NOISE/NEWS INTERNATIONAL

Volume 27, Number 4
2019 December

A quarterly news magazine and online digital blog published by I-INCE and INCE-USA

- Mercury Marine reveals its innovative world-class testing facility
- NOISE-CON 2019 from San Diego
- Getting to know the incoming I-INCE president
- Noise news from around the world

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Features

NOISE/NOTES 6

Establishing an Industry Benchmark: Mercury Marine Builds Innovative World-Class Testing Facility 7

Getting to Know You: Bob Bernhard, Incoming I-INCE President 16

How Energy Relations Explain Vibration Behavior 18

Industrial Noise Control Manufacturers Adopting Sustainable Composite Materials to Align with Green Industry Policies 21

Long Term Strategic Planning at INCE 23

NCAC Announce Winner of Laymon N. Miller Award 24

NOISE-CON 2019 Report 25

Departments

President's Column 3

Editor's View 5

Regional News 29

Book Reviews 30

International Representatives 32

Acknowledgments 35

Conference Calendar 35

Directory of Noise Control Services 36

Index to Volume 27 37

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NOISE/NEWS INTERNATIONAL

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I-INCE

The International Institute of Noise Control Engineering (I-INCE) is a worldwide consortium of societies concerned with noise control and acoustics. I-INCE, chartered in Zürich, Switzerland, is the sponsor of the INTER-NOISE Series of International Congresses on Noise Control Engineering, and, with the Institute of Noise Control Engineering of the USA, publishes this quarterly magazine and its blog. I-INCE has an active program of technical initiatives. It currently has fifty-one member societies in forty-six countries.

INCE-USA

The Institute of Noise Control Engineering of the USA (INCE-USA) is a nonprofit professional organization incorporated in Washington, DC, USA. The primary purpose of the Institute is to promote engineering solutions to environmental noise problems. INCE-USA publishes the technical journal *Noise Control Engineering Journal* and with I-INCE publishes this quarterly magazine and its blog. INCE-USA sponsors the NOISE-CON series of national conferences on noise control engineering and the INTER-NOISE Congress when it is held in North America. INCE-USA members are professionals in the field of noise control engineering, and many offer consulting services in noise control. Any persons interested in noise control may become an associate of INCE-USA and receive both this magazine and *Noise Control Engineering Journal*.

NNI and Its Online Supplement

www.noisenewsinternational.net

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- The current PDF issue of *NNI* available for free download
- Links to previous PDF issues of *NNI*
- An annual index of issues in PDF format
- A conference calendar for upcoming worldwide meetings
- Links to I-INCE technical activities and I-INCE technical reports

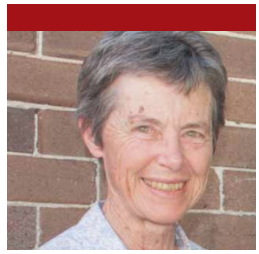
From the President of I-INCE

Looking back, 2019 has been a busy year. The INTER-NOISE Congress in Madrid was most successful, with a higher participation than expected (after concerns about conflicts with a number of other major congresses in Europe). Looking forward to 2020, the planning for the INTER-NOISE Congress in Seoul, August 23–26, 2020, is progressing well. (Visit http://internoise2020.org/ for more information.) While the basic structure of the congress remains consistent, each congress introduces some new aspects or trials some changes. For INTER-NOISE 2019, participants were fortunate to be able to join in the celebrations for the 50th anniversary for the Spanish Acoustical Society. For INTER-NOISE 2020, there will also be features related to the location in Korea, plus we will trial of having two speakers from different regions in the keynote time slots.

Looking further into the future, the 50th anniversary of I-INCE is to be celebrated at the INTER-NOISE 2021 in Washington. This congress is to be held at a venue close to the original venue for the first I-INCE congress. The board is working with INCE-USA to arrange for appropriate celebrations of the institute's achievements. If anyone has any special memorabilia from past INTER-NOISE congresses that may be of interest, please contact the secretary-general of I-INCE.

The initiative of the International Commission to hold an International Year of Sound in 2020 (IYS 2020) has given the impetus for many activities being held during the year to highlight the importance of sound in our world. The I-INCE was one of the initial founding supporters and has also sponsored the production of a short video on the theme of the year. This video will be launched at the opening of the IYS 2020 at the Sorbonne, Paris, on January 30, 2020. Following the launch, the video will be available freely on the website. Another centrally organized activity will be an international school competition that will be an expansion of the school competition held previously by the EAA. The IYS 2020 website (www.sound2020.org) includes the growing list of events and activities being held around the world, plus a growing number of resources. Major international congresses during 2020 have committed to using these gatherings of acousticians to hold some form of outreach event. As well, the website also lists events that will be arranged by national organizations and other interested groups. These range from plans for a public lecture, an educational activity, a musical performance, a display on sound in a regional library, and even a workshop to update *Wikipedia* listings for topics on sound. Any activities or events in accord with the theme of the IYS 2020 can be submitted for inclusion on the list and be provided with the logo for the IYS 2020.

One event in 2020 is the Quiet Drones symposium, organized by INCE Europe and CIDB, to be held in Paris, May 26–27, 2019 (www.quietdrones.org). I-INCE is one of the supporters of this very topical symposium. The drone industry is moving fast internationally, and regulatory bodies are yet to fully understand or deal with its impact. Already trials of drone deliveries of food and other items are being carried out in a number of countries; common complaints from the neighbors are invasion of privacy and excess noise. This symposium will gather a range of stakeholders including researchers, manufacturers, users, and regulators to discuss the future as well as options for management and control of the problem of noise impact.



Marion Burgess

As the end of the year approaches, so also does my term as president of I-INCE. I would like to take this opportunity to gratefully thank all those who have helped me during my term as president. The incoming board was elected at the time of the I-INCE General Assembly during the INTER-NOISE Congress in Madrid and was summarized in the September issue of *NNI*. It is important for any management board to have some new persons involved to allow for new ideas. However, this needs to be balanced with knowledge and experience, and the board will certainly gain this as Bob Bernhard takes on the role of president. He has served several terms as the general secretary of the board, and that means he has a deep understanding of all the operations of I-INCE. We can be sure that the organization is in good hands.

I take this opportunity to send you all the very best wishes for a happy, healthy, and prosperous 2020.

Marion Burgess
President, I-INCE

From the President of INCE-USA

President's Newsletter—November 10, 2019

Steve Marshall

Per INCE-USA annual tradition, the following represents the president's synopsis of the year's most noteworthy accomplishments and events. In August, the 2019 National Conference on Noise Control Engineering (NOISE-CON 2019) was cohosted by the Institute of Noise Control Engineering USA and the Transportation Research Board Committee on Transportation-Related Noise and Vibration (ADC40). The conference was attended by 454 participants. As part of the technical program, 237 technical papers were presented across four parallel sessions. An exposition was held during the technical program, beginning with a reception on Monday evening. A demonstration theater operated in the exposition area, where the latest in noise control products were presented. Over 50 companies participated in the conference exhibition.

Congratulations are extended to the conference organizing committee. Bryce Gardner and Chad Musser served as the conference cochairs; Judy Rochat served as the conference vice chair. positions of conference technical chair and technical vice chair were held by Yong-Joe Kim and Andrew Barnard, respectively. Serving as proceedings editors were Gordon Ebbitt and Sarah McGuire. Dana Lodico served as the student volunteer coordinator. The exposition manager was Regina Young. The conference secretariat was provided by Virtual, Inc.

INCE-USA membership remained stable this year at over 900 members, albeit with some effort spent collecting late dues. In response, please consider the exceptional value provided by INCE-USA membership by renewing your membership promptly. The success of the INCE-USA is clearly attributed to its members. Our appreciation is thus extended to Steve Sorensen, vice president of membership.

Our financial position continues to be strong. The institute currently enjoys the financial position of over US$1.4 million in assets and almost US$1 million in equity. The noise control engineering courses (path to Board Certification) have garnered more interest than anyone expected, which speaks well for our future. As a consequence of opening Board Certification to nonmembers, INCE-USA has opened a new and attractive path to membership. Please join me in also thanking Deane Jaeger, treasurer, and Paul Burge, vice president of Board Certification.

Time goes on, and leadership evolves. It is appropriate to welcome recent and new leaders into their respective roles. We look forward to Mike Bahtiarian stepping into the position as president next year. Randy Rozema has accepted the position of secretary. Judy Rochat is now serving as vice president of technical activities. Dana Lodico is the new vice president of honors and awards. Hether Fedullo is serving as the new vice president of conferences. Also, the INCE-USA welcomes John Lessard as the new INCE-USA business associate from Virtual, Inc. We look forward to continued success under John's tutelage. If I have missed anyone, please let me treat you to an order of raw oysters on Bourbon Street.

The success achieved this year for the INCE-USA was due to thousands of voluntary hours from its dedicated officers and directors, the maturing of the INCE-USA and IBO relationship, and the enthusiasm of its membership in general. The names of the contributors are too numerous to list here. Rather, I just ask that we do it again in 2020, and I look forward to welcoming you to NOISE-CON 2020 in New Orleans.

Steve Marshall
INCE-USA President

Editor's View

Welcome to the final issue of *Noise/News International* for 2019. This jam-packed issue looks back at NOISE-CON 2019 from San Diego, including details of award winners, with a special article on the winner of the 2019 Laymon N. Miller Award for Excellence in Acoustical Consulting, K. Anthony Hoover. As well as our regular NOISE/NOTES feature, book reviews, and regional updates, we have another tutorial from Eric Ungar explaining how energy relationships explain vibration behavior. Our cover feature for this issue describes the new Noise, Vibration, and Harshness (NVH) Technical Center from Mercury Marine at their PD&E Center in Fond du Lac, Wisconsin. It is a very interesting look at the development of a facility that aims to be a benchmark for the industry.

We also sit down with the incoming I-INCE president, Bob Bernhard, who is currently vice president for research at the University of Notre Dame. Bob has been a member of INCE-USA (one of the member societies of I-INCE) since about 1982 and has been a member of the board of directors of I-INCE since about 2000. Learn about his time with INCE, and a little more about Bob, in this issue.

With a new incoming president, it means we have to say goodbye and thank you to our outgoing president, Marion Burgess. I first met Marion at the International Congress of Acoustics in Madrid, back in 2007. At the time my focus was on finishing my PhD; little did I know I'd be working with her some 10 years later. It was great to have had the opportunity to work with her through *NNI* for the past few years, and I want to thank her for her help and advice along the way.

I hope you enjoy this issue of *NNI*. We'll see you all in 2020!

Eoin A. King, PhD

Eoin A. King, PhD

NOISE/NOTES

Eoin A. King, *NNI* Editor,

Brianna Cervello, *NNI* Social Media Assistant

NNI is on Facebook and Twitter. We try to keep our readers informed with noise news from all across the globe by highlighting interesting research and projects. Here is a roundup of some of the stories that have been making headlines. Follow @NNIEditor to stay up to date with all noise-related news!

