CASE STUDY OF NOISE ATTENUATION OF LARGE AUTOMOTIVE MANUFACTURING FACILITY

Colin Novak
University of Windsor, Mechanical, Automotive and Materials Engineering
401 Sunset Ave.; Windsor, ON; N9B 3P4; Canada

ABSTRACT

This case study reports on the efforts taken to significantly attenuate the overall noise exposure on several residential receptors from the operations of a large scale automotive manufacturing facility. The exercise began with an extensive noise survey of the facility to identify the significant noise contributors followed by the modeling of the noise propagation from these sources. Noise abatement measures were then modeled to predict attenuation values at the receptors which were then compared to legislated acceptable levels. A noise abatement plan was created along with a schedule to facilitate the attenuation recommendations. While not complete, the measures implemented thus far have exceeded all expectations.

SOMMAIRE

La présente étude de cas rapporte les efforts faits pour diminuer considérablement le bruit parvenant à plusieurs maisons en un quartier résidentiel des opérations d'une grande usine de construction automobile. On a commencé par dresser le plan des bruits créés par celle-ci afin d'identifier leurs sources importantes; ensuite on a modélisé la propagation du bruit émanant de ces sources. Des mesures de réduction du bruit ont ensuite été modélisées pour prédire le taux de diminution perçue dans le quartier, qui a été comparé aux niveaux permis par la loi. On a dressé un plan de réduction du bruit et un calendrier de sa mise en oeuvre. L'effet des mesures déjà exécutées a dépassé les espérances.

1. INTRODUCTION

This case study is the culmination of what originated as a two part effort. The first part was to conduct an extensive survey of existing noise levels impacting on immediate residential receptors from the activities of a large automotive manufacturing facility. The second part was to establish a noise abatement action plan to bring all noise levels within legislated guidelines. Since this facility is in operation 24 hours a day, the target time period for noise attenuation was during the night when acceptable levels are most stringent. This action plan was not to exceed two years in duration. The need to conduct this study was in part due to conditions which precipitated from a previous application to the Ontario Ministry of the Environment for a Certificate of Approval (Air) for a newly installed cooling tower. While the noise emissions from the cooling tower were found to be acceptable, other existing sources of noise were identified to be far in excess of ministry guidelines. Initially, day and nighttime measurements at all sensitive residential receptors were made with and without the plant in operation. In addition, all significant sources of noise emission from the building perimeter, openings and surrounding equipment were identified and quantitatively evaluated. The results of these measurements were then compared to the allowable noise levels as specified by the MOE in Publication NPC-205. From these results, problem areas were identified and noise abatement recommendations, including expected attenuation levels, were made for each of the identified significant noise contributors. This plan included a timetable for the implementation of the recommended mitigating measures.

2. INITIAL INVESTIGATION AND ANALYSIS

2.1 Identification of Residential Receptors and Measurement Results

Five sensitive residential receptors were identified around the property line perimeter of the manufacturing facility from which measurements were conducted. These were done during a shutdown to illustrate ambient conditions as well as with the plant in full production.

For the first location, the sound level meter was located at the property line some 80 metres from the nearest corner of the plant. This site was chosen for its close proximity to the truck entrance of the plant property as well as the loading bay where raw steel rolls are unloaded and stored from flatbed trucks. The second location was chosen for its close proximity to the truck turning area and the crane bay which has a large opening in the wall. The nearest residential receptor at this location is approximately 40 metres away. It should be noted that there is a Canadian National Railway line between this measurement location and the residential receptor. The third site was chosen for its proximity to the longest continuous exterior wall of the manufacturing section of the plant. This wall has several doors and windows as well as various pieces of equipment all of which are potential sources of noise. The fourth location was on the roof top of a storage warehouse building on the west side of the facility property line. This is the site of the nearest residential receptor for the entire plant. These measurements were taken directly in the plane of a second story bedroom window of the residential receptor. No measurements were made at ground level for this receptor since the warehouse building provided significant shielding from the plant operating noise. Location 5 was adjacent to the property line of a residential home which was directly exposed to several noisy pieces of equipment including the cooling tower that initiated the entire exercise. A summary of the Equivalent Sound Levels recorded for each of the measurement locations is given in Table 1.

