DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
321 BULLFINCH ROAD
PANAMA CITY, FLORIDA 32407-7015

IN REPLY REFER TO:
3963/FT00-03A
Ser 07-06/219
4 Oct 06

From: Commanding Officer, Navy Experimental Diving Unit
To: Commanding Officer, Naval Diving and Salvage Training Center (USCG Liaison Office)

Subj: DIVING ACCIDENT INVESTIGATION INVOLVING UNITED STATES COAST GUARD CUTTER HEALY (WAGB-20)

Encl: (1) Air Analysis Report
(2) NEDU Short Form Manned Test Plan TP06-31/32196
(3) VHS Video Tape dtd 27SEP06: NEDU Casualty Reconstruction

1. Background. Navy Experimental Diving Unit (NEDU) was notified on 18 August 2006 of a diving casualty which had occurred on the evening of 17 August 2006 on the United States Coast Guard (USCG) Cutter Healy, an icebreaker which was in the vicinity of Barrow, Alaska (77°12'N 177°35'W). The casualty involved a female officer diver (LT Hill) and a male enlisted diver (BM2 Duque), who were using Self Contained Breathing Apparatus (SCUBA). A third officer was involved in the dive but aborted the dive immediately after entering the water [redacted]. As the Department of Defense's diving accident rig investigation center, NEDU was requested to examine the diving systems involved and report findings to the investigative board which had been convened by USCG. As soon as NEDU was notified of the casualty, shipment of the diving equipment involved in the casualty was arranged via fastest traceable means.

2. Guiding Directives. US Navy diving requirements for Ice Diving/Cold Water Diving are delineated in Chapter 11 of the US Navy Diving Manual, Revision 5, published 15 August 2005. Due to the uniquely hostile environment to divers, topside support personnel and equipment, specific guidance is given in this chapter to ensure safety in operations is maintained. Normal diving procedures generally apply to diving in extremely cold environments. However, there are a number of specific equipment and procedural differences that, if followed, enhance divers' safety. In addition to logistical planning and navigational concerns that must be considered in cold water and ice diving, these environments have profound effects on the equipment that is being utilized to conduct diving operations. Cold water and

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ice diving is defined as that taking place in water at or below a temperature of 37° Fahrenheit. This temperature was set as a limit as a result of regulator freeze-up testing conducted here at NEDU, and there is a specific section of the list of equipment which is Authorized for Navy Use (ANU list) which specifies that equipment which has been proven to operate correctly in water at or less than 37° Fahrenheit. Even with special modifications to diving regulators designed for cold water, specific guidance in operation is provided to preclude regulator "freeze-up." Guidance is specifically given to ensure redundancy in equipment is maintained. Chapter 11, section 2.4.2 requires the use of a redundant SCUBA system, which is defined as twin scuba bottles, each having a separate K-valve and an approved cold-water regulator, or twin SCUBA bottles with a common manifold attached to a approved cold water regulator fitted with an additional second stage, otherwise known as an "octopus", for diving in water at or below 37° Fahrenheit. Further, Chapter 11 prohibits the use of a "life preserver" while wearing a variable volume dry suit, due to the potential covering of the suit's exhaust and inlet valves. Additional guidance is given in the chapter regarding diving equipment utilized for under-ice operations, specifically in that a weight BELT is required, and in guidance in use of variable volume dry suits. The requirement for a belt, instead of a weight harness or other weight-carrying equipment, is to facilitate easy jettison of the weights. The USN Dive Manual requires that "prior to the use of variable volume dry suits and hot water suits in cold and ice-covered waters, divers must be trained in their use and be thoroughly familiar with the operation of these suits".

3. NEDU received three sets of underwater breathing apparatus (UBA) associated with the HEALY (WAGB-20) ice diving incident. Five boxes containing ancillary equipment arrived at NEDU on 25 August 2006. Inventory was taken, and the equipment was allowed to dry. Three crates of critical life-support apparatus (three 100 cubic foot (CF) single steel SCUBA tanks, three regulators, and three buoyancy compensators (BC)) followed on 28 August 2006. All equipment was already tagged as to who was wearing each piece of equipment. Contents were inventoried and cataloged. Systems and equipment deemed to be germane to the investigation are described and discussed below.