Kidney Stones and Raindrops

The idea of a raindrop creating a crack in a windshield has led to a study that uses the same physics to pulverize kidney stones using sound waves. In a new paper published in *Physical Review Research*, Pei Zhong from Duke University, along with his former graduate student Ying Zhang, describes an experimental system to visualize the stress created by surface waves. The study put a lithotripsy device designed to shatter kidney stones with soundwaves in a vat of water covered by a sheet of glass, then set off a point-source explosion that expanded as a spherical shock wave. They were able to determine that the type of wave primarily responsible for most of the stress and damage, a leaky Rayleigh wave, propagates much faster than a second type of evanescent wave.

A Bioacoustic Fish Fence

A bioacoustic fish fence designed to herd migrating fish around water intakes and dams in Europe is being used in the state of Kentucky to deter the spread of invasive species in southern waters. The fence is a "behavioral barrier" that requires less maintenance than a physical barrier (such as a screen or an electric barrier). It releases bubbles and uses flashing lights and sound to influence the behavior of fish. A field trial of the fence is ongoing in Kentucky and will be in place for three years.

Crackdown on Fireworks in Scotland

The *Times* (UK) reports that authorities in Scotland are expected to announce strict restrictions on the private use of fireworks, to come into force next year. The restrictions are intended to reduce noise, stress on animals, and attacks on the emergency services.

Underwater Noise Pollution: The Ocean Noise Strategy

The National Oceanic and Atmospheric Administration (NOAA) recently released *The Ocean Noise Strategy Roadmap*, which seeks to ensure that NOAA more comprehensively addresses noise impacts to aquatic species and their habitat over the next 10 years. The road map is intended to serve as a high-level guide rather than a prescriptive listing of program-level actions. To discuss this, Michael Jasny, director of the Marine Mammal Protection Project, was recently interviewed on WNYC (in the US), and you can listen to that interview here.

Listen to What Mars Sounds Like

NASA has shared audio snippets of Martian quakes detected by the InSight lander earlier this year. The InSight lander was launched in 2018 and is designed to study the deep interior of Mars. Using a specialized seismometer called SEIS, the lander first detected shakes in April and has measured more than 100 rumblings since then.

A New Type of Wall . . .

Researchers at the University of Auckland (New Zealand) have been awarded almost $1 million to create a wall that would help reduce the transmission of low-frequency noises into neighboring rooms, while not taking up more floor space. They'll be looking at how acoustics metamaterials and Helmholtz resonators can be used to improve the noise-insulating properties of the wall.

Turn Down That . . . Cinema!

Golden Globe winner Hugh Grant hit the headlines recently for complaining about the volume in the cinema. He asked, "Am I old, or is the cinema MUCH TOO LOUD?" The incident provoked an outpouring of accounts of aural pain at other venues, the *Guardian* (UK) reports.

Establishing an Industry Benchmark: Mercury Marine Builds Innovative World-Class Testing Facility

Peter G. Lynde, PE

On December 6, 2018, Mercury Marine unveiled their new Noise, Vibration, and Harshness (NVH) Technical Center during a grand opening event held at their Product Development & Engineering (PD&E) Center in Fond du Lac, Wisconsin. This article recounts the journey taken by the owner, architect, engineers, contractors, and suppliers who, together, turned their vision into reality.

The Mercury Marine Vision

Mercury Marine has been at the forefront in NVH testing and development of marine products for decades. They consistently lead the industry in the production of outboard and sterndrive motors possessing world-class NVH attributes. In 2000, they opened their Plant 12 Sound Lab at their Wisconsin PD&E Center—a hemi-anechoic test room complete with a water tank designed to test outboard motors up to 250HP. This facility served Mercury Marine well for over a decade, but its use became limited due to the relentless evolution of product technology and motor horsepower. Mercury Marine recognized that a new facility was needed to test their future product mix and improve the NVH quality of their prop to helm marine propulsion solutions.

To continue as a leader in the marine segment in NVH attributes, additional test capacity was needed to meet and exceed product development goals. Two primary objectives established at program onset set the stage for the new facility:

1. The Technical Center would support all NVH development activities for Mercury Marine and support NVH development across the entire Brunswick product line.
2. The Technical Center would be located at the Mercury Marine PD&E Center to encourage and facilitate interaction and collaboration with their product development and engineering staff.

Though simply stated, meeting these two objectives would prove highly significant in the ultimate configuration of the facility.

Facility Configuration

In addition to satisfying the two primary program objectives, Mercury Marine identified several requirements deemed essential in the new facility.

Overall Facility Layout

The placement of the facility had to maintain proximity to Mercury PD&E, while allowing the facility to be separate to achieve aggressive performance targets. The facility must also allow free movement of Mercury and non-Mercury personnel through the public area of the facility, while maintaining compartmentalized control of the nonpublic spaces to ensure project confidentiality. In addition, it must be a low vibration environment designed to mitigate vibrations transmitted into the facility so that noise and vibration testing and sound level measurements would be highly accurate.

Test Facilities

Two highly flexible fully capable test chambers would be designed specifically for testing marine products. However, these chambers must also be configurable into standard hemi-anechoic spaces to test a wide array of products. These chambers must maintain a high level of flexibility and capability, not just for now but also for the future. There must be a low noise floor (low SPL) in the test chambers assuring that Mercury Marine is able to continue to develop products with "world-class" NVH attributes. The chambers had to allow for testing of higher HP engines, as industry trends have made clear the need to accommodate larger engines.

Support Facilities

It was important to consolidate NVH testing and support areas into one facility to optimize team efficiency. A jury evaluation/listening room was needed to perform jury evaluations of the sounds of Mercury products. The room had to be quiet enough to allow for undisturbed evaluation, but not so quiet that it created an unnerving environment for participants. Guest office and breakout rooms were required to provide temporary touchdown spaces for customers and visitors in the public area of the building.

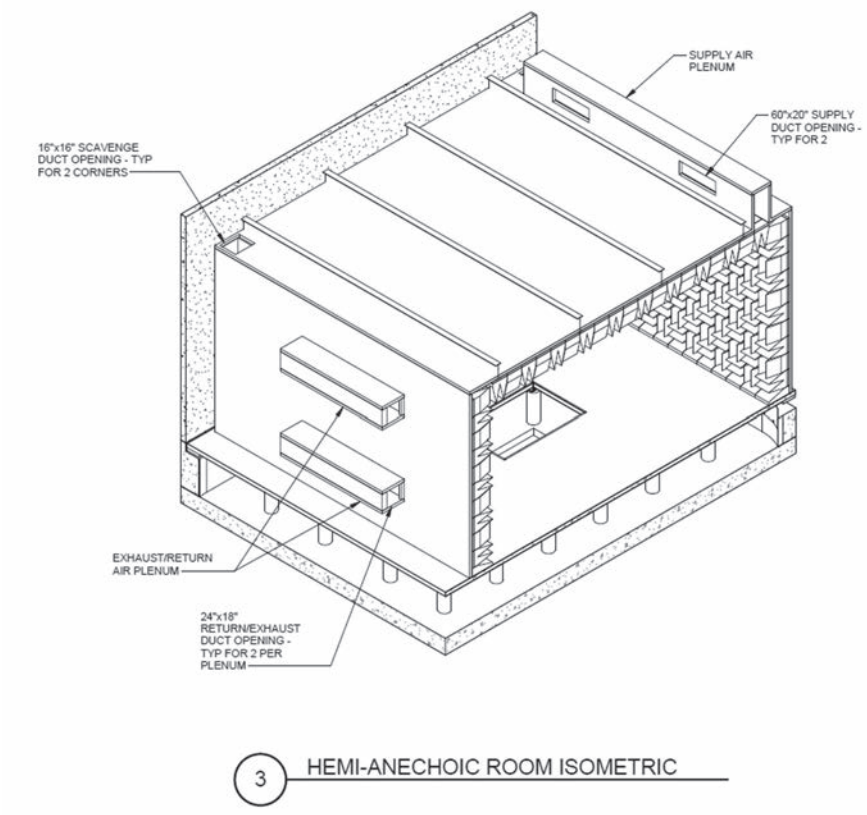


Fig. 1. Isometric view from Revit model

Fig. 2. Interior rendering of lobby

An engineering technician area was necessary to provide Mercury engineering technicians with the ideal place to perform their duties, while remaining efficient and organized. A modal MOI/CG test area was important to provide a space for performing modal analysis of products. The space must include a robust support structure to suspend engines and measure their Center of Gravity (CG) and Moment of Inertia (MOI). Lastly, a large indoor vessel instrumentation bay was needed to provide an indoor area for vessels up to 45 feet in length to accommodate development activities.

NVH Staff Office Space

The office space design incorporates floor-to-ceiling windows, infusing a combination of home base workstations and an open collaborative area with natural light. Upper cabinets and high lockers were omitted from the design plan to reduce visual mass and to maintain an open feeling. Stand-up workstations are located throughout the personal and common areas to encourage working while standing. Nontraditional workspaces are included to help further drive collaboration and innovation. LED lights are used throughout the facility to reduce energy consumption and improve work area comfort. In-floor heating is located on the outer walls of the first-floor lobby and test spaces to increase occupant comfort.

Engineering and Design

Extensive use of 3-D modeling was employed during the design and engineering stages to help visualize the many complex interrelationships of the facility. Kahn utilized Revit and Revit MEP modeling software to accurately coordinate and integrate building systems and easily create isometric views (fig. 1). Visualization tools such as Revit Live and Google cardboard were used to create “fly-throughs” and virtual reality

simulations of the building, allowing Mercury to fully understand the interior and exterior images the building would present (fig. 2).

Vibration Mitigation

An early task in the engineering of any new facility is the geotechnical investigation. This task was expanded to include ambient ground vibration measurements due to the sensitive noise and vibration testing planned for the facility. In order to ensure low background noise levels within the test facility, isolation of the test chambers was of paramount importance to mitigate structure-borne vibration transfer into the hemi-anechoic test chambers. Testing confirmed suspicions that undesirable low-frequency vibration levels were evident in the soil, and these were attributed to multiple sources, ranging from heavy vehicle traffic on the nearby Highway 41 to snowplow activity in campus parking lots. It was clear that engineered systems would be required to block these unwanted vibration levels from disrupting NVH testing in the new facility.

Marine product testing must replicate the open water environment to best simulate real world NVH characteristics. Each NVH test room is placed over a basement water reservoir. Though independent from each other, the basements share a common concrete mat foundation, which also serves as the floor of the reservoir. The mat foundation is 24-inch-thick steel-reinforced concrete bearing on compacted native soils. The mat foundation supports poured concrete walls and piers that, in turn, bear the load of the test room concrete slab. The perimeter foundation walls average 36 inches thick to resist the lateral forces associated with water on one side and earth on the other, as well as the unique geometry required for the vibration isolation systems. The high mass afforded by the foundation mat and walls mitigates the transmission of unwanted ground-borne vibration into the structure. To further attenuate unwanted ground-borne vibration, a three-foot band of sand material, in lieu of the native clay soils, was used for back-fill around the entire depth of the perimeter foundation walls.

