EVOLUTION OF NOISE CONTROL TECHNOLOGY

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Abstract

Since the late 1960's noise pollution has become more prevalent, and is still a critically ignored issue within Alberta. As noise pollution in our environment becomes an increasingly dramatic topic, more effective forms of noise control are required to satisfy the quality of life for the population that is encompassed by the undesirable noise sources. Original methods of noise control were inexpensive, non-technical, and grossly ineffective. We now have advanced to using extensive engineering and robust designs to increase the overall effectiveness and aesthetics of physical noise abatement equipment. A more recent development is the introduction of active noise control. This new technological solution administers low frequency sinusoidal waves to those undesirable incident waves, effectively cancelling portions of their amplitude and making the resultant wave significantly smaller in magnitude. This paper outlines the evolution of noise control measures which were the result of technological advancements and more stringent regulations enacted in legislation over time.

Introduction

There exist two main categories of environmental noise mitigation procedures: [1]source control and path control. Source control is the process of controlling noise production at

[1] Blies & Hansen, D.A., C.H. (2003). *Engineering Noise Control: Theory and Practice*. Philadelphia, PA: Taylor & Francis.

the contributing source. Examples of source control include operating level restrictions for "noisy" equipment, equipment designs to reduce vibration, and the utilization of electronics in substitution for mechanics. Path control is the mitigation of noise along a certain path of its propagation, generally used to lower noise pollution for a specific receiver. Path control is exercised through three main ideas, distance, reflection, and absorption. The idea of placing distance between source and receiver is quite straight forward, whereas reflection and absorption are characterized through the construction of noise barriers, noise curtains, exhaust silencers, and acoustically treated enclosures. Before the 1960's the ability to make accurate noise propagation calculations, as well as design decisions for noise control on industrial facilities were somewhat limited. Because of this, path control techniques were the earliest implemented noise mitigation procedures. When the Energy Resources and Conservation Board (ERCB) began instituting noise regulations in [2]1973, the need for higher quality noise abatement equipment increased. These regulations required more rigorous research and development in the area of noise mitigation, and ultimately resulted in the production of more effective and higher quality noise suppression equipment.

Early Noise Control

In the late 60`s and early 70`s noise mitigation techniques were quite limited. Companies in the oil and gas industry were, for the most part, uninterested in applying noise control to their facilities due to the lack of legislation limiting noise pollution. Those facilities

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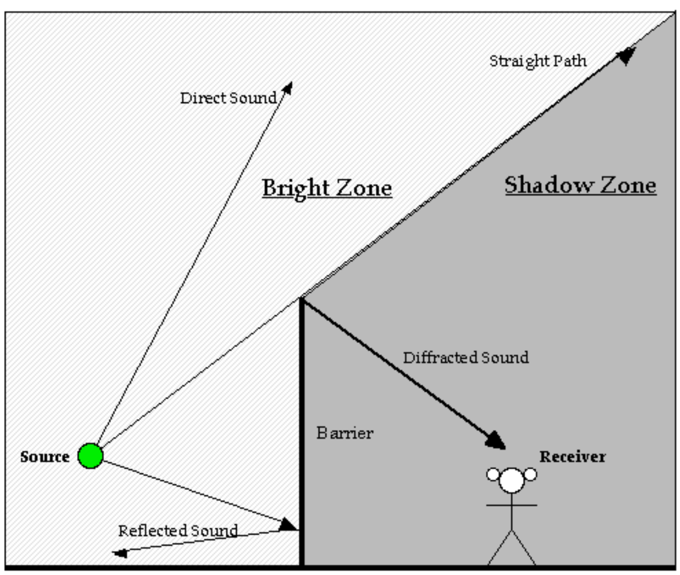
[2] DeGagne, D.C. (1999). The Evolution of Environmental Noise Legislation for Alberta's Energy Industry Over Three Decades. *Canadian Acoustical Association Conference*

which were treated during this era were done so out of respect for the surrounding population and environment, and were treated with rudimentary path control options, most often in the form of barriers. Such barriers that were erected were normally made of simple plywood, hay bales, or sometimes they were mounded soil barriers called berms. This style of barrier works well for certain applications, such as for roadside acoustic barriers, but they proved quite fruitless in typical oil and gas industry applications. The reason for this is that acoustic barriers provide attenuation, but only within their `shadow`. The shadow is the region behind the barrier that is lower than the angle formed by the incident sound waves and the top plane of the barrier. The shadow zone does not provide complete attenuation however, as there is also diffracted sound waves which pass downward from the barriers top plane as well as transmitted sound through the barrier.