4. Thermal Protection. Contained in the first shipment were 2 White's dry suits, of two different models. Both of them had been cut, most likely in the process of removal, and were labeled to be from LT Hill and BM2 Duque. The other drysuit was undamaged ([redacted]). Each drysuit was inspected. Both valves, inlet and exhaust, on each suit are made by [redacted]. Each drysuit's inflation valve, a small button approximately 1" in diameter located in the vicinity of the diver's sternum in each dry suit, was inspected and tested with LP air from one of the regulators in 28°F water to ensure each valve flowed air without freeze-up and did not leak when released. We removed the inlet valves from the dry suits and installed each in turn in the bottom of a 7" deep plastic bucket. We placed the steel 100 CF scuba tank and Apeks regulator first stage into ice/salt water at 28°F, and allowed the system to chill for 10 minutes. Multiple actuations of the inlet valve produced no free flow and though wearing gloves, the button did not seem significantly stiffer or more difficult to press than it did in warm air. The test was repeated several times and for 15 second bursts. No free flow from either inflation valve was observed.

The exhaust valves were also tested using the same method. Normal operation is to rotate the valve clockwise to shut, and counterclockwise to open. The valves do not allow free flow during the first 1/2 rotation counterclockwise, but are ready to exhaust when depressed. A slight tap allows gas to escape and then the valve reseats. If rotated more than 1/2 rotation counterclockwise, the valve becomes a variable exhaust, with 1.5 rotations to full open. Each exhaust valve was mounted in the bottom of the bucket and submerged, and no ingress of water was observed. After submerging the inverted bucket, the exhaust valves held back the pressure of the air trapped within, demonstrating proper operation.

The drysuit undergarment was a standard wooly underwear. Head protection was from an attached hood. Hand thermal protection appeared to be an assortment of gloves, ranging from a thin liner, to a heavy liner, to the outer glove, which was a five-finger drysuit glove with a rigid collar which mated to the drysuit sleeve.

5. Breathing Media. The three SCUBA tanks were delivered to Naval Surface Warfare Center, Panama City's Gas Analysis Lab. LT Hill's tank contained 90 pounds per square inch (PSI) of air; and ENS [redacted] tank contained 3000 PSI of air. Air analysis results of these two tanks, which are reported in enclosure (1), showed no adverse levels of contamination. BM2 Duque's tank read 0 PSI(empty), and no analysis was performed. No backup source of air (second SCUBA bottle) was found to be in the shipment of diving systems received.

6. Weights. Diving weights were contained in the weight pockets of the buoyancy compensators, instead of being held on a standard weight belt. Inspection of the buoyancy compensators revealed that BM2 Duque's BC contained no weight, but LT Hill's BC contained 50 lbs of soft weights. We were told by the USCG Investigation Team that BM2 Duque actually did have 50 lbs of soft weight in his BC during the dive but these weights were removed prior to shipment of the equipment to NEDU. NEDU did receive the weights in a crate in the shipment, and the weights marked from BM2 Duque were confirmed to total 50 lbs. Within the dive bag marked "[redacted]/Hill" and still moist from apparent use were four additional 2 lb ankle weights. [redacted]'s BC had 40 lbs of weight installed. Additional weight carried by the divers were their SCUBA cylinders: Steel 100 CF tanks have a negative buoyancy of 8.8 lbs full (3442 psi) and 1.3 lbs empty.

7. Buoyancy Compensators. All three buoyancy compensators were [redacted] "[redacted]" models, which are Approved for Navy Use (ANU). All units held air when inflated. All were equipped with emergency quick-release systems for the soft weight packs and appeared to be fully functional and intact, meaning that they had not been activated or deployed. When tested in the laboratory, the weight releases functioned properly. LT Hill's BC had an alternate air source (second stage), a [redacted], model "[redacted]", installed in place of the standard oral/power inflator. This second stage alternate air source is not on the Approved for Navy Use list. The "[redacted]" had a quick-disconnect fitting incompatible with the low pressure (LP) inflator hoses mounted on all three first stage regulators in use, meaning that it could not have been connected to a LP hose from any of the regulators, rendering this BC unable to be inflated using SCUBA air from an LP port. The other two [redacted] Ranger B/C's (BM2 Duque's and [redacted]

[redacted]s) inflator hoses were unmodified and had standard power inflator air fittings that could have been connected to an LP hose from a regulator first stage, had there been one additional LP hose installed on each of the regulators.

