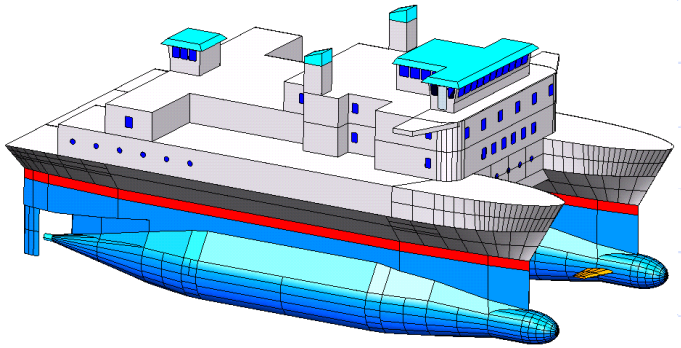
UNDERWATER NOISE:
For New Research Vessels



Michael Bahtiarian

Vice President,
Noise Control Engineering, Inc.
Billerica, Massachusetts

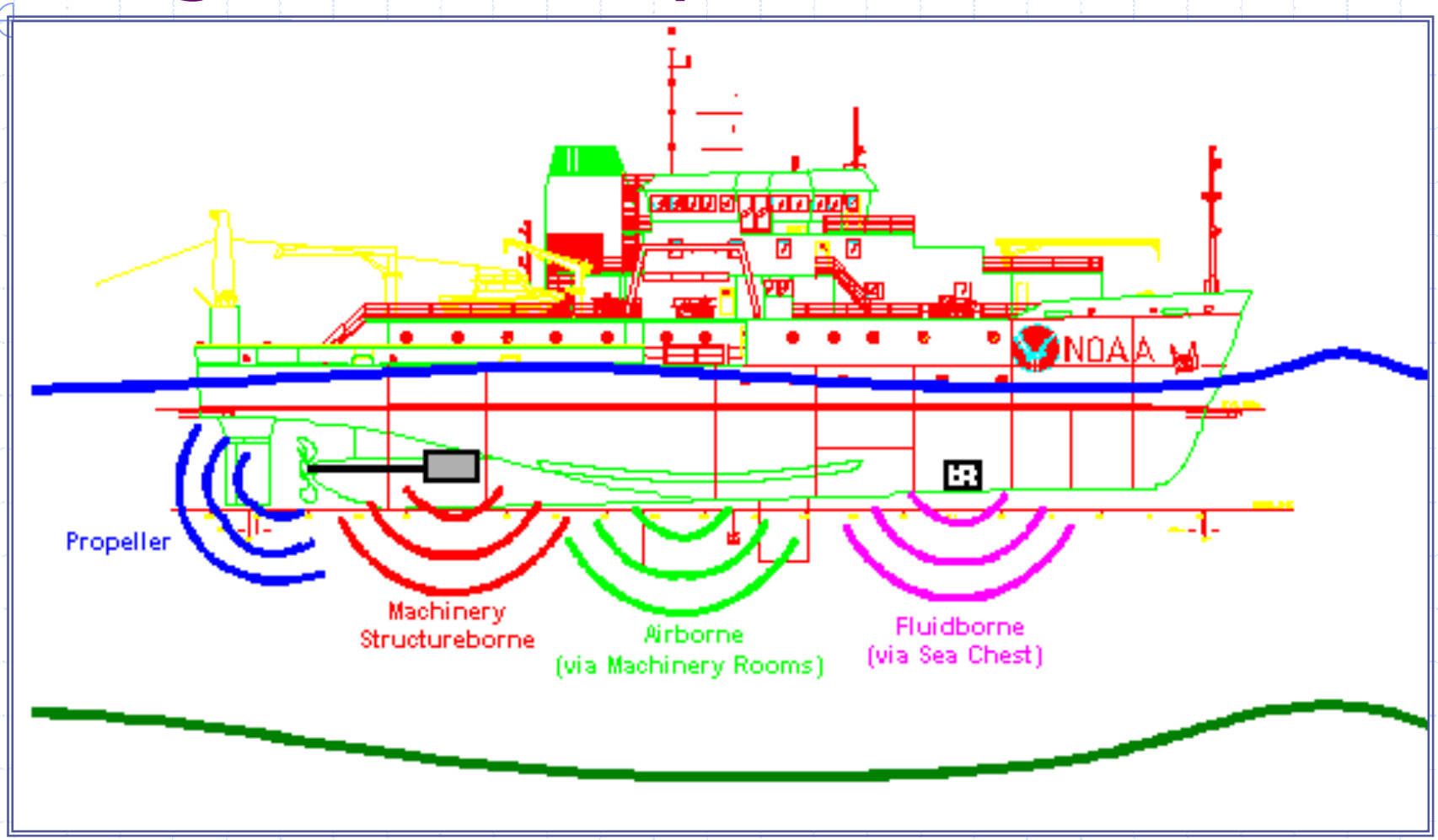
Presented to UNOLS Fleet Improvement Committee
March 8, 2011

R/V NOISE SOURCES

(in order of importance)

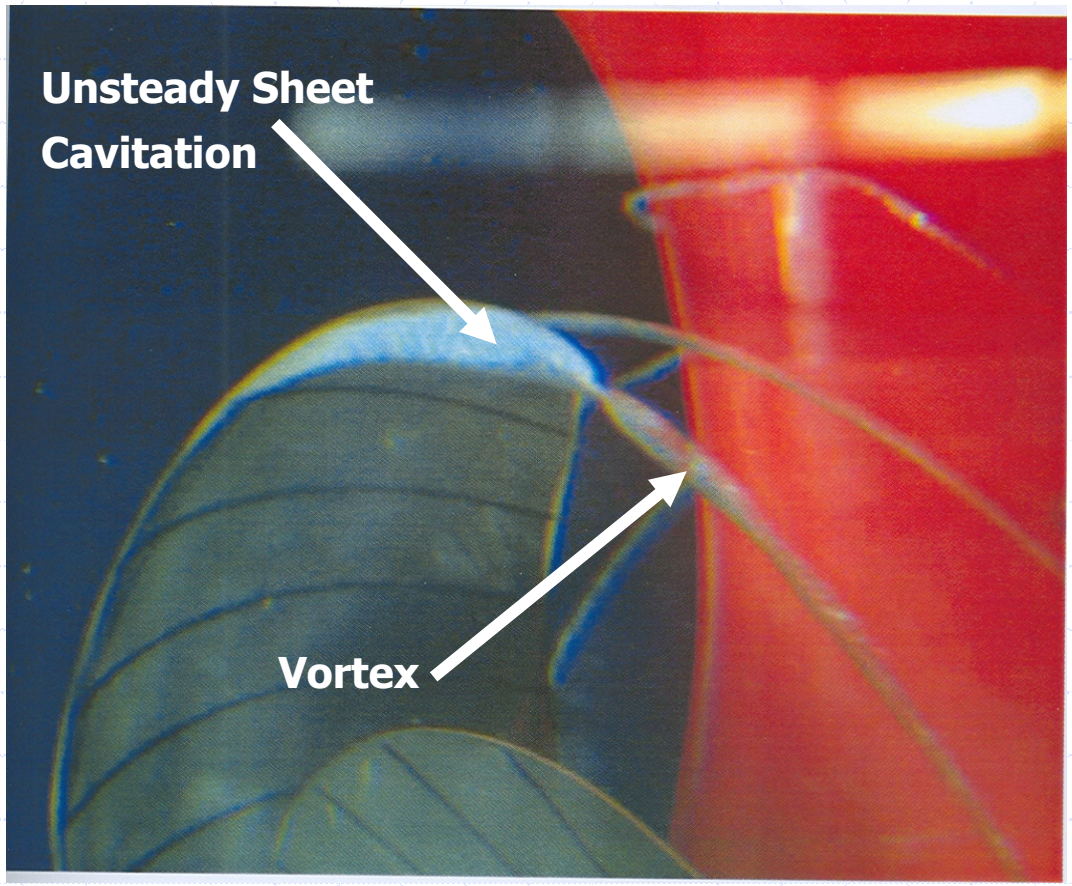
- Propeller
  - Cavitation
  - Bow Thrusters
- Machinery Noise
  - Propulsion Diesels or Motors
  - Diesel Generators
  - Large Reciprocating Machinery, Air Compressors
  - Hydraulic Power Units (HPU's)
- Sea Connected Systems
  - Main Seawater Cooling
  - Auxiliary Seawater Cooling
- HVAC Systems (mostly airborne noise)

