Sophisticated Noise Modeling at a Power Plant Provides a Win-Win Solution for All

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A critical noise control task undertaken at a power plant required the use of sophisticated noise measurements and modeling using Cadna-A. The results were successful, the client was extremely pleased, and several members of the neighboring community provided messages of appreciation for a job well done.

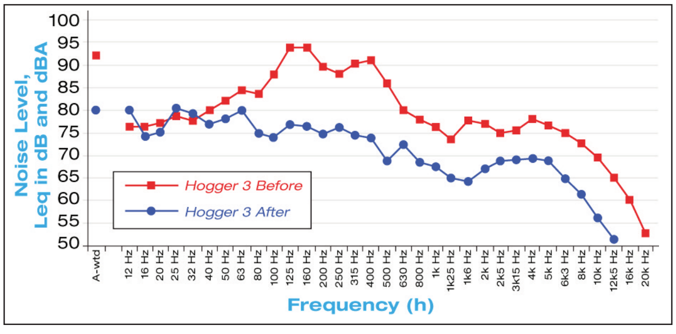
PB was engaged in the preliminary engineering/design and permitting of a significant expansion of British Gas North America's (BGNA) Lake Road Power Generation Plant located in Killingly, Connecticut—the addition of a fourth generating unit, a 411 MW Mitsubishi M501G combined-cycle unit. In recent years, it had become clear that start-ups of the plant's existing three units, which typically occurred early in the morning, were causing objectionable noise levels in the neighboring community. This issue was becoming a point of contention between the plant owners and the community. In addition, the neighbors were very concerned about the new Unit 4, which might be noisier than the existing units because it was larger.

We offered the services of our acoustical staff to help identify, analyze, and prove the effectiveness of a suitable solution. Success was essential; otherwise, the plant would not be granted its much desired expansion permit.

The Problem

The BGNA Lake Road Plant includes three Alstom GT-24 single-shaft combined cycle units with a total output of 800 MW. The GT-24s are fired on natural gas and No. 2 fuel oil. They have been in operation since 2001. The plant was designed originally to be a base-loaded facility and operate more than 8,000 hours per year. Because of changing conditions in the power market, however, each unit might start-up as many as 200 times a year. This usage has caused unplanned wear and tear on plant equipment that resulted in the increased levels of noise during start-ups.

Figure 1. Before and after hogger-silencer noise levels.



A site visit and noise measurement study showed that the main problem was likely the loud noise made whenever high-pressure steam was released to the environment through the hogger vents on each unit. Witnesses described this noise as sounding like a jet engine. As shown in the top curve in Figure 1, noise levels at 30.5 meters (100 feet) from the hogger were as loud as 92 dBA with predominant noise energy occurring in the 125 to 500 Hz third-octave band frequency range. For perspective, a noise at this loud level would require people to yell to be heard when standing within a few hundred feet of the hogger vents. While there were certainly many other noise sources associated with the plant, it was decided to find a solution to the hogger noise first and then see what other sources, if any, needed to be attenuated.

The Noise Control Solution

Based on other successful industrial noise control projects, we invited representatives from Industrial Acoustics Company (IAC) to join in the discussion to devise a suitable noise control solution. We developed the acoustical performance requirements for the job, and then IAC configured one of their lined-pipe silencers to accomplish the goals. It was 4.9 meters (16 feet) long with a 107-cm (42-inch) outer diameter and 61-cm (24-inch) inner diameter (Figure 2).

Lined-pipe silencers are not particularly exotic noise control devices; they are simply exhaust pipe extensions with a larger diameter to allow room for sound ▸

Figure 2. Hogger vent with new IAC lined-pipe silencer on one of three existing units.

absorptive materials, such as Fiberglas, to be packed-in along the pipe walls. Turbulent (i.e., loud) air flowing through the pipe comes in contact with the absorption material and is attenuated before exiting the pipe. Lined pipes must be designed carefully, however, to work within the expected air flow velocities, pressure drops, and temperature ranges, and to physically fit within the allotted space.

IAC guaranteed an insertion loss (i.e., noise reduction) of 20 dBA. Our team reviewed the lined-pipe design that IAC proposed, and we agreed that it would meet the need. Three lined-pipe silencers, one for each of the plant's three units, were installed in the spring of 2008 at a total cost (design, materials and installation) of about $206,300. Noise complaints from the neighboring community ceased immediately.