Vibration Isolation

Hemi-anechoic test facilities are nothing new within the NVH testing community; however, supporting test rooms on a steel coil vibration isolation system above a 66,000 gallon water reservoir was viewed as a one-of-a-kind installation (fig. 3). Driven by the presence of undesirable ambient ground vibration, isolation of the acoustic test chamber was deemed essential. Once value engineering analyses concluded coiled steel springs to be the best choice for the isolation system, the challenge became how to integrate these springs into the test facility. Test room floors are 6-inch-thick steel-reinforced concrete slabs designed for added stiffness to mitigate the potential for floor resonance. Vibration isolating mounts are placed between the foundation walls/piers and the underside of the test room floor and serve to isolate the test room floor and acoustic room structure from any remaining unwanted ground-borne vibration. The acoustic panel test chamber and its steel structural frame are supported on the perimeter of the floor slab, where the slab transfers its dead and live loads through a total of 42 steel coil isolation mounts. Mount loadings vary considerably and range from 2 kips to nearly 12 kips. Steel spring isolating elements afford 90 percent isolation efficiency from disturbing frequencies of 8 Hz and higher.

Engineered Water Reservoir

Testing of marine products, specifically outboard motors, requires a water reservoir to receive the thrust from

Fig. 3. Vibration isolation mount

engine props, but just a simple water tank is not enough. Replication of the flow characteristics realized in open water conditions was critical to accurately simulate the real-world environment. To achieve this state, Mercury engineers used computational fluid dynamics (CFD) analysis to optimize the depth and shape of the reservoir to mitigate unwanted turbulence and wake formation (fig. 4). The CFD analysis aided in confirming placement of floor support piers, ideal radius of reservoir corners, and configuration of underwater baffle plates. The CFD analysis also served as a value engineering tool, allowing initial conservative estimates of reservoir depth to be reduced substantially, lowering excavation and foundation costs. At full operating depth, the reservoir capacity is approximately 66,000 gallons.

Acoustic Isolation Systems

The exterior walls surrounding the test rooms prevent unwanted external sound sources from reaching the indoor test environment. Exterior noise events could

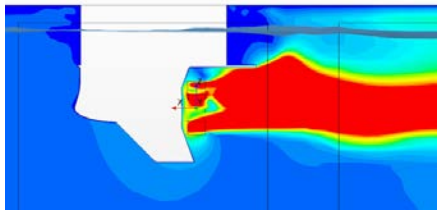


Fig. 4. Image from CFD analysis

easily produce ambient noise levels in excess of 80 dBA. These noise events could include construction activity; truck noise from the nearby Highway 41, Military Road, the service access road, and truck docks; as well as small aircraft or helicopter flyovers. These events are inherently unpredictable and unavoidable even by careful test scheduling.

With test room noise floor targets nearing NC-10, a minimum sound transmission class of STC-56 was necessary to afford effective reduction of unwanted sound from surrounding site activities. Research into precast concrete products found panels offering sound transmission class ratings as high as STC-61. With precast concrete a preferred choice, and part of the campus architectural vocabulary, the decision was made to construct the exterior perimeter walls with precast insulated concrete panels.

Room-within-a-room configuration was chosen to ensure maintenance of targeted background sound levels. With ground-borne vibration a concern, and test room isolation essential, the inner test room was best constructed of metal acoustic wall panels to significantly reduce the loading on vibration isolation mounts. Mercury selected Eckel Acoustics to supply the acoustic test rooms and their perforated metal anechoic wedge system to line the interior. Eckel furnished and erected the test room as a complete assembly with structure, panels, wedges, and doors, guaranteeing specified acoustic performance parameters were met.

Test Room Sizing

Originally conceived as a test facility exclusively for marine products, Mercury NVH Engineers advised the project team that Brunswick, Mercury Marine's corporate parent, had stipulated the test rooms be configured for NVH testing of the entire Brunswick product line—a line that covers outboard and sterndrive marine engines, electric trolling motors, and various other marine parts and accessories. This required an unprecedented level of flexibility to be designed into the test room infrastructure to accommodate a very wide range of acoustic test sources, both in physical size and sound level signature.

Conventional approaches to sizing hemi-anechoic test rooms generally assume the need for sound pressure level measurements in the free field of the test source. The recommended size and configuration of the test source for this facility was established by Mercury to allow the majority testing of the Brunswick family product line. Review of the products and their physical parameters yielded a source envelope measuring 90" L × 40" W × 70" H. In addition to the test source envelope, room sizing was also made in consideration of multiple guidelines including:

1. Compliance with mandatory requirements of applicable ANSI/ASA S12.55/ISO 3745 standards
2. Established industry practice
3. Benefit of experience gained on previous projects
4. Allowable clearances and access requirements around the applicable test source
5. Wavelength at room cutoff frequency
6. Requirements associated with room ventilation systems

The ANSI/ASA S12.55/ISO 3745 standard offers guidelines for determining the size of hemi-anechoic rooms. Interior room dimensions are a function of test source size, radius of measurement hemisphere, and distance to the reflecting plane based on the lowest cutoff frequency. These parameters yielded a room with internal dimensions (wedge tip-to-tip) of 38'L × 38'W × 19'H at the minimum desired room cutoff frequency of 60 Hz. However, the resultant square room does not satisfy industry practice for room proportions and could be subject to undesirable standing waves. Accordingly, room dimensions were adjusted to fall within guidelines as depicted in figure 5.

HVAC Systems

HVAC system engineering for the test rooms required that special consideration be given to the scavenging of exhaust from operating engines. Marine outboards discharge engine exhaust underwater through the hub of the propeller when operating off idle. When idling, exhaust is discharged through bypass ports above the waterline. Ventilation systems are needed to safely remove exhaust gases in both modes of operation, as well as manage the heat released from a wide range of engine products.

A single-pass 100 percent outside air HVAC system is used to ventilate the test room and mitigate CO and HC emissions released during active engine testing. The system is configured with three operating modes: Setup, Test Low, and Test High. Mercury testing engineers select the operating mode based on multiple testing parameters, including engine HP and anticipated thermal cycling.

In setup mode, systems operate at their lowest flow rates, providing the minimum amount of ventilation make-up air to the continuous scavenge exhaust system while moderating the test room temperature to its design setpoint. Test Low and Test High modes are used with active engine testing, with increasingly higher ventilation rates used to manage added heat loads from increased engine HP. With the test room constructed over a water reservoir, controlling temperature and relative humidity to required tolerances proved an added challenge to a task already made difficult by the single-pass, multi-step ventilation system. Custom air handling units were configured with several heating and cooling features

to allow these challenging conditions to be met.

The combination of high airflow rates and single-pass ventilation demanded specialized temperature controls given winter to summer temperature gradients characteristic of Wisconsin. With the facility's stand-alone nature and desire for energy efficiency dictating the use of natural gas, the heating system uses three direct-fired gas burner sections arranged in a 1/3–2/3 split and equipped with 30:1 turndown control valves to allow maintenance of +/− 2°F variance from heating setpoint. This same setpoint tolerance was required when operating in cooling mode and resulted in the use of direct expansion refrigeration for cooling cycles with two condensing units sized at 1/3 and 2/3 total system capacity. Each condensing unit stages multiple compressors to match capacity with test room heat loading. Finally, fuel supply systems are interlocked with the stepped HVAC control, allowing fuel solenoids to open only when HVAC is in Test Low or Test High mode and staying closed when in Setup mode.

General building HVAC systems were selected to optimize energy efficiency and provide Mercury with a comfortable indoor environment. High-efficiency (95 percent) condensing boilers generate low-temperature hot water (100°F to 120°F based on OA reset schedule) for use in both variable volume terminal unit reheat coils as well as in-floor radiant heating. The low-temperature hot water allowed for reduced system equipment complexity and simplified control technology while eliminating the need for heat exchangers and mixing valves. Self-regulating variable speed HW heating pumps kept energy consumption low.

Office interiors utilized cloud-style suspended ceiling systems that required the careful routing of ductwork systems so it would remain hidden above the clouds

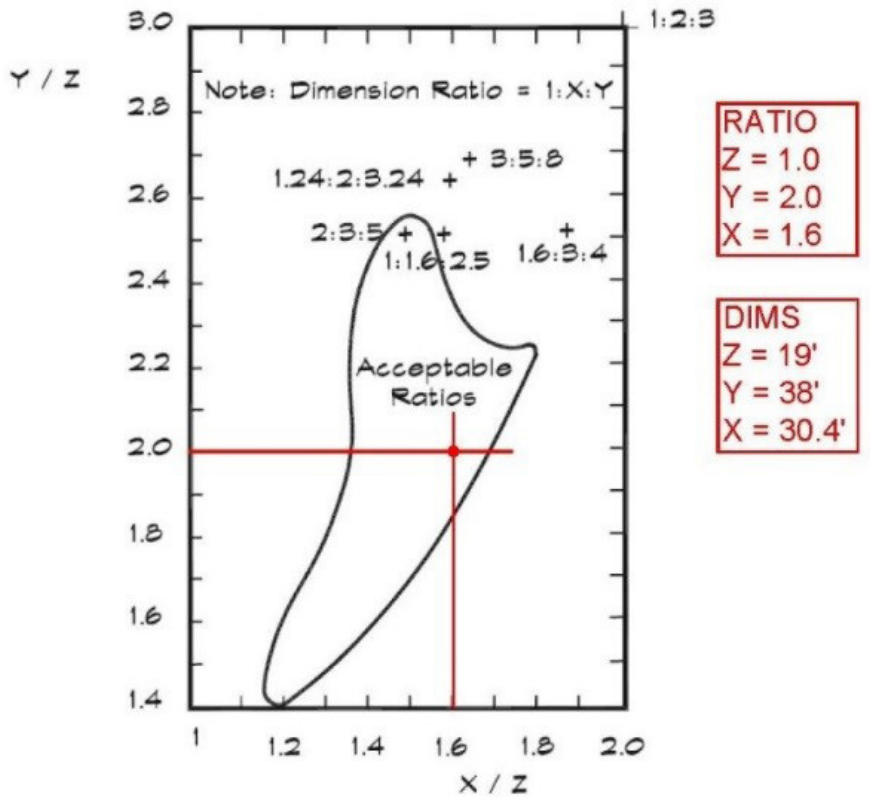


Fig. 5. Preferred room dimensions according to room modes

yet still retain ready access to terminal unit controls for system commissioning and routine maintenance.

Fire Suppression and Safety Systems

Test rooms are equipped with low-pressure water mist fire suppression systems, the first such application of this fire suppression technology on the Mercury PD&E campus. Water mist systems are 3-D fire suppression systems that work by cooling the fire as opposed to traditional gaseous suppression systems that smother fire conditions by displacing oxygen. Water mist systems maintain safe conditions for operating personnel while minimizing damage to facility infrastructure and test equipment.