Diagram of Ship Noise Sources



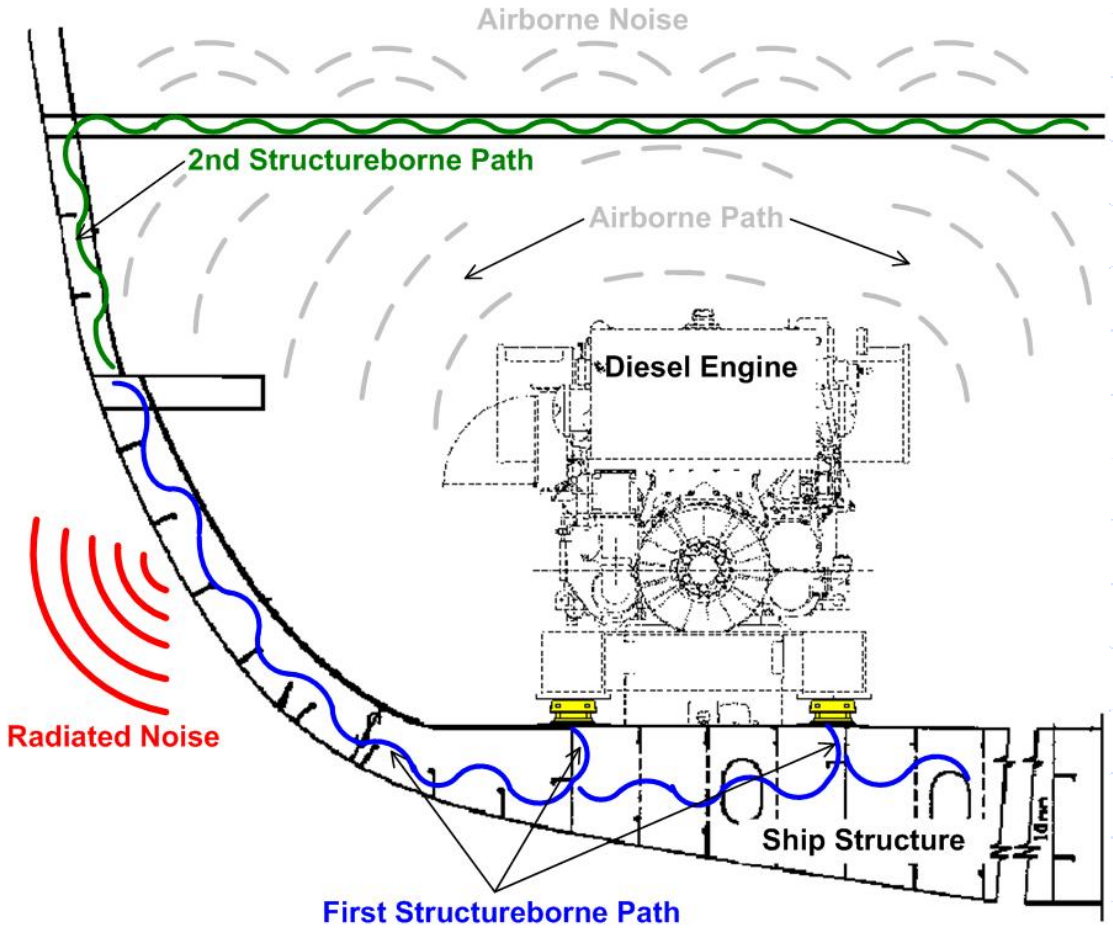
Propeller Noise – Cavitation…

… is the vaporization of water due to a decrease of the local pressure. This generates millions of very small vapor bubbles whose collapse generates significant underwater noise.



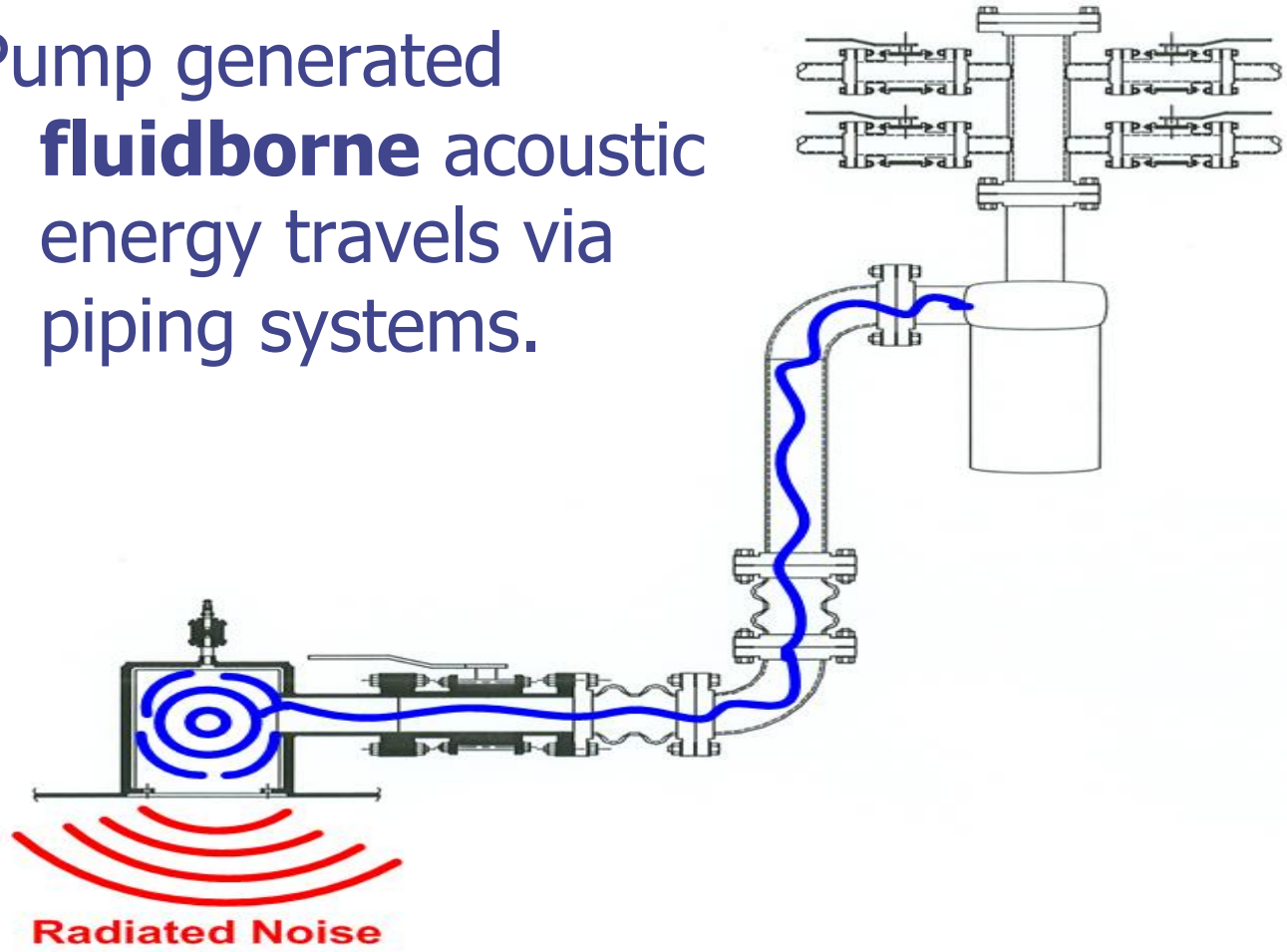
Paths for Machinery Noise

- Airborne
- First Structureborne
- Secondary Structureborne
- **U/W Radiated Noise**



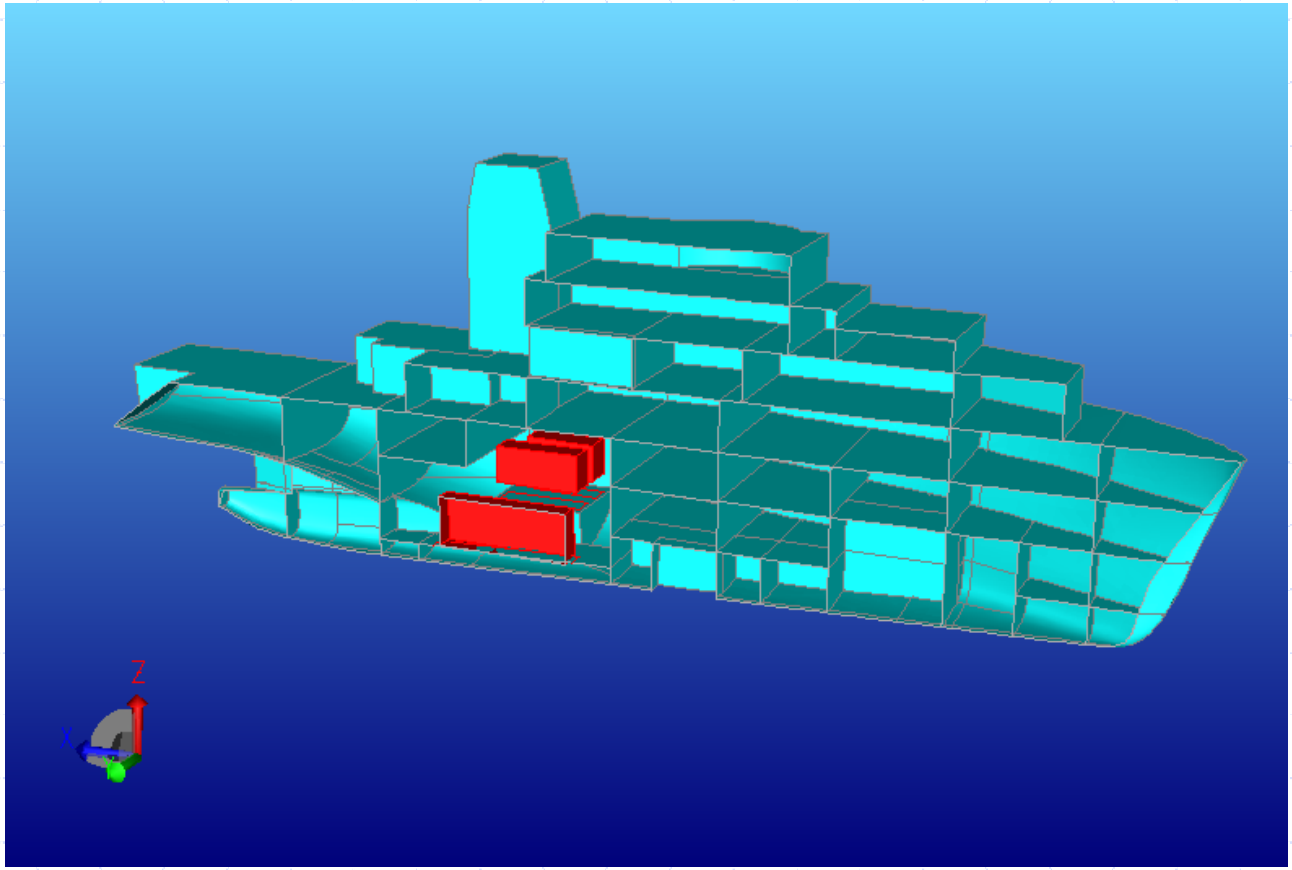
Sea Connected Systems – FluidBorne Noise

Pump generated **fluidborne** acoustic energy travels via piping systems.



Designer-NOISE™
Noise Prediction Software

- Algorithms Developed by NCE
- Computes A-Weighted & octave band sound for entire ship.
- NCE uses for UW noise with special transfer function.