8. Regulators. All divers used one [redacted] model [redacted] first stage regulator. This regulator is not on the Approved for Navy Use (ANU) list for cold water diving (below 37 degrees F). However, The [redacted] (PN/AP0500) IS on the ANU list for cold water. After checking with the manufacturer, we found that the first stages of the [redacted] and the [redacted] are identical. There is a small difference in size between the two model's second stages, but no difference in operational capability, according to the manufacturer. The [redacted] has four low-pressure (LP) connection ports available, of which one was connected to an [redacted] MK-II full face mask (FFM), another was connected to an [redacted] second stage for use as an octopus, and an LP power inflator hose was connected to a third port. The fourth port was unused and plugged. The [redacted] MK-II (positive pressure) is not on the ANU list for cold water diving. However, the [redacted] MK-IIG (non-positive pressure) is approved for use in cold water when paired with a [redacted] first stage regulator. In this case, the [redacted] MK-II second stage was paired to the [redacted] first stage, not a [redacted], as the ANU list requires.

LT Hill's second stage octopus hose was cut clean about 6" from the termination at the regulator first stage, as if it had been severed with a knife. The knife used to cut the hose was included (and tagged as such) in the dive gear shipped to NEDU. The LP hose stub was removed and the port plugged for testing. Each [redacted] Regulator first stage has 2 high pressure (HP) ports available, one of which was used for the pressure gauge/depth console, and the other was plugged.

The nose clearing block (equalizer pad) was missing from LT Hill's [redacted] FFM, but it is possible that it was installed during the dive and fell out somewhere prior to being received by NEDU, as they are easily dislodged; the other two FFMs contained the nose clearing blocks.

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The [redacted]MK-II and [redacted] second stages connected to the [redacted] first stage regulators were machine-breathed to extreme work rates under hyperbaric conditions simulating arctic salinity and temperature to a depth of 220 fsw. Breathing rates up to 90 Liters/minute (L/min) Respiratory Minute Volume (RMV) were tested; under extreme conditions, working divers may momentarily attain 90 L/min RMV. The three dive sets performed satisfactorily and were fully functional throughout the 90-minute test dive. As would be expected at high respiratory rates and at such depths under normal arctic conditions, ice formation was observed on the submerged but exposed metal parts, but did not compromise the performance of the breathing systems.

9. Depth/Pressure Console. On all three dive sets, a [redacted] dive console (consisting of a submersible pressure gauge, a analog depth gauge, and a compass) was connected to one of the ports via a high pressure (HP) hose. On both BM2 Duque's and LT Hill's consoles, the depth gauge sweep needle indicated that a depth exceeding 200 feet of seawater (fsw) had been reached during the dive. LT Hill's console hose had also been cut at about 6" from the termination on the regulator first stage. The HP hose stub was removed and the port plugged to facilitate testing.

10. Observations.

a. The weights contained in BM2 Duque's and LT Hill's BCs, added to the ankle weights, with the addition of the negative buoyancy from the full steel 100 CF SCUBA tanks, totaled in excess of 62 lbs at the commencement of the dive.

b. With only one LP hose connected to each regulator first stage, it could only have been possible to add air to either the diver's dry suit or to a BC, but not both. It would not have been possible to attach any of the LP hoses to LT Hill's BC, as the LP hose fitting and the BC power inflator fitting on her BC are incompatible.

c. In order to inflate any of the BC's, the [redacted] FFM would have had to be removed (under water), air obtained from the [redacted] second stage, and the BC manually inflated orally.

d. Finally, the only two ways to increase buoyancy with the systems used in this dive would have been for the divers to have 1) operated their drysuit inflation valve or 2) to dump their weights, which we know they did not do, since the divers were recovered with all the weights with which they started the dive.

11. In order to determine whether critical control features (drysuit inflation and exhaust valves, BC weight dump ripcord) of the systems used were accessible, especially for a diver wearing heavy gloves, NEDU outfitted a 170 lb, experienced male diver with the exact gear that BM2 Duque was wearing during this dive, and completed a functional test dive in NEDU's 15'-deep test pool according to enclosure (2). NEDU's test diver was wearing the same undergarments, drysuit, gloves, ankle weights, [redacted] split fins, SCUBA cylinder, BC with 50 lbs of soft weights, [redacted] regulator, and [redacted] FFM as BM2 Duque wore. The only differences were that the dive was conducted in fresh water instead of seawater, the water temperature was 85°F instead of 28°F, and the diver was breathing from NEDU's air system through a surface-supplied umbilical so that the diver could communicate with the test director. Enclosure (3) is the actual video (VHS NTSC format) of the test. The results of this testing show that even for a diver weighing 170 lbs, 50 lbs of soft weight is greatly in excess of what is needed to allow this diver to descend, even in a drysuit. The test also showed that despite the excessive weight carried, an experienced diver could have finned upward, even with split fins, to maintain buoyancy, at least within 10 feet of the surface. All drysuit controls, as well as the weight dump ripcord, were accessible, and the weight dump functioned properly. However, due to only 20 lbs of weight in the pockets which could be jettisoned, dumping this amount was insufficient to establish positive buoyancy for the diver on the bottom of the test pool (@15'), who continued to carry 30 lbs in the non-dumping pockets (as did BM2 Duque). A final test was for the diver to simply descend from the surface of the test pool to the bottom without adding air to the drysuit or finning, to see how fast an over-weighted diver would fall. That test is documented in the video, and while the speed of the falling diver was not determined quantitatively, it was obvious that an over-weighted, non-tended diver wearing a drysuit could easily have began a fall of speed sufficient to preclude ear equalization, and with the accompanying drysuit squeeze, loss of spatial orientation,

