SMALL BOAT TEST PLAN

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AVERY POINT, GROTON, CONNECTICUT 06340-6096

FINAL REPORT
APRIL 1987

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United States Coast Guard
Office of Engineering and Development
Washington, DC 20593
Standard tests to document the performance of Coast Guard small craft are outlined in this report. The test procedures for various calm and rough water aspects of small craft performance form general guidelines to be used in the writing of specific test plans for testing existing Coast Guard boats and candidate replacement craft. The Small Boat Test Plan is an extension, and in some cases an adaptation, of the existing General Test Plan for Advanced Marine Vehicles, with the focus on the special needs and requirements of small craft.
### METRIC CONVERSION FACTORS

#### Approximate Conversions to Metric Measures

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### Approximate Conversions from Metric Measures

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# TABLE OF CONTENTS

1.0 INTRODUCTION ........................................... 1

1.1 Purpose of the Small Boat Test Plan (SBTP) ........... 1
1.2 Background ........................................ 1

2.0 MISSION CRITERIA AND OPERATING CHARACTERISTICS ......... 1

3.0 SUGGESTED TEST PRIORITY LIST .......................... 3

4.0 TEST DESCRIPTIONS

<table>
<thead>
<tr>
<th>TEST NUMBER</th>
<th>PRINCIPAL CHARACTERISTICS</th>
<th>Page</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Deck Area and Internal Volume</td>
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</tr>
<tr>
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<td>Directional Stability</td>
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<tr>
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<td>Operational Capabilities</td>
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<td>Anchoring</td>
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<td>Time to Get Underway</td>
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<td>Visibility from Pilothouse/Coxswain Position Flat</td>
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<tr>
<td>25</td>
<td>Firefighting Capabilities</td>
<td>111</td>
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<tr>
<td>26</td>
<td>Helm and Throttle Response</td>
<td>114</td>
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<tr>
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<td>Maneuvering Speed</td>
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# LIST OF ILLUSTRATIONS

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<td>Tests Which May Be Conducted Concurrently</td>
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<td>Turning Radius Determination</td>
<td>27</td>
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<tr>
<td>7-1</td>
<td>Data Reduction By Hand</td>
<td>34</td>
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<tr>
<td>7-2</td>
<td>Histograms For Stable and Unstable Vessels</td>
<td>36</td>
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<tr>
<td>20-1</td>
<td>Naval Bar Chart</td>
<td>91</td>
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<tr>
<td>28-1</td>
<td>Boat Capacity Test Course</td>
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1.0 INTRODUCTION

1.1 Purpose of the Small Boat Test Plan (SBTP)

The objective of this effort is to compile and document comprehensive procedures which will be used for acquiring data on the performance and suitability of small boat replacements. The purpose for this effort is threefold. The document will provide a means of standardizing the way the Coast Guard looks at candidate small boat replacements which will facilitate a more accurate means of vessel comparison. It will also provide consistency to the full-scale trials program of existing Coast Guard small boats. Lastly, the tests will be described in detail to aid in the writing of specific test plans.

1.2 Background

The Research and Development Center (R&DC) was tasked by Commandant (G-DMT-2) in a statement of work dated 19 January 1981 to undertake the testing of an assortment of advanced marine vehicles and current Coast Guard vessels. Development of this Small Boat Test Plan was one of the requirements of that statement of work.

In 1981 a General Test Plan was written for use in the evaluation of all Coast Guard vessels. However, it did not address the needs of small boats. Research was conducted through journals containing information on foreign practices of small boat evaluations and through interviews of numerous small boat coxswains and crew members on both the Atlantic and Pacific coasts. The Small Boat Test Plan was developed from tests contained in the General Test Plan and through the information obtained through the research.

2.0 MISSION CRITERIA AND OPERATING CHARACTERISTICS

Coast Guard small boats have missions which require performance beyond that of the typical power boat. Prior to developing the Small Boat Test Plan, the small boat mission criteria and operating characteristics were determined. Although it may not be necessary for every small boat to have these characteristics, they were established in order to insure that tests were developed to cover all aspects of the mission performance.

SURVIVABILITY

(1) Self-righting
(2) Operate in surf environment
(3) Operate in heavy weather
(4) Watertight integrity
(5) Reliable equipment and machinery
MANEUVERABILITY

(6) Rapid helm response
(7) Rapid throttle response
(8) Directional stability
(9) Quick acceleration and stopping
(10) Slow speed agility

SPEED

(11) Decreased transit time and sustained speed in a seaway

POWER

(12) Adequate towing capability

SEAKEEPING

(13) Reduced vessel motions

RAPID RESPONSE

(14) Minimum time needed to get underway

RANGE

(15) Adequate fuel supply to perform several missions without refueling

HABITABILITY

(16) Acceptable noise levels
(17) Low vibrations
(18) Acceptable human factors in defined rough seas

VISIBILITY

(19) All around visibility for piloting station
(20) Reduced effects of vision loss from spray, icing, and fogging of windows

MAINTAINABILITY

(21) Minimize time and personnel needed to perform routine maintenance

OPERATIONS EQUIPMENT

(22) Communications: secure comms for ELT mission (VHF, loudhailer, etc.) Navigational: equipment properly placed so that it is functional (compass, Loran, RDF, radar, chart storage, etc.)
WORKING PLATFORM

(23) Adequate space or boarding, towing, and helo operations
(24) Adequate fendering system for boardings and towing operations
(25) Anchoring capability
(26) Towing bitt with sufficient strength and in proper location to be handled by one crew member

ACCOMMODATIONS

(27) Comfortable and secure seating for crew and passengers

FIREFIGHTING/DEWATERING

(28) Capabilities consistent with historical usage

WEAPONS

(29) Secure stowage for standard service issue weapons and associated ELT equipment
(30) Support for military preparedness
(31) Appropriate structural integrity of pilothouse to provide shelter from small arm rounds

3.0 SUGGESTED TEST PRIORITY LIST

Since Small Boat Testing may be conducted for any one of a number of reasons, the Test Director must prioritize the tests to be conducted so that the needs of the test program are met. For instance, if the testing is for acceptance trials of a contractor's vessel, then tests which verify the performance requirements of the contract must have the highest priority.

It is difficult to assign a strict, first-to-last priority list even for the general engineering characterization TECHEVAL's and OPEVAL's which are normally run (and to which this list is applicable), so the tests outlined in this guide have been grouped, based on previous experience and developmental needs, into 3 levels of priority.

The Test Director needs to be flexible, and if no further highest priority testing can be accomplished in a given time frame, as many lower priority tests should be run as possible, to gain the most possible information out of the always limited testing opportunities. (Within groups, tests are listed alphabetically, with no implied priority.)
Tests of the Highest Priority

Directional Stability
Fuel Consumption and Endurance
Helm and Throttle Response
Motion in Waves
Principal Characteristics
Speed Versus Power
Self Righting (if applicable)
Surf Operation (if applicable)
Visibility from the Pilothouse
Watertight Integrity

Tests of Medium Priority

Maximum Maneuvering Speed
Noise Level
Seakeeping Ability - Physiological
Slow Speed Agility
Spiral Test
Tactical Data
Towing Capability

Tests of Low Priority

Vibration Level
Operational Capabilities
Zig-Zag
Anchoring
Maintenance
Adverse Weather Operations
Moment to Heel and Trim
Firefighting
Time to Get Underway
Deck Area and Internal Volume

CONCURRENT TESTING

Figure 1 is a matrix of tests which can be conducted concurrently. Some tests are not included because they are not time limited. These include subjective evaluations where a questionnaire is to be filled out, evaluations involving observations by the test director, and evaluations where the data is acquired from ship's plans.
FIGURE 1. Tests Which May Be Conducted Concurrently
TEST NUMBER 1
PRINCIPAL CHARACTERISTICS

OBJECTIVE

To determine the principal characteristics of the marine vehicle and to collect general purpose plans and photographs.

PROCEDURE

Most of the data to be gathered in this test can be obtained from the ship's plans for the vessel being tested. Displacement data should be confirmed by comparing the draft for a known payload (fuel, water, lube oil, cargo, etc.) with the draft predicted from ship's plans. There may be a substantial difference between the payload the vessel was designed to carry and the actual payload it can carry without exceeding its maximum draft.

MEANS OF DETERMINING DATA - The following ship plans are to be obtained from the builder or owner of the vessel:

1. Outboard profile
2. Bow view outboard
3. Inboard profile
4. Deck plans for all decks (if applicable)
5. Midship section
6. Other cross sections showing machinery arrangement
7. Machinery arrangement drawings (for each deck)
8. Curves of form
9. Floodable length curves (only if test 18 is to be conducted)
10. Lines drawing

From these plans the following characteristics are to be determined:

1. Length overall (LOA)
2. Length between perpendiculars (LBP)
3. Maximum beam
4. Hull depth
5. Displacement (light ship)
6. Displacement (full load)
7. Draft (light ship)
8. Draft (full load)
9. Freeboard (maximum and minimum)
10. Minimum operating depth (full load draft plus 1 foot)
11. Radar antenna height (above full load waterline)
12. Height of eye from bridge (5'6" above Pilot House Deck or from normal coxswain's position)
13. Number of persons in crew
DATA FORMS

Form 1A is to be used to record this data. Form 1B is a check-off list of photographs to be taken.

PHOTOGRAPHIC DOCUMENTATION

Photographs of a general purpose nature are to be taken in this test. Some of the photographs may require the use of a helicopter. The photographs required are 35 mm slides and 8-1/2" x 11" prints taken from the following angles:

1. Beam view underway
2. Beam view at the dock
3. Bow view underway
4. Bow view at the dock
5. Stern view underway
6. Stern view at the dock
7. Bow view from 30 degrees to 60 degrees vertical angle
8. 30 degrees to 60 degrees vertical angle views broad on port and starboard bow, port and starboard beam, and broad on the port and starboard quarter
9. Stern view from 30 degrees to 60 degrees vertical angle

The photographs in items 7 through 9 are to be taken with the craft underway. Separate sets of photos should be taken if the craft has two significantly different operating configurations such as foilborne or hullborne in the case of a hydrofoil. Views designated to be taken at the dock can be taken with the vessel dead in the water away from the dock.

Sufficient videotape footage shall be taken so that a summary movie can be made of various craft photographed under this test. The movie will illustrate the differences and similarities between this vessel type and other vessel types. Brief and selective portions of the videotape shall be edited and provided with a voice-over narrative to show, in addition to the requirements above:

1. What the craft is
2. What is its basic performance
3. A record of any interesting evolutions (surf operations, boardings, etc.)
4. Important operational characteristics, problems, and abilities

ANALYSIS OF DATA

The only analysis required in this test is a calculation to determine what actual payload results in the design maximum displacement. This can be computed from the curves of form and the draft for a known payload.
DATA FORM 1A

PRINCIPAL CHARACTERISTICS

VESSEL NAME ___________________________ DATE __________________

RECORDER _______________________________

PLANS CHECK-OFF LIST (IF ANY PLANS ARE NOT APPLICABLE SO NOTE)

LINES DRAWING _______________ CROSS SECTIONS ______ ______
BOW VIEW _______________ FLOODABLE LENGTH _______________
OUTBOARD PROFILE _______________ MIDSHIP SECTION _______________
INBOARD PROFILE _______________ CURVES OF FORM _______________
DECK PLANS 3 __ 2 __ 1 ____ Main __ 01 __ 02 __ 03 ____

MACHINERY ARRANGEMENTS PLAN _______ PROFILE _______

PRINCIPAL CHARACTERISTICS

LOA ___________________________ LBP ___________________________
BEAM ___________________________ DEPTH _______________________
DISPLACEMENT (LIGHT SHIP) ___________ (FULL LOAD) ___________
DRAFT (LIGHT SHIP) ___________ (FULL LOAD) ___________
FREEBOARD (LIGHT SHIP) ___________ (FULL LOAD) ___________

MIN. OPERATING DEPTH OF WATER (FULL LOAD DRAFT +1') ___________

RADAR ANTENNA HEIGHT _______________________________________

HEIGHT OF EYE FROM HELM OR COXSWAIN'S POSITION __________

NUMBER OF CREW ___________________________
**DATA FORM 1B**

**PRINCIPAL CHARACTERISTICS**

**PHOTO CHECK LIST**

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<th>DATE</th>
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Note shot and roll number for each view

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Beam view underway

Stern view underway

Bow view underway

Views from 30 deg to 60 deg vertical angle underway

<table>
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<th>Bow</th>
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</table>

<table>
<thead>
<tr>
<th>Broad on port bow</th>
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</table>

<table>
<thead>
<tr>
<th>Broad on stbd bow</th>
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<table>
<thead>
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<table>
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<tr>
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</table>

<table>
<thead>
<tr>
<th>Broad on port quarter</th>
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<table>
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<th>Broad on stbd quarter</th>
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Views on dock or diw

<table>
<thead>
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<table>
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<table>
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TEST NUMBER 2
DECK AREA AND INTERNAL VOLUME

OBJECTIVE

To determine the available internal volume and deck area of the craft tested.

PROCEDURE

All data for this test will be obtained from the deck plans, lines drawing, and inboard profile. If these plans were not obtained in Test 1, they will need to be obtained from the builder or owner of the vessel.

MEANS OF DETERMINING DATA

Deck areas are to be obtained by measuring the gross deck area of compartments. The volume of these compartments may be calculated by multiplying the deck area by the height between decks taken from the inboard profile. Odd-shaped volumes such as tankage space should be computed using cross sectional areas and Simpson's rule. The following volumes and deck areas are to be determined.

1. Total enclosed volume of hull
2. Total enclosed volume of deckhouse
3. External deck area of each deck
4. Internal deck area of each deck
5. Maximum and minimum deck area or volume which is suitable for the following special uses:
   a. Liquids (fuel, water, lube oil, etc.)
   b. Accommodations (berthing, messing, sanitary, passageways)
   c. Machinery Space
   d. Pilot House, Bridge
   e. Provisions, Stores, and Cargo
   f. Stacks and Uptakes
   g. Ground Tackle (chain locker, winches, etc.)
   h. Operations equipment (towing, firefighting gear, weapons, etc.)

DATA FORMS

Form 2A is to be used to record this data.

ANALYSIS OF DATA

None required.
# DATA FORM 2A

## DECK AREA AND INTERNAL VOLUME

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### TOTAL ENCLOSED VOLUME OF HULL

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### TOTAL ENCLOSED VOLUME OF DECKHOUSE

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### EXTERNAL DECK AREA

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### INTERNAL DECK AREA

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### SPECIAL USE SUITABILITY

<table>
<thead>
<tr>
<th>MAX AREA/VOL</th>
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<tr>
<td>a. Liquids</td>
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<td>b. Accommodations, etc.</td>
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<tr>
<td>c. Machinery Spaces</td>
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<td>d. Pilot House</td>
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<td>e. Provisions and Cargo</td>
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<td>f. Stacks and Uptakes</td>
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<td>g. Ground Tackle</td>
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<td>h. Operations equipment</td>
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TEST NUMBER 3

SPEED VERSUS POWER

OBJECTIVE

To determine the speed/powering characteristics of the vessel under various conditions of load, operating configuration, and equipment disablement.

PROCEDURE

The design speed/power curves for the boat should be obtained if available. The maximum design speed should be obtained from this plan or some other reliable source. Additional data to be collected from plans or observations includes number of shafts, maximum SHP, and propeller characteristics (diameter, pitch, number of blades).

The actual speed/power performance of the vehicle is to be determined by making trial runs at various shaft RPM's. These trials should be conducted at RPM intervals from idle speed up to full power RPM. For outboard powered craft and other vessels where the trim of the propulsion unit and/or the hull can be varied, additional trials at various trim settings should be conducted.

If the displacement of the craft can be varied by more than 10 percent of full load displacement, then trials should be conducted near full load displacement and near light ship displacement. If the craft can operate in two distinctly different configurations (with an air cushion or without, as is the case for SES's), the test should be performed for each configuration. Likewise, certain cases of equipment disablement may be of interest. This could include one shaft locked for a multi-shaft vessel. It could also include an air fan disabled on an SES. In any event, the test procedure will not change although the maximum available power may change. Disabled equipment for this test must be listed in the SBTP.