Inspection of Table 1 shows that the noise levels measured at the chosen receptor locations during plant operation are significantly higher than the ambient noise levels at these same locations measured during the plant shut down. It should be noted that the night time measurements were conducted at the most critical locations when the guidelines are most stringent to illustrate the worst case scenario. Only day measurements were conducted at the first two locations, since truck traffic is not accepted at night. The proposed abatement measures for each of the five locations are discussed in detail in section 3.

Location #	Measurement Period	Plant Operating Condition	Leq (dBA)
1	Day	Not operating	59.1
		Operating	60.4
2	Day	Not Operating	56.2
		Operating	58.5
3	Night	Not Operating	48.5
		Operating	64.7
4	Night	Not Operating	46.1
		Operating	63.9
5	Night	Not Operating	50.2
		Operating	63.6

Table 1: Noise Measurements at Residential Receptors.

2.2 Identification of Significant Noise Contributors

In order to properly attenuate the noise at each of the receptor locations, identification and quantification of the noise contributors for each of the locations were conducted.

For the first two locations, there was very little difference between the sound levels with the plant in full operation and during shutdown. The significant noise contribution was from trucks sitting idle in the parking lot after dropping off their cargo. The increase in sound level at location 2 with the plant operating was the result of CN Rail traffic and not plant operations, therefore, no additional abatement measures were deemed necessary here.

Location 3 had several noise contributors. The identification of these sources along with overall sound level measurements at the source and receiver are given in Table 2.

Assuming a hemispherical radiation of noise, and from the sound level for each source at a one metre distance, the attenuated sound level contribution for each noise source at the receptor can be predicted. This distance attenuation is derived by the equation;

$$LP2 = LP1 - 10 \log (R2/R1)$$

Using the predicted noise contribution from each source at the receptor location, a predicted total sound level was calculated to be 69.7 dBA. This predicted noise level is approximately 5 dB greater than the measured noise level for this same location. This discrepancy is due to the fact that the

Source Item	Sound Level @ 1 m (dBA)	Distance to Residential Receptor (m)	Sound Level at Receiver (dBA)
3 Opened Windows	74.8	50	57.8
Fresh Air Supply Fan	77.3	45	61.2
Air Blower Unit	76.9	45	60.4
Compressor Room Intakes	81.8	59	63.9
Dust Collector Unit	83.3	70	64.8
48" Exhaust Fan	77.9	72	59.3
Total Sound Level at Residential Receptor (dBA)			**69.7**

Table 2: Predicted Sound Levels at Nearest Residential Receptor for Location 3.

predicted noise assumes that all sources of noise are present continuously, when in reality, many of them including the fans, compressors etc. cycle on and off throughout the day.

The significant contributors to the noise measured at location 4 were the open second story windows facing the residential receptor. These very long opened windows were approximately 50 metres away from the property line of the residential receptor. Measurements were made at a distance of one metre from the windows with the windows both opened and closed. With the windows open the sound level at the source was 85.5 dBA. Modeling these long windows as a line source, the expected level at the receptor would be 68.5 dBA. This is 4.6 dBA greater than the measured value of 63.9 dBA. This difference may be because of the directional characteristics since the line source is not perpendicular to the reception point and covers a viewing area from only 25 degrees to 50 degrees. With the windows closed, a 10 dB reduction was realized. Although significant, the reduction achievable by closing the windows is not enough to meet ministry standards for night time noise.

The significant contributors to the noise measured at location 5 were again the open second story windows facing the residential receptor as well as seven first floor doors and windows, a set of coolers, a water cooling tower and three roof stacks. The seven doors and windows are all in the same area and are assumed to produce equal amounts of noise. The second floor windows were assumed to act as a line source while the rest of the sources were assumed to radiate spherically. The identification of these sources along with overall sound level measurements at the source and receiver are given in Table 3. The modeled sound level of 65.5 dBA is only slightly higher than the measured sound level of 63.6 dBA.

