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Technical Evaluation of the Norwegian Crew Concept Boat (CG-502001) and Comparison to the 41-FT Utility Boat (UTB)

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16. Abstract

This report provides the results of the technical evaluation (TECHEVAL) of the Coast Guard boat CG-502001. This boat is being used to evaluate the Norwegian Crew Concept (NORCREW) at U.S. Coast Guard Station Taylors Island, Maryland.

The U.S. Coast Guard Research and Development Center conducted testing on 13-19 November 1992. This testing was executed to independently establish a performance baseline for the NORCREW boat CG-502001 and determine if there were any significant technical performance characteristics of the boat that could have a negative impact on the outcome of the NORCREW concept evaluation. The report compares the design and performance of the NORCREW CG-502001 with the 41-FT UTB. It is the opinion of the R&D Center TECHEVAL team that there are no technical performance characteristics of the CG-502001 that would have a negative impact on the outcome of the NORCREW concept evaluation.

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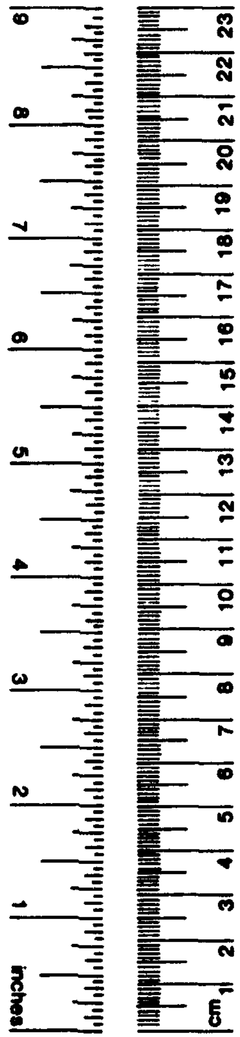
Approximate Conversions to Metric Measures

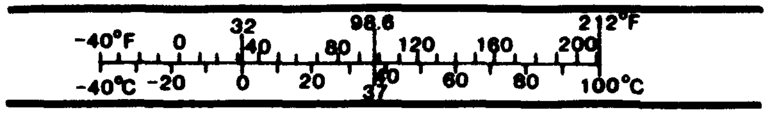
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares(10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

The Norwegian Crew Concept (NORCREW) is being evaluated by the Fifth Coast Guard District for Coast Guard Headquarters to determine if a live-aboard concept can provide acceptable mission performance at the station/small boat level. This concept employs a single live-aboard boat moored at a commercial marina to function as a stand-alone platform using the Group for operational control and administrative support and commercial providers for maintenance support. Existing Coast Guard small boats like the 41-FT UTB do not have live-aboard accommodations. The primary purpose of the CG502001 (502001) evaluation is to assess the NORCREW concept, not to judge the boat. In order for the NORCREW concept to be fairly evaluated, an "off-the-shelf" hull design was selected and customized to have similar technical performance capabilities to the Coast Guard's 41-foot Utility Boat. The Research and Development Center (R&DC) conducted a comparative technical test and evaluation of the 502001 and a 41-FT UTB to identify any operational or technical performance differences. A Crew Adaptation Study and Operational Test and Evaluation are also being accomplished by the R&DC and results will be provided as two additional reports in support of the NORCREW Concept Evaluation.

The testing demonstrated that in calm water, 502001 is three knots slower than a 41-FT UTB. It is nine feet longer, displaces 23,700 pounds more than the 41-FT UTB and is less maneuverable. However, it is the technical opinion of the R&DC's test team that the maneuverability of 502001 is adequate for safe navigation. The 502001 is overweight, exceeding the manufacturer's design Full Load Displacement by 2,100 pounds. The motion test demonstrated that the 502001 has better seakeeping abilities than the 41-FT UTB in roll, pitch, and heave. In head seas with significant wave heights of six feet, the crew of the 502001 was able to sustain a speed four knots greater than the 41-FT UTB, due to the improved seakeeping abilities of the 502001. Pending further verification under the Crew Adaptation Study, the reduced motions and improved accommodations of 502001 may decrease crew fatigue. Both boats have similar towing and salvage capabilities and carry a similar outfit. 502001 has a 10-inch greater draft and no keel or skeg protection for propellers. This potentially limits shallow water operations, but has not factored into any cases to date. The inflatable boat carried by 502001 adds operational flexibility, mitigating the draft limitation and extending shallow water capabilities over the 41-FT UTB. However, the coxswain will have to consider on-site sea conditions prior to deploying the inflatable boat. The range at cruising speed of both the 502001 and 41-FT-UTB is about the same. The fuel consumption of the 502001 is significantly greater than the 41-FT UTB at cruising and maximum speeds.

It is the opinion of the R&DC TECHEVAL Team that there are no technical performance characteristics of the 502001 that would have a negative impact on the outcome of the NORCREW Concept evaluation.

1.0 INTRODUCTION

This report provides the results of the Technical Evaluation (TECHEVAL) of the Coast Guard utility boat CG502001 (502001). This boat is being used to evaluate the Norwegian Crew Concept (NORCREW) at USCG Station Taylors Island, Maryland. The U.S. Coast Guard Research and Development Center (R&DC) conducted this testing on 13-19 November 1992. Calm water tests were completed in Chesapeake Bay, near Chesapeake Beach, Maryland, and near Hampton Roads, Virginia. Rough water tests were conducted in the Atlantic Ocean off Cape Henry, Virginia. The tests were conducted in accordance with the requirements of the NORCREW Test and Evaluation Master Plan (TEMP) [1] and the Research and Development Support Proposal [2]. Test procedures in the NORCREW TECHEVAL Plan [3] follow the General Test Plan for Marine Vehicle Testing [4] and the Small Boat Test Plan [5], except as noted in test descriptions.

1.1 Purpose of the Test

The primary purpose of this testing was to perform a comparative technical test and evaluation of the 502001 and a 41-FT UTB to identify any operational or technical performance differences that could have a negative impact on the outcome of the NORCREW concept evaluations. The testing also serves in establishing a performance baseline for the 502001 and provides useful information for future projects related to the acquisition of replacement UTBs.

1.2 Background

Current small boat stations have shore facilities which require significant financial and staff resources to support. Reducing or eliminating the shore facilities could reduce the operating expenses of small boat stations. It has been proposed that live-aboard boats could eliminate the need for shore facilities. Under this concept, the "on-watch" station crew lives aboard the small boat. The crew operates the boat with no station support and no shore facilities. Since station facilities are eliminated, "off-duty" crew members must live away from the unit. The concept has the potential for savings in crew costs and maintenance of station facilities. The concept is called the Norwegian Crew (NORCREW) because the idea is adopted from the Norwegian Society for Sea Rescue.

The boat being used to prototype the Norwegian Crew Concept, 502001, was constructed by Munson Mfg, Inc., in Edmonds, Washington. The boat was delivered to the Coast Guard in March 1992. It is a multi-mission utility boat, specified to operate with performance similar to a 41-FT UTB. An additional requirement of the boat is to provide accommodations for four crew members to live aboard. The boat is intended to be a self-supporting unit, without using any Coast Guard-owned shore facilities. It has limited office and administrative space. The boat carries emergency spare parts aboard. There is weapons storage for small arms and security for classified material. The boat has a generator for electricity when underway or when a shore tie is not available.

The primary mission of the 502001 is search and rescue. The boat is also capable of supporting law enforcement, recreational boating safety, port security and marine environmental protection. The station also conducts other operations such as national defense and aids to navigation support. The electronics suite and chart table workspace make the boat capable of short-range command and control functions. The hull provides a stable work platform for weather conditions up to sea state 3. The boat has towing capabilities for assisting craft up to 40 tons, and has an installed fire pump and fire hoses for fighting ship and pierside fires. It carries an inflatable boat that is useful for shallow water operations. 502001 has a stern ramp for launching and retrieving the inflatable boat. The stern ramp has the potential of being used for deployment of light equipment in marine environmental protection missions or recovery of persons or other objects from the water. The operational capability of the stern ramp is being addressed in the NORCREW Operational Test & Evaluation (OT&E). The 502001 has good radar and visual surveillance capabilities for close range security.

The builder, Munson Mfg, Inc., won a competitively awarded contract to build the live-aboard Utility Boat to Fifth Coast Guard District (CGD5) Specifications. The solicitation required the boat to be based on an existing boat design. The 502001 is a modification to the Munson "Hammerhead" 50-foot workboat design. Built in compliance with Navigation and Vessel Inspection Circular 11-80 guidelines, it has many commercial grade systems not normally found aboard USCG or U.S. Navy small craft.

The CGD5 requested R&DC support through Headquarters (G-NRS), in evaluating the Norwegian live-aboard concept to perform multi-mission operations. This evaluation will assess the feasibility of the NORCREW concept to perform small boat station duties in a multi-mission operational environment.

The R&DC has historically been involved with marine vehicle testing and has been involved in technical testing of nearly every Coast Guard vessel including new acquisitions, such as the 47-FT Motor Life Boat. By using validated techniques, the R&DC Tests and Evaluations results provide quantitative measures of performance to program sponsors to assist in the decision making process. The R&DC has a diverse core of personnel to support ship Test and Evaluation This includes naval architects, ocean engineers, mechanical engineers, and instrumentation specialists, both civilian and military.

R&DC support in the NORCREW evaluation focuses on three essential elements, technical comparison with a 41-FT UTB, crew adaptation, and operational effectiveness and suitability. The TECHEVAL of the 502001 fulfills the technical comparison element. The NORCREW concept assumes that the unit operated with this crewing will present no loss in operational capability compared to a single-boat station. The TECHEVAL measures the boat's performance relative to the 41-FT UTB and determine if any significant differences exist. Separate reports by the R&DC will address crew adaptation, and operational effectiveness and suitability.

1.3 TECHEVAL Objectives

The objectives of this testing were as follows:

a. Determine the technical suitability of the design for Coast Guard multi-mission operations similar to those performed by the 41-FT UTB.

b. Compare the performance capabilities of the 502001 to the characteristics of a 41-FT UTB.

c. Provide data needed by the Project Evaluation Board (PEB) to assess the effects of the technical characteristics of the 502001 on the outcome of the NORCREW concept evaluation.

d. Provide technical data describing the performance of 502001 to be used in future UTB Replacement acquisition projects.

To fulfill these objectives, it was necessary to measure the following properties:

- Principal Characteristics - Document the principal characteristics of the 502001.

- Vessel Mass Properties/Stability - Verify the weight and longitudinal center of gravity. Assess the vessel's stability and righting arm by means of an inclining experiment.

- Maneuverability and Control - Measure maneuverability and control of the 502001 to provide tactical data and to assess safety and performance throughout the operational envelope. Conduct standard and extreme operational maneuvers and measure the boat's responses during turning, accelerating, decelerating and low-speed operations to verify the expected performance and identify any unanticipated responses.

- Speed versus Power - Measure and analyze the 502001's speed versus power relationships. Assess the optimal settings for the boat's trim tabs under various operating conditions.

- Fuel Consumption, Range, and Endurance - Independently verify fuel consumption rates measured during speed/power trials in various operating conditions and estimate range based on predictions of usable fuel from the vessel's tankage. Determine limiting parameters on endurance.

- Times to Get Underway - Provide data for developing operating procedures and assessing the boat's capability for quick response missions.

- Firefighting/Dewatering/Emergency Response - Assess the boat's capability to provide assistance in case of fire, flooding and other emergencies. Although a requirement in the TECHEVAL Plan [3], this area was not addressed due to time limitations.

- Visibility from Deckhouse/Conning Stations - Visibility from boat control and conning stations is crucial to safe and efficient operation. Document and evaluate visibility via sight lines, photographic and other techniques.

- Noise Survey - Measure the level of airborne noise present under different operating conditions. Identify significant noise problems.

- Human Factors Engineering - Identify potential Human Factors Engineering problems which could impact the outcome of the NORCREW concept evaluation. Report on specific areas for further examination by human factors experts.

- Rough Water Performance - Verify through sufficient testing that the speed and seaway operational performance is as good as, or better than, that of the 41-FT UTB. Determine any operational limitations of the boat in various sea states.

Side-by-side seakeeping tests were conducted with the 502001 and a 41-FT UTB during November 13-19, 1992. For the TECHEVAL, it was necessary to document the motion characteristics of both vessels in the same sea conditions. Results from previous 41-FT UTB tests reported in references [6-8] were extracted to compare power versus speed and maneuvering characteristics to the 502001 test results.

The configuration of 502001 tested in this report is "as built" by Munson Manufacturing, Inc. of Edmonds, Washington, except for the following modifications completed since the Coast Guard accepted delivery of the boat in March 1992.

a. Engine Rating was changed to increase horsepower from 650 hp to 735 hp per engine.

b. Changes in outfit and minor habitability changes made by the crew have contributed to a weight growth of approximately 1,677 lbs since the boat was delivered.

c. In addition to the weight growth from operational outfitting, 300 lbs of R&DC test equipment was installed to conduct the testing.

d. The normal crew of 502001 for operations is four persons versus three for a 41-FT UTB. During the R&DC tests, five to seven persons were aboard (crew and test personnel).

1.4 Testing Performed

Table 1.1 lists the individual tests conducted for this TECHEVAL. Each test is intended to provide data to support one or more of the TECHEVAL specific objectives defined in Section 1.3. In general these test can be classified as:

a. Calm Water Tests - Tests which primarily require minimum wind velocity, current and sea state.

b. Rough Water Tests - Seakeeping and other tests which require unidirectional wave conditions in excess of sea state 3, but less than sea state 5.

TABLE 1.1
LIST OF TECHEVAL TESTS

Phase 1 Calm Water Tests

TEST NUMBER	TEST NAME
T-1	PRINCIPAL CHARACTERISTICS
T-2	STABILITY/INCLINING EXPERIMENT (includes craft weighing)
T-3	TACTICAL DIAMETER/TURNING PERFORMANCE
T-4	ZIG-ZAG MANEUVER
T-5	SPIRAL
T-6	ACCELERATION AND CRASH STOP
T-7	SPEED VS POWER
T-8	FUEL CONSUMPTION, RANGE AND ENDURANCE
T-9	TIMES TO GET UNDERWAY
T-10	ONBOARD NOISE SURVEY

Phase 2 Rough Water Tests

TEST NUMBER	TEST NAME
T-11	SEAKEEPING PERFORMANCE
T-12	SPEED VS SEA HEIGHT

The next section of this report describes each test with a brief discussion or reference to the procedure used, followed by the test results. Detailed test procedure descriptions can be found in the TECHEVAL Plan [3]. A summary section follows, which identifies strengths and weaknesses of the prototype boat and points out any anomalies in the test results. The report conclusion synopsizes all aspects of the TECHEVAL. Appendix A includes results of an inclining experiment conducted by the R&DC to measure static stability of the 502001, and Appendix B includes details of noise surveys performed on the 502001 and the 41350 at Station New London, Connecticut. Appendix C contains all of the 502001 and 41500 side-by-side seakeeping performance data.

1.5 Test Equipment

Figure 1.5.1 illustrates the major test equipment used to conduct the TECHEVAL and the general locations aboard the 502001.

2.0 502001 TECHNICAL CHARACTERISTICS

2.1 T-1 Principal Characteristics

This boat is intended to be similar in capabilities to a 41-FT UTB. Table 2.1.1 gives an overview comparison of the principal characteristics of the two craft.

TABLE 2.1.1
PRINCIPAL CHARACTERISTICS

BOAT CHARACTERISTIC	502001 [11]	41-FT UTB [8]
LENGTH OVERALL (FT)	50'6"	40'8"
BEAM (FT)	16'4"	13'6"
DRAFT (FT)	4'10"	4'1"
FULL LOAD DISPLACEMENT (LBS)	54,400(*)	30,700
HULL MATERIAL	ALUMINUM	ALUMINUM
CABIN MATERIAL	ALUMINUM	FIBERGLASS
MAXIMUM SPEED (KTS)	23.0(*)	26.0
IDLE SPEED (KTS)	5	5
FUEL CAPACITY (GAL)	644 (at 95%)	450
ENGINE MODEL	DETROIT DIESEL 8V92TA	CUMMINS VT903
TOTAL BOAT HORSEPOWER	1470(*)	640
CREW SIZE	4	3
HEIGHT OF EYE (FT)	10'6"	8'3"
VISIBLE HORIZON (NM)	3.8	3.3

(*) Results from TECHEVAL

As can be seen from the above table, the 502001 is larger in length, beam, draft, and displacement than the 41-FT UTB.

The 502001 has several features including:

- A waterline-level stern door and ramp that can be lowered to assist in operations such as launching an inflatable boat or other objects, or recovering objects from the water.
- Trim tabs to control vessel trim.
- Electronic engine controls.
- A "trolling" valve to allow low-speed operation.
- A hydraulically-driven fire pump powered by the boat's engines. The electronic engine controls automatically adjust the hydraulic pressure based on the pump demand.

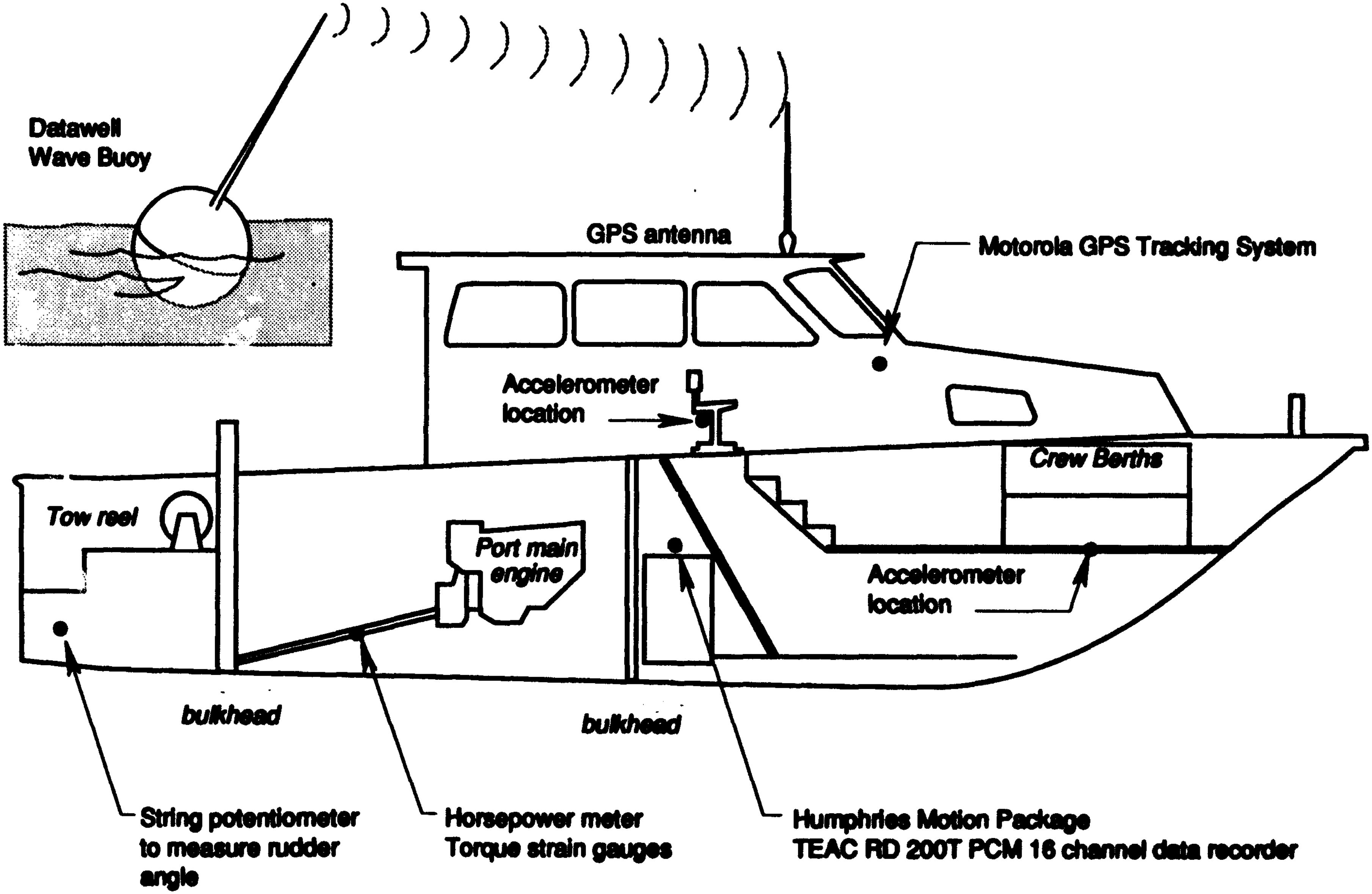


FIGURE 1.5.1 Location of Test Equipment on Board the 502001

- Sleeping Quarters for a crew of four in two bunk rooms and a main cabin settee that converts to a berth when needed.

- A special house load battery dedicated to boat service that is not part of the engine starting system.

- Heating and air conditioning system for all living spaces.

The hull shape is a deep-V design with a 16° deadrise angle. Views of the boat are shown in Figures 2.1.1a through 2.1.1c. This hull has no skeg. The propellers are the lowest point in the navigational draft.

The 502001 has an aluminum hull of 5086 alloy plate and 6061 alloy shapes. The hull has 30-inch frame spacing. The hull plating is 5/16-inch thick. The deckhouse and deck are 3/16-inch plate. The 41-FT UTB is constructed of 3/16-inch aluminum plate except for frames 11-13 where 5/16-inch plating is used to withstand extra load.

2.2 General Arrangement and Details of the 502001

Discussion of the General Arrangements of the 502001 will parallel the discussion of 41-FT UTB arrangements in the 41-FT UTB Type Manual [7]. Readers familiar with this reference may follow along to compare the layout of the two boats. Figures 2.2.1a and 2.2.1b illustrate the general arrangements of the 502001, and Figures 2.2.2a and 2.2.2b illustrate the 41-FT UTB for comparison. The drawings of the 502001 were extracted from the builder's drawings in reference [11].

Chain Locker: The forward-most compartment is the anchor line and chain locker. The compartment is accessed through a watertight deck hatch and contains the boat's anchor line. A hawse pipe for the anchor line comes through the deck just aft of the forward tow bitt.

Forepeak Void: A watertight void space for buoyancy and damage survival is provided below the chain locker.

Forward Cabin: The forward cabin provides berthing for four crew members in two staterooms. Each stateroom has two bunks, limited hanging storage and a sink with a mirror. Each stateroom has sealed windows, and a skylight for additional lighting which doubles as an escape hatch. Just aft of the staterooms is the head. On the port side is the toilet; on the Starboard side is a shower. Aft of the head is a ladder into the main compartment.

Crawl Space: Beneath the forward cabin is the crawl space, accessed through the storage and utility space. The crawl space provides access to tanks and equipment in the forward part of the boat including the Grey and Black water tanks, marine sanitation

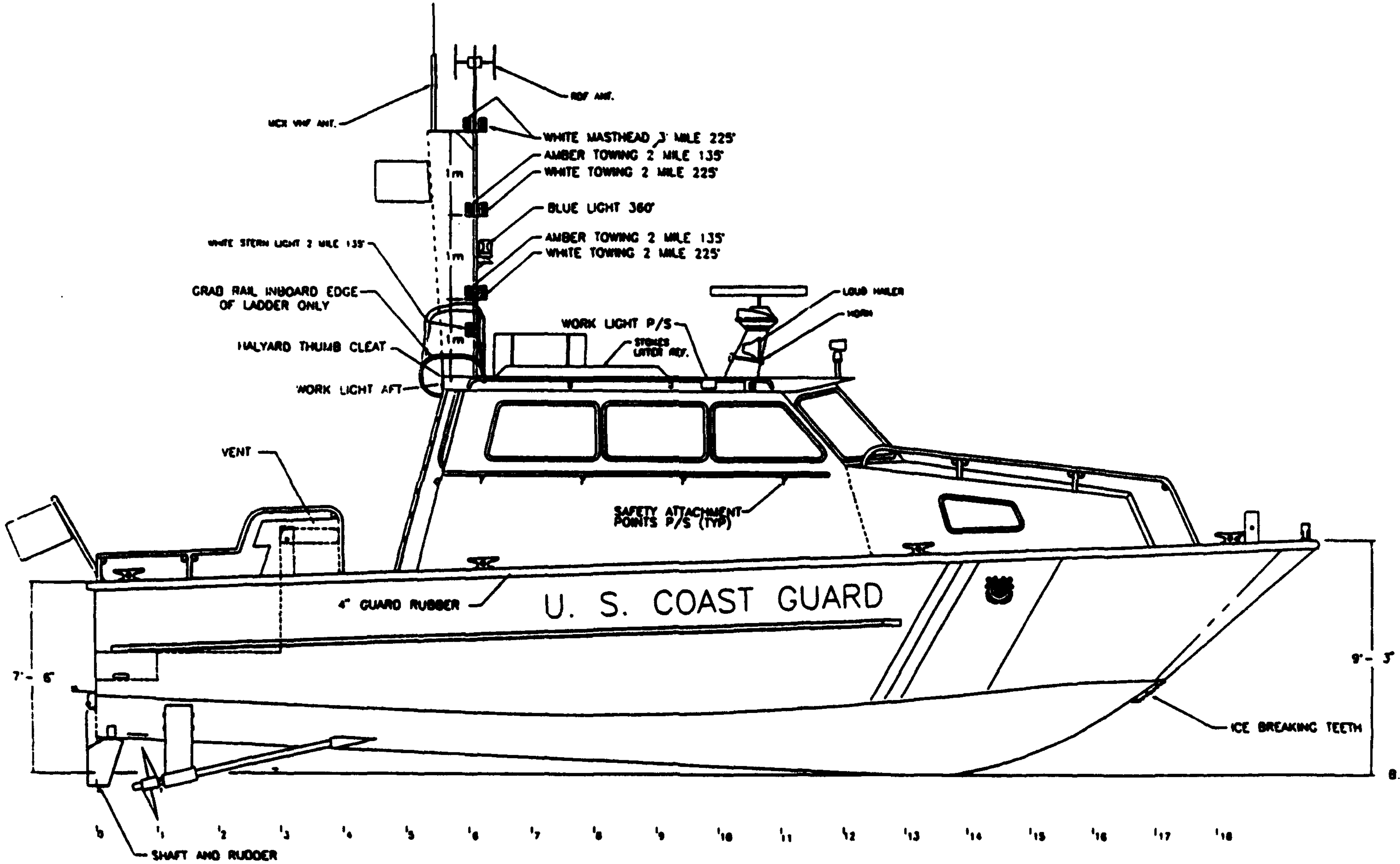


FIGURE 2.1.1a Outboard Elevation 502001

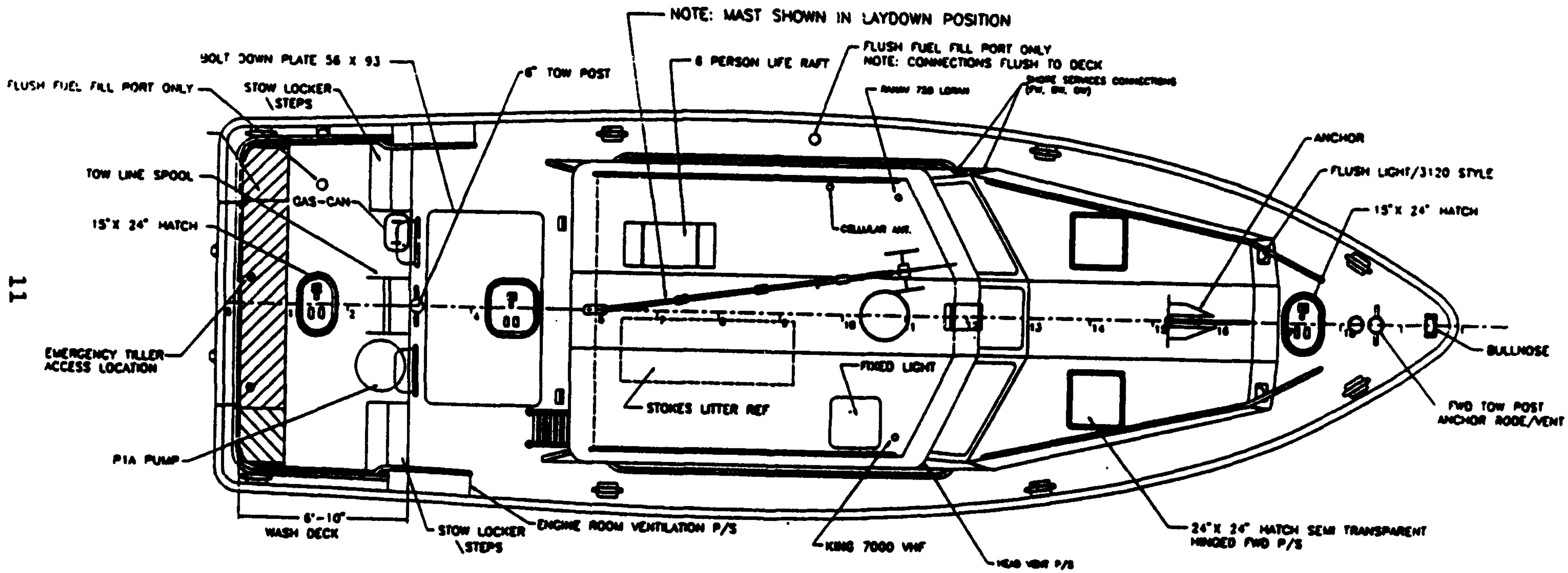


FIGURE 2.1.1b Outboard Plan 502001

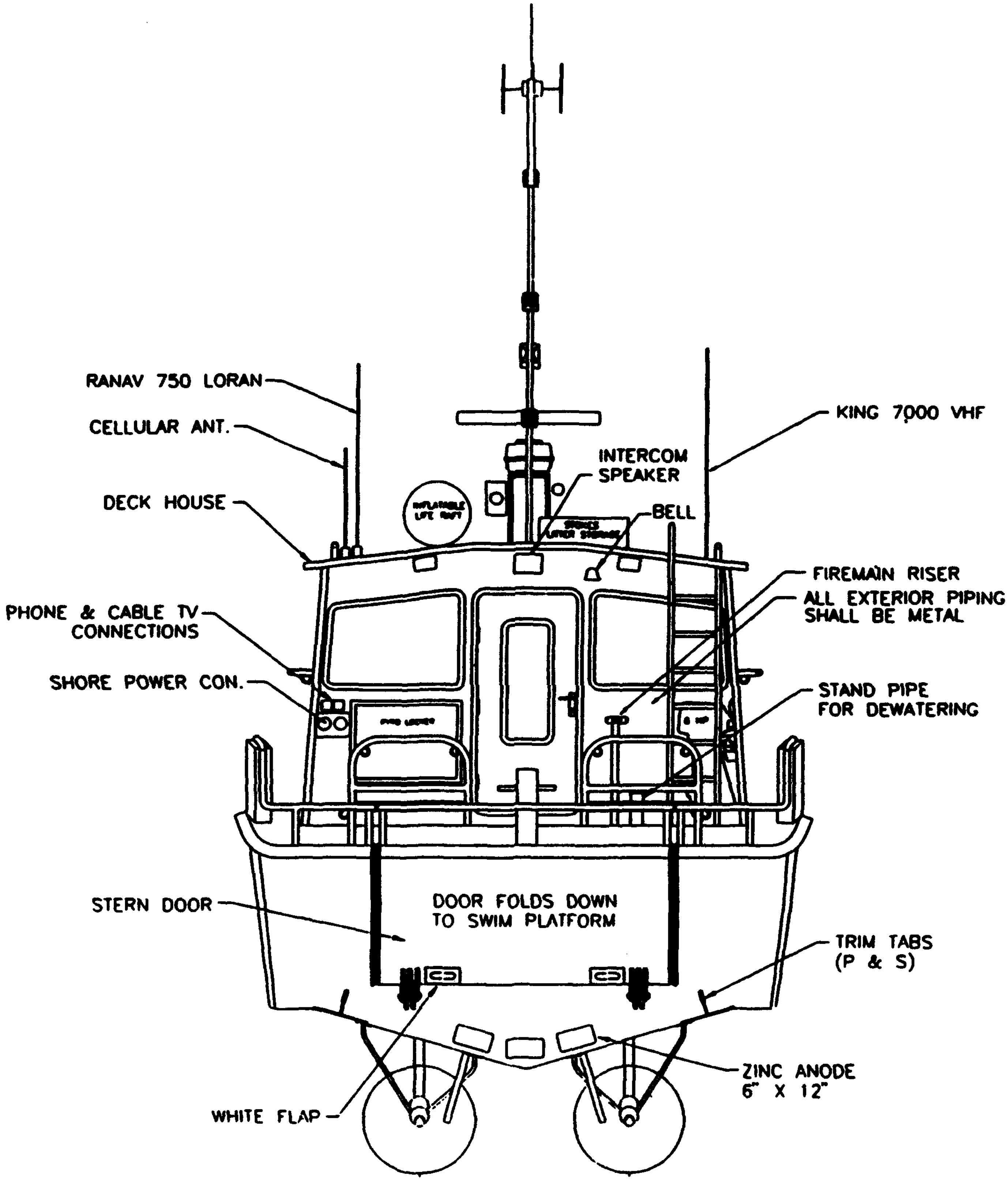


FIGURE 2.1.1c View from Astern 502001

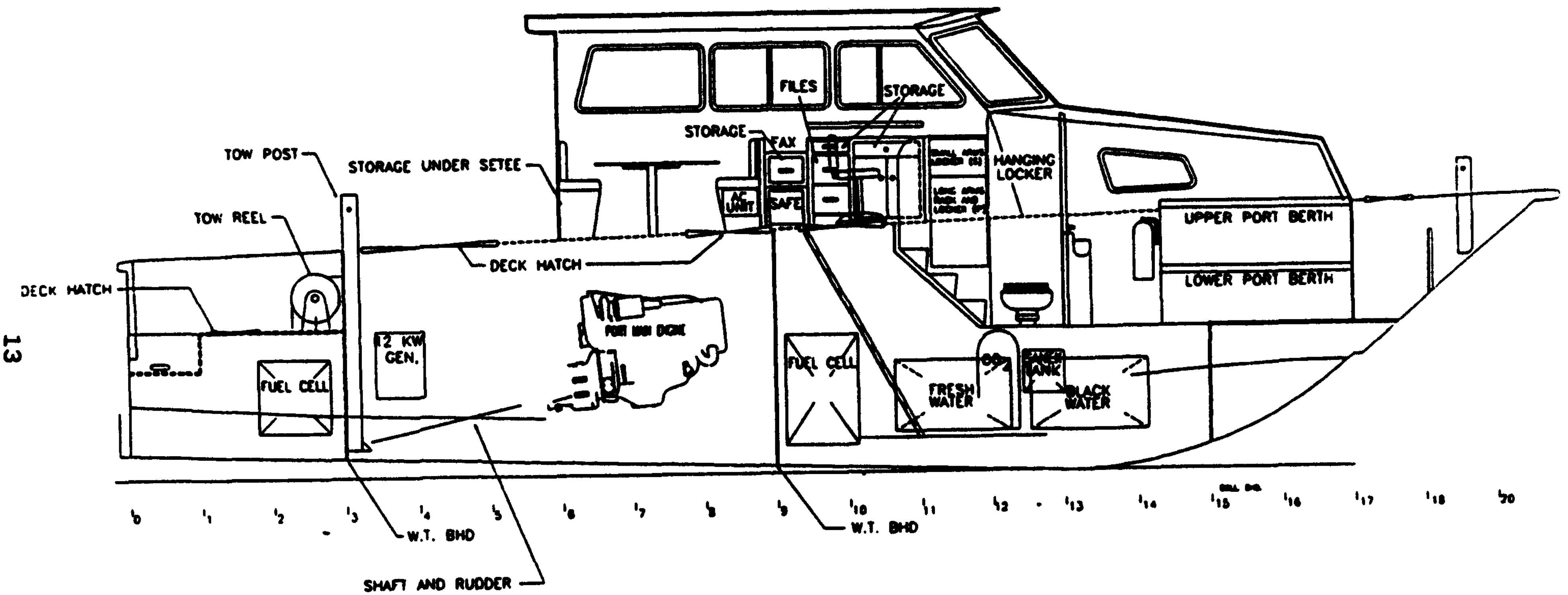


FIGURE 2.2.1a 502001 General Arrangements, Part 1

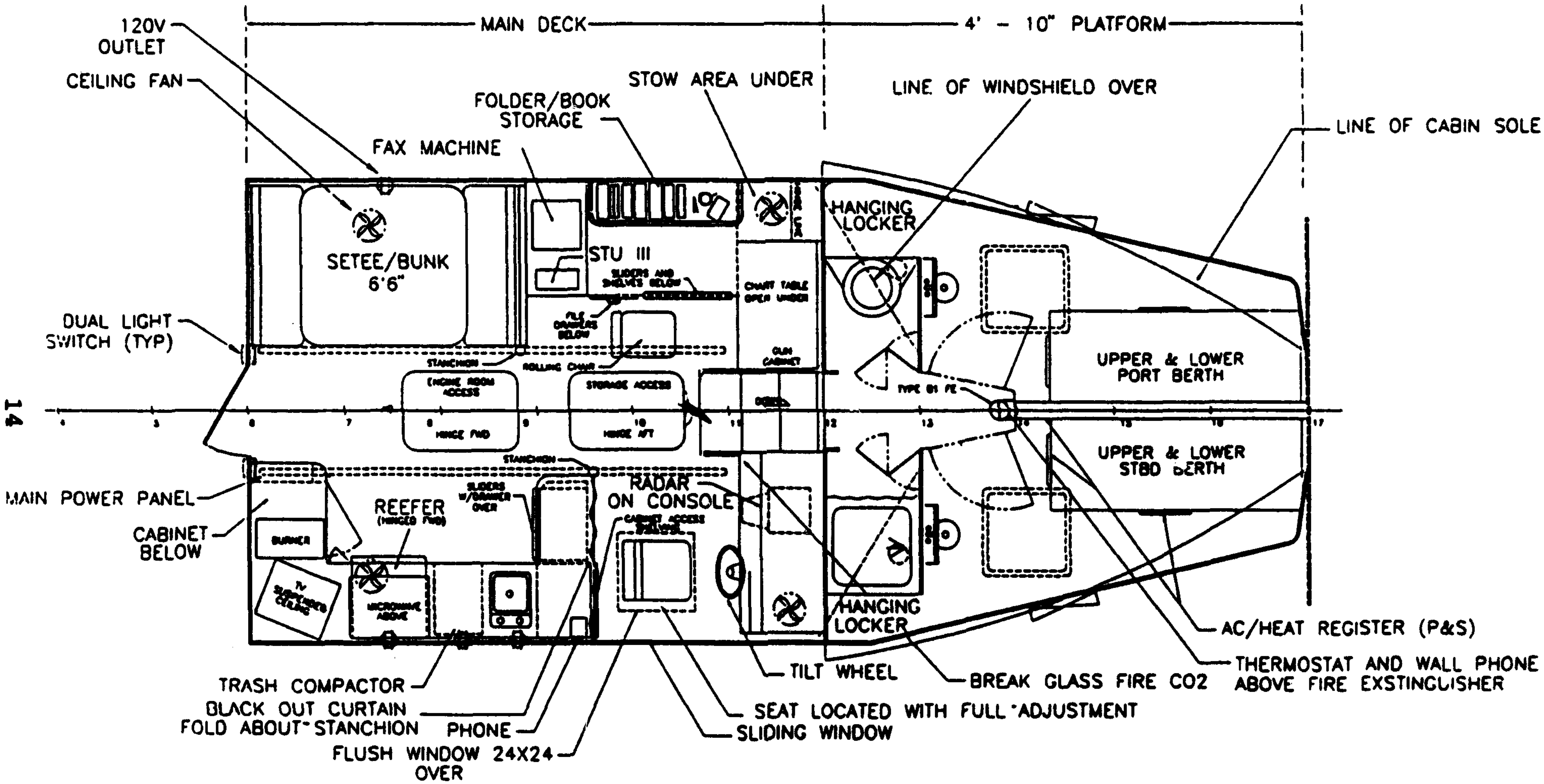


FIGURE 2.2.1b 502001 General Arrangements, Part 2

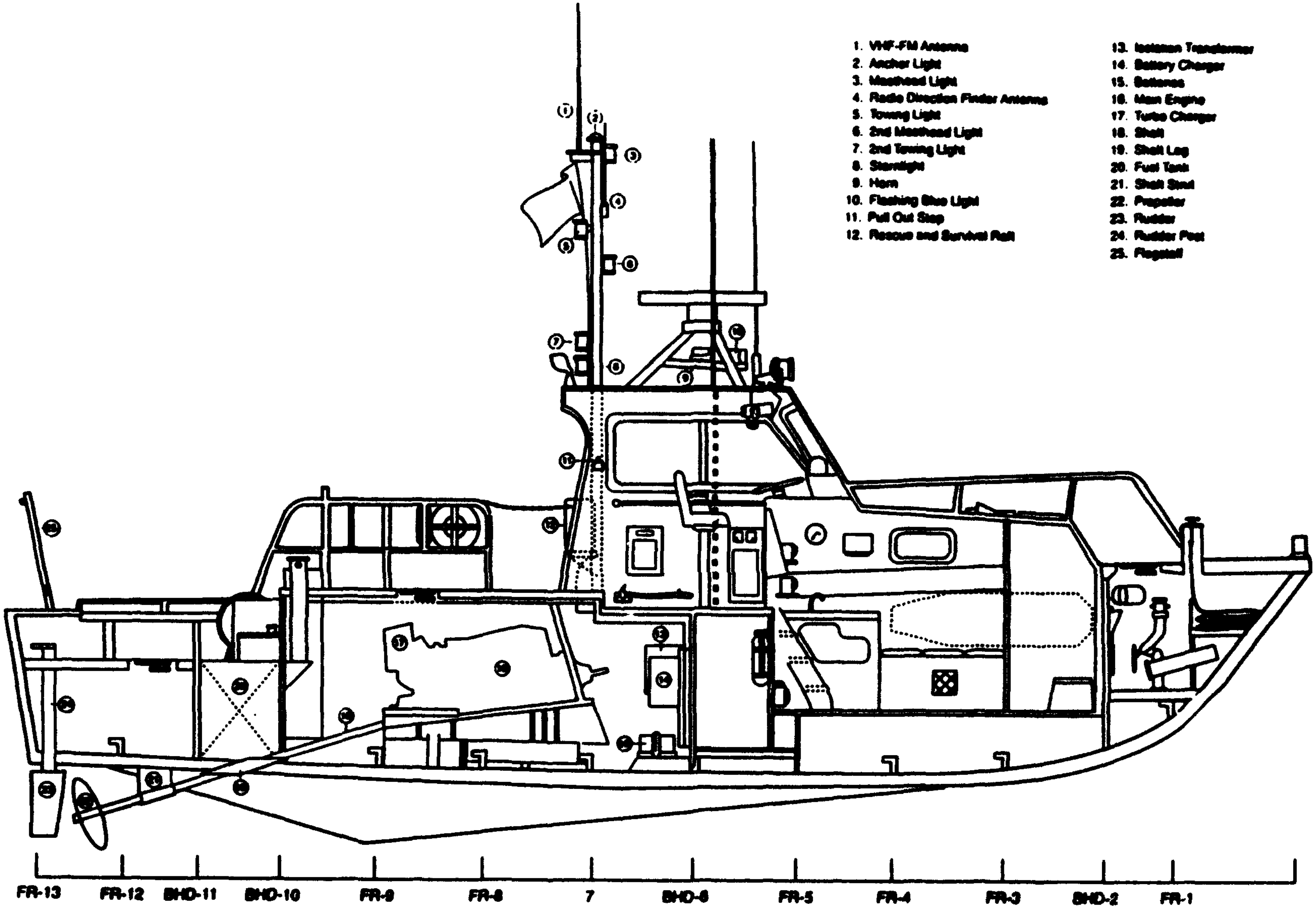


FIGURE 2.2.2a 41-FT UTB General Arrangements, Part 1

1. Bullnose
2. Forward Bitt
3. Forepeak Scuttle
4. Escape Hatch
5. Anchor
6. Handrail
7. Loudhailer
8. Searchlight
9. Loran-C Antenna
10. Radar Antenna
11. Pilothouse Handrail
12. Aft Floodlight
13. Radio Direction Finder Antenna
14. Sidelights
15. Fresh Water Fill & Vent
16. 110V AC Shore Tie
17. Pull-out Step
18. Engine Room Hatches
19. Engine Room Scuttle
20. Tow Bitt
21. Handrail/Mast Support Rail
22. Life Ring
23. Floating Electric Marker Light
24. M60 Gun Mount
25. Main Engine Air Intake
26. Fuel Tank Vents
27. Deck Storage Boxes
28. Fuel Oil Fill/Sounding Tube
29. 5-Gal. Gas Storage Can
30. Towline & Storage Reel
31. Dewatering Pump Canister
32. Lazarette Scuttle
33. Taffrail
34. Flagstaff Socket
35. Deck Cleats
36. Rub Rail
37. HF-SSB Antenna

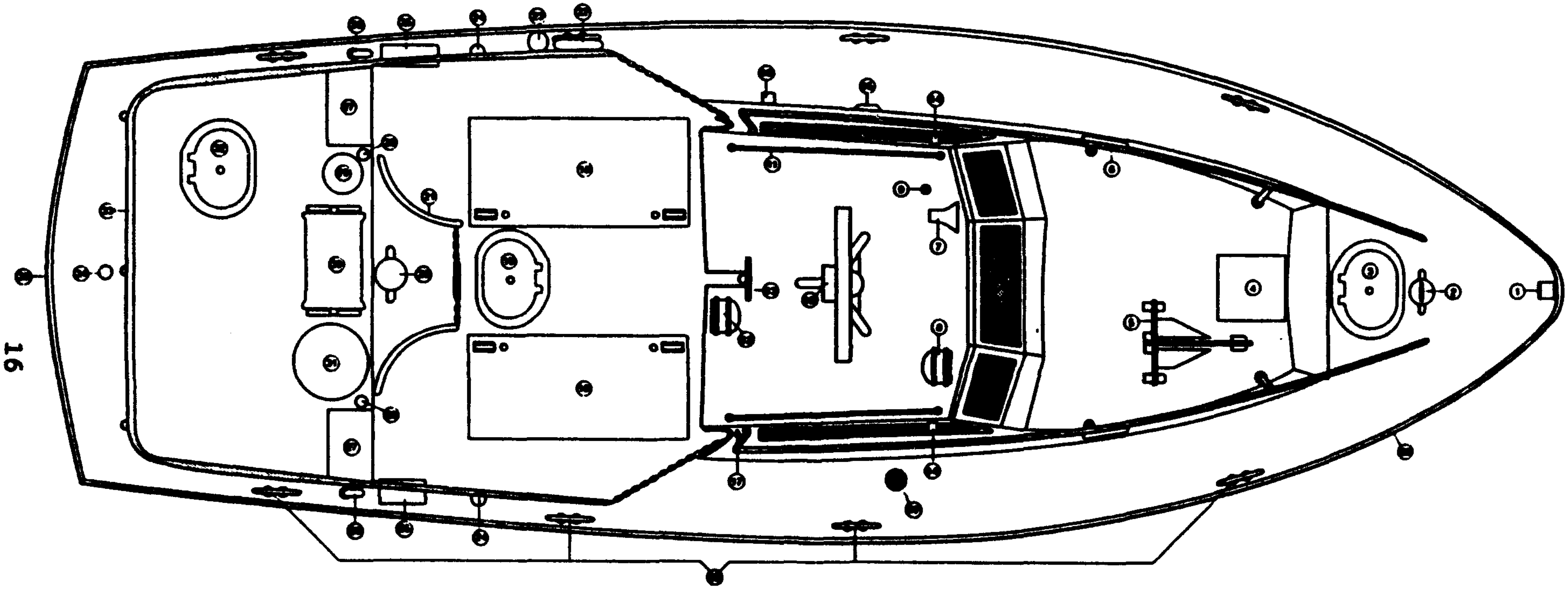


FIGURE 2.2.2b 41-FT UTB General Arrangements, Part 2

device and treatment chemical tank, forward bilge pump and forward AC unit.

