



Propeller Injury Avoidance Issues Meeting

Miami, FL – Miami International Boat Show - 2007
February 16, 2007

Minutes

Sponsored by:

United States Coast Guard
Office of Boating Safety
Recreational Boating Product Assurance Division

Minutes prepared by:

American Boat & Yacht Council, Inc. (ABYC)
613 Third Street, Suite 10
Annapolis, MD 21403
www.abycinc.org

ABYC[®]
Setting Standards for Safer Boating

Moderator Richard Blackman called the meeting to order at 1 PM EST.

Appendix A includes all in attendance.

Appendix B includes copies of the available presentations.

Carbon Monoxide Injury Avoidance Update:

Alberto Garcia, NIOSH began the meeting with a presentation describing the houseboat low CO generator testing as well as the ski boat testing on a boat equipped with an Indmar catalyzed engine. The presentation is attached as Appendix B.

Catalyzed generators were showing CO concentrations of 3-9 parts per million approx 4 minutes after start-up.

The ski boat tested showed approx 12,000 ppm at start and within 60 seconds ranging from 800-900 ppm. After 120 seconds there is almost a 94% reduction in CO emissions.

It's important to note that performance between catalyzed and non-catalyzed engines was not affected.

Propeller Injury Avoidance Update:

Dick Blackman discussed the new USCG propeller guard brochure which is in its second printing. Mr. Blackman had provided several hundred copies for distribution at the meeting. The brochure is found at www.uscgboating.org

Mr. Blackman then discussed the progress on the propeller guard test protocol that the USCG is currently conducting. The group of experts had met again in Boston in January to review the protocol and set a timeline for this summer. The protocol testing will continue this summer with more guards (number and brand to be determined by availability) and more boats in the 16 to 26 foot range. The USCG realizes that there will never be a one size fits all solution for this issue.

Mr. Blackman directed the audience to the USCG website (www.uscgboating.org) where a recently completed grant that catalogs currently marketed propeller guards exists. Mr. Blackman made a note that the grantee was not responsible for verification of product from those companies listed.

The USCG is working on a propeller safety information package for rental pontoon boats under direction from the Boating Safety Advisory Council.

Those attended asked the following questions:

When will the Notice of Proposed Rulemaking (NPRM) come out for engine cut-off lanyards? It is in the working stages as we speak.

Will the rental package be required? Will the rental package be presented to the whole group renting? Both these issues will be looked at by the contractors doing the follow up work.

Are any of these guards available for testing? We do not know yet, we will be contacting the manufacturers to ask them to provide product for use in the upcoming testing.

There is an absence of propeller information in the NASBLA approved courses, is there any way to add information? This is an issue that needs to be taken up with NASBLA (www.nasbla.org)

**Appendix A – USCG PROP Follow-up Meeting –
Contact List**

Mr. John Adey
ABYC
613 Third Street, Suite 10
Annapolis, MD 21403
jadey@abycinc.org

Mr. Kevin Bedsworth
Engineering Systems, Inc
9990 SW 77th Ave
Miami, FL 33156
kdbedsworth@ESI-FL.com

Mr. Peter Bryson
Onan
Peter.bryson@cummins.com

Mr. Bob Carttar
S2 Yachts (Pursuit Boats)
3901 St. Lucie Blvd.
Fort Pierce, FL 34946
bcarttar@pursuitboats.com

Mr. Pete Chisholm
Mercury Marine
P.O. Box 1939
Fond Du Lac, WI 54936-1939
Pete_chisholm@mercmarine.com

Mr. Mat Dillon
PPG
4100 Halaga Ave
Coconut Grove, FL 33133
msdillon@earthlink.net

Mr. Alberto Garcia
National Institute for Occupational Safety
and Health (NIOSH)
4676 Columbia Parkway MS-R5
Cincinnati, OH 45241
agarcial@cdc.gov

Mr. Rick Gipe
USCG
2100 2nd. St, SW
Washington, DC 20593
David.r.gipe@uscg.mil

Mr. Ron Hall
NIOSH
DART,EPHB (MS-R5)
4676 Columbia Parkway
Cincinnati, OH 45226
RMH2@cdc.gov

Mr. Matt Harvey
Forever Resorts/FCM
9801 S. Grant
Muncie, IN 47302
mharvey@fcmboats.com

Mr. Charles Hawley
West Marine
500 Westridge Dr
Watsonville, CA 95076
chuckh@westmarine.com

Mr. Uli Heinemann
IMCI
Rue Abbe Cuypers 3
B-1040 Brussels
Ulrich.heinemann@imci.org

Mr. Doug Kitts
Brunswick Boat Group
800 S Gay St. Suite 1700
Knoxville, TN 37929
Doug.kitts@brunswickboatgroup.com

Mr. Jim Krystosek
Enviroprop Corp
100 Central Ave E Suite 100
St. Michael, MN 55376
Jim.krystosek@gmail.com

Ms. Marcia Kull
Volvo Penta of the Americas, Inc.
1300 Volvo Penta Drive
Chesapeake, VA 23320
Marcia.kull@volvo.com

Mr. Nigel Lamb
Twin Anchors Houseboats
675 Old Town Road
PO Box 318
Sicamus, BC VOE 2VO
Canada
Nigel@twinanchors.com

Mr. Todd Lemke
Mercury Marine
6250 W. Pioneer Road
Fond Du Lac, WI 54936
Todd_lemke@mercmarine.com

