Safety in Mines Research Advisory Committee

# Quantification of noise sources in mechanical board and pillar coal mining

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# Executive Summary

*Research Enterprises at University of Pretoria* was commissioned to provide industry with a consistent set of noise data, based on a common measurement protocol, on representative continuous miners, roadheaders and load haul dumpers.

Measurements were conducted and documented in accordance with a test protocol based on procedures outlined in GEN420 in accordance with BS 7025. A total of ten machines were tested on surface. To gain improved understanding of the differences between on surface and underground noise levels, another five tests were conducted underground.

From the tests it may be concluded that generally the noise levels on continuous miners are very high. In one case 115 dB(A) was recorded. The conveyor chain seems to be the major offender in terms of noise generation on continuous miners. This is particularly so on surface. Once the machine is at the coalface, it seems as if the conveyor chain noise may be significantly dampened by the presence of coal on the chain. Under these circumstances the scrubber contribution becomes comparatively more important, and it seems as if most of the development effort should be focused on these two components.

In one case very significant attenuation of conveyor chain noise was accomplished underground, even though the chain was not covered with coal. This should be investigated further to establish the consistency of these results and to identify the mechanism involved in the attenuation, so that it may be exploited in other cases.

Another contributor to the noise is the cutting process itself. There seems to be enough evidence that – although there are some conflicting results – this mechanism is less important than the conveyor chain and scrubber mechanisms.

Hydraulic noise is the least important of the noise generating mechanisms.

In order to reduce continuous miner noise levels, it is clear that immediate efforts will have to be focused on conveyor chain and scrubber development. Noise reductions of the order of 10 dB needs to be obtained. Such reductions are very significant and will require fundamental redesign of the components involved. These changes will compromise the performance and productivity of these systems.

Noise levels caused by load haul dumpers are lower than for continuous miners (bearing in mind that load haul dumpers were only tested under maximum engine speed but no load conditions), but still high. Engine noise must be attenuated.

Because of performance, productivity and cost implications, the changes required to reduce noise levels will never be implemented spontaneously, and firm targets and associated penalties for not attaining these targets will need to be introduced to provide the impetus required to make real progress in this regard. Procedures to test for conformance will also have to be laid down.

Once these targets are set, individual manufacturers of conveyor chains and scrubber fans will be forced to critically consider their designs and improve or optimise these designs. This will prompt more detailed experimental investigations. It is believed that the present work will provide a very useful basis for such investigations as well as for the setting of conformance tests.

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# 1 Introduction

GEN420 identified typical noise sources in the mining industry. Further research was however required to identify and quantify specific noise levels on individual machines and machine components. Such information is required by machine manufacturers to modify the offending components appropriately or change their design strategies to reduce the overall noise levels of a machine. This will enable the industry to comply with the Health and Safety Act, thereby reducing the incidence of noise induced hearing loss.

*Research Enterprises at University of Pretoria* (REatUP was formerly known as LGI) was commissioned to provide industry with a consistent set of noise data, based on a common measurement protocol, on representative mining equipment. SIMRAC confined the study to Continuous Miners (CMs), roadheaders and Load Haul Dumpers (LHDs).

Measurements were conducted in accordance with a test protocol based on procedures outlined in GEN420. A total of ten machines were tested on surface. To gain improved understanding of the differences between on surface and underground noise levels, another five tests were conducted underground. In executing these tests, the authors relied extensively on the cooperation of personnel at Joy Mining Machinery in Wadeville and Steeledale, Voest-Alpine in Delmas as well as personnel at Koornfontein Gloria Shafts, Middelbult West and Twistdraai Colliery. This is gratefully acknowledged.

The results are presented here in a consistent format and should be useful to users as well as manufacturers of mining machines.

The results are critically evaluated and general conclusions are drawn. Recommendations are made with respect to the way forward.