Storage and Utility Space: Beneath the deck in the main cabin is the storage and utility space. This compartment is accessed through a hatch in the deck of the main cabin. In this compartment are the forward fuel tank (315 gallons at 95%), CO2 fire control system, fresh water tanks, bilge pump for the space and storage shelves for boat outfit and emergency spare parts.

Main Cabin: The main cabin is accessed through a watertight door in the aft bulkhead of the cabin. In the main cabin forward on the starboard side is the coxswain's station with engine controls, helm, gauges, radios, fathometer, autopilot, radar, direction finder, and compass. The coxswain has a chair that can swivel into two positions. On the port side forward is a chart table, book shelf, filing cabinet, and a safe for storing classified material. Aft on the port side is the galley settee seating for four with a table. The table top drops down to convert the settee into a fifth berth if needed. The HVAC for the compartment is under the forward seat of the settee. Aft on the starboard side is the galley. It includes a refrigerator, trash compactor, cabinets, stove top, convection microwave oven, sink and entertainment system.

Engine Room: The engine room is accessed from a deck hatch in the main cabin or through a watertight hatch on the main deck aft of the cabin. In this space are the two main engines, the generator, electrical distribution system, and the fire pump. The space is equipped with CO2 system for firefighting. To prevent a CO2 charge from venting out of the engine room while attempting to extinguish a fire, guillotine-type vent covers automatically close over the engine room intakes when the CO2 system is activated.

Lazarette: This space is accessed through a watertight hatch in the aft well-deck. In the lazarette is the hydraulic steering system, rudder posts and aft fuel tank (329 gallons at 95%).

Main Deck: On the main deck, just aft of the cabin, is the outboard motor for the inflatable boat, the pyrotechnics storage locker, the tow bitt, and shoretie connections.

Well Deck: Aft of the main deck is a well deck. Stored in the well deck area are the P-5 dewatering pump, fenders, and a tow reel with 600 feet of 3-inch nylon tow line. The well deck has a hinged transom door with a electric and manual winch for raising and lowering. The transom door may be lowered horizontally as a work platform or dropped further as a stern ramp.

2.3 Propulsion System

The boat is powered by two Detroit Diesel 8V92TA engines. The engines are designed to produce 735 shaft horsepower each at 2300 Engine RPM. The 3-inch Aquamet 19 steel propeller shafts are driven through Twin Disc reduction gears with a 2.04:1 ratio. The shafts drive 32-inch diameter, 32-inch pitch, four-blade propellers. The boat is equipped with a trolling clutch to allow slow speed operations. Engines and gears are controlled with electronic throttle controls.

2.4 Electrical Power System

The electrical power system has AC and DC power for the boat. The AC system has two parts: boat's service and the house system. Both AC systems are designed for 50 AMPs at 120VAC. The house system supports the TV/VCR, air conditioners, hot water heater, stereo and trash compactor. All other AC power is on the boat service system. AC power may be supplied either by shore tie or from the boat's diesel generator. The generator is rated for 12KW.

The DC system is in four parts: port and starboard main engine starting batteries, generator starting system, and the house supply. The main engine's starting batteries are 24VDC, and may be recharged by the engine alternators, or from the 120VAC system. The generator starting and house supply systems both are 12VDC systems. The house system may be recharged by the engine alternators or the 120VAC system.

3.0 TEST RESULTS

3.1 T-2 Weighing the Boat

Weighing of a boat is important in identifying the "as-built" weight, since weight impacts performance and mission capability. The R&DC weighed the 502001 to establish a basis for that configuration from which predictions of impacts of future weight changes can be made. The weight of the vessel was determined by direct hoisting with four calibrated load cells.

The condition of the vessel at the time of the weighing was as follows:

- -No crew on board
- -Aft and forward fuel tanks full
- -Fresh water tanks full
- -Gray and black water tanks empty

Four Revere force transducers (42T-D3-20K-C1P1) were used to make the measurements. The weight indicator (Model 4316) was calibrated for all four load cells. The 502001 was weighed at a commercial boat yard in Cambridge, Maryland, using their travelling hoist. Slings were used and positioned at the designated center sling locations 11 feet, 2 inches and 30 feet forward of the transom. The procedure was to weigh the vessel with all four transducers in-line with the slings, and connected to the weight indicator. The forward force transducers were removed and the aft two transducers were measured in a subsequent lift, providing the means to determine the LCG. The total scale weight was determined to be 53,677 $\pm$ 50 lbs. If an additional four-person crew (4 X 165 lbs) were added to this total scale weight, then the 502001 would weigh 2,337 lbs more than the 52,000 lbs full load weight reported by Munson. The LCG was calculated to be 20 feet forward of the transom or 2.5 feet aft of the engine room bulkhead. This is 7.3 inches forward of the design LCG specified by Munson and is discussed in section 3.7.

3.2 T-2 Inclining Experiment/Stability Calculations

The inclining of the 502001 was conducted at Taylors Island, Maryland. The TECHEVAL Plan [3] and Guidelines for Conducting Stability Test [9] were used to conduct the stability and inclining experiment. Inclining and Stability calculations were accomplished using the HEC Inclining and Stability Test program developed by Herbert Engineering Corp. for the USCG Naval Engineering Division. The program format follows that of reference [9].

The inclining was conducted with the boat at a dock with all lines slack and the water surface at a dead calm. Weights for inclining totaled 2805.6 lbs, including the personnel doing the inclining experiment. The plot of the inclining graph has a good straight slope as required by reference [9] and is located in the Appendix A.

Inclining a boat establishes the metacentric height (GM) and the boat's vertical center of gravity. From this the initial static stability of the boat can be assessed. Appendix A, Stability Test Report, NORCREW 502001, presents the results of the inclining experiment as well as stability results of the boat for light ship conditions (boat fully outfitted with fuel tanks and water tanks empty, and no crew on board), for rescue-ready full load (boat fully outfitted with fuel tanks and potable water tanks full, and a crew of four on board), a normal rescue return load (boat fully outfitted with all tanks down to 5%, crew of four, and four survivors), and a maximum rescue load (boat fully outfitted with fuel tanks and water tanks 95% full, crew of four, and four survivors aboard), a brief summary of the stability calculations are shown in Table 3.2.1.

TABLE 3.2.1
SUMMARY OF STABILITY CALCULATIONS AT VARIOUS LOAD CONDITIONS

	Light ship Condition	Full Load	Normal Rescue Load	Maximum Rescue Load
Disp(lbs)	47200	54100	48850	54450
KMt (ft)	11.43	10.62	11.22	10.59
VCG (ft)	6.36	5.94	6.39	5.99
GMo (ft)	5.07	4.68	4.83	4.60
FSM (ft-lbs)	.00	1232.00	1232.00	1232.00
FSC (ft)	.00	.02	.02	.02
GMt (ft)	5.07	4.66	4.81	4.58
LCG (ft)F	19.99	19.79	20.12	19.90
LCFd(ft)	3.30	3.52	3.35	3.53
LCB (ft)F	19.49	19.35	19.46	19.34
LCF (ft)F	18.24	18.47	18.29	18.47
KMl (ft)	79.16	72.21	77.35	71.90
MT1" (ft-Lbs/ins)	6633.30	6920.90	6689.66	6927.29
Trim (ft)F	.29	.29	.40	.36
List (° Stbd)	.54	.52	.16	.15

Note: 1. All displacement amounts were calculated from draft readings using the HEC Inclining and Stability Test program.

2. Abbreviations are defined in Appendix A.

The GMt as listed in Table 3.2.1 under all loading conditions exceeds the requirements of CFR 46, Part 173, Sub Part E [10] for towing. The 502001 heeling arm was calculated by using the weight of the boat and righting arm information for the boat at 54,000 lbs. The heeling arm shown in Figure 3.2.1 exceeds the requirements of the CFR for the towline tripping force of the rated tow load. Although the boat is still able to right itself beyond a 47° heel angle, at this angle down flooding at the engine room vents begins to affect the stability of the boat. The boat has a positive righting moment until a heel angle of approximately 75°.

3.3 T-3 Tactical Diameter/Turning Performance

Turning circles are a good, practical ship test for assessing maneuverability. Turning characteristics generally consist of four measurements which include advance, transfer, tactical diameter, and steady turning diameter or radius. These measurements are illustrated in Figure 3.3.1.

Turning circles were conducted on the 502001 at 10, 20, and 23 knots, north of Little Choptank River in water depths greater than 30 feet. Hydraulic trim tabs were set to normal crew settings of 10° and 8° for the starboard and port tabs, respectively. The turning performance data were measured using the R&DC's Tactical Maneuvering (TACMAN) GPS software. The GPS tracking system measured the boat's track over ground. The effects of current on the tactical performance measurements were removed by accounting for set and drift in the data reduction. Figure 3.3.2 illustrates the results of a set-and-drift correction. The boat executes a right turn and continues turning five circles in its own wake. The GPS-recorded track over the ground appears on the left as a trochoidal curve because of the effects of 1.2 knots of steady current. The corrected track on the right appears as a set of five nearly concentric circles, indicating the true path of the vessel through the water. The turning circle is measured from the corrected track and is accurate to within ± 15 feet relative to the recorded track, except during GPS fade-out. On a few occasions, the GPS receiver lost its lock with satellites which caused some spurious spikes in the recorded track lines. This made the post-processing of corrections for set-and-drift more difficult and may have reduced accuracy slightly.

The results of the tests conducted on the 502001, which will serve as baseline measurements for any future NORCREW boats of this size, are presented in the following tables for the speeds measured.

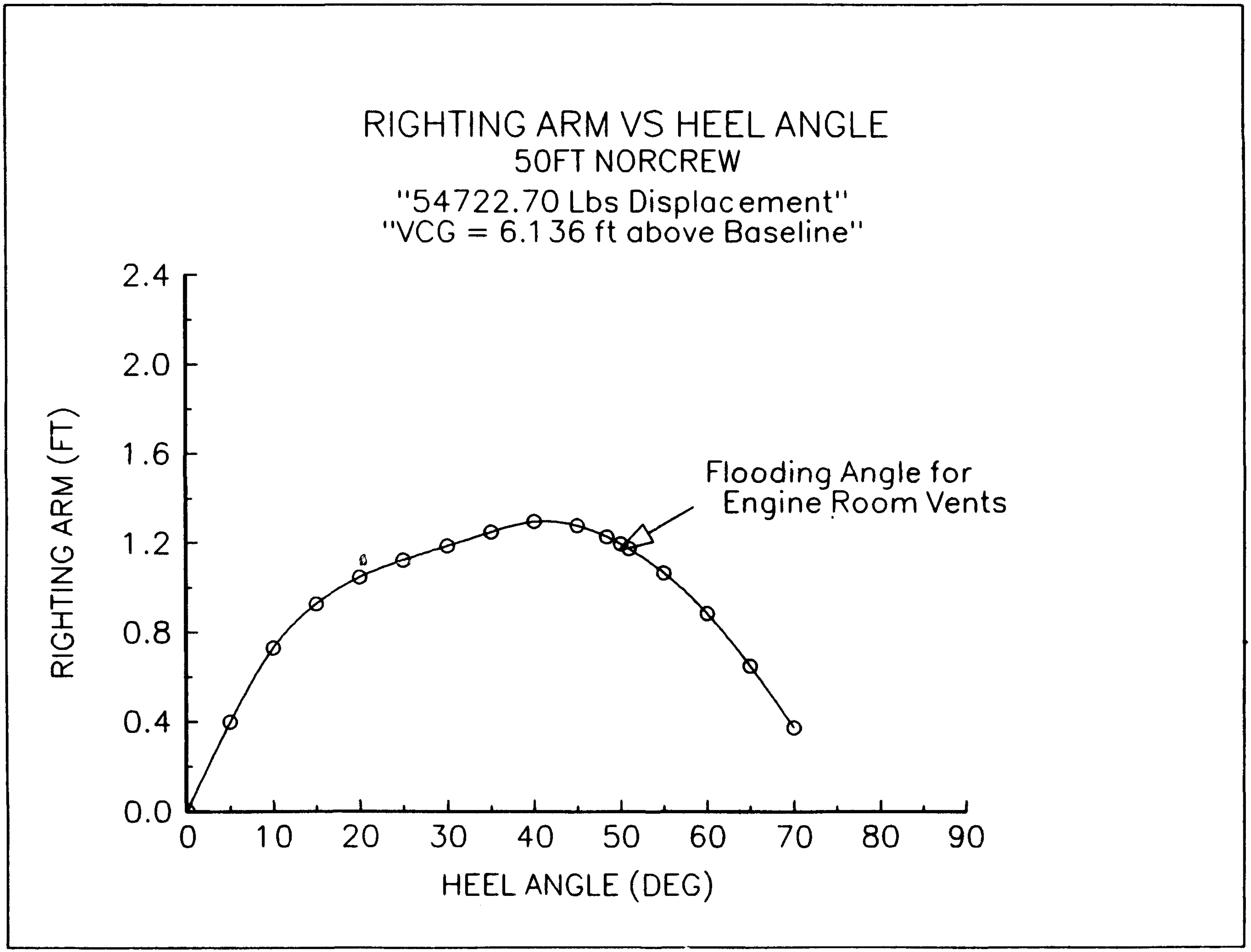


FIGURE 3.2.1 502001 Righting Arm vs Heel Angle

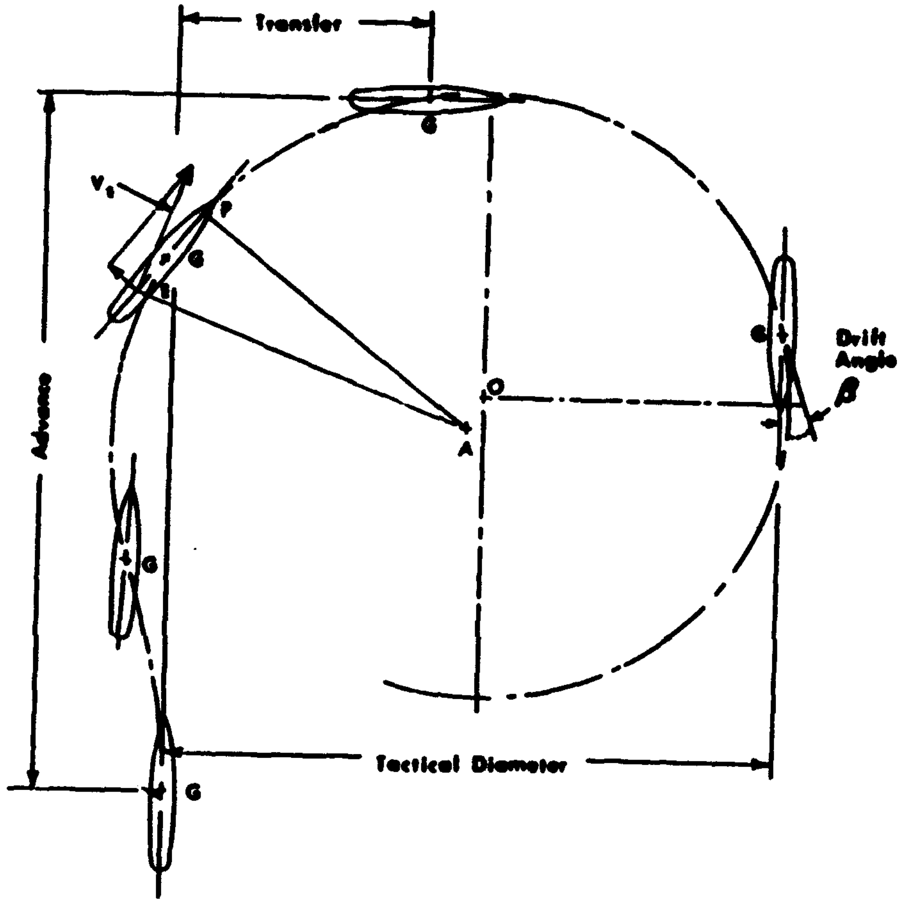


FIGURE 3.3.1 Typical Turning Path of a Vessel [14]

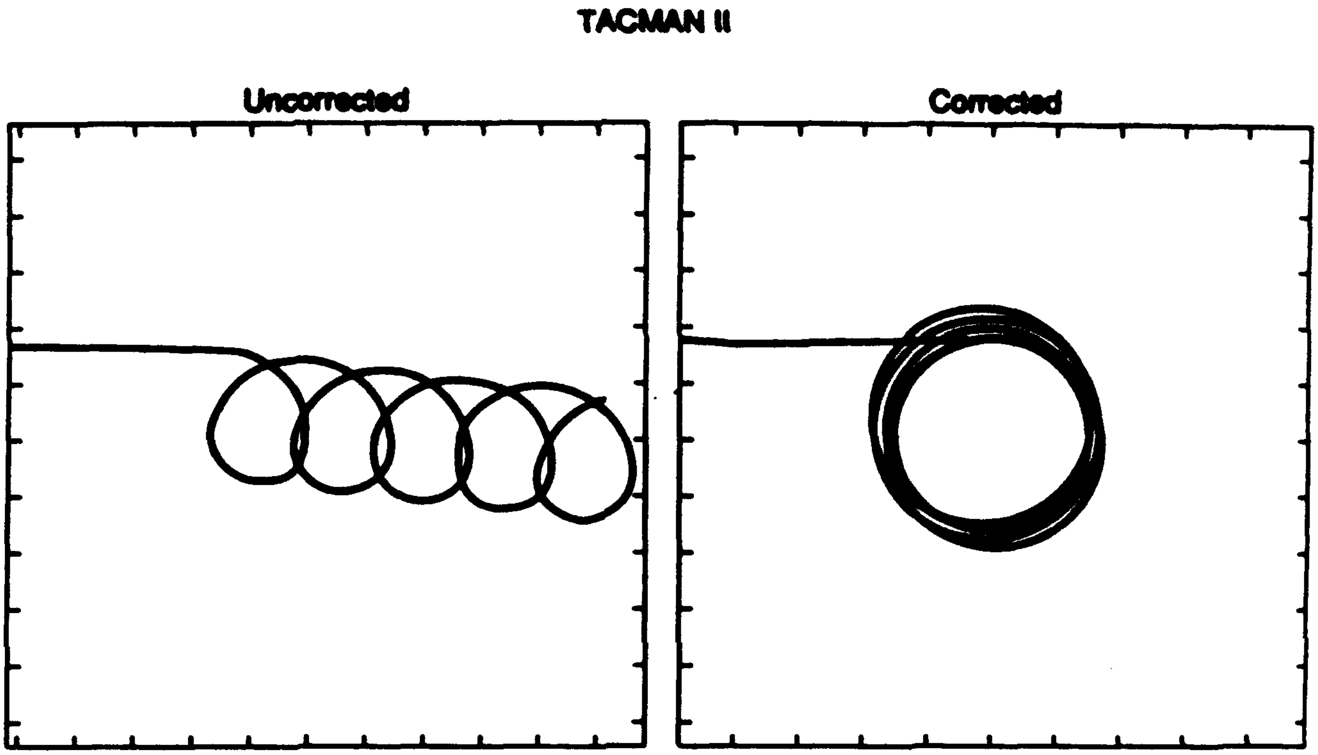


FIGURE 3.3.2 Set and Drift Corrections

(Example)

TABLE 3.3.1
TURNING PERFORMANCE AT 10 KNOTS
(1100 RPM)

Rudder Angle (deg)	Minimum Turning Radius (yards)	Time to Turn 360 Degrees (seconds)	Tactical Diameter (yards)	Advance (yards)	Transfer (yards)
38L	39	53	85	74	60
20L	63	78	114	66	102
10L*	120	164	292	147	194
10R*	132	140	194	133	102
20R	57	73	100	79	48
33R	38	66	72	126	44

*Some GPS fade-out occurred during tests which may account for the disparity between 10L and 10R maneuvers.

TABLE 3.3.2
TURNING PERFORMANCE AT 20 KNOTS
(2300 RPM)

Rudder Angle (deg)	Minimum Turning Radius (yards)	Time to Turn 360 Degrees (seconds)	Tactical Diameter (yards)	Advance (yards)	Transfer (yards)
38L	58	41	112	81	80
20L	94	65	203	142	123
10L	204	115	387	187	245
10R	191	117	376	267	238
20R	88	28	174	94	110
33R	64	46	114	118	65

TABLE 3.3.3
TURNING PERFORMANCE AT 23 KNOTS
(2525 RPM)

Rudder Angle (deg)	Minimum Turning Radius (yards)	Time to Turn 360 Degrees (seconds)	Tactical Diameter (yards)	Advance (yards)	Transfer (yards)
38L	67	31	139	113	99
20L	134	73	265	212	156
10L	195	102	365	255	190
10R	174	96	244	242	184
20R	85	49	130	112	99
33R	61	38	101	94	74

The handling characteristics reported in the CG502001 Manual provided by Munson Mfg., Inc. [11], describe a 200-foot (67 yard) turning radius at top speed with normal rate at the helm. The data collected by the R&DC tests agree with these results. The 502001 turning performance data demonstrates a tendency for turning maneuvers to port requiring more time and maneuvering room compared to turning maneuvers to starboard. Table 3.3.4 provides a comparison of minimum turning radius between a 41-FT UTB and the 502001 for a nominal 30° rudder. Table 3.3.4 includes a 502001 turning radius normalized to a 41-FT UTB boat length. It is expected that the longer 502001 has a greater turn radius since turning performance is a function of boat speed and length. Even the normalized 502001 turn radius in Table 3.3.4 is larger at 20 and 23 knots compared to the 41-FT UTB.

TABLE 3.3.4
COMPARATIVE MINIMUM TURNING RADIUS
PERFORMANCE AT VARIOUS SPEEDS

Speed (knots)	41-FT UTB (30° rudder)	502001 (33° rudder)	502001 Normalized to 41-FT Length*
10	35 yds (31 sec)	38 yds (66 sec)	31 yds
20	43 yds (31 sec)	64 yds (46 sec)	52 yds
23	39 yds (25 sec)	61 yds (38 sec)	49 yds

$$*(\text{41-FT UTB LENGTH}) \times \left(\frac{\text{502001 TURN RADIUS}}{\text{502001 LENGTH}}\right)$$

3.4 T-4 Zig-Zag Maneuver

The zig-zag test is a definitive ship trial for measuring the rudder's ability to control the boat in calm water. The test was conducted near CG Station Little Creek in approximately 50 feet of water. Wind during the test was less than 10 knots with seas less than one foot. A string potentiometer was attached to the port rudder and was used to synchronize the execution of rudder maneuvers with the boat's heading. Heading was recorded using the yaw gyro of the motions package installed near the vessel's center of gravity. The vessel's track was not recorded with the GPS system because of signal interference with structures from the nearby Norfolk Naval Base. The test was to have been performed at 10, 20, and maximum speed per the TECHEVAL Test Plan [3].

Figure 3.4.1 presents the results of a 10-knot zig-zag maneuver on the 502001. The average overshoot angle was determined to be 8°. This is less than the 10° overshoot demonstrated by the 41-FT UTB results in Figure 3.4.2. Figures 3.4.1 and 3.4.2 also demonstrate that the 502001 has about the same time to the second execute or rudder over. This parameter is a measure of the ability of the boat to rapidly change course. The time to the second execute will decrease with increased rudder effectiveness and with decreased directional stability. Generally, it appears the 502001 and the 41-FT UTB 10-knot zig-zag maneuvering characteristics are similar.

The collection of 20-knot data was attempted, but was not successful. This was due to the inability of the ship's compass to respond rapidly to high rates of turn. It appears that the ship's magnetic compass was heavily damped. The apparent lag in compass response prevented the coxswain from making a good judgment as to when a 20° course change actually occurred. The 20-knot trials were aborted because a complete zig-zag was not measurable under the circumstances. A 15-knot trial was attempted, shown in Figures 3.4.3 and 3.4.4, but as noted during the test, these were also suspect because of compass effects. In Figure 3.4.4, it appears that the coxswain, realizing a lag in the compass's response, tried to over-compensate for this effect which resulted in 15° zig-zags instead of 20°. Therefore, the only reliable zig-zag maneuver data collected were at 10 knots.

3.5 T-5 Spiral

The Dieudonne spiral test measures the directional stability, turn rate and course-keeping ability of a boat in calm water. This test was conducted off Chesapeake Beach, Maryland, in approximately 30 feet of water. Seas were less than 1.5 feet and winds were under five knots. The test was conducted at two speeds; ten knots (1100 RPM) and 22.4 knots (2550 RPM).

Starting from 15° right rudder, and decreasing rudder angle by increments specified in reference [3], the yaw rate was recorded using a Humphreys motion package yaw rate gyro and then averaged over a 1-minute period of steady turning for each rudder angle.

The directional stability of a vessel is important to those who navigate and operate the boat. If a boat is directionally unstable, it may turn at two different rates for a given rudder

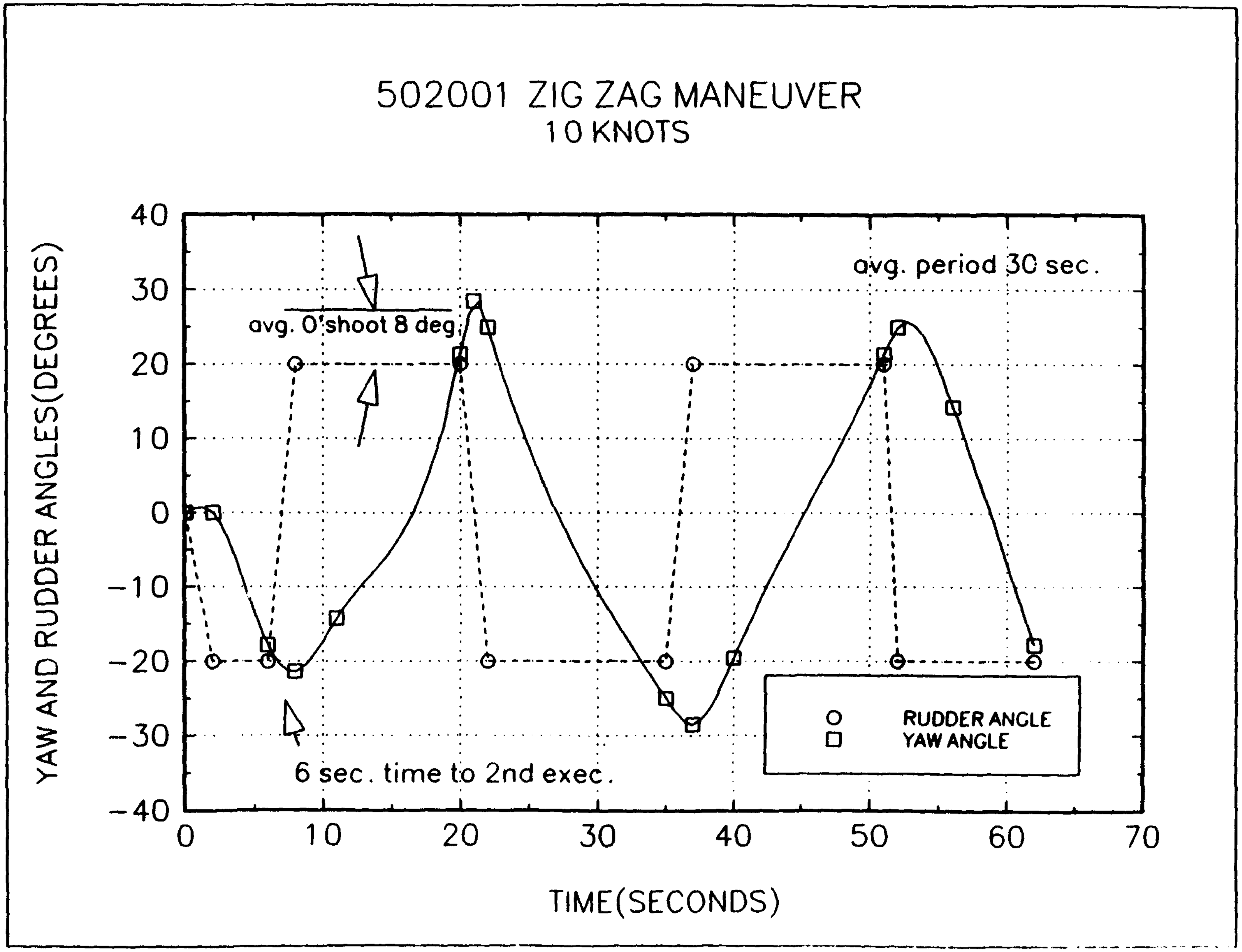


FIGURE 3.4.1 502001 Zig-Zag Maneuver at 10 Knots

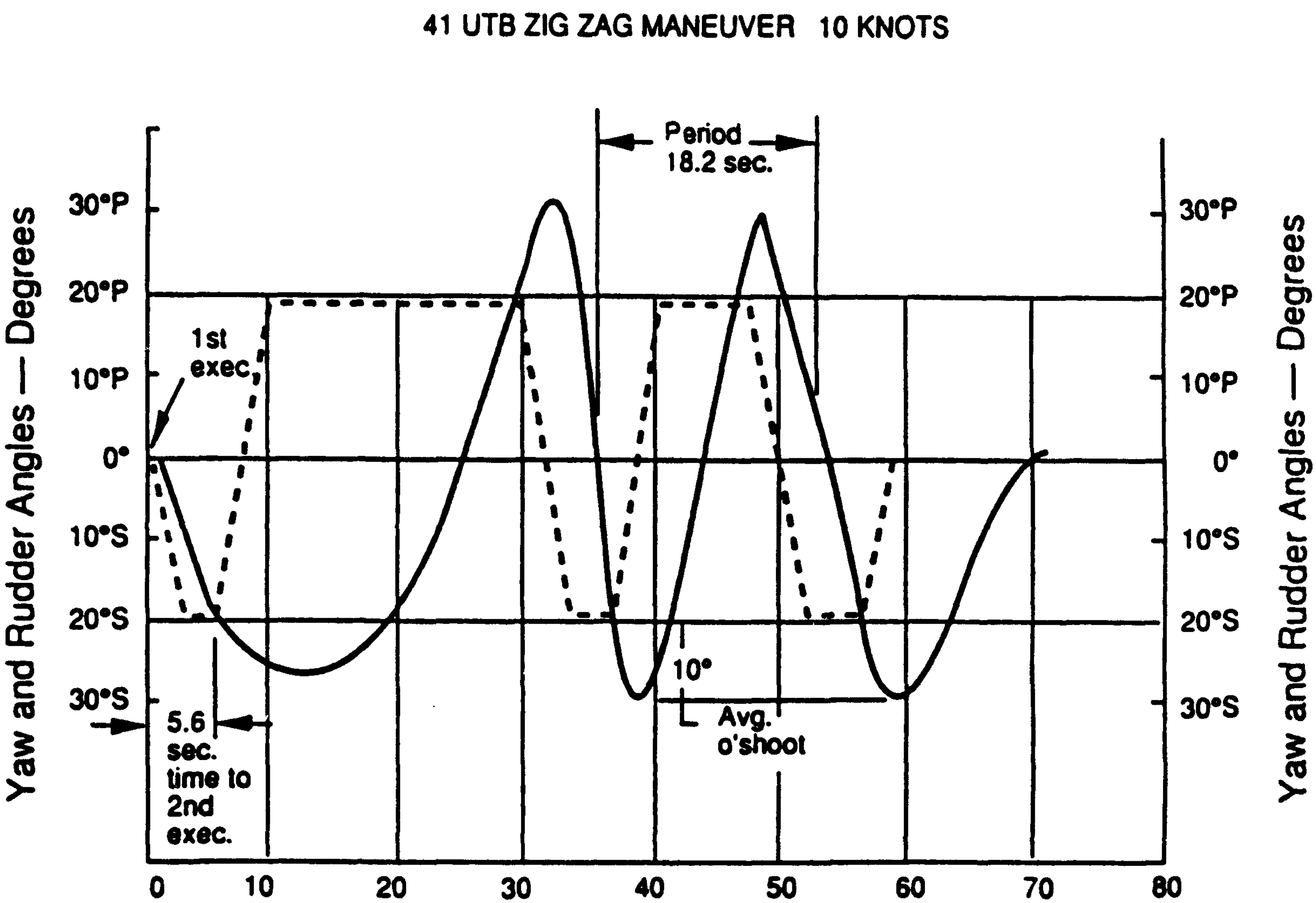


FIGURE 3.4.2 41-FT UTB Zig-Zag Maneuver at 10 Knots

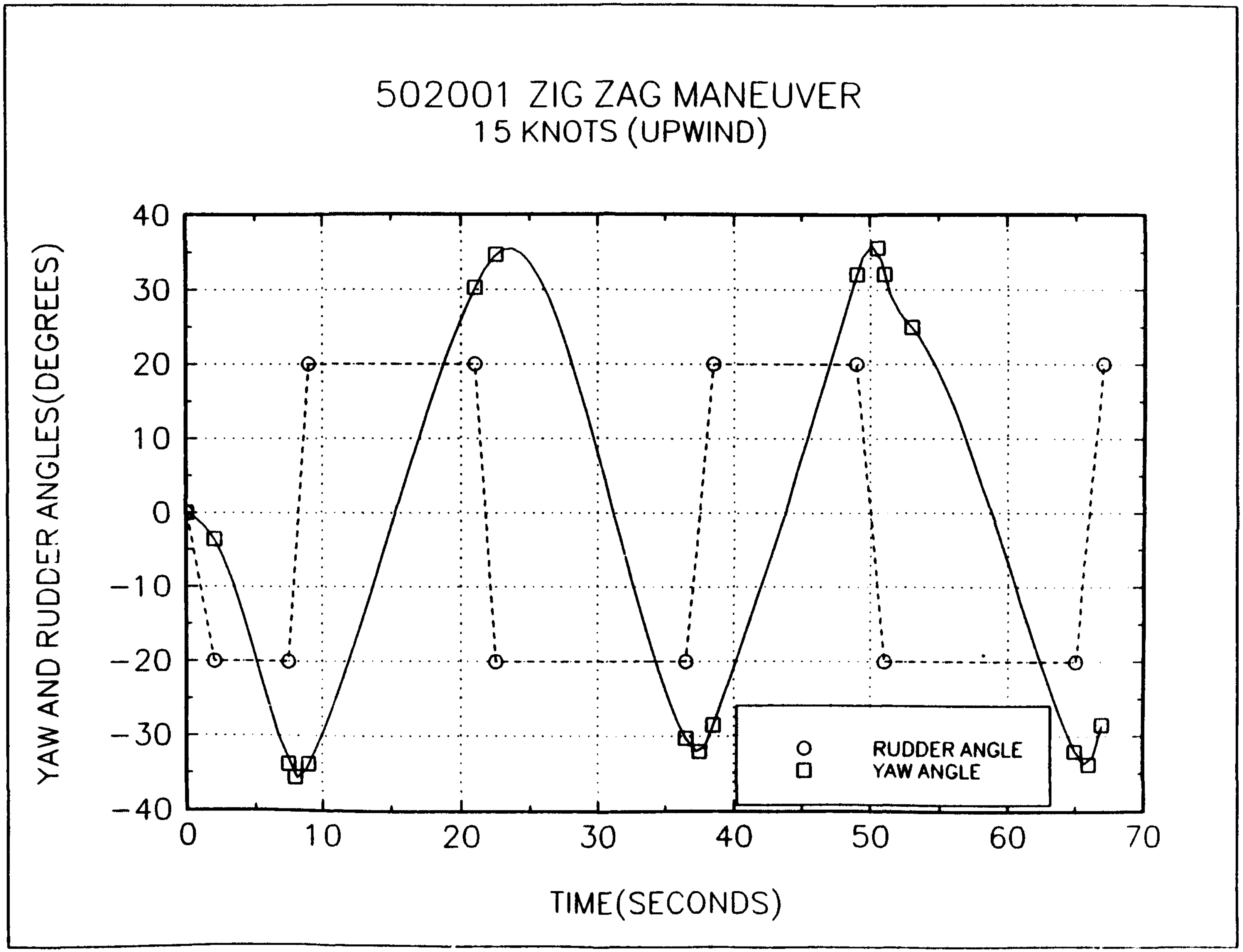


FIGURE 3.4.3 502001 Attempted Zig-Zag Maneuver at 15 Knots (Upwind)

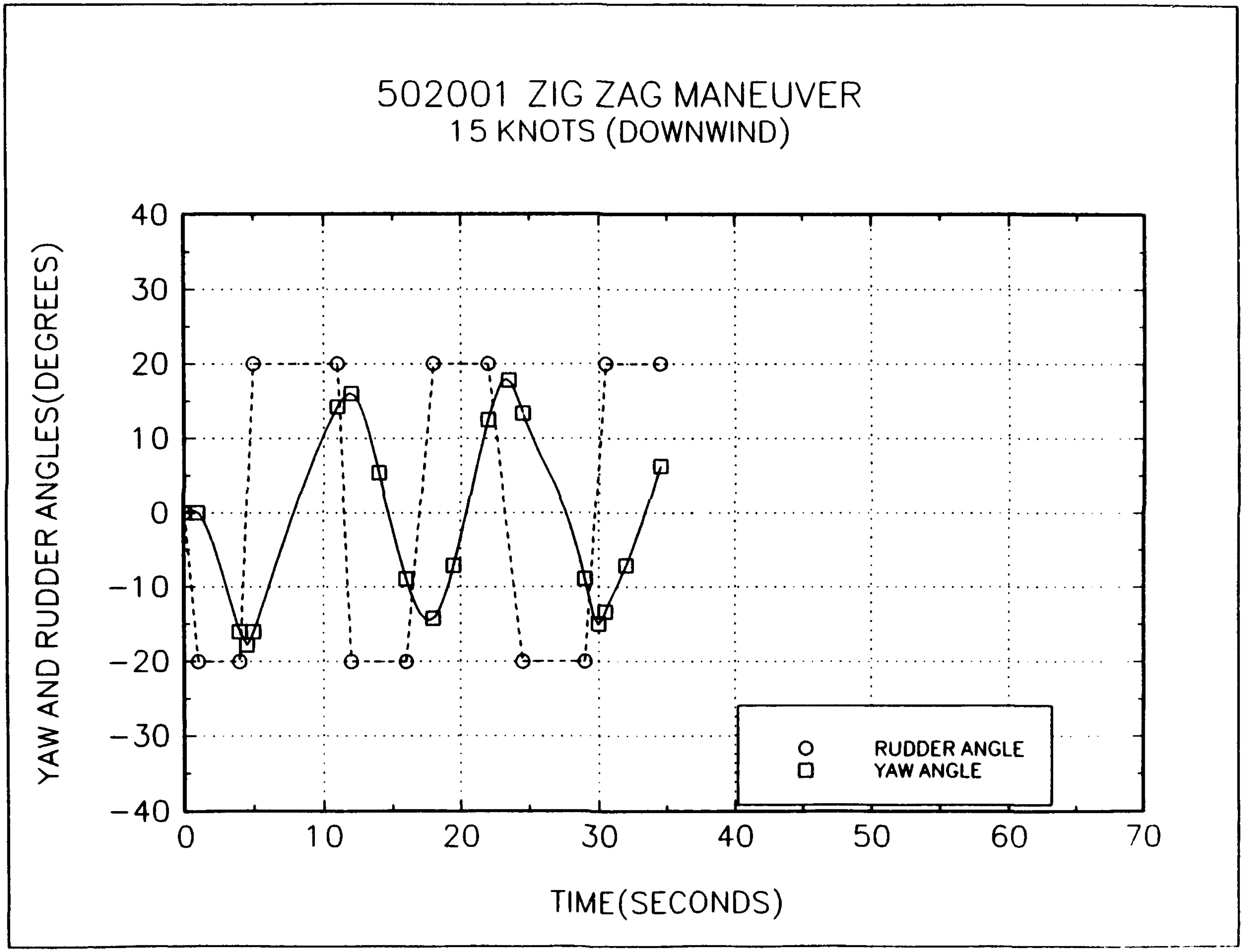


FIGURE 3.4.4 502001 Attempted Zig-Zag Maneuver at 15 Knots (Downwind)

angle, depending upon the initial conditions. Steady course-keeping may be difficult to maintain. With greater directional instability, a boat may turn without input from the helm or turn against the rudder. With too much directional stability, a boat may have reduced maneuverability, always trying to maintain a straight course.