3. NOISE ABATEMENT PROCEDURE

Once the significant noise contributors were identified and measured, the next step was to establish abatement measures to bring the theoretical noise levels to within ministry standards. Consideration given to the abatement recommendations included capital cost, implementation time frame and most importantly expected attenuation for each of the noise contributors.

3.1 Location 1 and 2

As was mentioned earlier, the only significant noise impact from the plant's activities at this location was identified as idling transport trucks which would frequently park and idle near the residential house for any where from 5 to 30 minutes presumably to fill out log books after being loaded at the docking bays. The proposed solution for this occasional source of noise was to prevent the practice of idling transport trucks near this residential receptor. This was be accomplished by placing large signs in the driveway area indicating that trucks are not permitted to stop and idle their engines in this area. These rules where enforced by plant security staff who where responsible to ensure that the truck drivers were aware and abided by the new rules. Given this, it is felt that no other abatement measures were required in this area.

Source Item	Sound Level @ 1 m (dBA)	Distance to Residential Receptor (m)	Sound Level without Attenuation (dBA)
2nd Story Windows	85.5	107	65.2
1st Floor Windows	91.8 (total)	99	51.9
Coolers	81.1	86	42.4
Cooling Tower	76.5	92	37.2
Stack #13	81.7	96	42.1
Stack #14	76.3	97	36.5
Stack #15	78.2	98	38.4
Total Sound Level at Residential Receptor (dBA)			**65.5**

Table 3: Predicted Sound Levels at Nearest Residential Receptor for Location 5.

3.2 Location 3

The ambient noise measurements at location 3 were about 48.5 dBA at night while the measurements conducted during plant operations, also at night, were approximately 64.7 dBA. This represents approximately a 16 dBA difference and a violation of the MOE limits. The representation of this location is amongst the worst case scenario for the entire facility. The significant contributors to the noise measured at this location are identified in Table 4. Table 4 shows the sound levels measured at a distance of one metre for each of these sources, the proposed abatement measure with its corresponding attenuation value, the attenuation due to the distance to the receiver and the expected sound levels at the receiver with and without the implementation of the proposed attenuation.

The three windows, located very close together, are assumed to act as a single noise source with a total sound level measured at one meter of 74.8 dBA. Assuming a hemispherical radiation of noise, the sound level at the receptor would be 57.8 dBA for this source alone. This hemispherical radiation

Source Item	Sound Level @ 1 m (dBA)	Abatement type	Predicted Attenuation @ Source (dB)	Distance to Residential Receptor (m)	Distance Attenuation (dB)	Sound Level without Attenuation (dBA)	Sound Level With Attenuation (dBA)
3 Windows	74.8	Louvre	19.2	50	17	57.8	38.6
Fresh Air Supply Fan	77.3	Louvre / Enclosure	17.1 + 9	45	16.5	61.2	34.7
Air Blower Unit	76.9	Louvre	19.4	45	16.5	60.4	41
Compressor Room Intakes	81.8	Barrier	19.7	59	17.9	63.9	44.2
Dust Collector	83.3	Muffler / Shield	8.4 + 11.3	70	18.5	64.8	45.1
48" Exhaust Fan	77.9	Louvre / Barrier	16.8 + 15.1	72	18.6	59.3	27.4
Total Sound Level at Residential Receptor (dBA)						**69.7**	**49.2**

Table 4: Predicted Sound Levels at Nearest Residential Receptor - Location 3.

assumption was also applied to all other sources along this section of the plant. It was proposed that the installation of louvres over the windows would allow air intake during the summer while the noise produced by this source could be attenuated by 19.2 dB making the total contribution from this source at the receptor 38.6 dBA. Table 5 shows the octave measurements of the windows without the louvres, the louvre attenuation values provided by the manufacturer and the expected attenuated values for the windows with the louvres.