# 2 Measured equipment

At a meeting of the Continuous Miner Noise Reduction Working Group of 15 May at the SIMPROSS offices, it was decided to measure the equipment outlined in Table 2.1 as representative of machines used in South African coalmines:

**Table 2.1 Representative machines**

Continuous miners and roadheaders:

| Equipment | Scrubber volume flow |
|---|---|
| HM31 | 8 & 13 $m^3$/s |
| HM21 | 8 & 13 $m^3$/s |
| ABM30 | 10 & 17 $m^3$/s |
| ABM85 | 10 & 17 $m^3$/s |

Load haul dumpers:

| Equipment | Bucket volume |
|---|---|
| Eimco | 3 $m^3$ |
| Toro | 5 $m^3$ |

This was not practically possible because of the non-availibility of some of these configurations. In a number of cases it was further not clear what configuration was about to be tested, until the test team came on site.

In the end the configurations outlined in Table 2.2 were tested:

**Table 2.2 Configurations tested**

| Equipment | Surface tests | Underground tests |
|---|---|---|
| HM31 | 35kW 7$m^3$/s<br>55kW 8$m^3$/s | 35kW 10$m^3$/s |
| HM21<br>HM17 | 75kW 10,5 $m^3$/s<br>75kW 10,5 $m^3$/s | <br>75 kW 10,5 $m^3$/s |
| ABM30 | 80kW 17 $m^3$/s<br>80kW 16 $m^3$/s | |
| ABM85<br>ABM80 | 75kW 17,5 $m^3$/s<br>4×20kW 2×6,6 $m^3$/s | 75 kW 17 $m^3$/s |
| Eimco 913<br>Eimco 925 | 3 $m^3$ | <br>5 $m^3$ |
| Toro 350 LP<br>Toro 350D | 5 $m^3$ | <br>No bucket |

The HM21 and HM17 CMs are very similar in terms of the noise generating components, whereas there are more significant differences between the ABM85 and ABM80 configurations.

Using numbers (01) to (15) as sequential test ID numbers that are used in this report to uniquely identify each test, the 15 tests that were conducted can be identified as in table 2.3:

**Table 2.3 Overview of test configurations**

| Test ID | Supplier | Equipment | Serial Number | Scrubber Bucket | Date | Location |
|---|---|---|---|---|---|---|
| 01 | Voest-Alpine | CM ABM30 | 016 | 17 $m^3/s$ | 2 Jun 2000 | Voest-Alpine Delmas |
| 02 | Joy | CM HM31 | SACM4066 | 7$m^3/s$ | 12 Jun 2000 | Joy Wadeville |
| 03 | Tamroc | LHD Toro | 400LP | 5$m^3$ | 21 Jun 2000 | Voest-Alpine Delmas |
| 04 | Tamroc | LHD Eimco | 913ADE | 3$m^3$ | 21 Jun 2000 | Voest-Alpine Delmas |
| 05 | Voest-Alpine | CM ABM85 | 021 | 17 $m^3/s$ | 28 Jun 2000 | Voest-Alpine Delmas |
| 06 | Joy | CM HM31 | SACM4028 | 8 $m^3/s$ | 4 Jul 2000 | Joy Wadeville |
| 07 | Joy | CM HM17 | SACM3012 | 10,5$m^3/s$ | 1 Nov 2000 | Joy Wadeville |
| 08 | Tamroc | LHD Eimco | 925 | 5 $m^3$ | 2 Nov 2000 | Twistdraai Colliery |
| 09 | Joy | CM HM31 | SACM4040 1 | 10$m^3/s$ | 2 Nov 2000 | Twistdraai Colliery |
| 10 | Tamroc | LHD Toro | 350D | - | 29 Nov 2000 | Middelbult West |
| 11 | Voest-Alpine | CM ABM85 | 021 | 17 $m^3/s$ | 29 Nov 2000 | Middelbult West |
| 12 | Voest-Alpine | Roadheader | 010 | 6,6 $m^3/s$ ×2 | 17 Jan 2001 | Voest-Alpine Delmas |
| 13 | Voest-Alpine | CM ABM30 | 027 | 16 $m^3/s$ | 17 Jan 2001 | Voest-Alpine Delmas |
| 14 | Joy | CM HM17 | SACM3012 | 10,5 $m^3/s$ | 2 Feb 2001 | Koornfontein Gloria Shaft |
| 15 | Joy | CM HM21 | SACM3023 | 10,5 $m^3/s$ | 14 Feb 2001 | Khutala Colliery |

In two cases the same machine that was used for surface tests, was also tested underground:

- A Joy HM17 (SACM3012) was tested on surface at Joy (07) and underground at Koornfontein Gloria Shaft (14).
- An ABM85 (021) was tested on surface at Voest-Alpine (05) and underground at Middelbult West Shaft (11).