Figures 3.5.1 and 3.5.2 show the 502001 has a very small slope of yaw rate vs rudder angle curve, indicating lower turn rates than the 41-FT UTB, Figures 3.5.3 and 3.5.4. Lower turn rates for the 502001 indicate less maneuverability i.e. larger turning radii as already presented in section 3.3. Both boats have good directional stability and are easy to keep on course, as shown by the lack of hysteresis in Figures 3.5.1 through 3.5.4.

3.6 T-6 Acceleration and Crash Stop

Acceleration and deceleration maneuvers were conducted to evaluate the boat's ability to start and stop in emergency situations. These tests were conducted using the TACMAN GPS tracking software to obtain velocity as a function of time. Figure 3.6.1 presents the results of the acceleration runs for two hydraulic trim tab settings. Trim tabs tested were set at 0/0 degrees and a normal crew setting of 10/8 degrees for the starboard and port tabs, respectively. The boat starts out slowly by plowing through the water in the first ten seconds and then accelerates rapidly to speed in approximately 20 seconds. Figure 3.6.2 compares the acceleration of the 41-FT UTB with the 502001. It is apparent that the 502001 accelerates much faster than the 41-FT UTB to about the same maximum speed. Please note that the data for the 41-FT UTB were obtained from reference [12].

The acceleration data were taken on Station New London's 41-FT UTB which was not tuned and therefore did not make its top speed. A well-maintained 41-FT UTB is likely to have better acceleration and top speed.

Unfortunately, a true crash stop initiated by a full reverse of the boat was not acquired. This was due to the limited GPS data that could be acquired in the test area. Interference from the Norfolk Naval Base caused an erratic behavior of the GPS and often a complete disconnect with satellite coverage. However, prior to losing GPS, deceleration data were acquired in the form of coasting to dead in the water (DIW) or by backing down on the throttles, see Figure 3.6.3. Deceleration to near DIW by backing down on the throttles takes about 15 seconds. The Munson handbook indicates complete crash stop by backing on throttles should take 1½ boat lengths. This test was conducted prior to delivery of 502001 to the Coast Guard, under different loading conditions. This compares with two boat lengths (80') or three to four seconds to crash stop for the 41-FT UTB (OpManual) [7].

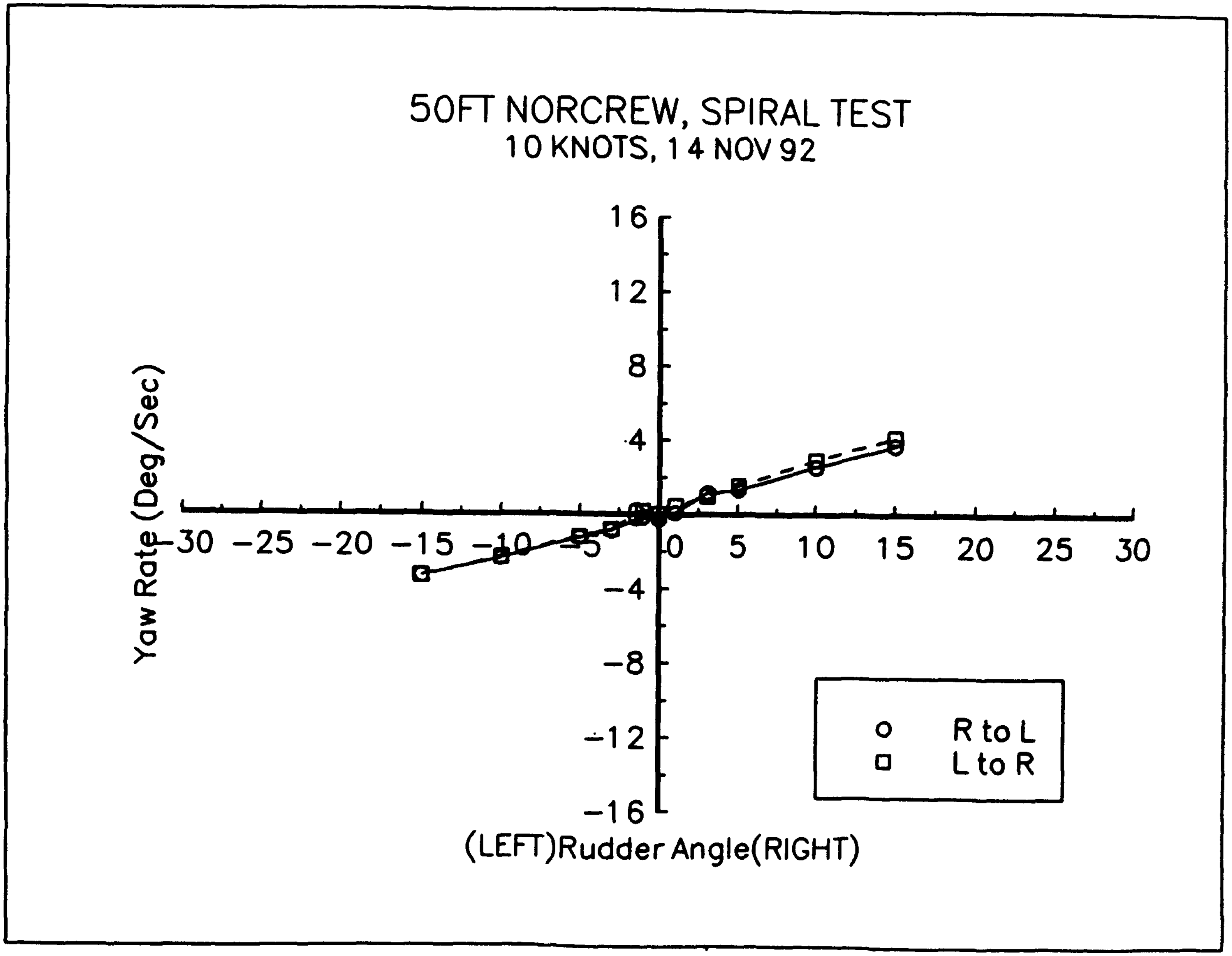


FIGURE 3.5.1 502001 Spiral Test 10 Knots

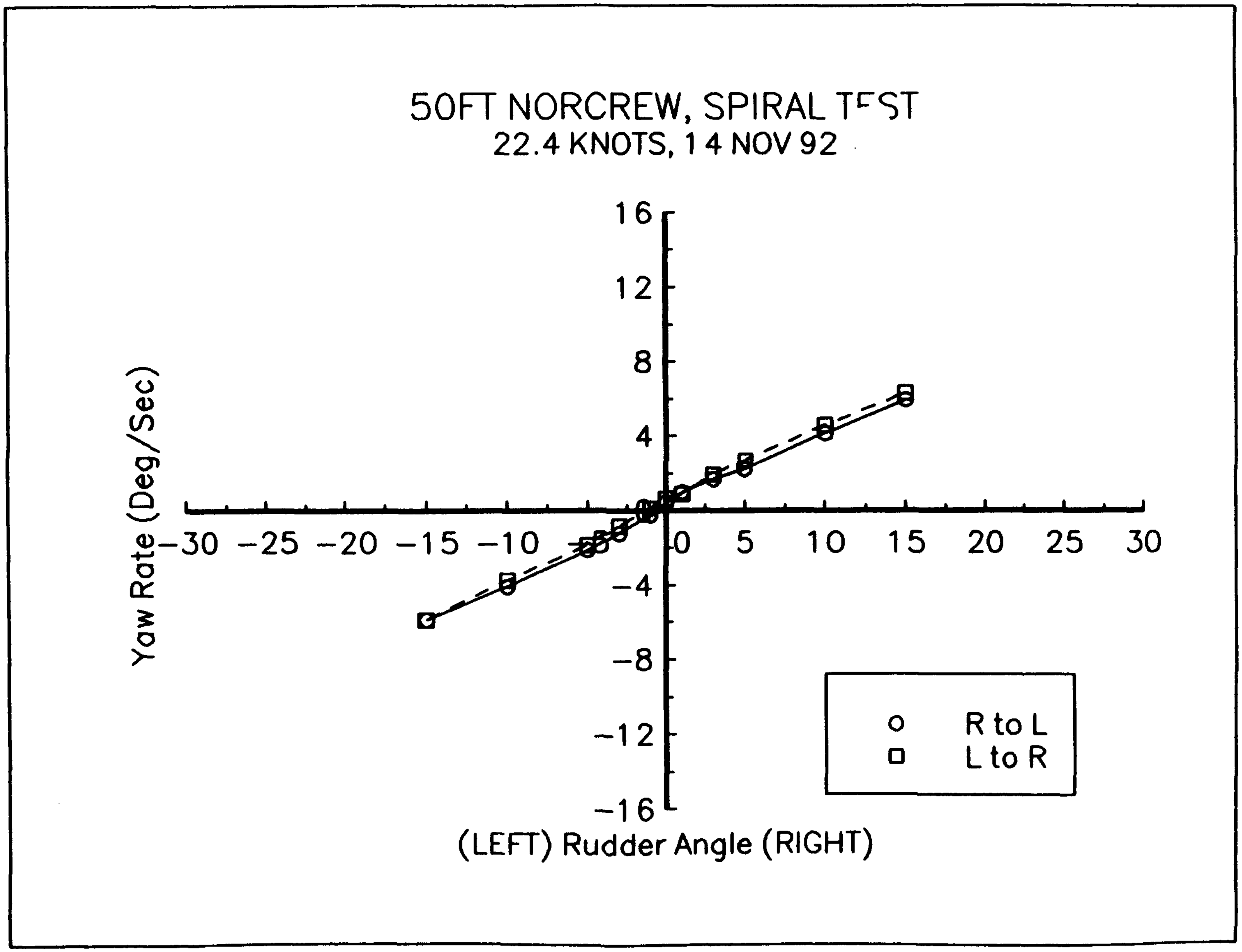


FIGURE 3.5.2 502001 Spiral Test 22.4 Knots

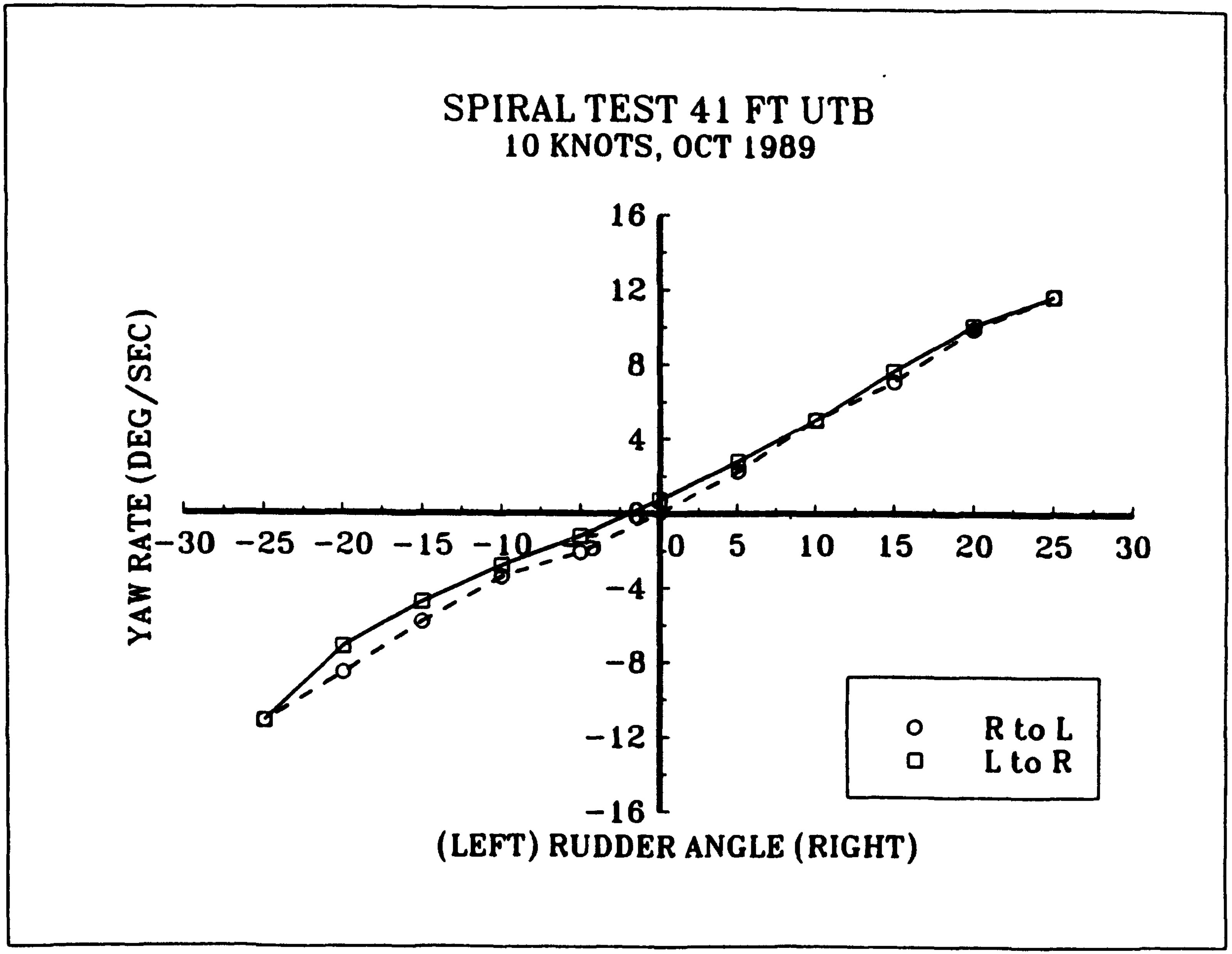


FIGURE 3.5.3 41-FT UTB Spiral Test 10 Knots

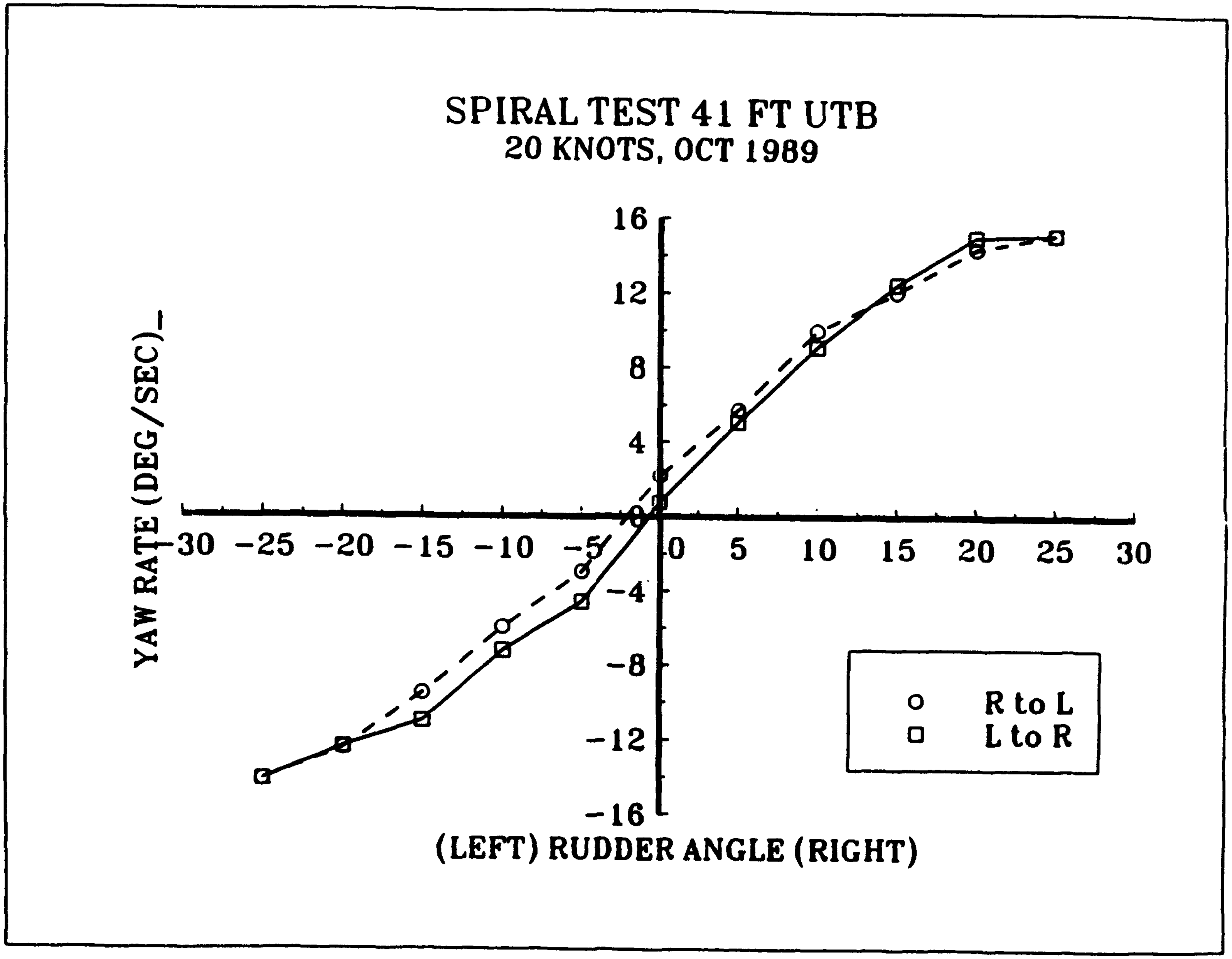


FIGURE 3.5.4 41-FT UTB Spiral Test 20 Knots

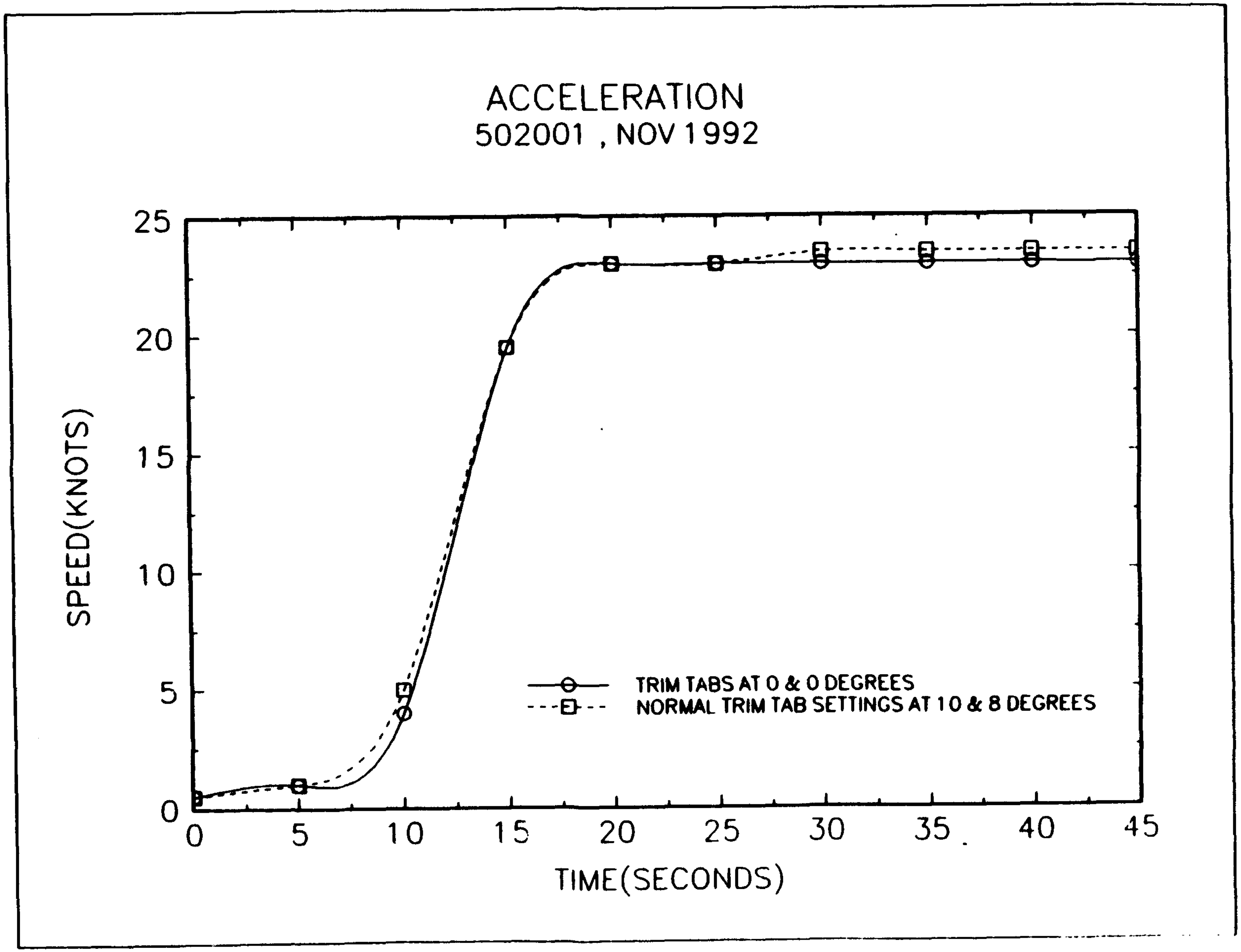


FIGURE 3.6.1 502001 Acceleration Test Results

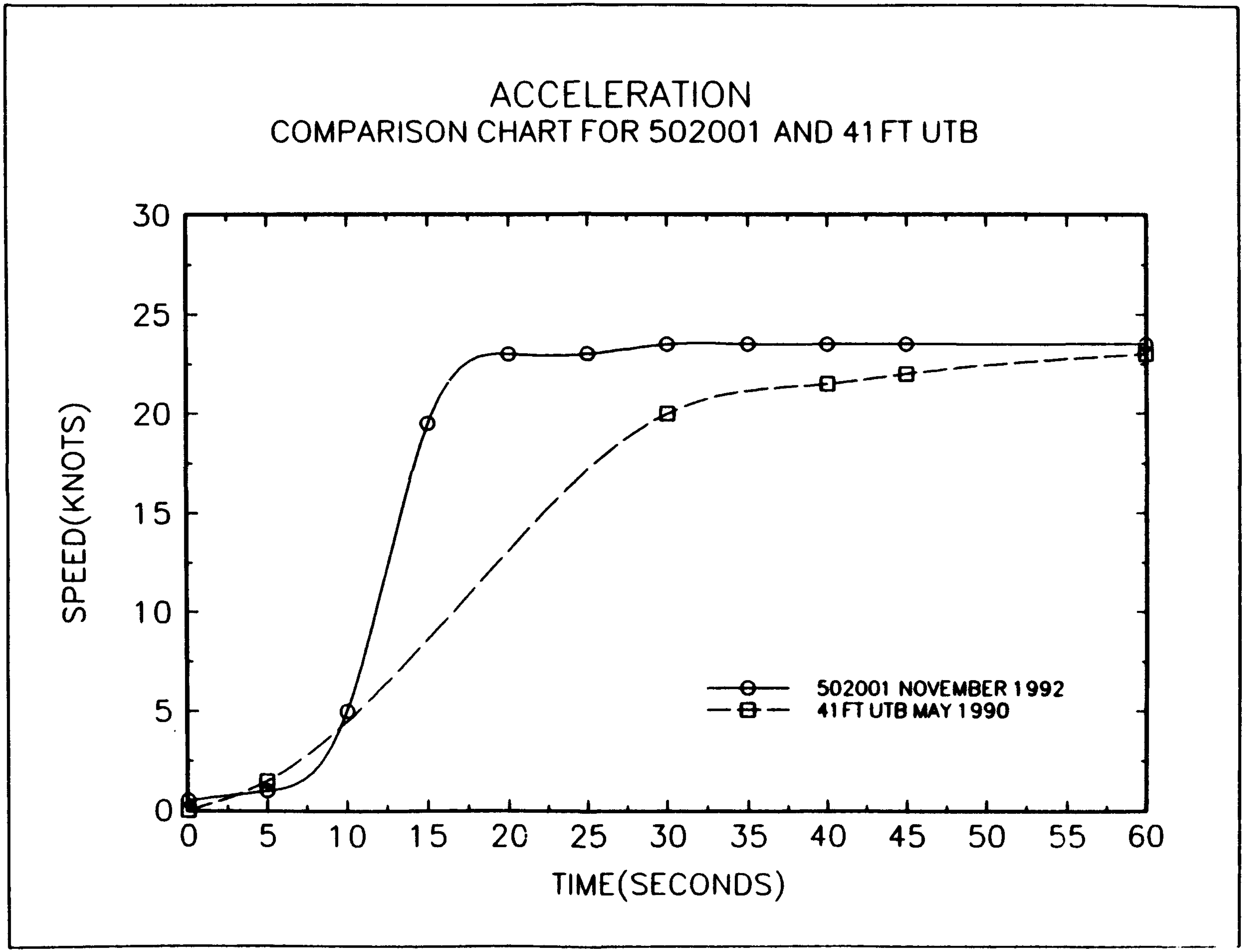


FIGURE 3.6.2 502001 and 41-FT UTB Acceleration Comparison

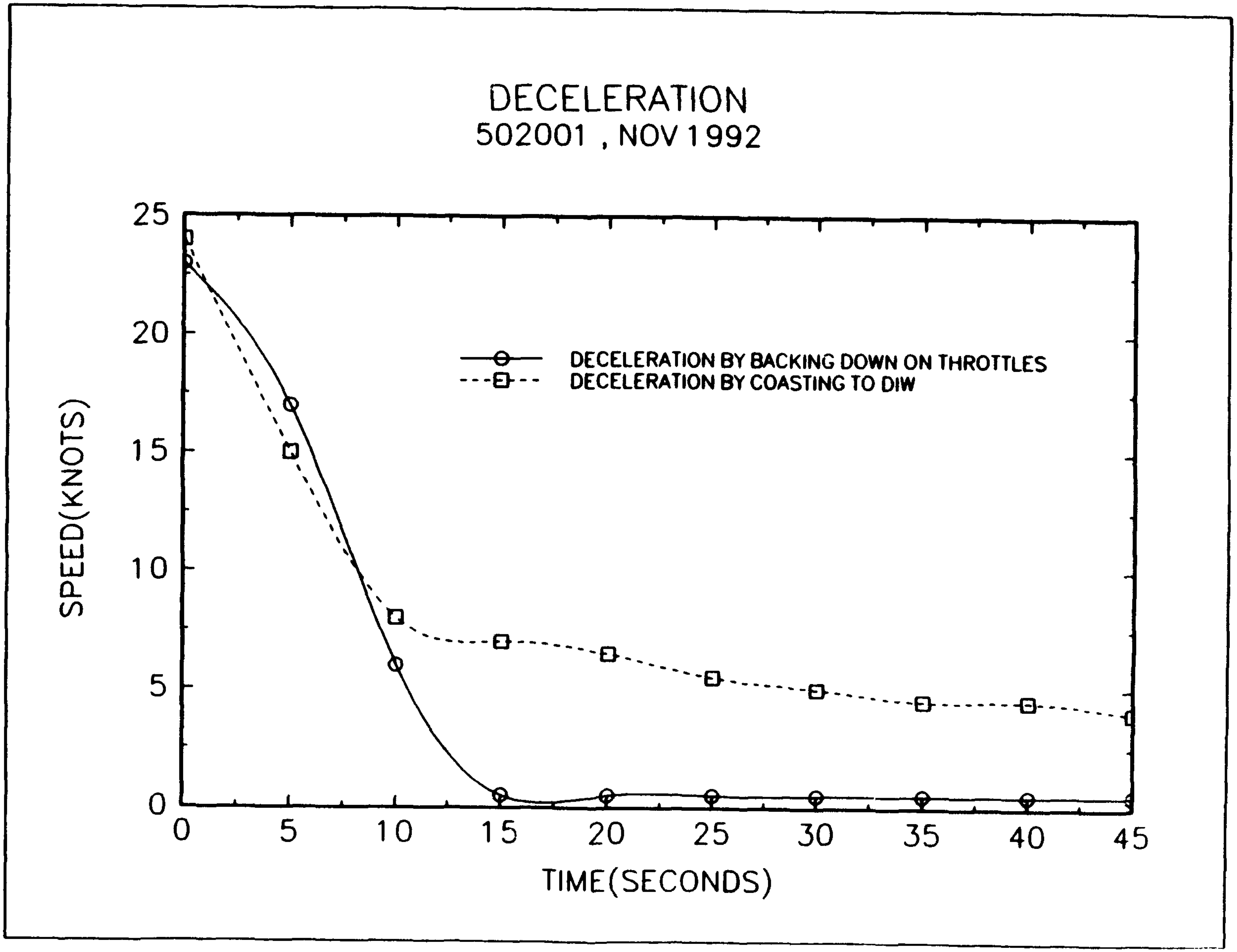


FIGURE 3.6.3 502001 Deceleration Test Results

3.7 T-7 Speed vs Power

Due to weather and sea conditions, speed vs power testing was conducted off Taylors Island, Maryland, and off Norfolk Naval Base in Virginia. All testing was done with seas under 1.5 feet, winds less than 15 knots, and water depths greater than 30 feet. To minimize all environmental effects, reciprocal runs were done with all results averaged, and runs were done in a randomized sequence. Selected runs were repeated to check for repeatability of the results.

Off Chesapeake Beach, Maryland, speed vs power measurements were made using the Differential GPS tracking system with the TACMAN II software. This system uses a repeating ground system set up by the R&DC Team at Taylors Island to increase the system's accuracy. Speeds are estimated accurate to ± 0.25 knots with this system.

The test range shown in Figure 3.7.1 was used to conduct speed vs power runs off of Norfolk Naval Base. The course was between two piers near the Norfolk Naval Base at Tanner Point and the range distance was one mile. Due to electromagnetic interference on this range, no GPS could be used, so all measurements were taken by observing the elapsed time to transit the known range distance. Estimated accuracy of these speed measurements is approximately ± 0.5 knots.

Power was measured using an Accurex model 1642A horsepower meter on each propeller shaft. This instrument measures shaft torsional strain with a strain gage and transmits the reading from the rotating shaft via an FM antenna. The torsional strain measurement is converted to a torque measurement, based on the shaft manufacturer's statement of the shaft's modulus of rigidity. A shaft torque calibration was not conducted, and this reflects on the overall accuracy of the horsepower measurements. The horsepower meter system includes a tachometer accurate to within 0.25% of actual RPM. The shaft RPM and torque measurements are automatically multiplied by the horsepower meter to obtain shaft horsepower. The system is considered to have a 5% maximum error; this includes the instrument errors and the uncertainty in the actual shaft modulus value, since the shaft was not calibrated. The output was recorded continuously on a TEAC model RD-200T Digital Audio Tape (DAT) format recorder. The recorded signals were filtered and averaged to obtain shaft horsepower for the run. Horsepower for a given speed is the average of the horsepower for two directions on the test course at the same engine RPM. Power measurements from the two shafts were summed to provide total horsepower.

The engines on the 502001 are rated to produce 735 horsepower per shaft at 2300 RPM which is consistent with the TECHEVAL results. This is far more than the 320 horsepower per shaft that the 41-FT UTB has. The increased displacement of the 502001

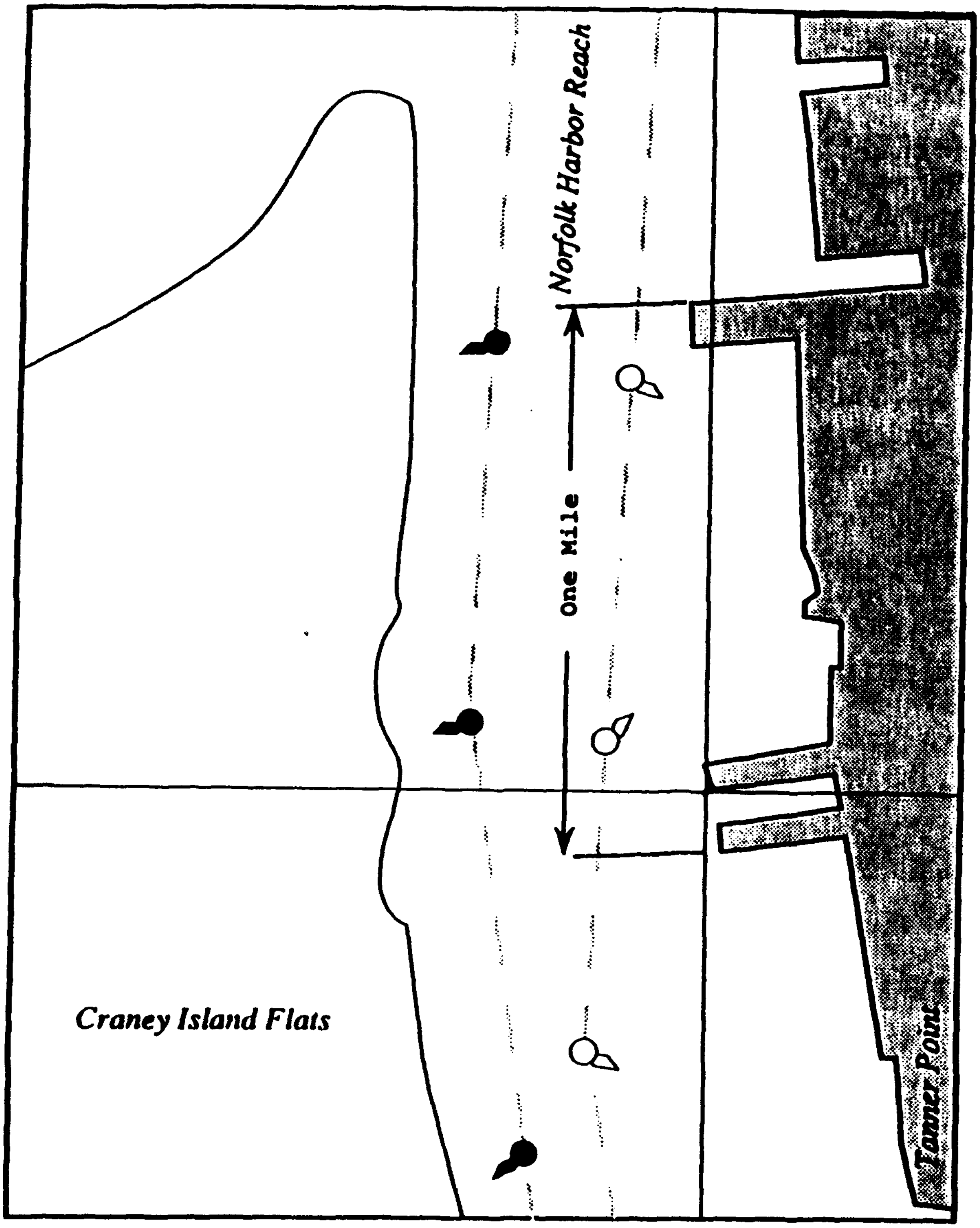


FIGURE 3.7.1 Speed vs Power Ranges

requires the increase in shaft horsepower to propel it at speeds comparable to the 41-FT UTB. With its hard chine planing hull, it reaches a maximum speed of 24 knots in calm water sea conditions. During testing, the maximum speed obtained was 22.4 knots. This is comparable to the 41-FT UTB cruising speed, but less than the maximum speed of 26 knots for the 41-FT UTB.

During the Speed vs Power testing, runs were made with the boat's trim tabs set at 0°, 5°, 10° and at 15°. This was done in an effort to determine the optimum trim tab settings for the boat.

Figure 3.7.2 compares the speed of the boat as a function of shaft horsepower at these trim tab settings. During calm water, trim tab settings of 5/5 maximize the speed vs horsepower output for this boat hull. At trim tab settings above 10/10, the top speed of the 502001 is reduced as the bow of the boat digs in. At a trim tab setting of 15/15; this reduction is five knots.

The boat test performance parameters: speed, horsepower, and weight, are combined into transport efficiency, E_T, and Froude number, $F_{n\nabla}$, to compare relative boat performance [16].

$$E_T = \frac{(W_{LB})\ (V_{KT})}{(P_{DL\ SHP})\ (326)} \quad \text{and} \quad F_{n\nabla} = \frac{V}{(g \times \nabla^{1/3})^{1/2}} \qquad (3.7.1\ \&\ 3.7.2)$$

where
- W_{LB} is the weight of the boat in pounds
- V_{KT} is the speed of the boat in knots
- V is the speed of the boat in ft/sec
- $P_{DL\ SHP}$ is the total shaft power for propulsion in horsepower
- ∇ is the displacement in cubic feet
- g is the gravitational constant

Figure 3.7.3 compares the transport efficiency of the 502001 versus the 41-FT UTB. The 502001 and the 41-FT UTB are comparable in efficiency for most Froude numbers. The 41-FT UTB is closer to the best performance curve [16] at maximum speed. Both boats are operating as semi-planing hulls.