Mr. Creig Mahty
GM
823 Joseph
Portal MI 44340
Creig.a.mahty@gm.com

Mr. Alex Marconi
Snell & Wilmer LLP
One Arizona Center
400 East Van Buren
Phoenix, AZ 85004-2202
amarconi@swlaw.com

Mr. Thomas Marhevko
NMMA
200 E. Randolph Drive
Suite 5100
Chicago, IL 60601
tmarhevko@nmma.org

Mr. David Marlow
Brunswick Boat Group
800 S. Gay St., Ste. 1700
Knoxville, TN 37929
Dave.marlow@brunswickboatgroup.com

Ms. Bernice McArdle
NMMA
200 E Randolph St, Suite 5100
Chicago, IL 60601
bmcardle@nmma.org

Mr. Ric McChesney
BRP
300 Seahorse Dr
Waukegan, IL 60085
Ric.mcchesney@brp.com

Mr. Timothy O'Connor
LEM Products, Inc.
4089 Landisville Road
Box 190
Doylestown, PA 18901
toconnor@lemproductsinc.com

Mr. Russ O'Daly
American Honda
1919 Torrance Blvd
Torrance, CA 90501
Russ.odaly@ahm.honda.com

Mr. Nik Parker
British Marine Federation
Marine House
Thorpe Lea Road
Egham TW20 8BF
United Kingdom
nparker@britishmarine.co.uk

Mr. Rich Ressler
GMPT
Richard.j.ressler@gm.com

Mr. Scott Rolseth
EnviroProp
100 Central Ave E, Ste 100
St. Michael, MN 55376
srolseth@gmail.com

Mr. Bruce Rowe
Forever Resorts, LLC
Forever Corporate Plaza
7501 E. McCormick Parkway
Scottsdale, AZ 85258
browe@foreverresorts.com

Ms. Cindy Squires
NMMA
444 N Capital St, NW, Ste 645
Washington, DC
csquires@nmma.org

Mr. Thomas Sutherland
Westerbeke Corp.
150 John Hancock Road
Taunton, MA 02780
tsutherland@westerbeke.com

Mr. Robert Taylor
Design Research Engineering
46475 DeSoto Court
Novi, MI 48377-1731
taylor@dreng.com

Mr. R.H. Townsend
SAFER
Dana Pt. CA
townsend@runbox.com

Mr. Mark Verwys
Plunkett & Cooney, P.C.
333 Bridge Street NW Ste 530
Grand Rapids, MI 49504
mverwys@plunkettcooney.com

Mr. Augusto Villalon
ANCON Marine Consultants, Inc.
3859 Cruz Drive
St. James City, FL 33956
sailalfin@aol.com

Mr. Gary Webb
Brunswick Boat Group
800 S Gay St, Suite 1700
Knoxville, TN 37929
Gray.webb@brunswickboatgroup.com

Mr. Bob White
Imanna Lab
515 Gus Hipp Blvd
Rockledge, FL 32955
Immanalab@bellsouth.net



USCG – NIOSH CO Update:

- **Evaluation of CO Emissions from Houseboats Generators (November 2006)**
- **Evaluation of the new Indmar Catalytic Technology (December 2006)**

Alberto Garcia, M.S.

G. Scott Earnest, Ph.D., P.E., C.S.P.

Ronald M. Hall, M.S., C.I.H.

Daniel R. McCormick*

**National Institute for Occupational Safety and Health
Division of Applied Research and Technology
Engineering and Physical Hazards Branch
* U.S. Coast Guard**

This work was performed under an interagency agreement between NIOSH and the United States Coast Guard

Disclaimer: The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy

Disclaimer: Mention of any company or product does not constitute endorsement by CDC, NIOSH

Relative CO Concentrations

CO in ppm	Limits/Symptoms
35	NIOSH REL; Max. exposure allowed by EPA outside for 1 hour
50	Maximum exposure allowed by OSHA over 8 hours
125	American Boat & Yacht Council limit over 5 minutes
200	NIOSH Ceiling; Mild headache, fatigue, nausea & dizziness
800	Dizziness, nausea, convulsions - 45 min, Death - 2 hours
1,200	Immediately Dangerous to Life and Health (IDLH)
6,400	Death in 10 to 15 min
5,000 - 10,000	Measured in open air or near swim platform
12,000	Immediate Death
7,000 - 30,000	Measured on houseboats in airspace under swim platform
	Source: NIOSH, AIHA and ABYC

DESCRIPTION OF EVALUATED RECREATIONAL VESSELS

- 3 Houseboats (November 2006):
 - Houseboat # 1 - 14' x 59' Equipped with a Westerbeke Safe-CO™ 14 KW Generator
 - Houseboat # 2 - 16' x 70' Equipped with a Westerbeke Safe-CO™ 20 KW Generator
 - Houseboat # 3 - 14' x 59' Equipped with a 12.5 KW Generator with aftermarket EFI and catalyst
- 1 Ski Boat (December 2006):
 - Equipped with single engine small block 350 in³
 - Exhaust Through the Transom at the water line
 - Configured with and without Catalytic Converter (based on the test scenario)

EQUIPMENT

- Ph.D. Toxi-Ultra (0 – 1,000 ppm)
- Dräger PAC III detectors (0 – 10,000 ppm)
- ECOM and Ferret Five Gas Emissions Analyzer
- TSI Q-trak with CO sensor
- MSHA glass evacuated containers
- Dräger detector tubes
- Garmin Global Positioning System
- HOBO Weather Station

