

Demolition & Construction


Noise Control for Occupied NICUs

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Reduction of Noise Disturbances in the NICU
During Facility Modification and Expansion

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Engineered Vibration Acoustics & Noise Solutions

- **Jack B. Evans, PE**
President & Principal Engineer
- Education & Experience:
 - 25+ Years Acoustical Consultation
 - 6 Years Facilities Engineering
 - BS Architectural Engineering, Univ. of Texas '75
- Case Study of Phoenix Children's Hospital
 - NICU Expansion & Rearrangement Planning
- Measurements at Memorial Hermann Woodlands Hospital
 - Data Acquired for Evidence Based Design Study
- Practical Measures to Isolate Occupied NICUs from Demolition & Construction Noise

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Agenda

- Acoustics, Noise & Vibration Terminology
- Transmission Paths
 - Airborne, Duct borne, Structure borne
- Acoustical & Vibration Criteria for NICUs
- Common Noise & Vibration Sources
 - Continuous Interior, Transient Interior
 - Intrusive Exterior (Environmental)
- Demolition & Construction (Unique)
 - Airborne, Impact, Impulse, Explosive

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Overview

- Protect Newborns, Mothers & Staff from:
 - Sleep interruption
 - Stress & Startle
 - Communication Interruption
 - Loss of Monitor & Alarm Signals
- Building Acoustics & Noise Control works for Normal Occupancy
- Special and Temporary Measures may be used for Demolition and Construction Noise

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Vocabulary / Glossary of Terms

◦ Attenuation	◦ Noise Reduction Coefficient (NRC)
◦ Bandwidth	◦ Octave (freq. ratio 2)
◦ Continuous	◦ Performance / Prescriptive
◦ Damping	◦ Q (directionality)
◦ Decibel (dB)	◦ Reflective / Reverberant
◦ Equivalent Level (Leq)	◦ Sound Transmission Class (STC)
◦ Frequency	◦ Spectrum
◦ Gravity	◦ Transient (Intermittent, Random)
◦ Hertz (cps)	◦ UL Assembly
◦ Isolation	◦ Vibration
◦ Just Detectable Difference	◦ Weighting (A, C, Linear/Flat)
◦ Kilo, KHz	◦ X
◦ Level (Lp, Lv),	◦ Y
◦ Masking	◦ Z

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1. Acoustics vs. Sound Isolation

- Absorber (*Rating = NRC*):
 - Low Density, Porous: Insulation, Foam, etc.
- Barrier (*Rating = STC*):
 - Dense, Solid: Wood, Glass, GWB, Concrete
- Damper:
 - Mass or Visco-elastic Material Applied
- Diffuser:
 - Articulated Reflective Surface
- Flanking Path:
 - "Leak," "By-Pass" or Secondary Path
- Demonstration

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2a. Airborne vs. Structure Borne

- Propagation Within a Room:
 - Direct Source to Receiver Path or Reflection
- Room to Room Airborne Transmission:
 - Horizontal via Wall, Door, Duct or Penetration
 - Vertical via Floor-Ceiling Assembly, Shaft or Penetration
- Room to Room Structure Borne Transmission:
 - Horizontal via Partition, Floor Slab, Pipes or Ducts
 - Vertical via Bldg. Columns, Pipe and Duct Risers
- Outside to Inside Airborne Transmission:
 - Horizontal via Windows, Doors, Wall or Openings
 - Vertical via Roof, Roof-top Equip. Ducts, Skylights

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2b. Airborne-Structure Borne Interaction

- Airborne Sound-Induced Structure Borne Vibration:
 - Loud Low-Frequency Sound Causes Vibration in Lightweight Structures, Such as Ceilings and Partitions
- Radiated Airborne Sound from Structure Borne Vibration:
 - Vibrating Surface Area Acts Like Loudspeaker to Radiate Sound
- Sound Reinforcement from Re-radiated Structure Borne:
 - Radiated sound is Additive Second Source
- Structure Borne Path Can Bypass "Buffer Zones":
 - Vibration Travels Long Distance with Little Attenuation
 - Sound is Easily Dissipated