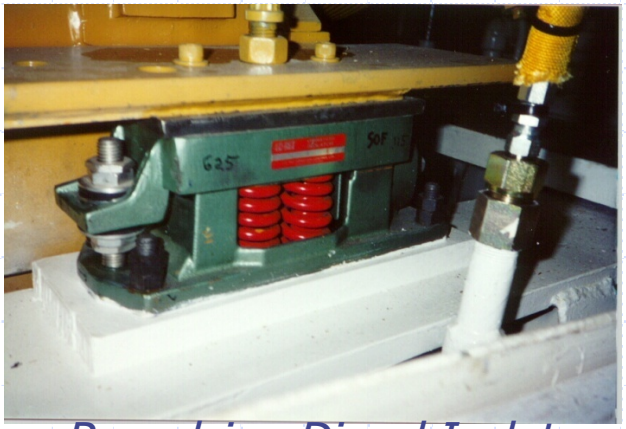
UW NOISE REDUCTION MEASURES

- Machinery Vibration Isolation
- Hull Structural Damping
- Airborne Noise Insulation
- Avoid Sound Shorts
- Use Quiet Machinery

Machinery Vibration Isolation

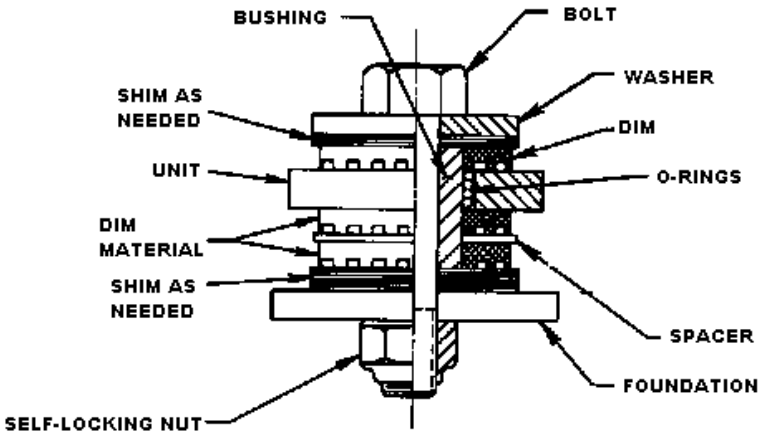
- Reduces vibration transmitted to hull.
- Should be used on:
  - Main Propulsion Engines
  - Diesel Generators
  - Air Compressors
  - All Reciprocating Machinery
  - Pumps > 5 hp

Genset Isolator



Propulsion Diesel Isolator

DIM Mounting



DIM MOUNT WITH DOUBLE SUPPORT PAD

Damping Tiles

- Reduces vibration within structure it is attached to.
- Began with use on Submarines.
- Use on hull and foundations of major machinery.

Acoustic Insulation

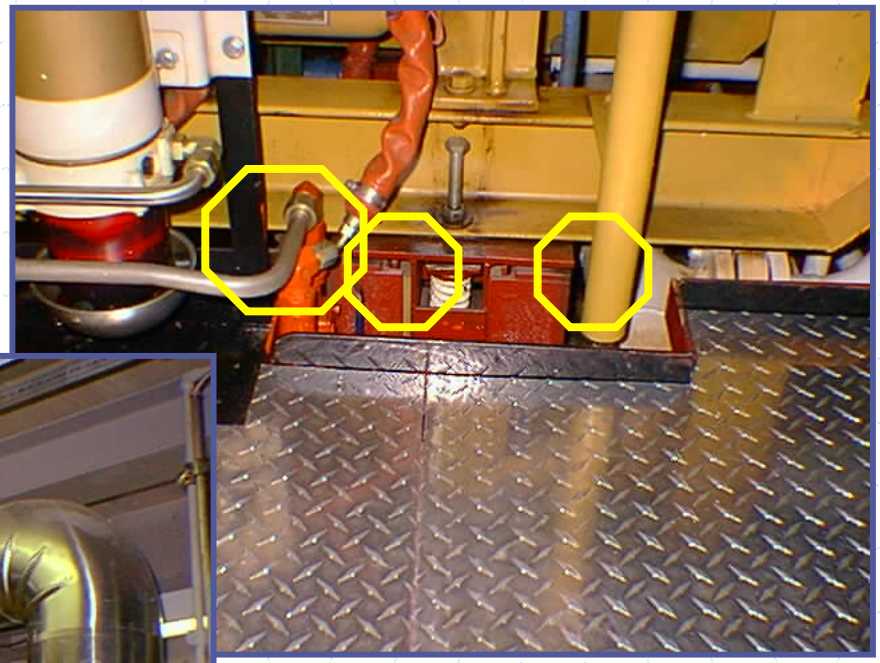
- Generally Consists of Fiberglass/Lead/Fiberglass w/ total thickness of 2 - 6”.
- Reduces airborne noise excitation of hull.
- Primary noise control treatment on most ships.
- Use on foundations and “wetted” ship structure.
- Lead mostly Barium loaded Sulfate.

Opening in Insulation during Construction.

Treatment Effectiveness

Treatment	AB	FSB	SSB
Vibration Isolation	0	10-20	0
Acoustic Insulation	5-10	0	0
Acoustic Absorption	3-5	3-5	3-5
Floating Floors/Rooms	10	10	10
Damping	0	5-10	5-10
Bow Thruster Treatments	10	10	10
HVAC Treatments	5	0	0
Misc. Treatments	3-5	3-5	3-5

Sound Shorts – Big Problem



CASE STUDIES

FRV OSCAR DYSON

R/V HUGH R. SHARP

FRV OSCAR DYSON

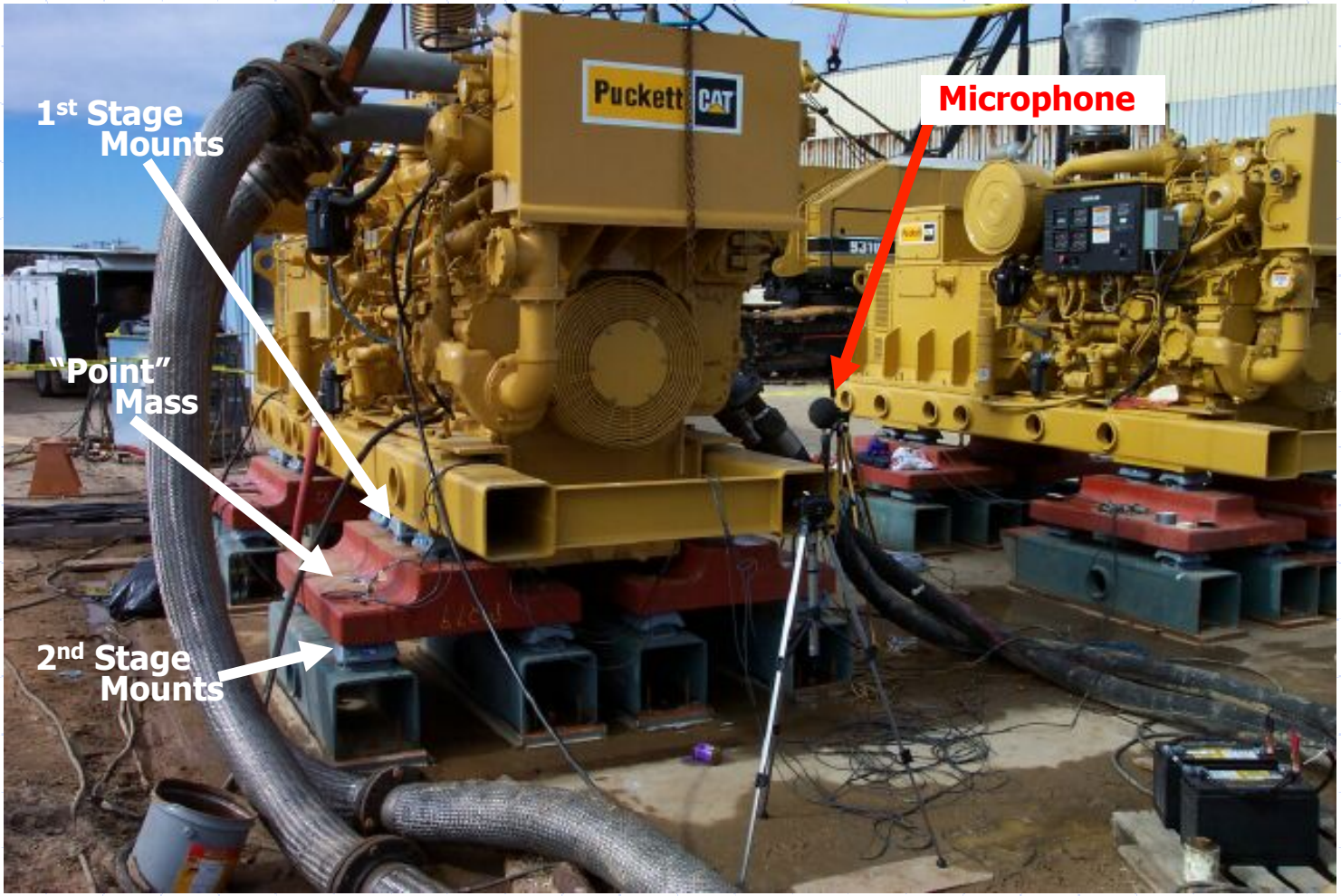
National Oceanic and Atmospheric Administration