all occurring in the cold and decreasing light level, that diver may have been challenged to maintain depth control.

12. Command point of contact is Mr. [redacted] NEDU's Diving Accident Investigator, who can be contacted at (850) 230-[redacted], or NEDU's Commanding Officer, who can be contacted at (850) 230-[redacted]

[redacted]

[redacted]

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Test Facility:	Air Analysis Report	Report To:
Naval Surface Warfare Center Panama City Chemistry Lab, Bldg#414 110 Vernon Avenue Panama City, FL 32407 850-235-5505	**Analysis Date:** 09/06/06 **Report Date:** 09/06/06	[redacted], NEDU Naval Surface Warfare Center Panama City Panama City, FL 32407

Sample Description: Analysis of air sample from accident investigation #07-06-A. Lt. Hill USCGC Healy.

Room Temperature: 73°F

In accordance with your request, the gas sample delivered to the gas analysis lab was analyzed and found to contain:

Standard Components

COMPONENT	MEASURED LEVEL	ANALYSIS METHOD	DETECTION LIMIT	ALLOWED LIMIT (ref.)
Oxygen	20.9%	GC-TCD	0.1%	20-22%(4)
Nitrogen	78.2%	GC-TCD	0.1%	None Specified (2,3,4)
Argon	0.9%	GC-TCD	0.1%	None Specified (2,3,4)
Carbon Dioxide	85 PPM	CO2-IR	7 PPM	1000 PPM(4)
Total Hydrocarbons	1.8 PPM	THA-FID	0.5 PPM	25 PPM(1,4)
Carbon Monoxide	<1.0 PPM	CO-IR	1 PPM	20 PPM(4)
Methane	1.8 PPM	GC-FID	0.3 PPM	None Specified (2,3,4)
Acetone	0.003 PPM	GC/MSD2	0.002 PPM	200 PPM(2)
Benzene	<0.002 PPM	GC/MSD2	0.002 PPM	1 PPM(2)
Chloroform	<0.002 PPM	GC/MSD2	0.002 PPM	1 PPM(2)
Ethanol	0.003 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Refrigerant CFC-113	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)

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Standard Components

COMPONENT	MEASURED LEVEL	ANALYSIS METHOD	DETECTION LIMIT	ALLOWED LIMIT (ref.)
Refrigerant CFC-11	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Refrigerant CFC-12	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Refrigerant CFC-114	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Isopropyl Alcohol	<0.002 PPM	GC/MSD2	0.002 PPM	1 PPM(2)
Methanol	<0.002 PPM	GC/MSD2	0.002 PPM	10 PPM(2)
Methyl Chloroform	<0.002 PPM	GC/MSD2	0.002 PPM	30 PPM(2)
Methyl Ethyl Ketone	<0.002 PPM	GC/MSD2	0.002 PPM	20 PPM(2)
Methyl Isobutyl Ketone	<0.002 PPM	GC/MSD2	0.002 PPM	20 PPM(2)
Methylene Chloride	<0.002 PPM	GC/MSD2	0.002 PPM	25 PPM(2)
Toluene	<0.002 PPM	GC/MSD2	0.002 PPM	20 PPM(2)
Trimethyl Benzenes	<0.002 PPM	GC/MSD2	0.002 PPM	3 PPM(2)
Xylenes	<0.002 PPM	GC/MSD2	0.002 PPM	50 PPM(2)
Odor	pass	nose/smell	pass/fail	Not objectionable (4,5)

Other Components

Note: The estimated measured level for other components is calculated based upon the instrument response to Benzene

COMPONENT	ESTIMATED MEASURED LEVEL	ANALYSIS METHOD	DETECTION LIMIT	ALLOWED LIMIT (ref.)
NONE				

Test results are only applicable to the sample identified in the sample description. The sample showed no appreciable contamination. All components were within their specified limit.

