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# Hydraulic excavator noise control case study as part of a comprehensive mitigation plan of an integrated open-pit coalmine and powerplant

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## ABSTRACT

Noise control of a 500 tonne, 2500 hp hydraulic mining excavator is used as a case study to describe the detailed noise control of one piece of equipment as part of a comprehensive noise mitigation plan of an integrated open-pit coalmine and powerplant. An environmental noise model of the entire mining and powerplant operations was developed and used to facilitate a combination of equipment operation and individual equipment noise reduction targets. Noise control equipment was designed and engineered to meet the equipment noise reduction targets and maintain equipment operation. The individual noise control equipment developed for a hydraulic mining excavator is detailed as a case study because the excavator noise levels were the highest in the mine. The individual noise sources which contribute to the overall noise signature of the excavator were measured and quantified for inclusion with the comprehensive environmental noise model. Noise control options for the various component noise sources were evaluated and the option to significantly reduce the engine exhaust noise source was selected. Custom, very high specification engine exhaust silencers were developed, installed, and commissioned to successfully reduce the excavator noise signature consistent with the comprehensive environmental noise model.

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## 1. INTRODUCTION

A comprehensive environmental noise model of an approximately 12,140 hectares open pit coal mine (displayed in Figure 1)[1] for electricity power generation was developed to determine noise levels compared to noise limits as specified by environmental noise regulations detailed in the Energy Resources Conservation Board (ERCB) Directive 038[2].