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3a. NICU Acoustical Criteria

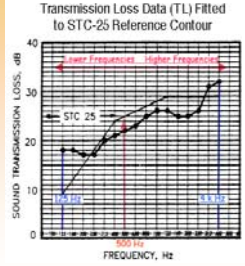
- Facility Criteria vs. Operational Criteria
(This presentation focuses on Facility Criteria)
- NICU Standards Criteria
 - Operational: Occupant Generated Noise
 - Facility: Building Systems Noise
- Building Design (Facility) Criteria
 - Continuous Background Noise (NC/RC)
 - Sound Isolation/Privacy (STC/IIC)
 - Room Acoustics/Reverberation (T60/NRC)
 - Green Guide for Health Care (Future LEED)





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3b. Building Design (Facility) Criteria

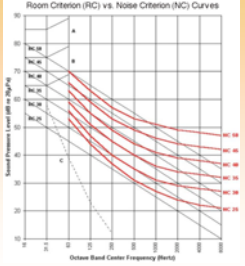


Transmission Loss Data (TL) Fitted to STC-25 Reference Contour

Lower Frequencies Higher Frequencies

STC 25

100 Hz 5000 Hz



Room Criterion (RC) vs. Noise Criterion (NC) Curves

Sound Pressure Level (dB re 20µPa)




Octave Band Center Frequency (Hz)

Partition & Floor-Ceiling Assy. Continuous Background Noise

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3c. Measurements vs. Criteria


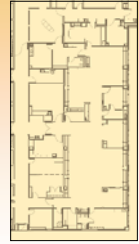
- Data from an Evidence-Based Design Study by WHR Architects, Inc. & JEAcoustics

- Corridor Noise Measurements
- Private Patient Room Measurements
- NICU Measurements

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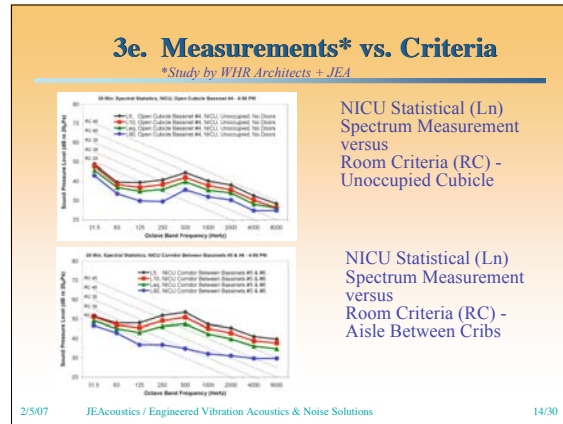
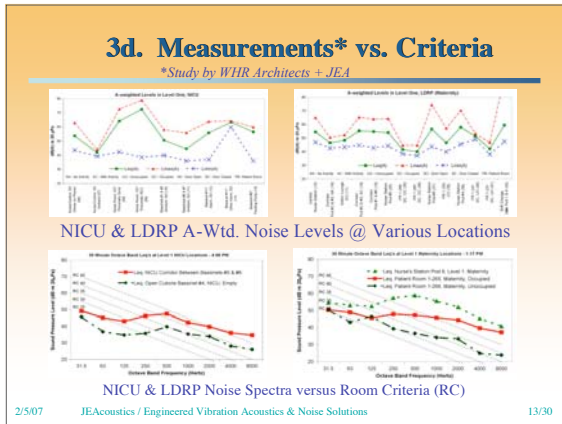
Woodlands Hospital* LDR & NICU

Floor Plans: "Pod" Style LDR and Small NICU

* Plans by WHR Architects, Inc.