The total sound level measured for the fresh air supply fan was 77.3 dBA at one metre with an expected contribution at the receptor of 61.2 dBA. It was proposed that an enclosure be constructed around the fresh air supply fan unit with a louvred intake. The louvred intake would be the same as that specified previously for the windows and was predicted to provide 17.1 db of attenuation. The enclosure was be constructed of 4 inch thick sound attenuation batt insulation, or rockwool, and capped with 18 gauge metal. This significant surface mass is assumed to provide at least as much attenuation as the 4 inch material capped with 5/8 inch gypsum thus providing an STC rating of at least 60. It was difficult to establish the total attenuation expected by the enclosure alone since it is difficult to determine how much noise was radiating from the fan structure separate from the intake noise due to their close proximately. Therefore, a modest attenuation of 9 dB is assumed thus giving a total contribution from this source at the receptor of 35.1 dBA.

The total sound level measured for the air blower unit was 76.9 dBA at one metre with an expected contribution at the receptor of 60.4 dBA. It was proposed that louvres be installed on the intake of this unit thus providing for an attenuated noise level at the receiver of 41.0 dBA.

The total sound level measured for the compressor room intakes was 81.8 dBA at one metre with an expected contribution at the receptor of 63.9 dBA. It was proposed that along this section of the plant, a 4.6 metre (15 foot) tall barrier be installed along an 80 foot length of the wall. It was recommended that the acoustical wall be located 2.1 metres from the building wall and have 1.5 metre returns at each end. The barrier would block line of sight for the compressor room intakes, a man door, the lower portion of the dust collector unit and the 48 inch prop fan to be discussed later. The barrier was constructed of 4 inch thick sound attenuation

Octave Band Frequency, Hz	Measured Value (dB)	Insertion Loss, dB	A-Weighting	A-Corrected Attenuation
16	78.9		-50.5	28.4
31.5	79.2		-39.4	39.8
63	76.3	-16	-26.2	34.1
125	76.2	-14	-16.1	46.1
250	70	-15	-8.6	46.4
500	73	-19	-3.2	50.8
1000	68.8	-23	0	45.8
2000	65.4	-19	1.2	43.6
4000	67.4	-19	1	49.4
8000	58.8		-1.1	38.7
10000	42.9		-4.3	38.6
Total Attenuated Sound Level (dBA)				**55.6**

Table 5: Window Louvre Attenuation.

1	**Octave Band Centre Frequencies**	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
2	Measured Octave Sound Levels (dB)	78.2	82	81.9	80.2	76.4	72.4	68.9	59.6
3	A-weighting for band	-26.2	-16.1	-8.6	-3.2	0.0	1.2	1.0	-1.1
4	Measure Weighted Octave Sound Levels (dBA)	52	65.9	73.3	77	76.4	73.6	69.9	58.5
5	Predicted total sound level (dBA)	**81.8**							
	Barrier Calculation								
6	Dsb [7 ft] (metres)	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
7	Spacial Correction to Dsb to account for distributed noise source	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
8	Dbr (metres)	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9
9	Bh metres	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
10	Sh (2/3) of dryer base height	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
11	Receiver height [1.5 metres] metres	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
12	Path length difference (metres)	1.553	1.553	1.553	1.553	1.553	1.553	1.553	1.553
13	Fresnel number	0.570	1.131	2.262	4.524	9.048	18.096	36.193	72.386
14	Barrier attenuation (insertion loss) (dB)	10.9	13.6	16.5	19.5	22.5	23.0	23.0	23.0
15	Predicted Octave Sound Levels (dBA)	41.1	52.3	56.8	57.5	53.9	50.6	46.9	35.5
16	**Predicted Lp from base (dBA)**	**62.1**							
17	**Attenuation Due to Distance (dB)**	**17.9**							
18	**Total Sound Level at Residential Receptor from this Source (dBA)**	**44.2**							

Table 6: Compressor Room Intake Noise Barrier Calculations.

batt insulation, or rockwool, and capped with 18 gauge metal. Like the previously discussed enclosure for the fresh air intake fan, the surface mass of this barrier is assumed to provide an STC rating of at least 60. It was assumed that the transmission loss due to the barrier effects was less than the absorbative characteristics of the wall material, therefore, the barrier effects were used for the assumed attenuation of this source. It was determined that with the barrier attenuation that the noise contribution from this source at the receptor would be 44.2 dBA. The barrier attenuation calculations for this source is shown in Table 6.