# 3 Measurement procedures

Equivalent Continuous A-weighted sound pressure levels $L_{Aeq}$ were measured in accordance with a noise test procedure defined in Appendix I of the GEN420 report (Maneylaws, Norman & Von Glehn, 1997). This procedure satisfies the requirements of BS 7025, and is partly based on the test code *A code of Practise for the Procurement of Underground Machinery and Procedure for Noise Testing* developed within the British coal mining industry.

In principle the tests comprised a series of $L_{Aeq}$ sound pressure level tests around the machine. In addition, sound power spectra were measured and for the surface tests, acceleration spectra were also measured.

Different but consistent test protocols were used for surface and underground tests.

## 3.1 Surface tests

On surface, $L_{Aeq}$ measurements were taken central to both sides and ends of the machine at a distance of 1 m from the machine surfaces and a height of 1,5 m. Measurements were also done at distances of 10 m. $L_{Aeq}$ measurements were taken at the operator head position. To assist in the identification of the problem frequency ranges, unweighted octave band filtered $L_{eq}$ measurements were also done at the operator position. All $L_{eq}$ and $L_{Aeq}$ measurement time periods were at least 20 s.

For continuous miners, these tests were conducted for four operating configurations: *Conveyor chain operational*, *Scrubber operational*, *Hydraulic pump operational*, and *All components operational*.

For LHDs the sound pressure level measurements were recorded for the engine running at maximum engine revolutions.

Acceleration spectra were measured at three locations on the machine (typically close to the cutter head, on the scrubber mount and close to the conveyor chain on CMs and on the radiator, on the side and on top of the machine for LHDs). Sound pressure spectra were measured at the operator position.

Sound measurements were done using a Rion NL-14 Precision Integrating Sound Level Meter. Sound pressure and acceleration spectra were recorded using a 4-channel DSPT SigLab 20-42 FFT analyser.

## 3.2 Underground tests

Underground it was generally not possible to measure $L_{Aeq}$ around the machine. It was therefore decided to position the test object on an intersection and measure at distances of 1 m, 3 m, 5 m and 10 m along the splits and roads on those sides were it was practically possible. This was done for *Scrubber operational* and *Conveyor chain* operational cases.

The following operating configurations were measured at the coalface (where practically possible): Conveyor chain loading into shuttle car while cutting and with scrubber operational, Conveyor chain loading without cutting and with scrubber operational, Hydraulic pump operational, Cutting with the scrubber operational, Cutting with scrubber not operational. All these measurements were done at the operator position.

Unweighted octave band filtered $L_{eq}$ measurements were also recorded at the operator position for the normal *All operational* configuration.

Sound pressure spectra were recorded using a battery driven portable Diagnostic Instruments PL202 FFT analyser.

## 3.3 Test environment

The preferred standardised test environment is an asphalt or concrete surface in the open air, away from buildings or walls.

Because of the limited open areas available at the Joy and Voest-Alpine plants, and the limited length of the electrical supply cables, tests were mostly done fairly close to buildings. In most cases the closest buildings were at least 10 m away.

Underground measurements were obviously conducted in the mine during normal operations. This required the movement of shuttle cars, the presence of jet fans, and other equipment, which may have interfered with some of the measurements. These interferences were however limited as much as possible by re-measuring when deemed necessary.

Underground tests usually took about three hours to complete, and this implied that the mining layout will have changed significantly during this period, which may also have affected some of the measurements.

It is nevertheless believed that fairly consistent measurements, and certainly quite representative measurements were possible.

LHD measurements were conducted on an intersection, under generally much better measurement conditions than for the CMs.

## 3.4 Background noise

Background noise was usually recorded before commencement of the tests. Generally the background noise was quite irregular, because of the closeness to workshops, forklifts in the vicinity, other mining activities, etc. Care was however taken, as far as was practically possible, not to include periods of particularly high background noise in the measured results.