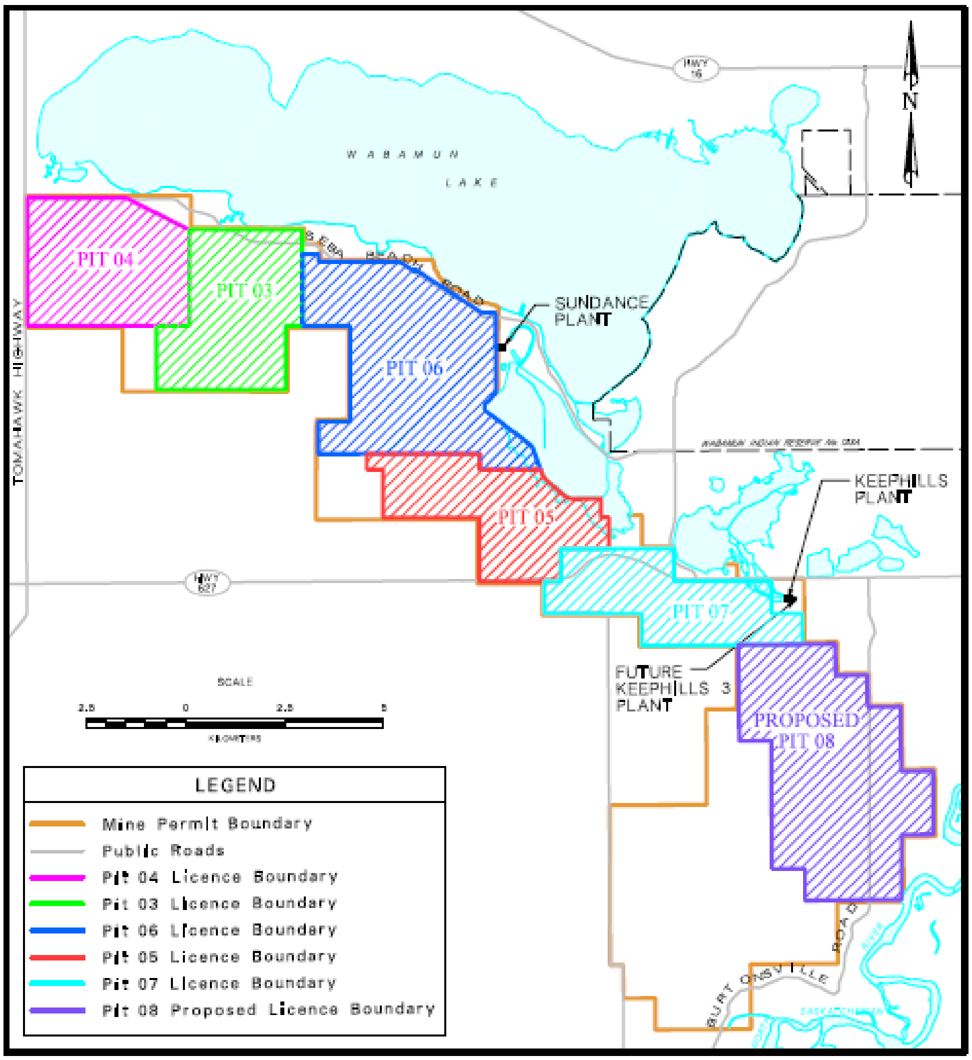


**Figure 1:** Mine and pit boundaries[1].

## 2. ENVIRONMENTAL NOISE MODEL

An environmental noise model of the combined mining and power generation noise sources was developed and used as a tool to identify and quantify feasibility and effect of noise reduction on individual noise sources. FFA Consultants in Acoustics and Noise Control were commissioned to develop the noise model[3].

The noise model included the major mining equipment displayed in Table 1. The noise generated by the Keephills Power Generating Station Units 1, 2, and 3 were also included to accurately model the cumulative noise impact of the combined mining and power generating operations.

**Table 1:** Mining Equipment Description

| | |
|---|---|
| Bucyrus 190B Shovel | LeTourneau L-1400 Loader |
| Caterpillar 657 Scraper | LeTourneau L-1850 Loader |
| Caterpillar 776D Heavy Hauler | D60K Drill |
| Caterpillar 789 Heavy Hauler | Dresser Marion 8050 Dragline |
| Komatsu 930 Haul Truck | Bucyrus 8750 Dragline |
| Liebherr T828 Haul Truck | Euclid Ash Haul Truck |
| Caterpillar 992 Front End Loader | Euclid Water Truck |
| Caterpillar D10 Dozer | O & K Terex RH200 Hydraulic Excavator |
| Caterpillar D11 Dozer | Bucyrus 495 Shovel |
| Caterpillar D9R Dozer | P & H 4100 Shovel |
| Caterpillar 844 Dozer | Caterpillar 785 Haul Truck |

To meet the 40 dBA Leq nighttime noise limit as specified by Directive 038, noise control was required on a number of pieces of mining equipment. The Terex RH200 untreated engine exhaust noise source was the largest single noise source and consequently required noise control.

## 3. HYDRAULIC SHOVEL NOISE REDUCTION

The Terex RH200 hydraulic shovel (displayed in Figure 2) is 500 tonne, 2500 hp hydraulic mining excavator used in prestripping operations. The shovel is powered by two Cummins K 1500-E 12 cylinder engines operating at 1,800 rpm.


**Figure 2:** Terex RH200 hydraulic shovel.

Stock noise control was not available to meet the noise control required as determined using the environmental noise model and consequently Noise Solutions Inc. was commissioned to design, construct, and install custom developed noise control to meet the specified noise control target.

## A. Noise Sources

The noise control target was determined based on the source sound power levels of the Terex RH200, displayed in Table 2. The sound power levels were developed from field sound pressure level measurements.