[1]Expressed as methane equivalents.
[2]Limits taken from Navy Dive Manual; Rev. 4, Table 15-5.
[3]OSHA Final Rule limits (not specified in Navy Dive Manual).
[4]Limits taken from Navy Dive Manual; Rev. 4, Table 4-1.
[5]Limits taken from Navy Dive Manual; Rev. 4, Table 4-2.

[redacted] 9-6-06
Analyst. Date

[redacted] 9-6-06
Test director. Date

Test Facility:	Air Analysis Report	Report To:
Naval Surface Warfare Center Panama City Chemistry Lab, Bldg#414 110 Vernon Avenue Panama City, FL 32407 850-235-5505	**Analysis Date:** 09/06/06 **Report Date:** 09/06/06	[redacted], NEDU Naval Surface Warfare Center Panama City Panama City, FL 32407

Sample Description: Analysis of air sample from accident investigation #07-06-B. [redacted] USCGC Healy.

Room Temperature: 73°F

In accordance with your request, the gas sample delivered to the gas analysis lab was analyzed and found to contain:

Standard Components

COMPONENT	MEASURED LEVEL	ANALYSIS METHOD	DETECTION LIMIT	ALLOWED LIMIT (ref.)
Oxygen	20.9%	GC-TCD	0.1%	20-22%(4)
Nitrogen	78.2%	GC-TCD	0.1%	None Specified (2,3,4)
Argon	0.9%	GC-TCD	0.1%	None Specified (2,3,4)
Carbon Dioxide	432 PPM	CO2-IR	7 PPM	1000 PPM(4)
Total Hydrocarbons	1.9 PPM	THA-FID	0.5 PPM	25 PPM(1,4)
Carbon Monoxide	<1.0 PPM	CO-IR	1 PPM	20 PPM(4)
Methane	1.9 PPM	GC-FID	0.3 PPM	None Specified (2,3,4)
Acetone	0.002 PPM	GC/MSD2	0.002 PPM	200 PPM(2)
Benzene	<0.002 PPM	GC/MSD2	0.002 PPM	1 PPM(2)
Chloroform	<0.002 PPM	GC/MSD2	0.002 PPM	1 PPM(2)
Ethanol	0.003 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Refrigerant CFC-113	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)

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Standard Components

COMPONENT	MEASURED LEVEL	ANALYSIS METHOD	DETECTION LIMIT	ALLOWED LIMIT (ref.)
Refrigerant CFC-11	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Refrigerant CFC-12	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Refrigerant CFC-114	<0.002 PPM	GC/MSD2	0.002 PPM	100 PPM(2)
Isopropyl Alcohol	<0.002 PPM	GC/MSD2	0.002 PPM	1 PPM(2)
Methanol	<0.002 PPM	GC/MSD2	0.002 PPM	10 PPM(2)
Methyl Chloroform	<0.002 PPM	GC/MSD2	0.002 PPM	30 PPM(2)
Methyl Ethyl Ketone	<0.002 PPM	GC/MSD2	0.002 PPM	20 PPM(2)
Methyl Isobutyl Ketone	<0.002 PPM	GC/MSD2	0.002 PPM	20 PPM(2)
Methylene Chloride	<0.002 PPM	GC/MSD2	0.002 PPM	25 PPM(2)
Toluene	<0.002 PPM	GC/MSD2	0.002 PPM	20 PPM(2)
Trimethyl Benzenes	<0.002 PPM	GC/MSD2	0.002 PPM	3 PPM(2)
Xylenes	<0.002 PPM	GC/MSD2	0.002 PPM	50 PPM(2)
Odor	pass	nose/smell	pass/fail	Not objectionable (4,5)

Other Components

Note: The estimated measured level for other components is calculated based upon the instrument response to Benzene

COMPONENT	ESTIMATED MEASURED LEVEL	ANALYSIS METHOD	DETECTION LIMIT	ALLOWED LIMIT (ref.)
NONE				

Test results are only applicable to the sample identified in the sample description. The sample showed no appreciable contamination. All components were within their specified limit.

[1]Expressed as methane equivalents.
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[4]Limits taken from Navy Dive Manual; Rev. 4, Table 4-1.
[5]Limits taken from Navy Dive Manual; Rev. 4, Table 4-2.

[redacted] 9-6-06
Analyst. Date

[redacted] 9-6-06
Test director. Date

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EQUIPMENT USED AND CERTIFICATION OF CALIBRATION

Date of Analysis: 6 September 2006 Reports 20060906DC01, 20060906DC02

1). (DT) Detector tubes.
A). The detector tubes are calibrated and certified at the factory.
B). The pumps are leak checked once prior to the days analysis.