Background noise levels were however generally significantly more than the ideal 10 dB lower than the operational noise levels, and no corrections have been made to the recorded noise levels for background noise. Hydraulic system sound pressure levels are influenced in some cases, but are so low anyway that this is of no concern.

To prevent wind noise at the microphone and for consistency of results, a windscreen was used during all sound level and pressure measurements.

The windscreen also protected the microphone from water spray during the underground measurements.

## 3.5 Calibration

The Rion NL-14 Precision Integrating Sound Level Meter was calibrated during May 2000 by the National Metrology Laboratory of South Africa at the CSIR. (See certificate of Conformance in Appendix A).

The sound level meter conformed to IEC651 and IEC804 specifications type 1. The microphone UC-53 conformed to the IEC651 specifications from 31,5 Hz to 16 kHz, while the octave band filter NX-04 conformed to the IEC225 specification in the frequency range 125 Hz to 16 kHz.

This report records the measured unweighted octave band filtered $L_{eq}$ values for 16 Hz, 31,5 Hz and 63 Hz centre frequency bands for completeness. Measurements in these bands are however not reliable.

The NC-73 sound level calibrator conformed to the IEC942 specification type 2. Acoustic calibration was done before and after each test, using the sound level calibrator.

# 4 Measurement results

The measurement results are recorded in 15 separate test reports, attached as Appendices B1 to B15. From these results a number of general conclusions can be drawn.

## 4.1 Surface tests on continuous miners

### 4.1.1 Sound pressure levels

$L_{Aeq}$s of 112,7 dB(A) (07), 115 dB(A) (13) and 113,6 dB(A) (15) were recorded in separate tests. Such levels are very high and are particularly evident at the rear of the continuous miners.

From the plotted sound pressure profiles in Appendices B1 to B15, it is clear that the conveyor chain generally is the most significant contributor to the noise levels, although the scrubber noise may, in its vicinity, be more significant and in some cases overshadow the effect of the conveyor chain.

As might be expected, at the rear of the machines, the conveyor chain contribution generally is very significant.

Table 4.1 records the $L_{Aeq}$ – values at the operator position for various components operational:

**Table 4.1 $L_{Aeq}$ – values at the operator position**

| **Test ID** | **$L_{Aeq}$ [dB(A)] All operational** | **$L_{Aeq}$ [dB(A)] Conveyor chain operational** | **$L_{Aeq}$ [dB(A)] Scrubber operational** | **$L_{Aeq}$ [dB(A)] Hydraulics operational** |
|---|---|---|---|---|
| 01 | 107.8 | 104,8 | 98,3 | 87,8 |
| 02 | 103,8 | 102,5 | 81,4 | 79,8 |
| 05 | 106,7 | 101,7 | 98,4 | 75,3 |
| 06 | 102,0 | 104,2 | 90,3 | 82,6 |
| 07 | 107,0 | 106,4 | 99,6 | 88,0 |
| 12 | 103,6 | 102,6 | 96,1 | 80,2 |
| 13 | 103,6 | 99,1 | 96,4 | 86,9 |
| 15 | 103,6 | 101,3 | 88,6 | 72,5 |
| Mean | **104,8** | **102,8** | **93,6** | **81,6** |

It is again clear that the conveyor chain makes the most significant contribution to the overall noise level with *All operational*. The scrubber effect at the operator ear is generally significantly less important, while the effect of the hydraulics may generally be considered insignificant.

Table 4.2 records the $L_{Aeq}$ – values 1 m behind the machine at the rear:

**Table 4.2 $L_{Aeq}$ – values 1 m behind the machine at the rear**

| Test ID | $L_{Aeq}$ [dB(A)] All operational | $L_{Aeq}$ [dB(A)] Conveyor chain operational | $L_{Aeq}$ [dB(A)] Scrubber operational | $L_{Aeq}$ [dB(A)] Hydraulics operational |
|---|---|---|---|---|
| 01 | 112.6 | 108.2 | 111.4 | 78,3 |
| 02 | 110.4 | 109.1 | 93.4 | 85,0 |
| 05 | 106.5 | 104.2 | 97.2 | 74,5 |
| 06 | 105.4 | 108.5 | 96,8 | 78,2 |
| 07 | 112.7 | 108.0 | 96,8 | 80,6 |
| 12 | 109.5 | 107.0 | 96,7 | 79,9 |
| 13 | 115.0 | 111.3 | 96,6 | 80,7 |
| 15 | 113.6 | 113.0 | 93,7 | 67,8 |
| Mean | **110.7** | **108.7** | **97,8** | **78,1** |

A similar pattern may be observed at the rear of the machines where operators and other personnel may often be busy. As might be expected, the conveyor chain sound pressure levels are more pronounced in this area.