Testing at various load conditions specified in [3] was not conducted. It is anticipated that any additional weight growth of the 502001 would further reduce the speed and fuel efficiency of the boat. Theoretical weight growth is presented in the Inclining and Stability Report of Appendix A and is summarized in Table 3.2.1. Weight growth forward of the center of flotation of the boat decreases the ability of the boat to plane. At the boat's present weight, trim tab settings above 5/5 are required to get the boat up on a plane. At settings above 10/10 the boat assumes a bow-down trim. This is presented in detail in section 3.7A. A review of the boat's hull profile and shafting arrangement design shows that it is within the accepted design

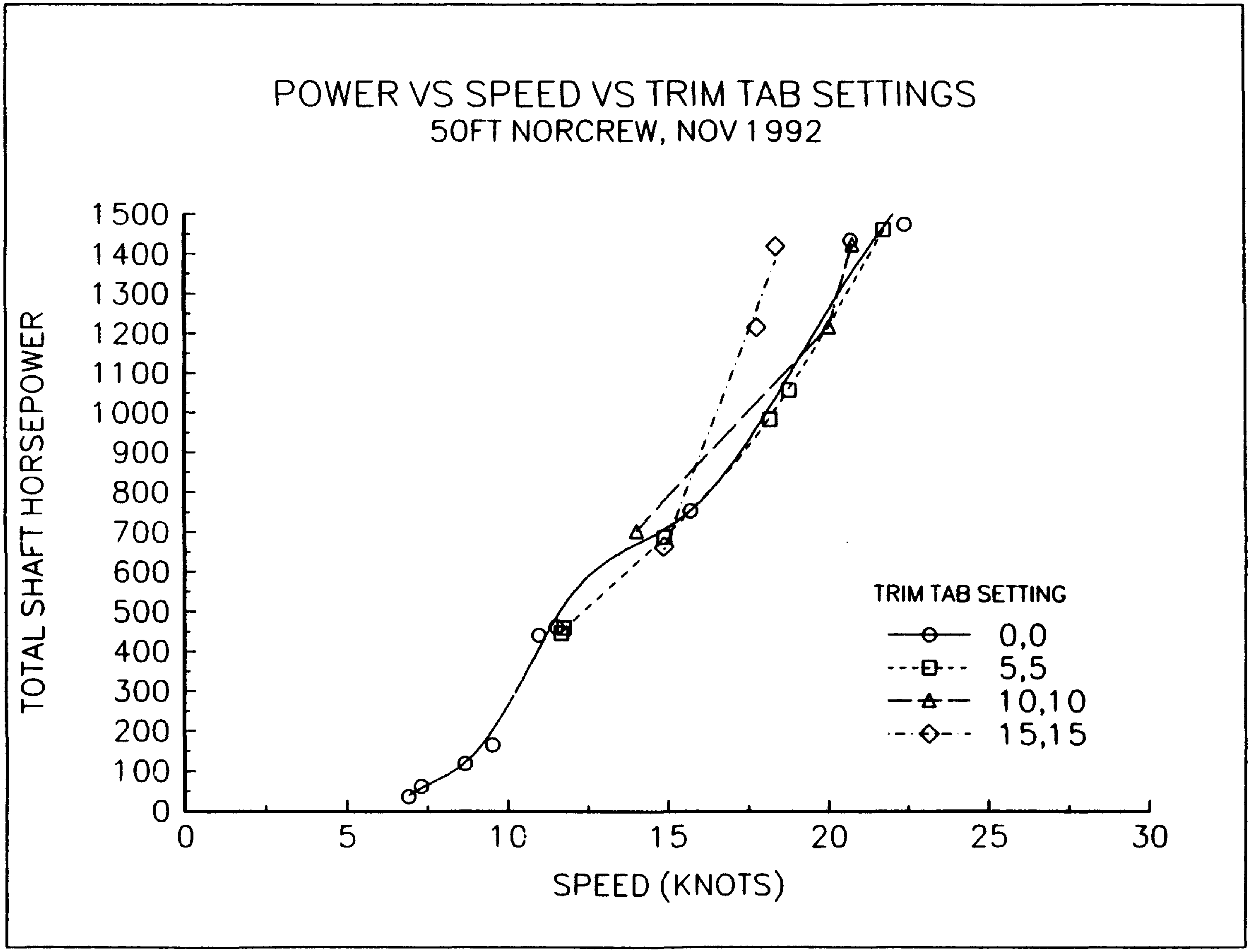


FIGURE 3.7.2 Power vs Speed vs Trim Tab Settings

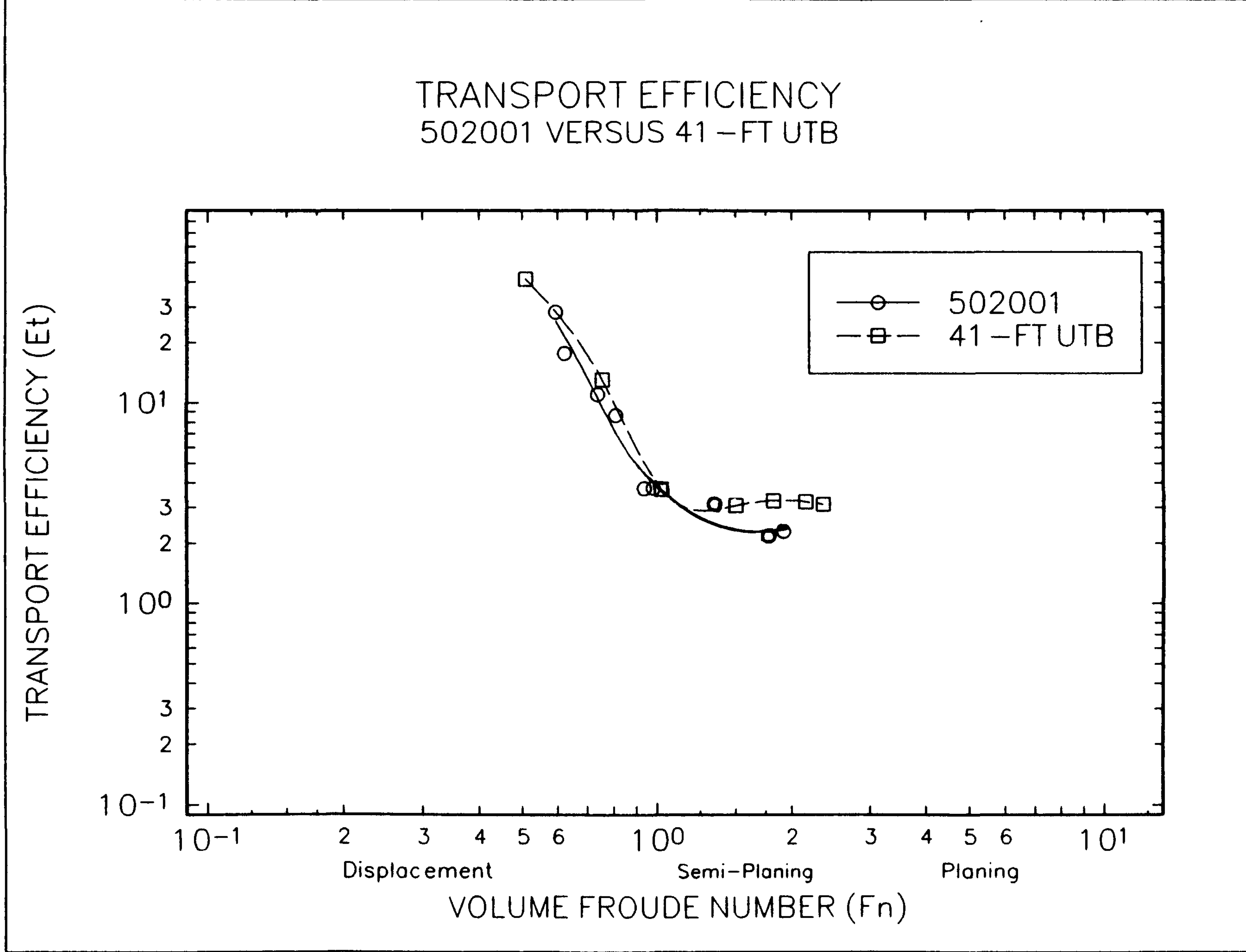


FIGURE 3.7.3 502001 and 41-FT UTB Transport Efficiency Comparison

criteria as presented by reference [13] for a planing hull design, but calculations of the Froude Number, reference [16], show a semi-planing hull as seen in Figure 3.7.3. The inability of this boat to plane with its trim tabs set at 0/0 is a direct result of excessive weight.

3.7A Trim vs Speed

Trim angle versus speed data were obtained concurrently with the speed versus horsepower measurement. All testing was done with seas under 1.5 feet, winds less than 15 knots, and water depths greater than 30 feet. To minimize all environmental effects, reciprocal runs were done with all results averaged, and runs were done in a randomized sequence. Selected runs were repeated to check for repeatability of the results.

Trim angle was measured using a Schaevitz digital inclinometer on the structurally mounted cabinet behind the coxswain's chair. This inclinometer was accurate to within ± 0.1° and has a response time constant less than one second. The instrument was read continuously by one of the test personnel during the test; the reported trim angle is the average angle observed during the test run.

Trim tab settings of 0/0, 5/5, 10/10 and 15/15 were used for testing the effect of various trim tab settings on the boat's trim angle. Above a 10/10 trim setting, the boat begins to acquire a bow-down trim and the resulting bow spray reduces visibility for the coxswain beyond the benefit of the decreased trim angle. The 41-FT UTB, without trim tabs, planes well with a slight bow-up trim. Figure 3.7A.1 shows the effects of trim tab settings on the trim angle vs speed of the boat.

3.8 T-8 Fuel Consumption, Range and Endurance

Testing to verify the 502001 boat's fuel consumption, range and endurance was conducted as time permitted. Due to engine problems with the boat during the test week, fuel range testing was limited to three major timed and one short run during transits to and from the test ranges and transit from Taylors Island to Little Creek, Virginia. Testing therefore was not done during ideal conditions, but reflect conditions which are commonly found on Chesapeake Bay.

Fuel range testing was done in quartering seas, with seas increasing from one to three feet in height. Northeast winds of 8 to 15 knots were encountered off the starboard quarter, with the boat loaded for testing and transit. Fuel measurements were taken using the ship's sounding rod and fuel tables. Soundings were done at the beginning and end of the runs with the boat maintaining its position in head seas or alongside the pier. Due to the motion of the boat, accuracy was ± 20 gallons. Fuel consumption amounts recorded during extended transit times best represent this boat's fuel consumption, range and endurance.

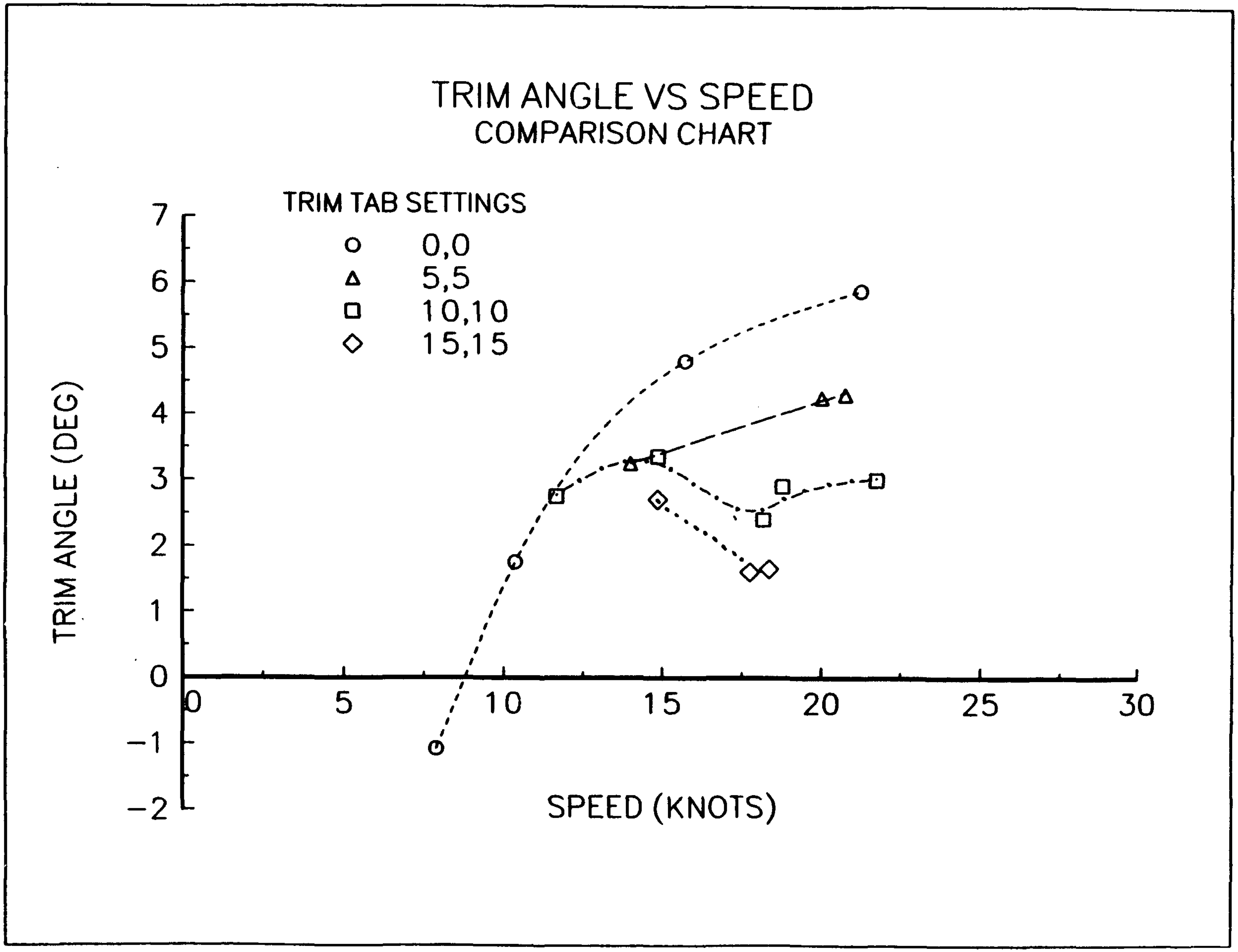


FIGURE 3.7A.1 502001 Trim Angle vs Speed at Various Trim Tab Settings

Using the fuel consumption data acquired and the available fuel figure of 644 gallons provided by Munson, the maximum range as a function of speed was calculated for the 502001. Figure 3.8.1 shows the fuel consumption of the 502001 compared to the 41-FT UTB. The 502001 uses about 1.5 times as much fuel as the 41-FT UTB at cruising speed. The 41-FT UTB data was from reference [8]. The average hours of operation of a 41-FT UTB is 650 hours [8]. This figure indicates that fuel cost for the 502001 will not be prohibitive to the Norwegian Crew Concept when the economic review is done.

The 502001 has a range of approximately 163 nm at its maximum speed of 22.75 knots and a range of 220 nm at a cruising speed of 21.3 knots. This range calculation assumes 644 gallons of usable fuel and an initial displacement of 54400 lbs. No low-speed fuel consumption runs were conducted during the test week. At cruising speeds, the 502001 requires more than 1.5 times the fuel of the 41-FT UTB, while at maximum speed the 50-foot boat requires more than 2.7 times more fuel than the 41-FT UTB.

Even with its greater fuel capacity, the 502001 does not have an increased range over the 41-FT UTB as seen in Figure 3.8.2. Further testing is needed to verify speed versus fuel consumption of 502001 if there are any plans to build more of these boats for Coast Guard use.

3.9 T-9 Time to Get Underway

This test measures the time to get underway in routine situations. This data will assist in developing operating procedures and assessing the boat's capability for quick response missions. During the course of the technical evaluation, the time required to get underway for three sorties was timed without the crew's knowledge. This data was averaged to determine the average time for each major step in getting underway for routine operations; Table 3.9.1 summarizes the test results. As seen in the results, even for routine missions, without the crew's knowledge of data taking, it takes less than ten minutes to get the 502001 underway. No problems with quick-response requirements for this vessel are anticipated. With the Norwegian Crew concept, the time required for the boat crew to go from the shore station to the boat is eliminated. Even with the slightly more complex mechanical plant, the 502001 can certainly get underway for an emergency response in less than ten minutes of notification, assuming that all crew members are on board at the time of the call. There is no documented minimum standard on how fast the 41-FT UTB needs to get underway. Therefore, a quantitative comparison between the 502001 and 41-FT UTB is not possible. Normally, a 41-FT UTB is expected to get underway in less than 30 minutes. This would include suiting up and collecting the necessary equipment from the station and transportation to the boat. This is likely to vary from station to station.

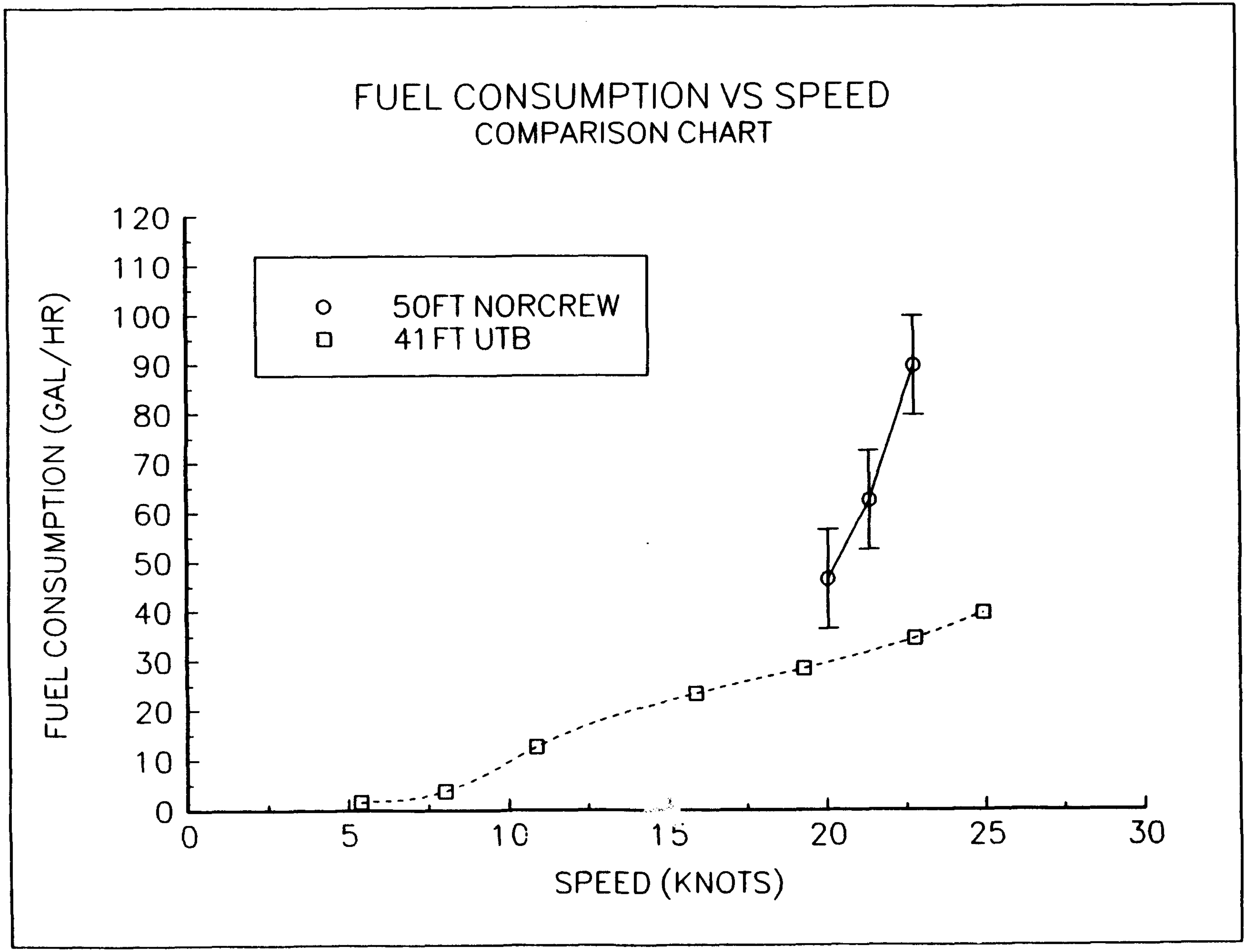


FIGURE 3.8.1 **502001 and 41-FT UTB Fuel Consumption vs Speed Comparison**

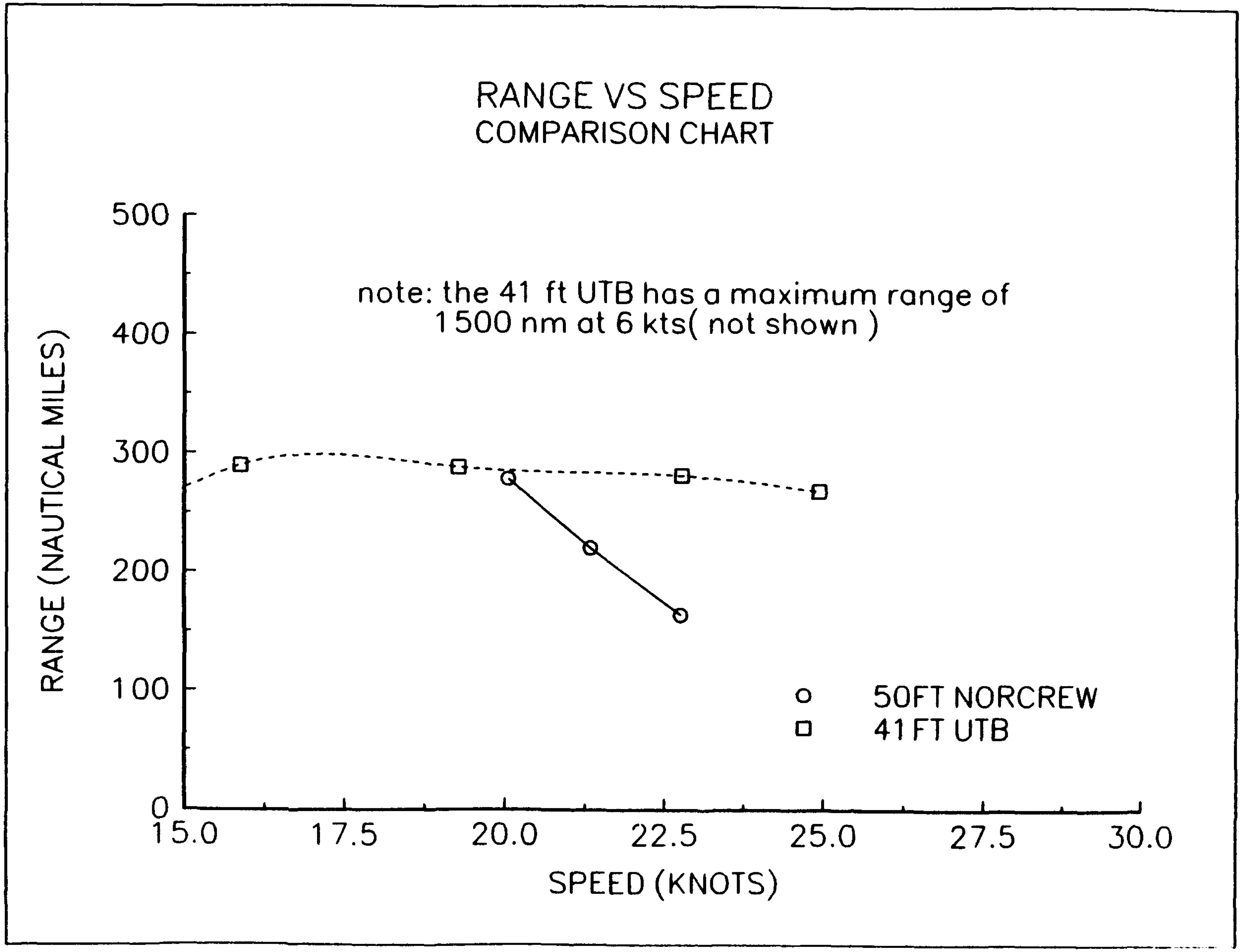


FIGURE 3.8.2 502001 and 41-FT UTB Range vs Speed Comparison

TABLE 3.9.1
TIME TO GET UNDERWAY (ROUTINE MISSIONS)

Event	Elapsed Time
NOTIFICATION	0:00
GENERATOR ON-LINE	3:00
SHORE TIES DISCONNECTED	5:00
MAIN ENGINES ON-LINE	7:40
UNDERWAY	9:40
SECURED FOR SEA	12:40

(From data collected during Non-Emergency Response. Anticipate Emergency response time to be less. Average of 3 responses.)

3.10 T-10 Onboard Noise Survey

A noise survey was performed on the 502001 NORCREW concept boat and the 41350 Utility Boat. The noise survey was performed to determine the levels of airborne noise present at key locations on board at cruising and maximum speeds. Detailed results of the noise survey, which include octave band nd "A" weighted sound measurements, are presented in Appendix B. Table 3.10.1 summarizes the averaged "A" weighted noise levels of the 502001 and 41350.

TABLE 3.10.1

502001 AND 41350 "A" WEIGHTED NOISE LEVELS
(dB re 20 μPa)

	Crew's Berthing	Coxswain Station	Engine Room	Galley	Tow Bitt
502001 22 KTS MAX SPEED	76	78	115	78	(1)
41350 25 KTS MAX SPEED	85	85	113	(2)	95
502001 19.5 KTS CRUISING SPEED	77	78	116	76	91
41350 12 KTS CRUISING SPEED	81	81	111	(2)	67

(1) Noise data not acquired with sound level meter at this speed because of sea spray on the deck space.

(2) A galley test location is not applicable to the 41-FT UTB.

The 502001 is quieter at the coxswain's station and the crew's quarters than the 41350. However, engineroom noise levels are slightly higher than the 41350. This was expected because of the 502001's larger engine. Noise levels outside the main cabin near the tow bitt of the 502001 are higher than the 41350 at cruising speed. Based on these recorded noise levels, it is recommended that the crew wear hearing protection when standing outside the main cabin at cruising and maximum speeds. The better noise levels in the 502001 living spaces can be attributed to the sound insulation material on the sides and overhead in all living spaces and the sound-absorbing carpeting. The 41-FT UTB does not have any sound insulation material.

The Contracting Officer Technical Representative's (COTR's) final report in reference [14] on the 502001 contract indicates that sound levels in the living spaces were never specified in the procurement documents for the boat. The contractor did agree to build a design to achieve 82 dBA at the coxswain's station. This appears to have been met. The COTR did recommend that sound level specifications be part of the requirements and verification testing of any future procurements of live-aboard boats.

3.11 T-11 Seakeeping Performance

These tests were performed to evaluate the operational performance of the 502001 in rough seas. A motion package was installed near the boat's center of gravity to record its pitch, roll, heave, surge, yaw, and sway. The motion package provides an "earth-fixed" coordinate system for motions measurement through the use of gyro-stabilized sensors. The motions package outputs were recorded on digital tape recorders for post-processing ashore. Side-by-side seakeeping testing was performed with the 502001 and the 41500 UTB to enable a direct comparison of performance. Direct comparisons can only be accomplished from side-by-side testing of vessels, due to the fact that no sea condition is identical in nature. Therefore, data taken from other testing cannot be used for direct comparisons, although with a large body of data, tendencies may be identified.

For this testing, the 41-FT UTB was instrumented with a motion package near the boat's center of gravity in the forward compartment against the engine room bulkhead. Accelerometers were installed at the motion package location and on the coxswain's chair post. Recorded were pitch, roll, heave, and accelerations. Seas were recorded with the R&DC's Datawell wave buoy, immediately after the side-by-side testing was completed. The 502001 and 41500 side-by-side seakeeping performance data are presented in Appendix C.

The significant wave height recorded (peak to trough) was 4.1 feet. The wave buoy results are presented in Table 3.11.1.

TABLE 3.11.1

502001 WAVE BUOY DATA (SINGLE AMPLITUDE)

AVG 1/10 HIGHEST AMPLITUDE	=	2.61 FT
AVG 1/3 HIGHEST AMPLITUDE	=	2.09 FT
ROOT MEAN SQUARE	=	1.47 FT
HIGHEST PEAK	=	3.41 FT

A beam sea encounter spectrum was derived from the wave buoy data using a spectrum analyzer to calculate the power spectral density (PSD) function. This is presented in Appendix Figure C-1 as wave energy density as a function of the wave encounter frequency. The buoy data is treated as a beam seas encounter spectrum because a vessel traveling in beam seas would encounter the same number of waves under ideal long crested wave conditions.

The side-by-side seakeeping tests were conducted at two different speeds in five different directions: head seas, bow seas, beam seas, quartering seas, and stern seas. Each leg of the test was run for approximately ten minutes and motions were recorded on tape. Appendix Figures C-2 through C-13 demonstrate polar diagrams of the motion response of both the 502001 and the 41500. These plots demonstrate the magnitude of the average of the 1/3 highest (H 1/3) amplitude motions as a function of heading. The H 1/3 motions are determined by counting the peaks (amplitude, not peak-to-trough value) appearing in a time series of motion data, determining the peak amplitude exceeding 1/3 of the motions, and taking the average of the amplitudes of the highest 1/3. These results demonstrate the degree of sensitivity of the boat to seas encountered in different directions. The 502001 exhibits less pitch response in head seas, about four degrees, at slow speeds and about 0.2 g's less heave acceleration for head, bow, beam, and quartering seas at both speeds tested.

Response Amplitude Operators (RAOs) were developed from the data collected during the TECHEVAL. RAOs are simply the ratio of the boat's resulting motion normalized to the encountered wave amplitude. They are useful transforms for estimating the boat's response to various sea conditions provided the assumption is valid that the responses are linearly related to the wave excitation. The most conservative response spectra were calculated for roll, pitch, and heave by using a spectrum analyzer to calculate power spectral density functions. The resulting response spectrums for both the 502001 and the 41500 are presented in Appendix Figures C-14 through C-19. Before the response spectra could be normalized into RAOs, the wave spectrum was transformed into a spectrum where frequency of encounter is considered, instead of the absolute wave frequency. The area under the modified spectrum remains the same since the total energy remains constant.

The head sea encounter spectra were calculated by using methods in Bhattacharyya [15]. The frequency of encounter and change in amplitude are obtained using the following formulation:

$$We = Ww - \frac{Ww^2 V}{g} \cos \mu \qquad (3.11.1)$$

$$S(We) = S(Ww) / [1-(2WwV/g) \cos \mu]^{\frac{1}{2}} \qquad (3.11.2)$$

where 'We' and "Ww" are the encounter and wave frequencies,
'V' is the speed of the boat,
'g' is the gravitational constant,
'μ' is direction and, in the case of head seas, equals 180°
and 'S( )' is the PSD amplitude

The results are presented in Appendix Figures C-20 and C-21. The RAOs presented in Appendix Figures C-22 through C-27 were calculated by dividing the roll response spectrum by the beam sea wave encounter spectrum, and the pitch-and-heave response spectrum by the head sea encounter spectrum. These results demonstrate that the 502001 has better seakeeping abilities over the 41500 in roll, pitch, and heave.

Acceleration data were collected in the side-by-side 502001 and 41500 seakeeping tests. Vertical acceleration data were collected at the centers of gravity (CGs) and underneath the coxswain's chairs. Vertical acceleration data were also collected near the crew's quarters on the longitudinal center line of the deck. These data were collected during the 10-minute runs in different sea encounters. A one-tenth highest, significant height, root mean square (RMS), mean, and a high were recorded for each run. Appendix Figures C-28 and C-29 present a relative comparison of RMS acceleration levels between the 502001 and 41500. The data presented were collected at the coxswain's chair and the center of gravity. From these two plots it is apparent that the acceleration levels experienced at the boat's CG and coxswain's chair are higher on the 41500 than the 502001. This is valid for the different sea encounters except for following seas, where the levels between the two boats are comparable.

An in-depth crew fatigue vibration treatment, in terms of comparisons with ISO Standards 2631/1 and 2631/3, was not performed. ISO Standard 2631/1 provides limits of exposure for vibrations transmitted to the human body in the frequency range of 1 to 80 Hz. ISO Standard 2631/3 treats the special case of vibrations below 1 Hz where motion sickness is likely to occur. There are several factors involved in determining human response to vibration levels. They are the vibration intensity, frequency, direction, and duration. Further study and analysis are recommended if the NORCREW concept is going to be considered for implementation with this hull design. A NORCREW vessel may be required to travel longer distances than the 41-FT UTB, but perhaps not as long as a WPB Coastal Patrol Boat. Therefore, fatigue limit requirements to be met by a NORCREW boat may be some compromise and depend to some degree on crew rotation schedules on the boat. A human vibration meter, a rubber disk that contains a triaxial accelerometer and measures a human's response to acceleration, should be used to quantify a range of acceptable vibration exposure times while underway.

3.12 T-12 Speed vs Sea Height

The maximum speed attainable in head seas was observed for the 502001 in several sea conditions. It was noted in seas of approximately 3-foot significant wave height that the 502001 could, at full throttles, maintain 2500 RPM at a speed observed at nearly 23 knots. The upper limit of speed for the 41-FT UTB in 3-foot significant waves is about 21 knots. Figure 3.12.1 shows a plot of speed versus sea state for the 502001 and a 41-FT UTB, assembled from various tests. When the wave height exceeds three feet, the 502001 is able to make better speed than the 41-FT UTB. During the side-by-side seakeeping between the 502001 and the 41500, the 41500 had to slow to around 14 knots in the 6- to 8-foot head sea swells. The 502001 rode out these same swells at 17 knots with relative ease, i.e., little slamming. The 502001 coxswain tried increasing the speed to 20 knots in these swells. Although the coxswain felt that 20 knots could have been held with some difficulty, it was his discretion to maintain the safer and more comfortable speed of 17 knots for the test.

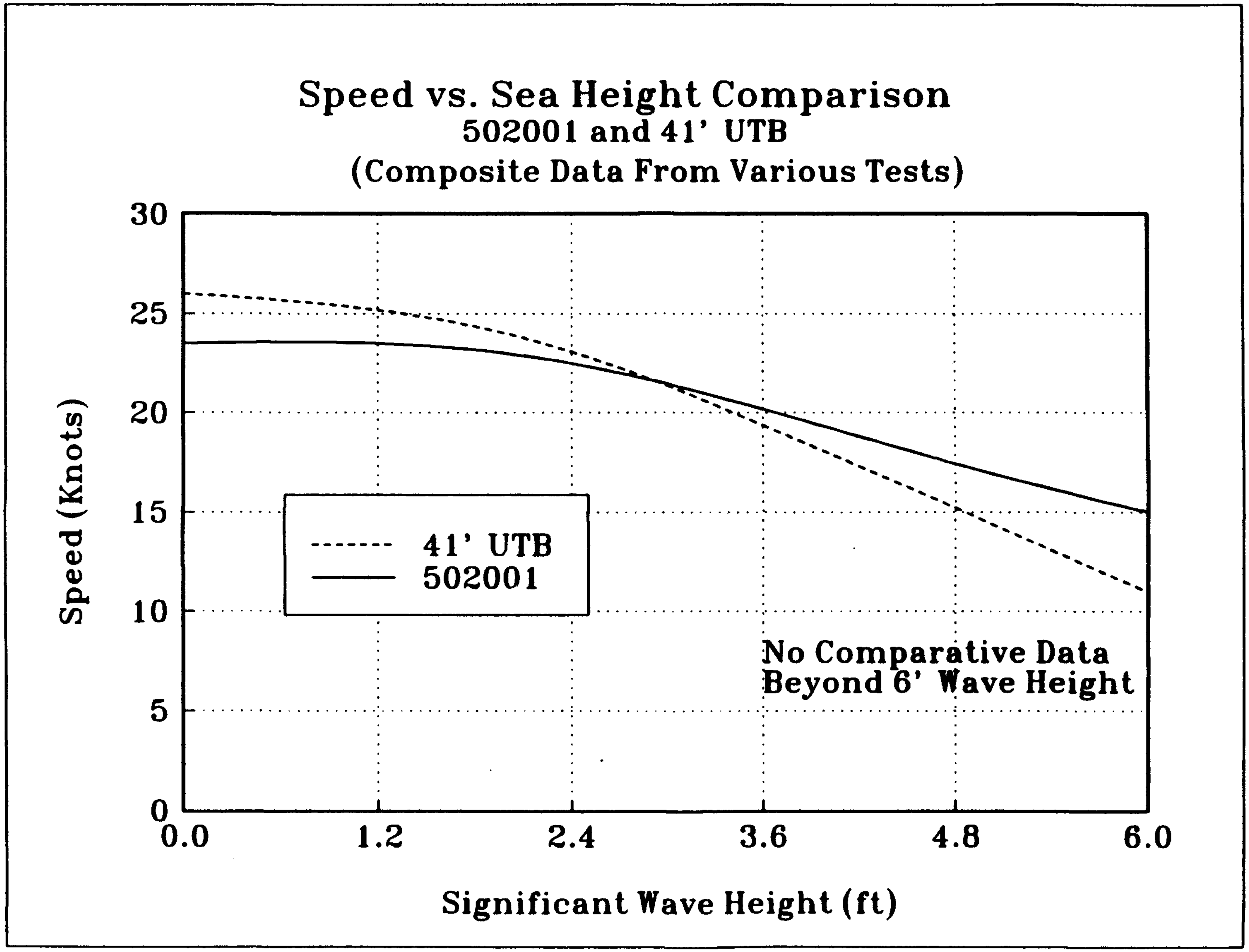


FIGURE 3.12.1 Speed vs Sea Height Comparison

4.0 502001 DESIGN ADVANTAGES AND DISADVANTAGES

4.1 Mechanical and Design Disadvantages Noted During TECHEVAL

During the technical evaluation, a survey of mechanical and design issues was completed. This survey was supplemented by discussions with the boat's crew and the Group Assistant Engineering Officer. Some of the problems noted are serious safety problems, and should be corrected. (The NORCREW Project Evaluation Board discussed many of these items during the board's meeting in March 1993.) Other problems may affect the crew's operational performance. These areas should be considered further in any future NORCREW boat designs.

Main Cabin Hatches: On the deck of the Main Cabin are two hatches. One hatch enters the engine room, the other goes to the Storage and Utility Space. These hatches were originally configured to open vertically, and to be pinned into place so the handles mounted on their undersides may be used when climbing down the ladder. The opening of the hatch with this configuration obstructed passage through the Main Cabin. It was unsafe to step around the hatch openings while the boat was underway. Even in port, it was difficult to step around the open hatches safely. It was also difficult to lift heavy equipment, spare parts or the inflatable boat out of the Storage Space because of the hatch configuration. The Group Engineer proposed an alternative hatch configuration and it has been implemented to correct the problem. The arrangement includes starboard side hinges on the auxiliary machinery space hatch and port side hinges on the engine room hatch both with manual slot-and-chain latch mechanisms. Future designs should consider different hatch placement, avoiding the boat's main traffic pathway.

Leaky Windows: The design of the side windows of the boat allows water to enter through their seals. This leakage is caused by the main engines drawing air from the main cabin through the unsealed engine room hatch. To prevent this may require resizing the main deck vents that supply intake air for the engines or installing air-tight seals to the main cabin to the engine room hatch or provide an alternate dry vent for the main cabin which will allow fresh air in with minimal entrained water. This problem was discussed at the March 1993 Project Evaluation Board meeting. At present, water entry causes problems for the crew where it seeps into electronics and publications located under the windows.

Limits to Coxswain's Field of View: The field of view of the coxswain from the steering station in the starboard forward part of the main cabin is limited by several obstructions. The frames on the forward windows are very wide, placed far forward and obstruct the view of a significant portion of the horizon. On a 41-FT UTB, window frames are closer to the coxswain, and therefore small movements of the coxswain's head allow a view of the area obstructed by the window frames. On the 502001, the coxswain must move away from the helm to ensure that the window frames are not obstructing objects/vessels on a constant bearing. The flare of the bow limits the view of nearby objects in the water directly ahead and at the bow. Because of the location on the starboard side of the boat, it is not possible to see objects in the water alongside the boat on the port side. In addition, the galley equipment obstructs the view aft, especially on the starboard quarter. The coxswain may not be able to see activity on the well deck and at the tow bitt because of these obstructions. This can cause safety problems during towing and recovery operations. Future designs should ensure that these obstructions are eliminated. A flying bridge control station could have advantages, especially in terms of height of eye and clear view of the deck and objects in the water. Given the existing design of the 502001, caution must be taken in incorporating a flying bridge into the design because of the decrease in stability from moving the weight of crew and controls higher.

Difficulties with Stern Ramp Winches: The stern ramp has an electric or hand crank powered winch with a cable system to raise and lower the ramp. The cable has parted three times while in use. The winch has been replaced twice, and the running gear was also replaced. While the ramp is extremely useful, the system to operate it must be improved. A Hydraulic system should be considered.

Lack of Low Hand-Holds in Cabin: In the main cabin, hand-hold rails are provided in the overhead. For short crew members, these hand-holds are too high to use. Some hand-holds for smaller persons are provided on the corners of tables and cabinets, along with some stanchions in the main cabin. This is generally unsafe for smaller persons when the boat is operating in a seaway due to the sharp edges of the millwork and the distance between any two hand-hold locations.

Window Fogging/Defrosting: In conditions of high humidity, the windows fog on the inside. The installed defrosting system is inadequate to clear this fogging. This creates an especially hazardous situation with the forward windows. The crew must be able to see forward for safe piloting, but it is difficult to reach the forward windows because of the configuration of the cabin. Someone must climb onto the chart-table and the dashboard space below the windows to wipe off the condensation. This is dangerous in a seaway, because there are no good hand-holds in this area. A dehumidifying system, and/or electric defogging windows may be required to improve visibility.

High Well-Deck Hand Rails: High handrails aft hinder working over the side. Coupled with the freeboard of the boat aft, and the arrangement of the handrails in the well deck, it is very difficult to lift objects over the side if the well deck stern ramp cannot be used. An alternative arrangement for handrails in the well deck should be considered to allow persons to work over the side.

Spray Obscures Visibility: When the boat is running at high speeds, a great deal of spray sometimes comes off the bow. This spray can go as high as the top of the pilothouse, and can completely obscure visibility. The problem is aggravated when the boat runs trimmed down by the bow, such as when operating with excessive trim tab angles. This spray contributes to the leaky window problem in the main cabin. The spray can also lead to increased icing when underway in cold temperatures. The boat has a large pilothouse area for accumulating ice, which would lead to decreased stability and slippery decks. A spray rail or refinement to the bow design to reduce the spray is recommended.

Fuel tanks and vent system: The original fuel tank vent system permitted sea water to ingress through the side vents and into the tank. All of the boat's tanks were vented through the side of the hull. An alternative vent arrangement was discussed at the March 1993 Project Evaluation Board meeting, when it was decided to raise, enlarge, and move these vents to the main-deck level to prevent this problem. It is not possible with the present fuel plumbing to strip fuel from the bottom of the aft tank. The fuel tanks do not have inspection covers that allow the periodic internal inspections required of these tanks.

Engine Room main deck hatch hazard: The engine room hatch into the main deck is a potential hazard when open. The hatch is along the center line, just outside the door from the main cabin. A person unaware of the open hatch could potentially fall into the engine room. Also, since this hatch (and the lazarette hatch) is not hinged, the hatch covers are "free" when the hatch is open. The hatch cover could potentially be lost over the side if the hatch must be opened in a seaway. A hinged hatch with "lock-open" latch mechanism as previously discussed is recommended.

Marine stove: The stove top and convection microwave oven on the boat are conventional shoreside equipment. There is no means to secure pots and cookware when it is rough. This can lead to dangerous spilling of hot foods when the crew is cooking. It was observed that while the boat was docked at Little Creek, the chop and wave slamming prevented use of the stove top.

Limited Storage Space for Personal: Storage space is inadequate for dry stores, refrigerated foods, consumable supplies, and personal gear. The lack of adequate, well-designed storage encourages poor stowage and a general lack of securing personal effects for sea.

Head Doors and Privacy: The vinyl doors lack durability, when one is broken there is little to no privacy. Generally, the head and shower do not have adequate sound proofing and their location along the main passageway degrades crew's comfort in using these facilities.

Reduced Storage Space for Publications: In keeping with the desire to reduce the administrative workload of the crew, the number of publications carried aboard has been reduced to a minimum. However, some of the publications required for crew training are not available onboard. This lack of training materials and documentation could have a negative effect on the crew's overall readiness. Some alternative means to provide the crew access for all necessary training materials is required, such as having all such material accessible on a laptop computer.

Condensation: In addition to the leaking windows and the fogging on the windows, condensation is a problem in general. The insulation behind the paneling in the main cabin was found to be saturated with moisture. A means to dehumidify the boat appears necessary.