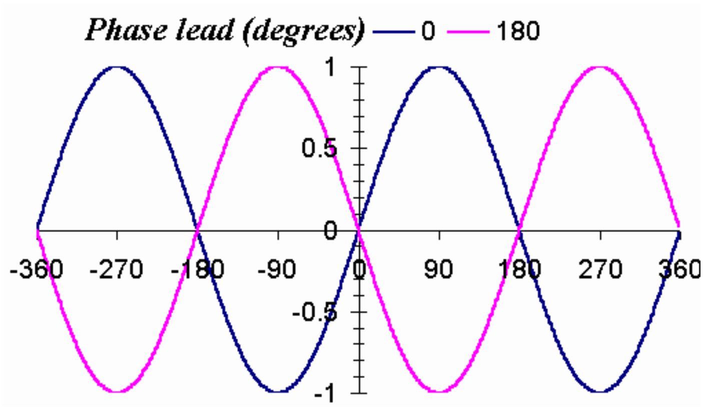


[3]***Figure 1: Sound Behavior at a Barrier***

[3] Rosenberg, E. (1997). Continued investigation of noise reduction by a random-edge noise barrier. In I. Busch-Vishniac (Ed.), *Acoustical Societ of America 133rd Meeting Papers* Austin: ASA World Wide Press.

In order for these barriers to work effectively in an oil and gas application, the barrier would have to be placed very close to the source, the receiver, or both, and would have to be inconveniently tall. This is an undesirable situation in the circumstance of a residence wanting relief from compressor station for obvious reasons.

Although the oil and gas industry was seemingly uninterested in noise control, the aviation industry discovered an important application for active noise control (ANC), using it to limit noise within the cockpits of helicopters and aircraft. These applications were based off the patents originally filed by Lawrence J. Fogel in the 1950's. [4]ANC is also referred to as 'antinoise'. Because noise is a sinusoidal pressure wave it consists of two phases; a compression phase and a rarefaction phase. The application of antinoise is when a sound wave with the same amplitude, but inverted phase (delayed 180^{o}) of an incident wave is combined with the incident wave.



[5]*Figure 2: Two Out of Phase Sinusoids*

[4] Chen & Li & Hu & Lu, K., S., H., J. (2008).Some physical insights for active acoustic structure. *Applied Acoustics*. *70*, 875-883.

[5] Wittenberg, P. (1997). Representing a radio wave with a sinusoid. Retrieved May 8, 2009, from Radar Problems Web site: http://radarproblems.com/chapters/ch05.dir/ch05pr.dir/c05p1.dir/c05p1.htm

Destructive interference will occur and effectively the waves will both be cancelled out (known as phase cancellation). The phase cancellation produces a resultant sound wave which is extremely faint, possibly even inaudible to the human ear. During this time ANC was a breakthrough technology, but was not able to be utilized in most applications due to its restriction of being used in confined space.

Besides an application of barriers and small enclosure ANC there were little other forms of noise control during this time. Compressor facilities were more often than not fitted with the least expensive mufflers available, which were little more than straight piping, and there were no effective forms of cooler silencers.

During these years of early noise control it was unusual to see original facility designs that took equipment noise control into consideration. It seems that one of the more prevalent noise control considerations taken into account by the oil and gas companies, at this time, was to avoid having the cooler inlets facing or aligned towards any nearby residents. As for the design of the compressor engines themselves there was little consideration for noise pollution as the engines were large and ran on low RPM which produced very distinctive low frequency noise. Noise control at this stage was retrofitted, that is, applied to sources after the original construction of the noise emitting devices.

Control Between the 80's and 1997

In Alberta the ERCB maintained and even increased regulation of noise pollution during the 80's. In the United States Ronald Reagan cut funding to the Environmental Protection

Agency's (EPA) acoustic program and regulation of noise control plummeted. Though the EPA's contribution to the regulation of noise pollution during this time was negligible, other organizations such as the Federal Aviation Administration (FAA) began pursuing robust research and development in source noise control. The FAA began changing flight plans to lower noise pollution in high density residential areas, and they also supported the design and manufacturing of quieter jet engines, and aerodynamic plane designs in order to lower aircraft noise. Programs during this time were also initiated to insulate homes which were located near aircrafts low-flying zones to eliminate some of the noise transmission into residencies.

During the 1980's the ERCB re-evaluated Directive 038 (Noise Control) multiple times and refined it from the very basic outline which it was in 1973 to the much more comprehensive Directive that we see today. The Directive's more stringent guidelines initiated an advancement of noise abatement technology and sparked more interest in noise control. However, there was still a lack of enforcement, as well as a lack of public knowledge, for the guidelines put forth in the Directive, so it remained that many oil and gas compressors operated without sufficient noise control, risking that they would not get any complaints. With the increase in number of compressor stations which emerged in Alberta over this period, public awareness of noise pollution increased, and through advertisement by the ERCB, the public soon realized that they could take steps to help stop the noise which was becoming a more prevalent nuisance. This resulted in a dramatic increase in noise complaints and enforcement actions by the ERCB.

Also during this time period city centers grew in size very quickly, and as a result traffic flow increased around these large centers. With increased traffic came excess road noise, which required that research be done to improve the reflective and absorptive capabilities of acoustic barriers used along the busy streets and freeways. [6]One key modification to barriers was to construct them out of corrugated metal with an absorbent coating, or brick rather than ineffective materials like plywood. Other improvements were made to the barrier designs as well, such as creating a random edge on the top plane of the barrier, rather than having it smooth, in order to increase noise deflection. The change from a flat top plane to a random edge top plane produced an attenuation of 3-8 dB (energy reduction of 16-50%) for the barriers. During these years the number of small innovations all contributed to a vast increase in the performance of noise control equipment for roadside applications.