FRV-40 – Design Features

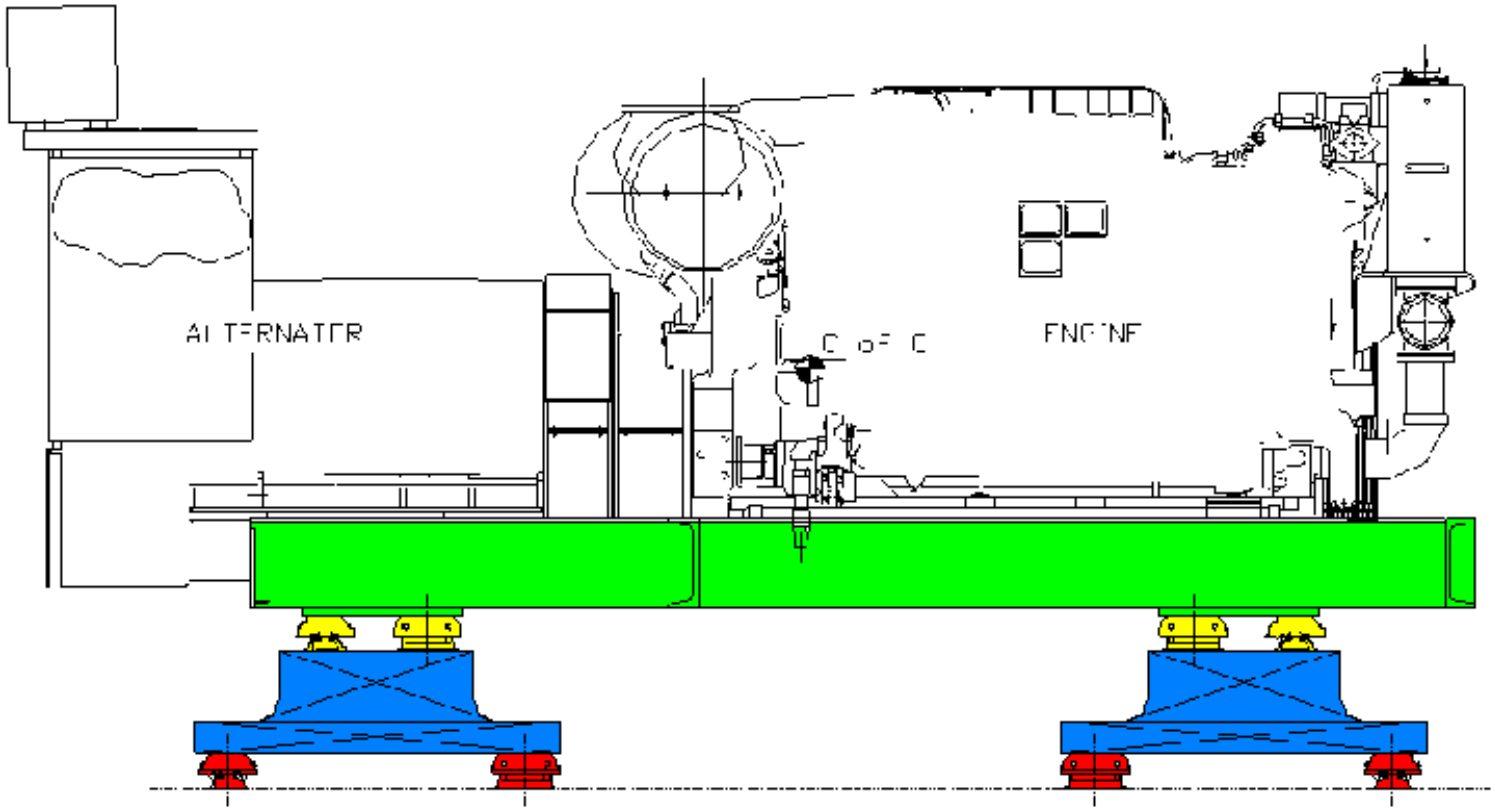
- Desinged to meet ICES Limit at 11 knots!
- Navy designed Hull/Propeller
- Diesel Electric Plant
- Double Isolated Diesel Generators
- Hard Mounted Tandem ASIR DC Motors
- Isolated Auxiliary Machinery & Piping
- Retractable Transducer Pod
- Extensive component and shipboard testing program.

FRV-40 – Hull & Propeller

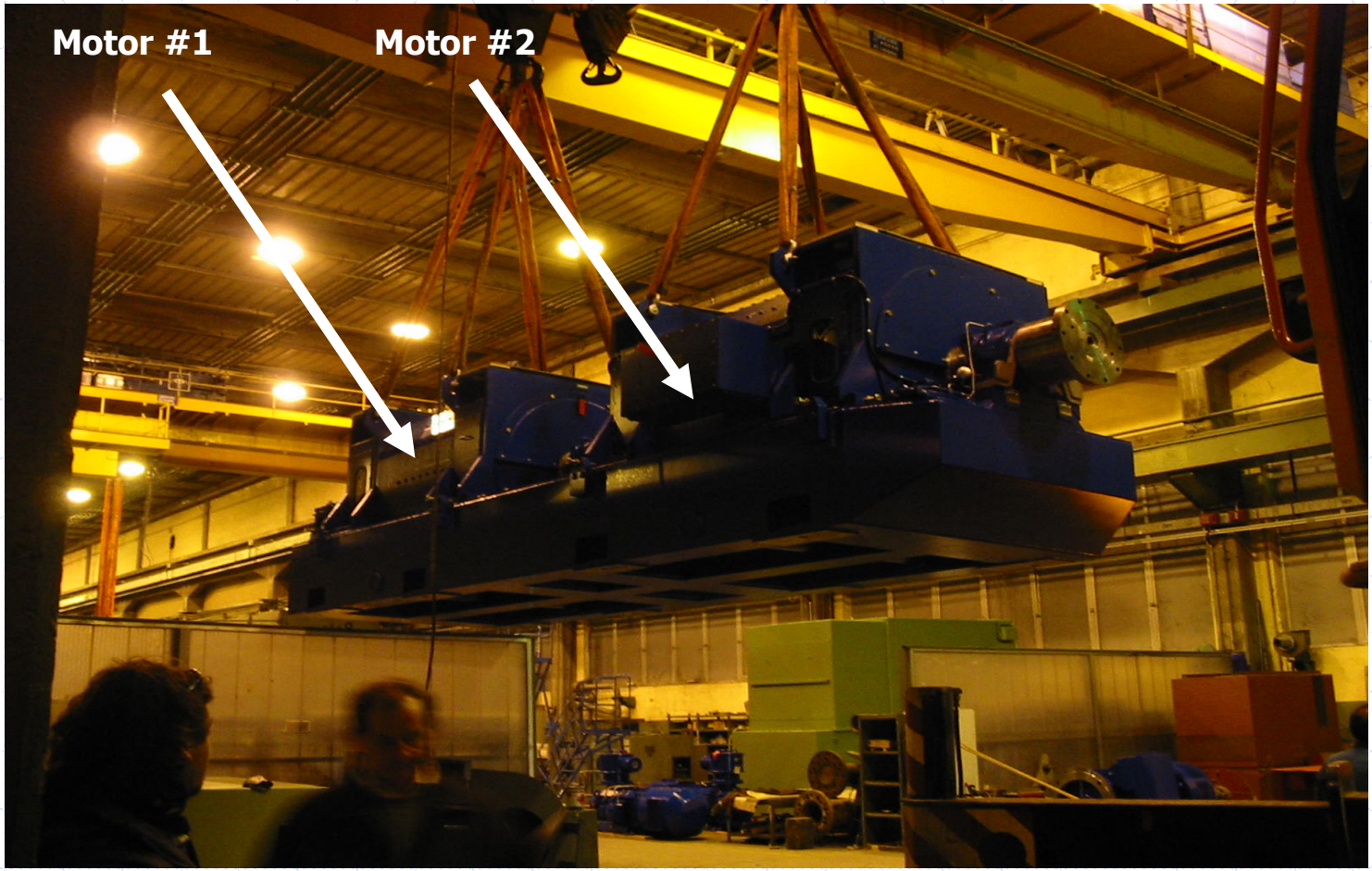
FRV-40 – Genset Isolation



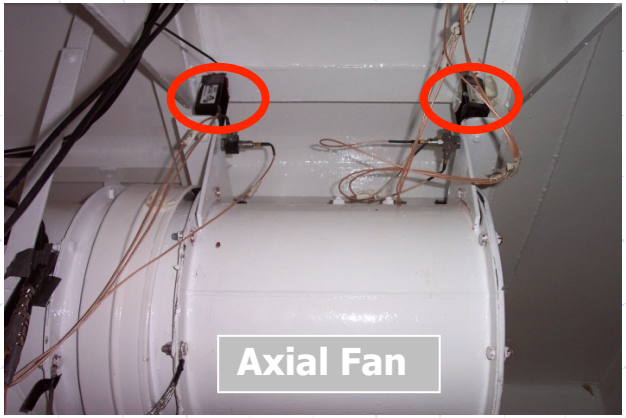
Genset Compound Mounting (NOAA FRV-40)