The total sound level measured for the dust collector unit was 83.3 dBA at one metre with an expected contribution at the receptor of 64.8 dBA. It was proposed that a shield, or noise barrier, be constructed around the fan unit using the same material previously discussed along with a 6 foot duct silencer for the dust collectors exhaust fan. It was predicted that the barrier and silencer combination would provide 19.7 dB of attenuation thus giving a total sound level at the receptor of 45.1 dBA. The attenuation calculations for the barrier is similar to that shown above. The 6 foot silencer recommended for the exhaust fan was a 6 inch diameter duct with 2 inch acoustical lining. The attenuation calculations for the silencer are given in Table 7.

The total sound level measured for the 48 inch propellor exhaust fan was 77.9 dBA at one metre with an expected contribution at the receptor of 59.3 dBA. It was proposed

Octave Band Frequency, Hz	**Measured Value (dB)**	**Insertion Loss, dB**	**A-Weighting**	**A-Corrected Attenuation**
16	80.7		-50.5	30.2
31.5	81.6		-39.4	42.2
63	75.9	-16	-26.2	33.7
125	87.8	-14	-16.1	57.7
250	79.5	-15	-8.6	55.9
500	76.1	-19	-3.2	53.9
1000	71	-23	0	48
2000	65.8	-23	1.2	44
4000	60	-19	1	42
8000	55.3	-19	-1.1	35.2
10000	46.2		-4.3	41.9
Total Attenuated Sound Level (dBA)				**61.4**

Table 7: Silencer Attenuation.

that an acoustical cowl and louvre be installed on this fan. This fan is also inside of the noise barrier previously discussed for the compressor room intakes and will benefit from this as well. It was predicted that the louvre and barrier would provide 16.8 and 15.1 dB of attenuation respectively. This would result in an overall noise level at the receptor of 27.4 dB for this source.

Measurements indicated that the highest noise level measured at the representative receptor in this area was 64.7 dBA with the plant in operation. The measurement made at this same location with the plant not operating was 48.5 dBA. This would indicate that during the night time, the plant may not produce levels in access of 48.5 dBA at this residential receptor. In other words, the facility needed to attenuate the sources effecting this receptor by 16.2 dBA. Inspection of table 2 indicates that the theoretical sound level at the receptor location with no abatement was 69.7 dBA. With the installation of the proposed noise abatement measures, the noise is modeled to reduce to 49.2 dBA thus providing an overall attenuation of 20.5 dB. This attenuation is 4 dB more than required according to the worst case scenario represented by the measured numbers. It is assumed that any differences between the theoretical and measured values were due mostly to directivity characteristics and that the relative difference is what is most important.

3.3 Location 4

The ambient noise measurement at location 4 was 46.1 dBA at night while the measurements conducted during plant operations, also at night, was 63.9 dBA. This represents a violation of the MOE limits by 18 dB. The significant contributors to the noise measured at this location were open second story windows facing the residential receptor. These windows were approximately 50 metres away from the property line of the residential receptor. With the windows open the sound level one metre from the source was 85.5 dBA. Modeling this source as a line source, the expected level at the receptor was 68.5 dBA. This is 4.6 dBA greater than the measured values which again may be explain by directional characteristics. With the windows closed, only a 10 dB reduction was realized. It was proposed that these windows be permanently closed and blocked with at least 3 inches of sound attenuation batt insulation with a single layer of 0.5 inch gypsum or better in order to achieve an STC rating of 51. This is expected to provide an overall attenuation of 48.4dB as compared to when the windows are in the open position. This would bring the noise contribution from this source at the represented receptor to well below the night time ambient levels. To allow for additional air intake it was proposed that 5 to 6 inline centrifugal fans be install on the roof in a less sensitive location. These fans would also be specified so that they will not add to the existing ambient noise. No other noise sources significantly impacted this receptor due to the significant barrier attenuation achieved from the adjacent warehouse building.