All trials are to be run on a straight line course with minimal wind, current and wave height (flat calm if possible, particularly for small craft). A water depth greater than \(10 \frac{HV}{(L)^{1/2}}\) is required where:

- \(H\) = trial draft
- \(V\) = maximum speed
- \(L\) = length on waterline

A test area with good LORAN-C coverage is essential if speed is to be determined using LORAN information. The minimum test run at each speed is one mile.
MEANS OF DETERMINING DATA

Shaft horsepower and speed data are desired for this test. For a multi-shaft vessel, the SHP for each shaft is to be summed to obtain the total SHP. The preferred method for collecting SHP data is to install a torque and RPM transducer on each shaft. Vessel speed may be calculated from LORAN-C positions. LORAN-C positions should be recorded with the minimum possible averaging. LORAN-C readings taken 15 seconds apart are considered acceptable.

On boats with outboard engines or other vessels where installation of torsion meters are impossible, speed and RPM data will only be collected. Vessel speed may be determined from an installed speedometer that is sufficiently accurate, a speed test course, or with a radar speed gun. RPM data can be obtained from a stock electric tachometer on the boat which is properly calibrated.

PARAMETERS VARIED AND HELD CONSTANT

For each test run, the shaft RPM will be held constant within the limits of controls. This will result in a constant average speed. It is important that the speed be held as constant as possible since only the average speed can be computed from vessel positions. Shaft torque and RPM are to be recorded at frequent intervals (several times per second if using electronic recording, every 15 seconds, with the recorder averaging mentally if recording by hand). Therefore, average SHP can be computed accurately even with RPM variations.

It is extremely important that near calm conditions prevail during these tests. Wave height should be less than 2 feet, and wind speed must be below 15 knots for WPB size vessels or larger. For small craft, no more than a light chop can be tolerated, and winds should be under 10 knots. When possible, the speed trials should be run with the wind on the vessel's beam. Water current must be below 1 knot. Rudder angle should never exceed 10 degrees. This includes turning the vessel to proceed on an opposite course.

The following data is to be collected:

1. Vessel position at least once every fifteen seconds
2. Exact time of position reading
3. Shaft torque for each shaft at least once per second
4. Shaft RPM for each shaft at least once per second
5. Draft and trim of vessel
6. Operating configuration, including engine and tab trim settings
7. Equipment considered disabled
8. Wave height and direction
9. Wind speed and direction
10. Current conditions from current tables or from other observations such as buoy positions
11. Water depth
12. Temperature and density of the water in the trial area
13. Rudder angle

For outboard engines and other craft where shaft torque measurements are not possible, the following data will be collected:

1. Average shaft or propeller RPM
2. Average speed
3. Draft and trim of vessel
4. Operating configuration, including engine and tab trim settings
5. Wave height and direction
6. Wind speed and direction
7. Current conditions
8. Water depth

**INSTRUMENTATION REQUIRED**

1. LORAN-C receiver which is capable of providing positions at intervals of 15 seconds or less, is capable of translating the readings to latitude-longitude coordinates, and can be interfaced with a computer data collection system.

2. A real-time clock either integral with the LORAN-C receiver or integral with the computer system recording the data. This clock should be accurate to 1 second.

3. A shaft torsionmeter capable of interfacing with the computer. A shaft torsionmeter is an instrument for measuring the torsional deflection of a shaft over a known portion of its length, while the shaft transmits power from the engine to the propeller. This deflection is proportional to the transmitted torque and can be combined with measured shaft RPM and suitable calibration and physical constants to calculate shaft horsepower.

Any of the following types of torsionmeters can be used:

- Variable mutual - inductance gauges
- Resistance - wire strain gauges
- Phase - shift gauges
- Permeability - magnetic

Calibration should be performed in place by jacking the shafts if possible. See SNAME "Code for Sea Trials 1973" for procedures for calibrating torsionmeters.

4. A shaft RPM counter capable of interfacing with the computer.
5. An anemometer for wind speed and direction. Hand recording of data is acceptable.

6. An electronic depth sounder. Hand recording is acceptable.

7. A hydrometer for measuring water density and a thermometer for measuring water temperature. Hand recording is acceptable.

8. Computer data system for recording data.

9. Rudder angle transducer.

For outboard engines and other craft where shaft torque measurements are not possible, the following instrumentation is required:

1. Speedometer (accurate 1 mph) or radar gun if a speed test course is not used.

2. Tachometer to determine shaft or propeller RPM.

DATA FORMS

Form 3A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Shaft torque and SRPM data are to be processed together with appropriate constants to determine shaft horsepower. The ship position data is to be used to determine average ship speed.

A curve showing speed versus horsepower is to be drawn based on the results of the speed runs. Notation is to be included on this curve of the draft and trim of the vessel, operating configuration, equipment disabled, sea and wind conditions, water depth, water temperature and density.

A curve of speed versus SRPM will also be drawn for use in estimating speed using SRPM.
DATA FORM 3A
SPEED VERSUS POWER

VESSEL NAME ________________________________ DATE __________

RECORER ________________________________

LOCATION ________________________________

DRAFT FWD ________________________________

AFT ________________________________

OPERATING CONFIGURATION ________________________________

EQUIPMENT DISABLED ________________________________

________________________________________

WAVE HEIGHT __________ WAVE DIRECTION __________

WIND SPEED __________ WIND DIRECTION __________

CURRENT SPEED __________ CURRENT DIRECTION __________

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<th>END TIME</th>
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<th>SRPM</th>
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WATER DEPTH ________________________________

TEMPERATURE WATER ________________________________

DENSITY OF WATER ________________________________

DATA DISKS/TAPE NO. ________________________________

TEST RUN NOS. ________________________________

16
TEST NUMBER 4

FUEL CONSUMPTION AND ENDURANCE

OBJECTIVE

To determine main engine fuel consumption. The amount of usable fuel which can be carried will be obtained and from this data the endurance for various operating conditions will be computed. Computing endurance requires that Test 3, speed versus power, be performed as well.

PROCEDURE

Data for this test can be collected during the speed versus power runs of Test 3 or any other operations in which the shaft horsepower is varied over its full range. Main engine fuel consumption will be compared to shaft horsepower.

MEANS OF DETERMINING DATA

Shaft horsepower and fuel flow data are required for this test. Shaft horsepower should be determined using a shaft torsionmeter and SRPM counter as described in Test 3. Fuel flow should be measured at a point in the fuel lines where fuel flow to a single engine or single auxiliary is present. For many diesel engines, the fuel is recirculated to the tank for injector and fuel pump cooling. In these cases, both the fuel to the engine and from the engine must be measured. Main engine fuel consumption should be measured over a range of speeds from idle through maximum power so that curves can be drawn.

For most engines, fuel consumption varies with both horsepower and torque. Because of this, fuel consumption data should be collected with the vessel traveling in a free-running, transit condition. Additional data can be collected for different operating configurations and during towing if desired.

Determining the fuel consumption of auxiliaries is not as critical as determining main engine fuel consumption. Therefore, appropriate indicators of engine or other auxiliary load can be recorded by hand while measuring fuel flow rate.

The amount of usable fuel carried should be determined from ship's plans.

PARAMETERS VARIED AND HELD CONSTANT

For each test run the shaft RPM should be held constant for a sufficient time to accurately measure fuel flow. This time will be largely dependent on the type of fuel meter used. The time required for a one-mile speed run is more than sufficient time for most fuel meters. Test runs should be made from idle RPM to full power in the free running condition. Additional runs should
be made if the craft has two or more significantly different operating configurations.

Wave height should be less than 4 feet for WPB or larger size craft during these trials, and under 2 feet for small craft, but they can be run in higher waves if necessary. Wind and current conditions will have little effect.

The following data are to be collected:

1. Shaft torque for each shaft at least once per second (every 15 seconds if recording by hand)
2. Shaft RPM for each shaft at least once per second (every 15 seconds if recording by hand)
3. Fuel flow
4. Operating configuration
5. Wave height
6. Water depth
7. Fuel oil temperature near flow meters (for density)
8. Fuel type

INSTRUMENTATION REQUIRED

1. A shaft torsionmeter is required which can be interfaced with the computer data-gathering system
2. A shaft RPM counter capable of interfacing with the computer data-gathering system
3. Flow measurements may be made using either clamp-on ultrasonic flow meters or in-line positive displacement meters, turbine meters, variable area meters, or measuring flow nozzles.
4. Water depth should be measured by an electronic depth sounder. Hand recording of data is acceptable.
5. Power indicators for auxiliary devices should be taken from existing instrumentation and may be recorded by hand.
6. A thermometer in the fuel line near the gauges is required to determine fuel density. Hand recording of the temperature is adequate.
7. Computer data system for recording data.

DATA FORMS

Form 4A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Shaft torque and SRPM data are to be processed together with appropriate constants to determine shaft horsepower. Fuel
consumption in weight units should be computed based on flow to and from the engine or device and from the temperature and type of fuel.

A curve showing fuel consumption versus power for each main and auxiliary engine or device is to be developed. Separate curves will be drawn for each operating configuration or for high torque loads such as towing conditions. Notation will be made on the curves of the operating configuration, wave height, and water depth.

Vessel endurance versus speed curve will be drawn using the results of this test and Test 3. This will only be done if Test 3 was performed. Notation will be made on these curves of operating configuration, minimum water depth, and usable fuel carried.
DATA FORM 4A
FUEL CONSUMPTION AND ENDURANCE

VEssel Name __________________________ Date __________
Recorder ______________________________
Operating Configuration ____________________
Wave Height ___________________ Wave Direction __________

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<thead>
<tr>
<th>RUN #</th>
<th>TIME</th>
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<th>PORT SHAFT</th>
<th>STBD SHAFT</th>
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<td>RPM HP</td>
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FUEL TYPE __________________ WATER DEPTH __________________
TEST NUMBER 5

TOWING CAPABILITY

OBJECTIVE

To determine the towline pull of the vessel in a static (bollard) pull condition and in an at-sea towing condition.

PROCEDURE

Bollard Pull

A line of adequate strength to safely withstand the full power bollard pull of the vessel is to be used. This line will be connected between the vessel and a shore anchoring point of sufficient strength. The towline pull will be measured by a load cell installed in this line. If the vessel being tested was not designed for towing, the best anchor point on the ship may not be apparent. If no adequate anchor point is available, this test should not be attempted. The strength of the towing bitt onboard the vessel should also be considered, and the tests must be discontinued immediately if the safe working load of any of the loaded components is reached.

A water depth of at least five times the vessel's draft is highly desirable. If water of this depth is not available the test can be conducted but the results will be affected due to the restriction in water flow to the propeller. In any case, sufficient room behind the vessel must be allowed so that the wake is not restricted and no circulating flow is established.

Bollard pull readings will be made for at least five levels of power between idle power and full power. Towline force must be allowed to stabilize before data are taken.

Towing at Sea

If a barge or other vessel is available for the test craft to tow, then at-sea towing trials can be performed. The procedure for these trials is the same as for the bollard pull tests except that speed will also need to be measured. The towing speed will be increased in steps until full power is reached or until the maximum safe towing speed (based on the size and character of the tow, the strength of the towing arrangements and prudent seamanship) is obtained. The tests must be discontinued immediately if the safe working load of any of the loaded components is reached.

If possible, two or more vessels of significantly different drag should be towed to better document the performance of the test vessel.
MEANS OF DETERMINING DATA

Shaft horsepower, towline pull, and speed are the principal data to be collected. Shaft horsepower requires the collection of data on shaft torque and shaft RPM. Towline pull force can be measured using a load cell in the towline. Speed for the at-sea trials will be determined from vessel positions at specific times.

Shaft thrust should also be recorded if instrumentation to measure the thrust is installed. This is rarely the case. Installing transducers to measure shaft thrust is not recommended because of the minimal value of the data obtained and the expense of the installation.

Propeller curves for the actual propellers installed should be obtained if available. These curves are useful in checking results.

PARAMETERS VARIED AND HELD CONSTANT

During the test, the shaft RPM will be set to a specific level and a reading of towline pull taken. In the at-sea towing trials, the power level must be maintained long enough to determine speed accurately. Wave height, wind speed, and current should be minimal as they will have a large effect on the results. The tests may be duplicated for different operating configurations if desired.

The following data are to be collected:

1. Shaft torque for each shaft at least once per second
   (see Instrumentation note 10)
2. Shaft RPM for each shaft at least once per second
3. Towline force once each second
4. Ship position updated at least once every fifteen seconds
5. Exact time of position readings
6. Draft and trim of the vessel
7. Operating configuration
8. Wave height and direction
9. Wind speed and direction
10. Current speed and direction
11. Water depth
12. Temperature and density of water in the trial area
13. Shaft thrust (if available)

INSTRUMENTATION REQUIRED

1. A shaft torsionmeter which can be interfaced with the computer data-gathering system.
2. A shaft RPM counter capable of interfacing with the computer
3. A load cell of adequate size to measure the maximum bollard pull. Read-out must be capable of interfacing with the computer.
4. LORAN-C receiver for position fixing
5. Real-time clock
6. Anemometer for wind speed and direction
7. Electronic depth sounder
8. Hydrometer for measuring water density
9. Thermometer for measuring water temperature
10. Computer data system for recording data. Hand recording of Items 6 through 9 is always acceptable. If a computer data system is not available, manual recording of all data may be employed recording the mentally deduced average value for each 15 second period.

DATA FORMS
Form 5A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION
None required.

ANALYSIS OF DATA
Shaft torque and SRPM data are to be processed together with appropriate constants to determine shaft horsepower. For the at-sea trials, the boat positions and time data will be used to compute average towing speed.

A curve will be drawn showing bollard pull versus shaft horsepower and versus SRPM. These curves will be annotated with the draft and trim of the vessel; water depth, density and temperature; wind speed and wave conditions and operating configuration.

If shaft thrust is available, a separate curve will be plotted of shaft thrust versus shaft horsepower.

Data from the at-sea trials will be plotted in the same way. Separate curves will be shown on the same plot if two or more vessels were towed. A plot of speed versus RPM while towing is also to be drawn.
DATA FORM 5A
TOWING CAPABILITY

VEssel NAME ___________________________ DATE __________________
RECORder ______________________________
LOCAtion _______________________________
DRAFT FORWARD ________________________
AFT ___________________________
OPERATING CONFIGURATION ________________________________
VEssel TOWED NAME ___________________________ TYPE ________________
LENgTH __________________ DISPLACEMENT __________________
WAVE HEIGHT __________________ WAVE DIRECTION ________________
CURRENT SPEED ________________ CURRENT DIRECTION ________________

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WATER DEPTH ___________________________
TEMPERATURE WATER ___________________________
DENsITY OF WATER ___________________________
DATA DISKS/TAPE NUMBER ___________________________
TEST RUN NUMBERS ___________________________

24
DATA FORM 5B

BOLLARD PULL

VESSEL NAME ___________________________ DATE ___________

RECORDER ______________________________

LOCATION ______________________________

DRAFT FWD ___________________________ DRAFT AFT ______________

WATER DEPTH _______________ TEMP _______ DENSITY ________

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25
TEST NUMBER 6
TACTICAL DATA

OBJECTIVE
To determine turning circle parameters, acceleration, and stopping characteristics of the test vessel.

PROCEDURE

Turning Circle

Turning circle data will be taken at three speeds ahead. These speeds are to correspond to approximately 1/3, 2/3, and maximum speed. If the test craft has two or more distinctive operating configurations, the test should be repeated for each.

At each of the three speeds, turns will be made both right and left at three rudder angles. These rudder angles are to correspond to 1/3, 2/3, and full rudder. All turns will begin with the ship on a straight course at stable speed. The course will continue until sufficient positional data points are available to accurately compute the speed. On signal, the rudder will be put over to the desired rudder angle and held there for the remainder of the turn. The turn will continue for 540 degrees or 1-1/2 times around.

If electronic position-indicating equipment is unavailable, or if its accuracy is insufficient, as is the case for small boats, an alternative procedure using buoys and an observer on shore may be used. A site is selected with adequate open area and minimum of current. The site should be opposite an on-shore or fixed anchorage observer position as shown in Figure 6. Two buoys are moored as indicated. The observer site is equipped with a pelorus or a transit. The distance "y" is measured and is sufficient to permit the vessel to develop full speed prior to reaching the turn point.