TYPE	MANUFACTURER (M) MATHESON (S) SENSIDYNE	Tube#	LOT#	EXP. DATE
Ammonia	Sensidyne	105SD	483124	OCT 31,2007
Chlorine	Sensidyne	109U	149044	NOV 30,2006
Hydrogen	Sensidyne	137U	374024	NOV 30,2006
Hydrogen Sulfide	Sensidyne	120U	784074	NOV 30,2006
Nitrogen Dioxide	Sensidyne	117SD	118055	NOV 30,2006
Sulfur Dioxide	Sensidyne	103SE	145016	JAN 31,2007

2). (THA-FID) Total Hydrocarbon Analyzer. Next Cal. Date: 9/28/2006
[redacted] Model [redacted] S/N:1001597
Calibration Gas: Cylinder # LL50120.

3). (CO-IR, CO2-IR) CO/CO2 Analyzer. Next Cal. Date: 09/13/2006
[redacted], S/N: 300251154467
Calibration Gas: Cylinder # CC118848.

4). (HA) Total Halogenated Hydrocarbon Analyzer.
[redacted] Model # [redacted], S/N: H25C-N-N-5N-E
Next Cal. Date: 9/28/2006
Calibration Gas: Cyl#LL70932.

5). (SOA) Servomix Oxygen Analyzer.
[redacted] Type: 00244701, S/N: 1944.
Next Cal. Date: Once daily for every group of analysis.
Calibration Gas: Cyl# CC118848, Cyl# A582.

6). (GMMA) [redacted] Mercury Analyzer.
Model [redacted], S/N: 431-4032, Next Cal. Date: 12/15/2006

7). (GC-TCD) [redacted] Chromatograph.
[redacted] Model [redacted], S/N:390507
Next Cal. Date: Once daily for each group of samples.
Calibration Gas: Cyl # CC118848.

8). (GC-FID) HP 5890 Gas Chromatograph. (2 month calibration interval)
Calibration Date: 9/06/2006, Next Calibration Date: 11/06/2006
Chromatograph Model #5890E, S/N: 3336A55655
HP Integrator Model #3396B, S/N: 3028A20869
Calibration Gas: Cyl# FF42059.

9). (GC/MSD2) Agilent and Entech Gas Analysis System
Calibration Date: 8/30/2006, Next Calibration Date: 9/30/2006
[redacted] 5973N Mass Selective Detector, S/N: US35120299
[redacted] 6890N Gas Chromatograph, S/N: CN10418053
[redacted] 7100A Pre-concentrator, S/N: 1136
[redacted] 4600A Dynamic Diluter, S/N: 1051
[redacted] 3100A Canister Cleaner, S/N: 1074
Calibration Gas: Cyl# FF42027, CC232256,
FF42085, FF42051.
A). 2-Butoxyethanol.
Standard concentration: 1.092 g/l in Methanol.
Cal. Standard Expiration Date: 10/02/2006
2-Butoxyethanol raw material Lot # HR01139DR.

10). **Calibration gases.**

A). Cylinder #LL50120, Expiration Date: 06/17/2008
25.0 PPM Methane in air, accuracy +/-2%.

B). Cylinder #CC118848, Expiration Date: 05/25/2008
21.0% O_2, 0.905% Argon, 352 PPM CO_2, 14.9 PPM CO,
Bal. gas Nitrogen, accuracy +/-2%.

C). Cylinder #FF42085, Expiration Date: 5/08/2007
2.10 PPM Acetone, 2.1 PPM Freon 12, 2.1 PPM Freon 114,
2.10 PPM Toluene, 2.01 PPM 1,1,1-Trichloroethane, 2.10 PPM Freon 113,
2.07 PPM 1,2,4-Trimethylbenzene, 2.10 PPM 1,3,5-Trimethylbenzene, 2.09 PPM M-Xylene,
2.05 PPM O-Xylene, 2.10 PPM Methylene Chloride, Bal. Nitrogen, accuracy +/-2%.

D). Cylinder #FF42027, Expiration Date: 4/25/2007
2.10 PPM Chloroform, 2.10 PPM Trichloroethylene,
2.10 PPM 1,1-Dichloroethene, 2.08 PPM t-1,2-Dichloroethylene,
2.08 PPM Vinyl Chloride, Bal. Nitrogen, accuracy +/-2%.