Test rooms were also equipped with Very Early Smoke Detection Apparatus (VESDA) systems used for both smoke and gas detection. VESDA systems continuously monitor the test room environment by drawing air at dozens of sampling points and scanning for smoke particulate and carbon monoxide.

Lastly, the test room fire alarm system incorporates heat detectors and infrared flame detectors to provide early warning of fire potential. These multiple safety systems are fully integrated with building, fire alarm, and ventilation systems to provide warning alarms and shutdown sequences.

Procurement and Construction

Despite a high measure of complexity owing to the acoustic and vibration isolation requirements of this facility, engineering and construction were fast-tracked to meet an aggressive occupancy target date. Engineering packages for foundations, structural steel, and building enclosure were released months ahead of architectural, mechanical, and electrical

Fig. 6. Concrete mat foundation

Fig. 7. Structural steel framing

Fig. 8. Test chamber

work packages. Early packages were also released for the acoustic test rooms and vibration isolation systems, ensuring these long lead specialty systems would arrive in a timely manner.

Procurement efforts were performed by both Mercury Marine and their construction manager, C. D. Smith. Long lead equipment such as acoustic test chambers were purchased months before construction began to ensure their arrival in their designated window of the project construction schedule.

Construction began in March 2018 with the ground-breaking ceremony held on April 5, 2018. Despite inclement weather, the pouring of the two-foot-thick concrete mat foundations began just two weeks later and concluded in early May (fig. 6). The precast concrete wall panels were lifted into place in mid-May and the first structural steel building column was placed on May 29, 2018 (fig. 7). Construction continued throughout the summer with a target date for completion in November 2018. Certain construction activities were scheduled for completion earlier than typically expected to accommodate special construction tasks. Mechanical ducting and fire protection piping located above the acoustic test rooms was installed early so as to precede test room erection and allow the test installer unencumbered access to the space. The test rooms are self-supporting, and only contact the spring-isolated floor slab, maintaining the highest degree of vibration isolation possible. However, the test rooms require multiple utilities to function and, as such, there are dozens of penetrations ranging from crane supports to compressed air throughout the test room walls. Installation of these utilities required close coordination between contractors and the test room installers to ensure correct installation and location to accommodate both the test room panel structure and wedge treatment (figs. 8 and 9).

The inherent complexity of NVH facilities demands open and frequent communication between the owner, architects, engineers, and contractors. Whether it be responding to unique field conditions or debating construction

sequencing, the project team was singularly focused on delivering a world-class facility to Mercury Marine.

Facility Performance

Mercury Marine provided measured sound spectra from their marine product line, including multiple examples of internal combustion engines, as well as ultra-quiet electric trolling motors. These varied spectra were used to establish a desired noise floor of approximately NC-10 (21 dBA) in the test rooms (fig. 10). During commissioning of the hemi-anechoic test chamber, background sound levels with ventilation systems off were measured at 16 dBA.

Mercury NVH engineers have since measured test chamber background sound levels at test room ventilation system operating modes of Setup, Test Low, and Test High. These three operating modes allow Mercury to select a ventilation mode to match the horsepower output of the engine under test (fig. 11).

Establishing an Industry Benchmark

Partnering efforts were of foremost importance on this project, as representatives from the engineering, construction, and supplier communities worked together to ensure its success. Mercury contracted directly with Albert Kahn for engineering services and with C. D. Smith for construction management services. They also held contracts directly with Rohde Brothers for mechanical systems engineering and construction and Pieper Electric for electrical contracting. Mercury also procured and managed direct buy contracts for major building systems, including Eckel for the acoustic test chambers, Mason Industries for vibration isolation systems, and J. F. Ahern for building fire suppression systems.

Fig. 9. Test chamber cut-away

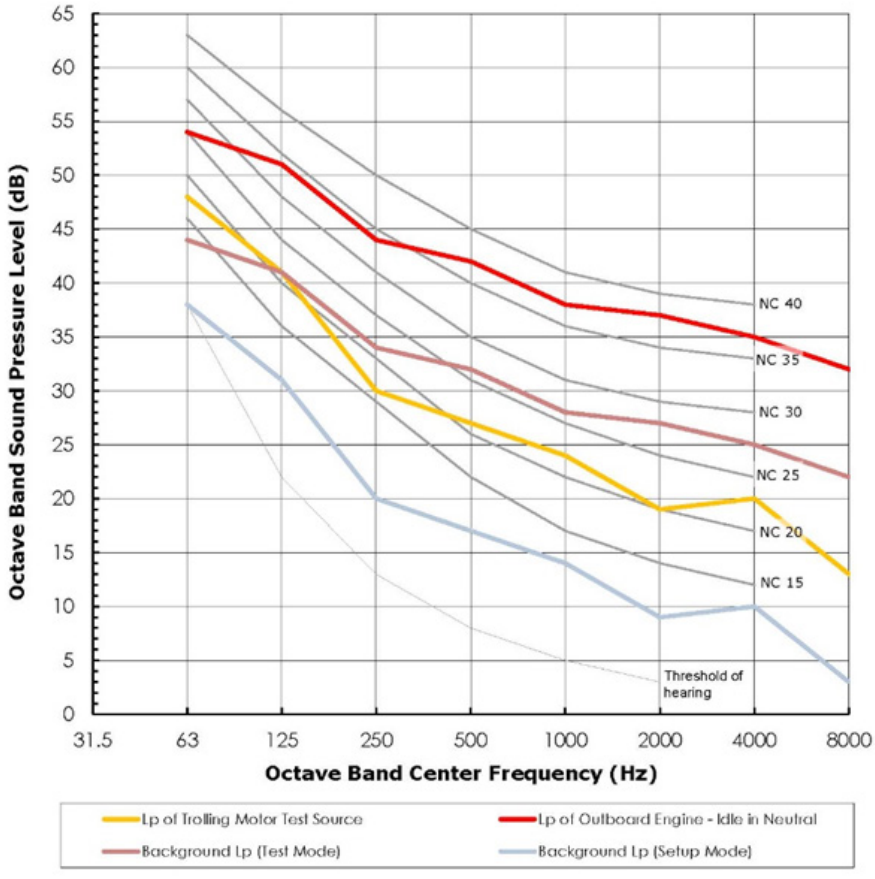


Fig. 10. Source sound levels and target noise floor

The uniqueness of this facility proved inspirational to many suppliers and constructors, who engaged in preliminary engineering and coordination efforts with enthusiasm. This proved to be significant as their experience helped the entire team to foresee problems and plan in advance for their resolution. Constructors were especially supportive in raising constructability concerns and offering alternative construction approaches essential to maintaining schedule and controlling costs. The owner's staff were particularly engaged in the entire engineering and construction effort, clearly recognizing the importance of this investment to Mercury. Throughout the project, they offered timely decision making and expert guidance on compliance requirements relative to Mercury design and construction standards.

The Mercury Marine NVH Technical Center has established an industry benchmark for excellence in noise and vibration testing facilities. It stands as a testament to the high achievement possible with successful collaboration between the owner, architect, engineers, and contractors.

About the Author

Peter G. Lynde, PE, is senior vice president and corporate secretary with Albert Kahn Associates, Inc., Detroit, MI. He can be reached at 313-202-7880 or peter.lynde@akahn.com.

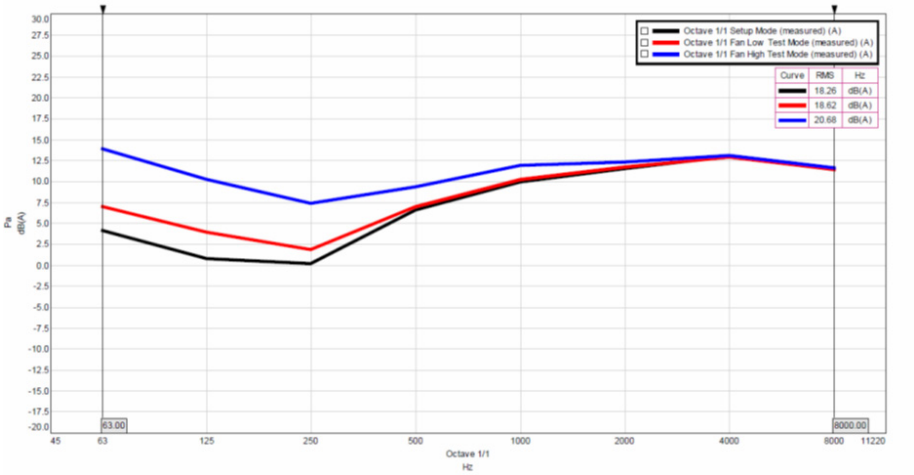


Fig. 11. Achieved test room background sound levels

Acknowledgments

Owner:	Mercury Marine David Hahn, Facilities Construction Manager Doug Czaikowski, Manager of Engineering Test Facilities Jeff Etapa, Program Director—Sea Ray Andrew Waisanen, Manager—NVH & Structures
Architect-Engineer:	Albert Kahn Associates, Inc. Peter G. Lynde, Principal Ryan Alm, Project Architect
Civil Engineering and Façade Consultant:	Excel Engineering Tom Schermerhorn, Principal
Construction Manager:	C. D. Smith Jason Bos, Project Manager Kevin Halbach, Site Superintendent
Mechanical Contractor:	Rohde Brothers Michael Rohde, President
Electrical Contractor:	Pieper Electric, Inc. Bob Woloszyk, Branch Manager
Fire Protection Contractor:	J. F. Ahern Fire Wade Lenz, Project Manager
Acoustic Test Rooms:	Eckel Industries Jeffrey Morse, Vice President
Acoustic Test Room Installer:	Viking Enterprises, Inc. David E. Engdall
Vibration Isolation Systems:	Mason Industries Jonathan Reinhardt, Regional Sales Manager

Getting to Know You: Bob Bernhard, Incoming I-INCE President

Quick Stats

Name: Bob Bernhard
Title: Vice President for Research, University of Notre Dame
Location: South Bend, Indiana, USA
Years with I-INCE: I've been a member of INCE-USA (one of the member societies of I-INCE) since about 1982 and have been a member of the board of directors of I-INCE since about 2000.
Born and raised: On a typical family farm in northern Iowa, USA, in the 1950s and 1960s.
Education: BS in Mechanical Engineering, PhD in Engineering Mechanics from Iowa State University, and MS in Mechanical Engineering from the University of Maryland, College Park.
Favorite music artist: Nobel Prize winner Bob Dylan
Favorite pastime or hobby: Hanging out at the beach on Lake Michigan
Favorite sports team (if applicable): Notre Dame Women's Basketball (2018 national champions)

Career

What is the most important part of your job?
Growing the research and scholarship programs at Notre Dame. The university has very high aspirations and has given us the resources to build the research programs commensurate with the reputation of a great university of the twenty-first century.