HVAC System Vents and Controls: Some crew members have complained about the HVAC system controls and vent arrangements. In the sleeping quarters there is only one control. The crew would prefer two zones, one for each stateroom. The vent arrangement in the forward cabin does not allow for good circulation of air. A modification to improve this system was proposed at the March 1993 Project Evaluation Board meeting.

Lounging/Furniture Arrangements: Crew members have complained that the arrangement of the settees are not comfortable for lounging during non-working hours. The settees cannot comfortably seat all crew members. Crew members must turn their necks sideways to an uncomfortable angle to view the TV from the settees and the bench height is too high for short people to reach the floor. Some improvements to furniture and arrangements may be possible for future live-aboard boats.

Cold Weather HVAC Problems: The Heating, Ventilating and Air Conditioning System was inoperable in cold weather. At water temperatures less than 40°F, the unit ices up, thereby preventing heating to occur, and at temperatures above 86°F the unit does not provide cooling. The specification required all systems on the boat to operate with water temperatures between 98°F and 28°F.

Emergency Operations: The location of the emergency steering valve inside the lazarette makes engaging the emergency steering a dangerous job in rough weather. This valve should be relocated to be usable from ;the welldeck. The emergency tiller requires excessive strength to operate.

Overboard Discharges: Are located such that a small vessel towed alongside is in danger of being swamped.

4.2 Mechanical and Design Advantages Noted During TECHEVAL

There are several very useful advantages of the features incorporated in the 502001. This section lists a few of the advantages that should be considered further for any class of USCG small boats.

Live-Aboard Accommodations for the Crew: The most unique features, and the features with the most marked advantage, are the facilities on the 502001 for the crew to live aboard. The boat can be operated to remain overnight at remote locations away from its dock. The long transit time to return to home port can be eliminated. The habitability improvements of this boat should reduce crew fatigue. Future UTB replacements should consider the advantages of improved habitability to determine if this feature should be incorporated in other boats.

Stern Ramp: The arrangement of the well deck and the stern ramp permit the crew to deploy pollution control booms from the boat. The stern ramp is also useful as a platform and for recovering persons and objects from the water. The safety of recovering persons from the stern, near the propellers, remains an operational issue.

Inflatable Boat: The 502001 carries an inflatable boat that has been reinforced on the bottom due to wear by the stern ramp during launch and recovery. The boat has an outboard motor and is used for shallow water operations. The ability to launch and recover a small outboard-powered boat from a USCG Utility Boat may provide significant flexibility for a variety of missions.

Improved Command and Control Facilities: The large plotting table, secure voice cellular phone and FAX, VHF Marine communications, autopilot and navigation equipment on the 502001 make the boat an excellent short-range command and control platform.

5.0 SUMMARY

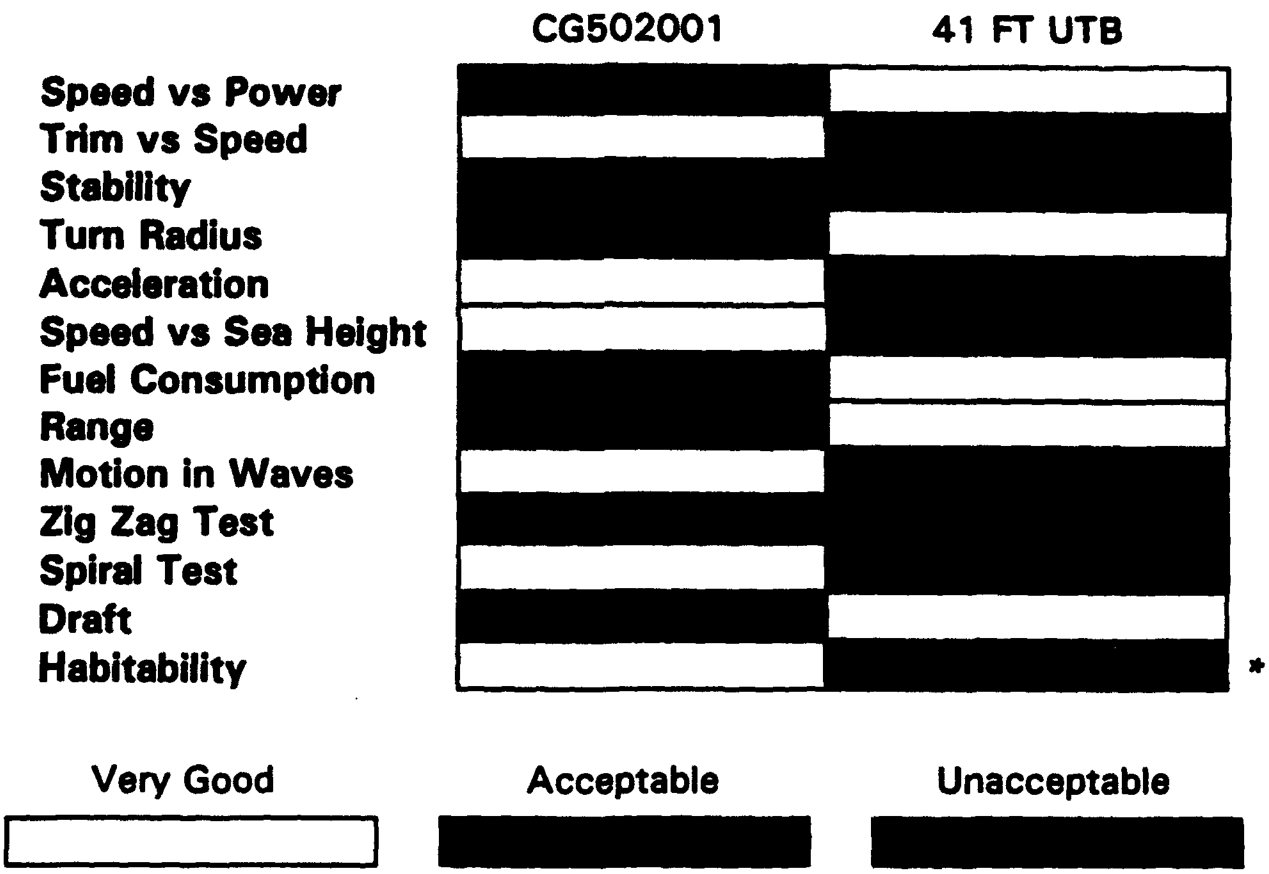
Table 5.1 summarizes the overall results of the technical evaluation comparison between the two boats. The 502001 has a better ride quality during rough seas and improved habitability over the 41-FT UTB. In general, the crew is less fatigued as a result of the improved ride and increased habitability. A study to quantify the actual improvement in crew mission performance was not a part of this project.

The TECHEVAL tests conducted in November of 1992 have established a performance baseline for the 502001 NORCREW Concept boat. Performance areas measured include maneuvering, powering and seakeeping performance of the boat. Although it is important to document the performance characteristics of any new addition to the Coast Guard fleet, the data collected here are primarily to be used to support the assessment of the operational capability of the NORCREW concept. It is essential to understand that the Coast Guard is focusing its evaluation on the NORCREW live-aboard concept to perform Coast Guard multi-mission operations and not so much the craft itself. However, if the craft cannot technically meet Coast Guard performance expectations equivalent to the 41-FT UTB then the testing of the concept may be invalidated. The TECHEVAL tests would reveal if there were any significant technical performance characteristics of the boat that could have had a negative impact on the outcome of the NORCREW concept evaluation.

In terms of principal characteristics, the 502001 is larger in displacement, length, beam, and draft than the 41-FT UTB. The 41-FT UTB has a center skeg whereas the propellers are the lowest point in the draft of the 502001. The larger size of the 502001 and the propeller exposure increases the risk of grounding damage over that of the 41-FT UTB. Although the 502001 boat is larger than the 41-FT UTB, it is difficult to imagine if the same level of habitability could have been possible with a 41-FT NORCREW boat.

The turning maneuvers, zig-zag, and spiral testing of the 502001 all demonstrated that the 502001 has good stability of the helm but decreased maneuverability than the 41-FT UTB. The difference was expected because the tightness of turning maneuvers is related to the boat's length and speed. Still, the turning performance of the 502001 is adequate for safe navigation and maneuvering and should not impact the NORCREW concept evaluation.

TABLE 5.1
A Relative
Comparison of Technical Performance Characteristics



* This is a relative comparison. Habitability for a 41-FT UTB is unacceptable for living aboard since it does not have accommodations.

Acceleration of the 502001 is good. It accelerates faster to its top speed than the 41-FT UTB but the 502001's top speed during testing was 22.4 knots versus a 41-FT UTB's 26 knots. The boat also has difficulty planing without the use of its trim tabs at settings above 5°. This boat is most efficient when it planes, but any mechanical problems with the trim tabs could prevent planing and lead to increased fuel consumption and reduced range. Above trim tab settings of 10°, the 502001 acquires a bow-down trim causing bow spray which reduces visibility. In addition, the top speed of the 502001 is reduced as much as five knots. It was found that the 502001 requires 1.5 to 2.7 times more fuel than a 41-FT UTB at cruising and maximum speeds, respectively.

The results of the side-by-side seakeeping tests demonstrated that the 502001 has better seakeeping abilities than the 41-FT UTB. The 502001, while having a slower maximum speed in calm sea conditions than the 41-FT UTB, is a more sea-state tolerant platform and can maintain a faster speed in adverse sea conditions.

For noise levels in octave bands centered at 250 Hz and lower, personnel comfort and voice communication requirements did not meet OPNAVINST standards. "A" weighted noise level requirements were met. Compared to the 41-FT UTB, the 502001 is quieter at the coxswain's station and crew's berthing, but about the same in the engine room. Use of the engine room hatch in the main cabin required the crew to wear hearing protection. Aside from being disruptive to crew members, frequent exposure to cabin noise levels at high boat speeds, and occasional exposure when the hatch covers are opened, may impose a health risk. Further analysis may be needed to study the effects on a live-aboard crew.

Mechanical and design issues identified during the TECHEVAL and during day-to-day 502001 operational use could pose some threat to a fair evaluation of the NORCREW concept. The problems discussed included the dangerous configuration of the main cabin hatches, salt water intrusion through leaky windows, poor field of view at the coxswain's station, lack of cabin hand-holds for shorter crew members, inadequate window defrosting system, and a few other minor problems discussed in 4.1. These problems are specific to the 502001 and are typical of the types of problems found on a prototype boat. All of these problems could be corrected for a production boat. Nevertheless, these problems could skew crew perceptions of the capability and habitability as it applies to the NORCREW Concept evaluation.

Considerable discussion has focused on minor design problems with the 502001 and shortcomings in performance when compared to the 41-FT UTB, but there are also some unique advantages to this boat. They include the live-aboard accommodations, a stern launch ramp, inflatable boat, and improved command and control facilities.

6.0 CONCLUSIONS

Table 5.1 provides a relative comparison between the 502001 and a 41-FT UTB based on the results of the technical evaluation. Although the data collected demonstrated some differences, the 502001 is considered technically suitable as a Coast Guard multi-mission platform. The 502001 should be capable of performing search and rescue, and supporting law enforcement, marine environmental protection, and recreational boating safety missions. Some of the technical differences noted include the larger size of the 502001 as a potential negative aspect of the boat where fuel use is concerned. The larger size does have a positive aspect in seakeeping performance which was demonstrated in the side-by-side comparison between the 502001 and a 41-FT UTB. The configuration of the 502001 propellers as the lowest point in its navigational draft increases the risk of grounding damage over the 41-FT UTB which has a large skeg for protection. The turning performance of the 502001 was found to be adequate for safe navigation and maneuvering, but not as good as the 41-FT UTB. It was determined that the 502001 cannot plane without the use of trim tabs set between 5 and 10 degrees. Based on standard noise criteria for craft 100 FT or less in length, neither the personnel comfort or voice communication requirements are met for the crew's berthing and coxswain's station, respectively. Although this may raise concern, it is common that small, fast vessels typically do not meet required noise standards. The 41-FT UTB does not meet the voice communications standards either.

It is the opinion of the R&DC TECHEVAL Team that there are no technical performance characteristics of the 502001 that would have a negative impact on the outcome of the NORCREW Concept evaluation. Whether or not the 502001 is the proper platform for a class of boats dedicated to this staffing arrangement would depend on the mission requirements placed on such a boat and would require further study.

7.0 REFERENCES

[1] NORCREW Test and Evaluation Master Plan (TEMP), February 1992

[2] Research and Development Support Proposal

[3] TECHEVAL Plan for the Norwegian SAR Concept Boat (502001), USCG R&DC, REV. 08/31/92

[4] M.J. Goodwin, "General Test Plan for Marine Vehicle Testing," USCG R&DC, Reprinted July 1986

[5] C.A. Kohler and R.R. Young, Small Boat Test Plan, USCG R&DC, Report Number CG-D-14-87

[6] C. Hervey and J. Bellemare, "TECHEVAL Report, 41-FT UTB and 44-FT MLB Baseline Tests", Enclosure to USCG R&DC Letter 709208, 20 September 1990

[7] 41' UTB Type Manual, COMDTINST M16114.2, U.S. Coast Guard Headquarters, Washington DC, 1980

[8] R.D. Sedat, E.S. Purcell, and C.L. Hervey, "Full Scale Trials of Pre-swirl Vanes and Modified Propellers on a 41-FT Utility Boat", USCG R&DC, Report Number CG-D-03-89.

[9] Guidelines for Conducting Stability Tests, Enclosure (1) to Navigation and Vessel Inspection Circular No. 15-81, 16 Dec 1981

[10] Code of Federal Regulations 46 Parts 166 to 199, Revised as of October 1, 1992

[11] CG502001 Manual, Munson Mfg, Inc., Hammerhead Aluminum Boats

[12] Darrell E. Milburn, Technical Characteristics Verification of the 47-FT MLB, Coast Guard Report No. CG-D-02-92

[13] J.B. Hadler, "The Prediction of Power Performance on Planing Craft", SNAME Annual Meeting Nov 10-11, 1966.

[14] LCDR C. Adams, COTR Final Report Ltr. on the SAR Boat Contract No. DTCG80-91-3FA893, dated March 9, 1992.

[15] Bhattacharyya, "Dynamics of Marine Vehicles", John Wiley and Sons, New York, 1978.

[16] D.L. Blount, "Achievements with Advanced Craft", Technical Proceedings "From The Sea To The Future", Small Boats Symposium '93 May 26-27, 1993.

STABILITY TEST REPORT

NORCREW

OFFICIAL NO. : CG502001

Date of Inclining
17 NOV 1992

United States Coast Guard
Research & Development Center

REFERENCES

Ref. No.	Title	Document No.	Date
1	GENERAL ARANGEMENT SEARCH AND RECOVERY VESSEL	623-100	
2	HULL MARKINGS/DOCKING PLAN	623-602	
3	STOWAGE PLAN	623-670	
4	HULL CONTROL DIMENSIONS	623-801	
5	HAMMERHEAD MUNSON MFG (SHIP'S MANUAL)	CG502001	

TEST INFORMATION

TEST SITE	:	TAYLOR'S ISLAND, MD
DATE	:	17 NOV 1992
TIME	:	07:30
VESSEL DESCRIPTION	:	NORWEGIAN CREW CONCEPT BOAT (UTB)
TYPE/CLASS	:	50FT
BUILDER	:	MUNSON MFG., INC
HULL No.	:	502001
DATE BUILT	:	1992
HULL	:	HULL, HAMMERHEAD DESIGN, HARD CHINE PLANING HULL ALUMINUM PLATE, TRIM TABS AFT
MACHINERY	:	(2) DETROIT DIESEL 8V92TA'S 710 HP (EA) AT 2300 RPM
OWNER	:	U.S. COAST GUARD
TEST REQUESTED BY	:	GROUP BALTIMORE
TEST CONDUCTED BY	:	U.S.C.G. R&D CENTER
CALCULATIONS BY	:	E.A. WEAVER
REPORT PREPARED BY	:	E.A. WEAVER
DUPLICATE VESSELS	:	NA
Weather and Tide	:	CLEAR AND SUNNY, ABSOLUTE CALM, WATER LIKE GLASS NO CURRENT
Mooring Condition	:	MOORED AT DOCK ALL LINES SLACK LINE TO FORPEAK AND AFT PORT CLEAT
Ship Condition	:	SHIP DISABLED WITH STBD ENGINE HEAD REMOVED TESTING EQUIPMENT ONBOARD

PRINCIPAL DIMENSIONS

Length - Over All	:	49.500	ft	(49ft- 6.00in)
- Between Perpendiculars	:	43.170	ft	(43ft- 2.04in)
Reference Water Line	:	DESIGN WATERLINE		
Breadth - Extreme	:	16.300	ft	(16ft- 3.60in)
- Molded, at Midship	:	15.790	ft	(15ft- 9.48in)
- Molded, at Reference W.L.	:	13.250	ft	(6ft-11.28in)
Depth - Molded, at Midship	:	7.960	ft	(7ft-11.52in)
Draft - to Baseline, at Reference W.L.	:	3.460	ft	(3ft- 5.52in)
- to Bottom of Keel, at Ref. W.L.	:	3.460	ft	(3ft- 5.52in)
Design Drag Between Perpendiculars	:	0.000	ft	(0ft- 0.00in)
Displacement, in Sea Water, at Ref. W.L.	:	51990.39	L	
Freeboard, at Midship, at Ref. W.L.	:	4.800	ft	(4ft- 9.60in)
Freeboard at Low Point of Sheer	:	4.000	ft	(4ft- 0.00in)
Location of Low Point of Sheer (from AP)	:	21.585A	ft	(21ft- 7.02in)A
Location of ports in the hull which may affect stability	:	0 0		

PERSONNEL IN ATTENDANCE

Names & Duties of Test Personnel : E. WEAVER - TEST SUPERVISOR, PENDULUM #1
LCDR D. MILBURN - CONTROL OF WEIGHT MOVEMENT
B. MACESKER
B. DESRUISSEAU
K. LEVREDGE
J. PRITCHARD

Designer's Representative(s) : NA

Builder's Representative(s) : NA

USCG Representative(s) : LCDR D. MILBURN

Owner's Representative(s) : K. LEVREDGE

DRAFT SUMMARY & WATERLINE CALCULATION

No.	Location Side	Location Label	Location ft-AP	Drafts from Freeboards ft	Drafts at Draft Marks ft	Combined Draft ft	Average Draft ft	Use for WL	Calculated Draft ft	Dev ft
1	Port	Aft Marks	0.000	---	3.420	3.420	3.400	Line	3.400	0.000
	Stbd			---	3.380	3.380				
2	Port	Midship	---	---	---	---	---	No	---	---
	Stbd			---	---	---				
3	Port	Fwd Marks	33.127F	---	3.580	3.580	3.645	Line	3.645	0.000
	Stbd			---	3.710	3.710				

Drafts - AP:	3.400 ft	MS:	3.560 ft	FP:	3.719 ft
Trim:	0.319F ft	List:	0.00 in	Hog/Sag:	0.000 ft
		:	0.00 deg		

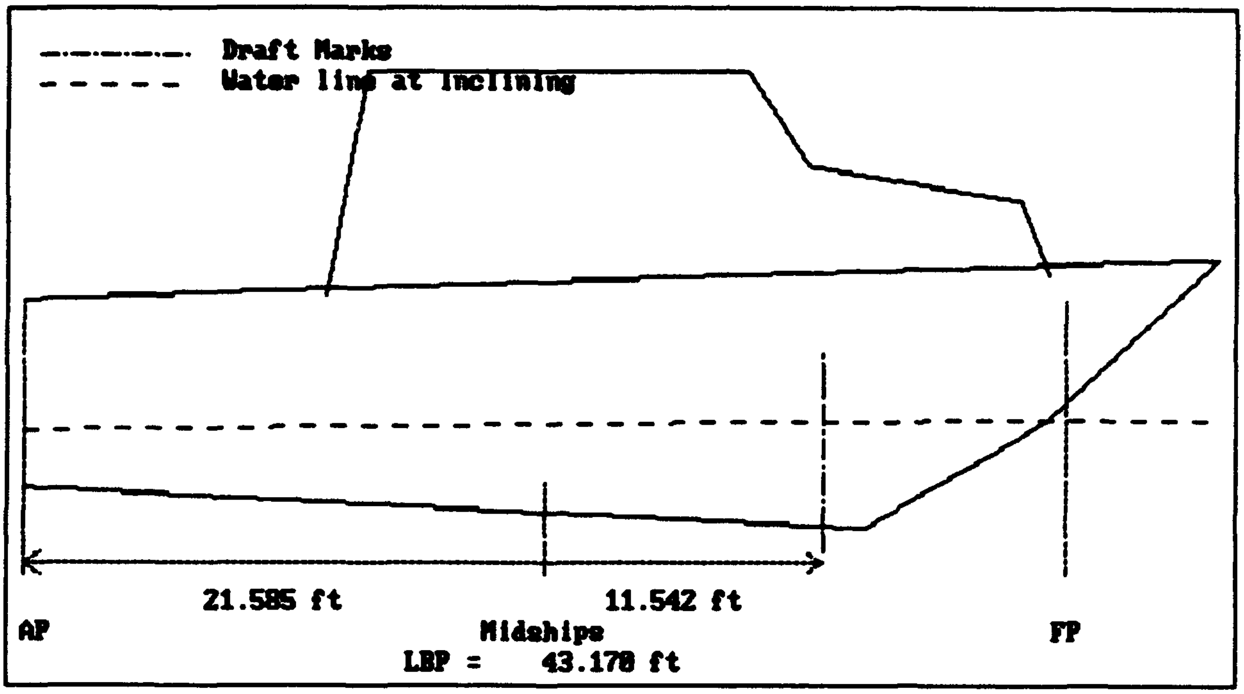
Measured Temperature deg-F :	46.00	Density:	1.0241 MTons/m3
Measured Specific Gravity :	1.0260	:	35.037 ft3/Ltons
Specific Gravity at 60 deg-F:	1.0262		
Corrected Displacement :	54683.88 Lbs		

Note - All drafts are measured to baseline.

Symbols - Use for WL : No - this draft is NOT used for waterline calculations.

Line - this draft is used with a straight line waterline calculation.

SHIP AT TIME OF STABILITY TEST
Condition 0



DRAFT MARK LOCATIONS

Aft Marks Distance ft-AP	Aft Marks Height ft-BL	Fwd Marks Distance ft-AP	Fwd Marks Height ft-BL
0.000	0.000	33.127F	0.000
0.000	4.500	33.127F	4.500
0.000	4.600	33.127F	5.000
0.000	4.700	33.127F	6.000

	Molded Drafts				
Aft Marks	: 3.400 ft	Aft Perp.	: 3.400 ft	Trim between Perps:	0.319F ft
Forward Marks	: 3.645 ft	Forward Perp.	: 3.719 ft	Hog or Sag :	0.000 ft
				Mn Deck Thickness :	0.000 in

PENDULUM & INCLINING WEIGHT DATA

PENDULUM DATA

No.	LOCATION	LENGTH TO BATTEN in
1	MIDSHIP 5FT AFT ENGRM FWD BLKHD	156.125

INCLINING WEIGHT DATA

LOCATION : 50 FT NORCREW MAIN DECK

DESCRIPTION : STEEL WEIGHTS AND PEOPLE
: 0

CERTIFICATION: 0

No.	IDENTIFICATION	WEIGHT Lbs	VCG ft-BL	LCG ft-AP	TCG ft-CL
1	NO. 1	100.800	7.910	13.752F	0.000
2	NO. 2	100.800	7.910	13.752F	0.000
3	NO. 3	53.760	7.910	13.752F	0.000
4	NO. 4	53.760	7.910	13.752F	0.000
5	NO. 5	40.320	7.910	13.752F	0.000
6	NO. 6	241.920	8.080	18.752F	0.000
7	NO. 7	168.000	8.450	26.252F	0.000
8	NO. 8	181.440	8.250	22.502F	0.000
9	NO. 9	206.080	8.450	26.252F	0.000
10	NO. 10	176.960	8.080	18.752F	0.000

INCLINING MOMENTS

TRIAL No.	WT No.	WEIGHT L	INITIAL POSITION TCG ft-CL	DISTANCE MOVED ft	TRIAL POSITION TCG ft-CL	MOMENT ft-Lbs	TOTAL MOMENT ft-Lbs
1	1	100.800	0.000	0.000	0.000	0.000	
	2	100.800	0.000	0.000	0.000	0.000	
	3	53.760	0.000	0.000	0.000	0.000	
	4	53.760	0.000	0.000	0.000	0.000	
	5	40.320	0.000	0.000	0.000	0.000	
	6	241.920	0.000	0.000	0.000	0.000	
	7	168.000	0.000	0.000	0.000	0.000	
	8	181.440	0.000	0.000	0.000	0.000	
	9	206.080	0.000	0.000	0.000	0.000	
	10	176.960	0.000	0.000	0.000	0.000	0.000
2	1	100.800	0.000	0.000	0.000	0.000	
	2	100.800	0.000	0.000	0.000	0.000	
	3	53.760	0.000	0.000	0.000	0.000	
	4	53.760	0.000	0.000	0.000	0.000	
	5	40.320	0.000	0.000	0.000	0.000	
	6	241.920	0.000	0.000	0.000	0.000	
	7	168.000	0.000	7.500S	7.500S	1260.000S	
	8	181.440	0.000	0.000	0.000	0.000	
	9	206.080	0.000	7.500S	7.500S	1545.600S	
	10	176.960	0.000	0.000	0.000	0.000	2805.600S
3	1	100.800	0.000	0.000	0.000	0.000	
	2	100.800	0.000	0.000	0.000	0.000	
	3	53.760	0.000	0.000	0.000	0.000	
	4	53.760	0.000	0.000	0.000	0.000	
	5	40.320	0.000	0.000	0.000	0.000	
	6	241.920	0.000	0.000	0.000	0.000	
	7	168.000	0.000	7.500P	7.500P	1260.000P	
	8	181.440	0.000	0.000	0.000	0.000	
	9	206.080	0.000	7.500P	7.500P	1545.600P	
	10	176.960	0.000	0.000	0.000	0.000	2805.600P

INCLINING MOMENTS

TRIAL No.	WT No.	WEIGHT L	INITIAL POSITION TCG ft-CL	DISTANCE MOVED ft	TRIAL POSITION TCG ft-CL	MOMENT ft-Lbs	TOTAL MOMENT ft-Lbs
4	1	100.800	0.000	0.000	0.000	0.000	
	2	100.800	0.000	0.000	0.000	0.000	
	3	53.760	0.000	0.000	0.000	0.000	
	4	53.760	0.000	0.000	0.000	0.000	
	5	40.320	0.000	0.000	0.000	0.000	
	6	241.920	0.000	7.500S	7.500S	1814.400S	
	7	168.000	0.000	7.500S	7.500S	1260.000S	
	8	181.440	0.000	7.500S	7.500S	1360.800S	
	9	206.080	0.000	7.500S	7.500S	1545.600S	
	10	176.960	0.000	7.500S	7.500S	1327.200S	7308.000S
5	1	100.800	0.000	0.000	0.000	0.000	
	2	100.800	0.000	0.000	0.000	0.000	
	3	53.760	0.000	0.000	0.000	0.000	
	4	53.760	0.000	0.000	0.000	0.000	
	5	40.320	0.000	0.000	0.000	0.000	
	6	241.920	0.000	7.500P	7.500P	1814.400P	
	7	168.000	0.000	7.500P	7.500P	1260.000P	
	8	181.440	0.000	7.500P	7.500P	1360.800P	
	9	206.080	0.000	7.500P	7.500P	1545.600P	
	10	176.960	0.000	7.500P	7.500P	1327.200P	7308.000P
6	1	100.800	0.000	7.500S	7.500S	756.000S	
	2	100.800	0.000	7.500S	7.500S	756.000S	
	3	53.760	0.000	7.500S	7.500S	403.200S	
	4	53.760	0.000	7.500S	7.500S	403.200S	
	5	40.320	0.000	7.500S	7.500S	302.400S	
	6	241.920	0.000	7.500S	7.500S	1814.400S	
	7	168.000	0.000	7.500S	7.500S	1260.000S	
	8	181.440	0.000	7.500S	7.500S	1360.800S	
	9	206.080	0.000	7.500S	7.500S	1545.600S	
	10	176.960	0.000	7.500S	7.500S	1327.200S	9928.800S

INCLINING MOMENTS

TRIAL No.	WT No.	WEIGHT L	INITIAL POSITION TCG ft-CL	DISTANCE MOVED ft	TRIAL POSITION TCG ft-CL	MOMENT ft-Lbs	TOTAL MOMENT ft-Lbs
7	1	100.800	0.000	7.500P	7.500P	756.000P	
	2	100.800	0.000	7.500P	7.500P	756.000P	
	3	53.760	0.000	7.500P	7.500P	403.200P	
	4	53.760	0.000	7.500P	7.500P	403.200P	
	5	40.320	0.000	7.500P	7.500P	302.400P	
	6	241.920	0.000	7.500P	7.500P	1814.400P	
	7	168.000	0.000	7.500P	7.500P	1260.000P	
	8	181.440	0.000	7.500P	7.500P	1360.800P	
	9	206.080	0.000	7.500P	7.500P	1545.600P	
	10	176.960	0.000	7.500P	7.500P	1327.200P	9928.800P

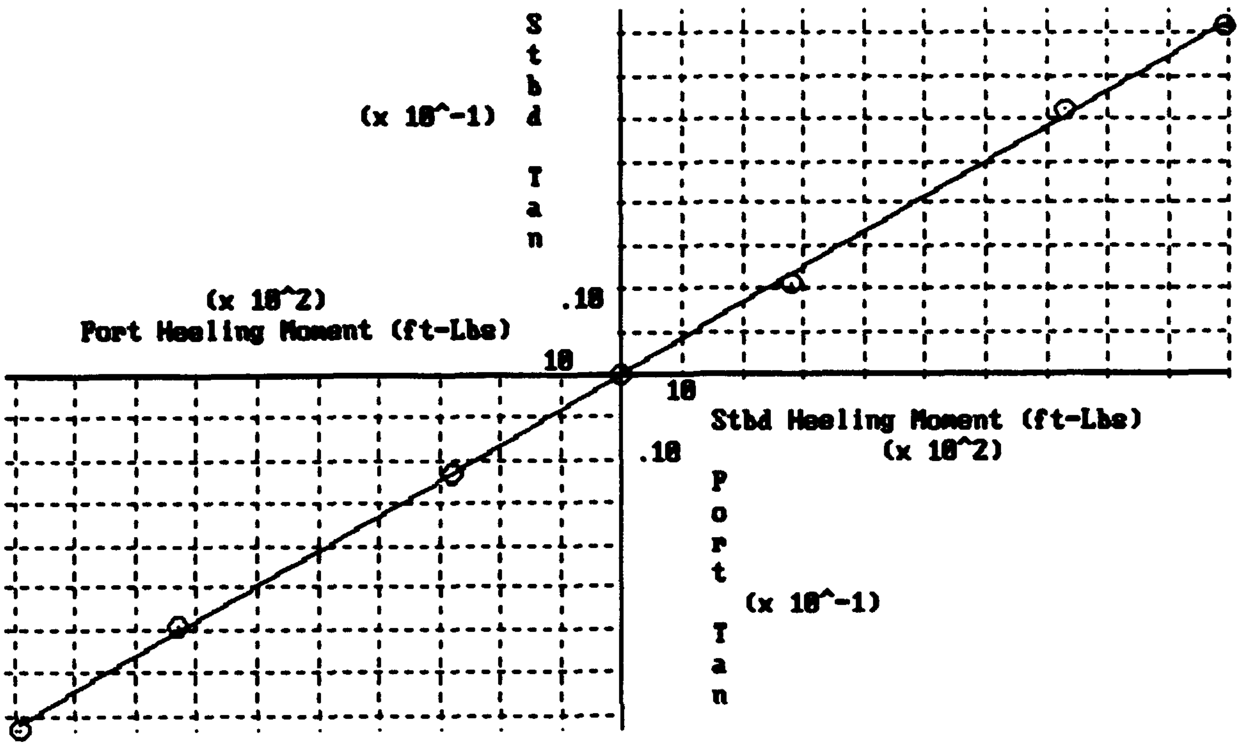
SUMMARY OF TANGENTS

TRIAL	PEND No.	PEND READING in	REF. POSITION in	PEND MOVEMENT in	PEND LENGTH in	TANGENT	INCL IN AVG	AVERAGE TANGENT
1	1	12.000	12.000	0.000	156.125	0.00000	Y	0.00000
2	1	13.633	12.000	1.633S	156.125	0.01046S	Y	0.01046S
3	1	10.188	12.000	1.812P	156.125	0.01161P	Y	0.01161P
4	1	16.875	12.000	4.875S	156.125	0.03122S	Y	0.03122S
5	1	7.375	12.000	4.625P	156.125	0.02962P	Y	0.02962P
6	1	18.375	12.000	6.375S	156.125	0.04083S	Y	0.04083S
7	1	5.500	12.000	6.500P	156.125	0.04163P	Y	0.04163P

Note: The Reference Pendulum Position corresponds to the initial pendulum reading.

SHIP AT TIME OF STABILITY TEST

PLOT OF MOMENT vs TANGENT



SHIP AT TIME OF STABILITY TEST

GMt Calculation

SUMMARY OF TANGENT AND MOMENT VALUES

Trial No.	Total Moment ft-Lbs	Average Tangent	Trial GM ft
1	0.000	0.00000	-----
2	2805.600S	0.01046S	-----
3	2805.600P	0.01161P	-----
4	7308.000S	0.03122S	4.280
5	7308.000P	0.02962P	4.511
6	9928.800S	0.04083S	4.447
7	9928.800P	0.04163P	4.361

Vessel GMt at time of Stability test = 4.411 ft
Probable Absolute Error = 0.05084 ft
Corrected Vessel Displacement = 54683.88 Lbs
Slope = delta Moment / delta Tangent = 241228.31

Note: Final GMt = Slope / Displacement. Slope is determined from the least squares fit of trial data.

SHIP AT TIME OF STABILITY TEST

CONDITION 0

TRIM AND DISPLACEMENT SUMMARY

Mld Drafts - at Aft Perp.	:	3.400	ft	
- at Midship	:	3.560	ft	
- at Forward Perp.	:	3.719	ft	
Trim between perpendiculars	:	0.319F	ft	
Hog or Sag	:	0.000	ft	
LCF (from AP)	:	18.471F	ft	(at Mean Draft between Perps.)
Draft at LCF	:	3.537	ft	(on st. line between Perps.)
Corrected Draft at LCF	:	3.537	ft	(correction = +- 0.00*hogsag)
Displacement at LCF Draft	:	54619.71	Lbs	(corrected for hog/sag)
Sp Gr used for Displ calc	:	1.0250		
Sp Gr of Flotation Water	:	1.0260		(at 46.00 deg-F)
	:	1.0262		(at 60 deg F)
Total Displacement	:	54683.88	Lbs	(in flotation water)

STABILITY SUMMARY

Virtual Metacentric Height (GMo)	:	4.411	ft	(from trial results)
Free Surface Correction	:	0.022	ft	(for liquids as inclined)
Transverse Metacentric Height (GMt)	:	4.434	ft	(GMo + FS)
KMt above Baseline	:	10.571	ft	(@ LCF draft from hydro table)
VCG above Baseline	:	6.137	ft	(KMt - GMt)
KMl above Baseline	:	71.741	ft	(@ LCF draft from hydro table)
Long'l Metacentric Height (GMl)	:	65.604	ft	(KMl - VCG)
Moment to Trim 1 in	:	6925.13	ft-Lbs	(GMl * Displacement / LBP)
Trimming Lever	:	0.485F	ft	(Trim * MCT1 / Displacement)
LCB (from AP)	:	19.342F	ft	(@ LCF draft from hydro table)
LCG (from AP)	:	19.828F	ft	(LCB - Trimming Lever)
Period of Complete Roll (T)	:	3.36	secs	
Apparent Radius of Gyration	:	6.369	ft	(T * SQR(GMo) / 1.108)
Rolling Constant	:	0.53		(T * SQR(GMo) / Beam)

LIGHT SHIP

CONDITION 1

Flotation Water Specific Gravity = 1.0250

ITEM	WEIGHT Lbs	VCG ft-BL	VMOM ft- Lbs	LCG ft-AP	LMOM ft- Lbs	TCG ft-CL	TMOM ft- Lbs
Ship in Condition 0	54683.88	6.137	335604.69	19.828F	1084247.88F	0.000	0.00
Liquids as Inclined to Deduct	-4185.28	2.430	-10169.55	16.210F	-67845.19F	0.025S	-102.62S
Dry Items to Deduct	-3660.16	7.364	-26951.71	21.020F	-76937.24F	0.396P	-1451.07P
Dry Items to Relocate	0.00	0.000	0.00	0.000	0.00	0.000	0.00
Dry Items to Add	120.96	5.333	645.08	18.335F	2217.74F	1.500S	181.44S
Add'l Liquids to Add/Deduct	247.01	5.333	1317.32	8.127F	2007.36F	3.000S	741.04S
Light Ship (Condition 1)	47206.42	6.365	300445.81	19.991F	943690.56F	0.048S	2270.94S

STABILITY CALCULATION

KMt	11.435	ft
VCG	6.365	ft
GMo	5.071	ft
F.S. Moment	0.00	ft-Lbs
F.S. Correction	0.000	ft
GMt Corrected	5.071	ft

TRIM CALCULATION

LCF Draft	3.301	ft
LCB (from AP)	19.497F	ft
LCF (from AP)	18.239F	ft
KMl	79.158	ft
MT1in	6633.30	ft-Lb/in
Trim	0.293F	ft
List	0.54S	deg

MOLDED DRAFTS

F.P.	3.470	ft
A.P.	3.177	ft

MOLDED DRAFTS AT MARKS

Fwd Marks	3.402	ft
Aft Marks	3.177	ft

LIQUIDS AS INCLINED TO BE DEDUCTED

DIESEL OIL (Sp.Vol. = 40.7925 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
1	FWD FUEL OIL	0-11.13	58.13	426.743	2.667	1138.12	23.752F	10135.79F	0.000	0.00	463.68
2	AFT FUEL OIL	1-11.50	318.50	2338.165	2.667	6235.89	5.835F	13642.04F	0.000	0.00	761.60
	TOTAL DIESEL OIL		376.63	2764.908	2.667	7374.01	8.600F	23777.83F	0.000	0.00	1225.28

FRESH WATER (Sp.Vol. = 35.8814 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
3	FRESH WATER PORT	0-11.38	66.18	552.336	1.667	920.74	31.252F	17261.35F	6.667P	3682.43P	0.00
4	FRESH WATER STBD	0-11.38	66.18	552.336	1.667	920.74	31.252F	17261.35F	6.667S	3682.43S	0.00
5	GRAY WATER STBD	0- 3.25	18.91	157.822	1.500	236.73	33.335F	5260.93F	1.333S	210.38S	0.00
6	BILGE WATER	0- 0.00	9.23	77.033	8.000	616.27	20.627F	1588.93F	0.000	0.00	0.00
	TOTAL FRESH WATER		160.50	1339.529	2.012	2694.49	30.886F	41372.55F	0.157S	210.38S	0.00

SALT WATER (BLACK) (Sp.Vol. = 35.0062 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
7	BLACK WATER PORT	0- 1.63	9.45	80.841	1.250	101.05	33.335F	2694.80F	1.333P	107.76P	0.00
	TOTAL SALT WATER (BLACK)		9.45	80.841	1.250	101.05	33.335F	2694.80F	1.333P	107.76P	0.00

HYDRAULIC OIL (Sp.Vol. = 42.4320 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
8	HYDRAULIC OIL	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
	TOTAL HYDRAULIC OIL		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
TOTAL ALL TANKS	4185.278	2.430	10169.55	16.210F	67845.19F	0.025S	102.62S	1225.28

DRY ITEMS TO BE DEDUCTED

TOTAL INCLINING WEIGHTS

No.	DESCRIPTION	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
1	Inclining weight : NO. 1	100.800	7.910	797.33	13.752F	1386.15F	0.000	0.00
2	Inclining weight : NO. 2	100.800	7.910	797.33	13.752F	1386.15F	0.000	0.00
3	Inclining weight : NO. 3	53.760	7.910	425.24	13.752F	739.28F	0.000	0.00
4	Inclining weight : NO. 4	53.760	7.910	425.24	13.752F	739.28F	0.000	0.00
5	Inclining weight : NO. 5	40.320	7.910	318.93	13.752F	554.46F	0.000	0.00
6	Inclining weight : NO. 6	241.920	8.080	1954.71	18.752F	4536.36F	0.000	0.00
7	Inclining weight : NO. 7	168.000	8.450	1419.60	26.252F	4410.25F	0.000	0.00
8	Inclining weight : NO. 8	181.440	8.250	1496.88	22.502F	4082.67F	0.000	0.00
9	Inclining weight : NO. 9	206.080	8.450	1741.38	26.252F	5409.91F	0.000	0.00
10	Inclining weight : NO. 10	176.960	8.080	1429.84	18.752F	3318.27F	0.000	0.00
11	TOTALS	1323.840	8.163	10806.48	20.065F	26562.80F	0.000	0.00

TOTAL TEST EQUIPMENT

No.	DESCRIPTION	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
12	INCLINE OFFICER	206.080	1.600	329.73	20.835F	4293.58F	0.000	0.00
13	HUMPHREYS CONTROL BOX	49.280	6.000	295.68	23.752F	1170.47F	2.500P	123.20P
14	HUMPHREYS SENSOR BOX	53.760	5.333	286.70	23.752F	1276.88F	0.000	0.00
15	TEAC REC CASE	47.040	7.000	329.28	23.752F	1117.27F	2.500P	117.60P
16	LAP TOP	17.920	8.667	155.31	20.002F	358.43F	3.600P	64.51P
17	TOOL KIT	15.680	8.667	135.90	23.127F	362.62F	2.400P	37.63P
18	HP MONITOR	15.680	12.000	188.16	28.752F	450.82F	3.200P	50.18P
19	KEYBOARD	4.480	11.750	52.64	28.752F	128.81F	3.000P	13.44P
20	MISC TOOLS	8.960	8.667	77.66	28.752F	257.61F	3.200P	28.67P
21	SURGE PROTECTORS	4.480	11.333	50.77	23.752F	106.41F	5.600P	25.09P
22	CORDS	8.960	8.667	77.66	28.752F	257.61F	3.200P	28.67P
23	HP COMPUTER	73.920	9.333	689.90	28.752F	2125.31F	3.200P	236.54P
24	TOTALS	506.240	5.273	2669.38	23.518F	11905.83F	1.433P	725.54P

No.	DESCRIPTION	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
25		0.000	0.000	0.00	0.002F	0.00F	0.000	0.00