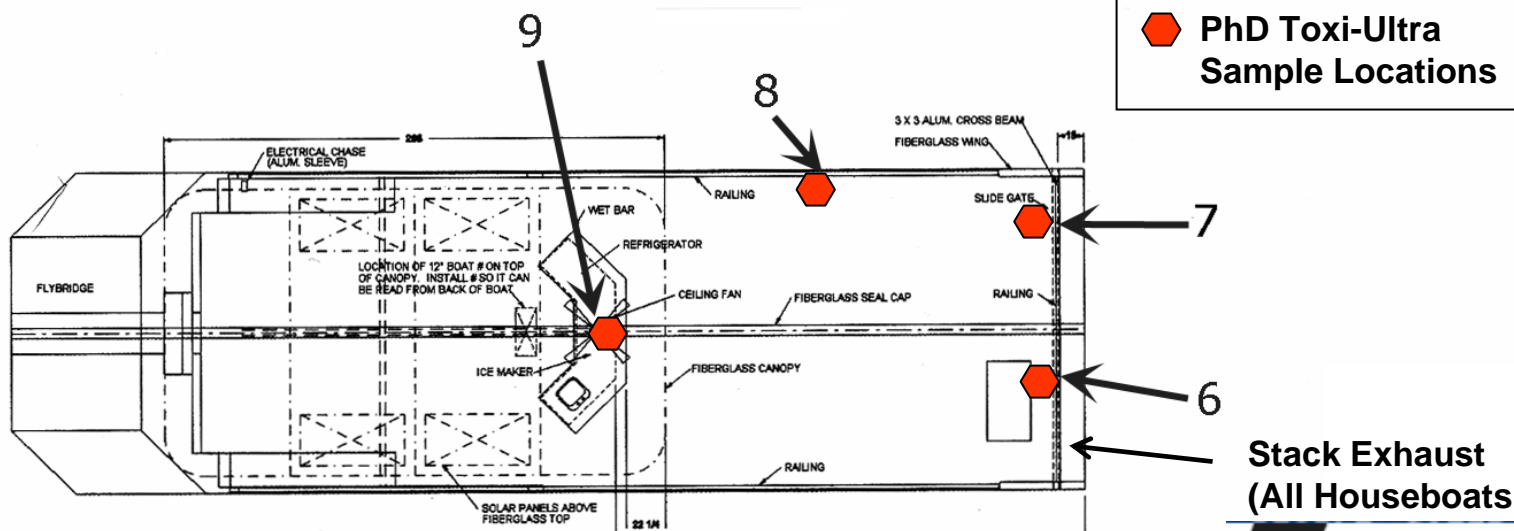
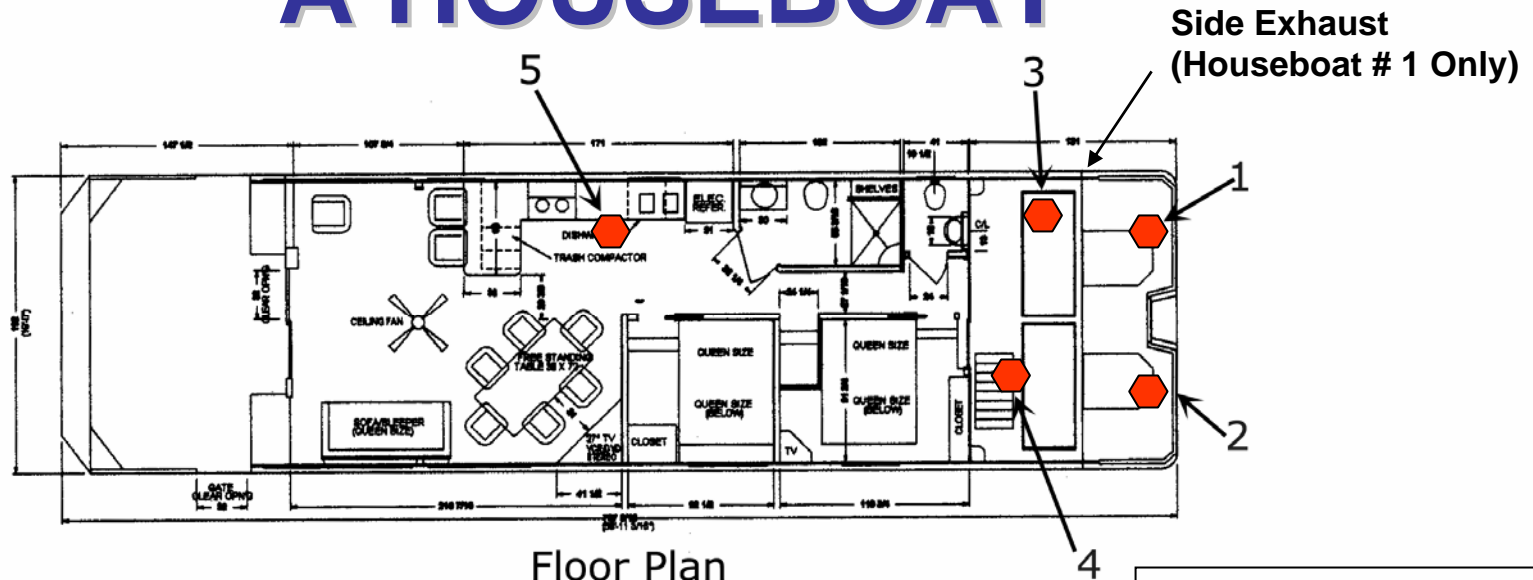
METHODS

- Evaluations typically took several hours for each boat.
- CO monitors, weather station and stop watches were synchronized with the computer's clock to accurately correlate each test with downloaded data.
- CO monitors were placed at various locations on the boat.
- Air sampling occurred while boats were stationary for Houseboats and moving for the Ski Boat.
- Grab samples and detector tubes were also collected on a regular basis for additional CO data.