The vessel is positioned at the start point, is started, and is moved at the desired speed along the path indicated on Figure 6. Upon reaching the turn point buoy, the desired helm order is executed. The vessel continues in a circle until it has turned 180 degrees and reached the signal point. The observer notes and records the angle between the starting path and the signal point. To pinpoint time, a signal may be transmitted from the vessel to the observer at the instant the two turn buoys are aligned, indicating the 180 degree point.

The vessel is repositioned at the starting point and proceeds to accomplish the next speed and helm order.
FIGURE 6-1. Turning Radius Determination

\[ r = \frac{1}{2} x = \frac{1}{2} y \tan \phi \]

\( \phi \) — Distance between buoys to be equal to the craft's beam plus 12 feet
More complicated optical tracking schemes can be devised using multiple observers and points of reference to gain the same sort of X-Y position information as the electronic systems, with obvious limitations in range and allowable weather conditions.

**Acceleration and Stopping**

The time and distance to accelerate from dead in the water to full speed ahead will be found in this test as well as the time to come to a stop from full ahead (crash stop) and the time to go from full ahead to full astern (crash reversal). In each of these trials, maximum power is to be used. Position information will again be used to determine the distances involved and the deviation from the base course when stopping and reversing. The rudder should be left amidships during these maneuvers.

**MEANS OF DETERMINING DATA**

The key parameters for the turning circles include: ship speed, ship position, shaft RPM, and rudder angle all measured against time. The parameters for acceleration and deceleration trials include ship speed and ship position measured against time. Ship heading is a secondary parameter for the turning circle trials.

Ship speed can be obtained from the ship's position so does not need to be collected separately. Accurate rudder angle and SRPM are important and transducers should be installed to measure these quantities. Ship heading is useful for analyzing the data and should be recorded if motion instrumentation is installed. If not, the time for passing each 90 degrees from the base course should be noted manually.

**PARAMETERS VARIED AND HELD CONSTANT**

The same water depth, wind, wave, and current conditions apply to these trials as apply to Test 3, speed versus power. Namely:

- **Water Depth** \(10 \frac{H}{V/L^{1/2}}\)
- **where** \(H\) = vessel draft
  \(V\) = maximum speed
  \(L\) = LBP
- **Wave Height** < 2 feet for WPB or larger, light chop for small boats
- **Wind Speed** < 15 Knots for WPB or larger, 10 Knots for small boats
- **Current Speed** < 1/4 knot

The parameters to be varied for each of the trials has already been described under PROCEDURE.
The following data is to be collected for the turning circle trials:

1. Ship position at least every fifteen seconds for ships, every five seconds for boats.
2. Exact time of each position
3. Shaft RPM
4. Rudder angle
5. Draft and trim of vessel
6. Operating configuration
7. Wave height and direction
8. Wind speed and direction
9. Current speed and direction
10. Water Depth
11. Temperature and density of water
12. Ship's heading or time of passing each 90 degrees
13. Roll angle, if motions package is available

Data for the acceleration and deceleration trials is the same except that rudder and roll angle information is not required.

INSTRUMENTATION REQUIRED

1. LORAN-C receiver, or microwave position finding equipment which can be interfaced with computer data-gathering system, OR a pelorus or engineers transit and several buoys.
2. Real-time clock
3. Shaft RPM counter
4. Rudder angle transducer
5. Anemometer for wind speed and direction
6. Electronic depth sounder
7. Thermometer and hydrometer for water temperature and density
8. Motion package (only if already installed)
9. Computer data-gathering system. No attempt should be made to conduct this test without suitable recording equipment.

DATA FORMS

Form 6A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.
ANALYSIS OF DATA

Turning circle data will be shown in the form of tables and plots of the following parameters:

1. Speed (approach and during turn)
2. Rudder angle
3. Approach RPM
4. Base course
5. Advance
6. Transfer
7. Tactical diameter
8. Turning circle diameter
9. Time at 360 degrees

Notation will be included of the other data collected.

See "Principles of Naval Architecture" for a complete description of each of the turning circle parameters, which will be obtained from the plots of position versus time. Generally some hand fairing of the data will be needed in order to get a smooth ship's track, and to enable the distances and diameters to be measured. The alternate procedure using the shore observer computes the turning circle diameter only using the formula shown in Figure 6.

Deceleration and acceleration data will be reported as curves of reach and speed versus time. Plots of the vessel's trackline will also be given for the deceleration trials. These plots will be annotated with the other data collected.
DATA FORM 6A
TACTICAL DATA

VESSEL NAME ____________________________ DATE __________
RECORDER ________________________________
TIME START __________________________ LOCATION ______________
FINISH ___________________________________
DRAFT FORWARD __________________________
AFT ______________________________
OPERATING CONFIGURATION ________________________________
WAVE HEIGHT ___________________ WAVE DIRECTION __________
WIND SPEED ___________________ WIND DIRECTION __________
CURRENT SPEED ___________________ CURRENT DIRECTION __________
WATER DEPTH ________________________________
WATER TEMPERATURE ________________________________
WATER DENSITY ________________________________
RUN NUMBER ________ RUDDER ANGLE ________ SPEED ________

<table>
<thead>
<tr>
<th>TIME</th>
<th>HEADING</th>
<th>BASE COURSE = BC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BC ± 90</td>
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<tr>
<td></td>
<td></td>
<td>BC ± 180</td>
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<tr>
<td></td>
<td></td>
<td>BC ± 270</td>
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<tr>
<td></td>
<td></td>
<td>BC ± 360</td>
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<td></td>
<td></td>
<td>BC ± 450</td>
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<tr>
<td></td>
<td></td>
<td>BC ± 540</td>
</tr>
</tbody>
</table>

DATA DISKS/TAPE NUMBER ________________________________
TEST NUMBER 7

DIRECTIONAL STABILITY

OBJECTIVE

To assess the vessel's ability to be steered on a straight course. This test evaluates the entire ship system, including the helmsman or coxswain, and can be used to identify problems such as yawing in following seas.

PROCEDURE

The test consists of having the helmsman hold as steady a course as he/she is able for 10 minutes. A landmark on shore makes the best heading reference, but a gyro or magnetic compass may be used. When conducting the test in calm water, any course may be chosen. If the seas are relatively calm, but a wind in excess of 10 kts is present, a course either directly into or with the wind should be chosen. If the seas are over 2-3 ft, multiple courses should be run as per Test Number 13 - Motion in Waves.

Repeat tests should be run with different helmsmen.

MEANS OF DETERMINING DATA

Some means must be provided for recording the activity of the vessel's steering system. This may involve taking a signal from an existing rudder or drive angle indicator, or fitting such a device to the tiller, rudder post, wheel or outboards. The signal (preferably a voltage) should be recorded on an analog tape recorder. Alternatively, it may be used as an input to a Digital Data Acquisition System.

PARAMETERS VARIED AND HELD CONSTANT

The helmsman, to the best of his/her ability, attempts to hold the course of the vessel constant. The throttle settings are left unchanged for the duration of the test, as are all other relevant operating characteristics. Tests may be run at different speeds; suggested speeds are the vessel's Economical Cruise speed, Maximum Speed, and Minimum Speed.

The following data is to be collected:

1. Draft and Trim of the vessel
2. Operational Configuration
3. Wave height and direction
4. Wind Speed and direction
5. Current speed and direction
6. Water depth
7. Experience Level of Helmsman
INSTRUMENTATION REQUIRED

1. Anemometer for wind speed and direction
2. Depth sounder
3. Rudder angle indicator or equivalent
4. Analog tape recorder or digital Data Acquisition System
5. Signal Analyzer
6. Hand recording is suitable for all data other than rudder angle.

DATA FORMS

Data form 7a is to be used to record data on conditions of the test. Data form 7b may be used to reduce rudder angle data from sources not recorded on tape, or if a signal analyzer or program is not available.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

The signals of the rudder angle transducers shall be reduced to engineering units and plotted as an amplitude histogram with rudder angle as the x-axis. This is most easily done by using a signal analyzer. The y-axis values should be non-dimensionalized by using the number of observations, or the total time of the test, as appropriate. If a digital Data Acquisition System is used to record the data, then the raw data must be processed using the appropriate software to yield a histogram.

If the data must be reduced by hand, a hard copy of the time history should be obtained. This may be a strip chart or oscillograph trace, or a printout of the digitized data. The range of the rudder angle output should be divided into at least 20 (preferably many more) equal bands. For strip chart data, the total time the trace is within each band is found. For tabular data, giving the signal at equally spaced time intervals, the number of times the signal is within each band is tabulated. The results are then divided by the total time of the test or the total number of observations to non-dimensionalize the plot. A bar graph, with the bands of helm activity as the ordinate and the non-dimensionalized occurrences as the abscissa, is then constructed. Figure 7-1 shows examples of data reduction by hand.

The Mean, Standard Deviation, and Skewness should be computed for the non-dimensionalized distribution.

INTERPRETATION OF DATA

Since this test is new, and is not referenced in the standard Naval Architecture texts, a few notes on its interpretation are in order.
Tabular Output

<table>
<thead>
<tr>
<th>Time</th>
<th>Rudder Angle (deg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00:00</td>
<td>0.08 (Band 10)</td>
</tr>
<tr>
<td></td>
<td>0.11 (Band 11)</td>
</tr>
<tr>
<td>0:00:10</td>
<td>0.34 (Band 12)</td>
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<tr>
<td></td>
<td>0.24 (Band 11)</td>
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<tr>
<td></td>
<td>0.22 (Band 11)</td>
</tr>
<tr>
<td></td>
<td>0.36 (Band 12)</td>
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<tr>
<td>etc.</td>
<td>etc.</td>
</tr>
</tbody>
</table>

Band | Range | Occurrences | Non-dimensional |
-----|-------|-------------|-----------------|
1    |       |             |                 |
10   | 0-15  | n10         | n10 total       |
11   | 15-30 | n11         | n11 total       |
12   | 30-45 | n12         | n12 total       |
20   |       |             |                 |
Total = \( \sum n_i \) = n10 + n11 + n12 + \( \ldots \) + n20

Strip Chart or Oscillograph Trace

FIGURE 7-1. Data Reduction by Hand
If the vessel is directionally stable, the seas flat, the winds calm, and there are no asymmetries in the hull, rudder, steering system, etc., the histogram will show a relatively narrow normal distribution centered on zero. If there are any influences on the vessel which are non-symmetrical, such as misaligned dual rudders, wind or waves from the beam or quarter, then even a stable ship will display a shift in the peak of the distribution to the right or left of center, along with some spreading away from the mean (an increase in the standard deviation). As a ship becomes less stable, the distribution spreads, until finally an un-stable vessel will show a double-peaked histogram.

Typical histograms for stable and unstable vessels are shown in figure 7-2. A vessel with neutral stability will exhibit a curve somewhere between these extremes. If a vessel's stability is suspect, a spiral test is strongly recommended to provide additional information.
Stable

Unstable

No Asymmetries

With bent rudder, wind on beam, etc.

FIGURE 7-2
DATA FORM 7a

DIRECTIONAL STABILITY (RUDDER ANGLE HISTOGRAM)

<table>
<thead>
<tr>
<th>VESSEL NAME</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RECORDER</td>
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<tr>
<td>LOCATION</td>
<td>WATER DEPTH</td>
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<tr>
<td>TIME START</td>
<td>FINISH</td>
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<tr>
<td>OPERATING CONFIGURATION</td>
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<tr>
<td>WAVE HEIGHT</td>
<td>WAVE DIRECTION</td>
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<td>WIND SPEED</td>
<td>WIND DIRECTION</td>
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<td>DRAFT FWD</td>
<td>AFT</td>
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<td>RUN #</td>
<td>SPEED</td>
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<td>HELMSMAN &amp; EXPERIENCE</td>
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<tr>
<td>TIME START</td>
<td>FINISH</td>
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<tr>
<td>TAPE COUNT START</td>
<td>FINISH</td>
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<td>RUN #</td>
<td>SPEED</td>
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<td>HELMSMAN &amp; EXPERIENCE</td>
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<td>HELMSMAN &amp; EXPERIENCE</td>
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<td>TIME START</td>
<td>FINISH</td>
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<td>TAPE COUNT START</td>
<td>FINISH</td>
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</tbody>
</table>

37
## DATA FORM 7b

### DIRECTIONAL STABILITY (RUDDER ANGLE HISTOGRAM)

<table>
<thead>
<tr>
<th>Band (#)</th>
<th>Range (volts)</th>
<th>Range (deg)</th>
<th>Occurrences or Time in band (# or sec)</th>
<th>Non-dimensional</th>
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Total Time or Occurrences = __________________________
TEST NUMBER 8
MANEUVERABILITY - SPIRAL TEST

OBJECTIVE

To determine the vessel's maneuverability using the Dieudonne Spiral Maneuver.

PROCEDURE

For conventional displacement craft speed has little effect on directional stability as measured by this test. Since unconventional craft are to be tested, it is recommended that at least two ahead speeds and one astern speed be tested. These speeds should be approximately 1/3 and 2/3 speed ahead and half speed astern. If they are known, the boat's speed most unfavorable to directional stability should be substituted.

If two or more significantly different operating configurations are possible each should be tested. The test is very sensitive to wave and weather conditions. The spiral test is intended to provide a measure of the directional stability of the ship. If the vessel is unstable, it usually possesses two stable yaw rates for the same rudder angle. Significant wind or sea loads can cause the yaw rate to switch from one of these rates to the other. Winds, therefore, must be less than five knots and seas less than one foot.

With the vessel in the specified operating configuration and proceeding ahead at the designated speed on a steady course, the rudder is moved to 15 degrees to starboard and held until the turning rate becomes steady. The rudder is then moved to each of the following successive settings and held until a steady turning rate is obtained, 10 deg. R, 5 deg. R, 3 deg. R, 1 deg. R, 0 deg., 1 deg. L, 3 deg. L, 5 deg. L, 10 deg. L, 15 deg. L, 10 L, 5 deg. L, 3 deg. L, 1 deg. L, 0 deg., 1 deg. R, 3 deg. R, 5 deg. R, 10 deg. R, 15 deg. R.

If any of the rudder angles is overshot, it is essential to leave the rudder at that angle and not return it to the value listed.

MEANS OF DETERMINING DATA

Rudder angle and yaw rate are the key parameters in this test. The rudder angle can be set by the helmsman using installed indicators if these are known to be reasonably accurate. However, the actual rudder angle should be measured with a transducer installed on the rudder shaft. Yaw rate should be measured with a motion transducer. This is preferable to reading gyro angles at fixed time increments and provides an excellent indication of when the yaw rate has settled to a steady value.
Boat speed is not critical and can be approximated by setting shaft RPM to a value known to produce the desired speed. If an accurate means of setting the speed is not known, then the boat's position should be plotted and the speed calculated on-scene until a reasonably close approximation to the required speed is obtained.

PARAMETERS VARIED AND HELD CONSTANT

As mentioned earlier, wind and weather conditions are particularly critical for this test. Required values are:

Wind Speed     < 5 knots  
Wave Height    < 1 foot

In addition, water current should be less than one knot. The parameters to be varied have been described under PROCEDURE.