	WEIGHT	VCG	VMOM	LCG	LMOM	TCG	TMOM
TOTAL ALL ITEMS	3660.159	7.364	26951.71	21.020F	76937.24F	0.396P	1451.07P

DRY ITEMS TO BE ADDED

No.	DESCRIPTION	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
1	STBD ENGINE HEAD	120.960	5.333	645.08	18.335F	2217.74F	1.500S	181.44S
	TOTAL ALL ITEMS	120.960	5.333	645.08	18.335F	2217.74F	1.500S	181.44S

ADDITIONAL LIQUIDS TO ADD/DEDUCT

DIESEL OIL (Sp.Vol. = 40.7925 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
1	FWD FUEL OIL	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
2	AFT FUEL OIL	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
	TOTAL DIESEL OIL		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

FRESH WATER (Sp.Vol. = 35.8814 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
3	FRESH WATER PORT	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
4	FRESH WATER STBD	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
5	GRAY WATER STBD	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
6	BILGE WATER	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
	TOTAL FRESH WATER		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

SALT WATER (BLACK) (Sp.Vol. = 35.0062 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
7	BLACK WATER PORT	0- 0.00	0.00	0.000	0.000	0.00	0.002F	0.00F	0.000	0.00	0.00
	TOTAL SALT WATER (BLACK)		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

HYDRAULIC OIL (Sp.Vol. = 42.4320 ft3/LT)

No.	DESCRIPTION	SOUNDING ft-in	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
8	HYDRAULIC OIL	0- 0.00	35.00	247.014	5.333	1317.32	8.127F	2007.36F	3.000S	741.04S	0.00
	TOTAL HYDRAULIC OIL		35.00	247.014	5.333	1317.32	8.127F	2007.36F	3.000S	741.04S	0.00

	WEIGHT	VCG	VMOM	LCG	LMOM	TCG	TMOM	FREE SURF
TOTAL ALL TANKS	247.014	5.333	1317.32	8.127F	2007.36F	3.000S	741.04S	0.00

50FT FULL LOAD

CONDITION SUMMARY

SHIP FULLY LOADED READY FOR RESCUE RUN
4 PEOPLE ONBOARD AND ALL FUEL AND WATER TANKS FULL

Flotation Water Specific Gravity = 1.0250

ITEM	WEIGHT Lbs	VCG ft-BL	VMOM ft- Lbs	LCG ft-AP	LMOM ft- Lbs	TCG ft-CL	TMOM ft- Lbs
Light Ship	47206.42	6.365	300445.81	19.991F	943690.56F	0.048S	2270.94S
TOTAL	660.00	8.250	5445.00	22.502F	14851.00F	0.050S	33.00S
DIESEL OIL	4977.32	2.670	13289.45	14.634F	72840.38F	0.000	0.00
FRESH WATER	1251.90	1.667	2086.91	31.252F	39123.63F	0.000	0.00
SALT WATER (BLACK)	0.00	0.000	0.00	21.585F	0.00F	0.000	0.00
HYDRAULIC OIL	0.00	0.000	0.00	21.585F	0.00F	0.000	0.00
Condition Total	54095.64	5.939	321267.16	19.789F	1070505.50F	0.043S	2303.94S

STABILITY CALCULATION

KMt	10.624	ft
VCG	5.939	ft
GMo	4.685	ft
F.S. Moment	1232.00	ft-Lbs
F.S. Correction	0.023	ft
GMt Corrected	4.663	ft

TRIM CALCULATION

LCF Draft	3.520	ft
LCB (from AP)	19.350F	ft
LCF (from AP)	18.457F	ft
KMl	72.216	ft
MT1in	6920.90	ft-Lb/in
Trim	0.286F	ft
List	0.52S	deg

MOLDED DRAFTS

F.P.	3.684	ft
A.P.	3.398	ft

MOLDED DRAFTS AT MARKS

Fwd Marks	3.617	ft
Aft Marks	3.398	ft

DRY WEIGHTS - 50FT FULL LOAD

No.	DESCRIPTION	TOTAL WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
1	CREW MEMBER	165.000	8.250	1361.25	18.752F	3094.00F	2.800S	462.00S
2	CREW MEMBER	165.000	8.250	1361.25	18.752F	3094.00F	2.600P	429.00P
3	CREW MEMBER	165.000	8.250	1361.25	26.252F	4331.50F	2.500P	412.50P
4	CREW MEMBER	165.000	8.250	1361.25	26.252F	4331.50F	2.500S	412.50S
5	TOTALS	660.000	8.250	5445.00	22.502F	14851.00F	0.050S	33.00S
	TOTAL ALL ITEMS	660.000	8.250	5445.00	22.502F	14851.00F	0.050S	33.00S

LIQUIDS - 50FT FULL LOAD

DIESEL OIL (Sp.Vol. = 40.7925 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
1	FWD FUEL OIL	100.0	333.00	2444.614	2.670	6527.12	23.752F	58063.27F	0.000	0.00	470.40
2	AFT FUEL OIL	100.0	345.00	2532.708	2.670	6762.33	5.835F	14777.11F	0.000	0.00	761.60
	TOTAL DIESEL OIL		678.00	4977.322	2.670	13289.45	14.634F	72840.38F	0.000	0.00	1232.00

FRESH WATER (Sp.Vol. = 35.8814 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
3	FRESH WATER PORT	100.0	75.00	625.948	1.667	1043.45	31.252F	19561.81F	6.670P	4175.07P	0.00
4	FRESH WATER STBD	100.0	75.00	625.948	1.667	1043.45	31.252F	19561.81F	6.670S	4175.07S	0.00
5	GRAY WATER STBD	0.0	0.00	0.000	1.500	0.00	33.335F	0.00F	1.330S	0.00S	0.00
6	BILGE WATER	0.0	0.00	0.000	8.000	0.00	20.627F	0.00F	0.000	0.00	0.00
	TOTAL FRESH WATER		150.00	1251.896	1.667	2086.91	31.252F	39123.63F	0.000	0.00	0.00

SALT WATER (BLACK) (Sp.Vol. = 35.0062 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
7	BLACK WATER PORT	0.0	0.00	0.000	1.500	0.00	33.335F	0.00F	0.000	0.00	0.00
	TOTAL SALT WATER (BLACK)		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

HYDRAULIC OIL (Sp.Vol. = 42.4320 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
8	HYDRAULIC OIL	0.0	0.00	0.000	5.333	0.00	8.127F	0.00F	3.000S	0.00S	0.00
	TOTAL HYDRAULIC OIL		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
TOTAL ALL TANKS	6229.217	2.468	15376.36	17.974F	111964.00F	0.000	0.00	1232.00

50FT RESCUE LOAD

CONDITION SUMMARY

SHIP WITH LIGHT LOAD - TANKS EMPTY RETURNING TO BASE WITH 8 PEOPLE ONBOARD

Flotation Water Specific Gravity = 1.0250

ITEM	WEIGHT Lbs	VCG ft-BL	VMOM ft- Lbs	LCG ft-AP	LMOM ft- Lbs	TCG ft-CL	TMOM ft- Lbs
Light Ship	47206.42	6.365	300445.81	19.991F	943690.56F	0.048S	2270.94S
TOTAL	1320.00	8.250	10890.00	25.127F	33167.00F	1.212P	1600.50P
DIESEL OIL	248.87	2.670	664.47	14.634F	3642.02F	0.000	0.00
FRESH WATER	62.59	1.667	104.35	31.252F	1956.18F	0.000	0.00
SALT WATER (BLACK)	0.00	0.000	0.00	21.585F	0.00F	0.000	0.00
HYDRAULIC OIL	0.00	0.000	0.00	21.585F	0.00F	0.000	0.00
Condition Total	48837.88	6.391	312104.66	20.117F	982455.75F	0.014S	670.44S

STABILITY CALCULATION

KMt	11.223	ft
VCG	6.391	ft
GMo	4.832	ft
F.S. Moment	1232.00	ft-Lbs
F.S. Correction	0.025	ft
GMt Corrected	4.807	ft

TRIM CALCULATION

LCF Draft	3.353	ft
LCB (from AP)	19.456F	ft
LCF (from AP)	18.292F	ft
KMl	77.350	ft
MT1in	6689.66	ft-Lb/in
Trim	0.402F	ft
List	0.16S	deg

MOLDED DRAFTS

F.P.	3.585	ft
A.P.	3.183	ft

MOLDED DRAFTS AT MARKS

Fwd Marks	3.491	ft
Aft Marks	3.183	ft

DRY WEIGHTS - 50FT RESCUE LOAD

No.	DESCRIPTION	TOTAL WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
1	CREW MEMBER	165.000	8.250	1361.25	18.752F	3094.00F	2.800S	462.00S
2	CREW MEMBER	165.000	8.250	1361.25	18.752F	3094.00F	2.600P	429.00P
3	CREW MEMBER	165.000	8.250	1361.25	26.252F	4331.50F	2.500P	412.50P
4	CREW MEMBER	165.000	8.250	1361.25	26.252F	4331.50F	2.500S	412.50S
5	PASSENGER	165.000	8.250	1361.25	28.252F	4661.50F	2.500P	412.50P
6	PASSENGER	165.000	8.250	1361.25	28.252F	4661.50F	2.800P	462.00P
7	PASSENGER	165.000	8.250	1361.25	26.252F	4331.50F	2.400P	396.00P
8	PASSENGER	165.000	8.250	1361.25	28.252F	4661.50F	2.200P	363.00P
9	TOTALS	1320.000	8.250	10890.00	25.127F	33167.00F	1.212P	1600.50P

TOTAL ALL ITEMS	1320.000	8.250	10890.00	25.127F	33167.00F	1.212P	1600.50P

LIQUIDS - 50FT RESCUE LOAD

DIESEL OIL (Sp.Vol. = 40.7925 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
1	FWD FUEL OIL	5.0	16.65	122.231	2.670	326.36	23.752F	2903.16F	0.000	0.00	470.40
2	AFT FUEL OIL	5.0	17.25	126.635	2.670	338.12	5.835F	738.86F	0.000	0.00	761.60
	TOTAL DIESEL OIL		33.90	248.866	2.670	664.47	14.634F	3642.02F	0.000	0.00	1232.00

FRESH WATER (Sp.Vol. = 35.8814 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
3	FRESH WATER PORT	5.0	3.75	31.297	1.667	52.17	31.252F	978.09F	6.670P	208.75P	0.00
4	FRESH WATER STBD	5.0	3.75	31.297	1.667	52.17	31.252F	978.09F	6.670S	208.75S	0.00
5	GRAY WATER STBD	0.0	0.00	0.000	1.500	0.00	33.335F	0.00F	1.330S	0.00S	0.00
6	BILGE WATER	0.0	0.00	0.000	8.000	0.00	20.627F	0.00F	0.000	0.00	0.00
	TOTAL FRESH WATER		7.50	62.595	1.667	104.35	31.252F	1956.18F	0.000	0.00	0.00

SALT WATER (BLACK) (Sp.Vol. = 35.0062 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
7	BLACK WATER PORT	0.0	0.00	0.000	1.500	0.00	33.335F	0.00F	0.000	0.00	0.00
	TOTAL SALT WATER (BLACK)		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

HYDRAULIC OIL (Vol. = 42.4320 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	CG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
8	HYDRAULIC OIL	0.0	0.00	0.000	5.333	0.00	8.127F	0.00F	3.000S	0.00S	0.00
	TOTAL HYDRAULIC OIL		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
TOTAL ALL TANKS	311.461	2.468	768.82	17.974F	5598.20F	0.000	0.00	1232.00

SOFT MAXIMUM LOAD

CONDITION SUMMARY

SHIP WITH MAXIMUM LOAD - TANKS 95% FULL RETURNING TO BASE WITH 8 PEOPLE ONBOARD

Flotation Water Specific Gravity = 1.0250

ITEM	WEIGHT Lbs	VCG ft-BL	VMOM ft- Lbs	LCG ft-AP	LMOM ft- Lbs	TCG ft-CL	TMOM ft- Lbs
Light Ship	47206.42	6.365	300445.81	19.991F	943690.56F	0.048S	2270.94S
TOTAL	1320.00	8.250	10890.00	25.127F	33167.00F	1.212P	1600.50P
DIESEL OIL	4728.45	2.670	12624.97	14.634F	69198.32F	0.000	0.00
FRESH WATER	1189.30	1.667	1982.56	31.252F	37167.44F	0.000	0.00
SALT WATER (BLACK)	0.00	0.000	0.00	21.585F	0.00F	0.000	0.00
HYDRAULIC OIL	0.00	0.000	0.00	21.585F	0.00F	0.000	0.00
Condition Total	54444.18	5.987	325943.34	19.896F	1083223.25F	0.012S	670.44S

STABILITY CALCULATION

KMt	10.589	ft
VCG	5.987	ft
GMo	4.602	ft
F.S. Moment	1232.00	ft-Lbs
F.S. Correction	0.023	ft
GMt Corrected	4.579	ft

TRIM CALCULATION

LCF Draft	3.531	ft
LCB (from AP)	19.345F	ft
LCF (from AP)	18.466F	ft
KMl	71.900	ft
MT1in	6927.29	ft-Lb/in
Trim	0.361F	ft
List	0.15S	deg

MOLDED DRAFTS

F.P.	3.738	ft
A.P.	3.377	ft

MOLDED DRAFTS AT MARKS

Fwd Marks	3.654	ft
Aft Marks	3.377	ft

DRY WEIGHTS - 50FT MAXIMUM LOAD

No.	DESCRIPTION	WEIGHT Lbs	TOTAL VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs
1	CREW MEMBER	165.000	8.250	1361.25	18.752F	3094.00F	2.800S	462.00S
2	CREW MEMBER	165.000	8.250	1361.25	18.752F	3094.00F	2.600P	429.00P
3	CREW MEMBER	165.000	8.250	1361.25	26.252F	4331.50F	2.500P	412.50P
4	CREW MEMBER	165.000	8.250	1361.25	26.252F	4331.50F	2.500S	412.50S
5	PASSENGER	165.000	8.250	1361.25	28.252F	4661.50F	2.500P	412.50P
6	PASSENGER	165.000	8.250	1361.25	28.252F	4661.50F	2.800P	462.00P
7	PASSENGER	165.000	8.250	1361.25	26.252F	4331.50F	2.400P	396.00P
8	PASSENGER	165.000	8.250	1361.25	28.252F	4661.50F	2.200P	363.00P
9	TOTALS	1320.000	8.250	10890.00	25.127F	33167.00F	1.212P	1600.50P
	TOTAL ALL ITEMS	1320.000	8.250	10890.00	25.127F	33167.00F	1.212P	1600.50P

LIQUIDS - 50FT MAXIMUM LOAD

DIESEL OIL (Sp.Vol. = 40.7925 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
1	FWD FUEL OIL	95.0	316.35	2322.382	2.670	6200.76	23.752F	55160.09F	0.000	0.00	470.40
2	AFT FUEL OIL	95.0	327.75	2406.072	2.670	6424.21	5.835F	14038.25F	0.000	0.00	761.60
	TOTAL DIESEL OIL		644.10	4728.455	2.670	12624.97	14.634F	69198.34F	0.000	0.00	1232.00

FRESH WATER (Sp.Vol. = 35.8814 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
3	FRESH WATER PORT	95.0	71.25	594.650	1.667	991.28	31.252F	18583.72F	6.670P	3966.32P	0.00
4	FRESH WATER STBD	95.0	71.25	594.650	1.667	991.28	31.252F	18583.72F	6.670S	3966.32S	0.00
5	GRAY WATER STBD	0.0	0.00	0.000	1.500	0.00	33.335F	0.00F	1.330S	0.00S	0.00
6	BILGE WATER	0.0	0.00	0.000	8.000	0.00	20.627F	0.00F	0.000	0.00	0.00
	TOTAL FRESH WATER		142.50	1189.301	1.667	1982.56	31.252F	37167.44F	0.000	0.00	0.00

SALT WATER (BLACK) (Sp.Vol. = 35.0062 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
7	BLACK WATER PORT	0.0	0.00	0.000	1.500	0.00	33.335F	0.00F	0.000	0.00	0.00
	TOTAL SALT WATER (BLACK)		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

HYDRAULIC OIL (Sp.Vol. = 42.4320 ft3/LT)

No.	DESCRIPTION	% FULL	VOLUME gal	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
8	HYDRAULIC OIL	0.0	0.00	0.000	5.333	0.00	8.127F	0.00F	3.000S	0.00S	0.00
	TOTAL HYDRAULIC OIL		0.00	0.000	0.000	0.00	21.585F	0.00F	0.000	0.00	0.00

	WEIGHT Lbs	VCG ft-BL	VMOM ft-Lbs	LCG ft-AP	LMOM ft-Lbs	TCG ft-CL	TMOM ft-Lbs	FREE SURF ft-Lbs
TOTAL ALL TANKS	5917.755	2.468	14607.54	17.974F	106365.79F	0.000	0.00	1232.00

APPENDIX

HYDROSTATIC TABLE

Trim between Perpendiculars = 0.000 ft
Specific Gravity = 1.0250

	DRAFT ft	DISPLACEMENT Lbs	KMt ft-BL	LCB ft-AP	LCF ft-AP	KMl ft-BL	MT1in ft-Lb/in
1	0.167	8.96	0.680	32.400F	32.060F	31.900	0.55
2	0.250	40.32	1.030	31.960F	31.510F	37.500	2.92
3	0.333	89.60	1.380	31.520F	30.880F	46.100	7.97
4	0.417	159.04	1.730	31.060F	30.200F	53.300	16.36
5	0.500	271.04	2.080	30.580F	29.560F	61.400	32.12
6	0.583	409.92	2.430	30.110F	28.910F	69.100	54.68
7	0.667	589.12	2.780	29.640F	28.250F	76.100	86.54
8	0.750	819.84	3.140	29.160F	27.590F	83.700	132.46
9	0.833	1099.84	3.490	28.670F	26.930F	91.200	193.62
10	0.917	1440.32	3.840	28.180F	26.270F	98.900	274.97
11	1.000	1850.24	4.190	27.690F	25.600F	106.600	380.73
12	1.083	2320.64	4.550	27.200F	24.930F	113.400	507.99
13	1.167	2860.48	4.900	26.700F	24.240F	121.300	669.79
14	1.250	3480.96	5.260	26.200F	23.560F	129.000	866.81
15	1.333	4191.04	5.610	25.690F	22.870F	136.700	1105.93
16	1.417	4979.52	5.970	25.190F	22.190F	144.200	1386.08
17	1.500	5871.04	6.330	24.690F	21.560F	148.600	1684.11
18	1.583	6849.92	6.700	24.200F	21.060F	149.100	1971.51
19	1.667	7929.60	7.070	23.750F	20.640F	147.100	2251.65
20	1.750	9101.12	7.450	23.320F	20.280F	143.700	2524.57
21	1.833	10360.00	7.830	22.930F	19.980F	139.600	2791.78
22	1.917	11710.72	8.220	22.580F	19.710F	135.100	3054.05
23	2.000	13151.04	8.610	22.250F	19.480F	130.600	3315.43
24	2.083	14680.96	9.000	21.950F	19.270F	126.100	3573.60
25	2.167	16300.48	9.390	21.680F	19.090F	121.700	3829.37
26	2.250	18009.60	9.780	21.420F	18.920F	117.600	4088.35
27	2.333	19810.56	10.350	21.190F	18.780F	113.600	4344.22
28	2.417	21750.40	12.450	20.970F	18.690F	110.100	4622.65
29	2.500	23829.11	13.060	20.770F	18.580F	106.800	4912.65
30	2.583	25990.72	13.260	20.580F	18.450F	103.500	5192.72
31	2.667	28250.87	13.440	20.410F	18.360F	100.900	5502.49
32	2.750	30580.47	13.400	20.250F	18.240F	98.300	5802.75
33	2.833	32970.57	13.280	20.100F	18.140F	95.900	6103.54
34	2.917	35421.11	13.030	19.960F	18.090F	93.300	6379.41
35	3.000	37920.97	12.800	19.840F	18.040F	90.900	6653.96
36	3.083	40461.11	12.510	19.720F	18.030F	88.400	6904.41
37	3.167	43019.20	12.040	19.620F	18.090F	84.300	7000.46
38	3.250	45610.88	11.650	19.540F	18.190F	81.000	7131.65

Note: Drafts are measured from the baseline (molded)

HYDROSTATIC TABLE (cont'd)

Trim between Perpendiculars = 0.000 ft
Specific Gravity = 1.0250

	DRAFT ft	DISPLACEMENT Lbs	KMt ft-BL	LCB ft-AP	LCF ft-AP	KMl ft-BL	MT1in ft-Lb/in
39	3.333	48209.29	11.300	19.470F	18.270F	78.000	7258.75
40	3.417	50821.13	10.980	19.410F	18.360F	75.300	7387.13
41	3.500	53450.88	10.690	19.360F	18.440F	72.800	7511.43
42	3.583	56100.79	10.420	19.320F	18.510F	70.400	7623.92
43	3.667	58777.59	10.190	19.280F	18.610F	68.605	7784.00

Note: Drafts are measured from the baseline (molded)

VESSEL PROFILE DESCRIPTION

PROFILE COORDINATES

	LOCATION LOCATION ft-AP	HEIGHT HEIGHT ft-BL		LOCATION ft-AP	HEIGHT ft-BL		LOCATION ft-AP	HEIGHT ft-BL		ft-AP	ft-BL
1	0.002F	1.416 L	5	42.502F	3.750 L	9	42.502F	8.660 M	13	14.162F	15.600 L
2	35.002F	0.000 L	6	49.502F	9.167 L	10	41.252F	11.200 L	14	12.502F	8.000 L
3	37.502F	1.250 L	7	0.002F	7.833 L	11	32.502F	12.400 L			
4	40.002F	2.500 L	8	0.002F	1.416 M	12	30.002F	15.600 L			

Note: L = draw line to this location from previous coordinate
M = move to this location without drawing line

APPENDIX B

502001 NORCREW AND 41350 UTILITY BOAT NOISE SURVEYS

Sound testing was conducted on the 502001 SAR concept boat on 19 November 1992 at several key locations on the boat. The locations tested are as follows:

Location A - starboard crew's berthing
Location B - coxswain's station
Location C - engine room
Location D - galley
Location E - tow bitt

Figure B-1 illustrates the approximate locations of the noise measurements on the 502001 boat. Octave band and "A" weighted Sound Pressure Levels (SPLs) were measured at cruising speed (19.5 knots) and maximum speed (22 knots). A minimum and maximum were recorded using the fast response level of a Bruel & Kjaer (B&K) 2231 precision sound level meter. Tables B-1 and B-2 present the octave band SPLs measured in decibels relative to 20 micro-pascals.

TABLE B-1

502001 OCTAVE BAND NOISE LEVELS

2195 RPM/19.5 KTS

(dB re 20 μPa)

OCTAVE BAND	LOCATION (HIGH/LOW)				
FREQUENCIES	A	B	C	D	E
31.5	99.1/91.4	89.5/83.1	89.0/86.0	91.4/82.1	92.7/84.6
63	94.3/86/7	91.6/81.6	98.6/93.0	89.6/83.3	103.0/96.4
125	94.8/87.8	90.1/80.8	103.2/96.4	91.5/81.1	106.9/97.1
250	81.4/75.7	79.6/75.8	105.2/102.8	80.0/76.0	96.9/89.9
500	70.9/66.1	75.6/72.1	108.3/106.4	74.1/68.9	86.2/83.7
1000	U	69.9/67.7	110.4/107.6	69.9/65.9	84.1/80.4
2000	U	68.3/65.9	109.3/108.3	67.7/65.4	79.7/78.8
4000	U	U	104.0/102.4	U	75.7/73.2
8000	U	U	108.7/104.4	U	72.9/70.4
16000	U	U	101.9/100.0	U	U

Note that "U" indicates an underrange of the sound level meter.

TABLE B-2

502001 OCTAVE BAND NOISE LEVELS

2372 RPM/22 KTS

(dB re 20 μPa)

OCTAVE BAND	LOCATION (HIGH/LOW)				
FREQUENCIES	A	B	C	D	E*
31.5	95.9/89.2	93.0/86.0	93.4/88.0	94.3/85.8	
63	94.0/86.9	91.0/85.6	101.8/95.1	93.4/86.6	
125	90.6/85.4	85.5/80.2	110.9/109.9	91.3/83.7	
250	81.6/76.9	81.5/77.4	107.5/105.1	81.9/78.0	
500	74.6/69.6	74.2/73.0	107.6/105.6	76.9/70.2	
1000	70.2/62.2	73.0/70.1	111.1/110.1	74.9/68.0	
2000	U	70.1/67.5	110.4/99.5	72.8/67.1	
4000	U	U	101.4/104.0	U	
8000	U	U	106.4/102.7	U	
16000	U	U	99.3/97.6	U	

*Noise data not acquired with sound level meter at this speed because of sea spray on the deck space.

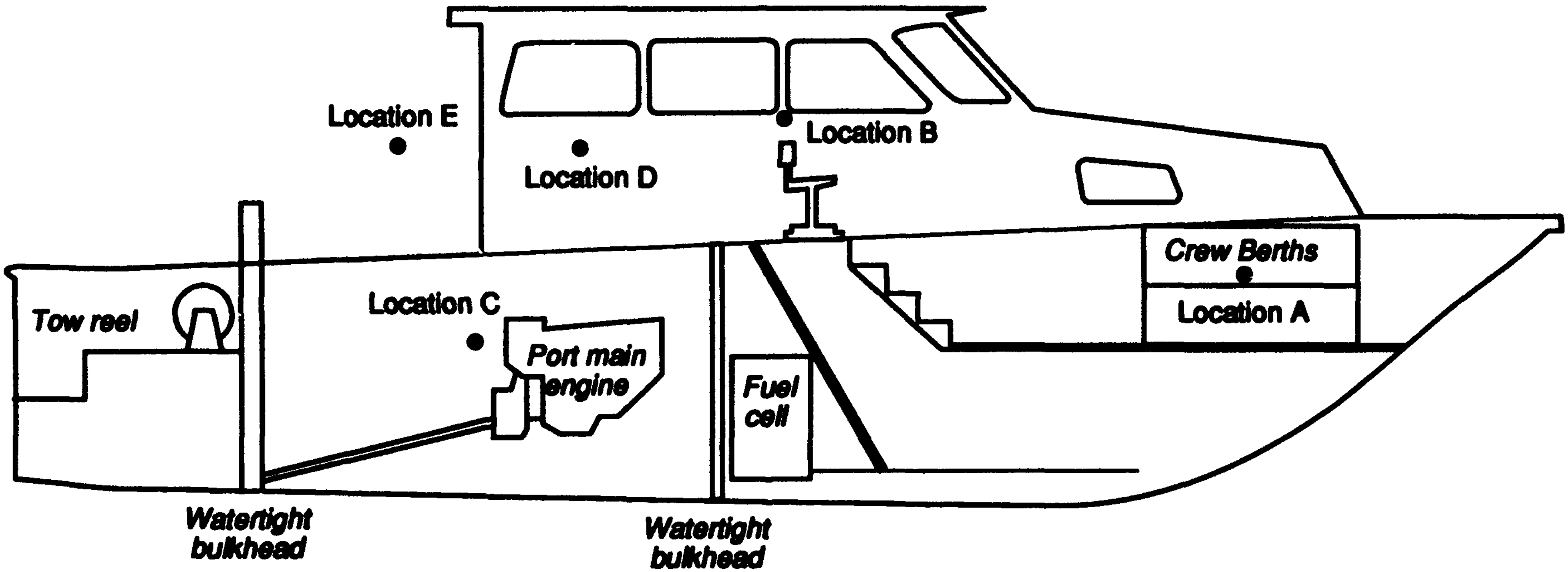


FIGURE B-1 Location of Noise Measurements on the 502001 NORCREW Concept Boat

Figures B-2 and B-3 present an overlay of the average octave band SPLs for the respective speeds measured. OPNAVINST 9640.1 provides recommended noise levels for various spaces on crafts 100 feet or less in length. These levels are reproduced in Figure B-4. Based on these suggested requirements, neither the personnel comfort requirements of category B or the voice communications category A are met for locations A (crew's berthing) or B (coxswains station), respectively, on 502001, for noise levels in octave bands centered at 250 Hz and lower.

High noise levels were apparent when the main cabin engine room hatch was opened. The crew was conscious of this and diligently put on their hearing protection prior to opening the hatch. However, exposure to a less careful crew might be risky. An analysis by an occupational health specialist is recommended to determine if there exist any risk to crew members for long-term exposure.

In testing location A (crew's berthing), it was noted that a resonant low frequency sound was emanating from the cubbyhole storage space between the upper and lower bunks. The noise appeared to be driven by engine and propeller structure borne noise which were channeled and amplified through the cubbyholes. The noise level directly in front of the cubbyhole was 97 dBA.

The results of the "A" weighting measurements using the B&K sound level meter are presented in Table B-3.

TABLE B-3

502001 "A" WEIGHTED NOISE LEVELS

(dB re 20 μPa)

	LOCATION (HIGH/LOW)				
	A	B	C	D	E
2195 RPM/ 19.5 KTS	79.8/74.5	79.1/76.3	115.8/115.3	78.4/74.4	92.3/89.9
2373 RPM/ 22 KTS	78.3/74.5	79.6/77.3	116.0/114.8	80.2/74.9	*

*Noise data not acquired with sound level meter at this speed because of sea spray on the deck space.

"A" weighted noise level requirements from Figure B-4 for craft up to 100 feet for the pilot house and berthing spaces are met. A general goal specified in OPNAVINST 9640.1 is that the "A" weighted sound level at full throttle should not exceed 84 dB at the helmsman's station and in the passenger crew compartments. Figure B-5 presents the results of the "A" weighted measurements in graphical form.

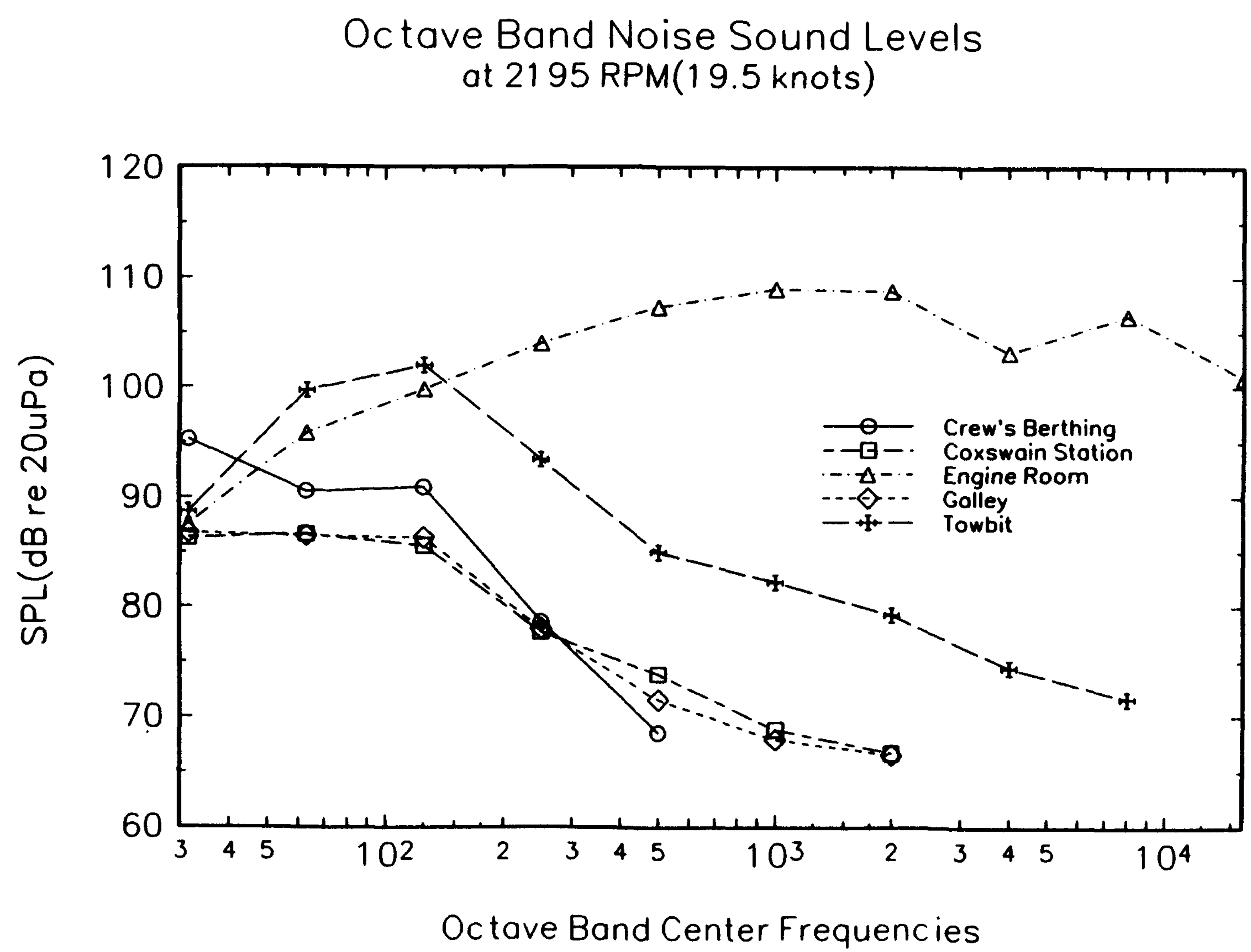


FIGURE B-2 **Average Octave Band SPLs for Various Locations on the 502001 at Cruising Speed**

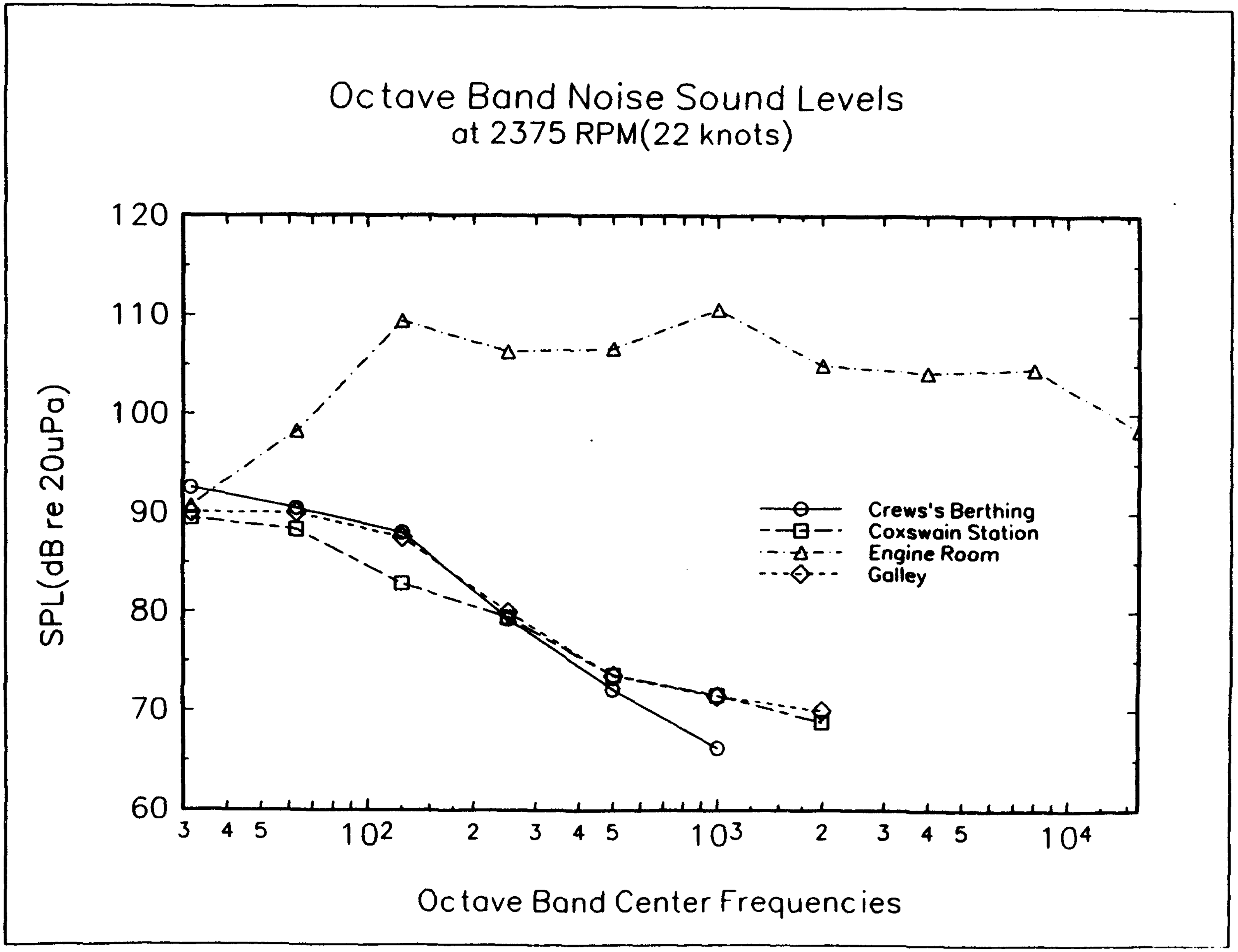


FIGURE B-3 **Average Octave Band SPLs for Various Locations on the 502001 at Maximum Speed**

NOISE CATEGORIES

Category	Definition
A	Spaces where direct speech communication must be understood with minimal error and without repetition. Acceptable noise levels are based on approximate talker-listener distances, either 3 or 12 feet, as appropriate (A_3 may be used for distances up to 6 feet.)
B	Spaces where comfort of personnel in their quarters is the primary consideration and where communication considerations are secondary.
C	Spaces where it is essential to maintain especially quiet conditions.
D	High noise-level areas where voice communication is not important, where ear protection is not provided, and where prevention of hearing loss is the primary consideration.
E	High noise-level areas where voice communication is at high vocal effort and where amplified speech and telephones are normally available.

RECOMMENDED NOISE CATEGORIES* AND A-WEIGHTED SOUND LEVELS FOR SMALL CRAFT

< 150'

Space	Speed	Craft Overall Length, ft	
		Up to 100	101 to 150
Pilot House	Maximum	E (82)	A_3 (70)
Radio Room	Maximum	E (82)	A_3 (70)
Combat Information Center	Maximum	E (82)	A_3 (70)
Chart Room	Maximum	E (82)	A_3 (70)
Enclosed Operating Stations	Maximum	E (82)	A_3 (70)
Berthing and Living Space	Maximum	D (84)	E (82)
Berthing and Living Space	Slow Patrol	B (70)	B (70)
Messroom	Maximum	D (84)	E (82)
Messroom	Slow Patrol	B (70)	B (70)
Galley	Maximum	D (84)	E (82)
Galley	Slow Patrol	B (70)	B (70)
Workshop	Maximum	D (84)	D (84)
Open Bridge	Maximum	D (84)	E (82)
Passenger Compartment	Maximum	D (84)	E (82)

RECOMMENDED OCTAVE-BAND* SOUND-PRESSURE LEVELS FOR SMALL CRAFT (db re 20 μPa)

Noise Category	Octave Band Center Frequency, Hz			
	31.5	63	125	250
A_3, B	90	84	79*	76
D , E	105	100	95	90

*In addition to meeting the A-weighted limits of Table I-5, the low frequencies shall be limited to the levels given in the above table.

FIGURE B-4 OPNAVINST 9640.1, Recommended Noise Levels for Various Spaces on Craft 100 Feet or Less

Preliminary TECHEVAL results, including 502001 noise data, were presented at the March 1993 Project Evaluation Board (PEB) meeting. PEB members suggested that a noise comparison to the 41-FT UTB would be desirable. R&DC personnel made arrangements with Station New London to collect similar noise data on the 41350 on 22 and 29 April 1993 at locations similar to those collected on the 502001. The locations tested were:

Location A - survivor's cabin
Location B - coxswain's station
Location C - engine room
Location E - tow bitt

Octave band and "A" weighted Sound Pressure Levels were measured at the 41350's cruising speed (12 knots) and maximum speed (25 knots) as was done on the 502001. Table B-4 and Table B-5 presents the Octave Band SPLs measured in decibels relative to 20 micro pascals for the 41350. Figure B-6 and Figure B-7 display this information graphically.

TABLE B-4

41350 OCTAVE BAND NOISE LEVELS

1800 RPM/12 KTS

(dB re 20 μPa)

OCTAVE BAND FREQUENCIES	LOCATION (HIGH/LOW A	B	C	E
31.5	82.2/72.2	87.7/79.7	90.8/84.6	81.0/77.5
63	82.1/77.1	89.3/86.7	95.3/90.6	96.4/93.6
125	87.5/80.2	92.4/90.7	102.0/98.3	102.2/99.2
250	78.0/76.7	83.6/79.9	103.6/99.3	89.4/86.8
500	80.9/76.4	77.5/74.6	102.3/99.9	88.7/86.3
1000	77.7/75.5	75.1/70.9	106.8/105.8	87.0/84.5
2000	74.5/72.7	71.4/69.6	105.8/104.8	78.2/77.2
4000	70.2/68.9	68.2/66.8	102.1/100.5	74.9/73.5
8000	U	61.7/ U	93.0/92.0	68.3/66.0
16000	U	U	87.4/86.4	U

Note that "U" indicates an underrange of the sound level meter.