TEST MATRIX HOUSEBOATS

Test Condition	Exhaust and Generator Condition
1	Side Exhaust, No Generator Load
2	Side Exhaust, Partial Generator Load
3	Side Exhaust, $\frac{3}{4}$ to Full Generator Load
4	Stack Exhaust, No Generator Load
5	Stack Exhaust, Partial Generator Load
6	Stack Exhaust, $\frac{3}{4}$ to Full Generator Load

TYPICAL SAMPLE LOCATIONS ON A HOUSEBOAT



PhD Toxi-Ultra Sample Locations

November 2006 Testing

- Testing was conducted after two full seasons of rental use.
- Preliminary results indicate similar findings with the March 2005 and November 2005 evaluations.
- In the process of writing the report.
- Oxygen sensor inspected before testing on both houseboats # 1 & 2. Oxygen sensor found to be working properly.
- Houseboat # 1 - 14 KW Generator – 4,656 hours.
 - During this testing we evaluated the old catalyst and the replaced it and evaluated new catalyst in the 14 KW unit.
- Houseboat # 2 - 20 KW Generator – 2,836 hours.
- Houseboat # 3 – 12.5 KW Generator, during this testing we evaluated the effectiveness of the aftermarket EFI and catalyst.

Houseboat # 1 equipped with the 14 KW Generator (November 2006 Results)

- **CO Monitors (on and around boat in areas that could be potentially occupied)**
 - Side exhaust on lower stern deck starboard side (highest concentrations) - Peak of 7 ppm (average 1.9 ppm)
 - Old Catalyst – Stack exhaust on upper stern deck port side
 - Peak of 7 ppm (average of 1.9 ppm)
 - New Catalyst - Stack exhaust on upper stern deck port side
 - Peak of 3 ppm (average of 1.5 ppm)
- **Gas Emissions analyzer, Detector Tubes, and evacuated Containers**
 - With the new catalyst, preliminary data indicates similar results as the previous study
 - Cold Start (before catalyst is warm) resulted high CO concentrations in stack
 - Few minutes later CO concentrations were low
 - Example (evacuated containers) 75,000 ppm at cold start

Houseboat # 2 equipped with the 20 KW Generator (November 2006 Results)

- **CO Monitors (on and around boat in areas that could be potentially occupied)**
 - Stack exhaust on upper deck port side (highest concentration) - Peak of 3 ppm (average of 1.7 ppm)
- **Gas Emissions analyzer, Detector Tubes, and evacuated Containers (taken Directly in the stack)**
- Preliminary data indicates similar results as the previous study
 - Cold Starts (before catalyst is warm) high CO concentrations in Stack
 - Few minutes later CO concentrations were low
 - Example (evacuated containers) 118,700 ppm at start – 4 minutes later 265 ppm

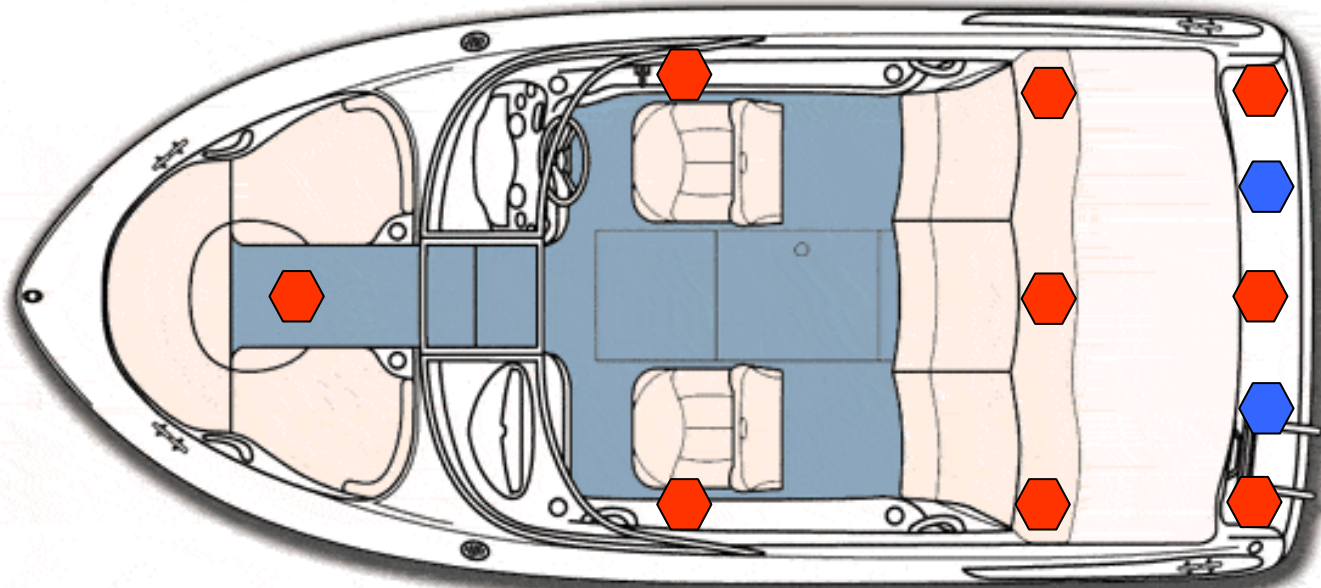
Houseboat # 3 equipped with the 12.5 KW Retrofit EFI Generator (November 2006 Results)