What's the best part about I-INCE?
I've been involved with I-INCE for a long time and worked with outstanding people from across the world. The strength of I-INCE is the INTER-NOISE congresses that continue to grow and evolve. I'm encouraged to see new topics and new faces every year. I take these as great signs of the importance and vitality of I-INCE. But I'm also pleased to see other activities of I-INCE. The Young Professionals Program is a great success at connecting younger noise control engineers with our profession. I congratulate Patricia Davies and her predecessor, Raj Singh, for growing this program. I hope we can continue to develop additional programs than promote noise control, disseminate understanding of noise control principles, and connect practitioners worldwide.

What do you want people to know about I-INCE during your tenure?
For my tenure as president, I plan to focus on renewal and inclusion. I plan to visit as many of the member societies as possible, either for leadership meetings or for annual technical conferences. In ways large and small, I am hoping to listen to members of the member societies to understand how I-INCE can be even more relevant to their professional lives and how we can include them in our activities.

Personal

Tell us about your family.
My wife Deb and I have 4 grown children: 3 sons and a daughter. They are all engineers and all live on the East Coast of the United States. Two are married. We have 4 grandchildren, all boys, including a pair of 18-month-old twins.

As a child, what did you want to be when you grew up?
All I imagined as a child was getting a professional job that would be secure. I would never have envisioned the career path that eventually played out. I've been blessed with surprise opportunities at various points that I had not anticipated. I've also been blessed that the opportunities were always great learning opportunities that ultimately led to my current position, which is a great fit to my talent, experience, and personality.

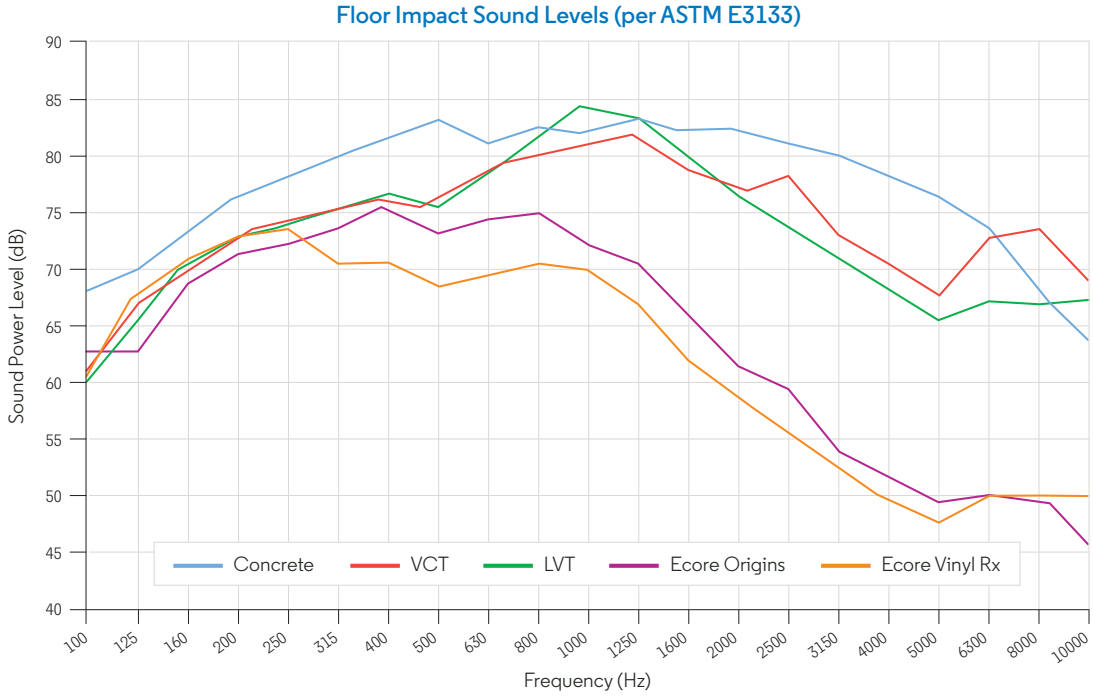
What's the best advice you've ever received?
I've had great mentors who helped me identify my weaknesses and see how I was perceived by others. They also introduced me to literature in organizational psychology that I've found both relevant to my positions and interesting. Collins's book *Good to Great* had the most influence on me, but a number of other books, including those by Stephan Covey and Daniel Pink, have had a significant influence on my thinking.

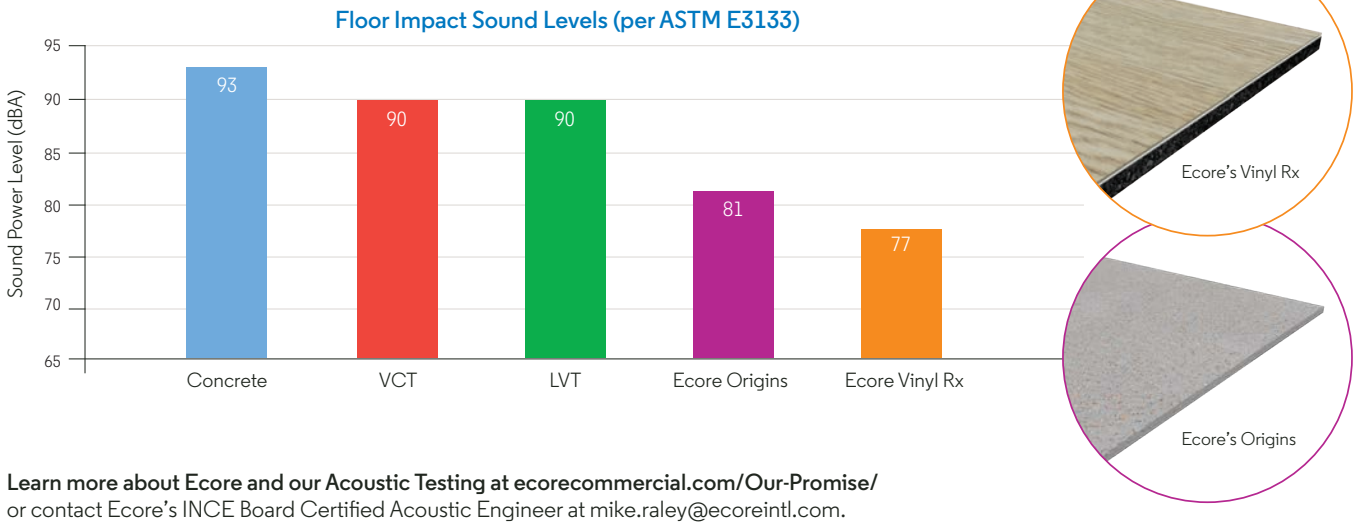
ecore™

New Floor Impact Sound Test Data available from Ecore

PERFORMED BY INTERTEK INDEPENDENT IAS-CERTIFIED LAB IN YORK, PA

Floor impact sound levels from Ecore's Vinyl Rx were 13dB lower than those from generic VCT and LVT. This makes Vinyl Rx an excellent choice for uses like hospitals where the standard flooring choice to reduce noise, carpet, presents many maintenance and health issues.





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or contact Ecore's INCE Board Certified Acoustic Engineer at mike.raley@ecoreintl.com.

ecorecommercial.com • 877.258.0843

How Energy Relations Explain Vibration Behavior

Eric E. Ungar
Acentech, Inc., Cambridge, MA

Much can be learned about why vibrating systems behave the way they do by considering the energy associated with vibrations and by studying its implications with the aid of phase plane curves. Such curves represent the relation between the velocity and the displacement of a simple spring-mass model, which may represent a mode of a vibrating system or structure. It is on this model that the following discussion is based.

Energy Exchange in Free Vibration

Let us look at the classical vibrating system consisting of a mass m supported on a linear spring with spring constant k. The total energy W_T in such a system consists of the kinetic energy W_m "stored" in the mass and the potential energy W_S stored in the spring. If the spring at a given instant is deflected an amount x from its static equilibrium position and the mass moves with a velocity v, then

$$W_T = W_m + W_s = mv^2/2 + kx^2/2 \qquad (1)$$

In absence of damping, the total energy remains constant as the system vibrates, and there occurs an interchange between the kinetic and potential energies. The greatest velocity v_0 then occurs at the instant at which the displacement is zero, and the greatest displacement x_0 results when the velocity is zero. If there is no loss of energy, then

$$W_T = mv_0^2/2 = kx_0^2/2 \qquad (2)$$

The upper part of the diagram of figure 1 is a convenient visualization of these relations. It shows a parabolic curve that represents the dependence of W_S on the displacement x and indicates the partition of total energy into its potential and kinetic energy components.

Phase Plane

The lower part of figure 1 is an elliptical curve that shows the variation of velocity with displacement implied by the energy relation of equation (1) that is represented by the upper part of the figure. One may readily visualize that a point representing the system's status moves along the curve of this "phase plane" plot as a vibration progresses.

For a system with a linear spring (whose deflection is proportional to the force applied to it), the aforementioned curves are true parabolas and ellipses. For springs with other types of force-deflection characteristics, or in the presence of other forces, such as gravitational and magnetic ones, one obtains diagrams similar to figure 1, but the curves take on somewhat different shapes.

For example, a phase plane plot corresponding to a mass bouncing across a gap between two springs essentially consists of two half ellipses (one on the left and one on the right) connected by horizontal constant velocity lines

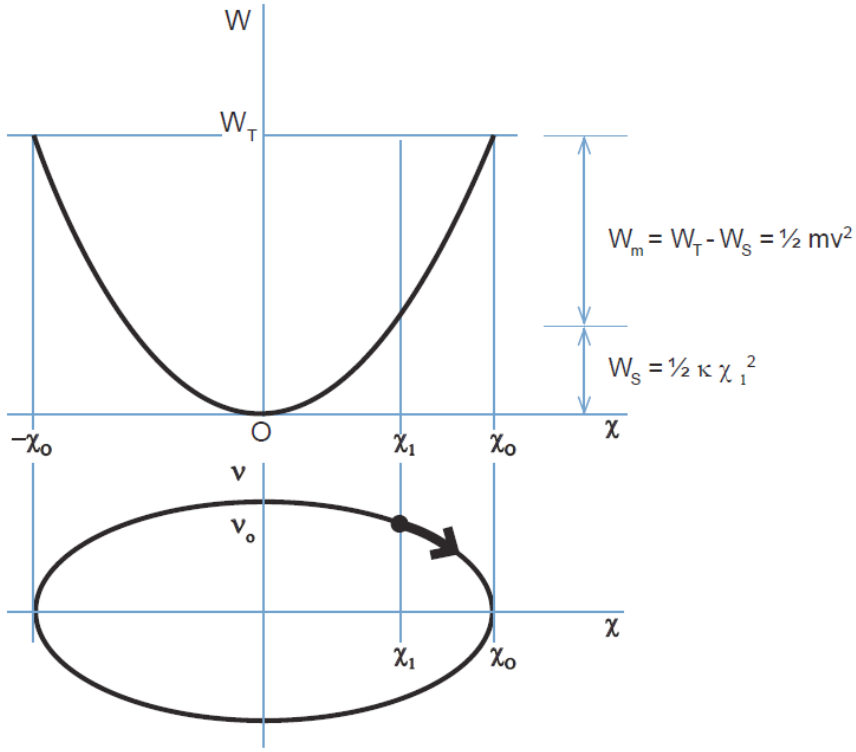

Fig. 1. Energy relations and the phase plane

extending over the length of the gap. A phase plane plot corresponding to a mass supported on a spring whose stiffness increases with increasing deflection (perhaps representing a rubber element) will have the shape of a distorted ellipse with a positive maximum displacement whose magnitude is smaller than that of the greatest negative displacement.