TABLE B-5

41350 OCTAVE BAND NOISE LEVELS

2600 RPM/25 KTS

(dB re 20 μPa)

OCTAVE BAND FREQUENCIES	LOCATION (HIGH/LOW) A	B	C	E
31.5	92.9/83.3	101.9/93.0	98.4/88.2	86.9/77.5
63	88.7/84.0	91.8/87.4	103.5/96.8	98.5/94.2
125	91.0/86.9	93.8/89.9	106.2/103.8	101.5/98.1
250	90.0/86.4	94.6/88.6	106.7/104.3	97.4/94.3
500	83.0/80.3	84.0/79.6	106.1/103.9	95.0/91.0
1000	79.4/76.8	77.2/73.3	110.6/108.9	89.6/87.4
2000	75.6/73.1	76 [illegible]/74.4	109.7/108.4	87.1/85.0
4000	71.5/69.6	72.9/71.4	105.8/103.7	83.5/82.0
8000	[illegible] 1/62.4	69.8/67.8	102.2/101.4	78.2/75.4
1600		U	96.1/95.5	70.1/67.8

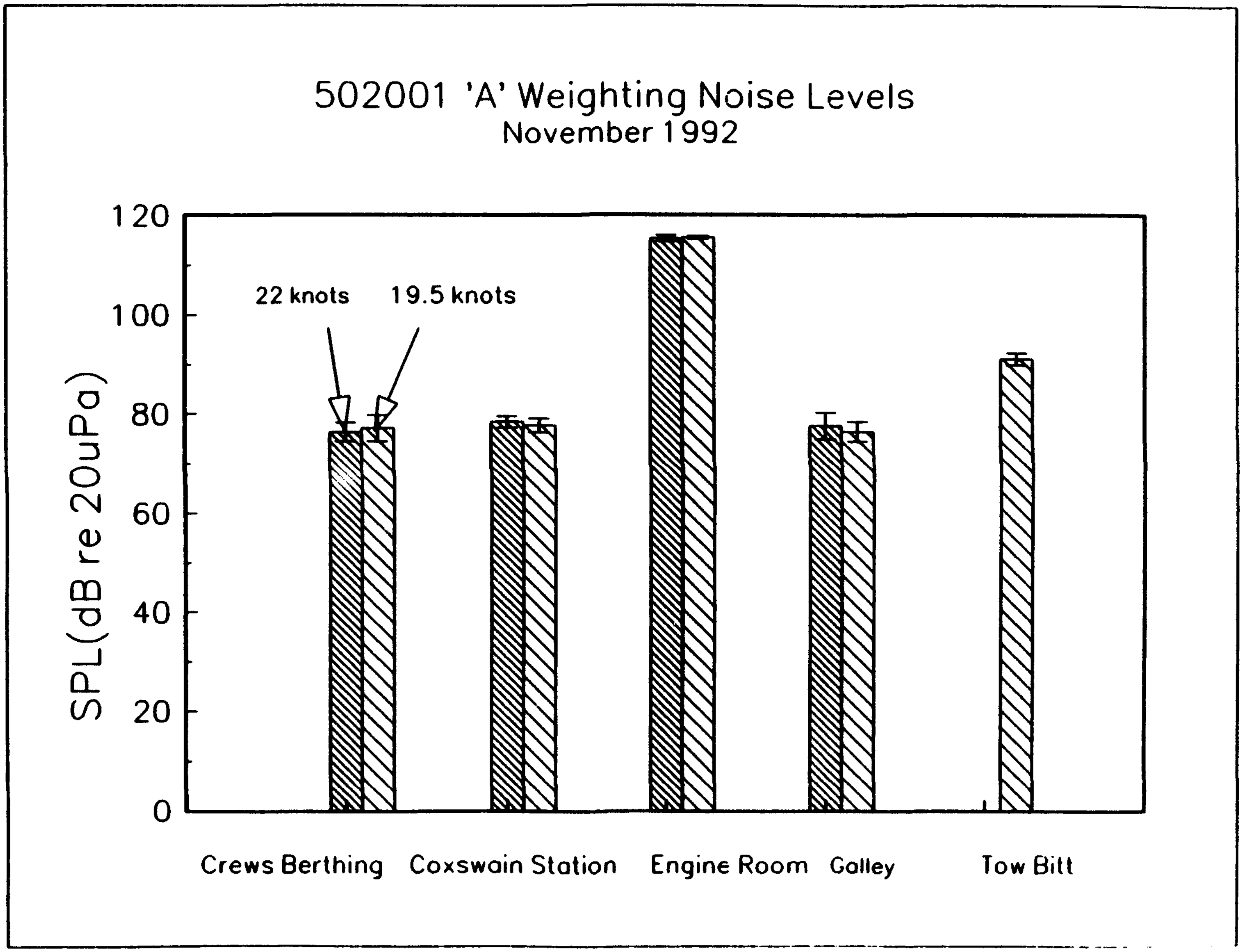


FIGURE B-5 502001 "A" Weighted Sound Level Measurements at Various Locations

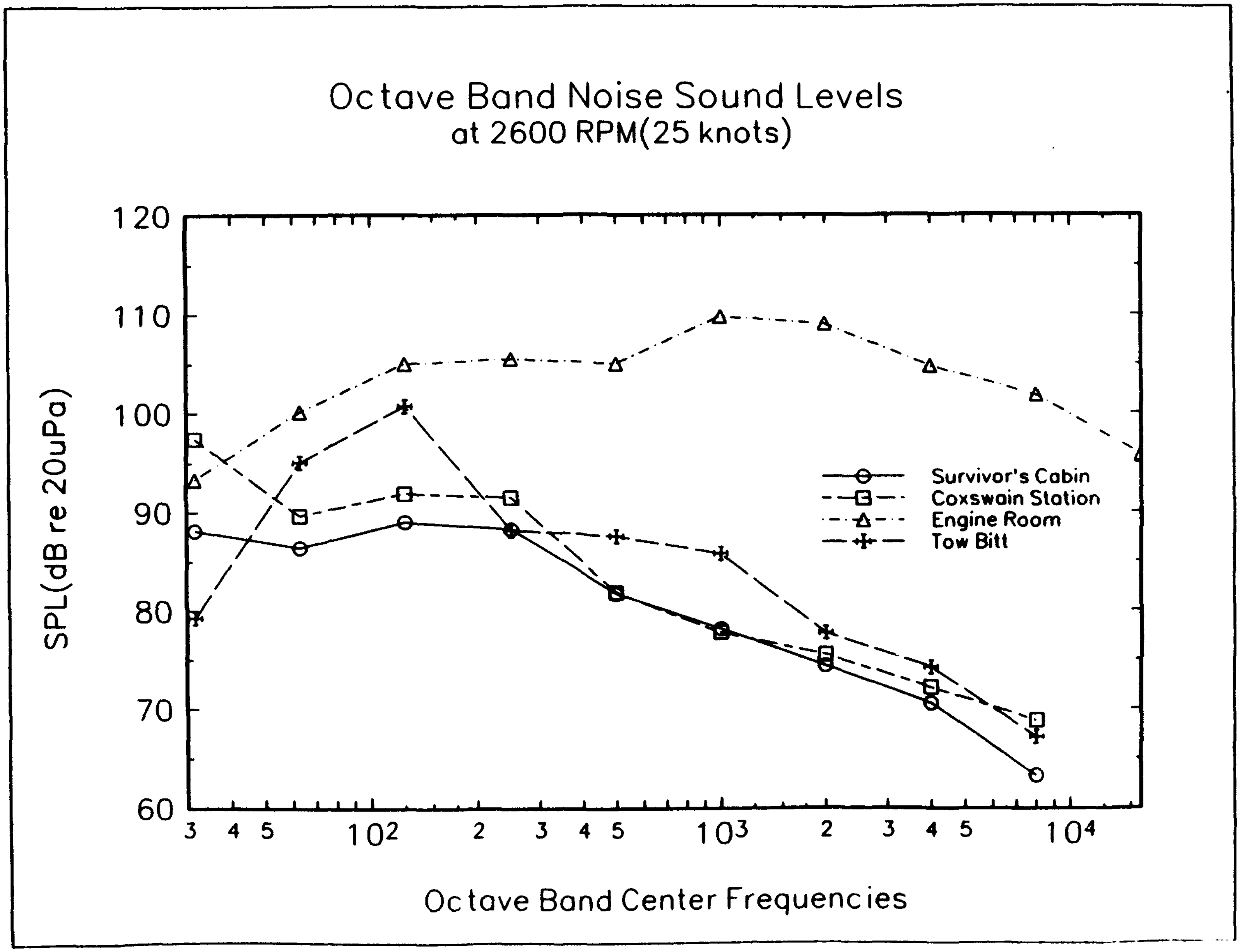


FIGURE B-6 Average Octave Band SPLs for Various Locations on the 41350 at Cruising Speed

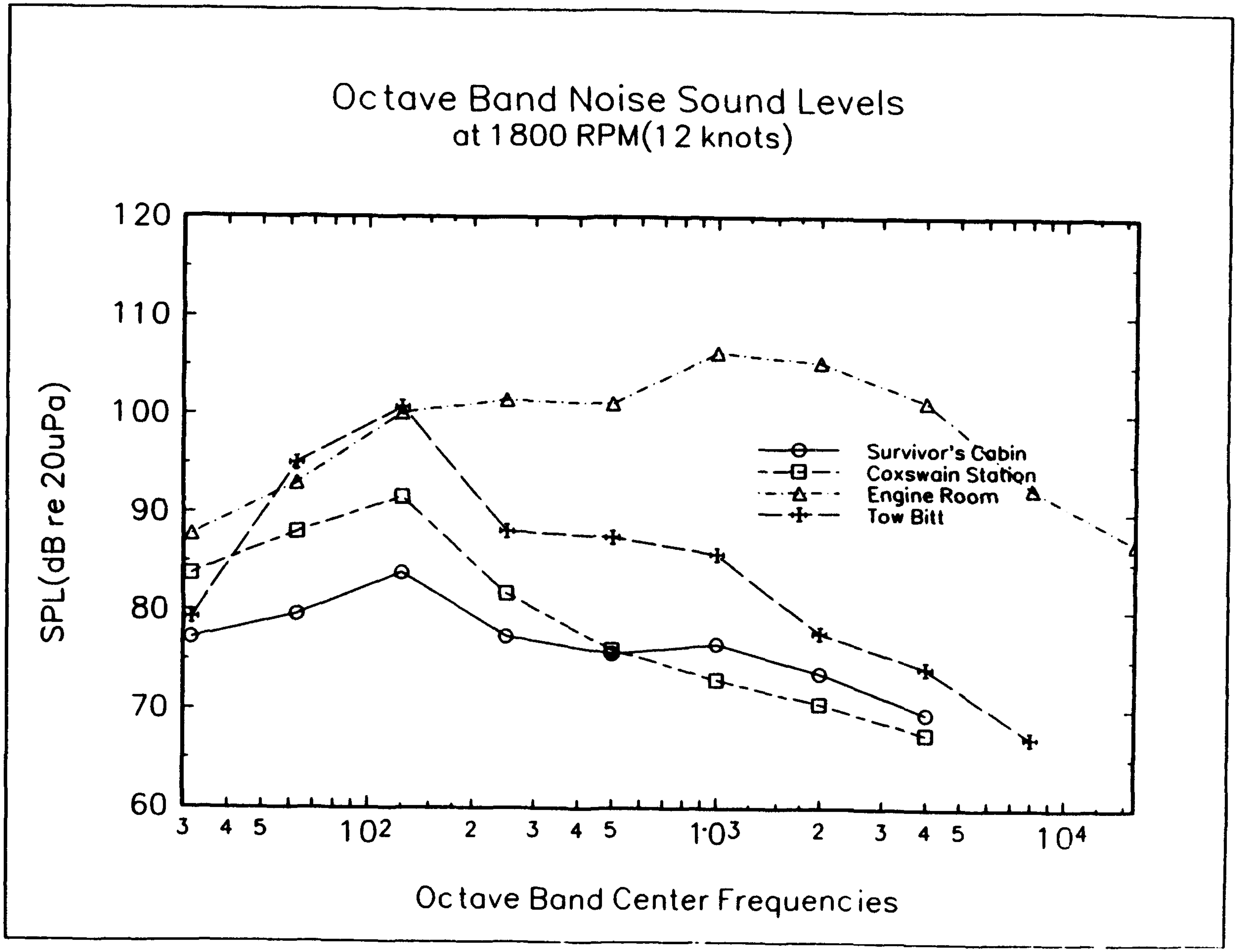


FIGURE B-7 Average Octave Band SPLs for Various Locations on the 41350 at Maximum Speed

Table B-6 presents the A weighted measurements from the B&K sound level meter and Figure B-8 presents the results in graphical form. Note that there are no Galley noise measurements.

TABLE B-6

41350 "A" WEIGHTED NOISE LEVELS

(dB re 20 μPa)

	LOCATION (HIGH/LOW)			
	A	B	C	E
1800 RPM/ 12 KTS	82.0/80.4	83.4/78.2	111.2/110.3	70.3/64.3
2600 RPM/ 25 KTS	85.9/83.3	87.1/83.2	111.4/113.8	96.5/94.0

The results of the "A" weighted noise level measurements of the 502001 and the 41350 are compared graphically in Figure B-9.

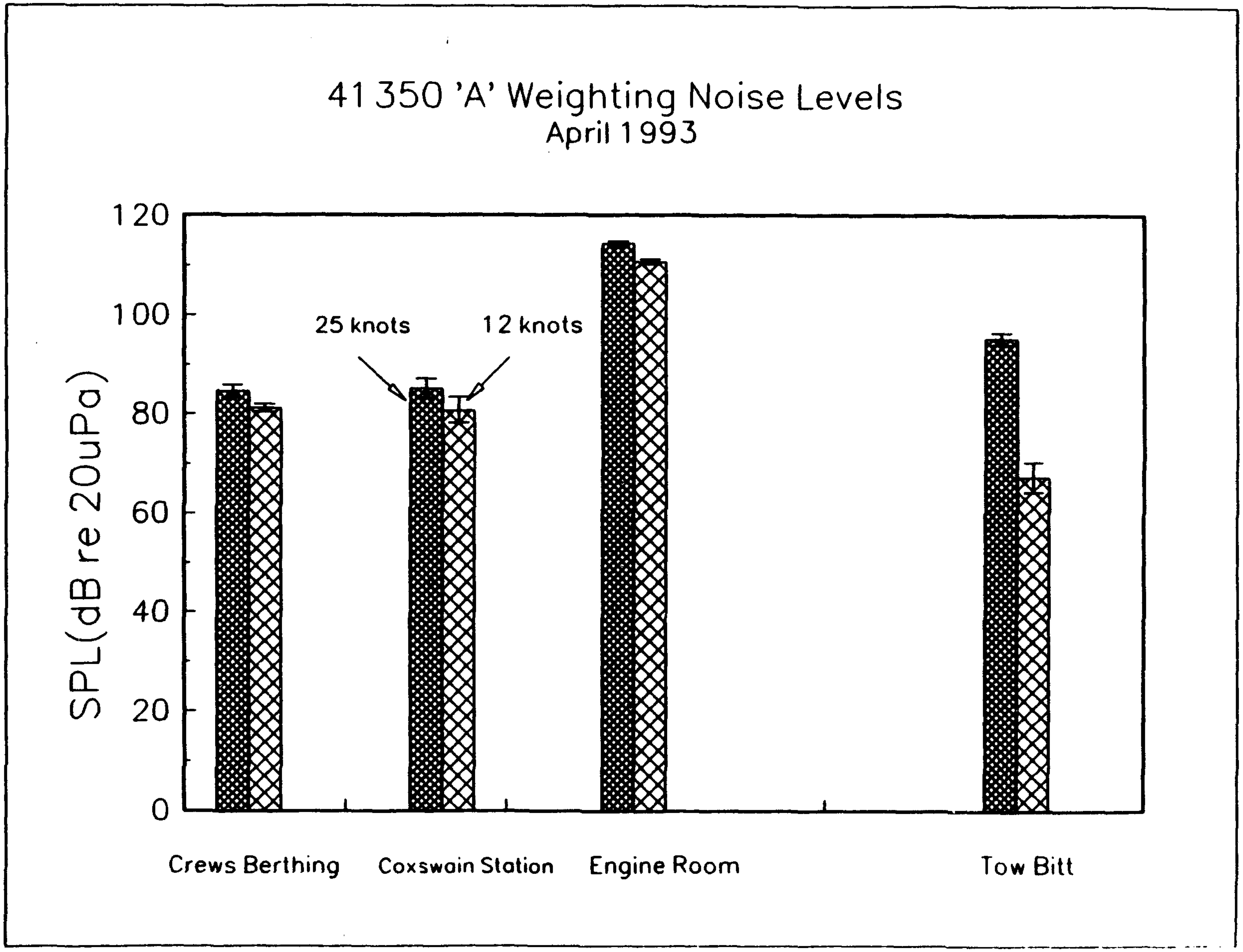


FIGURE B-8 41350 "A" Weighted Sound Level Measurements at Various Locations

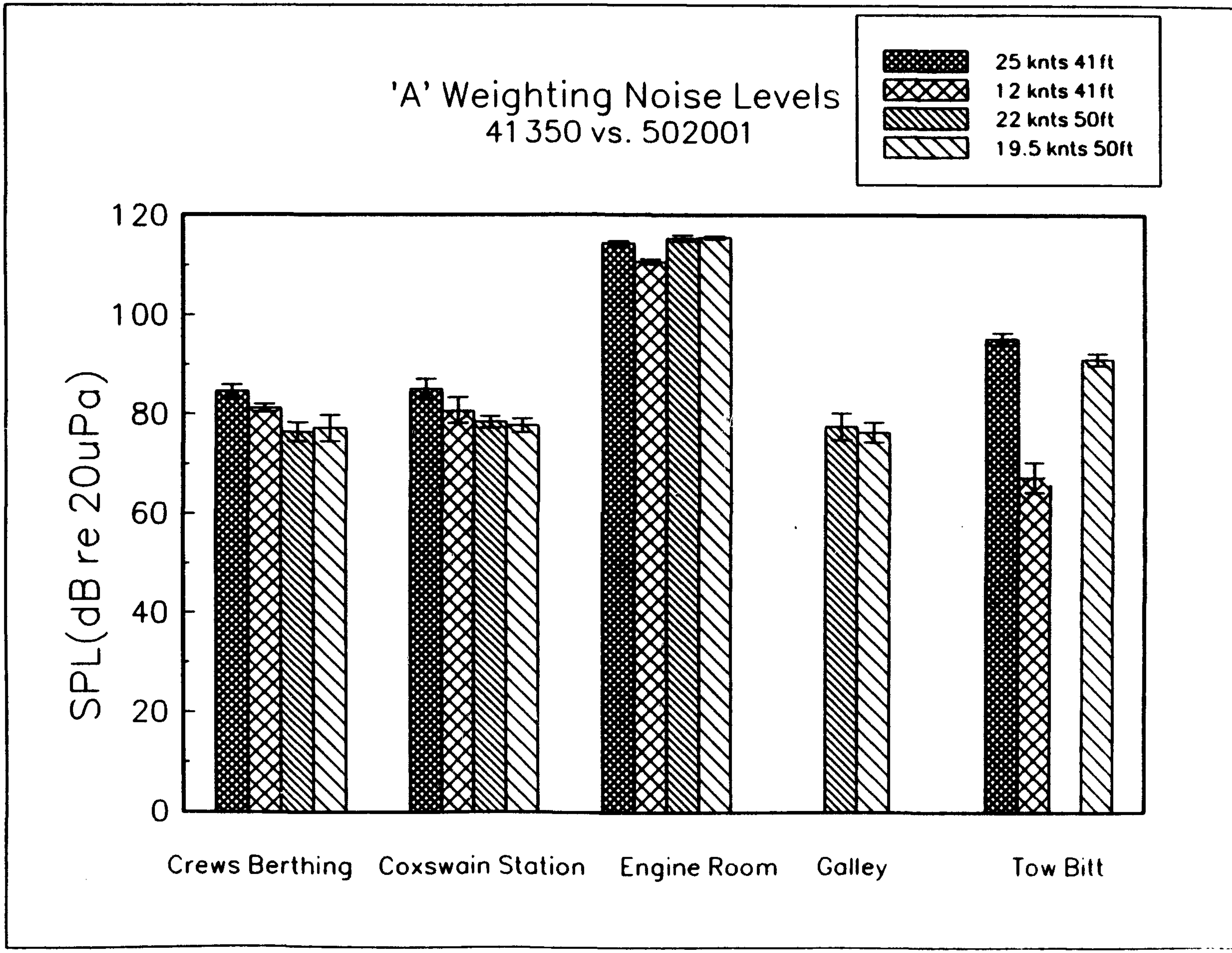


FIGURE B-9 **"A" Weighted Sound Level Measurements of the 41350 vs. 502001 at Various Locations**