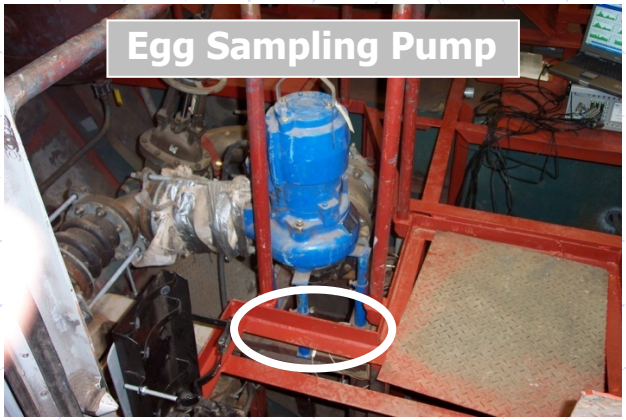


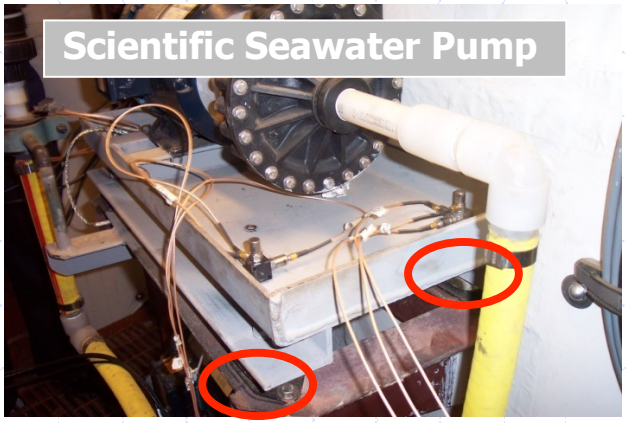
FRV-40 – Propulsion Motor



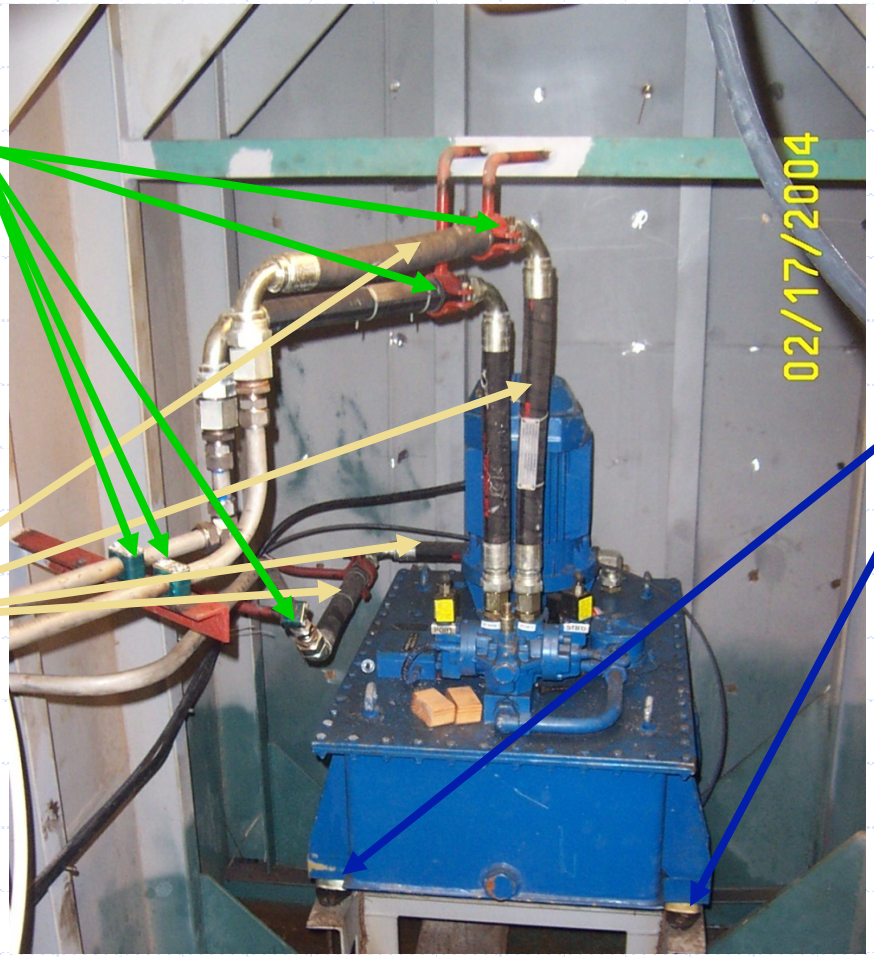
FRV-40 – Isolated Auxiliaries







FRV-40 – Typical Isolation System



FRV-40 – Required Testing

- Machinery Vibration in Factory
- Machinery Noise in Factory
- Machinery Vibration in Ship
- Airborne Noise in all Ship Spaces
- Structural Vibration in Ship (wide)
- Sonar Self Noise
- Underwater Radiated Noise

FRV-40 – Required Testing

R/V HUGH R. SHARP

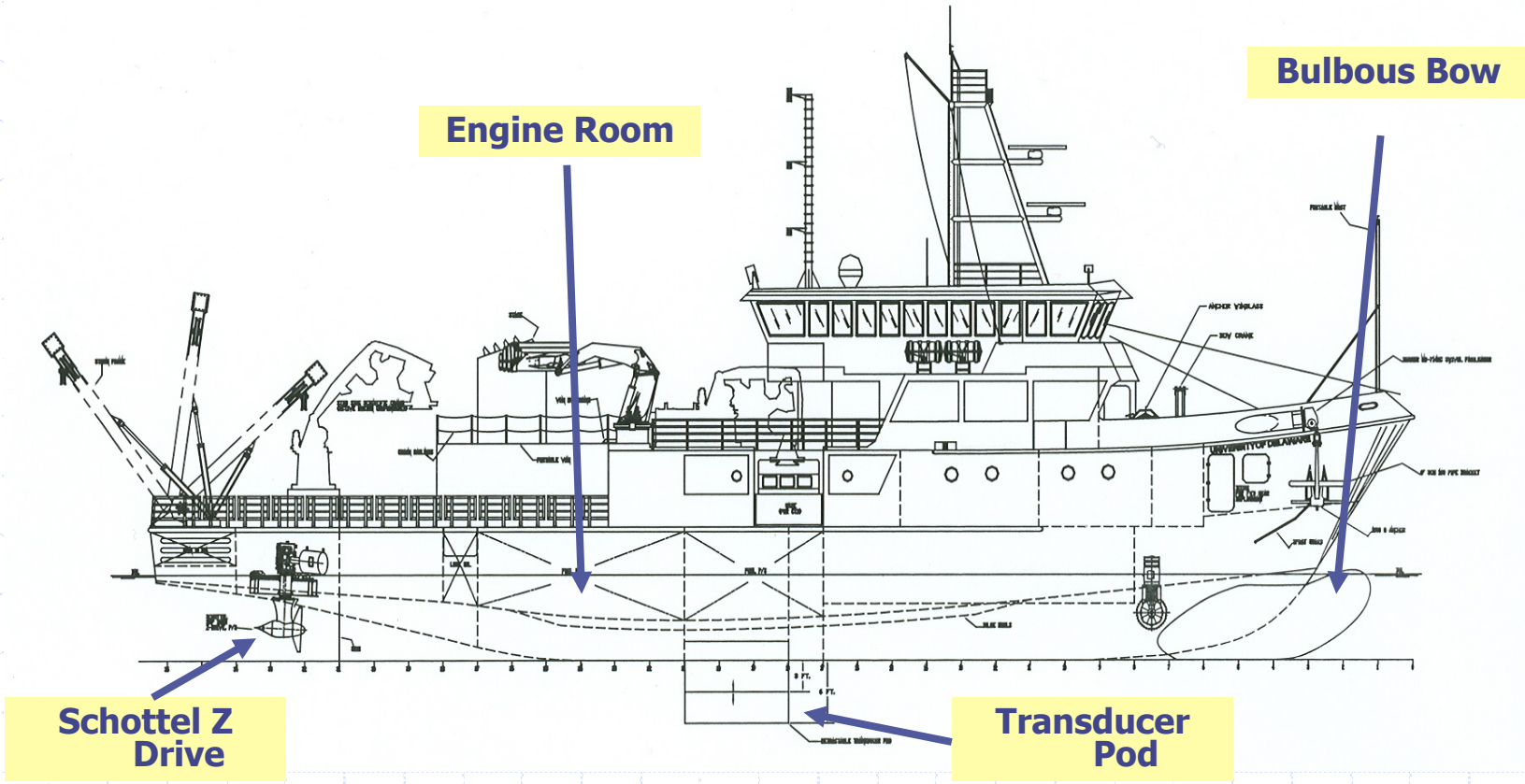
University of Delaware

OWNER: Univ. of Delaware, College of Marine Sciences
MISSION: General Research
BUILDER: Dakota Creek, Industries (Anacortes, WA)
DESIGNER: Bay Marine, Inc. (Barrington, RI)
DELIEVERY: January 2006