From the sound pressure profiles in Appendices B1 to B15, the scrubber noise is clearly non-symmetrical, depending on which side the scrubber is mounted.

Noise levels associated with the hydraulics are consistently significantly lower than the conveyor chain and scrubber noise levels. In some instances fairly high maximum levels were recorded at particular positions around the machines: 93,0 dB(A) (02), 88,0 dB(A) (07) and 89,0 dB(A) (13). These levels are however still significantly lower than the contributions from the other mechanisms.

### 4.1.2 Attenuation with distance

In the first 10 m away from the machine, the noise levels diminish at slower than the ideal rate of 6 dB/doubling of distance, which is applicable to the *far field* of a point source. It is clear that operators and other personnel working around these machines will usually be active in the acoustic *near field* and implies that the precise sound pressure levels will be very dependent upon the features of the specific machine. This is particularly noticeable at the rear of the machine because of the protruding nature of the conveyor chain and the significant contribution that the conveyor chain itself makes.

### 4.1.3 Effect of operating geometrical configuration

Consideration of test (06) will reveal that the *All operational* sound pressure levels are in some cases significantly lower than the *Conveyor chain operational* sound pressure levels. This seemingly impossible result was caused by the fact that the cutter head was raised during the conveyor chain tests. This reduced the shielding of the conveyor chain noise and lead to significantly higher sound pressure levels.

All other surface tests were conducted with the cutter head in the lowered position, and the results (especially for conveyor chain noise) are therefore probably somewhat lower than would be under raised cutter head conditions. It must be borne in mind that a changed machine geometrical configuration may significantly influence the results obtained.

### 4.1.4 Pressure spectra

From table 4.3 it is clear that frequencies of maximum sound pressure level typically ranges from 125 to 1000 Hz. This is confirmed by the narrow band spectra. This should be of importance to component designers.

**Table 4.3 Centre frequency of highest octave**

| Test ID | All operational [Hz] | Conveyor chain [Hz] | Scrubber [Hz] |
|---|---|---|---|
| 01 | 500 | 500 | 500 |
| 02 | 500 | 500 | 1000 |
| 05 | 1000 | 250 | 1000 |
| 06 | 125 | 63 | 125 |
| 07 | 500 | 250 | 500 |
| 12 | 1000 | 1000 | 500 |
| 13 | 1000 | 1000 | 500 |
| 15 | 125 | 125 | 125 |

### 4.1.5 Acceleration spectra

No simple correlations between the measured acceleration spectra and the observed sound spectra could be found. This is probably because of the fact that the acceleration measurements have been done on hard parts of the machine structures. Design programmes to reduce the system noise levels, will require much more detailed investigations of the surface acceleration levels and distributions.

In this report these spectra are only reported for a 0 – 5000 Hz bandwidth. More detailed information which include measurements over 0 – 200 Hz and 0 – 10000 Hz bandwidths, are available electronically. This information can be used as the basis for more detailed experimental investigations.

## 4.2 Underground tests on continuous miners

### 4.2.1 Correlation between surface and underground measurements

Two sets of tests were conducted on CMs that were tested on surface as well as underground. In the first case a Voest-Alpine ABM85 was tested on surface at Voest-Alpine in Delmas (05) and at Middelbult West Shaft (11). In the second a Joy HM17 was tested on surface at Joy in Wadeville (07) and subsequently underground at Koornfontein Gloria Shaft (14). Table 4.4 records the measurements as taken at the operator positions while the CMs where positioned at an intersection during the underground tests and there were no coal on the conveyor chains.