3.4 Location 5

The ambient noise measurements at location 5 was 50.2 dBA at night while the measurements conducted during plant operations, also at night, was 63.6 dBA. This represents a violation of the MOE limits by 13.4 dB. The significant contributors to the noise measured at this location are the open second story windows facing the residential receptor, seven first floor doors and windows, a set of coolers, a water cool-

Source Item	**Sound Level @ 1 m (dBA)**	**Attenuation type**	**Predicted Attenuation @ Source (dB)**	**Distance to Residential Receptor (m)**	**Distance Attenuation (dB)**	**Sound Level without Attenuation (dBA)**	**Sound Level With Attenuation (dBA)**
2nd Story Windows	85.5	Close and Block	48.4	107	20.3	65.2	16.8
(7) 1st Floor Windows	91.8 (total)	Barrier	11.1	99	39.9	51.9	40.8
Coolers	81.1	Barrier	8.2	86	38.7	42.4	34.2
Cooling Tower	76.5	Barrier	8.8	92	39.3	37.2	28.4
Stack #13	81.7	N/A		96	39.6	42.1	42.1
Stack #14	76.3	N/A		97	39.7	36.5	36.5
Stack #15	78.2	N/A		98	39.8	38.4	38.4
Total Sound Level at Residential Receptor (dBA)						**65.5**	**46.3**

Table 8: Predicted Sound Levels at Nearest Residential Receptor - Location 5.

ing tower and three roof stacks. The seven doors and windows are all in the same area and were assumed to produce equal amounts of noise. The second floor windows were assumed to act as a line source while the rest of the sources were assumed to radiate spherically.

The second floor windows are the same as those considered for location 4. As in the previous case, it was proposed that these windows be blocked with sound attenuation insulation which would give an attenuation of 48.4 dB. For the seven windows and doors, the coolers and the cooling tower it was proposed that a 3.05 metre (10 foot) high and 19 metre wide barrier be constructed to break line of sight to these noise sources. The barrier was to be attached to an existing quench oil storage building which will provide the rest of the required shielding.

The expected attenuation values for these measures are given in Table 8. It can be seen that a total attenuation of 19.3 db was realized. This meets the required attenuation to bring the sound level down to the acceptable ambient levels for both day and night time.

4. ABATEMENT SCHEDULE

In order to complete the above abatement measures, a two year plan was established which was to commence immediately after the plan had been approved by the MOE. During the first year, the following item were proposed to be completed. The signs in the area of residential receptor 1 disallowing the parking and idling of transport trucks were to be erected and enforced by plant security personnel. For location 3, it was proposed that the louvres be installed on the three windows at the east end of the building, the enclosure and louvre were to be installed on the Fresh Air Supply Fan and the louvre was to be installed on the air blower unit. Also, the shield and duct silencer was to be installed on the Dust Collector unit and the louvre and cowl was to be installed on the 48 inch propellor fan. During the second year, it was proposed that the south facing second story windows near receptor 4 be closed and blocked with sound attenuating material and that the 3.05 metre tall barrier wall be constructed in order to protect residential receptor 5 from the coolers, water cooling tower and the open first floor windows and door. Also during this period, it was proposed that the 4.57 metre tall barrier wall be installed along the north wall to protect the residential receptors from any noise from the compressor room air intakes.

5. INTERIM RESULTS

While a final investigation of the results of the abatement measures is still outstanding to date, an interim investigation was conducted with approximately half of the abatement recommendations addressed.

The signs at location 1 indicating that trucks are not permitted to idle on the property have been erected and followup investigations with the nearby residents have confirmed that these new procedures have been successful in lessening the noise impact from the truck traffic.