The following data is to be collected:

1. Boat speed and corresponding RPM  
2. Rudder angle  
3. Yaw rate  
4. Wind velocity and direction  
5. Boat's base course  
6. Water depth  
7. Wave height and direction  
8. Draft and trim of vessel  
9. Operating configuration  
10. Current speed and direction

INSTRUMENTATION REQUIRED

1. LORAN-C receiver may be required if accurate speed versus RPM data is not available.  
2. Rudder angle transducer capable of interfacing with computer  
3. Yaw rate transducer (motion package) capable of interfacing with computer.  
4. Anemometer for wind speed and direction  
5. Depth sounder  
6. Computer data-gathering system

DATA FORMS

Form 8A is to be used to record the data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.
ANALYSIS OF DATA

Yaw rate will be plotted against rudder angle and annotated with the other parameters obtained. This plot gives a direct indication of the stability or instability of the vessel.
DATA FORM 8A
MANEUVERABILITY - SPIRAL TEST

VEESLE NAME _______________________________ DATE ____________

RECORDER ________________________________

BASE COURSE ___________ SPEED ___________ RPM ___________

WAVE HEIGHT ___________ WAVE DIRECTION ________________

WIND SPEED ___________ WIND DIRECTION ________________

CURRENT SPEED ___________ CURRENT DIRECTION ________________

WATER DEPTH ________________________________

DRAFT FORWARD ________________________________

AFT ________________________________

OPERATING CONFIGURATION ________________________________

<table>
<thead>
<tr>
<th>Rudder Angle (Deg.)</th>
<th>Start Time</th>
<th>Tape Counter</th>
<th>Rudder Angle (Deg.)</th>
<th>Start Time</th>
<th>Tape Counter</th>
</tr>
</thead>
<tbody>
<tr>
<td>15R</td>
<td></td>
<td></td>
<td>15L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10R</td>
<td></td>
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<td>10L</td>
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<tr>
<td>5R</td>
<td></td>
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<td>3R</td>
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<td>1R</td>
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<td>15L</td>
<td></td>
<td></td>
<td>15R</td>
<td></td>
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</tbody>
</table>

DATA DISKS/TAPE NUMBER ________________________________

TEST RUN NUMBERS ________________________________
TEST NUMBER 9
MANEUVERABILITY - ZIGZAG TEST

OBJECTIVE

To determine the vessel's maneuverability using the zigzag maneuver and to determine the limit of low speed maneuverability.

PROCEDURE

The results of this test are dependent on the vessel speed used during the test. As a result, the test should be conducted at different speeds and using different operating configurations. Three speeds are recommended. These are idle speed, half ahead, and full ahead. Each significantly different operating condition should be tested in the zigzag maneuver. Low speed maneuverability need only be tested in the operating configuration most likely to be used for low speed maneuvering. If the vessel cannot operate at speeds less than 6 knots, the low speed maneuvering tests cannot be performed.

With the vessel in the specified operating configuration and proceeding ahead into the wind at the specified speed, move the rudder at the maximum rate and perform the following maneuvers:

Rapidly move the rudder from amidships to 20 deg. R - hold until vessel's heading is 20 degrees to the right of the original course.

Rapidly move the rudder from 20 deg. R to 20 deg. L - hold until vessel's heading is 20 degrees to the left of the original course.

Rapidly move the rudder from 20 deg. L to 20 deg. R - hold until vessel's heading is 20 degrees to the right of the original course.

Rapidly move the rudder from 20 deg. R to 20 deg. L - hold until original heading is restored. Steady on original course. Additional zigzags can be made before returning to base course if desired.

In the low speed maneuverability test, the following procedures will be used:

With the vessel in the specified operating configuration and proceeding into the wind on a steady course at six knots ahead, conduct the following maneuvers:

Lay the rudder to 10 deg. R and hold for 30 seconds.

Move the rudder to 10 deg. L and hold for 30 seconds.
Move the rudder to 0 deg. and hold for 30 seconds.

Return to the base course and adjust the speed to six knots with the rudder at 0 deg.

Lay the rudder to 35 deg. R and hold for 30 seconds.

Move the rudder to 35 deg. L and hold for 30 seconds.

Move the rudder to 0 deg. and hold for 30 seconds.

Return to base course and adjust to the next speed.

Repeat the maneuver with the speed decreased at one-knot intervals until the speed at which the vessel does not respond to the helm is determined.

Wind speed should be below 15 knots and wave height should be below three feet for WPB and larger vessels during these trials. 10 knots and 2 feet are the limits for small boats, and calmer seas are preferred.

**MEANS OF DETERMINING DATA**

No critical measurements are required for the low speed maneuverability trials. For the zigzag maneuver, the rudder angle, yaw angle, and vessel position are required. Ship speed is not critical and can be approximated using SRPM.

**PARAMETERS VARIED AND HELD CONSTANT**

Wind speed and wave height limits were given earlier. Current should be less than one-half knot. Water depth should be as specified for speed/power trials.

The following data is to be collected for the zigzag maneuver:

1. Base course
2. Time of rudder shifts
3. Rudder angle
4. Yaw angle
5. SRPM while on base course initially
6. Wind velocity and direction
7. Wave height and direction
8. Current speed and direction
9. Water depth
10. Draft and trim
11. Boat's position
12. Operating configuration

These same data will be collected for the low speed maneuverability test. Rudder angle and yaw angle measurements for that test are not critical and can be eliminated if desired.
INSTRUMENTATION REQUIRED

1. Rudder angle transducer capable of interfacing with a computer
2. Yaw angle transducer (motion package) capable of interfacing with a computer
3. Anemometer for wind speed and direction
4. Depth sounder
5. LORAN-C receiver capable of interfacing with a computer
6. Real-time clock

DATA FORMS

Form 9A is to be used to record the data for the zigzag maneuver and Forms 9A and 9B will be used for the low speed maneuverability trials. Other data will be stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

For the zigzag maneuver, the data will be presented as plots of rudder angle, yaw angle, and position all against time. These plots will be annotated with the other parameters measured.

The following parameters measured from the plots will be presented in tabular form:

(a) Time from first execute to second execute
(b) Period of the zigzags
(c) Overshoot yaw angle
(d) Overshoot width of path

For the low speed maneuverability test, the maximum departures of yaw from the base course will be reported in tabular form for each speed-rudder angle combination. Also reported will be the speed at which the ship could no longer effectively maneuver.
# DATA FORM 9A

**MANEUVERABILITY - ZIGZAG TEST**

<table>
<thead>
<tr>
<th>VESSEL NAME</th>
<th>DATE</th>
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</thead>
<tbody>
<tr>
<td>RECORDER</td>
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<tr>
<td>TIME START</td>
<td>LOCATION</td>
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<tr>
<td>OPERATING CONFIGURATION</td>
<td></td>
</tr>
<tr>
<td>BASE COURSE</td>
<td>SRPM</td>
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<tr>
<td>DRAFT FORWARD</td>
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<tr>
<td>AFT</td>
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<tr>
<td>WATER DEPTH</td>
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<td>WAVE DIRECTION</td>
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<td>WIND SPEED</td>
<td>WIND DIRECTION</td>
</tr>
<tr>
<td>CURRENT SPEED</td>
<td>CURRENT DIRECTION</td>
</tr>
<tr>
<td>TIME OF FIRST EXECUTE</td>
<td>LORAN POSITION LAT</td>
</tr>
<tr>
<td>TIME OF SECOND EXECUTE</td>
<td>LONG</td>
</tr>
<tr>
<td>TIME END OF TEST</td>
<td>LORAN POSITION LAT</td>
</tr>
<tr>
<td></td>
<td>LONG</td>
</tr>
</tbody>
</table>

**NOTE:** MAINTAIN BASE COURSE ± 2 DEGREES FOR AT LEAST 30 SECONDS BEFORE FIRST EXECUTE.

USE 20 DEGREES RUDDER AND MAINTAIN UNTIL COURSE IS BASE COURSE ± 20 DEGREES.

SET YAW GYRO TO ZERO WHILE ON BASE COURSE INITIALLY.

**DATA DISKS/TAPE NUMBER**

**TEST RUN NUMBERS**
DATA FORM 9B

LOW SPEED MANEUVERABILITY

VESSEL NAME __________________________ DATE __________

RECORDER ______________________________

RUDDER ANGLE/SPEED CHECK-OFF LIST

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<tr>
<th>HELM ORDER</th>
<th>6 KNOTS</th>
<th>5 KNOTS</th>
<th>4 KNOTS</th>
<th>3 KNOTS</th>
<th>2 KNOTS</th>
<th>1 KNOT</th>
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</table>
TEST NUMBER 10

SLOW SPEED AGILITY

OBJECTIVE

To assess a vessel's ability to maneuver at slow speed in tight quarters, such as encountered in docking, towing, and man-overboard situations.

PROCEDURE

Using small buoys, a rectangular box, open at one end, 1 1/2 boat lengths wide by 2 boat lengths long is laid out in a sheltered area away from strong winds, waves and currents. A qualified coxswain enters the box on one of the short ends so that the vessel under test is completely within the box, then by casting about (using any combination of helm and throttle settings desired), performs a 180 degree turn and exits the box, without having touched the sides of the enclosure. This maneuver should be performed several times, with several coxswains, and a 41 ft UTB, a 44 ft MLB or a RHI should be available for comparison.

This test should not be considered valid unless at least 3 coxswains perform the maneuver 5 times in each of two vessels, the test vessel and a reference vessel.

MEANS OF DETERMINING DATA

The success or failure of the vessel to perform the tests is the primary data to be collected. Secondary data shall include the time from the bow's entrance into the box until the stern's exit, the engine RPM and/or throttle setting used at the start of the test, the number of helm and propeller direction changes needed to perform the maneuver, and the helmsman's evaluation as recorded on Data Form 10.

PARAMETERS VARIED AND HELD CONSTANT

The operating condition of the vessel shall be typical for it's designed mission. The Helmsman should be a qualified small boat Coxswain experienced in UTB, MLB, TANB, RHI or other small boat operations. Use of several different Coxswains with different levels and types of experience is strongly recommended. Wave height, wind speed and current should be minimal as they will have a large effect on the results.

The following data is to be taken:

1. Success or failure of each maneuver
2. Time to complete the maneuver
3. Engine RPM or throttle setting upon entering the course
4. Number of Back and Fill attempts needed to complete the maneuver
5. Draft and Trim of the vessel
6. Operational Configuration
7. Wave height and direction
8. Wind Speed and direction
9. Current speed and direction
10. Water depth
11. Exact dimensions of the test enclosure

**EQUIPMENT REQUIRED**

1. At least 7 marker buoys, preferably with a staff such as a man-overboard buoy.
2. Stopwatch
3. Anemometer for wind speed and direction
4. Depth sounder
5. Polypropylene line marked at one-foot intervals or other means to accurately position the buoys
6. Hand recording is suitable for all data

**DATA FORMS**

Form 10 is used to record the data, and Questionnaire 10 is used to record the Coxswain's impressions

**PHOTO DOCUMENTATION**

A video record of the maneuver is highly desirable. Still photos at regular intervals may also be taken.

**ANALYSIS OF DATA**

The number of successful maneuvers shall be divided by the number of attempts to determine the success ratio. The time to complete the maneuver should be presented as an average, and if there appears to be a "learning curve" it shall be presented as a function of the number of attempts. The results from the questionnaires should be tabulated and presented, along with any significant comments on Data Form 10.
**DATA FORM 10**
**SLOW SPEED AGILITY**

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VESSEL NAME</td>
<td></td>
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<tr>
<td>DATE</td>
<td></td>
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<tr>
<td>RECORDER</td>
<td></td>
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<tr>
<td>LOCATION</td>
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<tr>
<td>WATER DEPTH</td>
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<td>TIME START</td>
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<td>FINISH</td>
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</tr>
<tr>
<td>OPERATING CONFIGURATION</td>
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<tr>
<td>DRAFT FWD</td>
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<tr>
<td>AFT</td>
<td></td>
</tr>
<tr>
<td>WAVE HEIGHT</td>
<td></td>
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<td>WAVE DIRECTION</td>
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<td>WIND SPEED</td>
<td></td>
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<tr>
<td>WIND DIRECTION</td>
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<tr>
<td>RUN NUMBER</td>
<td></td>
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<tr>
<td>COXSWAIN</td>
<td></td>
</tr>
<tr>
<td>BOAT</td>
<td></td>
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<tr>
<td>SUCCESSFUL ?</td>
<td></td>
</tr>
<tr>
<td>TIME (SEC)</td>
<td></td>
</tr>
<tr>
<td># OF BACK/FILLS</td>
<td></td>
</tr>
</tbody>
</table>

Draw a sketch showing the dimensions of the test course. Note how the buoys were located (i.e., using a transit, measuring line, etc).
QUESTIONNAIRE 10 - SLOW SPEED AGILITY

VESSLE NAME ____________________________

YOUR NAME ____________________________ DATE __________

TIME IN SMALL BOATS _______________________

This questionnaire covers some of the aspects of slow speed boat handling that are difficult to measure. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question or if it does not apply to the boat you tested. If there are any additional comments you would like to make regarding slow speed handling, please include them in the Remarks section.

1. Overall, how do you feel the slow speed handling of this boat compares to a 44 ft MLB?

<table>
<thead>
<tr>
<th>Much better</th>
<th>Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better</td>
<td>Much worse</td>
</tr>
<tr>
<td>About the same</td>
<td>Not Observed</td>
</tr>
</tbody>
</table>

2. Overall, how do you feel the slow speed handling of this boat compares to a 41 ft UTB?

<table>
<thead>
<tr>
<th>Much better</th>
<th>Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better</td>
<td>Much worse</td>
</tr>
<tr>
<td>About the same</td>
<td>Not Observed</td>
</tr>
</tbody>
</table>

3. Overall, how do you feel the slow speed handling of this boat compares to a RHI?

<table>
<thead>
<tr>
<th>Much better</th>
<th>Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better</td>
<td>Much worse</td>
</tr>
<tr>
<td>About the same</td>
<td>Not Observed</td>
</tr>
</tbody>
</table>

4. How do you rate the overall slow speed handling of this boat?

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Terrible</td>
</tr>
<tr>
<td>Only fair</td>
<td></td>
</tr>
</tbody>
</table>

5. How would you rate the ease of use of the engine controls?

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Terrible</td>
</tr>
<tr>
<td>Only fair</td>
<td></td>
</tr>
</tbody>
</table>

6. How would you rate ease of use and power of the helm?

<table>
<thead>
<tr>
<th>Excellent</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>Terrible</td>
</tr>
<tr>
<td>Only fair</td>
<td></td>
</tr>
</tbody>
</table>
QUESTIONNAIRE 10 - SLOW SPEED AGILITY (cont’d)

7. Can the Coxswain see the side of the boat from his position?
   - Yes ___
   - No ___
   Comments ___________________________________________________________________

8. Can the Coxswain communicate with the crew from his position?
   - Yes ___
   - No ___
   Comments ___________________________________________________________________

9. Without yelling?
   - Yes ___
   - No ___
   Comments ___________________________________________________________________

10. Can the Coxswain easily reach the controls?
    - Yes ___
    - No ___
    Comments ___________________________________________________________________

11. Can the Coxswain easily read the gauges without distraction
    or interference from other objects?
    - Yes ___
    - No ___
    Comments ___________________________________________________________________

12. How would you rate the overall arrangement of the Coxswain’s
    position for slow speed handling?
    - Excellent ___
    - Poor ___
    - Good ___
    - Terrible ___
    - Only fair ___

13. What is the boat’s behavior when backing with the helm
    centered and both engines reversed at the same speed?
    - Veers sharply to Port ___
    - Drifts to Stbd ___
    - Drifts slowly to Port ___
    - Veers to Stbd ___
    - Backs relatively straight ___
    - Not Observed ___

14. Does the boat back easier in one direction than the other?
    - Much easier to back to Port ___
    - Easier to Stbd ___
    - Easier to back to Port ___
    - Much easier to Stbd ___
    - About the same ___
    - Not Observed ___
QUESTIONNAIRE 10 - SLOW SPEED AGILITY (cont’d)

15. How would you rate the rudder effectiveness in reverse?
   Excellent ___  Poor ___
   Good ___      Terrible ___
   Only fair ___

16. How would you rate the boat’s ability to "twist" with the throttles split?
   Excellent ___  Poor ___
   Good ___      Terrible ___
   Only fair ___

17. Does the boat twist easier in one direction than the other?
   Much easier to twist to Port ___  Easier to Stbd ___
   Easier to twist to Port ___  Much easier to Stbd ___
   About the same ___  Not Observed ___

18. Remarks. Comment on any factors concerning slow speed handling which were not covered above.
TEST NUMBER 11

SELF-RIGHTING ABILITY

OBJECTIVE

To determine whether or not a vessel can, without outside influence, right itself from a 180 degree capsize, and to assess the time such a righting will take, the damage done the vessel in a capsize and righting, and the possible hazards to it's crew.

The Overturning/Righting Moment curve at large angles of heel may also be verified using this test procedure.