E). Cylinder #FF42051, Expiration Date: 4/20/2007
2.10 PPM Ethanol, 2.16 PPM Isopropanol,
2.10 PPM Methanol, 2.19 PPM Methyl Ethyl Ketone,
2.10 PPM Methyl Isobutyl Ketone, 2.01 PPM Freon 11, 2.16 PPM Benzene,
Bal. Nitrogen, accuracy +/-2%.

F). Cylinder # LL70932, Expiration Date:4/27/2008.
9.99 PPM Chloromethane, Bal. Air, accuracy +/-2%.

G). Cylinder#A582, Expiration Date: N/A
Research Purity Oxygen, 99.999%.

H). Cylinder#CC232256, Expiration Date: 04/07/2007
3.04 PPM Formaldehyde, 0.986 PPM Acrolein, Bal. Nitrogen, accuracy: +/-5%

I). Cylinder#FF42059, Expiration Date: 8/11/2008
5.03 PPM Methane, 2.02 PPM Acetylene, 2.03 PPM Ethylene,
2.02 PPM Ethane, Bal. Nitrogen, accuracy: +/-1%

11). [redacted] Flow Controllers.
Model [redacted], S/N: 53914, Next Cal. Date: 10/05/2006

12). [redacted] Flow Check Meter
S/N: 003704, Next Cal. Date: 1-09-2007.
S/N: 011030, Next Cal. Date: 9-25-2006.

13). [redacted] Test gauge
0-200 psig, accuracy 0.25% of scale.
Cat#68033-07, S/N: 57443.
Next Cal. Date: 7/13/2007.

14). [redacted] Test gauge
0-100 psig, accuracy 0.25% of scale.
Cat#68033-06, S/N: 57442.
Next Cal. Date: 7/13/2007.

15). [redacted] Thermometer.
Model [redacted], S/N:6601, Next Cal. Date: 6/28/2008.
Model [redacted], S/N: 4688, Next Cal. Date: 6/28/2008.
Model [redacted] S/N: 2310474, Next Cal. Date: 3/28/2008.

16). [redacted] Scale.
Model [redacted] S/N:1127102591.
Next Cal. Date: 1/14/2007.

17). [redacted] Scale.
Model [redacted], S/N: G31930
Next Cal. Date: 7/14/2007.

18). [redacted] Multirange Scale
Model [redacted] S/N: 1905526
Next Cal. Date: 1/14/2007.

19). [redacted] Moisture Monitor
Model# [redacted] S/N: 303B8027
Next Cal. Date: 6/19/2007.

20). (CMP) [redacted] Flow Meter
Model [redacted], S/N:192107
Next Cal. Date: 7/13/2007.

Test Uncertainty

The following tables gives the test uncertainties associated with this test report.

TEST UNCERTAINTY					
ANALYSIS METHOD	DATE	% TEST UNCERTAINTY	ANALYSIS METHOD	DATE	% TEST UNCERTAINTY
GC-TCD			CO-IR	6/5/2006	14.9 PPM +/- 2.0%
Oxygen	9/6/2006	21% O2 +/-2.0%	CO2-IR	6/5/2006	352 PPM +/-2.0%
Argon	9/6/2006	0.902% Ar +/-2.2%	HA	8/28/2006	9.99 PPM +/-3.3%
Nitrogen	9/6/2006	78.1% N2 +/-2.8%	GC-FID		
SOA	6/5/2006	21% O2 +/-2.3%	1% Mix Accuracy	9/6/2006	CONC. CAL GAS </=5.3%
OMP	N/A	4.86 mg/m^3 +/-9%	AMA	N/A	5.0%
THA-FID	8/28/2006	25.0 PPM +/-2.0%	DT	N/A	25.0%
			GFMA	N/A	15.0%
QA_SHEET_UNCERTAINTY.XLS					

TEST UNCERTAINTY FOR GC/MSD2			
Compounds	PPB	$\%U_{TEST}$	MDL (PPB)
Formaldehyde	11	23.3	2.7
Freon-12	4	5.6	0.4
Freon-114	4	7.6	0.4
Vinyl Chloride	4	3.9	0.5
Methanol	4	9.4	0.6
Ethanol	4	10.1	0.8
Freon-11	4	4.5	0.5
Acrolein	4	6.6	0.7
Acetone	4	12.9	0.9
Isopropanol	4	5.2	0.7
1,1-Dichloroethene	4	3.3	0.3
Freon-113	4	6.5	0.4
Methylene Chloride	4	7.7	0.4
T-1,2-Dichloroethene	4	3.3	0.3
MEK	4	6.1	0.4
Chloroform	4	3.1	0.4
1,1,1-Trichloroethane	4	4.6	0.3
Benzene	4	4.5	0.3
Trichloroethylene	4	3.1	0.3
MIBK	4	20.2	1.3
Toluene	4	4.0	0.4
m-Xylene	4	4.8	0.5
o-Xylene	4	4.6	0.5
1,3,5-trimethyl Benzene	4	3.6	0.4
1,2,4-Trimethyl Benzene	4	3.6	0.4
2-Butoxyethanol	113	5.4	<19.0

I certify that the above data is correct.