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- ### 4. Common Noise & Vibration Sources
- **Continuous**
 - Bldg. Equipment
 - AHU, Exhaust
 - Pumps, Pipes
 - Elec. Transformers
 - Cont. On Equip.
 - Light Ballasts
 - Traffic Noise (Intrusive Environmental)
 - **Transient**
 - Speech
 - Rolling
 - Impacts
 - Footfall Traffic
 - On/Off Equip.
 - Elevators
 - Patient Monitors
 - Pagers
 - **Environmental**
 - Street Traffic
 - Helicopter & Aircraft
 - Sirens
 - Outdoor Bldg. Equip.
 - Amplified Music
 - Outdoor Machines
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- ### 5. Demolition & Construction Noise & Vibration Sources
- **Machinery**
 - Compressors
 - Generators
 - Vent Fans
 - Lamp Ballast
 - Vacuum
 - Pallet Jack
 - Power Lift
 - **Tools**
 - Hammers
 - Saws
 - Circular
 - Reciprocating
 - Drills
 - Anchor Setters
 - Grinders
 - Chippers
 - **Miscellaneous**
 - Speech
 - Material Staging
 - Impacts
 - Scraping
 - Radios
 - Backup Alarms
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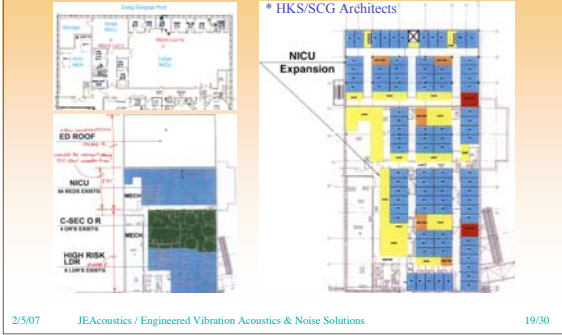
6. Source - Path - Receiver

- Reduce Noise, Vibration Where Created
 - Attenuate
 - Isolate
- Prevent or Reduce Energy Along Path
 - Isolate
 - Damp
- Attenuate Noise at Receiver
 - Attenuate
 - Mask

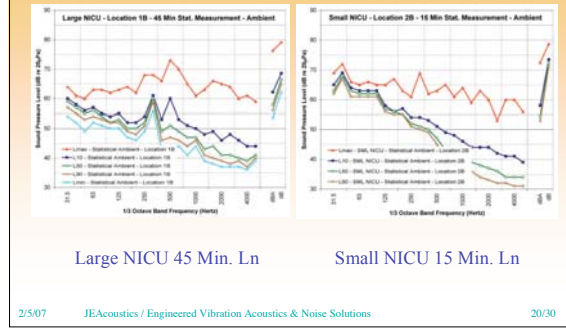
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- ### 7. Implementation
- Space Planning
 - Phasing & Scheduling
 - Involve the Construction Contractor
 - Pre-Determine For Various Conditions
 - Temporary vs. Permanent Noise Barriers
 - Off-site vs. On-site fabrication of assemblies
 - Methods of Demolition
 - Materials Staging & Movement
 - Materials & Methods of Construction
 - Feasibility of Temp. NICU Evacuation/Relocation
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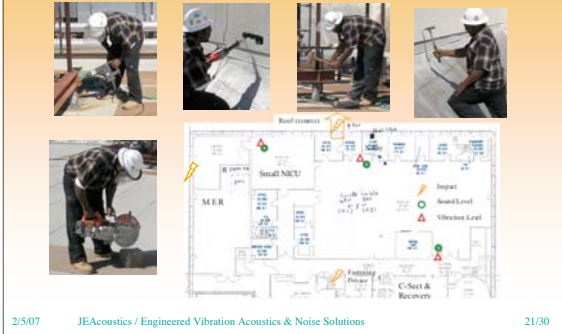
8. Demolition & Construction Expansion Plan* & Measurements



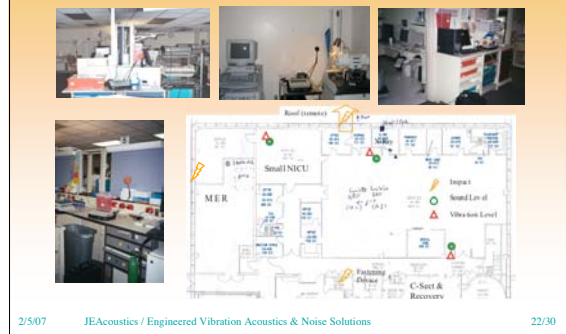
9. Small and Large NICU Stat. (Ln) Noise Measurement Results