Noise Measurements

We performed a series of noise measurements to document the "after" noise conditions. It was hoped that the noise tests would confirm that the plant's noise emissions at the nearest property line had been reduced sufficiently to comply with the Connecticut State Noise Regulation of 51 dBA and BGNA's corporate noise goal of 45 dBA. Measurements were taken on-site to evaluate noise levels attributable solely to the plant and at the nearest property line.

On-Site Hogger Vents. The "after" measurement results, shown in the bottom curve in Figure 1, indicated that the new silencers were working effectively. On a broadband basis, the "after" condition was 12 dBA quieter than the "before" condition. Significant reductions of as much as 18 decibels could also be seen in the crucial third-octave bands ranging from 125 Hz to 500 Hz. But the full extent of the silencers' noise attenuation performance could not be measured because the noise contribution from the plant's other noise sources limited the quietest level that could be measured for just the hogger vents.

Property Line Measurements. Noise from the plant was barely audible at the property line location and only for brief moments because other background noise sources, most notably traffic, dominated the acoustic environment there. This fact meant that noise levels at the property line attributable just to the plant needed to be determined using means other than simple direct measurements.

The results of the measured 1-minute L_{eq} levels (i.e., energy-averaged noise levels during 1-minute periods) are shown in Figure 3 for the on-site monitor and the property line monitor. Several noteworthy findings can be determined from these results:

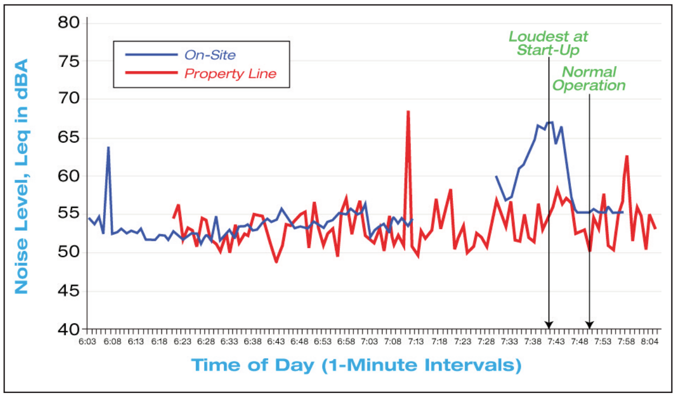
- There is no clear correlation between time-varying noise levels at the two sites. This means, as described above, that the noise level at the property line was dominated by other non-plant-related noise sources.
- The loudest minute during start-up occurred at 7:42 AM, yet there was no obvious corresponding elevation in noise level at the property line.
- The noise level during normal operations was about 12 decibels quieter than the loudest moment during start-up.

Sophisticated Noise Modeling Used to Determine Plant Noise Compliance

An often-used method of identifying and quantifying plant-related noise levels at more distant property line locations is to model the noise contribution attributable solely to the plant to a more distant point of interest. This method is particularly useful when background noise levels are dominated by other non-plant-related sources, such as in this case. To this end, the on-site noise measurements are extremely useful because they are dominated by plant-only noise due to their relatively close proximity to the plant. We positioned the on-site monitor about 110 meters (360 feet) from the façade of the control room building. In contrast, the property line monitor was located about 558 meters (1,830 feet) away from the same façade.

Plant-only noise levels at the property line were analyzed using the Cadna-A® noise model developed by DataKustik GmbH that implements ISO Standard 9613-2 for environmental noise sources and sound propagation characteristics. This is an extremely sophisticated three-dimensional model in which a noise source is assembled from point, line and/or area components; each emitting sound power in octave bands or broadband A-weighted format. Distance losses, ground attenuation, foliage areas, and barrier/

Figure 3. Measured 1-minute L_{eq} noise levels.



berm effects are applied automatically, and the resulting noise levels are computed at any number of receptor locations of interest.

The Cadna-A model can generate noise contour lines (isopleths) on a base map showing how noise radiates from the sources and how it is affected by intervening structures and terrain. The noise contour lines are useful for presenting the results in a graphical format that can be easily interpreted to estimate the noise level at any location of interest.