[redacted]
Analyst

9-6-06
Date

[redacted]
Test Director.

9-6-06
Date

6, 7c

27 Sep 06

NEDU SHORT FORM MANNED TEST PLAN

1. TEST TITLE: MANNED EVALUATION OF POSSIBLE DIVE EQUIPMENT ERGONOMIC FACTORS CONTRIBUTING TO USCGC *HEALY* DIVING ACCIDENT

2. TEST PLAN NUMBER: TP06-31/32196

3. SPONSOR: NAVSEA 00C

4. TASK LEADER: LCDR [redacted]

5. REQUESTED TEST START/COMPLETION DATES: 27 SEP 2006

6. PURPOSE: Conduct a series of manned dives in NEDU test pool to a maximum depth of 15 fsw using trained Navy diver and all diving equipment worn by Coastguard divers during USCGC *Healy* Artic water dives (i.e., White dry suit, undergarments, five-finger gloves, under-gloves, buoyancy compensator, steel 100 tanks, 50 lbs of weight [20 lbs in removable pouch, 30 lbs in fixed BC vest pockets], [redacted] full face mask, split-fins etc.) to determine: a) ability of diver to maintain position in water column by finning while adding air to dry suit, b) ability of BC to lift diver dressed as accident divers were dressed, c) ability of diver to actuate dry suit add-valve and exhaust valve, d) ability of diver to drop additional weight emergently, e) restriction in movement due to suit squeeze and f) duration to onset of discomfort/disability due to suit squeeze as reported using underwater communications.

7. TEST ITEM DESCRIPTION: *Healy* Artic diving "accident" ensemble as detailed above with exception of the inclusion of a lightweight tending umbilical with diver communications cable. [redacted] FFM is to be fitted with communications microphone and bone phone.

8. TEST PROCEDURE REFERENCE: U. S. Navy Diving Manual, Revision 5

9. PROCEDURE/TEST PARAMETERS:

   a. Don equipment, surface checks with BC fully inflated, tended descent when instructed with diver attempting to maintain position in water column by finning. Diver to communicate comfort level and equipment operational difficulties.
   b. Diver on bottom, completely empty BC and dry suit. Weigh the diver on the tending line to determine amount of negative buoyancy.
   c. Activate dry suit add valve while on bottom, be prepared for possible uncontrolled ascent.
   d. Activate dry suit exhaust valve to return to bottom and empty suit.
   e. Release weights from BC vest beware of potential uncontrolled ascent.

f. Surface, attach LP whip to BC vest, descend when instructed, and replace weights into vest.
g. Using BC inflator, fill BC with air, ascend to surface without actively swimming.
h. Exit water, make report to Dive Supervisor.

10. GAS REQUIREMENTS: 3000 psi air in steel 100's

11. EQUIPMENT TO BE USED: *Healy* accident ensemble. Diver will have a tending umbilical, communications, and trained tender on the surface.

12. RISKS/SAFETY CONCERNS: Routine risk of diving U.S. Navy approved SCUBA equipment and following approved methods. There is a small risk of uncontrolled ascent following dry suit or BC inflation with attending risk of pulmonary over-inflation which will be mitigated by prior training, current awareness of risk, and diver supervision. Treatment chamber and medical personnel will be on the dive side during training dive.

13. EMERGENCY PROCEDURES: As per U.S. Navy Diving Manual. Diver will be equipped with a secondary air regulator. A stand by diver will be present during the training dive. Diver will have a tending umbilical attached with bidirectional communications with surface support.

14. TERMINATION CRITERIA: Diver, Task Leader, Dive Supervisor, or Medical Monitor may terminate this dive at any time for any stated reason.

15. TEST COMPLETION DELIVERABLE: Accident report to Coast Guard. Lessons learned report to NAVSEA 00C.

ORIGINATOR:	Name /(Code)	[redacted] LCDR MC USN
	06	[redacted] 27Sep 06
APPROVED:	00	[redacted] 27 Sep 06
VIA:	00D	[redacted]
	06	[redacted] 27Sep06
	03	[redacted] 10/27/06
CC:	02	
	SMO	
	IRB Chair	

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Enclosure (2)

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