PROCEDURE

The subject vessel is loaded as nearly as possible to it's operational condition. Outfitting on a vessel under construction should be very nearly complete, less electrical and electronic equipment which cannot withstand immersion. The vessel's doors and hatches should be secured as they would normally be in heavy weather and/or breaking surf conditions. Two crane slings, preferably wide fabric webbing, with a safe working load equivalent to the displacement of the vessel are attached to the gunwale of the vessel and lead under the keel to emerge opposite their attachment point. If a remote quick release can be arranged, at the attachment point of either the slings to the boat, or of the crane hook to the slings, this would diminish any effect of the crane wire or the slings on the boat's ability to right. The boat should be moored with a minimum of restraint to roll, as if for an inclining, and there should be at least one boat length clearance in all directions from any fixed or floating obstruction. The test director must make allowances for the vessel rolling in either direction once the slings have been released.

If there are any protective devices fitted to minimize damage in a capsize, such as engine or radar scanner cutoffs, they should be operating, along with the systems they protect.

Tension is slowly taken up on the crane until the vessel is inverted (175 degrees minimum). When the Test Director is certain that all is ready, the tension is released suddenly, either with a remote release or by releasing the brake on the crane. A weight on the crane wire may cut down on possible backlash of the winch drum.

MEANS OF DETERMINING DATA

The roll angle versus time is the principal data to be collected during the test. The roll angle should be measured using: 1) a transducer rigidly attached to the boat's structure and capable of recording 360 degrees of roll, and 2) by using a pendulum type indicator on the superstructure, transom, or stem of the vessel.
large and legible enough to be read and photographed from a reasonable distance. Some method of synchronizing all observations should be employed.

The crane load versus roll angle can be used to compute the righting moment at the extreme roll attitudes seen during the test, and can be measured using the crane's own load indicator, or by using a load cell between the crane hook and the slings.

PARAMETERS VARIED AND HELD CONSTANT

The vessel's inertial properties (Displacement, Center of Gravity, Metacentric Height, Free Surface and Roll Gyradius) should be held constant during repeated tests, and should adhere as closely as possible to the vessel's actual operational condition. The buoyancy, drag, and watertight integrity of all hull and topsides structures should also be preserved, and should also reflect actual operating conditions. For example, masts must be fitted, and structures of similar weight, profile and buoyancy to the various radomes and antennas that would normally be fitted. In between repeat tests, the vessel should be boarded and checked for damage. Any water shipped should be measured as it is removed, and note made of any spilled fluids, etc.

Water depth is immaterial, other than it should be at least equal to 1 1/2 times the height of the highest point on the vessel. Wind, wave and current conditions should be as calm as possible.

The following data is to be collected:

1. Roll angle versus time
2. Crane load versus time (optional)
3. Water depth
4. Vessel draft and trim, before and after test
5. Water shipped and damage suffered

INSTRUMENTATION REQUIRED

1. Roll transducer capable of measuring 360 degrees. Ideally this would be a vertical gyro, but a dampened pendulum attached to a rotary encoder (optical, slide wire, etc) or a vertical accelerometer may be used instead.
2. Visual reading pendulum mounted on superstructure.
3. Depth sounder
4. Time code generator (optionally 2, with one outputting to photo or video equipment)
5. Recording equipment for roll and time code (analog)
6. Lines plans and hydrostatics curves
DATA FORMS

Data form 11a is to be used to record data on conditions of the test. Data form 11b is to be used to tabulate roll angle and crane load versus time from sources not recorded on tape.

PHOTO DOCUMENTATION

Data is also to be recorded photographically. At a safe distance directly astern of the vessel, high speed still photography (interval motor drive), video and/or motion picture equipment (in that order of desirability) should be setup to record the vessel's righting motions. The visual indicating pendulum should be visible, and ideally time information should be included in the image in some manner.

ANALYSIS OF DATA

The signals of the roll transducers shall be reduced to engineering units and plotted as a function of time. The first derivative of the roll angle with respect to time shall also be computed and plotted. The time to right from 180 degrees to zero degrees roll shall be reported, along with the water shipped and damage sustained.

The crane load data must be converted to overturning moments by analyzing the still pictures and the lines plan to assess the moment arm through which the overturning force was acting. In this way, a righting moment versus roll angle curve can be computed, since overturning moments equal righting moments in the static condition of equilibrium. Corrections must be made for the weight of crane wire and boat attachment tackle.
DATA FORM 11a
SELF RIGHTING ABILITY

VESSEL NAME ___________________________ DATE _____________

RECORDER ________________________________

LOCATION ________________________________ WATER DEPTH ______

TIME START ____________________________ FINISH _____________

OPERATING CONFIGURATION ________________________________

WAVE HEIGHT ________________ WAVE DIRECTION ________________

WIND SPEED ________________ WIND DIRECTION ________________

BEFORE TEST

DRAFT FWD ________________ AFT ________________

AFTER TEST

DRAFT FWD ________________ AFT ________________

WATER TAKEN ABOARD ________________________________

______________________________

DAMAGE ________________________________

______________________________

______________________________

DATA STORED ON TAPE: ________________________________

TAPE COUNT START ________________ TAPE COUNT FINISH ________________

DIGITIZED DATA ON DISK ________________ FILE NAME __________________
DATA FORM 11d
SELF RIGHTING ABILITY

OVERTURNING MOMENTS (OPTIONAL)

<table>
<thead>
<tr>
<th>TIME (SEC)</th>
<th>ROLL ANGLE (DEG)</th>
<th>CRANE LOAD (POUNDS)</th>
<th>ESTIMATED ARM (FT)</th>
<th>MOMENT (FT-LBS)</th>
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<tbody>
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58
TEST NUMBER 12

MOMENT TO HEEL AND TRIM

OBJECTIVE

To determine the effect of moving a fixed weight already on board the vessel in the athwartship direction. Also to be determined is the radius of gyration about the fore and aft axes of the vessel.

PROCEDURE

The moments to heel and trim the vessel are available from the curves of form. However, the center of gravity assumed for the curves of form may be significantly different from the true center of gravity. The actual metacentric height will be confirmed by inclining the vessel through a small angle by moving fixed weight already on board. The procedures for a standard inclining experiment will be followed except that the inventory on board at the time of the experiment will be considered the in-service inventory and no additions or subtractions will be made. Tanks should be either entirely empty or pressed up. The actual level of each tank will be measured before the experiment.

The vessel will also be sallied in the athwartships directions in order to determine the roll period. This will be accomplished by adding and quickly removing a weight from the vessel.

Weather for these tests must be excellent. They will be accomplished near a dock, preferably at slack tide with minimal wind or current effects. Waves are to be less than six inches.

MEANS OF DETERMINING DATA

In the inclining experiment, a known weight is moved through a precise distance and the resulting angle of heel or trim is precisely measured. The conventional method for measuring the angle is with a long pendulum.

A motion package capable of accurately (± 1/4 degrees) measuring pitch and roll angles is required for the radius of gyration experiments. A weight will be added to the hull and removed to induce a pure roll motion and the roll decay curve will be recorded.

PARAMETERS VARIED AND HELD CONSTANT

Water depth is not critical for this experiment but should be at least ten feet greater than the draft of the vessel if possible.
Wave and weather conditions should be nearly dead calm. Namely:

Wind speed < 5 knots
No current
Wave < 6 inches

If possible, the vessel should be headed into the wind for the trials.

The following data is to be collected for the inclining experiment:

1. Known weight
2. Distance weight is moved
3. Heel or trim angle (± 1 minute of arc)
4. Initial draft and trim
5. Water temperature and density
6. Wind speed and direction
7. Wave height
8. Tank soundings
9. Deck plans
10. Sounding tables
11. Righting moment curves for vessel
12. Water depth

For the radius of gyration test, the following is required:

1. Continuous roll or pitch angles (± 1/4 degrees)
2. Initial draft and trim
3. Tank soundings
4. Water depth

INSTRUMENTATION REQUIRED

1. Large pendulum
2. Crane and a large weight; weight size will depend on the vessel tested. An angle of approximately 2 degrees is required.
3. Motion package
4. Computer or tape data collection system
5. Thermometer and hydrometer
6. Sounding tapes
7. Depth sounder

DATA FORMS

Data Forms 12A and 12B will be used to record data from these experiments. Other data will be recorded on magnetic tape or computer disks.

PHOTO DOCUMENTATION

None required.
ANALYSIS OF DATA

The metacentric (GM) height will be reported together with tank soundings, deck plans, and sounding tables for the tanks. No attempt will be made to reduce the data to determine the hull CG because the GM value for heel is more appropriate to the study of vessel motions and stability. The resulting data will be compared to the vessel's righting moment curve if it is available. The moment to trim one foot will also be reported from the curves of the form.

The radius gyration can be determined from the formula:

\[
\text{Period} = \frac{1.1080 \times K}{(\text{GM})^{1/2}}
\]

where K is the radius of gyration
Period is the measured roll period
GM is the metacentric height computed by

\[
\text{GM} = \frac{w \times d}{W \times \tan \Theta}
\]

From the inclining experiment

w = weight of object moved (known weight)
d = distance moved
W = weight of the vessel
\(\Theta\) = the heel or trim angle measured

Radius of gyration and motion decay curves will be reported for roll motions.

REFERENCES

For further discussion of the inclining experiment, see the following references:


United States Coast Guard Navigation and Vessel Inspection Circular No. 15-81, "Guidelines for Conducting Stability Tests".

**DATA FORM 12A**

**INCLINING EXPERIMENT**

**PRE-TEST PREPARATIONS**

<table>
<thead>
<tr>
<th>VESSEL</th>
<th>DATE</th>
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<table>
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<tr>
<td>STBD FWD</td>
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<td>READ TO NEAREST 1/4 INCH</td>
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<tr>
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<td>PORT AFT</td>
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<table>
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<th>WATER DEPTH</th>
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<th>WATER DENSITY</th>
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**CHECK LIST**

- HAVE TANK LEVELS BEEN ADJUSTED? ____ PERSONNEL BRIEFED? ____
- VALVES SECURED TO PREVENT TRANSFER OF LIQUIDS? ____
- SWINGING WEIGHTS SECURED? ____ GANGWAY STOWED? ____
- LINES SLACKED? ____
DATA FORM 12A
INCLINING EXPERIMENT
PAGE 2

VEssel Name ___________________________ Date _______________________

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<td>MAX STBD</td>
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<tr>
<td>WEIGHT USED</td>
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TANK SOUNDINGS ATTACHED? ______________

SOUNDING TABLES ATTACHED? ______________

CURVES OF FORM ATTACHED? ______________

RIGHTING MOMENT CURVES ATTACHED? ________

DRAW DIAGRAM SHOWING WEIGHT LOCATIONS AND DISTANCES
DATA FORM 12B
RADIUS OF GYRATION EXPERIMENT

VEssel ___________________________ DATE ___________________________
RECODER ___________________________ LOCATION ___________________________
START TIME ___________________________ FINISH TIME ___________________________

DRAFDTS
  FWD __________  AFT __________

GM ______  HOW WAS GM OBTAINED ? __________________________

TANK SOUNDINGS ATTACHED ? __________________________

WAS DATA RECORDED ? ________  OR PERIOD TIMED ? ________

DATA DISK/TAPE NUMBER __________________________

TEST RUN NUMBERS __________________________

TIMES
<table>
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</table>
TEST NUMBER 13
MOTION IN WAVES

OBJECTIVE

To determine the response amplitude operators of the vessel to waves. This may be required for all six degrees of freedom. Also to be determined are the significant wave height $H_{1/3}$ and corresponding significant motions.

PROCEDURE

This test requires that a motion package capable of measuring the motions desired as well as appropriate recording equipment be placed aboard the test vessel. A method of measuring wave amplitudes in the test area is also required. This is usually accomplished by placing a wave buoy in the water and recording its motions during the time interval of the test.

The vessel is to be operated on courses which will produce head seas, astern seas, beam seas, seas broad on the bow, and seas broad on the quarter. Ship motions will be recorded for each of these directions over a 20-minute period. Wave height from the wave buoy will also be recorded. The vessel should remain as close to the wave buoy as possible. The following pattern of courses is preferred:

![Course Pattern Diagram]

The tests will be conducted for one speed and one operating configuration. Additional speeds and operating configurations can be specified. The maximum vessel speed and preferred operating configuration for that speed will be used if no variation is specified.

MEANS OF DETERMINING DATA

The motion package should contain a gyroscopic reference to horizontal and a fixed horizontal (yaw) angle reference. Ship angular motions are measured relative to these fixed references. The angles are:
The angles are:

- roll - about longitudinal axis
- pitch - about athwartships axis
- yaw - about vertical axis

The same fixed reference should be used to measure accelerations or velocities relative to an "earth" reference. This is the preferred method. Accelerations or velocities relative to a "ship" reference are also an accepted way to conduct the test. Linear motions to be measured are

- heave - vertical direction
- sway - athwartships direction
- surge - longitudinal direction

Wave buoy data is usually in the form of vertical motion. This may be an acceleration of velocity but should be integrated over time to provide a vertical buoy displacement which is taken to equal the wave height variation with time.

**PARAMETERS VARIED AND HELD CONSTANT**

Water depth is not critical to this test but should be at least five times the draft of the vessel. Wave height should usually be between two to six feet for vessels in the 100- to 200-foot range. Two to four foot seas are recommended for testing small boats. Too small a wave height produces small motions and too large a wave height produces non-linear response. Wind and current have only a small effect on the results. Testing in a well developed sea is preferred.

Vessel speed and operating configuration will be held constant for each series of courses. Additional series may be conducted for different speeds or configurations. Speed may be set to sufficient accuracy using shaft RPM. Course and speed should be maintained for at least 20 minutes on each leg to provide sufficient data for analysis.

The following data is to be collected:

1. Wave height versus time
2. Vessel motions versus time - roll, pitch, yaw, heave, sway, and surge
3. Water depth
4. Operating configuration
5. Shaft RPM
6. Apparent wave direction
7. Vessel course
8. Draft and trim of vessel
9. Wind speed and direction
10. Location of motion package
INSTRUMENTATION REQUIRED

1. Wave buoy with necessary recording and telemetry equipment. A wave staff may also be used if suitable.
2. Motion package capable of measuring the desired motions
3. Recording equipment for motion package (analog required)
4. Depth sounder
5. Anemometer for wind speed

DATA FORMS

Data Form 13A is to be used to record data not stored on tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Wave and motion data will be converted from a time to a frequency scale using a spectrum analyzer with a Hanning windowing function. The response amplitude operator (RAO) for each motion will be produced. This RAO is only an approximation to the true RAO for the vessel and must be used with caution in predicting vessel motions under other wave conditions.

Wave heights and motion amplitudes will also be sorted and the value of the 1/3 highest motions or wave heights computed. The 1/10 highest amplitudes will also be presented.
DATA FORM 13A
MOTION IN WAVES

VEssel Name __________________________ Date __________________

Recorder ______________________________________________________

Operating Configuration _________________________________________

RPM ____________________ Speed _______________________________

Draft Forward _______________ Draft Aft __________________________

Apparent Wave Direction _______________ True

Wind Speed _______________ Wind Direction ________________ True

Water Depth __________________ DensitY __________________________

Location of Motion Package ______________________________________

<table>
<thead>
<tr>
<th>RUN #</th>
<th>Vessel Course</th>
<th>Direction To Waves</th>
<th>Start Time</th>
<th>Finish Time</th>
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</table>

Data Disk/Tape Number __________________________________________

68
TEST NUMBER 14

SURF OPERATIONS

OBJECTIVE

To determine the ranking of a subject vessel's surf handling compared to one or more existing Coast Guard vessels.

PROCEDURE

The suitability of a vessel for the near-shore rescue mission depends on a number of factors such as seakeeping, ruggedness, reliability, etc. This test focuses on the handling aspects of the near-shore rescue mission, and is designed as a comparison between a test vessel and a Coast Guard reference vessel. Suitable reference vessels are the 44 ft MLB and the 30 ft SRB.

At least 3 complete boat crews shall be assembled (one for each test boat plus one extra to be rotated in), with each crewmember being a qualified Surf Coxswain. A suitable test location must be chosen to provide challenging surf and inlet conditions. The test vessel and the reference vessel should be thoroughly prepared for the tests so that they are at the peak of their capabilities. A safety vessel should be available at all times and arrangements for rapid response of other Coast Guard resources to any emergency must be made, as the hazards of surf operations cannot be underestimated.