- **CO Monitors (on and around boat in areas that could be potentially occupied)**
 - Stack exhaust on upper deck port side (highest concentration) - Peak of 4 ppm (average of 3.3 ppm)
- **Gas Emissions analyzer, Detector Tubes, and evacuated Containers (taken Directly in the stack)**
- Preliminary data indicates similar results as the previous study
 - Cold Starts high CO concentrations in stack 7.2% (72,000 ppm)
 - Example (evacuated containers) 65,000 ppm at start – 2,200 ppm 5 min later
 - Constantly ranging between 2,500 and 5,000 ppm after start
 - When under load CO measurements reached >10,000 ppm

TEST MATRIX SKI BOAT

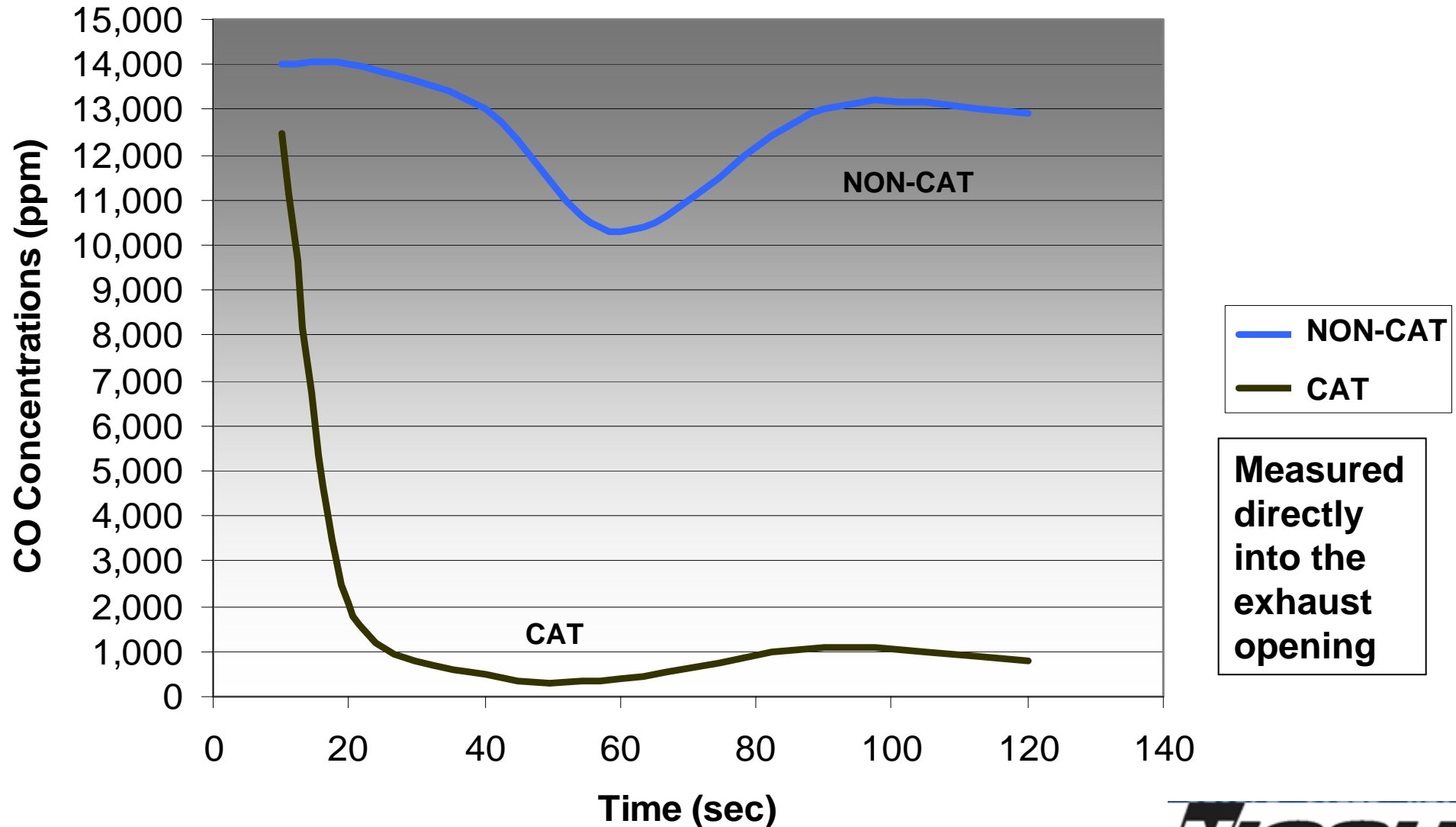
Test Condition	Speed and Direction
1	5 mph heading North and South
2	10 mph heading North and South
3	15 mph heading North and South
4	25 mph heading North and South
5	Open throttle heading North and South