**Table 4.4 Correlation between surface and underground measurements**

| Test ID | $L_{Aeq}$ [dB(A)] Conveyor Chain | | $L_{Aeq}$ [dB(A)] Scrubber | |
|---|---|---|---|---|
| ABM85 | | | | |
| (05) On surface | 101,7 | Difference +1,8 | 98,4 | Difference +3,0 |
| (11) Underground | 103,5 | | 101,4 | |
| HM17 | | | | |
| (07) On surface | 106,4 | Difference -16,2 | 99,6 | Difference -4,0 |
| (14) Underground | 90,2 | | 95,6 | |

From these measurements it follows that the conveyor chain noise increased somewhat in one case from the surface to the underground condition, and significantly reduced in the other. Increases may be caused by increased free play or reflections from the roof, while coal dust filling openings and preventing metal-to-metal contact may play a beneficial role in other cases. It is however not clear precisely what caused the very significant 16,2 dB(A) reduction for the HM17, and it could be most informative to further investigate the reasons for this significant reduction, as well as the consistency of this behaviour.

Scrubber noise is lower in one case and higher in another. This may be because of the effects of absorption and reflections from the tunnel walls and roof.

### 4.2.2 Sound pressure levels

Table 4.5 records equivalent sound pressure levels measured for scrubber and conveyor chain operational conditions at the operator position, while the CMs were positioned on an intersection, for all three the CMs that were tested underground:

**Table 4.5 $L_{Aeq}$ – values at operator position with CM on intersection**

| **Test ID** | **$L_{Aeq}$ [dB(A)] Conveyor chain operational** | **$L_{Aeq}$ [dB(A)] Scrubber operational** |
|---|---|---|
| 09 | 105,3 | 95,7 |
| 11 | 103,5 | 104,6 |
| 14 | 90,2 | 95,6 |
| Mean | **99,7** | **98,6** |

Because of too few underground measurements, it is difficult to make conclusive deductions from these results. Compared to table 4.1 it does however look as if $L_{Aeq}$ for conveyor chain operational may be very similar to the levels experienced on surface. Test (14) seems to be an exception at 90,2 dB(A). Scrubber levels also seem to be more or less similar, with test (11) at 104,4 dB(A) which looks high.

This seems to indicate that provided surface tests are compared to tests on an intersection, sound pressure levels could be more or less comparable.

Table 4.6 records equivalent sound pressure levels measured for various operating conditions, again at the operator position, but now with the CM at the coalface:

**Table 4.6 $L_{Aeq}$ – values at the operator position with CM at coalface**

| **Test ID** | **$L_{Aeq}$ Cutting Scrubber operational Loading** | **$L_{Aeq}$ Not Cutting Scrubber operational Loading** | **$L_{Aeq}$ Hydraulic Pump operational** | **$L_{Aeq}$ Cutting Scrubber operational** | **$L_{Aeq}$ Cutting only** |
|---|---|---|---|---|---|
| 09 | 99,3 | 98,8 | 92,2 | 98,3 | 93,0 |
| 11 | 104,4 | 95,6 | 77,0 | 105,4 | 97,4 |
| 14 | 97,1 | NM | 80,4 | NM | NM |
| Mean | **100,3** | **97,2** | **83,2** | **101,9** | **95,2** |

Maximum underground noise levels with everything operational now seems noticeably lower than the on-surface levels (see Table 4.1), but still very high. It is believed that the loading of the conveyor chains, makes the most significant difference in this case.

Sound pressure levels due to cutting alone seems to be significantly lower than is the case when cutting with scrubbers on (last two columns in Table 4.6). The difference is clearly more than 3 dB, which indicates that cutting noise is less than scrubber noise. Conclusions are however not straightforward, because of the large difference (104,4 tot 95,6 dB(A)) observed for test (11) between the cases where scrubbers were on, loading was taking place and cutting was in one case taking place while in the other it was not. It is suspected that this large change has more to do with changed loading conditions than with the cutting itself. Because of the fact that hearing protectors were worn during all these tests, it was not always easy to detect significant changes in the process being observed.

It is therefore believed that the cutting noise is less significant than the scrubber noise.

Hydraulic noise is still significantly less important than other noise generating mechanisms.

### 4.2.3 Attenuation with distance

Attenuation of sound pressure levels as one moves away from the machine is significantly less than on surface, probably because of the fact that the splits and roads resemble one-dimensional ducts. This implies that although the sound pressure levels are generally somewhat lower at the operator position than on surface, people working around the machine will still be exposed to very high levels of sound pressure.