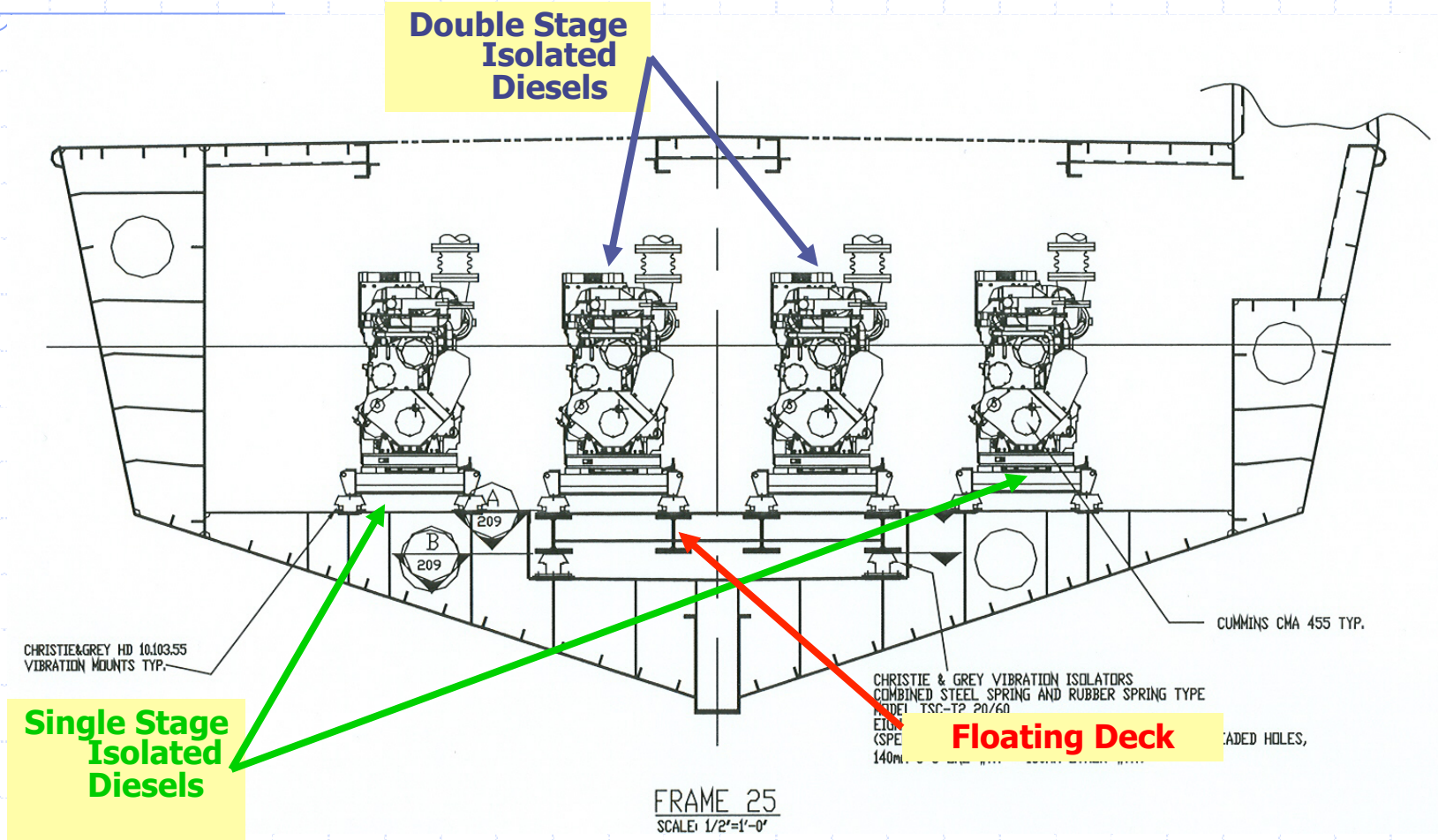
R/V SHARP – Design Features

- Designed to meet ICES Limit at 8 knots
- Diesel Electric Plant
- Double Isolated Diesel Generators
- Isolated ASIR DC Motors
- Isolated Schottel Z-Drives
- Isolated Auxiliary Machinery
- Retractable Transducer Pod

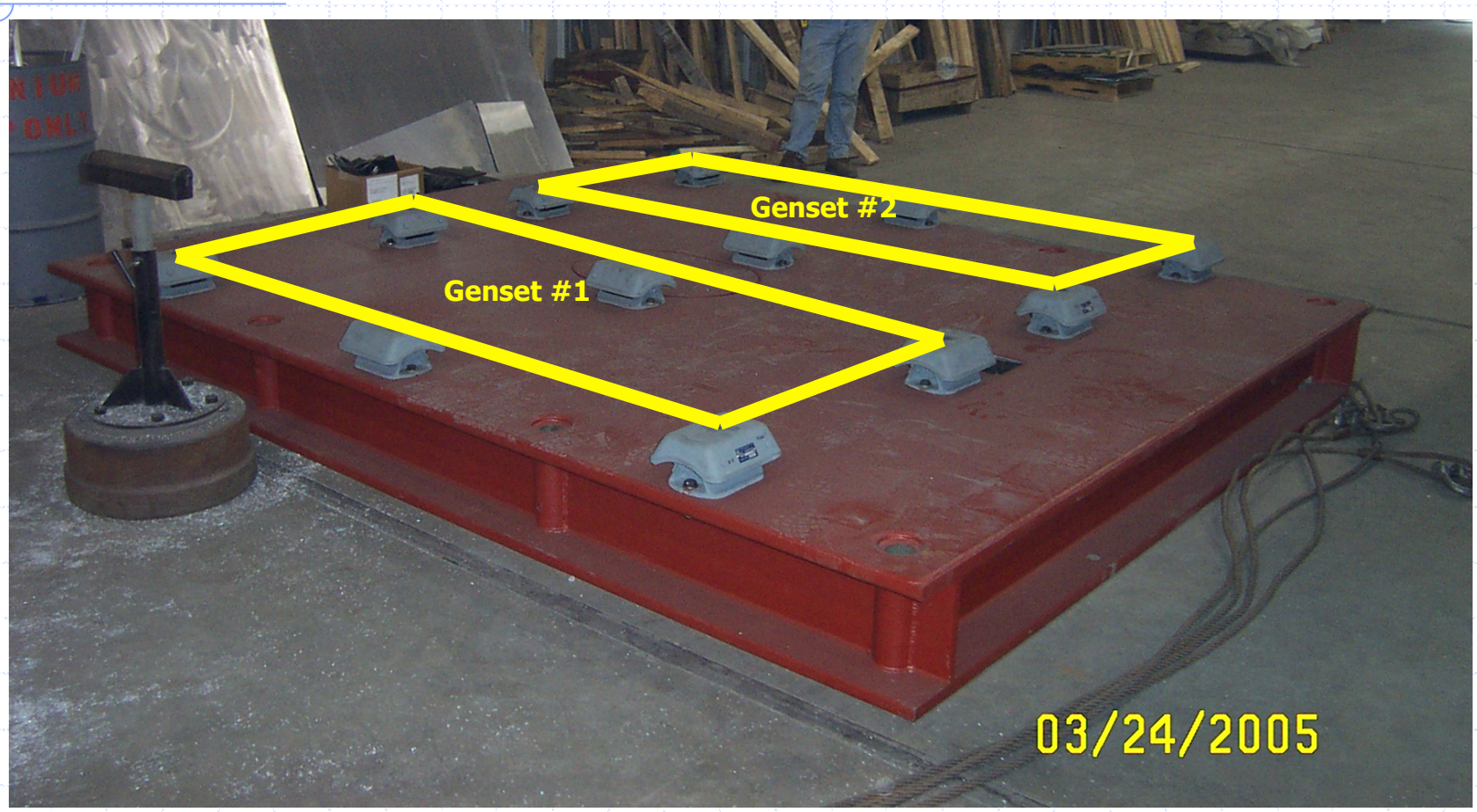
R/V SHARP - Profile



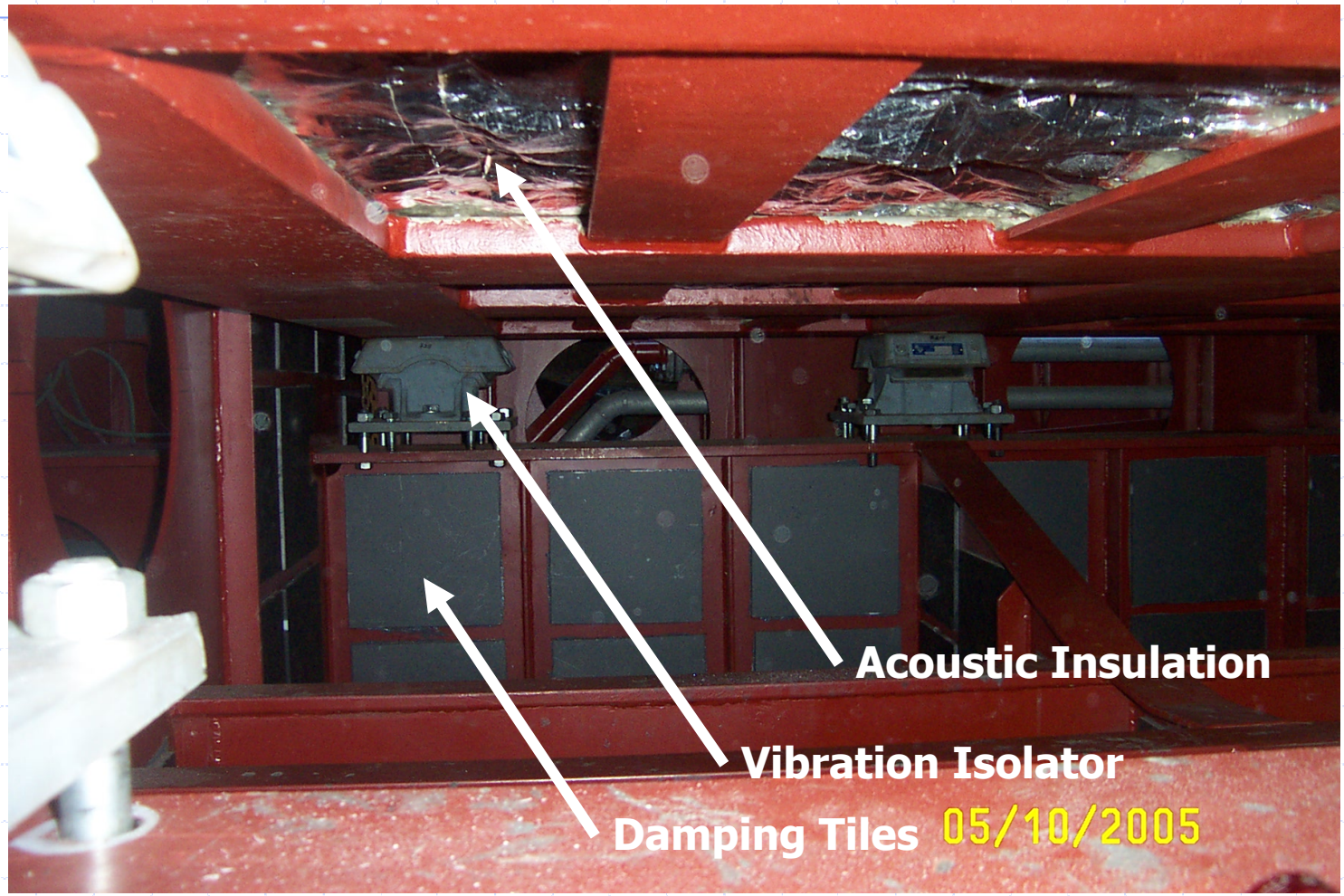
R/V SHARP – Floating Deck Diagram



R/V SHARP – Floating Deck During Construction



R/V SHARP – Floating Deck
How Many Treatments Here?