Along location 3, a noise enclosure has been installed on the 48" Exhaust Fan which resulted in a noise reduction of 21 dB. This is about 4 dB greater than predicted. The dust collector unit was relocated inside the building and all exterior ducting was enclosed with noise attenuating material. At a distance of one metre away, this piece of equipment was now all but inaudible. The Fresh Air Supply fan and Air Blower unit were also enclosed with noise attenuating material and louvres were installed on the intakes. Preliminary measurements indicated that the realized attenuation values are also greater than predicted. The windows along this wall have been permanently filled with solid acoustical panels. And it was observed that no noise was detectable at the openings. The largest noise contributor in this location was from the intake louvres for the air compressor room. Instead of shielding this source as originally suggested, the entire compressor room was relocated in a less noise sensitive area of the plant with new, quieter, compressor units. The noise emissions measured at a distance of one metre from the newly acoustically treated openings was 59 dBA. This is approximately a 23 dB noise reduction. While night time measurements were not made at the residential receptor for this location, it is felt that the improvements made thus far have greatly lessened the impact on these houses.

At the time of the visit, implementation of the remaining abatement measures were still outstanding.

6. CONCLUSIONS

Large scale noise investigations are extremely dynamic in nature with a great deal of variables to consider. While not entirely complete, this case study is on the road to a successful end. The abatement measures implemented thus far have exceeded all expectations.

This case study illustrates how a complex noise problem can be broken down into several small parts and then synthesized back into a whole result. That being an overall reduction in noise to an acceptable level.

This case study also illustrated that while actual measurements and predicted results may differ, they do provide important relative values that can be used as effective tools for noise attenuation prediction and implementation.

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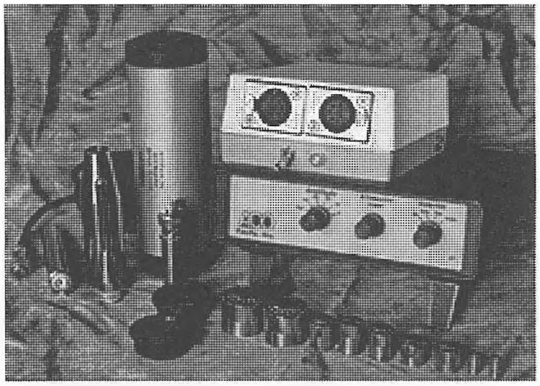

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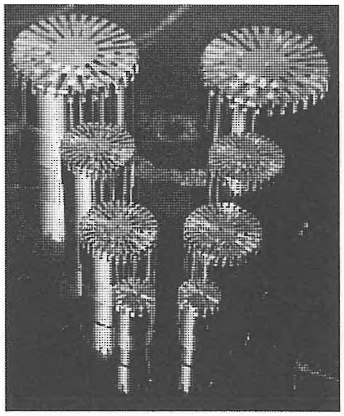

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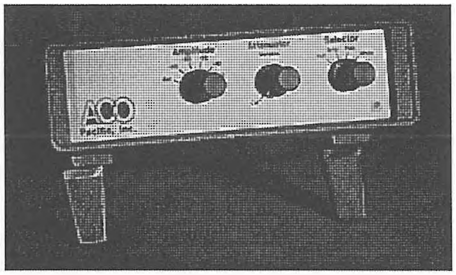

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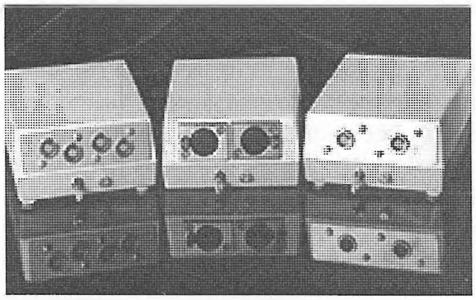
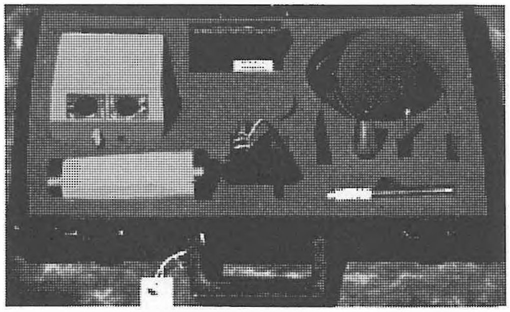
2 and 4 Channels - Gain Available
XLR and Lemo™ Connectors