The boat crew personnel should be randomly divided into crews, and assigned to boats. The boats should then undertake a typical surf boat maneuvers such as running in and out of inlets, entering and exiting the surf zone, performing man-overboard drills in the surf and picking up a simulated casualty in the surf. Only one maneuver at a time will be attempted during each test session. The details of each maneuver should be worked out in advance in planning discussions with the boat crews. Once a procedure is decided upon, it should be duplicated as nearly as possible for every test. The maneuver should be duplicated several times by each coxswain, until he feels he is performing the maneuver to the best of his and the boat's capabilities. The other members of the boat crew shall then take turns at the helm, and the maneuvers repeated, until each member of the boat crew has performed the maneuvers. Boat crews should then be changed, and members of the crews re-assigned in a "round robin" fashion, so that the effects of different helmsmen and different crews can be randomized. If possible, testing should be conducted in a variety of different conditions, continuing to re-assign crews and boats.

Different types of boats, while all being suitable for surf rescue, may require different handling techniques to perform the same tasks. Sufficient time to familiarize the boat crews with the subject vessel should be allowed prior to the test sessions.
and instruction from an expert (such as a manufacturer's representative) in the handling of the subject vessel to be sought.

MEANS OF DETERMINING DATA

Upon the completion of each test session, the crew shall score the boats on their ability to perform the session's maneuvers using questionnaire 14. This should be done as soon as the crews return from the session. Discussion of the session should be limited until after the questionnaire has been filled out to avoid influencing each individual's perceptions of the boats.

The usual test condition data shall also be recorded.

PARAMETERS VARIED AND HELD CONSTANT

The factor to be evaluated is the boat; the effect of the crew is minimized by using the "round-robin" assignment of certified/qualified crews and boats. Other conditions are out of the Test Director's control, but surf should be at least 4 ft during the test sessions. The test area must have suitable areas of surf and/or inlet conditions.

The following data is to be collected:

1. Draft and Trim of the vessel
2. Operational Configuration
3. Wave height and direction
4. Wind Speed and direction
5. Current speed and direction
6. Water depth in the test area

INSTRUMENTATION REQUIRED

1. Anemometer for wind speed and direction
2. Depth sounder
3. Hand recording is suitable for all data

DATA FORMS

Data form 14 is to be used to record data on conditions of the test. Questionnaire 14 is to be used to record the boat crew's impressions of each test session.

PHOTO DOCUMENTATION

Video tape records of the boats performing the maneuvers are highly desirable, preferably filmed from a helicopter and with a voice-over narrative describing the boat, the maneuver, and any other relevant information. If there are any significant problems or weaknesses encountered in the handling of the boats, they should be documented with a videotape recording of a demonstration designed to exhibit the boat displaying its particular vice.
ANALYSIS OF DATA

The responses to the questionnaires shall be tabulated and the mean, standard deviation, and variance of each ranking computed for each boat. The statistical significance of each ranking shall be checked by the appropriate method (such as a T-Test), and only statistically significant responses reported. It is suggested that a 90% confidence level be used to judge statistical significance.
DATA FORM 14
SURF HANDLING

VESSEL NAME _______________________ DATE __________
RECORDER _______________________________________
LOCATION ______________________ WATER DEPTH _____
TIME START ______________________ FINISH __________
OPERATING CONFIGURATION _______________________________________
WAVE HEIGHT ______ WAVE DIRECTION __________
WIND SPEED ______ WIND DIRECTION __________
CURRENT SPEED ______ CURRENT DIRECTION __________
DRAFT FWD ___________________ AFT ___________________

COMMENTS ON SURF/INLET CONDITIONS:
This Questionnaire is designed to evaluate the vessel's ability to perform in the surf environment. Each question asks you to rank the vessel from 1 to 10, 1 indicating low capability (bad) and 10 indicating high capability (good). Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question or if it does not relate to the maneuver we have just performed. If there are any additional comments you would like to make regarding surf handling, please include them in the Remarks section.

DO NOT DISCUSS THE DAY'S TESTING WITH ANYONE UNTIL YOU HAVE COMPLETED THE QUESTIONNAIRE. IT IS VITAL THAT WE GET YOUR IMPRESSIONS, AND NOT THAT OF YOUR CREW OR OF THE GROUP AS A WHOLE.

IF YOU TESTED MORE THAN ONE BOAT THIS TEST SESSION, FILL OUT A QUESTIONNAIRE FOR EACH BOAT.

TEST MANEUVER FOR THIS SESSION ____________________________

1. What is your rating of the boat's ability to perform this maneuver?
   1 2 3 4 5 6 7 8 9 10 not observed

2. What is your rating of the boat's speed capability relative to this maneuver?
   1 2 3 4 5 6 7 8 9 10 not observed

3. What is your rating of the boat's rudder control relative to this maneuver?
   1 2 3 4 5 6 7 8 9 10 not observed

4. What is your rating of the boat's acceleration relative to this maneuver?
   1 2 3 4 5 6 7 8 9 10 not observed

5. What is your rating of the boat's rolling motions relative to this maneuver?
   1 2 3 4 5 6 7 8 9 10 not observed

73
6. What is your rating of the boat's heaving and pitching motions relative to this maneuver?

   1  2  3  4  5  6  7  8  9  10 not observed

7. What is your rating of the boat's yawing motions relative to this maneuver?

   1  2  3  4  5  6  7  8  9  10 not observed

8. What is your rating of the boat's forgiveness of error relative to this maneuver?

   1  2  3  4  5  6  7  8  9  10 not observed

9. What is your rating of the visibility from the helm relative to this maneuver?

   1  2  3  4  5  6  7  8  9  10 not observed

10. What is your rating of the deck arrangement relative to this maneuver?

    1  2  3  4  5  6  7  8  9  10 not observed

11. Your safety depends on the capabilities of this vessel. Assign a confidence rating to it, taking in all the test sessions thus far.

    1  2  3  4  5  6  7  8  9  10 not observed
OBJECTIVE

To measure and interpret aspects of boat's motion which may be a physiological burden to its crew.

PROCEDURE

A) Vertical accelerations are to be measured when the boat is underway in head seas running 2-4 feet high.
   1) With a vertical accelerometer mounted in the boat's pilothouse.
   2) With a human response vibration meter mounted in the vicinity of the vertical accelerometer in 1).

If there is reason to believe that other locations on the boat (such as the engine room) may contribute larger values of acceleration, then these areas should also be measured.

B) Rolling motion may be measured by a motion package near the boat's center of gravity, or it may be measured in the pilothouse with a viscously damped inclinometer connected to a tape recorder for permanent record purposes.

C) Pitching motion may be measured by a motion package near the boat's center of gravity, or it may be measured in the pilothouse with a viscously damped inclinometer connected to a tape recorder for permanent record purposes.

D) Measure and record sea spectrum, boat's heading and speed.

PARAMETERS TO BE MEASURED AND HELD CONSTANT

A) Vertical accelerations are to be measured (minimum) and recorded in the frequency range 0.1-80 HZ (See Data Form 15A).

B) Concurrently, with A) above, measure accumulative vibration level as measured by a human response meter (such as Bruel & Kjaer Type 2512 Meter and Printer Type 2312).

C) Periodically, the human response meter is switched to measure acceleration in the Y (abeam) direction, and also in the X (fore and aft) direction.

D) Roll and Pitch are to be measured and recorded concurrently with accelerations.
All of the above is to be recorded on a multi-channel/tape recorder so that analysis of the data may be accomplished at a later date.

DATA ANALYSIS

Data is to be analyzed as shown on Data Form 15A. Any other data obtained is to be summarized and correlated with data which has undergone frequency analysis in order to determine if any inferences can be derived from the data obtained.
DATA FORM 15A
SEAKEEPING ABILITY - PHYSIOLOGICAL

VEssel NAME ___________________________ DATE ___________________________

LOCATION OF ACCELEROMETER ____________________________________________

NAME AND MODEL OF ANALYZER ___________________________________________

ANALYST NAME ___________________________ M u l t i p l e _____________________

Heave Motion Analysis (1-80 Hz)

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<th>Center Band HZ</th>
<th>3rd Octave Passband</th>
<th>(RMS)²</th>
<th>RMS X</th>
<th>Weight Factor</th>
<th>RMSw</th>
<th>(RMSw)²</th>
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<tbody>
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<td>1.25</td>
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*RSee International Standard ISO 2631-1978(E), Table 3

Total (RMSw)² = __________
Total RMSW = __________

Motion Sickness Analysis (1.0 Hz)

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<th>3rd Octave Passband</th>
<th>(RMS)²</th>
<th>RMS</th>
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TEST NUMBER 16

SUSCEPTIBILITY TO SLAMMING

OBJECTIVE

To determine the frequency of slam during runs at various speeds.

PROCEDURE

Tests will be conducted into waves of sufficient heights to cause slamming of the bow. A range of speeds will be used to determine slam frequency versus speed for constant sea condition and operating configuration. The test can be repeated for different operating configurations and sea states. All tests will be conducted with head seas.

MEANS OF DETERMINING DATA

Accelerometers will be installed in the bow of the test craft as near the bottom of the hull as possible. The data from these accelerometers will be continuously recorded during each run. Counters which are set to measure accelerations above a certain level can also be used.

PARAMETERS VARIED AND HELD CONSTANT

Operating configuration and sea state will be the constants in this evaluation. Wave height should be sufficiently high to cause the vessel to experience slamming. Wind, water depth, and current conditions are not critical to this test.

Speed will be varied into the seas. The vessel will run at each speed for a sufficient time to accurately determine the frequency of slamming. The time required will depend on how many slams are occurring and hence on the sea state.

The following data is to be collected:

1. Bow vertical acceleration versus time
2. Wave height
3. Operating configuration
4. Shaft RPM
5. Draft and trim of the vessel

INSTRUMENTATION REQUIRED

Accelerometers and analog recording instrumentation or acceleration level counters.

DATA FORMS

Data Form 16A or 16B will be used to record data not stored on analog tape.
PHOTO DOCUMENTATION
None required.

ANALYSIS OF DATA

Bow acceleration data is to be run off on a strip chart and the number of slams in a given period of time counted. Results will be presented in the form of a plot of slam frequency versus speed for each configuration tested. The plots will be annotated with wave height, operating configuration, and draft.
DATA FORM 16A
SUSCEPTIBILITY TO SLAMMING

VESSEL NAME ___________________________ DATA __________________
RECORDER ______________________________
EST. WAVE HEIGHT _______________________ LOCATION __________________

OPERATING CONFIGURATION ________________________________

DRAFT FORWARD ___________________________
AFT ___________________________

<table>
<thead>
<tr>
<th>RUN NUMBER*</th>
<th>SHAFT RPM</th>
<th>DATA TAPE NUMBER</th>
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*NOTE: IF ACCELERATION LEVEL COUNTERS ARE USED, RECORD DATA ON DATA FORM 16B.
DATA FORM 16B
SUSCEPTIBILITY TO SLAMMING

VESSEL NAME ______________________________ DATA ____________________

RECORDER ________________________________

EST. WAVE HEIGHT ____________________ LOCATION ______________________

OPERATING CONFIGURATION ________________________________

DRAFT FORWARD ________________________________

AFT ________________________________

RECORD THE READINGS FROM THE STATISTICAL SHOCK LEVEL COUNTERS BELOW

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<th>LEVEL 2</th>
<th>LEVEL 3</th>
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81
TEST NUMBER 17

PERFORMANCE IN ASTERN SEAS

OBJECTIVE

To determine vessel maneuverability in astern seas.

PROCEDURE

The zigzag maneuver described in Test 9 will be conducted in a significant sea state (three to eight feet for WPB or larger, two to four feet for small boats). Base course will be with the waves (astern seas) and vessel speed should be significantly less than the wave speed. The other procedures of Test 9 are to be followed.

MEANS OF DETERMINING DATA

Same as for zigzag maneuver in Test 9.

PARAMETERS VARIED AND HELD CONSTANT

Same as Test 9.

INSTRUMENTATION REQUIRED

Same as Test 9.

DATA FORMS

Data Form 9A is to be used for data not stored on computer disks or tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Data will be presented as described in Test 9 for the zigzag maneuver. It is recommended that Test 9 also be conducted in order to compare the results. Any significant effect on maneuverability caused by astern seas should be apparent from the results.
TEST NUMBER 18

WATERTIGHT INTEGRITY

OBJECTIVE

To obtain the floodable length curve of the vessel and to ship check each bulkhead for watertight integrity.

PROCEDURE

The floodable length curve for the vessel is to be obtained from the vessel's builder or owner. This curve provides data necessary to determine compartment standards for vessel and points out any watertight integrity problem areas. Bulkheads which were assumed watertight in developing the floodable length curves should be ship checked visually and/or by pressurizing the compartment to insure that they truly are watertight bulkheads and that the as-built configuration has not defeated their purpose.

DATA FORMS

No forms are required but discrepancies in watertight integrity must be documented.

PHOTO DOCUMENTATION

Discrepancies found should be documented with photographs as well as in writing.

ANALYSIS OF DATA

The floodable length curve will be provided together with any discrepancies in watertight subdivision discovered.
TEST NUMBER 19

OPERATIONAL CAPABILITIES

OBJECTIVE

To obtain operator's evaluations of the vessel in performing the operational missions assigned.

PROCEDURE

The following evolutions will be performed several times under their prescribed conditions:

Man Overboard Recovery

An "Oscar" dummy will be used to simulate the pick-up of an unconscious victim. Average wave height shall be recorded on Questionnaire 19A.

Towing

A second vessel within the towing capabilities of the test vessel will be picked up in tow in a moderate sea state. Average wave height during the test shall be recorded on Questionnaire 19B.

Boarding Operations

A second vessel will be boarded by a crewman off the test vessel in a calm to moderate sea state. Wave height and factors which affect the safe transfer of boarding members shall be recorded on Questionnaire 19C.

Helo Operations

In a calm to moderate sea state helo operations shall be conducted by transferring "Oscar" from the test vessel to a helicopter using a Stokes litter. Average wave height shall be recorded on Questionnaire 19D.

MEANS OF DETERMINING DATA

Crew members will be given a questionnaire following the completion of the operational evolutions.

DATA FORMS: Questionnaires 19A, 19B, 19C and 19D will be used.

PHOTO DOCUMENTATION: Videotape recordings of the evolutions should be performed whenever possible, preferably from a helicopter.

ANALYSIS OF DATA: Responses will be collated and significant points will be emphasized.
QUESTIONNAIRE 19 - MAN OVERBOARD RECOVERY

VESSLE ____________________________ DATE __________

EVALUATOR ________________ AVG WAVE HEIGHT ________________

This questionnaire covers some aspects of the vessel's ability in recovering victims, conscious and unconscious, from the water. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question or if it does not apply. If there are additional comments you would like to make regarding other points of victim recovery, you may include them in the Remarks section.

1. Ability of the vessel to maintain a heading into the surf.
   Excellent  Good  Satisfactory  Poor  Not Observed

2. Visibility of the victim in the water while making the approach.
   Excellent  Good  Satisfactory  Poor  Not Observed

3. Ability of the vessel to maintain a position next to the victim.
   Excellent  Good  Satisfactory  Poor  Not Observed

4. Ease of recovering the victim from the water.
   Excellent  Good  Satisfactory  Poor  Not Observed

5. Ease of communications between coxswain and pick-up crewmen.
   Excellent  Good  Satisfactory  Poor  Not Observed

6. Was the vessel's freeboard a factor in making recovery of the victim from the water difficult?
   Yes  No

7. Is there a lack of handrails or other safety features available for the crew to assist in picking up the victim?
   Yes  No

8. Do appendages or other aspects of the vessel make recovery of the victim more dangerous?
   Yes  No

9. Remarks. Comment on specific details of the vessel's capabilities which assisted or hindered recovery of the victim in the water. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Are there improvements which could be made to the vessel to make the operation easier?

85
This questionnaire covers some aspects of the vessel's towing capability. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding other points of the towing operation, you may include them in the Remarks section.