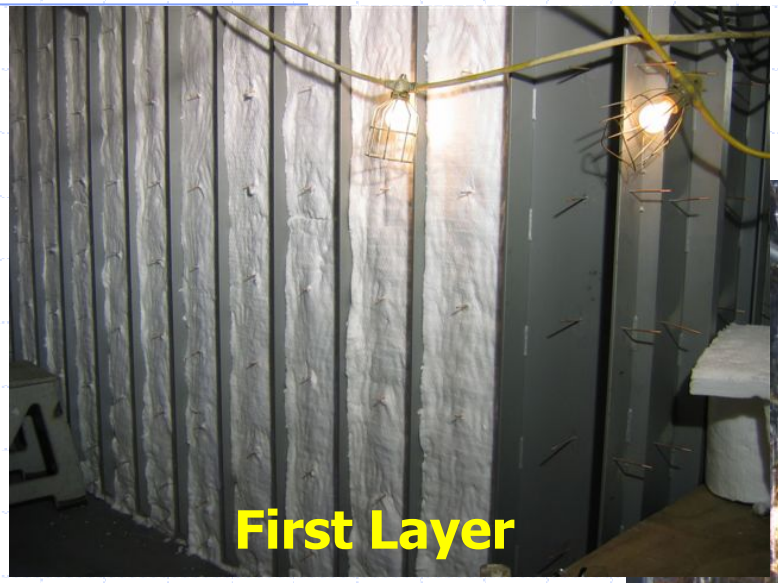


R/V SHARP – Floating Deck
Very Close 2 Stages of Isolation

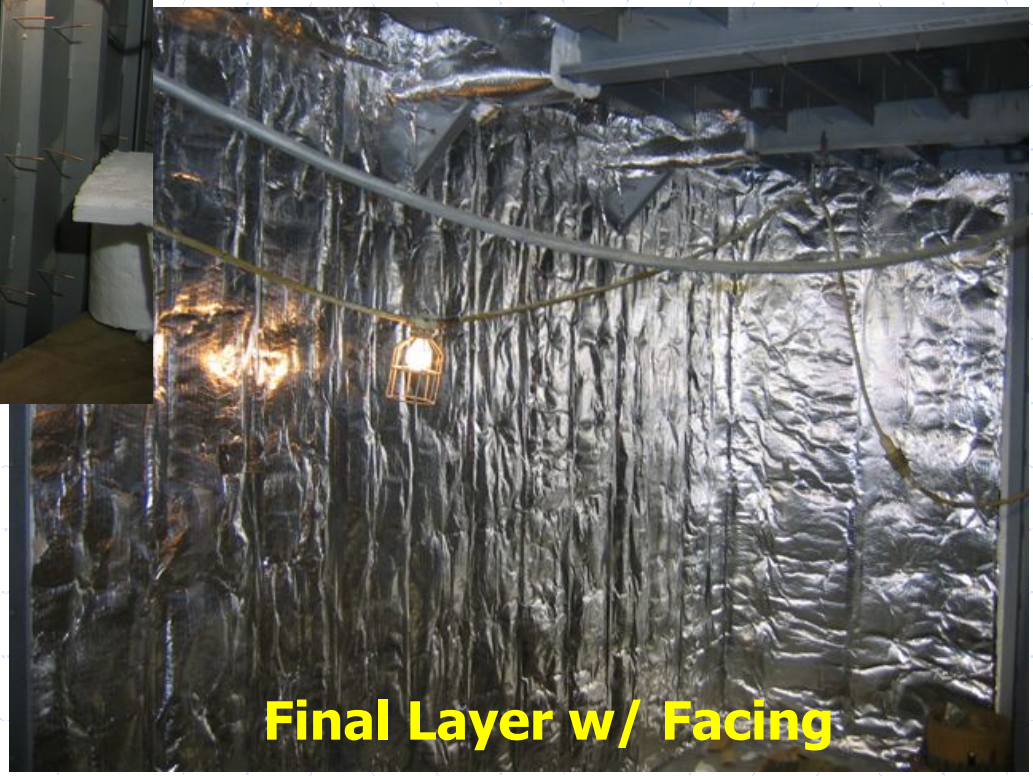
R/V SHARP – Floating Deck Close-Up Vibration Isolator

R/V SHARP – Damping Tiles

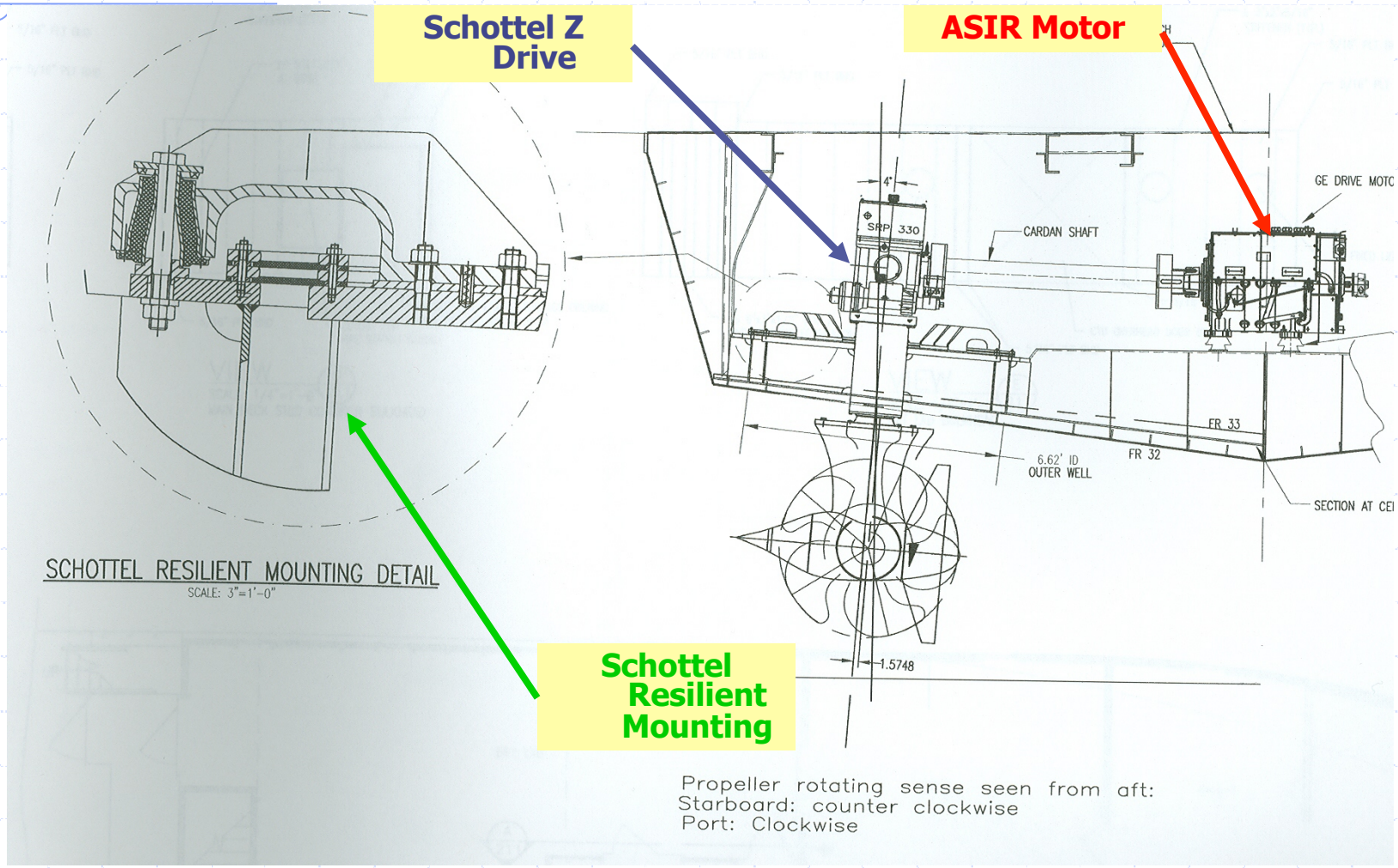
R/V SHARP – & Insulation



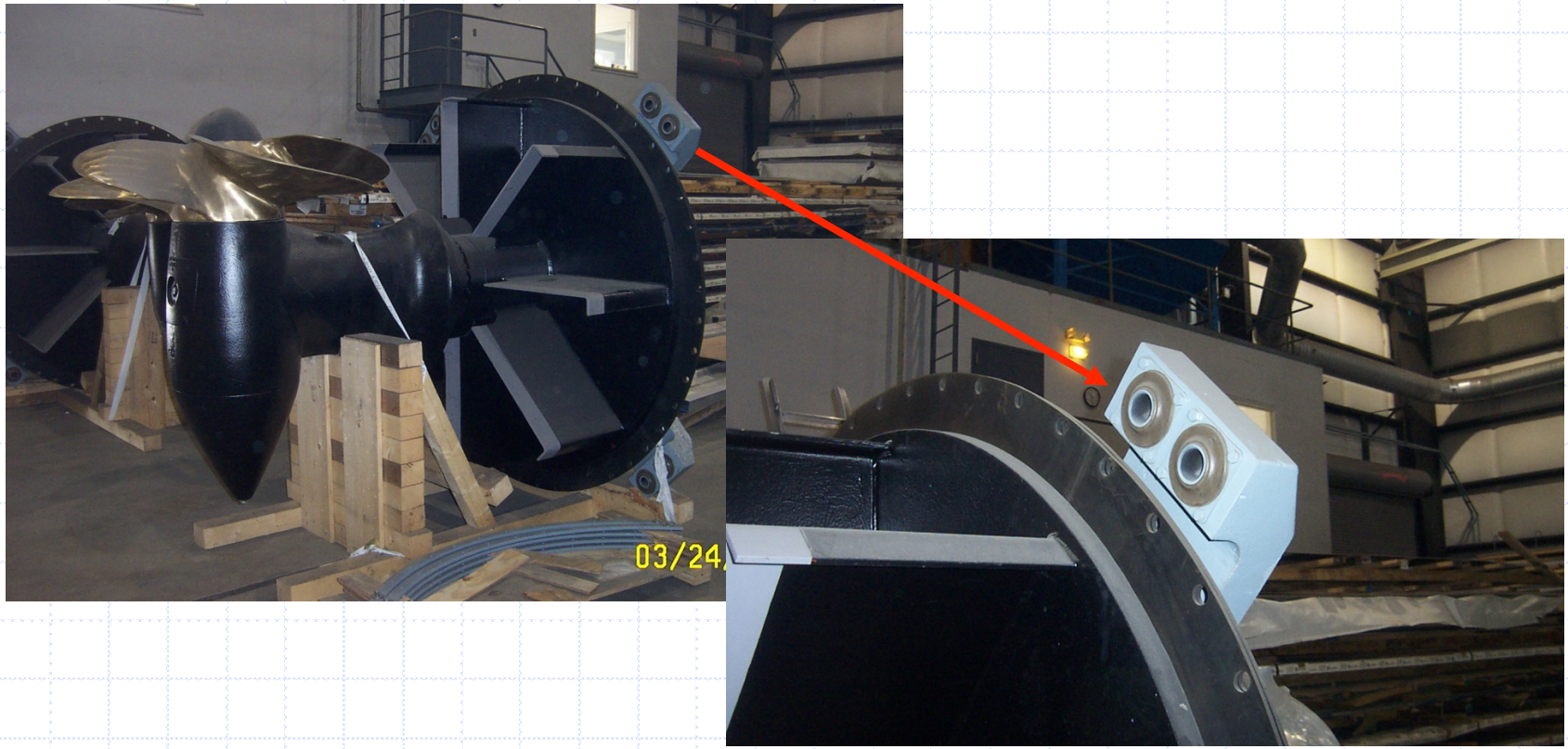
Acoustic Insulation is three layers of 4 lbs/ cu ft ceramic fiber, specially selected for low frequency transmission loss.



