Demolition & Construction

Noise Control for Occupied NICUs

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

JEACOUSTICS

- **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

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

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

Vocabulary / Glossary of Terms

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

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

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

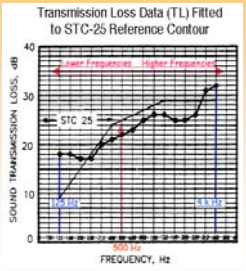
2b. Airborne-Structure Borne Interaction

- 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

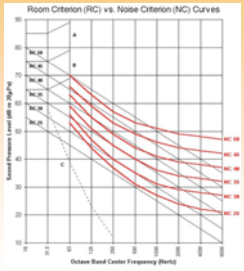
3a. NICU Acoustical Criteria

- 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)

3b. Building Design (Facility) Criteria



Partition & Floor-Ceiling Assy.



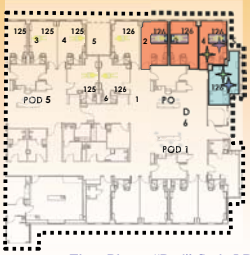
Continuous Background Noise

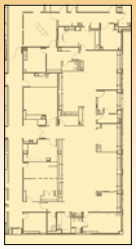
3c. Measurements vs. Criteria

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

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

Woodlands Hospital* LDR & NICU



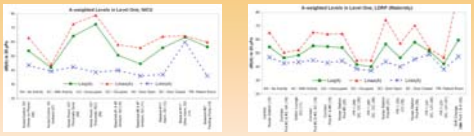


Floor Plans: "Pod" Style LDR and Small NICU

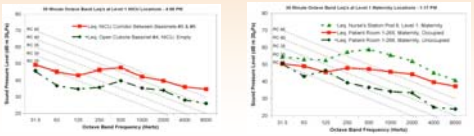
* Plans by WHR Architects, Inc.

3d. Measurements* vs. Criteria

**Study by WHR Architects + JEA*



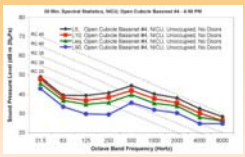
NICU & LDRP A-Wtd. Noise Levels @ Various Locations



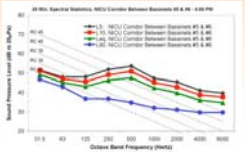
NICU & LDRP Noise Spectra versus Room Criteria (RC)

3e. Measurements* vs. Criteria

**Study by WHR Architects + JEA*



NICU Statistical (Ln) Spectrum Measurement versus Room Criteria (RC) - Unoccupied Cubicle



NICU Statistical (Ln) Spectrum Measurement versus Room Criteria (RC) - Aisle Between Cribs

4. Common Noise & Vibration Sources

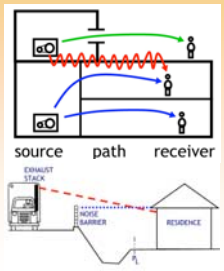
- Continuous
  - Bldg. Equipment
  - AHU, Exhaust
  - Pumps, Pipes
  - Elec. Transformers
  - Cont. On Equip.
  - Light Ballasts
  - Traffic Noise (Intrusive Environmental)
- Transient
  - Speech
  - Rolling
  - Impacts
  - Footfall Traffic
  - On/Off Equip.
  - Elevators
  - Patient Monitors
  - Pagers
- Environmental
  - Street Traffic
  - Helicopter & Aircraft
  - Sirens
  - Outdoor Bldg. Equip.
  - Amplified Music
  - Outdoor Machines

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

6. Source - Path - Receiver

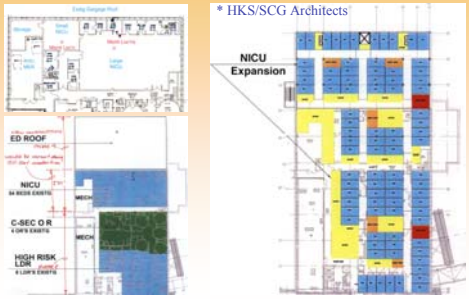
- Reduce Noise, Vibration Where Created
  - Attenuate
  - Isolate
- Prevent or Reduce Energy Along Path
  - Isolate
  - Damp
- Attenuate Noise at Receiver
  - Attenuate
  - Mask