## 4.3 LHD noise levels

Measured LHD equivalent sound pressure levels are recorded in table 4.7. This table includes surface ( (03) and (04) ) as well as underground ( (08) and (10) ) results.

**Table 4.7 2 $L_{Aeq}$ – values for LHDs**

| **Test ID** | **$L_{Aeq}$ Operator** | **$L_{Aeq}$ Rear 1m** |
|---|---|---|
| 03 | 96,2 | 104,7 |
| 04 | 95,7 | 93,5 |
| 08 | 95,7 | 98,6 |
| 10 | 95,6 | 101,4 |

Operator noise levels are very similar on surface and underground. It is also clear from test (03) that LHDs can generate very high sound pressure levels and can not be ignored in the combat against noise.

More detailed consideration of cases (08) and (10) in Appendix B indicates that attenuation with distance is again significantly less than on surface.

# 5 Conclusions and recommendations

To quantify the noise associated with continuous miners, roadheaders and load haul dumpers, a series of ten tests were conducted on surface and another five tests were conducted underground.

These tests were conducted and documented in a consistent way according to procedures outlined in GEN420 in accordance with BS 7025.

From the tests it may be concluded that generally the noise levels on CMs are very high. In one case 115 dB(A) was recorded. The conveyor chain seems to be the major offender in terms of noise generation on continuous miners. This is particularly so on surface. Once the machine is at the coalface, it seems as if the conveyor chain noise may be significantly dampened by the presence of coal on the chain. Under these circumstances the scrubber contribution becomes comparatively more important, and it seems as if most of the development effort should be focused on these two components.

In one case very significant attenuation of conveyor chain noise was accomplished underground, even though the chain was not covered with coal. This should be investigated further to establish the consistency of these results and to identify the mechanism involved in the attenuation, so that it may be exploited in other cases.

Another contributor to the noise is the cutting process itself. There seems to be enough evidence that – although there are some conflicting results – this mechanism is less important than the conveyor chain and scrubber mechanisms.

Hydraulic noise is the least important of the noise generating mechanisms.

In order to reduce continuous miner noise levels, it is clear that immediate efforts will have to be focused on conveyor chain and scrubber development. Noise reductions of at the very least 10 dB needs to be obtained. Such reductions are very significant and will require fundamental redesign of the components involved. These changes will compromise the performance and productivity of these systems.

Noise levels caused by LHDs are lower than for CMs (bearing in mind that LHDs were only tested under maximum engine speed but no load conditions), but still high. Engine noise must be attenuated.

Because of performance, productivity and cost implications, the changes required to reduce noise levels will never be implemented spontaneously, and firm targets and associated penalties for not attaining these targets will need to be introduced to provide the impetus required to make real progress in this regard. Procedures to test for conformance will also have to be laid down.

Once these targets are set, individual manufacturers of conveyor chains and scrubber fans will be forced to critically consider their designs and improve or optimise these designs. This will prompt more detailed experimental investigations. It is believed that the present work will provide a very useful basis for such investigations as well as for the setting of conformance tests.

# References

**Maneylaws, A., Norman, G. & Von Glehn, F.H. 1997** An examination of methods whereby noise levels in current and new equipment may be reduced. SIMRAC Final Project Report GEN420. Pretoria: Department of Minerals and Energy, 153 pp.

# Appendix A  Rion NL-14 Certificate of Conformance

CSIR
National Metrology Laboratory
Custodian of the **national measuring standards of South Africa**
PO Box 395
Pretoria 0001 South Africa
Tel. + 27 12 841-4152
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## CERTIFICATE OF CONFORMANCE

| | |
|---|---|
| **Calibration of** | : INTEGRATING SOUND LEVEL METER<br>½ " MICROPHONE<br>SOUND LEVEL CALIBRATOR<br>OCTAVE BAND FILTER |
| **Manufacturer** | : RION |
| **Model number** | : NL-14, UC-53, NC-73, NX-04 |
| **Serial number** | : 10162026, 53718, 10844969, 10360699 |
| **Calibrated for** | : UNIVERSITY OF PRETORIA |
| **Calibration procedure** | : NML-AV\AS-0007 Rev 1A<br>NML-AV\AS-0008 Rev 1A<br>NML-AV\AS-0009 Rev 1A<br>NML-AV\AS-0010 Rev 1A |
| **Period of calibration** | : May 2000 |
| **Date of issue** | : 05 July 2000 |
| **Certificate number** | : **AV\AS-2189** |
| **Calibrated by** | : E Struthers<br>(012) 841 3698 |
| **Checked by** | : CS Veldman |
| **Page** | : 1 of 4 |