R/V SHARP – Isolated Z-Drive

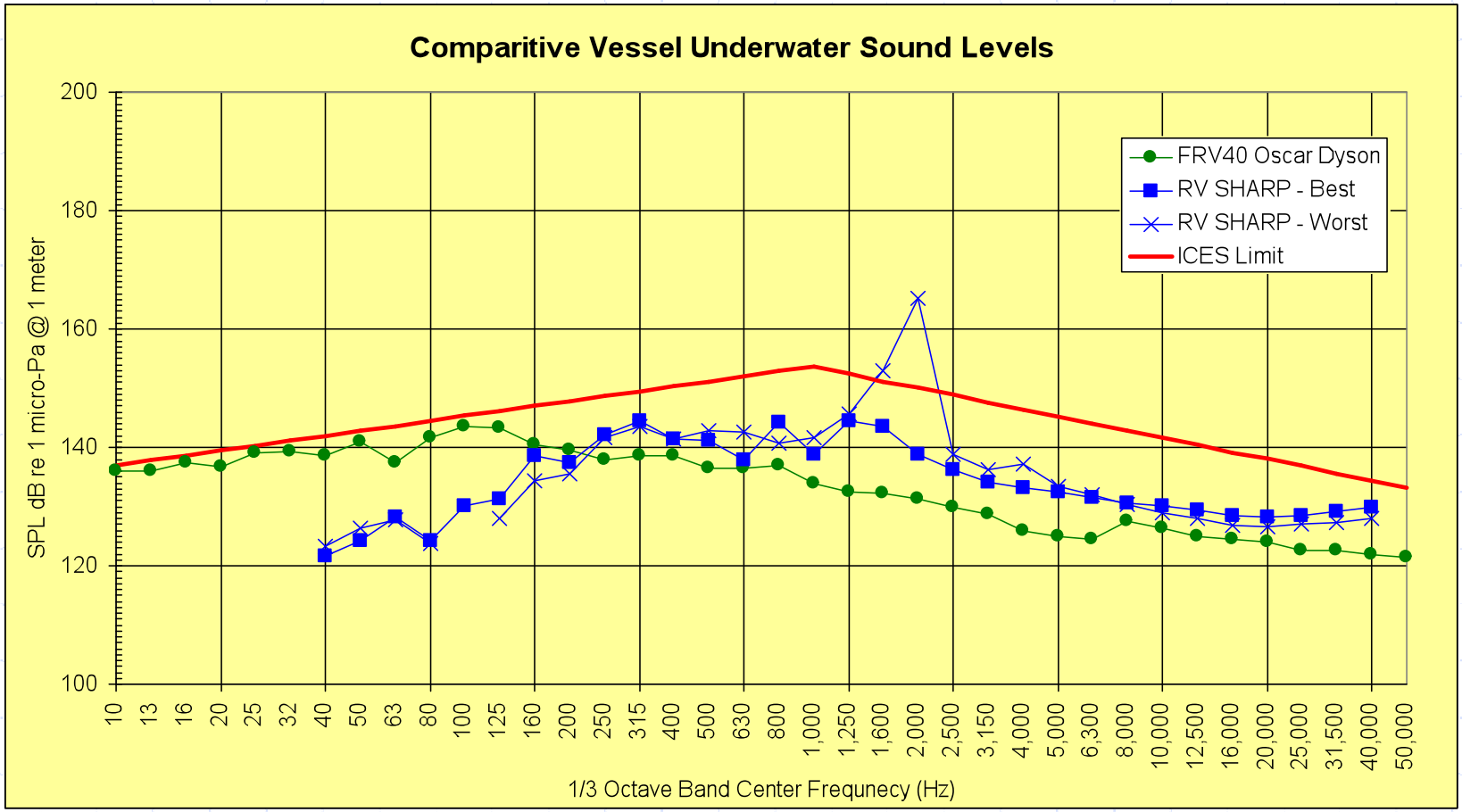


R/V SHARP – Isolated Z-Drive

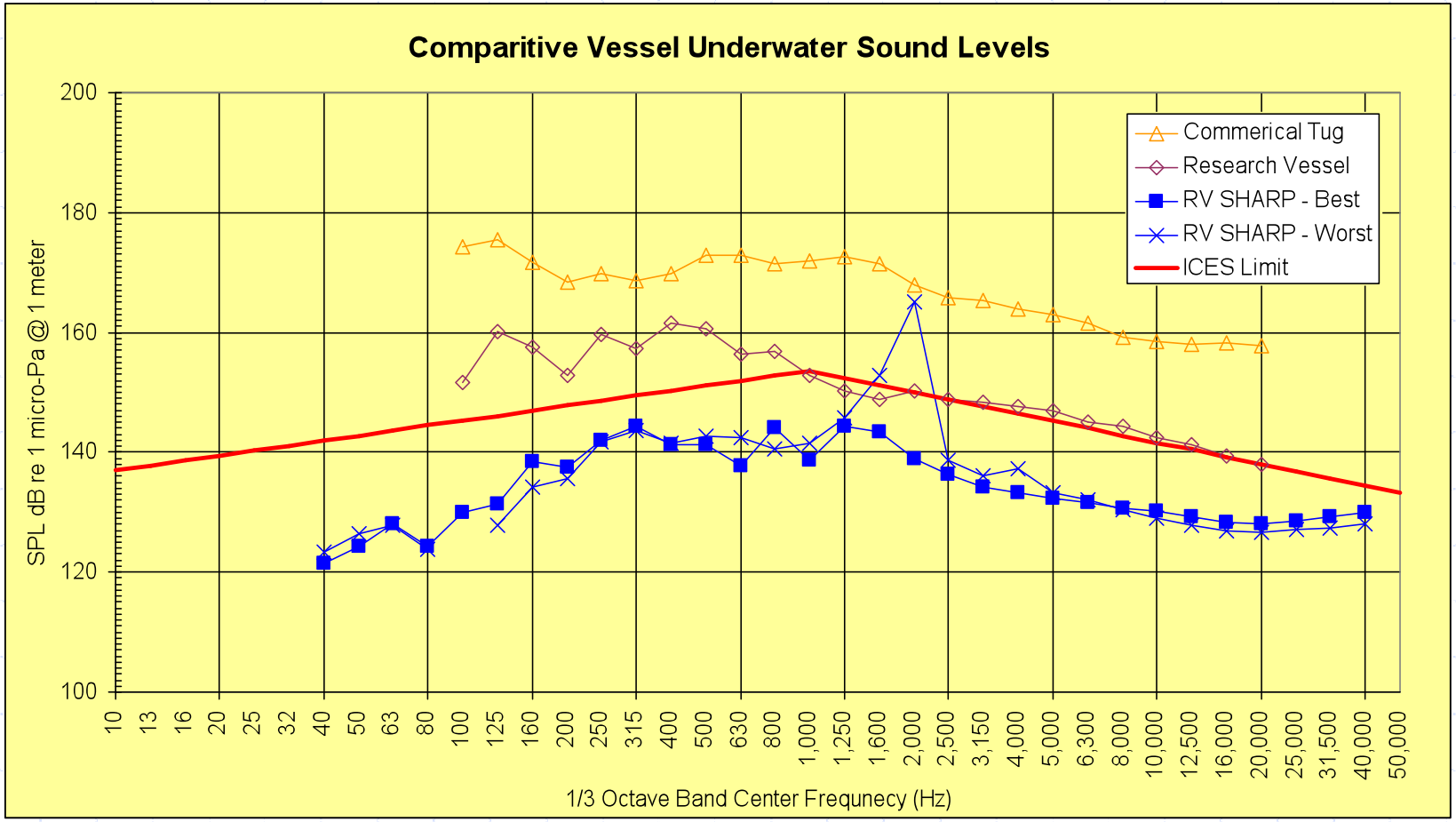


R/V SHARP – Isolated Z-Drive As Installed on the Ship

MEASURED RESULTS:
R/V SHARP vs. NOAA FRV-40



MEASURED RESULTS:
Other Vessels



Conclusions – Acknowledgements

- UW Noise can be predicted and measured using commercial methods.
- Vessels can be quieted to low levels (ICES) using COTS materials and machinery.
- NCE Acknowledges our clients:
  - VT Halter Marine (& NOAA)
  - University of Delaware
- Author Contact Info
  - mikeb@noise-control.com
  - 978-670-5339, x21