TYPICAL SAMPLE LOCATIONS ON A SKI BOAT



-  PhD Toxi-Ultra Sample Locations
-  Dräger Pac III Sample Locations

RESULTS SKI Boat, Ferret Data Measurements from Cold Crank



% Reduction vs. Time

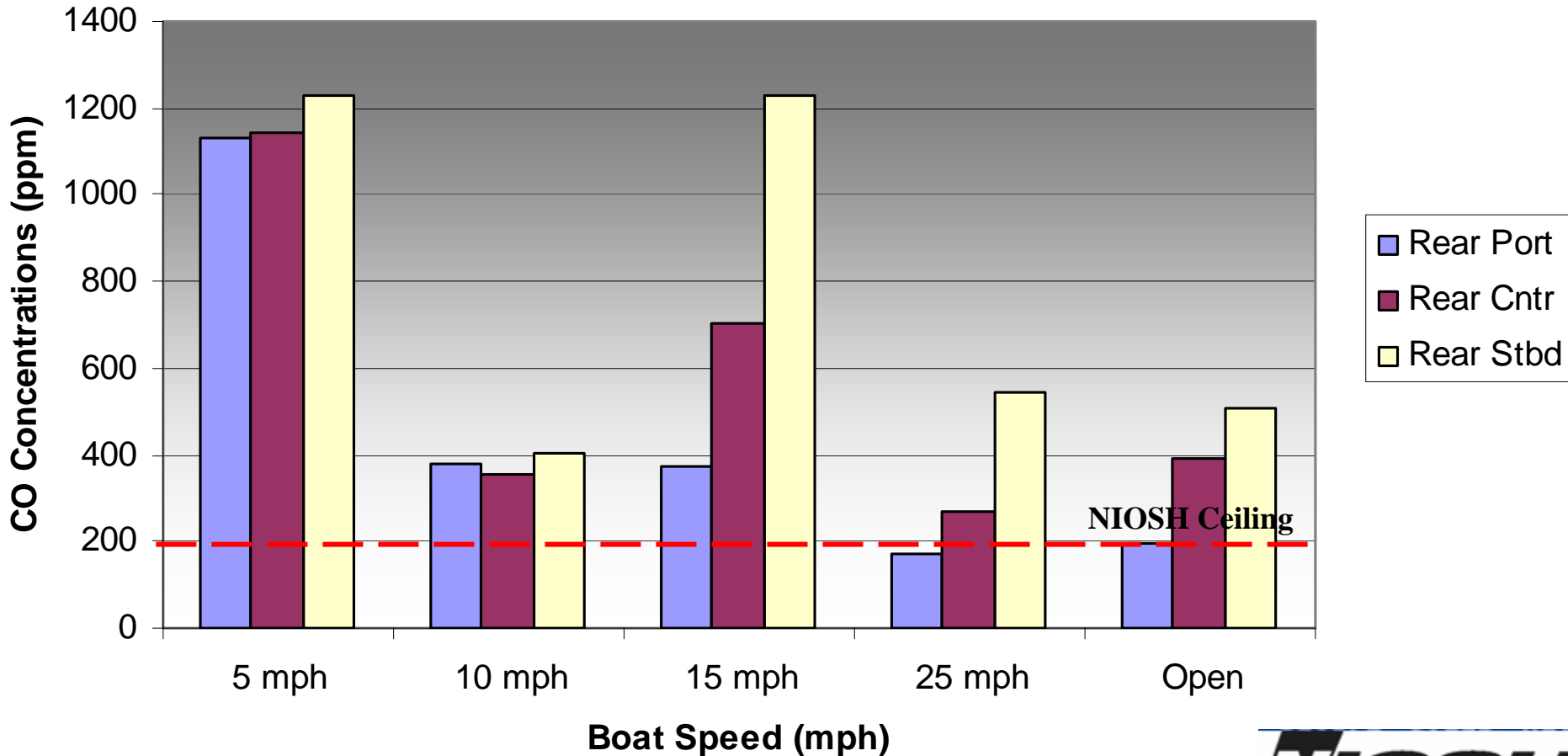
Ski Boat with Catalytic Converter

(Measurements collected from exhaust opening)