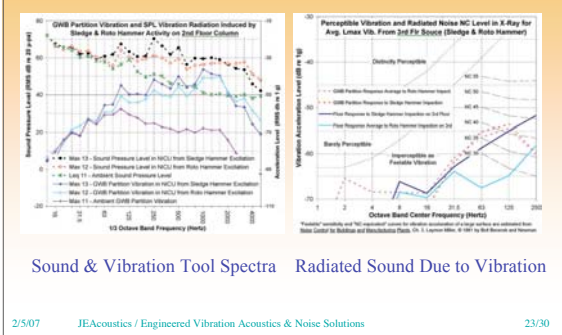
10a. Simulated Demolition Noise & Vibration Measurement Sources



10b. Simulated Demolition Noise & Vibration Measurement Locations



11. Simulated Demolition Impact & Vibration Measurement Results



12c. Demolition & Construction Noise Control Recommendations

- Hospital should meet with the architect/engineer and construction team
 - Not adequate to instruct contractor to use quiet construction methods
 - Predetermine and agree to specific impact and machine-tool noise measures
 - Create buffer areas for NICU admin & infant areas
 - Non-sensitive spaces adjacent to partition re-radiation surfaces
 - No doors or windows that directly connect NICU with Construction Zone
 - Retrofit door seals on frames + 2nd solid-core door in frame if connecting door
 - Retrofit 2nd layer of laminated glass in window frames
 - Choose non-impact demolition procedures.
 - Choose non-vibratory demolition procedures
 - Schedule noisy procedures during most busy time in NICU
 - Intrusive transient events not as perceptible during busy time with local transients
 - Place slab isolation joints in new concrete work
 - Discontinuities should be complete
 - Place resilient floor mats on demo, fabrication and construction floors
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12. Demolition & Construction Noise Control Plan Illustration

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12a. Demolition & Construction Noise Control Recommendations

Architectural

- 1. Temporary sound barrier at partitions
 - a. Blanket w/ barrier septum
 - b. Mass-loaded vinyl sheet
 - c. Drywall on furring studs
- 2. Modify Floor:
 - a. Rubber floor surface
 - b. Floor deck over resilient underlayment
- 3. Vibration isolate isolette legs, counters
- 4. Door seals
- 5. Modify NICU ceilings:
 - a. Ceiling hanger vibration isolators
 - b. Substitute composite barrier-absorber tiles
 - c. Lay barrier sheet or blanket over ceiling

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12b. Demolition & Construction Noise Control Recommendations

Structural (major cost & complexity)

- Isolate the NICU slab from demo
 - o Cut the slab along a column line
 - o Support the slab edge along the cut line.
 - Secondary Columns and beams
 - Isolator pads between corbel support and beam.
- Insert "whole building" vibration isolators
 - o Vertical vibration transmission from above or below
 - o Check ducts, pipes, etc.

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12c. Demolition & Construction Noise Control Recommendations

Building Systems Engineering (MEP)

- Segregate Demo/Const from NICU
 - o Reroute Ducts between NICU and Construction Zone
 - o Place Attenuators in R/A Transfers & Ducts
 - o Lagging Enclosures Around Ducts & Pipes.
 - o Flexible Couplings in Pipes, Ducts & Conduits
- Vibration Isolation For Pipes
- Seal Wall Penetrations

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Summary

- Sensitive spaces temporary relocation
- Scheduling of demolition and construction sequences.
 - o Individual impact noise events may be tolerated,
 - o Continuous or repetitive events may sensitize occupants
- Multiple simultaneous impact events are additive
 - o Slightly louder
 - o More feelable
- Physical control of noise and vibration at source
- Re-radiated sound from partition and ceiling surfaces
- Floor vibration transmission into furnishings and casework
- Novel conceptual ideas

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Acknowledgements

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- Woodlands Memorial-Hermann Hospital
- Kathleen Philbin, PhD, re: J. Perinatology papers 2000 & 2006

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*Oh, By the way:
The contractor doesn't really finish,
At least not in the time allocated.*


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Noise Control for Occupied NICUs

Thanks for your kind attention.

Any Questions?


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