(for Director)

The CSIR is empowered by the Measuring Units and National Measuring Standards Act, 1973 (Act 76 of 1973), as amended, to keep and maintain all national measuring standards.

CALIBRATION OF INTEGRATING SOUND LEVEL METER
½ " MICROPHONE, SOUND LEVEL CALIBRATOR AND FILTER

## 1. PROCEDURE

The instrument was electrically calibrated according to the relevant clauses of IEC 651 and 804 specifications. The instrument complete with the microphone was acoustically calibrated according to the relevant clauses of IEC 651 specification. The instrument complete with filters was electrically calibrated according to IEC 225 specification. The sound level calibrator was calibrated according to IEC 942 specification. The following equipment was used:

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|---|---|
| B & K 4228 Pistonphone | (AS-WS-10) |
| B & K 4144 1" Pressure Microphone | (AS-WS-03) |
| B & K 2627 1" Pre-amplifier | (AS-14) |
| R & S AFGU Synthesized / Function Generator | (AS-21) |
| HP 4437A 600Ω Step Attenuator | (AS-29) |
| B & K 2610 Measuring Amplifier | (AS-16) |
| B&K 4226 Acoustic Calibrator | (AS-52) |
| Fluke 45 Dual Display Multimeter | (AS-30) |
| B & K 2307 Level Recorder | (AS-24) |
| B & K 1023 Sine Generator | (AS-22) |
| R & S UPD Audio Analyser | (AS-71) |

The accuracies of the abovementioned equipment were traceable to the relevant national standards.

## 2. RESULTS

2.1 The following parameters of the sound level meter were calibrated and conformed to the IEC 651 and IEC 804 specifications, type 1.

Input sensitivity
Range attenuator (at 31,5 Hz, 1 kHz and 8 kHz)
A and C-weighting networks (20 Hz - 20 kHz)
Linear
Dynamic characteristics (slow, fast and impulse)
Leq (integrating averaging)
Impulse Leq

**Date of issue** : 05 July 2000

**Certificate number** : **AV\AS-2189**

**Calibrated by** : E Struthers (012) 841 3698 ............................

**Checked by** : CS Veldman ............................

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2.2 The following parameter of the microphone was calibrated and conformed to the IEC 651 specifications:

Microphone frequency response: 31,5 Hz - 16 kHz

2.3 The following parameters of the sound level calibrator were calibrated and conformed to the IEC 942 specification, type 2:

Frequency at nominal value 1000 Hz
Sound Pressure Level at nominal value(s) 94 dB
Total Harmonic Distortion

2.4 The following parameter of the octave band filter was calibrated and conformed to the IEC 225 specification:

Frequency accuracy: 125 Hz - 16 kHz

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## 3. REMARKS

3.1 The reported uncertainties of measurement were calculated and expressed in accordance with the BIPM, IEC, ISO, IUPAP, OIML document entitled "A Guide to the Expression of Uncertainty in Measurement" (International Organisation for Standardisation, Geneva, Switzerland, 1993).

3.2 The reported uncertainties of measurement are based on a standard uncertainty multiplied by a coverage factor of k=2, which, unless specifically stated otherwise, provides a level of confidence of approximately 95 %.

3.3 The calibrations were carried out at an ambient temperature of 23 °C ± 2 °C and a relative humidity of 50 %RH ± 25 %RH.

3.4 Only the parameters given in 2.1, 2.2, 2.3 and 2.4 were calibrated.

3.5 The actual readings obtained are available on request.

3.6 The octave band filter should not be used for frequencies below 125 Hz.

3.7 The above statements of conformance are based on the measurement value(s) obtained, extended by the estimated uncertainty of measurement at $1\sigma$, being within the appropriate specification limit(s).

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