**Table 2:** Terex RH200 untreated noise source sound power levels[3].

| Description | Sound Power Level | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Octave Band Centre Frequency [Hz] | | | | | | | | | Sum |
| | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | [dBA] |
| **Engine Exhausts** | **112.4** | **121.0** | **136.7** | **132.0** | **124.4** | **116.1** | **115.2** | **111.2** | **67.0** | **127.5** |
| Hydraulic Radiators (side) | 102.0 | 106.4 | 116.5 | 117.6 | 115.6 | 112.9 | 108.8 | 102.6 | 93.1 | 117.7 |
| Engine Room (top) | 104.9 | 106.6 | 112.7 | 113.4 | 110.1 | 109.9 | 106.0 | 97.9 | 91.0 | 113.9 |
| Engine Radiators (rear) | 104.7 | 108.0 | 117.1 | 116.5 | 111.8 | 107.3 | 102.2 | 96.1 | 88.6 | 113.6 |
| Hydraulic Radiators (top) | 102.1 | 99.8 | 107.9 | 108.7 | 107.7 | 105.4 | 101.5 | 96.7 | 88.1 | 110.0 |
| Hydraulic Boom | 98.4 | 99.3 | 109.3 | 106.2 | 102.7 | 98.2 | 93.7 | 87.0 | 78.2 | 104.3 |
| **Terex RH200 Sum** | **114.3** | **121.6** | **136.8** | **132.3** | **125.3** | **119.0** | **116.8** | **112.2** | **96.7** | **128.3** |

The engine exhausts noise source is the most significant as it is approximately 10 dBA higher than the next noise source. This is because the engine exhausts have no noise control (i.e. muffler) and the noise levels are due to untreated raw exhaust noise displayed in Figure 3.

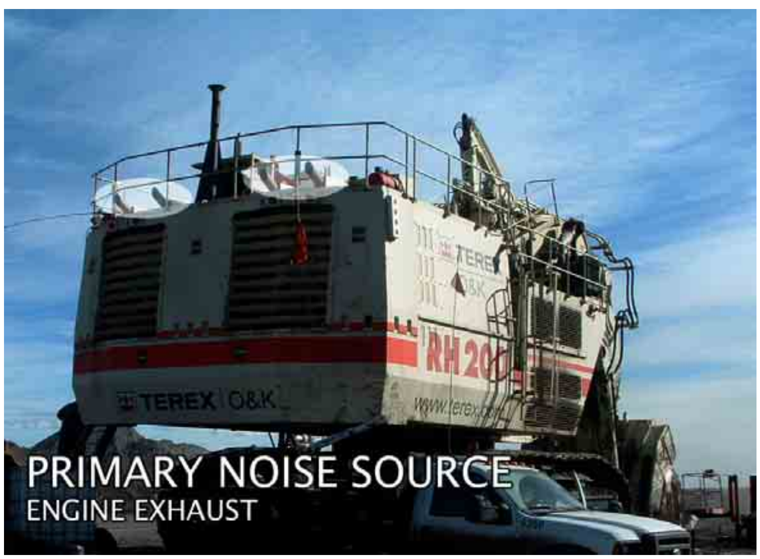


**Figure 3:** Terex RH200 engine exhausts.

The treated engine exhaust sound power levels are displayed in Table 3. The required noise control is the difference of the values of Table 2 and Table 3 resulting in a required engine exhaust noise reduction of 20.9 dBA and an overall machine noise reduction of 7.4 dBA.

A custom combination reactive and absorptive engine exhaust silencer was developed to meet the required noise reduction and as part of the development, associated sub-development components were identified in order to accommodate the installation and operation of the required engine exhaust silencer.

**Table 3:** Terex RH200 treated noise source sound power levels[3].

| Description | Sound Power Level | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Octave Band Centre Frequency [Hz] | | | | | | | | | Sum |
| | 31.5 | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 | [dBA] |
| **Engine Exhausts (with NC)** | **109.4** | **111.0** | **121.7** | **107.0** | **94.4** | **86.1** | **83.2** | **76.2** | **27.0** | **106.6** |
| Hydraulic Radiators (side) | 102.0 | 106.4 | 116.5 | 117.6 | 115.6 | 112.9 | 108.8 | 102.6 | 93.1 | 117.7 |
| Engine Room (top) | 104.9 | 106.6 | 112.7 | 113.4 | 110.1 | 109.9 | 106.0 | 97.9 | 91.0 | 113.9 |
| Engine Radiators (rear) | 104.7 | 108.0 | 117.1 | 116.5 | 111.8 | 107.3 | 102.2 | 96.1 | 88.6 | 113.6 |
| Hydraulic Radiators (top) | 102.1 | 99.8 | 107.9 | 108.7 | 107.7 | 105.4 | 101.5 | 96.7 | 88.1 | 110.0 |
| Hydraulic Boom | 98.4 | 99.3 | 109.3 | 106.2 | 102.7 | 98.2 | 93.7 | 87.0 | 78.2 | 104.3 |
| **Terex RH200 Sum** | **112.7** | **114.7** | **124.4** | **121.5** | **118.4** | **115.9** | **111.7** | **105.3** | **96.8** | **120.9** |

