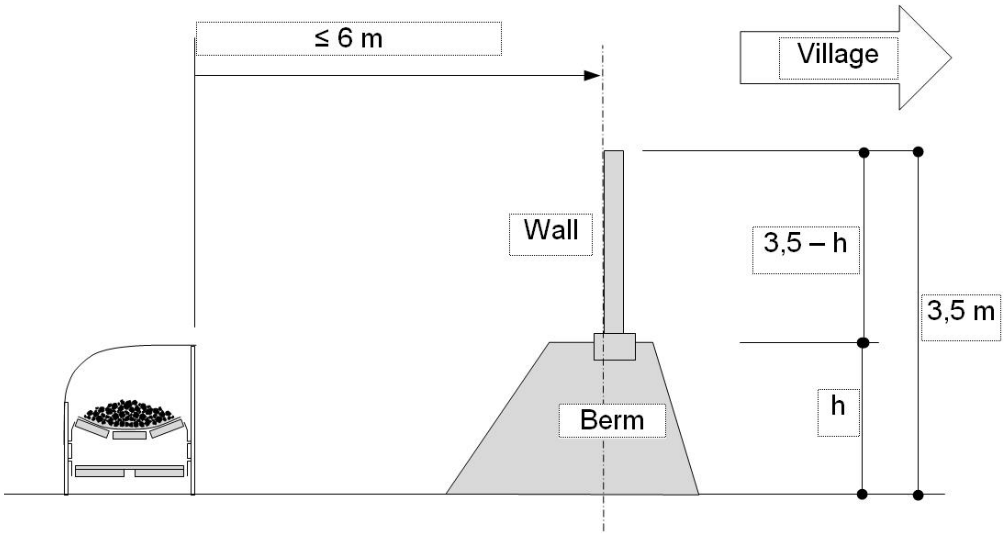

Figure 4. Example of noise berm between an overland conveyor and a rural village

ABOUT THE AUTHOR

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Ben van Zyl is an acoustic consulting engineer in private practice based in Pretoria, South Africa. After graduating with a Batchelor's degree in electronic engineering from the University of Pretoria in 1970, he worked as chief research engineer in the Acoustics Division of the CSIR. Apart from applied research and consulting in various fields of acoustics, he pioneered the principle and developed practical instrumentation for the measurement of sound intensity, a vector quantity inherent in the formulation of sound power and various other acoustic parameters and properties. This work formed the subject of an MSc (Eng) (Cum Laude), followed by a PhD and sponsorship to develop and assess industrial applications of sound intensity in the Netherlands (Dutch Ministry of the Environment) and Denmark (Brüel & Kjaer). In 1998 he joined Denel where he worked in the SA Space Programme as manager of systems integration and environmental test laboratories. He also worked in the Acoustics Division of the SABS, before venturing into private practice in 1995.

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