PS9200KIT

Includes: PS9200 (XLR) Power Supply
AC Adaptor
4012 Preamplifier w/CA4012-5 Cable
Selection of 1/2 Inch Type 1 Microphone
WS1 - 3 inch Windscreen
SC1 Die Cut Storage Case (SC2 optional)
Options: 511E SPL Calibrator (shown)
"G" Gain Stage

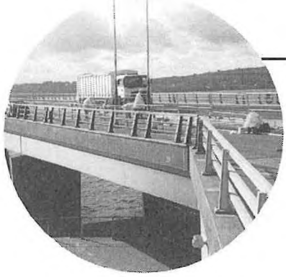


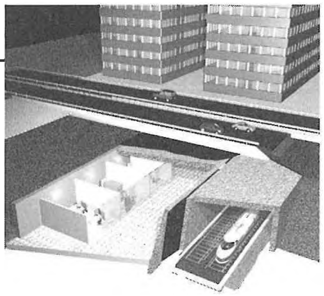
ACOustics Begins With ACO™

Vibration Insulation

2 ways Regupol Regufoam

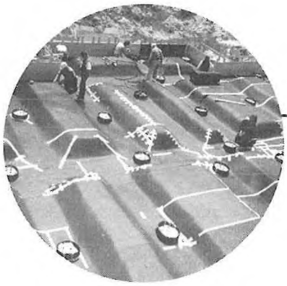
1 goal **Optimal vibration absorption and insulation of <u>structure-borne sound</u> using recycled rubber and foam materials.**

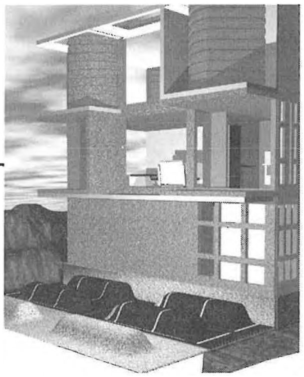




Road Construction

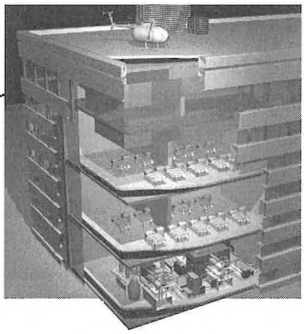
For rail and tunnel construction, as well as for road and bridge construction, Regupol and Regufoam are used for vibration insulation and shockproofing.





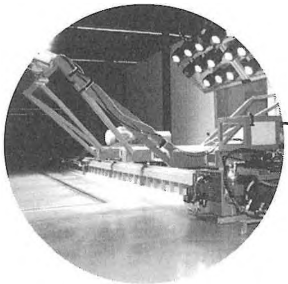
Foundations

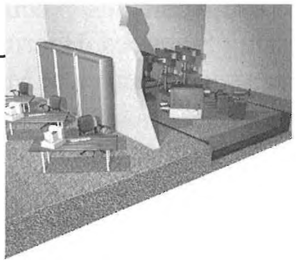
To protect against ground vibration, Regupol and Regufoam insulate large buildings with appropriate load distribution slabs.



High-Rise Building

Whether for elevator motors, pumps, ventilation systems or block-type thermal power stations, structure-borne sound insulation and vibration absorption with Regupol and Regufoam are simple and permanent.





Industry

Here Regupol and Regufoam are used for the active insulation of machines and passive insulation of floor slabs for precision measuring instruments, laboratory facilities or measuring chambers. Both subcritical and supercritical bearings are possible.

For more information and
technical data call:
Paul Downey, B. Eng.
Business Development Manager

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www.regupol.com

Phone: 416.440.1094
Toll free: 800.322.1923
Fax: 416.440.0730
Email: pcd@regupol.com