Why Constant Natural Frequency?

By considering movement of a point that represents the state of the system along a phase plane curve, one may readily understand why a vibrating system's time to complete a cycle of vibration remains constant or, equivalently, why it has a constant natural frequency. Since the velocity corresponding to any particular deflection determines the time required for the incremental change in the displacement, the time required for moving from a given displacement to the next is always the same. This also holds for the time it takes for completion of a cycle (a phase plane point's complete round-trip)—that is, for the period of the oscillation.

In vibrations with smaller vibration energies, the greatest deflections, as well as the greatest velocities, are smaller, so that smaller vibrations are represented by smaller ellipses (see fig. 2). In such a vibration, the velocity associated with a given deflection is smaller, and the time it takes to traverse an increment of displacement is longer, but the phase plane

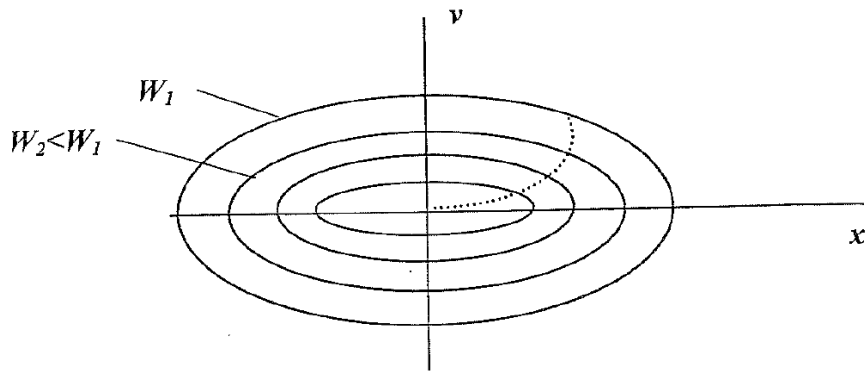

Fig. 2. Phase plane trajectories at different energies

point has a shorter total distance to cover, leading one to expect that the period T and the natural frequency are independent of the total energy of vibration. This may not be intuitively obvious, but can be verified mathematically.

Free Vibrations with Damping

Since damping produces an energy loss and smaller energies correspond to smaller ellipses, a point in the phase plane representing a decaying vibration moves toward the origin along a spiral-shaped path. With small damping the spiral is tight, with greater damping the spiraling toward the origin is more rapid, and with extremely high damping, one may expect a curtailed spiral path like that of the dotted curve of figure 2, representing a non-oscillatory drifting to zero deflection.
Recall that viscous damping is proportional to velocity, and note that as a point moves along an elliptical (or nearly elliptical) phase plane curve, it is at the greatest (absolute) velocity, as well as at zero velocity, twice per cycle. Thus, one would expect the energy not to decay smoothly but with twice per cycle fluctuations—that is, with fluctuations at twice the natural frequency. Indeed, a mathematically derived plot of the time-variation of the energy magnitude shows fluctuations about the "average" exponential decay at twice the natural frequency.

Concluding Remarks

The foregoing discussion has presented some introductory insights one may obtain from phase plane analyses. However, much more can be learned from such analyses. Phase plane relations have, in fact, been used extensively to study the motions of nonlinear systems. See, for example, the classic *Nonlinear Vibrations in Mechanical and Electrical Systems*, by J. J. Stoker (Interscience Publishers, first published in 1950); and "Nonlinear Vibrations," chapter 12 of *Theory of Vibration with Applications*, by W. T. Thomson (Prentice-Hall, Inc., 1981).

Industrial Noise Control Manufacturers Adopting Sustainable Composite Materials to Align with Green Industry Policies

A Study by Future Market Insights

Over 152 million units of industrial noise control systems were sold in 2018, totaling a market value worth US$ 4.8 billion. Our recent study finds that the industrial noise control market is expected to grow at 3.7 percent y-o-y in 2019. Key factors influencing the growth of industrial noise control market include

- growing awareness of harmful levels of industrial noise;
- increasing emphasis on the protection of workers and employees from noise pollution;
- stringent environment regulation related to industrial noise control; and
- incorporation of integrated noise control technologies in advanced industrial machinery.

The industrial noise control industry is witnessing a shift toward biodegradable materials over traditional materials. Manufacturers are incorporating green and sustainable materials in the design and development of industrial noise control units to align with the ongoing trend for sustainability.

Polymer and Composites Remain Preferred Materials, Accounted for Over 4 in 10 Sales in 2018

Our study finds that polymer and composites are highly preferred materials for the manufacturing of industrial noise control units. Over 4 in 10 industrial noise control units sold in 2018 were made of polymer and composites.

Polymers and composite materials have higher soundproofing properties as compared to other materials such as glass, metal, and fabric. In addition, new developments in composite materials provide biodegradability and recyclability, leading to higher sales.

Vibration Isolation Units Highly Sought After

We found that over 8 in 10 industrial noise control units sold in 2018 were equipped with vibration isolation units. As vibrations can significantly impact the overall productivity and durability of a range of industrial machines, industrial noise control with vibration isolation units are highly sought after.

The study thoroughly analyzed demand trends of different vibration isolation units such as isolation/machinery pads, isolation mounts, equipment bases, and spring isolators. Among these, sales of isolation mounts were higher in 2018 and the demand trend will continue in the future as manufacturers consistently introduce advanced and more efficient vibration isolation mounts.

The industrial noise control market is also studied for flexible and rigid industrial noise control instruments. While both these noise control units significantly address noise pollution issues, our study finds that flexible noise control units accounted for the second highest sales in 2018, and demand for rigid noise barriers is expected to grow at 4 percent in 2019.

Industrial Noise Control Utilization in Internal Application Prominent Accounted for 7 in 10 Sales in 2018

Our study estimates that demand for industrial noise control units for internal noise control application remained higher as compared to the application in external noise control. In 2018, 7 in 10 industrial noise control units sold were for internal application, and the demand will continue to grow in the future.

Elevated sound levels at workplaces and other commercial or residential places can cause negative human health conditions such as hearing impairment, annoyance, sleep disturbance, hypertension, and, in some cases, ischemic heart disease. Dissemination of knowledge regarding these harmful effects is contributing to increasing sales of industrial noise control units in the internal noise control application.

Due to the growing awareness of environmental noise as a potential health concern, industrial measures are being taken to address the impact of external noise sources. The study shows that the

adoption of industrial noise control for external noise control application will grow at 3.9 percent y-o-y in 2019.

Demand for Industrial Noise Control Units Consolidates in Manufacturing Sector

According to the study, the manufacturing sector remains a prominent end user of industrial noise control units. Different manufacturing industry verticals such as electrical and electronics, industrial machinery, automotive, metal, and others significantly integrate industrial noise control measures.

Over 7 in 10 industrial noise control units were sold in the manufacturing sector in 2018, wherein industrial machinery vertical account for the highest sales, as keeping the noise within the OSHA levels in the different manufacturing sectors is pivotal in ensuring health and wellness of employees.

Demand in East Asia Continues to Surge; Europe Represents Second Largest Market

As per report valuation, countries in East Asia including China, Japan, and South Korea registered significant demand for industrial noise control units in 2018. In terms of sales volume, Europe followed East Asia, and collectively these regions accounted for over 6 in 10 unit sales.

China remains the leading consumer of industrial noise control. A prominent manufacturing sector in the country contributes to the significant demand for industrial noise control. In Europe, Germany, followed by France and the UK, accounted for a considerable bulk of regional demand in 2018.

While the growth prospects seem steady for the industrial noise control market, the development of advanced industrial machineries integrated with noise-canceling technologies and sound or vibration absorbers can impede the market growth in the future.

According to our report, the industrial noise control market is projected to grow at 3.9 percent volume CAGR through 2028.

About the Author

These insights are based on a report on the industrial noise control market by Future Market Insights.

Long Term Strategic Planning at INCE-USA

Gordon Ebbitt

Ebbitt Acoustical Consulting, LLC

There are many key activities at INCE-USA. Among them are the *Noise Control Engineering Journal* (*NCEJ*), INCE Board Certification (now run as an independent board and open to nonmembers of INCE-USA), yearly technical conferences (INTER-NOISE when it is in the United States and NOISE-CON when it is not), and the INCE Digital Library (which contains all *NCEJ* articles as well as all INTER-NOISE and NOISE-CON proceedings). Though the leadership of INCE-USA is proud of these activities, the institute is always looking for ways to expand its activities to better meet the needs of its members, the noise control engineering community, and the public. To that end, the institute has met to develop plans to better serve these groups.

Strategic planning meetings were held during the INCE-USA Board of Directors meeting in January 2019 and have continued through conference calls and a second meeting at NOISE-CON 2019. The meetings have involved all board members, INCE-USA officers, and staff, along with specialists in strategic planning from Virtual, Inc., which serves as the INCE-USA business office.

As part of this activity, our vision and mission statements have been evaluated and are being streamlined and updated to bring them in line with the current state of noise control engineering and the goals of INCE-USA. Some final details are still being worked out, but the new statements are nearly ready to provide direction for the institute's future plans.

In addition to the vision and mission statements, specific strategic plans are being considered. During an initial brainstorming session, 13 strategic initiatives were identified. Those were ranked in importance, and 3 have been chosen for immediate development: (1) increasing the awareness of the public and the engineering community regarding the effects of noise and noise control engineering solutions, (2) enhancing INCE-USA's online educational activities, and (3) promoting and expanding the INCE-USA technical activities committees.

To increase awareness in noise and noise control, INCE-USA will be considering social media and other means to engage the engineering community and the public. Another activity that will be considered is public outreach sessions. These have already been conducted at several NOISE-CONs. In some cases, sessions have been directed toward the general public; in others, teachers have been given kits to demonstrate acoustic principles. Whether these will be continued or whether other methods should be used to reach the public will be considered. Another initiative being considered is the development of a product noise rating (PNR). This would be a noise rating that would provide product labeling for noise. This would be similar to the energy rating labels that are currently used for home appliances.

INCE-USA already provides a series of noise control courses. Their satisfactory completion can fulfill part of the requirement for INCE Board Certification. INCE-USA will consider expanding these efforts and also will consider additional courses, conference workshops, streamed conference sessions, webinars, and other means to disseminate information. The online digital library, which is available to all I-INCE member societies, will also be enhanced and promoted.