Time (sec)	Reduction (%)
10	10.71
20	85.00
40	96.15
60	96.12
90	91.54
120	93.80

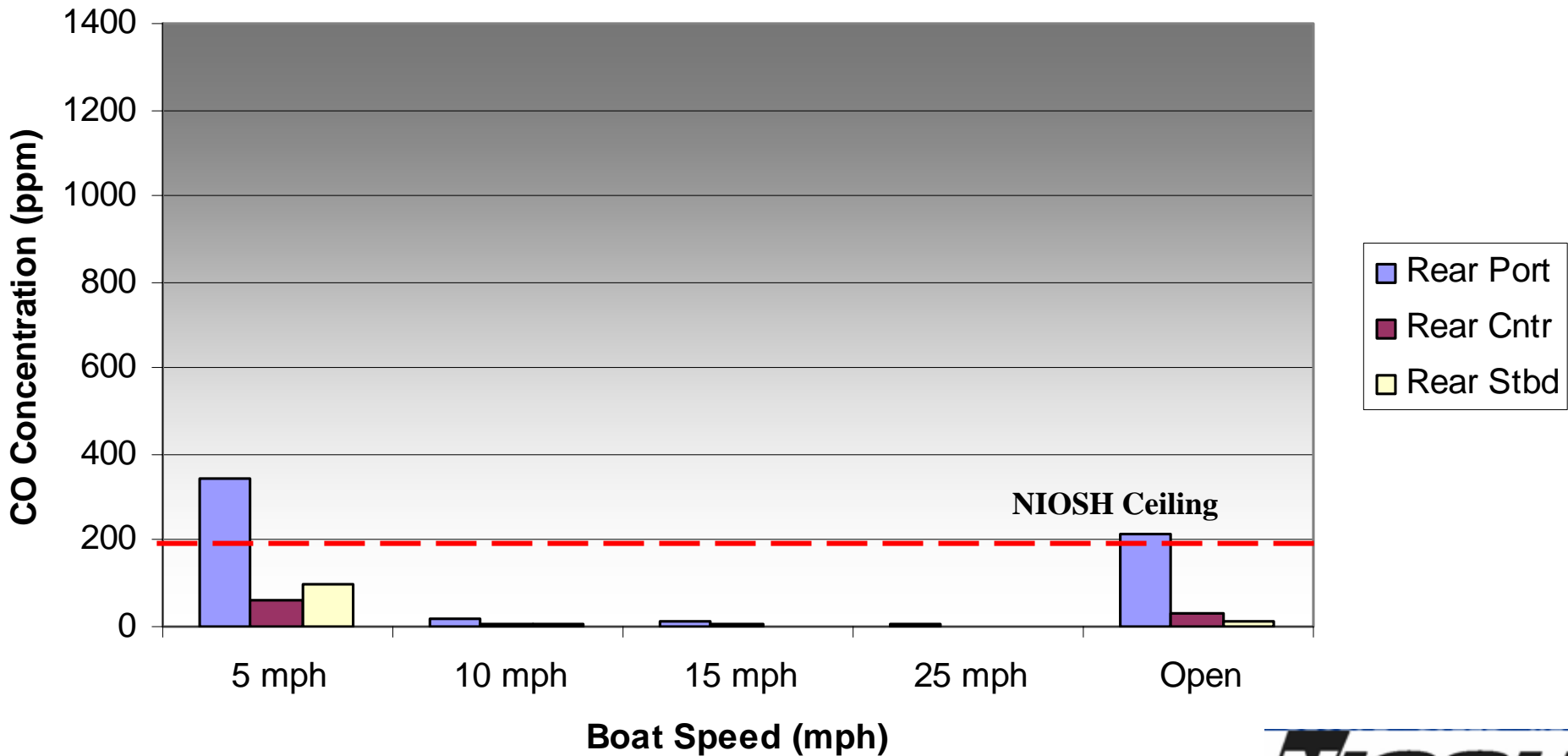
RESULTS SKI Boat, Toxi-Ultra Data

CO Distribution NON-CAT Engine
Heading South, Transom Exhaust

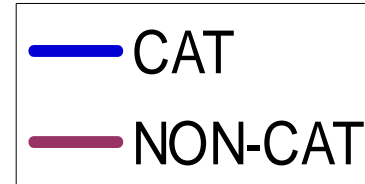
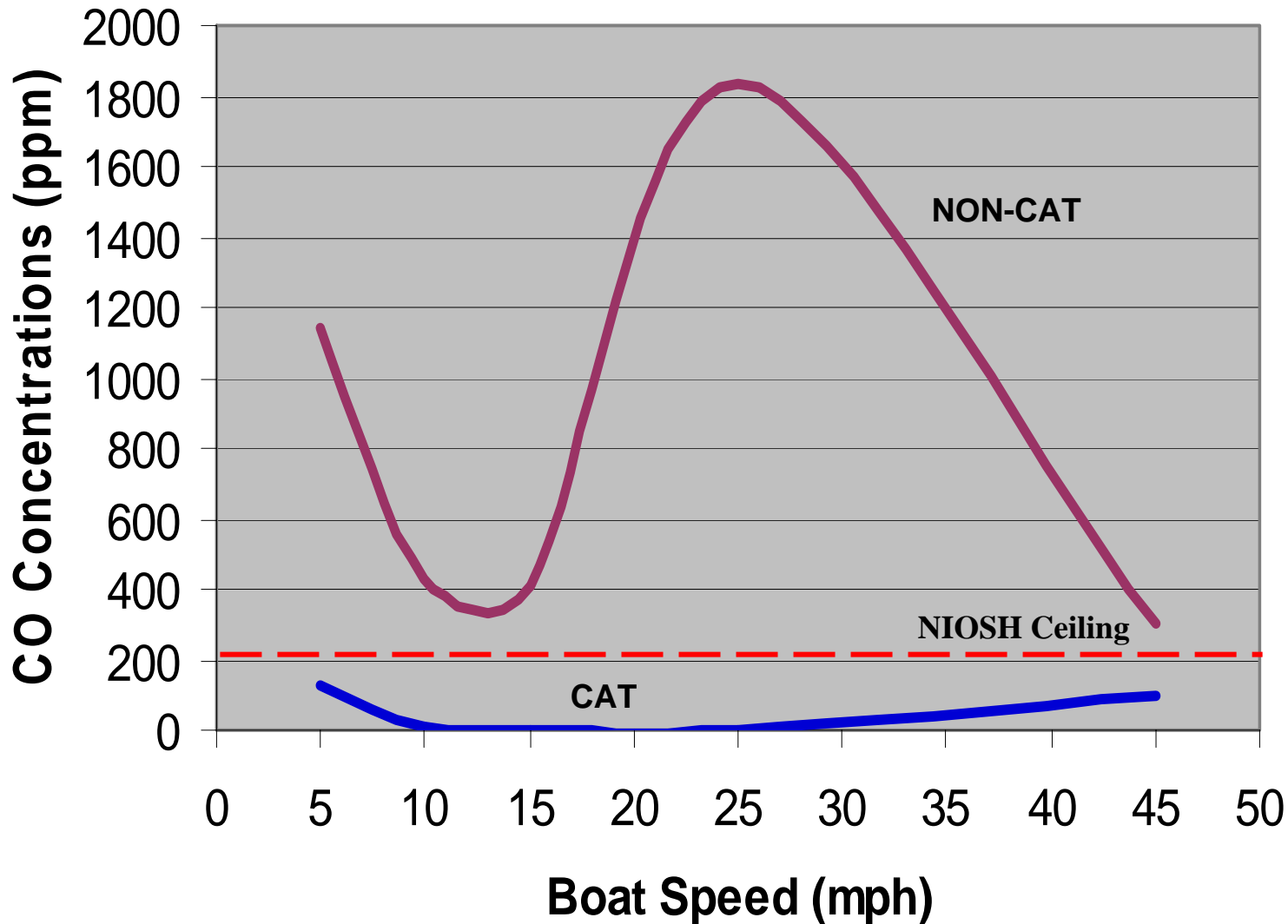