## B. Structural Reinforcement

In order for the structure of the machine to support the additional weight of the engine exhaust silencers, a dynamic finite element analysis (FEA) was conducted by WBM Canada Inc. This study identified structural reinforcement required to ensure machine integrity during operation with the additional weight of the engine exhaust silencers.

## C. Exhaust Venturi Replacement

Engine exhaust silencers contribute backpressure on the exhaust system. In order to accommodate the backpressure of the engine exhaust silencers the intake and exhaust system were required to be redesigned to meet the engine backpressure specifications. The intake and exhaust system were coupled on the RH200 through an exhaust venturi used to draw the dust collected in the intake filter boxes out of the intake box and out the exhaust, displayed in Figure 4.

Removing the exhaust venturis would allow sufficient exhaust backpressure to accommodate the engine exhaust silencers. Removing the exhaust venturis and the dust evacuation function that was provided on the intake filter boxes required a modification of the intake filter assembly.

**Figure 4:** Engine air intake filters and exhaust venturis.

The exhaust venture was removed and the intake filter boxes were replaced with self-evacuating (drop-out) intake filters. The redesigned intake, exhaust, and engine exhaust silencers are displayed in Figure 5.

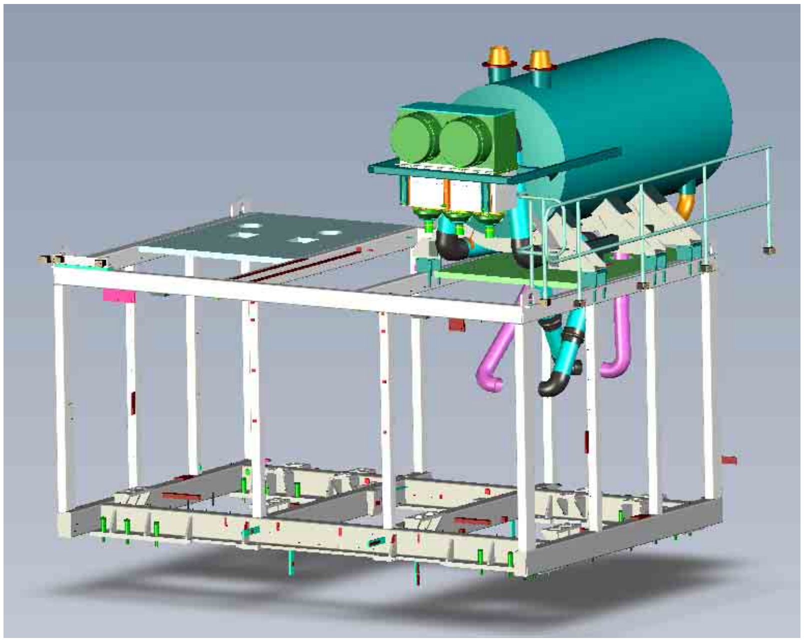

**Figure 5:** Modified intake and exhaust system with engine exhaust silencer.

## 4. CONCLUSIONS

The noise reduction target of the Terex RH200 was successfully achieved and the installation is displayed in Figure 6.

**Figure 6:** Terex RH200 engine exhaust silencer installation.

As part of designing the required noise reduction of the engine exhaust system by installing custom engine exhaust silencers, additional machine modifications were required on the structure, engine intake and exhaust systems of the machine.

The noise control was identified and specified using the environmental noise model of the combined mining and power generation operations to enable operations to meet the cumulative noise target specified by Directive 038.

## ACKNOWLEDGMENTS

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## REFERENCES

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