The INCE-USA technical activities committees provide forums for members to exchange ideas. They also provide a lot of the organization's need to create sessions for the conferences held in the United States. Steps are being taken to enhance meeting opportunities for these committees at INCE-USA conferences, support the work of the committees, develop new committees as new areas become important, and make it easier for these groups to contribute to the conferences.

Though some initial steps are already underway, the general scope and the specific tasks to support these initiatives are still being worked out. The specific activities noted above may or may not make it into the final plans. In the coming months, INCE-USA will be finalizing those plans and will see how they fit with the overall strategic long-term goals of the institute. It's an exciting time! Because our goals are directed toward the general noise control engineering community and the public, the institute welcomes comments and contributions from everyone. If you have ideas for new INCE-USA activities, please send an email to the INCE-USA business office at ibo@inceusa.org.

NCAC Announce Winner of Laymon N. Miller Award

The National Council of Acoustical Consultants (NCAC) is an international organization committed to supporting the acoustical profession through recognizing expert acoustical consultants and engineers; promoting opportunities for peer interaction; and providing a reference tool for the public to learn more about the profession and to find a consultant matched to their needs. Since 1962, NCAC member firms have led their profession in technical expertise, research, innovation, and development of real-world applications in all types of environments.

NCAC is pleased to announce that the recipient of the 2019 Laymon N. Miller Award for Excellence in Acoustical Consulting is K. Anthony Hoover. This award was developed jointly by the NCAC and INCE-USA. The award will be independently bestowed by NCAC in odd-numbered years and by INCE-USA in even-numbered years.

This award is given to an individual who has practiced acoustical consulting in an exemplary manner over a sustained period of time to improve acoustical environments in and around buildings, transportation systems, workplaces, and recreational and other occupied spaces, such that the quality of life for citizens and communities is significantly enhanced.

Hoover was nominated for the Laymon N. Miller Award for Excellence in Acoustical Consulting by his peers and fellow NCAC members. Words chosen to describe Hoover and his work include the following: "In a career of nearly four decades, he has been responsible for the design, testing, and implementation of acoustics and noise control designs in over 2,000 projects of almost every conceivable type. He has contributed much to the quality of acoustical life for many by his long and excellent service as a leader in acoustical consulting." Hoover has had an important role in developing the classroom acoustics standard, ANSI S12.60, which has improved educational opportunities for countless children.

He began his consulting career with Cavanaugh Tocci Associates in 1982, and in 2007 joined with Ron McKay and Dave Conant (and everyone) at McKay Conant Hoover, Inc.

An assistant professor for 20 years, Hoover introduced the science and practice of acoustics to thousands of students at the Berklee College of Music, as well as at other institutions, including Boston Architectural Center, Harvard University, and Massachusetts Institute of Technology. He continues to lead the Acoustical Society of America (ASA) College of Fellows, which provides outreach and mentoring for many early career acousticians. He also leads the ASA Meetings Subcommittee on Jams, which provides a musical and social outlet that attracts hundreds of young, and older, convention-going acousticians.

Hoover's encomium read, "His generous guidance to other consultants and acousticians has influenced many outstanding careers. Tony is often found busy, working diligently behind the scenes, for the benefit and recognition of others."

NCAC presented the medallion to Hoover during an award ceremony at its annual meeting, September 13–15, in Atlanta, GA.

Contact NCAC

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NOISE-CON 2019 Report

NOISE-CON 2019 was held August 26–28, 2019, at the Sheraton Hotel and Marina in San Diego, CA—the eighth largest city in the United States. It was cohosted by the INCE-USA and the Transportation Research Board Committee on Transportation-Related Noise and Vibration (ADC40).

As part of the technical program, over 160 technical papers were presented across four parallel sessions, under the conference theme: Catch the next wave in noise control engineering.

While organizing a conference of this size requires time and help from many individuals, the principal congress organizers were Bryce Gardner and Chad Musser (conference cochairs), Judy Rochat (conference vice chair), Yong-Joe Kim (technical chair), Andrew Barnard (technical vice chair), and Gordon Ebbitt and Sarah McGuire (proceedings editors). The exposition manager was Regina Young, and Michaela Lindstrom served as the student volunteer coordinator.

Conference attendees were treated to sunshine, great food, and an even better technical program.

Monday, August 26

The opening ceremony was held on Monday morning. INCE-USA President Steve Marshall welcomed everyone to San Diego and described the events of the week. He also announced details of the exciting new demo theatre that would be in the exposition. Conference Cochair Chad Musser also took to the stage to welcome all attendees, and encouraged everyone to enjoy the conference and to take some time to see and get to know the beautiful and vibrant city of San Diego. He wished us a productive and memorable week filled with a variety of presentations, papers, and plenary addresses covering a highly diverse range of topics and industries.

The first plenary lecture was excellently delivered by Dr. J. Stuart Bolton from Purdue University. The topic of his talk was "Poro-Elastic Materials and the Control of Low Frequency Sound." He explained that in the introductory sections of active noise control and metamaterial articles, it is often said that "conventional" (i.e., poro-elastic) materials such as foams and fibrous media do not work well at low frequencies. While that observation may be true for the simplest treatments, there are many cases in which excellent weight and cost-effective acoustical treatments can be realized by using poro-elastic media. He offered examples and interesting anecdotes from his past.

Following this lecture, the technical program began. The day had four parallel sessions covering a wide array of topics, from noise policies, legislation, and regulations to structural acoustics.

The day also saw several special events, including the INCE Board Certification information session and networking breakfast, the Women in Noise Control Engineering lunch, a student breakfast, and the student paper competition. There was also a tribute session for Jerome E. Manning, who passed away in June 2018 after a distinguished lifelong career in acoustical engineering.

The day concluded with the opening reception of the exposition. There were 54 different exhibitors. There was also a demo theatre where exhibitors had a chance to present their latest products to attendees. It included a roving microphone and housed several interesting talks and interactions. Attendees were also invited to play exhibitor bingo!

Tuesday, August 27

The congress continued on Tuesday and opened with the INCE awards ceremony and a plenary lecture. The plenary lecture was delivered by John Maxon

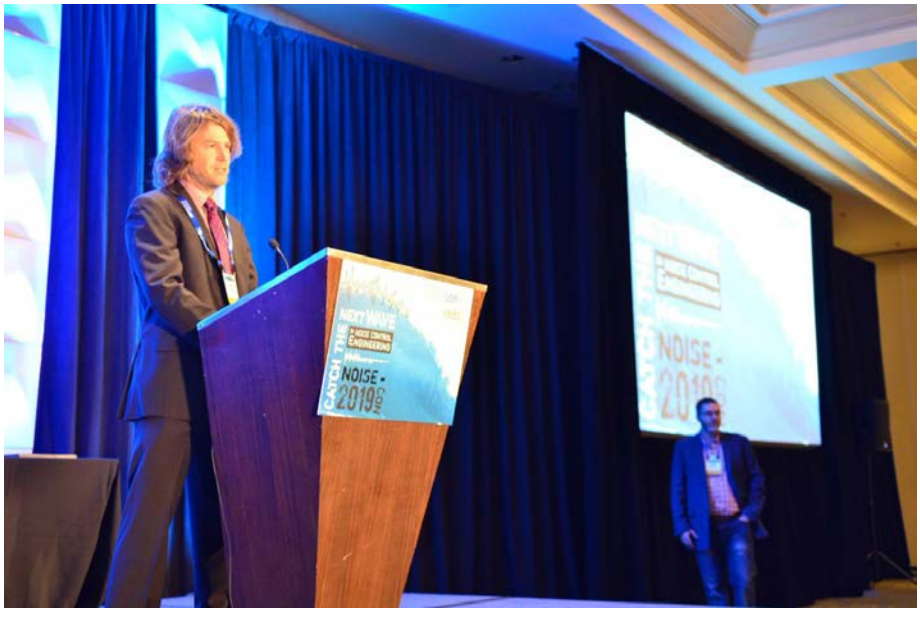

Fig. 1. Chad Musser welcoming everyone to NOISE-CON 2019

Fig. 2. Dr. Stuart Bolton giving the opening plenary at NOISE-CON 2019

from Gulfstream Aerospace Group. He talked about joining Gulfstream in 2004 as a technical specialist after working for Gulfstream's parent company, General Dynamics, for more than 18 years. While there, he specialized in structural acoustic and vibration analysis at Electric Boat, helping to make US submarines undetectable. Transitioning from undersea to in-air acoustics and vibration analysis, he introduced the Statistical Energy Analysis (SEA) acoustic and vibration modeling tool to Gulfstream and directed the development of Gulfstream's Acoustic Test Facility (ATF). Both the SEA predictive modeling tool and the ATF have been instrumental in the development of thermal acoustic treatment for several Gulfstream jets.

Following this lecture, the technical program began. The day was jam-packed, beginning with five parallel sessions. Sessions continued throughout the day, with topics covering everything from fitness noise and vibration to acoustic metamaterials.

Tuesday also saw the technical tour, which visited the Hubbs-SeaWorld Research Institute, where attendees were given an overview of research on the effects of human-made noise on animals

Fig. 3. Paul Burge (VP for board certification) at the information session for INCE-USA Board Certification

Fig. 4. The live demo theatre at the exposition

Fig. 5. John Maxon during Tuesday's plenary lecture

Fig. 6. The final plenary of NOISE-CON 2019 being presented by Dr. Peter Gerstoft

and of the recently developed guidelines for limiting exposure. The Hubbs-SeaWorld Research Institute is a nonprofit scientific research organization committed to conserving and renewing marine life to ensure a healthier planet.

Wednesday, August 28

Wednesday morning began with a plenary lecture by Dr. Peter Gerstoft from Scripps Institution of Oceanography, University of California, San Diego. He is a fellow of the Acoustical Society of America and an elected a member of the International Union of Radio Science, Commission F. The title of his talk was "Exploring the Earth with Seismic Noise: Anthropogenic and Exogenic Noise Sources," and he talked about his work on extracting information from noise (acoustic, seismic, EM) with the help of signal processing, compressive sensing, and machine learning.

The day continued with technical sessions, which included papers on IT noise, product noise, and building and architectural acoustics, along with technical meetings. In the afternoon there

Table 1. 2019 Michiko So Finegold Award winners. This award supports US graduate students and young professionals traveling to NOISE-CON 2019 to present their work on noise effects, development of noise policy, and related aspects of noise control engineering.

Student/Young Professional	University/Organization
Won Hong Choi	Purdue University
Stephania Vaglica	Michigan Tech University
Yongjie Zhuang	Purdue University
Gong Cheng	University of Kentucky
Steven Senczyszyn	Michigan Tech University
Guo Long	University of Cincinnati
Sunit Girdhar	Michigan Tech University

Table 2. 2019 Halberg Foundation Award winners. This award supports North American undergraduate or graduate students traveling to NOISE-CON 2019 to present their work in any areas of noise control engineering.