The oil and gas industries use of new noise control technology remained relatively unchanged during this period, and it was not until the mid 1990's that new innovations in noise control started to become evident. In 1994 new conceptual designs of cooler inlet and engine silencers emerged. These designs featured remarkable Direct Insertion Loss capabilities, not previously seen in conventional noise suppression equipment. In 1997 Rod MacDonald formed a new company, [3]Noise Solutions Inc. (NSI), which carried these earlier designs to even greater refinement. With new, reliable, and effective noise suppression equipment now in the market the oil and gas industry began to purchase, and implement, noise abatement equipment onto their compressor stations as a form of noise

[6] Rosenberg, E. (1997). Continued investigation of noise reduction by a random-edge noise barrier. In I. Busch-Vishniac (Ed.), *Acoustical Societ of America 133rd Meeting Papers* Austin: ASA World Wide Press.

path control. Retrofitting this noise abatement equipment ensured facilities would be built to be compliant with the noise regulations. Through various forms of communication, rural residents began to realize that there were effective ways to manage noise problems, and not only that, but oil and gas operators were quick to purchase this equipment to comply with the regulations set in the ERCB Directive.

Current Noise Control

Since 1997 new innovative, and custom, noise abatement equipment continues to be designed, or refined, and manufactured for a steadily growing market. Noise suppression equipment for oil and gas facilities ceased to be stock parts on some warehouse shelf; rather it was designed specifically for each job. For example, custom ventilation silencing packages started to be produced both to keep the compressors cool, and allow the operators to keep building doors and windows closed, eliminating noise from escaping the building. A greater understanding of sound propagation and better engineering tools allowed for an increase in design efficiency. Engineers were designing ever more effective products. With increased public awareness about the state of noise control the oil and gas industry has made noise impact analysis, and the use of noise abatement equipment, standard on compressor packages.

Not only did the ability to produce path noise controls increase, but also did the ability to apply source controls. For example, fans traditionally used wide, straight blades, which produced an irritating low frequency noise due to the amount of air resistance during their cycle. To reduce the amount of fan blade noise, blades were altered from the traditional style to thinner, angled blades, which work to reduce drag while the hub is rotating

(C. Faszer, personal communication, 05, 05, 2009). Engines have also undergone some noise source control. Engines for compressors are now being made smaller, have thicker piston walls, and run at higher RPM, which causes the engines to produce higher frequency noises then before, which are easier to attenuate. Though the engine re-design was primarily for performance reasons, it none-the-less resulted in positive acoustic properties.

Residential applications of noise control have also become quite popular in more recent years. Since the technology is getting better silencer designs can be made smaller and using less material, which means that they are cheap enough for everyday consumers. Some such silencers are utilized on domestic air conditioners, within vacuum cleaners, and within motor vehicles. ANC has also advanced quite far, but unfortunately it is still only utilized within confined spaces such as automobiles, airplanes, and some auditoriums. Products which were released utilizing ANC technology in the oil and gas industry have been unpopular, expensive, and yet not as effective as physical path control systems.

Future Noise Control

With constantly increasing technology and understanding of pressure wave physics the possibilities for noise mitigation could be endless. In time it may be possible to adapt microphones, and speakers, to be capable of operating in the harsh conditions encountered in oil and gas applications, making ANC a more viable option. Once path control techniques get to a point of robustness not readily available today, the next step is more comprehensive source noise control. Innovative forms of source control could involve the re-design of conventional compressor packages, making the engines quieter, or possibly to eliminate some of the noise sources altogether.

Ultimately, future noise control is dependent on those who are entering the industry. If educational institutions continue with acoustics training programs there will always be bright and innovative people coming into the workplace. This new generation of acousticians will bring new ideas and "out of the box" ways to approach problems. This is how most new ideas and technology are born.

Conclusion

It has taken many years for Society to reach a point where noise pollution is no longer acceptable, and has become an increasingly significant environmental issue. With the increase of public awareness, and a firming of regulations by organizations like the ERCB, technological advancements are necessary to fulfill these expectations. As we have seen, advancements in path noise control have been quite fruitful and abundant, but as time continues and noise pollution increases, it can be assumed that equipment designs will have greater consideration of its noise potential. The application of source noise control in initial designs will make applying path control simpler and less expensive.

Due to advanced computer software and a growing resource of experience in acoustics, it is now possible to generate both source and path noise control for almost any emitter of sound. A significant challenge remains in the education of all parties involved on the impacts of noise, and the solutions, that exist to manage these to acceptable levels from a regulatory and societal level. Convening conferences such as the Banff Spring Noise Conference in addition to maintaining proper media relations are two very productive methods of increasing public awareness, and supporting other professionals in their endeavours to help control the issues surrounding environmental noise pollution.