The Cadna-A model for the BGNA Lake Road Plant was first configured by importing a Google Earth® base map of the area. The plant was modeled as a vertical plane source representing the entire façade of the building facing the two noise monitoring locations. Equivalent sound power octave band levels of the plant were then computed by taking into account the on-site sound pressure level measurements and the distance of 110 meters (360 feet) to the plant's façade. In this manner the Cadna-A model was "calibrated" so that it would duplicate the results that were actually measured at the on-site monitoring location. This calibration exercise was crucial to ensure that modeled noise levels at any point or distance of interest would, with all reasonable expectation, be identical to what the measured noise levels would have been at the same point of interest due solely to plant noise.

Two Cadna-A models were configured: one for the loudest moment during the start-up process (Figure 4), and the other for the plant's normal operating condition (Figure 5). The results of the two Cadna-A model runs indicated that plant-only noise levels at the property line location would be 45 dBA L_{eq} during the loudest moment of start-up, and then drop down to 36 dBA L_{eq} once the plant settles into normal operating mode. It was therefore concluded that noise attributed solely to the plant would comply with both the Connecticut State Noise Regulations limit of 51 dBA and BGNA's corporate noise goal of 45 dBA at the nearest property line during start-up and normal operating conditions.

Conclusion

This was an excellent example of PB being able to provide a client with a total solution. Based on an excellent working relationship with this client, additional PB staff were welcomed by the client to analyze and resolve this consequential challenge. PB's staff, expertise, and analysis tools allowed for a professional evaluation and solution of a major community noise concern, and in doing so, supported the client's desire to expand their power plant.

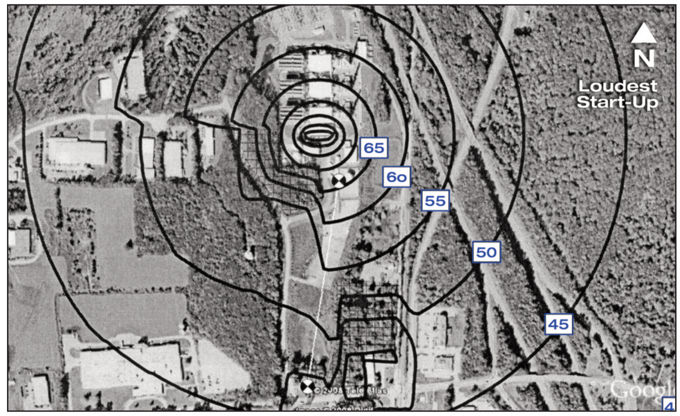


Figure 4. Cadna-A model results for loudest start-up.

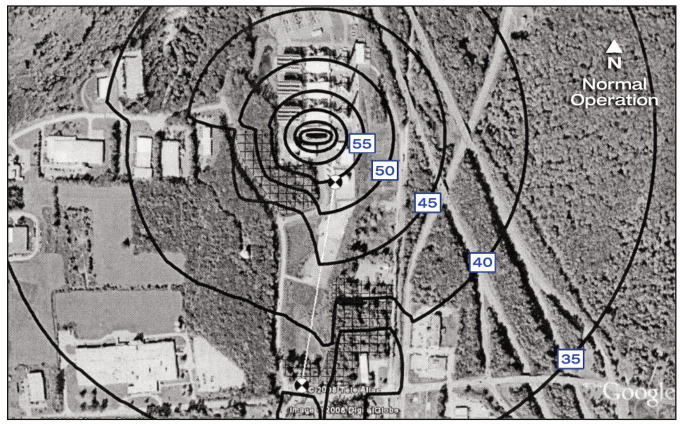


Figure 5. Cadna-A model results for normal operation.

This project also gave us a unique opportunity to make use of sophisticated noise measurement and modeling techniques to prove that our solutions were indeed successful. Everybody won in this case; the community got the peace and quiet they wanted, the town administrators gained confidence that noise associated with the plant's future expansion would not be problematic, and most importantly, the client was thrilled with PB's competence and professionalism in solving what had been a vexing problem. □

Acknowledgements:

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Related Web Sites:

- DataKustik: (www.DataKustik.com)
- Industrial Acoustics Company (IAC): (www.IndustrialAcoustics.com)

Erich Thalheimer is a senior noise and vibration engineer with PB in the Boston office. He joined PB in 1996 to manage the noise control program for the Big Dig project in Boston (Central Artery and Tunnel project). Since that time he has gone on to develop FHWA's new roadway construction noise model (RCNM) and handbook and, more recently, the new Construction Noise Regulations for the City of New York.