1. How would you rate the overall towing ability?
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

2. Towing bitt location (astern tow).
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

3. Cleat location (side tow).
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

4. Visibility for maneuvering close to tow.
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

5. Visibility when towing.
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

6. Available power.
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

7. Maneuverability with tow.
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

8. Docking with tow.
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

9. Communications with crew handling towline.
   - Excellent
   - Good
   - Satisfactory
   - Poor
   - Not Observed

10. Were differences in gunwale height a problem for side tows?
    - Yes
    - No

86
11. Does the propeller cavitate or aerate?
   Yes  No

12. Did problems occur with the towline?
   Yes  No

13. Were there any problems associated with towing in the surf?
   Yes  No

14. Remarks. Include any comment you have concerning this boat. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Be specific in your comments. Could improvements be made to the vessel to make towing easier?
This questionnaire covers some aspects of the vessel's boarding capability. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding other points of the boarding operation, you may include them in the Remarks section.

1. How would you rate the vessel as a boarding platform?
   Excellent  Good  Satisfactory  Poor  Not Observed

2. Maneuverability alongside another vessel
   Excellent  Good  Satisfactory  Poor  Not Observed

3. Fendering system of the boat.
   Excellent  Good  Satisfactory  Poor  Not Observed

   Excellent  Good  Satisfactory  Poor  Not Observed

5. Communications with boarding party.
   Excellent  Good  Satisfactory  Poor  Not Observed

   Excellent  Good  Satisfactory  Poor  Not Observed

7. Deck lighting?
   Excellent  Good  Satisfactory  Poor  Not Observed

8. Remarks. Include any comment you have concerning this boat. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Be specific in your comments. Could improvements be made to the vessel to make boardings easier?
QUESTIONNAIRE 19D - HELO OPERATIONS

VESSSEL ___________________________ DATE ____________
EVALUATOR ___________ AVG WAVE HEIGHT ____________

This questionnaire covers some aspects of the vessel's helo support capability. Answer the questions you feel are within your experience. Check "Not Observed" if you do not feel qualified to answer the question. If there are additional comments you would like to make regarding other points of the helo support operation, you may include them in the Remarks section.

1. How would you rate the vessel in performing helo operations?
   Excellent    Good    Satisfactory    Poor    Not Observed

2. Was it difficult to maintain position under the helicopter?
   Yes        No

3. Were there any obstructions which interfered with the stokes litter?
   Yes        No

4. Were there any problems associated with transferring the victim to the helicopter?
   Yes        No

5. Were there any problems with communications between helmsman, pilot, and crewmen working on deck?
   Yes        No

6. Is adequate lighting for night operations provided?
   Yes        No

7. Remarks. Include any comment you have concerning this boat. Be sure to comment on any question where you rated this boat as poor or where you answered "Yes" concerning a problem area. Be specific in your comments. Could improvements be made to the vessel to make helo operations easier?
TEST NUMBER 20
ADVERSE WEATHER OPERATION

OBJECTIVE
To evaluate the vessel's capability to operate in adverse weather conditions.

PROCEDURE
The vessel will be placed inside an environmental chamber which is capable of controlling the temperature and humidity and simulating conditions of rain or icing. Alternatively, test sites with the appropriate climatic conditions may be used with slight changes in procedure. Testing will cover the following three problem areas of adverse weather operations:

Visibility from Pilothouse

The first test will evaluate how rapidly and effectively spray and water can be cleared from the pilothouse windows. This test will be conducted at ambient temperature. The chamber will be darkened and a standard Naval Bar Chart (see Figure 20-1) will be illuminated by an outdoor AC spotlight with a 100-watt bulb positioned 3' in front of it. The bar chart will be positioned 25' from the pilothouse windows. Rain should be produced covering an area from the bow of the vessel up to the pilothouse windows and extending 5' beyond the beam of the vessel on either side. Wind, generated at a speed 10 mph greater than the vessel's maximum speed, will drive the rain against the pilothouse windows. The intensity of the rain will commence at 1/2" per hour and be increased until the bar chart is no longer clearly visible from inside the pilothouse with the windshield wipers and/or rearview screens operating. This will be recorded on the data sheet. The generated wind speed will then be decreased in 5 mph increments until the bar chart is entirely visible.

The second test will evaluate the ability of the vessel to de-fog the windows. The maximum number of personnel authorized shall be placed in the crew compartment to ensure a moisture source for frost/fog formation. The air temperature will be lowered and humidity increased gradually until the de-fogging system can no longer keep the windows clear. This will be determined by use of the bar chart as in the previous test. The temperature and humidity conditions (both inside the vessel and outside) where the de-fogging system is ineffective will be recorded.

The third test will evaluate if visibility can be maintained under icing conditions. This will be achieved by lowering the temperature of the chamber and applying rime ice to the windows until ice accumulates at a rate of 1/4" per hour. The icing rate
RESOLUTION TEST OBJECT RT-5-75

Produced by:
Graphic Arts Research Center
Rochester Institute of Technology
Rochester, New York 14623

With the assistance of:
Naval Surface Weapons Center
Photographic Engineering and Services Division
Silver Spring, Maryland 20910

FIGURE 20-1
shall then be increased. The temperature and icing rate at which
de-icing is no longer possible (i.e., the transparent areas of
the crew compartment are completely obscured) will be recorded.

An alternative procedure for de-icing evaluation can be
conducted without facilities for simulating ice formation. The
transparent areas of the craft should be marked with a grease
pencil or felt-tip pen into a grid of equal sized squares. With
the external temperature 0 degrees F or below, water is sprayed
onto the glazing until an even coating of 1/4" of ice is applied.
The heater/defroster is then operated until no further clearing
is observed and the percentage of the glazed area cleared is
recorded.

The final test determines the ability of the windshield
washers and wipers to clear salt spray from the pilothouse
windows. The transparent areas of the craft should be marked
with a grease pencil or felt-tip pen into a grid of equal sized
squares. Salt water is to be sprayed on the windows and allowed
to dry. The windshield washers and wipers are then operated for
one minute and the portion of the transparent area cleared is
recorded.

**Deck Equipment Operation**

As much of the deck equipment as possible will be operated at
a temperature of no higher than 0 degrees F. Any discrepancies
will be noted.

**Cold Cranking of the Main Engines**

Before the chamber is cooled, the engine will be started and
run for twenty minutes to verify that all systems are operating
properly. Engine fluids shall be those specified by the
manufacturer or the Coast Guard for use in winter conditions.

The chamber will then be cooled to the specified temperature
(0 degrees F if not specified) and 50% relative humidity. The
vessel will be maintained at those conditions for at least 6
hours or until all components are within 4 degrees F of the test
temperature before attempting to start the main engines. A fully
charged, cold-soaked battery shall be used for each attempt. The
manufacturer’s starting procedure will be followed and the
starter engaged continuously for no longer than 60 seconds during
each attempt. If an engine will not start on any attempt, it
shall be started using heat, starting fluid, etc., allowed to
warm up and then cold-soaked again before making another attempt.
Similarly, if the engine starts successfully, allow it to reach
normal operating temperature before shutting down and re-cooling
for the next attempt. The number of successful attempts
necessary for satisfactory performance will be determined by the
Test Director.
PARAMETERS VARIED AND HELD CONSTANT

The key parameters in the testing such as temperature, humidity, wind speed, rainfall intensity, and icing rate are all controlled by the environmental chamber. Other variables such as heater outlet temperature, engine oil sump temperature, raw water temperature, etc., shall be recorded. See the references for detailed guidelines.

DATA FORMS

Form 20A is to be used to record the data. Temperatures of equipment, etc., can be recorded manually or electronically.

PHOTO DOCUMENTATION

35 mm still photographs will be taken during each increment of the visibility tests.

REFERENCES

U.S. Army Test and Evaluation Command (TECOM) Test Operation Procedures (TOP):

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<th>Title</th>
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<td>2-2-708</td>
<td>ADA 090590</td>
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<td>Climatic Chamber Testing</td>
<td>7-3-521</td>
<td>ADA 074049</td>
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<tr>
<td>Engine Cold-Starting and Warmup Tests</td>
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<td>ADA 089535</td>
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<tr>
<td>Rain and Freezing Rain</td>
<td>2-2-815</td>
<td>ADA 029317</td>
</tr>
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DATA FORM 20A
ADVERSE WEATHER OPERATION

VEssel NAME ______________________ DATE __________
RECORDER ______________________

VISIBILITY FROM PILOTHOUSE (TEST 1):

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<tr>
<th>TEMPERATURE</th>
<th>RELATIVE HUMIDITY</th>
<th>WIND SPEED</th>
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<tr>
<th>RAIN INTENSITY</th>
<th>VISIBILITY (SAT/UNSAT)</th>
<th>WIND SPEED</th>
<th>VISIBILITY (SAT/UNSAT)</th>
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VISIBILITY FROM PILOTHOUSE (TEST 2):

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<tr>
<th>AMBIENT TEMPERATURE</th>
<th>RELATIVE HUMIDITY</th>
<th>CREW COMPARTMENT TEMP</th>
<th>RELATIVE HUMIDITY</th>
<th>TIME</th>
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VISIBILITY FROM PILOTHOUSE (TEST 3):

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<th>AMBIENT TEMPERATURE</th>
<th>RELATIVE HUMIDITY</th>
<th>ICING INTENSITY (INCHES/HR)</th>
<th>VISIBILITY (SAT/UNSAT)</th>
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PERCENTAGE OF TRANSPARENT AREA CLEARED ________________
DATA FORM 20A
ADVERSE WEATHER OPERATION

DECK EQUIPMENT OPERATION:
LENGTH OF COLD SOAK
TEMPERATURE RELATIVE HUMIDITY
DISCREPANCIES

COLD CRANKING OF ENGINES:
DESCRIPTION OF TEST RESULTS
TEST NUMBER 21
ANCHORING

OBJECTIVE
To determine the ability of the vessel to anchor, riding ability at anchor, and the maximum force at which the anchor will hold.

PROCEDURE
The vessel will be anchored several times in different weather conditions. After each evolution, the crew members involved will fill out a questionnaire on the various aspects of the evolution. The direction which the vessel rides relative to the wind the seas, and to the anchor line will be recorded as well.

MEANS OF DETERMINING DATA
Data will be obtained through direct observation and questionnaires filled in by the crew.

PARAMETERS VARIED AND HELD CONSTANT
Anchoring will be conducted in various weather conditions to determine limitations. The following data is to be collected.

1. Wave height and direction
2. Wave speed and direction

INSTRUMENTATION REQUIRED
Anemometer for wind speed and direction.

DATA FORMS
Form 21A will be used by the test director for recording observations of anchoring. Questionnaire 21B will be filled by the ship's crew.

PHOTO DOCUMENTATION
None required.

ANALYSIS OF DATA
Important observations and crew comments will be summarized in the report.
DATA FORM 21A

ANCHORING

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<th>VESSEL NAME</th>
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<th>WAVE HEIGHT</th>
<th>RELATIVE WAVE DIRECTION</th>
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QUESTIONNAIRE 21B
ANCHORING

VESSEL NAME _______________________________________

YOUR NAME _____________________________ DATE __________

TIME ON BOARD ___________________________

This questionnaire covers some of the aspects of anchoring which are difficult to measure. Answer the questions which you feel are within your experience. Check Not Observed if you do not feel qualified to answer the question or if it does not apply to your vessel. If there are additional comments you would like to make regarding anchoring, you may include them in the Remarks section. This questionnaire is intended to be filled out immediately after an anchoring evolution.

1. What is your estimate of the wave height during the anchoring?

    Wave height ______ feet

2. Were there any significant problems related to the anchoring?

    Not Observed _____ No _____ Yes _____

3. If so, were the problems related to the:

    Anchor _____ Anchor windlass _____
    Shape of the hawse ______
    Chain stoppers or Anchor Chain ______
    Similar equipment ______
    Other (explain) __________________________

4. Describe briefly what the problems were.

    __________________________________________
    __________________________________________
    __________________________________________
    __________________________________________
    __________________________________________
    __________________________________________
ANCHORING

5. Do you feel there is a risk of damaging hull appendages while anchoring? These could include foils, air cushion seals, etc.

Not observed _____ No _____ Yes _____

6. If yes, what items are in risk of damage?

________________________________________

7. Describe the vessel's ride at anchor

Excellent  Good  Satisfactory  Poor  Not Observed

8. Do you feel there is a risk of damage to hull appendages while riding at anchor?

Not observed _____ No _____ Yes _____

9. If yes, what items are in risk of damage?

________________________________________

11. Overall, how do you compare the ease of anchoring this vessel to MLB?

Not observed _____ About the same _____

Much easier _____ More difficult _____

Easier _____ Much more difficult _____

12. What was the primary reason for the ease of anchoring being easier or more difficult?

________________________________________

13. Remarks. Includes comments on any aspects of anchoring not covered in the questions above which you feel are important.

________________________________________
TEST NUMBER 22
TIME TO GET UNDERWAY

OBJECTIVE
To determine the time required to get the vessel underway from a normal in-port condition in a situation requiring rapid response.

PROCEDURE
The object of this test is to find how fast the crew can get the vessel underway in an urgent situation such as a SAR call. The craft will begin in a basically dead plant condition on shore ties if possible. It is important that the crew be well trained in their duties. The objective of the test is to measure the vessel's performance and not the crew's; delays caused by the crew still learning their jobs should be avoided. The principal measurement will be the elapsed time from first notification until the vessel departs the dock. It is advisable to record the time of other significant events taking place during the process of getting underway. These include:

- Notification of test start
- Main engines started
- Shore ties disconnected
- Engineering plant ready to get underway
- Operations ready to get underway
- Deck ready to get underway

A SAR incident can be fabricated for this test. For small boats where the crew would normally be in the ready room upon notification of an actual incident, the crew should be onboard, or at least on the dock before the test is started. The distance from the coffee pot to the boat is not an important test parameter.

MEANS OF DETERMINING DATA
The only data required is the time of occurrence of various events. These may be determined from observations (preferred) or from logged events in the deck and engineering logs.

PARAMETERS VARIED AND HELD CONSTANT
None. This test should be an unrehearsed measurement of a typical time to get underway.

DATA FORMS
Form 22A will be used for recording data for this test.

PHOTO DOCUMENTATION, ANALYSIS OF DATA
None required. Times will be reported as they occurred.
DATA FORM 22A
TIME TO GET UNDERWAY

VESSEL NAME ___________________________ DATE ___________
RECORER ________________________________

1. INITIAL NOTIFICATION ________________________________
   MAIN ENGINE STARTED ________________________________
   SHORE TIES DISCONNECTED ______________________________
   ENGINEERING PLANT READY TO GET UNDERWAY ______________
   OPERATIONS PLANT READY TO GET UNDERWAY ______________

2. VESSEL LEAVES DOCK (LAST MOORING LINE IN) ______________
   TOTAL ELAPSED TIME: ITEM 2, MINUS ITEM 1 ______________

3. COMMENTS: (LIMITING FACTORS, HAZARDS, ETC.)
   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
OBJECTIVE

To determine the vibration level of the primary hull structure at a small number of key points.

PROCEDURE

The vibration of the main hull structure will be determined in this test. A small number (6 or less) of vibration pickups will be installed in locations around the vessel. Pickups will be secured near hard points in the structure such as deck bulkhead intersections so as to measure the vibration of the whole hull structure locally. Secondary vibrations such as local plating vibrations are not of interest. Pickups will normally be positioned at intervals along the main deck from the bow to the stern and near the pilot house. Vibrations data should be collected in calm water over a range of speeds from idle to full ahead and from idle to full astern. Zero speed vibrations should also be recorded. Additional data may be collected in actual operations in a variety of sea conditions. If two or more significantly different operating configurations are possible, vibration measurements should be made for each.

MEANS OF DETERMINING DATA

A small number of vibration pickups will be used. These may sense either accelerations or velocities in the vertical direction.

PARAMETERS TO BE USED AND HELD CONSTANT

In the calm water trials the vessel should be operated with normal equipment on line. Speed is to be varied by changing the SRPM in steps. Vertical vibrations of the primary structure only will be measured.

Wave conditions for the calm water portion of the tests must not exceed 1 foot. Wind and current should have little effect on the results. Water depth must be greater than five times the draft.