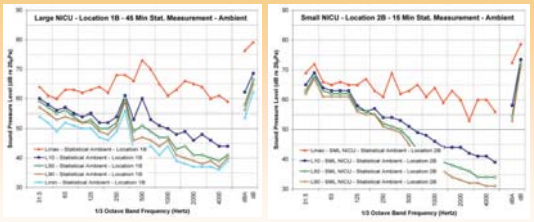
7. Implementation

- 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

8. Demolition & Construction Expansion Plan* & Measurements



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

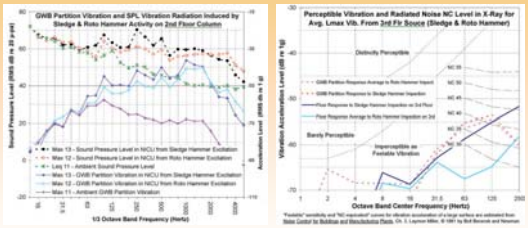


Large NICU 45 Min. Ln Small NICU 15 Min. Ln

10a. Simulated Demolition Noise & Vibration Measurement Sources

10b. Simulated Demolition Noise & Vibration Measurement Locations

11. Simulated Demolition Impact & Vibration Measurement Results

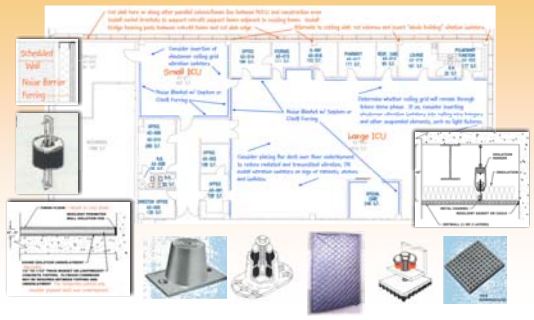


Sound & Vibration Tool Spectra Radiated Sound Due to Vibration

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

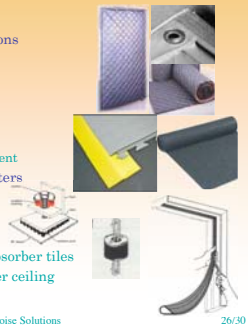
12. Demolition & Construction Noise Control Plan Illustration



12a. Demolition & Construction Noise Control Recommendations

Architectural

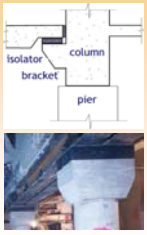
- 1. Temporary sound barrier at partitions
  - a. Blanket w/ barrier septum
  - b. Mass-loaded vinyl sheet
  - c. Drywall on furring studs
- 2. Modify Floor:
  - a. Rubber floor surface
  - b. Floor deck over resilient underlayment
- 3. Vibration isolate isolette legs, counters
- 4. Door seals
- 5. Modify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



12b. Demolition & Construction Noise Control Recommendations

Structural (major cost & complexity)

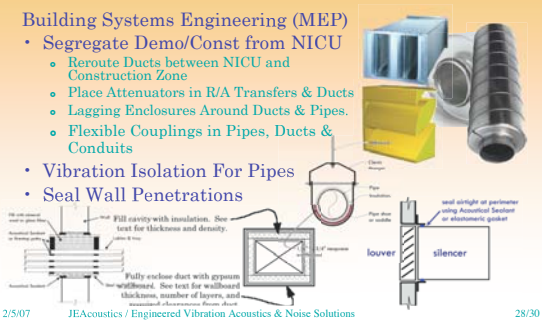
- Isolate the NICU slab from demo
  - Cut the slab along a column line
  - Support the slab edge along the cut line.
    - Secondary Columns and beams
    - Isolation pads between corbel support and beam.
- Insert "whole building" vibration isolators
  - Vertical vibration transmission from above or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



12c. Demolition & Construction Noise Control Recommendations

Building Systems Engineering (MEP)

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



Summary

- Sensitive spaces temporary relocation
- Scheduling of demolition and construction sequences.
  - Individual impact noise events may be tolerated,
  - Continuous or repetitive events may sensitize occupants
- Multiple simultaneous impact events are additive
  - Slightly louder
  - 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

Acknowledgements

- Moe Stein, FAIA, HKS / SCG Architects, Phoenix, AZ
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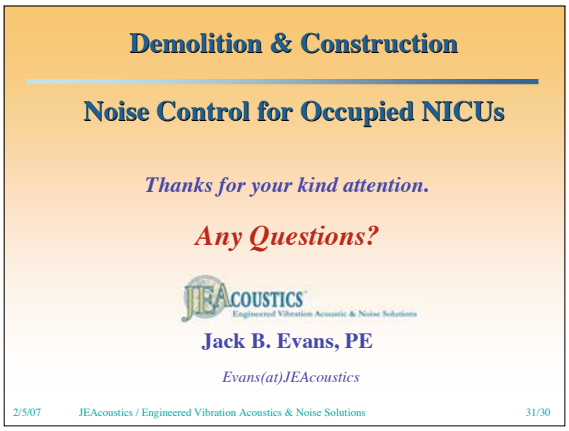
- Phoenix Children's Hospital, Phoenix, AZ
- Mark Vaughan, AIA, WHR Architects, Houston, TX
- Woodlands Memorial-Hermann Hospital
- Kathleen Philbin, PhD, re: J. Perinatology papers 2000 & 2006

Help Finding an Acoustical Consultant
National Council of Acoustical Consultants
(www.NCAC.com)

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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