RESULTS SKI Boat, Toxi-Ultra Data

CO Distribution CAT Engine Heading South, Transom Exhaust



RESULTS SKI Boat, Dräger PAC III Data (CAT vs. NON-CAT Engine)



Measurements collected on swim platform

DISCUSSION

HOUSEBOAT EVALUATION

- The Westerbeke Safe-CO generators equipped with a catalyst and electronic fuel injection, resulted in low CO emissions and indicated safe levels in potentially occupied areas around the boat for either exhaust configuration.
- Initial cold crank measurements were high directly into the stack 118,700 ppm (11.87%) and then dramatically reduced to approximately 200 ppm (directly into the stack) after approximately 5 minutes.

DISCUSSION

HOUSEBOAT EVALUATION

- Degradation on the catalyst installed on the 14 KW unit was observed after 4,656 hours of operation. This catalytic converter was replaced and the emissions were again within safe limits.
- Maintenance and follow manufacturers replacement schedule is important for the proper performance of this technology.
- Use of vertical stack is a good redundant safety measure.

DISCUSSION

SKI BOAT EVALUATION

- At idle, the Indmar new catalytic technology resulted in an average 92% reduction of CO emissions (measured directly into the exhaust opening).
- Performance did not seem to be affected since both, catalytic and non-catalytic engines were able to reach the same top speed at open throttle (about 48 mph).
- Wind and weather conditions play an important role on pollutant dispersion when the boat is underway.
- CO concentrations are typically higher at the stern of the boat and gradually lower as you move forward.

GENERAL FACTORS INFLUENCING CO EXPOSURES

- Exhaust configuration (Hub, Transom, Underwater, Stack)
- Boat speed
- Wind conditions
- CO generation rate and engine load
- Boat design and shape
- Distance between exhaust outlets and individual's breathing zone

OBSERVATIONS & RECOMMENDATIONS

- Continue evaluating new catalytic technology in propulsion engines to evaluate performance over time and observe potential degradation of the catalytic converter.
- These catalytic technologies reduce CO and other air pollutants (including CO) from engine exhaust. This reduction will be translated into a considerable reduction of CO related poisonings.
- Underwater exhaust will significantly reduce CO concentrations inside the boat compared to surface exhaust.

OBSERVATIONS & RECOMMENDATIONS

- Maintenance is important for the performance of these low – emission technology.
- Manufacturers should continue their development of cleaner burning engines with catalytic converters since they have the potential to greatly reduce CO concentrations to safer levels.

FUTURE WORK

- NIOSH and USCG would like to work with other manufacturers to test generators or propulsion engines equipped with catalytic technology.
- Initiate studies of CO exposures when performing water-sports activities. This requires finishing the study protocol and submit it through NIOSH internal clearance process.
- Evaluate the Indmar technology after several hundred hours of operation and compare results to the baseline testing performed last December 2006.



Questions?

SAFER • HEALTHIER • PEOPLE™

AL • CHRONIC DISEASE PREVENTION • INFECTIOUS DISEASE PROTECTION • IMMUNIZATION • INJURY PREVENTION • PRI
CHILD HEALTH • GLOBAL PARTNERSHIPS • MINORITY OUTREACH • MONITORING HEALTH • COMMUNITY PARTNERSHIPS
SAFER • HEALTHIER • PEOPLE • SAFER • HEALTHIER • PEOPLE • SAFER • HEALTHIER • PEOPLE • SAFER • HEA
HEALTH EDUCATION • EPIDEMIOLOGY • WORKPLACE HEALTH • IMMUNIZATION • WORKPLACE SAFETY • TRAINING • C
LTH • PREVENTION RESEARCH • PRIVATE SECTOR PARTNERSHIPS • PUBLIC HEALTH WORKFORCE • WOMEN'S HEALTH