The following data is to be collected:

1. Hull vibrations
2. SRPM
3. Operating configurations
4. Draft and trim
5. Wave height
6. Location of vibration pickups
7. Water depth
INSTRUMENTATION REQUIRED

1. Vibration pickups with amplifiers
2. Analog tape recorder
3. Shaft RPM counter
4. Depth sounder

DATA FORMS

Data Form 23A will be used to record data not stored on analog tape.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Data will be processed by a spectrum analyzer to produce curves of vibration amplitude versus frequency. No other vibration analysis is required. The amplitude and frequency of the most severe vibrations at each location will be noted.
DATA FORM 23A
HULL VIBRATIONS LEVEL

VESSEL NAME __________________________ DATE __________

RECORER ________________________________

LOCATION OF TEST __________________________

OPERATING CONFIGURATION __________________________

DRAFT  FWD ________
       AFT ________

WAVE HEIGHT ___________  WATER DEPTH ___________

LOCATION OF PICKUPS
   #1 __________________________
   #2 __________________________
   #3 __________________________
   #4 __________________________
   #5 __________________________
   #6 __________________________

SRPM'S USED (LIST)
__________________________
__________________________
__________________________

DATA TAPE(S) USED # __________

TEST RUN NUMBERS
__________________________
__________________________
TEST NUMBER 24

NOISE LEVEL

OBJECTIVE

To survey the entire vessel and record noise levels in each compartment and at selected locations on the exterior decks.

PROCEDURE

Sound level measurements are to be made with both A and C weightings. A measurement will be made at the center of each compartment and at every position used by the crew. This includes every compartment except voids, fuel and water tanks, chain lockers and similar spaces. In the engine room, additional locations may be designated. Sound measurements will also be made at a number of locations on exterior decks.

Sound levels will be taken with the vessel traveling at full speed with normal equipment operating. Additional speeds and operating configurations may be specified.

Sea and weather conditions are not critical in this test. However, data should not be taken in extreme wind and wave conditions which may cause a lot of noise themselves.

MEANS OF DETERMINING DATA

A hand-held noise level meter will be used and the data hand recorded.

PARAMETERS VARIED AND HELD CONSTANT

Ship speed and operating configuration should be constant during the period of the survey. Changes in equipment on line should also be avoided. The following data is to be recorded:

1. Compartment name or location
2. Sound level on A and C weighting in decibels
3. SRPM
4. Operating configuration
5. Wave height
6. Wind speed

INSTRUMENTATION REQUIRED

1. Sound level meter with A and C scale weightings
2. Anemometer for wind speed.

DATA FORMS

Data form 24A is to be used to record all data.
PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

Raw data will be tabulated by compartment. If additional speeds or operating configurations are specified, the data will be tabulated together for comparison purposes.
DATA FORM 24A

NOISE LEVEL

Vessel Name __________________________ Date __________

Recorder ______________________________

Operating Configuration ______________________________

Shaft RPM __________ Speed __________

Wave Height __________ Wind Speed __________

Compt. or location

<table>
<thead>
<tr>
<th>A Weighting</th>
<th>C Weighting</th>
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<tbody>
<tr>
<td>dB</td>
<td>dB</td>
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TEST NUMBER 25

VISIBILITY FROM THE PILOTHOUSE/COXSWAIN FLAT

OBJECTIVE

To determine the area of visibility from each of the primary operator positions.

PROCEDURE

A transit or theodolite will be positioned at each principal operators position in the pilot house and the field of view will be surveyed in terms of both horizontal and vertical angles. A height of eye of 5'6" above the pilot house deck will be used unless seats are provided which would change the height of eye. The actual height of eye will be approximated in those cases.

Principal operators stations will be determined by the location of seats or other bridge equipment. If positions are not apparent as in the case of a roving deck operator then three positions spaced across the bridge width will be used.

MEANS OF DETERMINING DATA

Field of view from each operating position will be completely mapped out in terms of vertical and horizontal angles. The limits to this field of view include the window frames, the bow or stern of the vessel or any deck fixtures which interfere with a clear line of sight. A transit or theodolite must be used to measure the angles accurately.

PARAMETERS VARIED AND HELD CONSTANT

None. Angles will be measured with the vessel at the dock.

INSTRUMENTATION REQUIRED

Transit or theodolite

DATA FORMS

Data Form 25A is to be used to record data from these tests.

PHOTO DOCUMENTATION

A series of still photographs should be taken from each position measured. These photographs should cover the 360 degrees horizontal arc measured and should show the total field of view. Photographs are to be taken with instant camera film or other print film.
ANALYSIS OF DATA

The 360 degrees horizontal cylinder will be unrolled (developed) and the vertical angles limiting the field of view will be shown as a function of the horizontal angles. The fraction of total clear viewing area from +15 to -20 degrees will be calculated. This fractional area can be used to compare different vessels.
DATA FORM 25A

VISIBILITY FROM THE DECKHOUSE/COXSWAIN FLAT

VEssel Name _________________________ Date ____________

Recorder ____________________________

Sketch in area measured indicating data points by number

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<tr>
<th>Angle</th>
<th>Angle</th>
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<th>Data Point Number</th>
<th>Horizontal Angle</th>
<th>Vertical Angle</th>
<th>Data Point Number</th>
<th>Horizontal Angle</th>
<th>Vertical Angle</th>
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110
TEST NUMBER 26

FIREFIGHTING CAPABILITIES

OBJECTIVE

To insure that the vessel's fire pump operates at the rated capacity.

PROCEDURE

A single section of fire hose, most commonly 1-1/2 or 2-1/2 inch diameter, will be attached to the vessel's firemain system at the hose station farthest from the fire pump. A flow meter/pressure digital readout instrument is attached to the end of the fire hose. A standard Navy all-purpose nozzle shall be attached to the discharge side of the instrument. If additional hose is needed to reach a drainage area, it shall be added between the instrument and the nozzle. If this is not possible, as in the case of a fire monitor system, a flow meter should be installed inline somewhere along the system. The fire pump should be brought up to test speed and the flow rate measured. If a pressure gauge is attached to the discharge side of the pump, these readings should also be recorded. The pump will be operated at several speeds beginning with speeds less than the rated speed, including the rated speed, and finishing with speeds higher than rated speed.

MEANS OF DETERMINING DATA

Whenever possible, a digital readout instrument should be used. An alternative method is use of a stopwatch and a 55-gallon drum. The elapsed time taken to fill the drum will determine the discharge rates.

PARAMETERS VARIED AND HELD CONSTANT

For each test run the pump shaft RPM should be held constant while the flow rates are being measured. The same fire hose and discharge orifice should be used for all the tests.

The following data is to be collected:

1. Pump shaft RPM
2. Discharge pressure (if gauge is present in psi)
3. Flow rate (in gallons per minute)
INSTRUMENTATION REQUIRED

1. A digital readout flow meter/pressure gauge. 
   or 
1. A chronometer or stopwatch accurate to one second 
2. A large container (55-gallon drum). 
   or 
2. An in-line flow meter (if fire hose attachment isn't possible).

DATA FORMS

Form 26A is to be used to record the data.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

From the data collected, curves will be produced showing flow rate as a function of pump RPM and discharge pressure as a function of flow rate if a pressure gauge is installed.

The flow rate of the pump at rated pump RPM will be used to determine whether the pump was installed properly. The curves will be used to produce a pump operation envelope, a range of speeds where the pump will deliver required pressure and flow rate.
DATA FORM 26A
FIREFIGHTING CAPABILITIES

VEssel NAME _________________________ DATE __________
REcORDER ____________________________

<table>
<thead>
<tr>
<th>PUMP SPEED (RPM)</th>
<th>FLOW RATE (GPM)</th>
<th>DISCHARGE PRESSURE (PSI)</th>
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ARE THERE ANY RESTRICTIONS ON ENGINE SPEED OR MANEUVERING DUE TO OPERATIONS OF THE FIRE PUMPS?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
TEST NUMBER 27
HELM AND THROTTLE RESPONSE

OBJECTIVE
To assess the response of a vessel's control systems.

PROCEDURE

Throttle Response
This test is somewhat similar to the quick pickup procedure of test 7. The boat is initially at rest with the engines idling and the clutch disengaged. As quickly as possible, the throttles are advanced and the clutches engaged. If the engine stalls, the test is repeated with a slower advance. The time it takes to physically advance the throttles is noted, along with the time to reach maximum rated engine RPM. When the engines heave reached maximum RPM, the throttles are retarded, and the gears (or propellers on a CRP installation) reversed, until full throttle in reverse is reached. The trials are then run with the opposite sequence so the vessel goes from full astern to full ahead. Repeat runs are conducted and the times averaged. If the trim of the propulsion unit is adjustable, it should be varied and the tests re-run.

Helm Response
Since the flow of water over the rudder may affect the moment and the power required to shift the rudder, this test should be conducted underway at a reasonable maneuvering speed. The angle from rudder stop to stop should be measured with a protractor prior to conducting this test. With the helm initially centered, the helm is shifted to hard over as rapidly as possible, and the time noted. The rudder is then brought from stop to stop in the other direction and that time is noted. After centering the rudder, the test is performed starting in the opposite direction from the initial test.

On larger vessels, they may be a lag between the time the helm is put over and the time the rudder moves to hard over. It may be necessary to instrument both the helm and the rudder (or other steering unit) to fully describe the response of the control system in this case.

U-turn Maneuver
Proceeding at the fastest reasonable maneuvering speed, the vessel makes a 180 degree course change as quickly as possible. It would be prudent to conduct the Maximum Maneuvering Speed test before attempting this test. The time is noted from the first helm movement to settling down on the reciprocal course. Repeat runs are conducted and the times averaged.
MEANS OF DETERMINING DATA

The time to complete each maneuver shall be measure using a stopwatch and manually recorded.

PARAMETERS VARIED AND HELD CONSTANT

The operating condition of the vessel shall be typical for it's designed mission. Wave height, wind speed and current should be minimal, but they will not have a large effect on the results.

The following data is to be taken:

1. Success or failure of each maneuver
2. Time to complete the maneuver
3. Engine RPM or throttle setting
4. Draft and Trim of the vessel
5. Operational Configuration
6. Wave height and direction
7. Wind Speed and direction
8. Current speed and direction
9. Water depth

EQUIPMENT REQUIRED

1. Stopwatch
2. Anemometer for wind speed and direction
3. Depth sounder
4. Hand recording is suitable for all data

DATA FORMS

Form 27 is used to record the data.

PHOTO DOCUMENTATION

None required.

ANALYSIS OF DATA

The time to complete each maneuver should be presented as an average. The Rudder Rate, and Turning Rate should be computed for the Helm Response and 180 Degree Turn Maneuver, respectively.
DATA FORM 27
HELM AND THROTTLE RESPONSE

<table>
<thead>
<tr>
<th>VESSEL NAME</th>
<th>DATE</th>
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<tr>
<th>RECORDER</th>
<th>WATER DEPTH</th>
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<thead>
<tr>
<th>LOCATION</th>
<th>TIME START</th>
<th>FINISH</th>
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<tr>
<th>OPERATING CONFIGURATION</th>
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<table>
<thead>
<tr>
<th>DRAFT FWD</th>
<th>AFT</th>
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<tr>
<th>WAVE HEIGHT</th>
<th>WAVE DIRECTION</th>
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<tr>
<th>WIND SPEED</th>
<th>WIND DIRECTION</th>
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THROTTLE RESPONSE

<table>
<thead>
<tr>
<th>RUN NUMBER</th>
<th>NEUTRAL TO FULL AHEAD</th>
<th>FULL AHEAD TO FULL ASTERN</th>
<th>NEUTRAL TO FULL ASTERN</th>
<th>FULL ASTERN TO FULL AHEAD</th>
<th>STALL</th>
</tr>
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<tbody>
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HELM RESPONSE

<table>
<thead>
<tr>
<th>RUN NUMBER</th>
<th>CENTER TO STBD LOCK</th>
<th>LOCK TO LOCK</th>
<th>CENTER TO PORT LOCK</th>
<th>LOCK TO LOCK</th>
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U-TURN MANEUVER

<table>
<thead>
<tr>
<th>RUN NUMBER</th>
<th>RPM</th>
<th>TIME TO TURN 180 DEG</th>
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116
TEST NUMBER 28
MANEUVERING SPEED

OBJECTIVE

To determine the safe maneuvering speed for:

1. Boats that are 20 feet or more in length and capable of a top speed of 35 mph (30 knots) or more using manufacturers' rated horsepower.

2. Boats that are less than 20 feet in length and capable of a top speed of 30 mph (25 knots) or more using manufacturers' rated horsepower.

PROCEDURE

The boat should be rigged as close as possible to its operational condition. Boats with permanently installed fuel tanks shall be no more than one-half full. Outboard boats without permanent fuel tanks should be tested beginning with one full portable tank for each motor. Portable tanks should be in their designated location or placed as far aft as practicable. The use of the following safety equipment is required during testing because of the potential for exceeding the capabilities of the boat while performing this test.

1. Type I or II PFD
2. Crash helmet
3. Emergency Ignition Stop Switch

Quick Turn Test

To conduct a Quick Turn Test, the driver operates the boat straight ahead at a given throttle setting, beginning with 1/2 maximum throttle. The wheel is turned 180 degrees in one direction in 1/2 second or less and held at that position without changing the throttle or trim settings during or after the wheel change. The boat completes the maneuver successfully if it is capable of completing a 90 degree turn without the driver's loss of confidence in maintaining control.

If the boat successfully completes the Quick Turn Test, increase the boat's entry speed incrementally until the boat does not complete the test or successfully completes it at maximum throttle. The highest speed at which the boat successfully completes the Quick Turn Test is the maneuvering speed.

Test Course Method

The test course, as shown in Figure 28-1, should begin with the boat's throttle set a 1/2 maximum throttle. A minimum of three consecutive runs are made in each direction, passing
Boat Capacity Test Course

35 M.P.H. to 50 M.P.H.
outside the designated avoidance marker without contacting any of
the course markers. Increase the throttle setting by five mph
increments until the maximum speed at which the boat successfully
completes the course is determined. This speed is the maximum
maneuvering speed.

It is recognized that operator skill and familiarity with the
boat will affect the test results. It is therefore considered
permissible to make a number of practice runs through the test
course at any throttle setting. During testing there should be
no change in the positions of any equipment or personnel. The
tests shall be terminated upon evidence of oscillating motion in
the roll or yaw axes while negotiating the course.

MEANS OF DETERMINING DATA

Speed, the most important factor in this test, will be measured
with an installed speedometer or radar speed gun. The maximum
full throttle speed will be verified by radar or by the average
of not less than two passages over a measured course in both
directions.

PARAMETERS VARIED AND HELD CONSTANT

Testing should be conducted on smooth, calm water with the wind
speed below 10 knots. No additional loads other than a driver
who weighs no more than 200 lbs will be aboard the boat. The
motor trim angle should be adjusted to provide maximum full
throttle speed short of excessive porpoising or propeller
ventilation so that there is no loss of directional control.

INSTRUMENTATION REQUIRED

1. Speedometer, accurate to 1 mph, if possible.

2. Radar speed gun, for vessels where installation of
speedometer would be difficult or impossible.

DATA FORMS: Form 28A is to be used to record the data.

PHOTO DOCUMENTATION: Data is also recorded photographically from
an angle as directly above the test course as possible. Video or
motion picture photography is the desired method to evaluate the
vessel's motion during the Quick Turn and Test Course maneuvers.

ANALYSIS OF DATA: The only analysis required in this test is to
determine the maximum maneuvering speed if less than the full
throttle speed. This can be obtained from the driver's
observations recorded on the data sheet and photographic
documentation.
**DATA FORM 28A**

**MANEUVERING SPEED**

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<tr>
<th>VESSEL NAME</th>
<th>DATE</th>
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<tr>
<th>FULL THROTTLE SPEED</th>
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**Quick Turn Test:**

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<tr>
<th>Throttle Setting</th>
<th>Vessel Speed</th>
<th>Test Result (Sat/Unsat)</th>
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120
DATA FORM 28A
MANEUVERING SPEED

VESSEL NAME __________________________________ DATE ___________________________

FULL THROTTLE SPEED __________________________________________________________

Quick Turn Test:

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<tr>
<th>Throttle Setting</th>
<th>Vessel Speed</th>
<th>Test Result (Sat/Unsat)</th>
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Test Course Method:

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<th>Throttle Setting</th>
<th>Vessel Speed</th>
<th>Test Result (Sat/Unsat)</th>
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