Student	University
Caoyang Li	University of Kentucky
Keyu Chen	University of Kentucky
Zhuang Mo	Purdue University
Weimin Thor	Purdue University
Yu Xiong	Penn State
Brittany Wojciechowski	Wichita State University

Fig. 7. Andrew Barnard and Steve Marshall at the awards ceremony

Fig. 8. Dana Lodico awards the Outstanding Educator Award to Dr. David W. Herrin

Fig. 9. Brittany Wojciechowski, one of the Michiko So Finegold Award winners, with INCE-USA President Steve Marshall and Dana Lodic (VP for honors and awards)

was a workshop on "Transportation Noise Analyses: Incorporating Commonly Ignored Elements of Traffic Noise."

With technical sessions complete, events continued into Thursday, with an IT technical committee, TRB committee meeting, and TRB young professionals meeting.

Awards

NOISE-CON also gave INCE-USA the opportunity to recognize a variety of award winners in 2019. Dr. David W. Herrin, University of Kentucky, was awarded the Outstanding Educator Award. During the award presentation, it was noted that Dr. Herrin's research is of very high quality, and he is well respected in his field. He is an excellent mentor of his graduate students, and his students regularly win best-paper awards. K. Anthony Hoover of McKay Conant Hoover was recognized with the Laymon N. Miller Excellence in Acoustical Consulting Award (presented at the NCAC conference—learn more about this award elsewhere in this issue). David Nelson was also elected as an INCE-USA fellow for his significant contributions in the advancement of noise control engineering in the areas of IT and product noise and his substantial contributions to INCE conferences and planning. INCE-USA also gave several students awards to deserving winners, summarized in tables 1 and 2.

Regional News

Pan-American News

Brazil—ProAcústica

The Brazilian Association for Acoustical Quality (ProAcústica)—an I-INCE member society since 2013—is a nonprofit civil entity with the purpose of congregating companies and professionals looking to develop applied acoustics in Brazil, a field that also covers the science of vibrations. It recently held elections for officers and the board of directors, the results of which are available here.

In their updates, ProAcústica report that the Urban Noise Map for the Central Area of the City of São Paulo was recently launched. This coincided with the International Noise Awareness Day and saw a symbolic bicycle pedaling act on a noisy street in downtown São Paulo. More information on these activities is available here.

Fig. 1. Bicycling for Noise Awareness Day in downtown São Paulo

European News

Association of Acoustic Consultants of Ireland

The Association of Acoustic Consultants of Ireland (est. December 2018) recently released their Environmental Noise Guidelines for Local Authority Enforcement and Planning Sections. The guide is a complete reference to suggested appropriate noise assessment standards for use by planning authorities in the Republic of Ireland. The objective of the publication is to ensure that consistent, relevant, appropriate, and enforceable conditions are attached to proposed future developments. More details are available here.

Book Reviews

Loudspeaker Modeling and Design: A Practical Introduction

Geoff Hill
Routledge (2018)
346 pp., hardbound, $US170
ISBN 978-0-815-36132-9

In writing *Loudspeaker Modelling and Design: A Practical Introduction*, Geoff Hill intended to offer a realistic and worldly approach to loudspeaker design to an audience already initiated into the world of audio theory. The book aims to ignore the tropes of typical theory laden textbooks in favor of clear and concise language. As an acoustician by trade and a lifelong musician, the details behind varying loudspeaker designs have been in my peripheral for some time. Having a surface level understanding of loudspeaker anatomy, I found the book to be an introduction to the strategic planning, design, and implementation of loudspeaker testing. The book is primarily aimed at those with a background in physics or acoustics eager to explore the world of loudspeaker design but unsure where to look for a practical application of loudspeaker theory.

The book is divided into eight parts. Hill begins by addressing the theory behind loudspeaker functionality, maintaining a fluid pace by peppering more intensive theory only when it is necessary for the reader to grasp the larger concept, but leaving the proofs for many statements for the reader to investigate. Hill then describes his practical approach to modeling the performance of a loudspeaker. These explanations take place in parts 1 and 2. In parts 3 and 4, Hill explains many of the common methods for modeling the performance of loudspeakers such as polynomial models and the small signal model. While the explanations of a wide variety of loudspeaker modeling techniques are helpful, Hill acknowledges that these methods are not one-size-fits-all and describes the importance of understanding the goals of the loudspeaker being designed and how these goals will determine the most useful modeling process. Hill also maintains this practical approach by describing to the reader how different materials may impact the budget of the loudspeaker's design and how certain design criteria may save on cost but will limit the performance of the loudspeaker in loudness, frequency, performance, or durability.

In the later parts of the book, Hill describes methods of gauging the performance of loudspeakers after they have been built. These include general methods of acoustical testing in anechoic chambers and, more specifically, testing methods for the accurate measurement of loudspeaker components such as the drive units. The final section of the book also contains Hill's white paper on tetrahedral test chambers. This white paper makes comparisons between loudspeaker measurements made using a traditional IEC baffle and those made using tetrahedral test chamber. The measurements from the tetrahedral test chamber are found to be clearer than those using a traditional IEC baffle, and Hill postulates that the simplified setup of the tetrahedral test chamber offers increased repeatability over more complicated methods. After this white paper, Hill has an appendix that includes detailed instructions for loudspeaker modeling using software such as ABEC (Acoustic Boundary Element Calculator), VACS (Visualizing Acoustics), FEMM (Finite Element Methods Magnetics, an FEA magnetics program by David Meeker), Fusion360, and more. These tutorials offer the reader many different ways to begin digitally modeling a loudspeaker design, and Hill provides the reader with lines of code to aide those unfamiliar with the software.

The book also includes a short biography of the author. Geoff Hill has been a contributing member to the Audio Engineering Society for many years and has worked with multiple consultancies in the UK throughout his career, as well as with technology companies such as Motorola and Bowers & Wilkins. He is a graduate of Greater Brighton Metropolitan College and now consults on loudspeaker design privately through his latest venture, Hill Acoustics, located in Cambridgeshire, UK.

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Below is a list of congresses and conferences sponsored by International INCE and INCE-USA. A list of all known conferences related to noise can be found by going to the International INCE website (www.i-ince.org/).

Don't forget: 2020 is the International Year of Sound!
http://sound2020.org

June 29–July 1, 2020
NOISE-CON 2020
New Orleans, Louisiana, USA
https://www.inceusa.org/noisecon20/

June 15–18, 2020
13th ICBEN Congress on Noise as a Public Health Problem
Karolinska Institutet
Stockholm, Sweden
https://www.icben2020.se/

August 23–26, 2020
INTER-NOISE 2020
49th International Congress and Exposition on Noise Control Engineering
Seoul, Korea
https://internoise2020.org

August 1–4, 2021
INTER-NOISE 2021
50th International Congress and Exposition on Noise Control Engineering
Washington, USA
http://www.i-ince.org/

Directory of Noise Control Services

Information on listings in the Directory of Noise Control Services is available from the INCE-USA Business Office, 11130 Sunrise Valley Dr., Suite 350, Reston, VA 20191-4371 Telephone: +1.703.437.4073 email: ibo@inceusa.org.

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Intertek 5
4Silence 15
Ecore 17
Scantek, Inc. 20
INCE Membership 22
INCE-USA: Become Board Certified 29
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Books Available

Noise and Vibration Control, edited by Leo L. Beranek
Noise Control in Buildings, by Cyril M. Harris

Index to Volume 27

Asia-Pacific News
Korean Society for Noise and Vibration Engineering Spring Conference 2019, **27** (1): 24

Book Reviews
27 (2): 18; **27** (3): 20; **27** (4): 30

Conference Calendar
27 (1): 28; **27** (2): 23; **27** (3): 27; **27** (4): 35

Directory of Noise-Control Services
27 (1): 29; **27** (2): 24; **27** (3): 28; **27** (4): 36

Editor's View
27 (1): 5; **27** (2): 5; **27** (3): 4; **27** (4): 5

European News
Association of Acoustic Consultants of Ireland, **27** (4): 29
UK—Institute of Acoustics, **27** (2): 17

Features
Calling All Students! Upcoming INCE-USA Student Awards for 2019, **27** (1): 12
Calling All Young Professionals! INTER-NOISE 2019 Grants and Activities, **27** (1): 19
CAOHC Releases Education Video on Workplace Noise Concerns and Controls, **27** (3): 17
Erasmus+ The Noise Training Project, **27** (2): 12
Establishing an Industry Benchmark: Mercury Marine Builds Innovative World-Class Testing Facility, **27** (4): 7
From the Archives: Member Society Profile—The French Acoustical Society (SFA) in 1993, **27** (2): 7
From the Archives: The Past Quarter Century, **27** (1): 8
From the Archives: We Catch Up with Dr. Eric E. Ungar, **27** (1): 7
Getting to Know You: Bob Bernhard, Incoming I-INCE President, **27** (4): 16
How Energy Relations Explain Vibration Behavior, **27** (4): 18
Industrial Noise Control Manufacturers Adopting Sustainable Composite Materials to Align with Green Industry Policies, **27** (4): 21
Long Term Strategic Planning at INCE-USA, **27** (4): 23
NCAC Announce Winner of Laymon N. Miller Award, **27** (4): 24
Quiet Deliveries Make for More Livable Cities, **27** (3): 14
Sensitive Equipment Criteria and Footfall-Induced Vibrations—Background and Problems, **27** (2): 13
Summary of Transportation Noise and Public Health Outcomes, **27** (1): 13
Upcoming INCE-USA Awards and Honors for 2019, **27** (1): 10
Vibration Control: An Overview and Checklist, **27** (3): 18

International Representatives
27 (1): 25; **27** (2): 20; **27** (3): 24; **27** (4): 32

Meetings and Conferences
INTER-NOISE 2019 Report, **27** (3): 7
NOISE-CON 2019 Report, **27** (4): 25
NOISE-CON 2019: Catch the Next Wave in Noise Control Engineering!, **27** (2): 10
Welcome to INTER-NOISE 2019 MADRID, **27** (1): 20

Member Society Profile
From the Archives Update: Member Society Profile—French Acoustical Society (SFA) in 2019, **27** (2): 8

NOISE/NOTES
27 (1): 6; **27** (2): 6; **27** (3): 6; **27** (4): 6

Obituaries
Jiri Tichy, 1927–2019, **27** (3): 12

Pan-American News
Brazil, **27** (4): 29
Brazil—ProAcústica, **27** (2): 17
Canada—Canadian Acoustical Association (CAA), **27** (2): 17
USA—INCE-USA, **27** (2): 17

President's Column
From the I-INCE Treasurer, **27** (1): 4
From the I-INCE VP Communications and Webmaster, **27** (2): 4
From the President of I-INCE, **27** (1): 3
From the President of I-INCE, **27** (2): 3
From the President of I-INCE, **27** (3): 3
From the President of I-INCE, **27** (4): 3
From the President of INCE-USA, **27** (4): 4