APPENDIX C

502001 NORCREW AND 41500 SIDE-BY-SIDE SEAKEEPING PERFORMANCE DATA

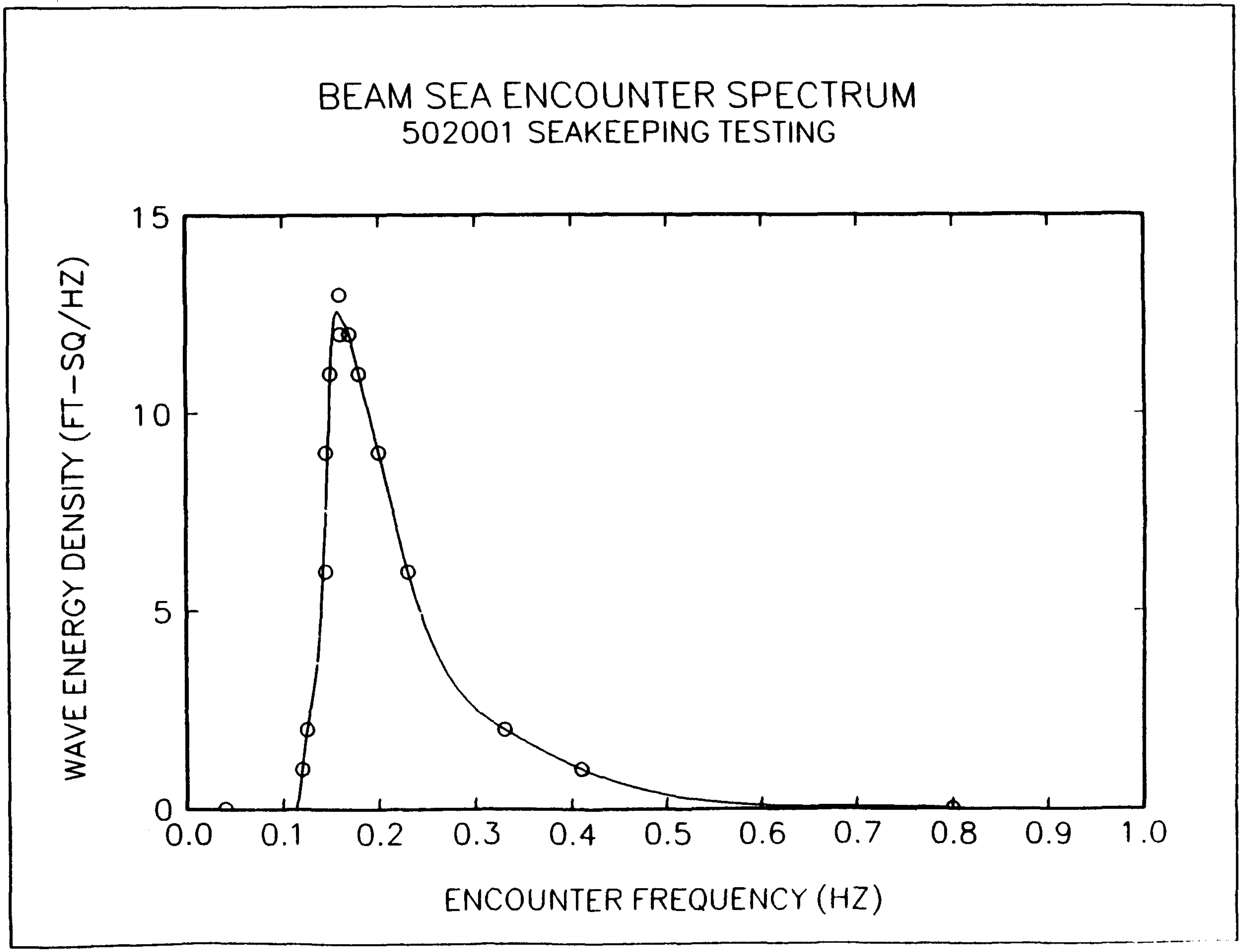


FIGURE C-1: Wave Buoy Recorded Beam Sea Encounter Spectrum

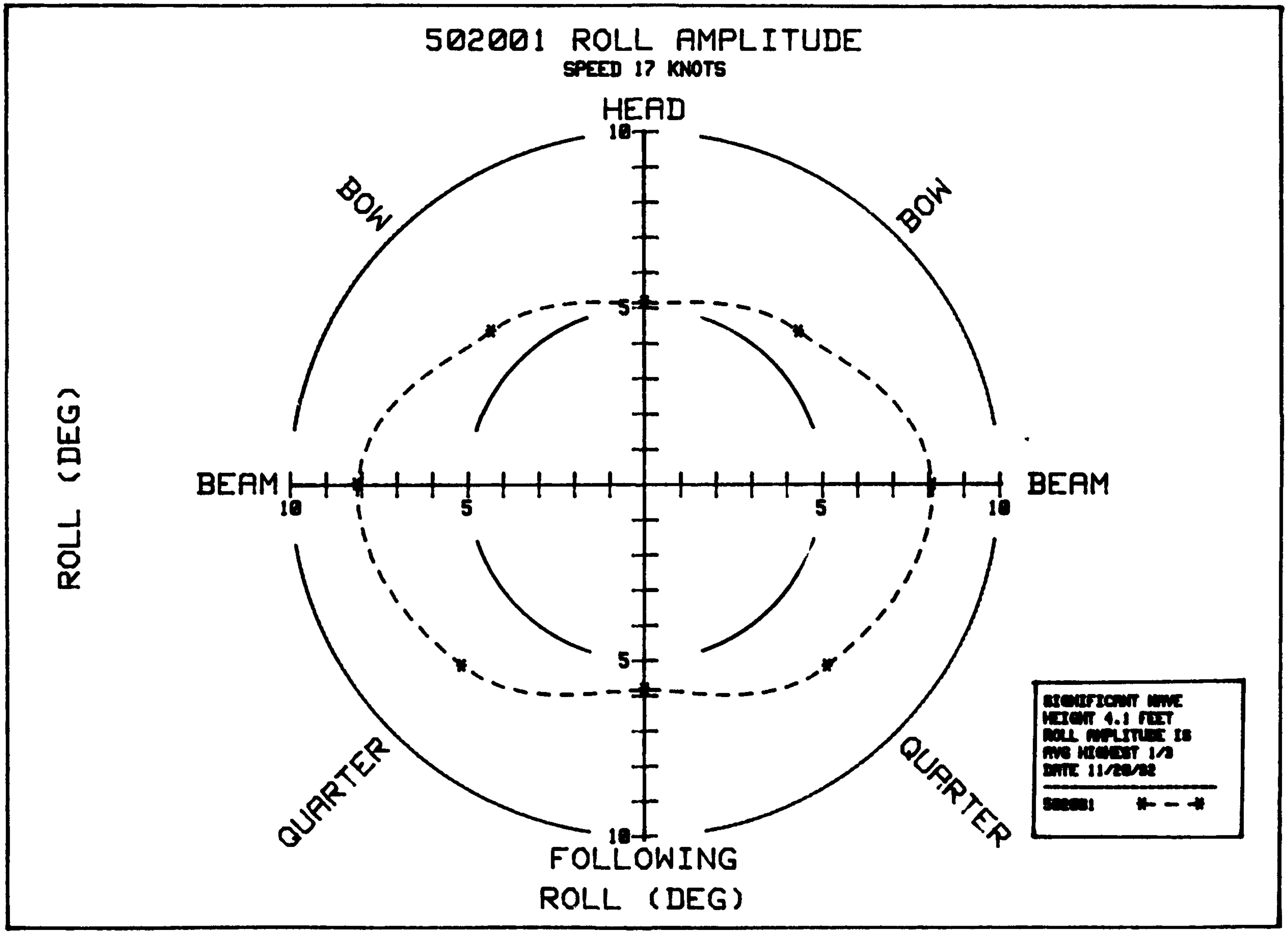


FIGURE C-2 502001 Roll Amplitude, 17 Knots

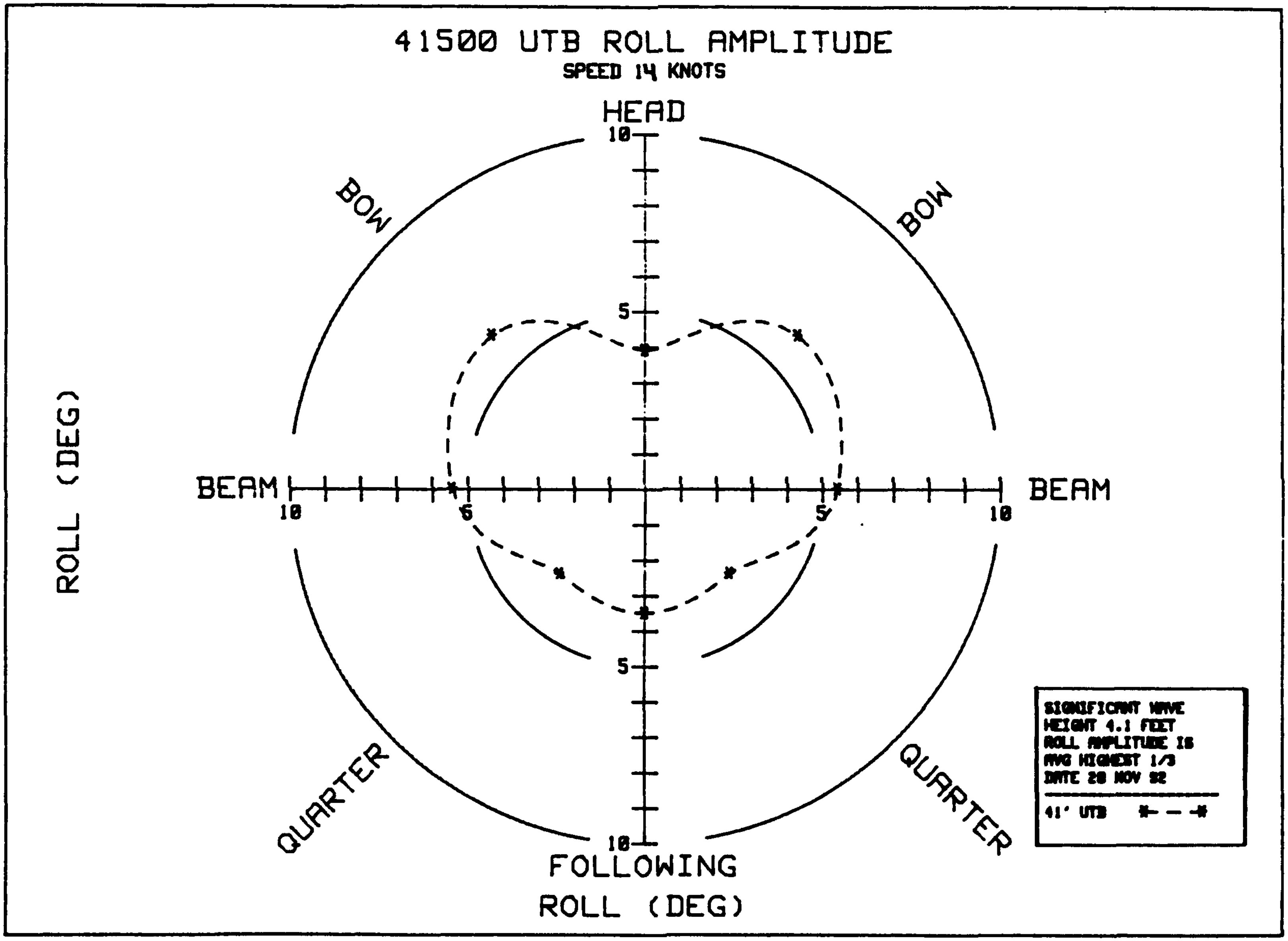


FIGURE C-3 41500 Roll Amplitude, 14 Knots

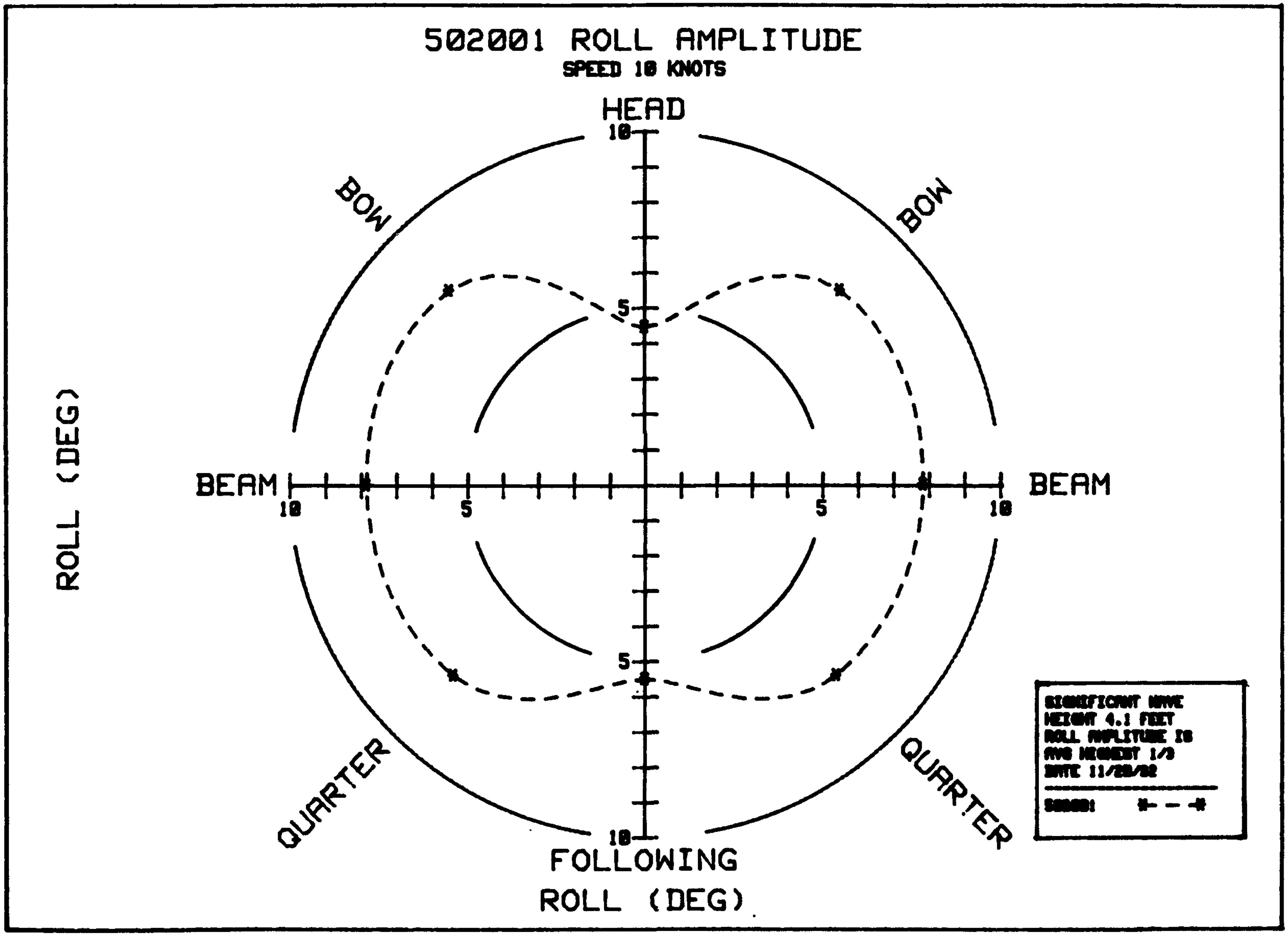


FIGURE C-4 502001 Roll Amplitude, 10 Knots

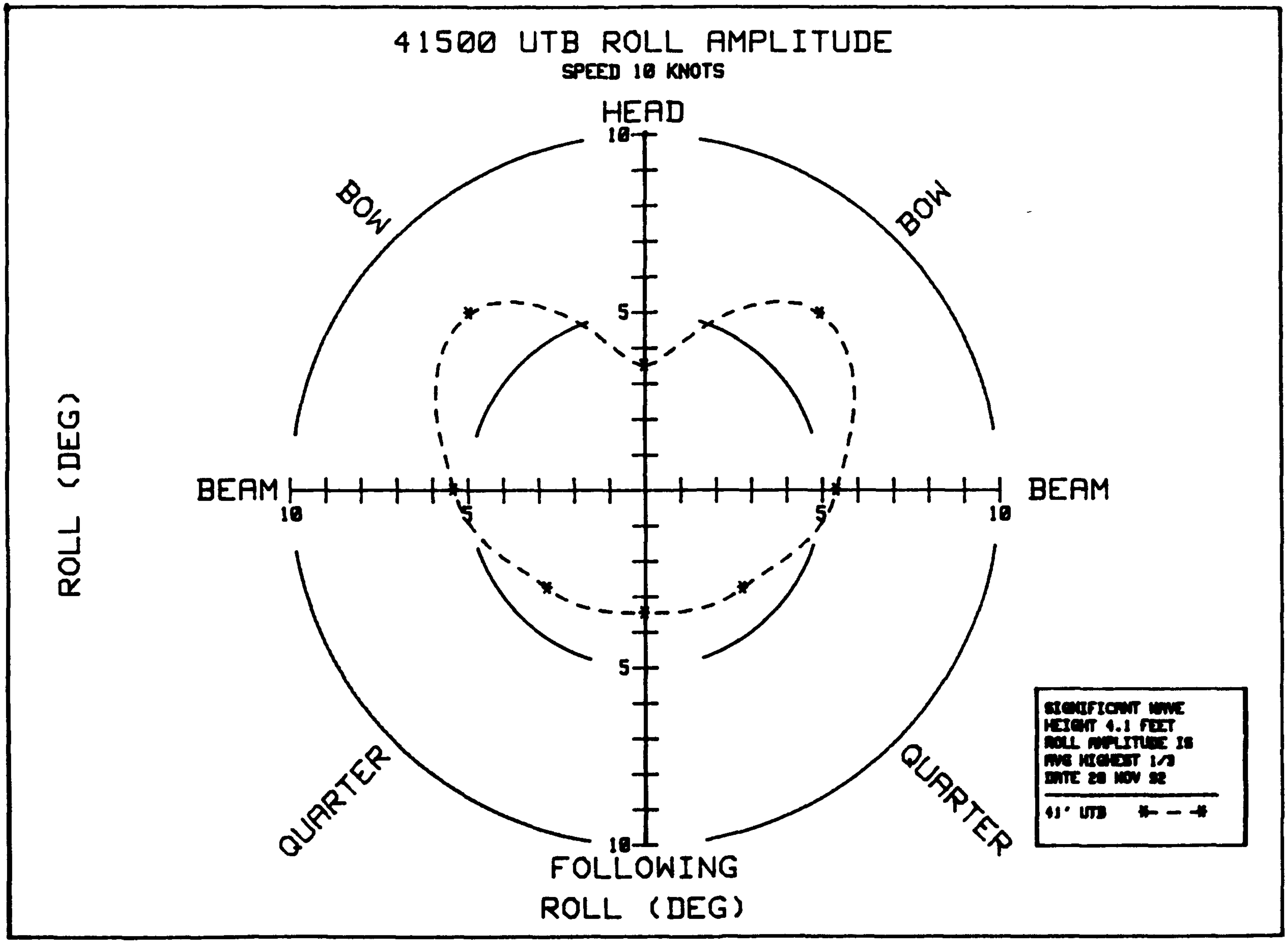


FIGURE C-5 41500 Roll Amplitude, 10 Knots

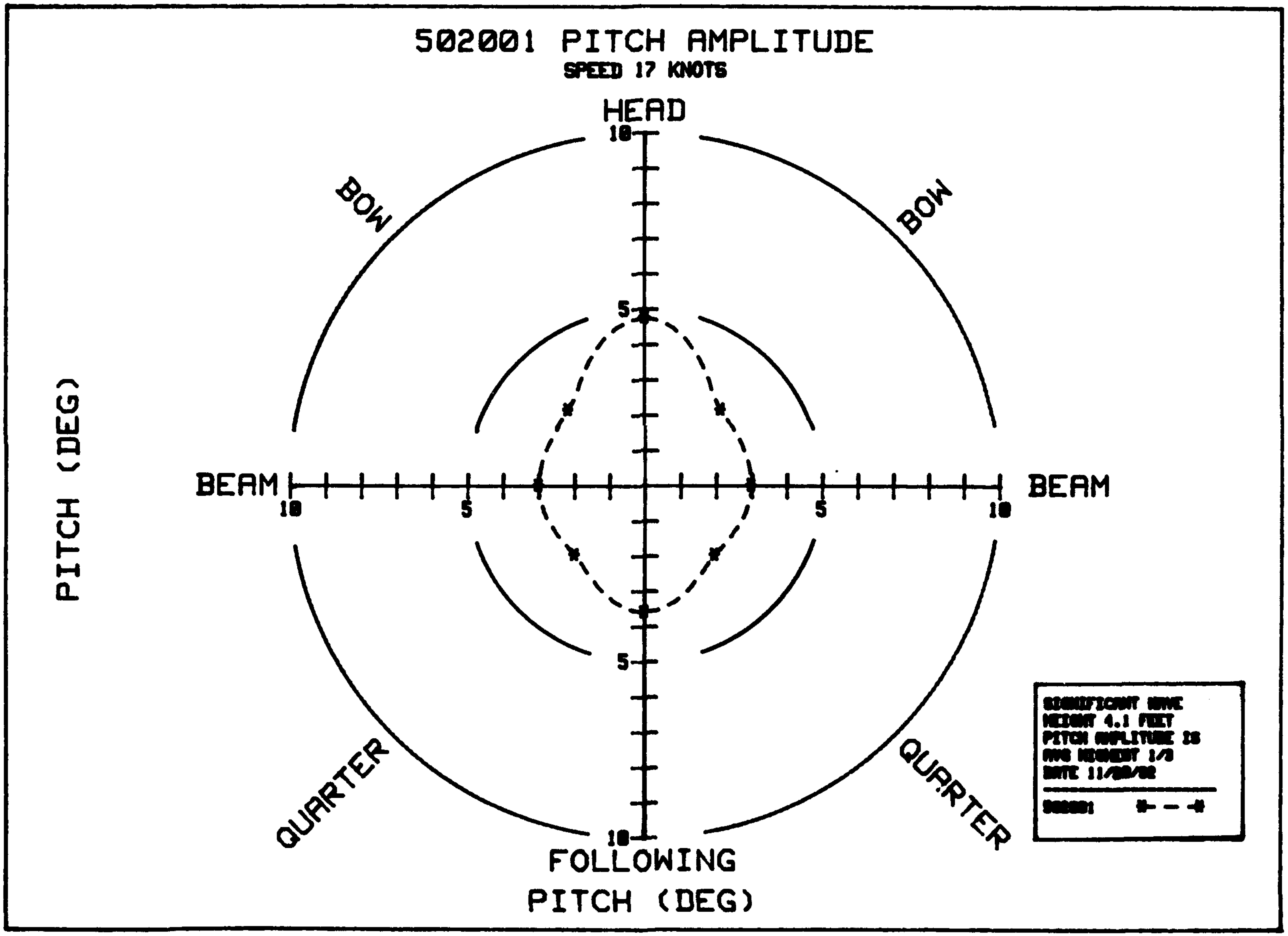


FIGURE C-6 502001 Pitch Amplitude, 17 Knots

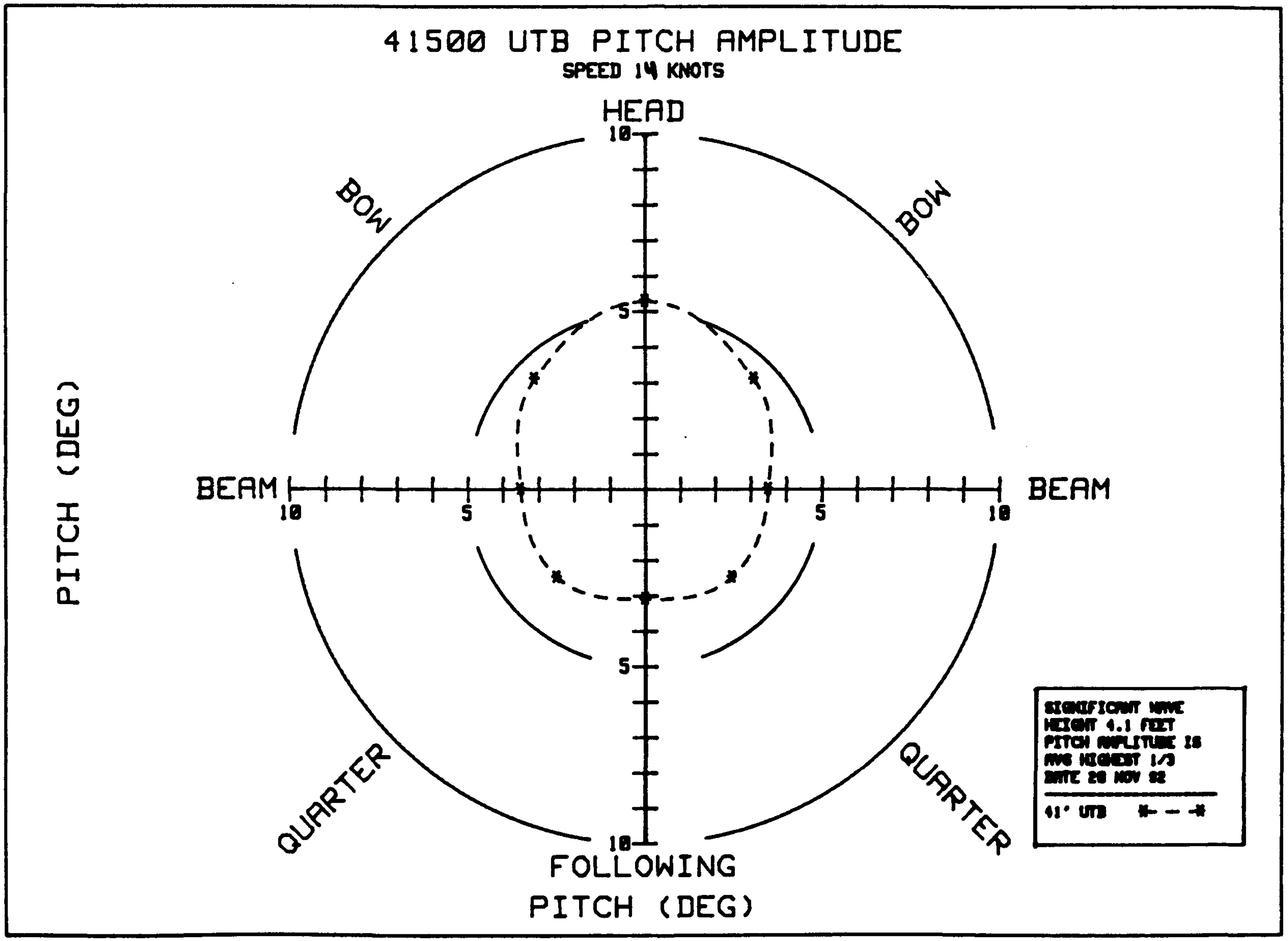


FIGURE C-7 41500 Pitch Amplitude, 14 Knots

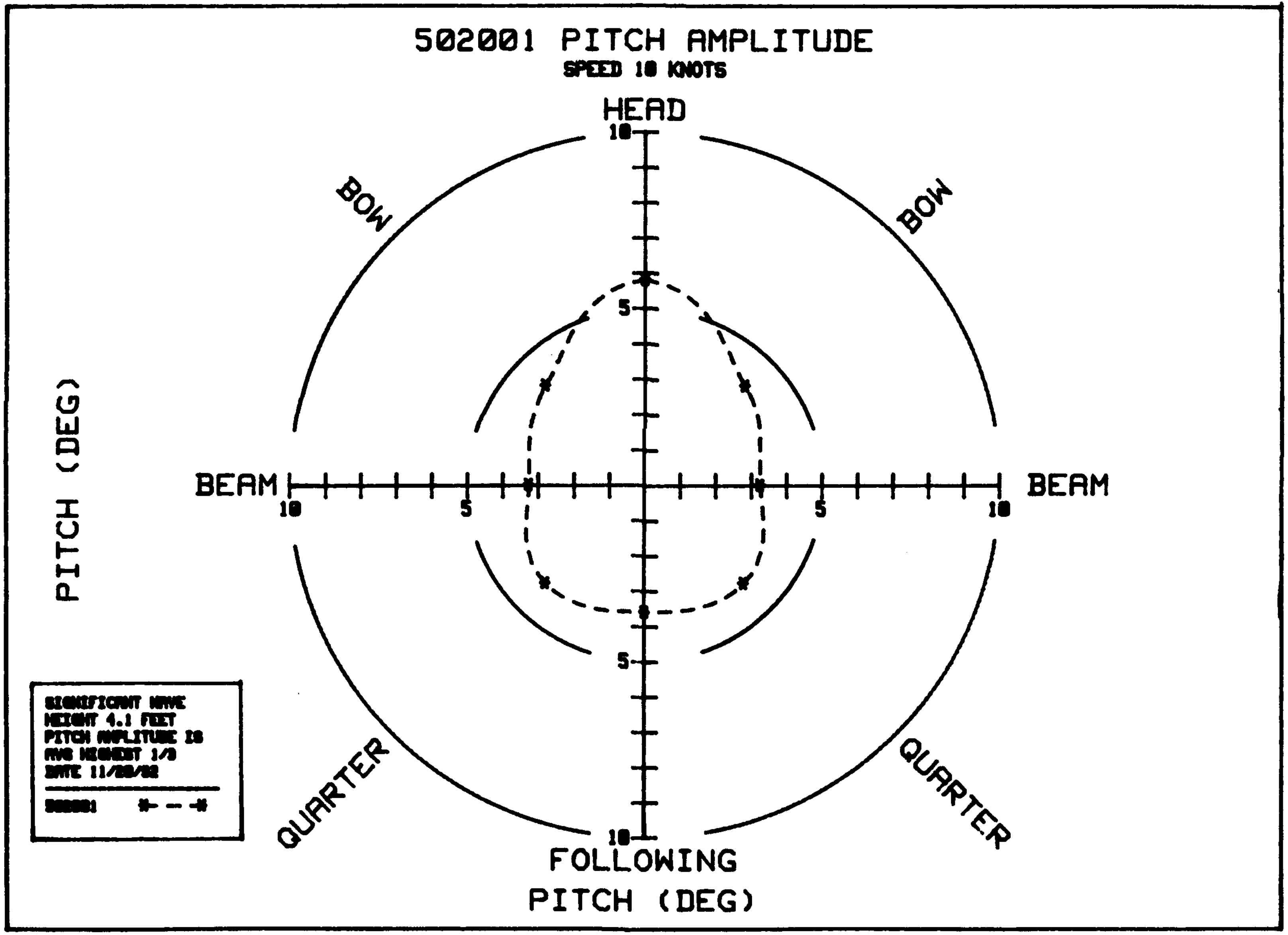


FIGURE C-8 502001 Pitch Amplitude, 10 Knots

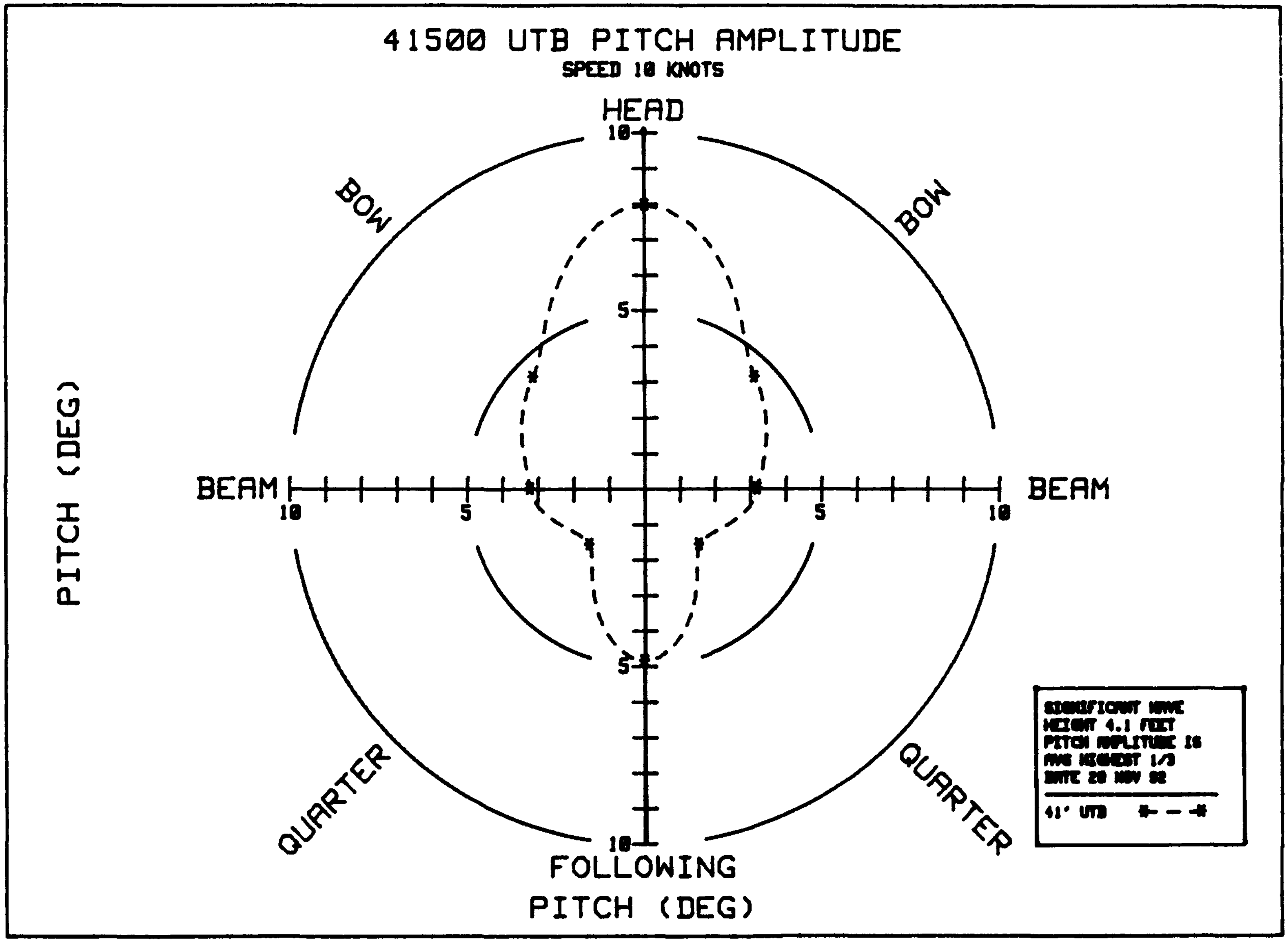


FIGURE C-9 41500 Pitch Amplitude, 10 Knots

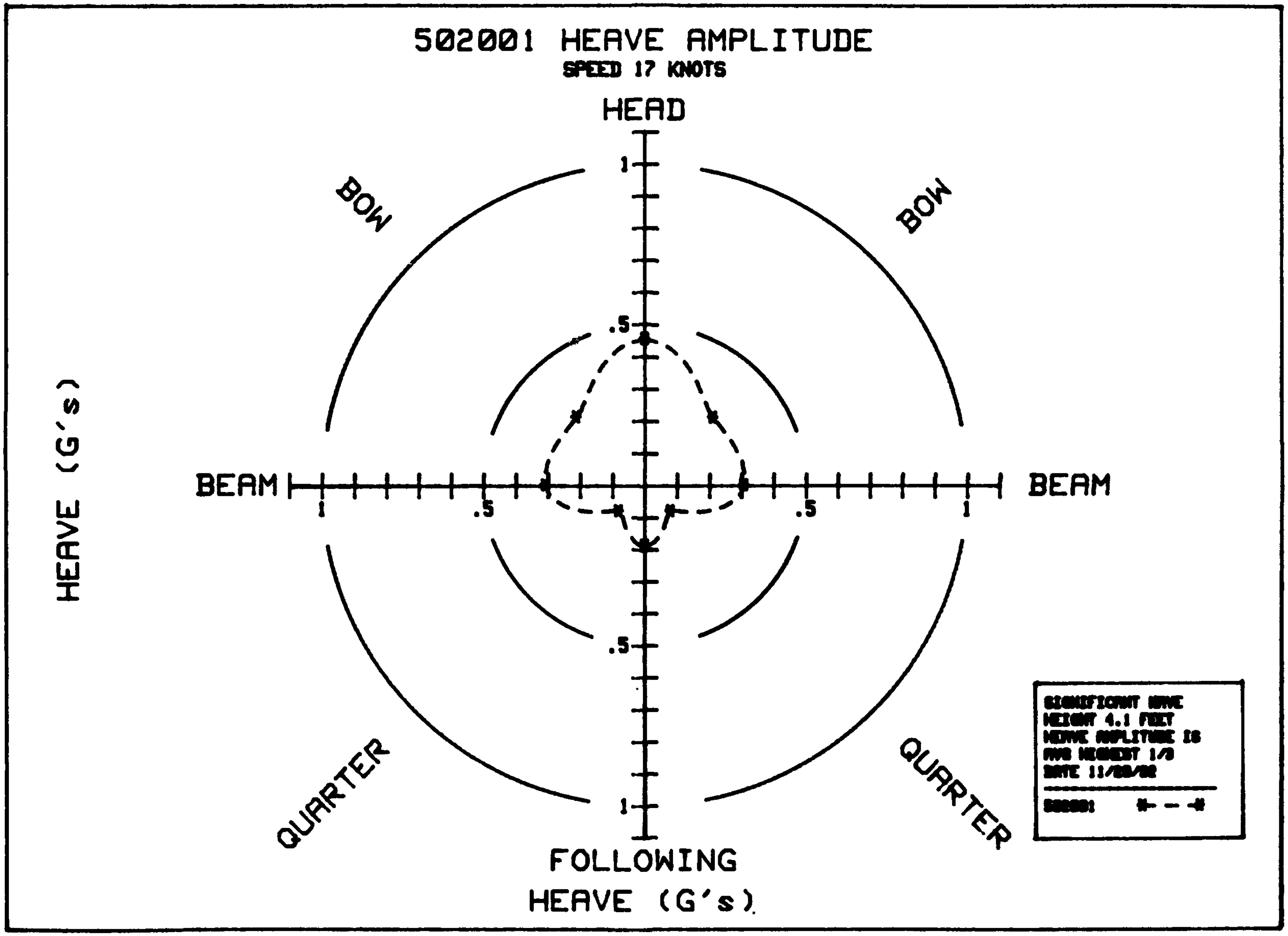


FIGURE C-10 502001 Heave Amplitude, 17 Knots

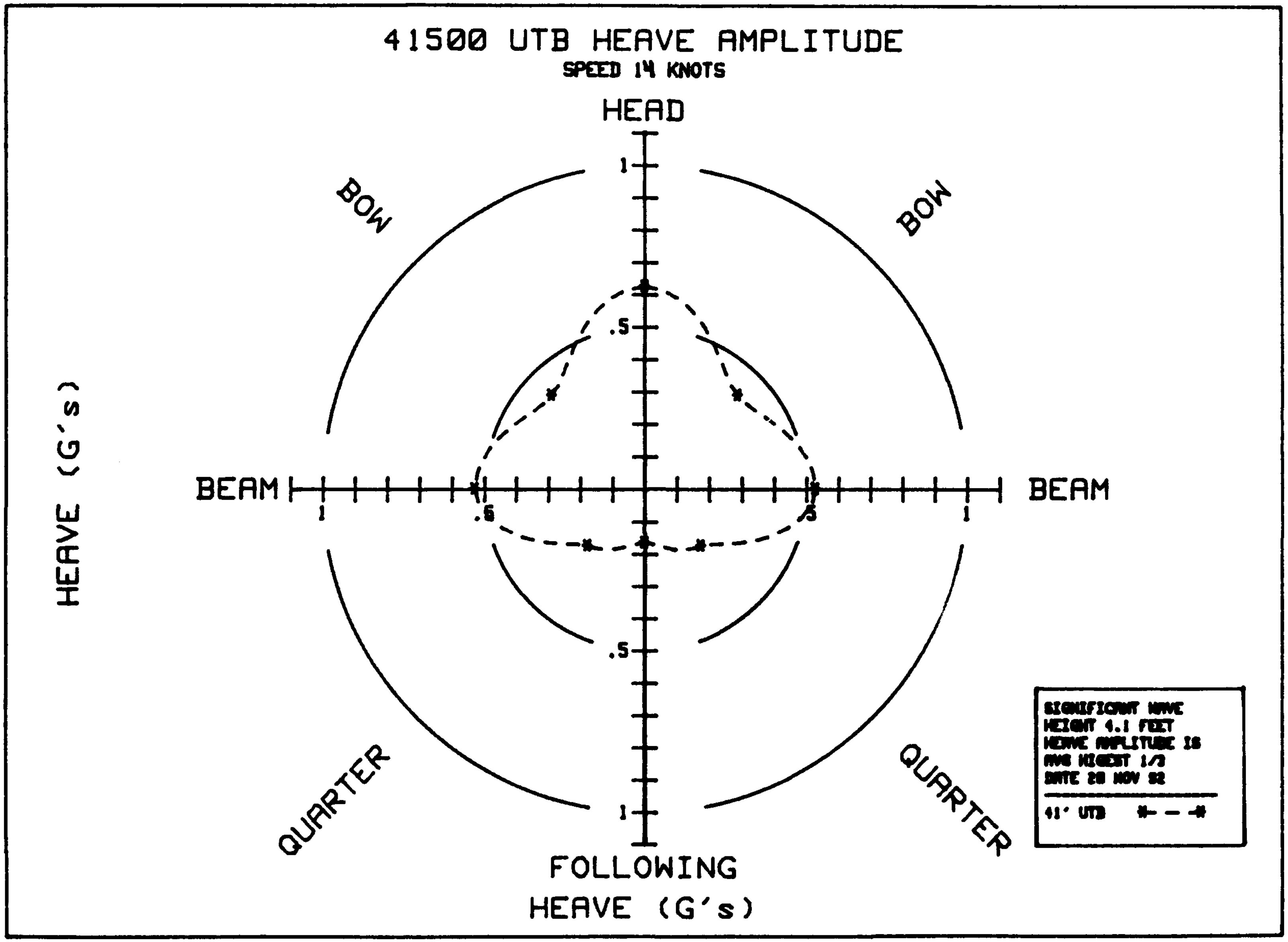


FIGURE C-11 41500 Heave Amplitude, 14 Knots

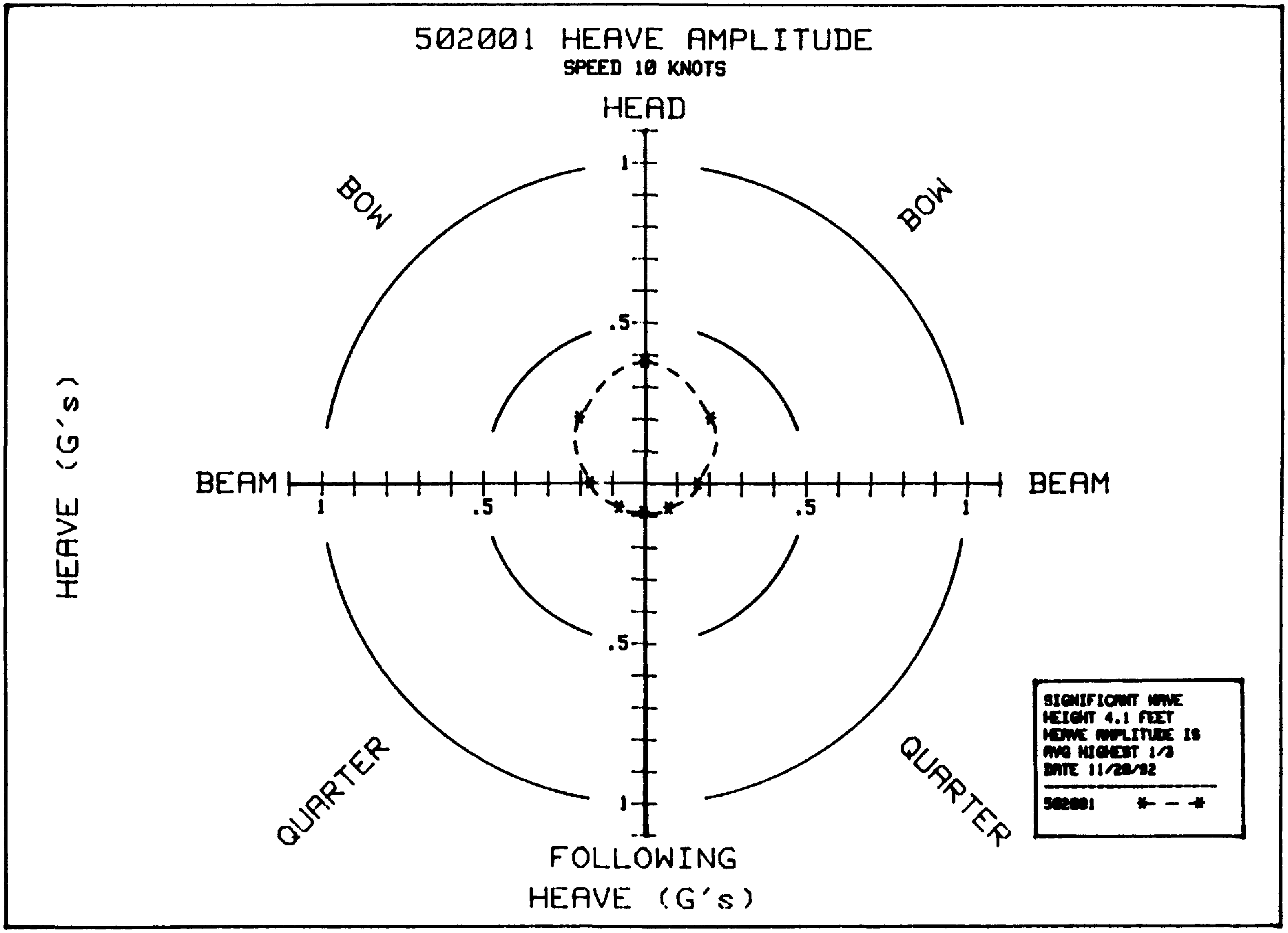


FIGURE C-12 502001 Heave Amplitude, 10 Knots

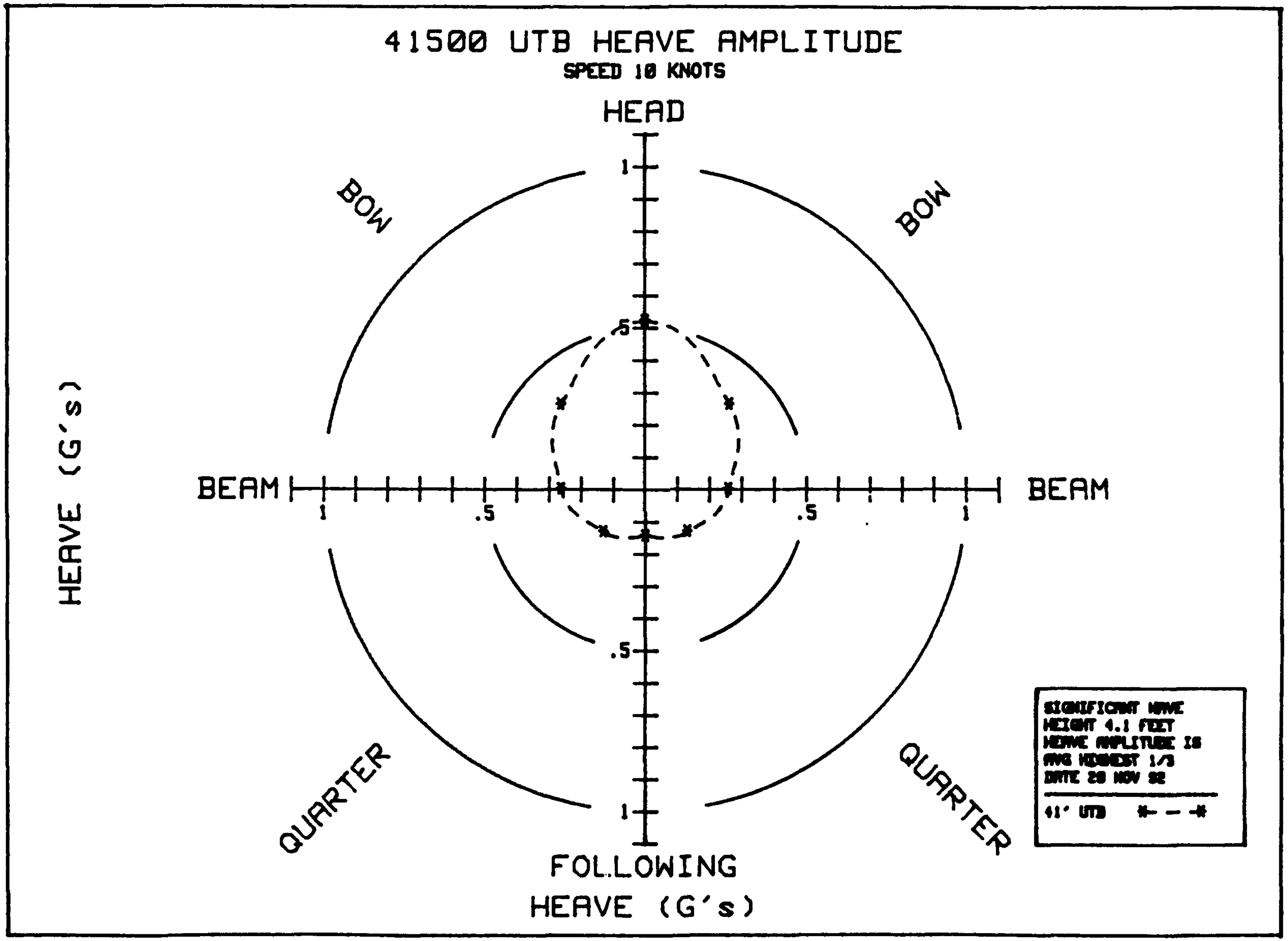


FIGURE C-13 41500 Heave Amplitude, 10 Knots

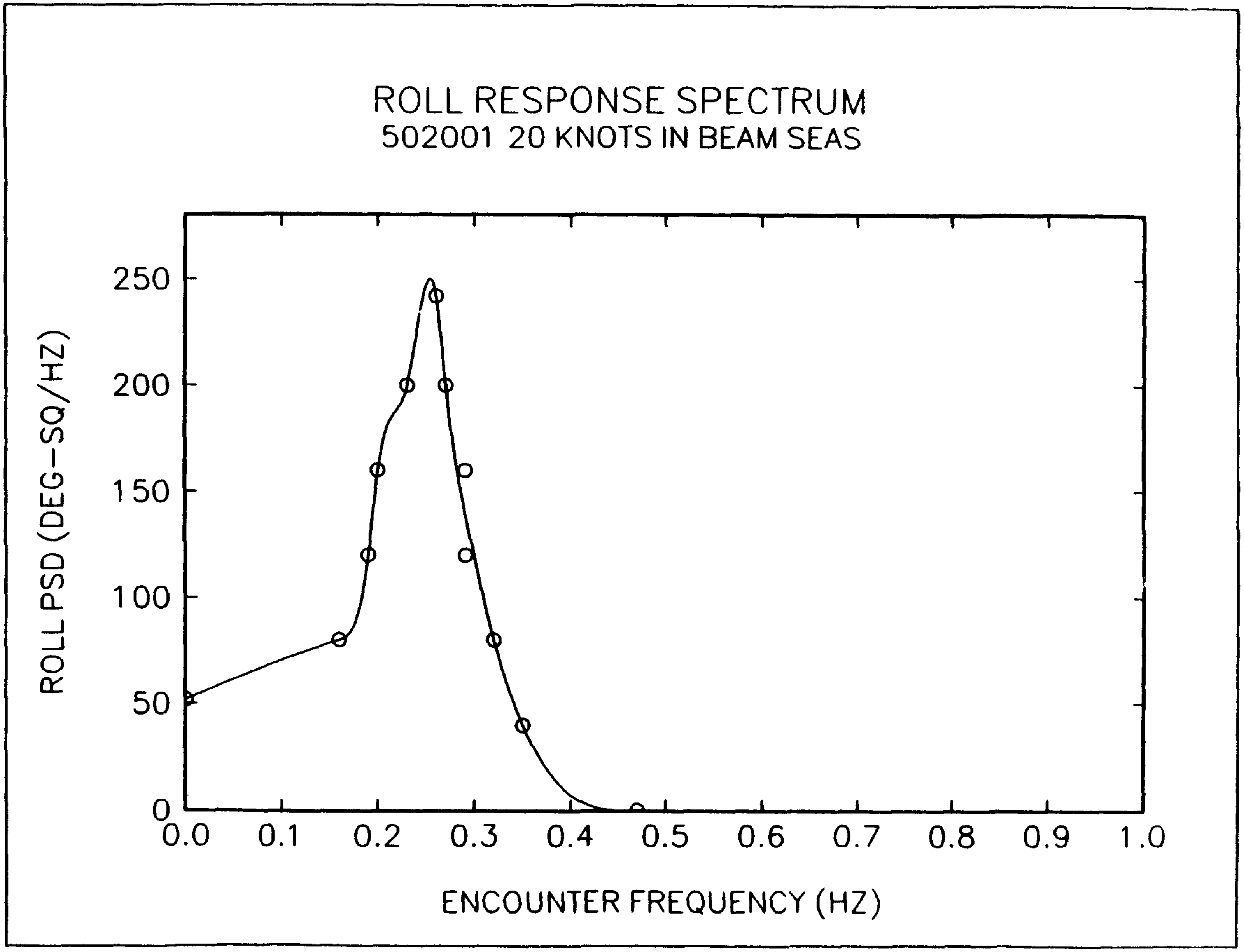


FIGURE C-14: 502001 Roll Response Spectrum at 20 Knots

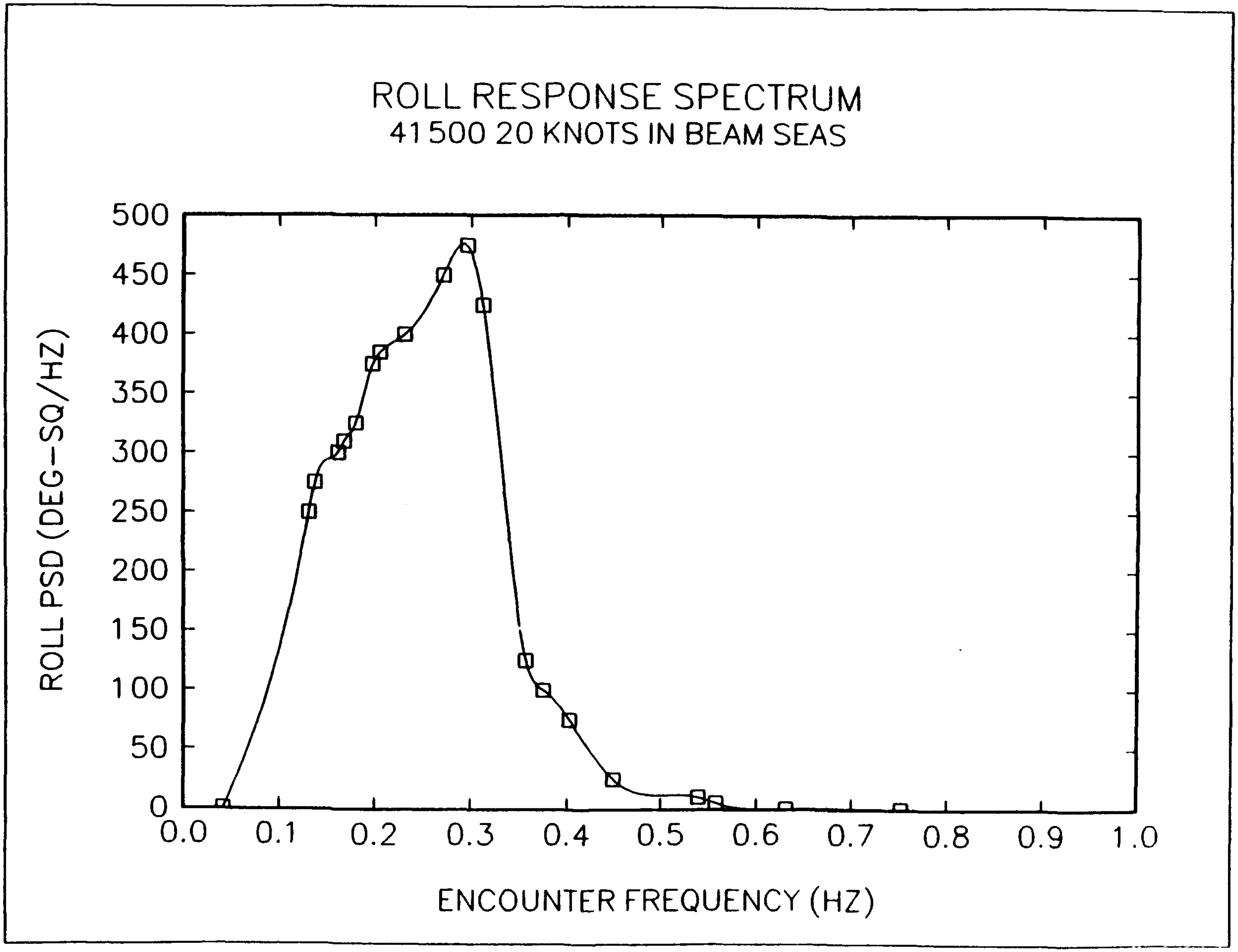


FIGURE C-15: 41500 Roll Response Spectrum at 20 Knots

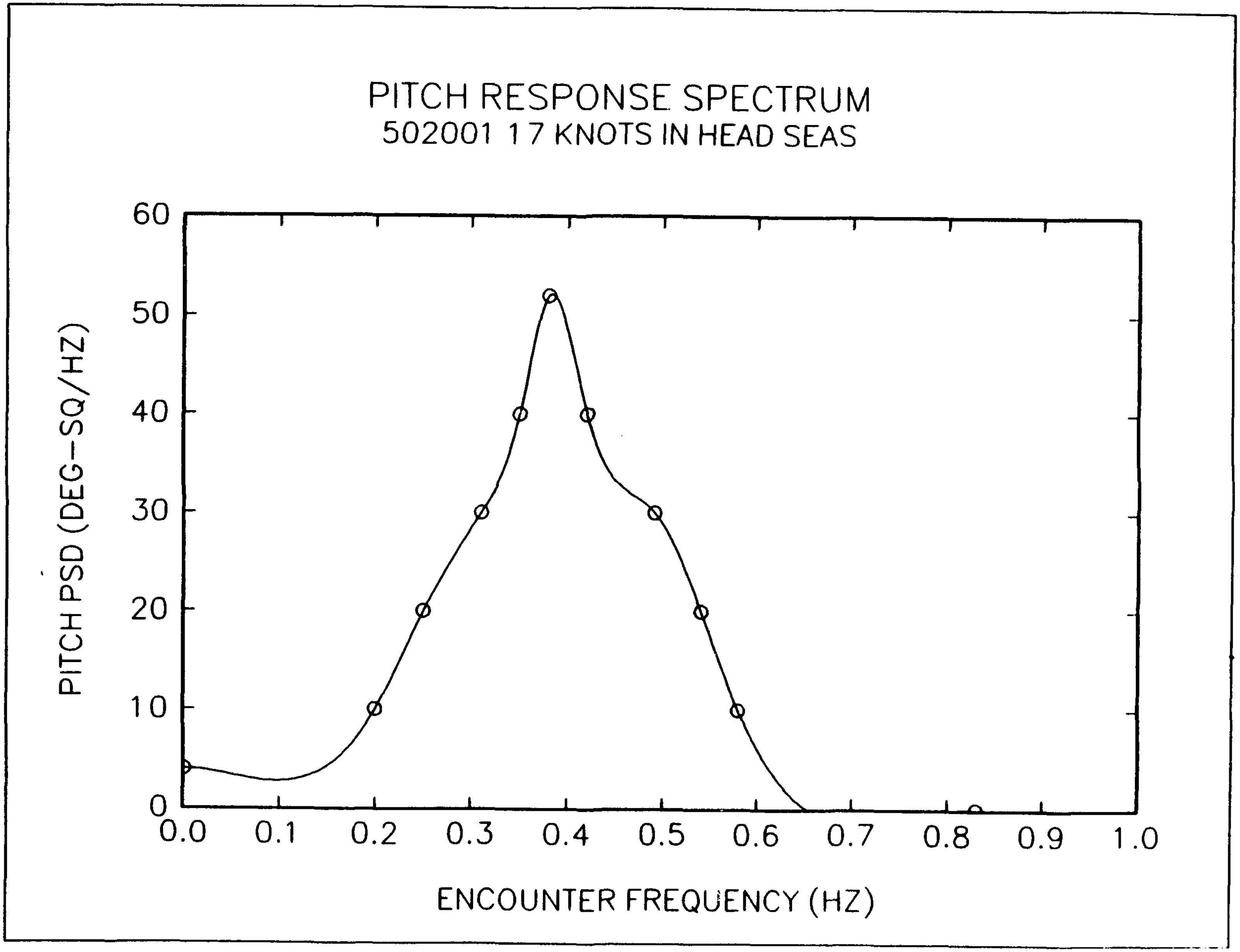


FIGURE C-16: 502001 Pitch Response Spectrum at 17 Knots

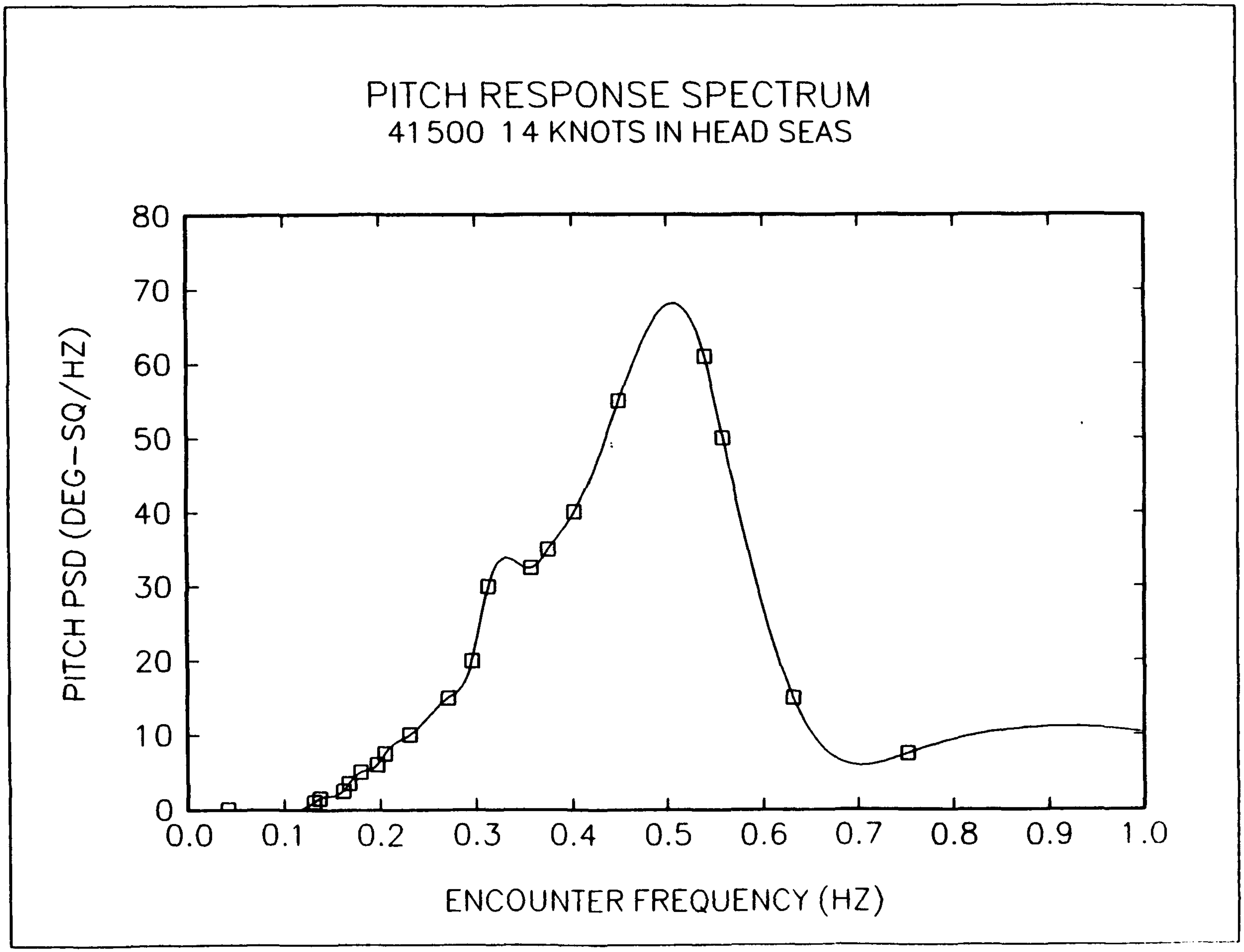


FIGURE C-17: 41500 Pitch Response Spectrum at 14 Knots

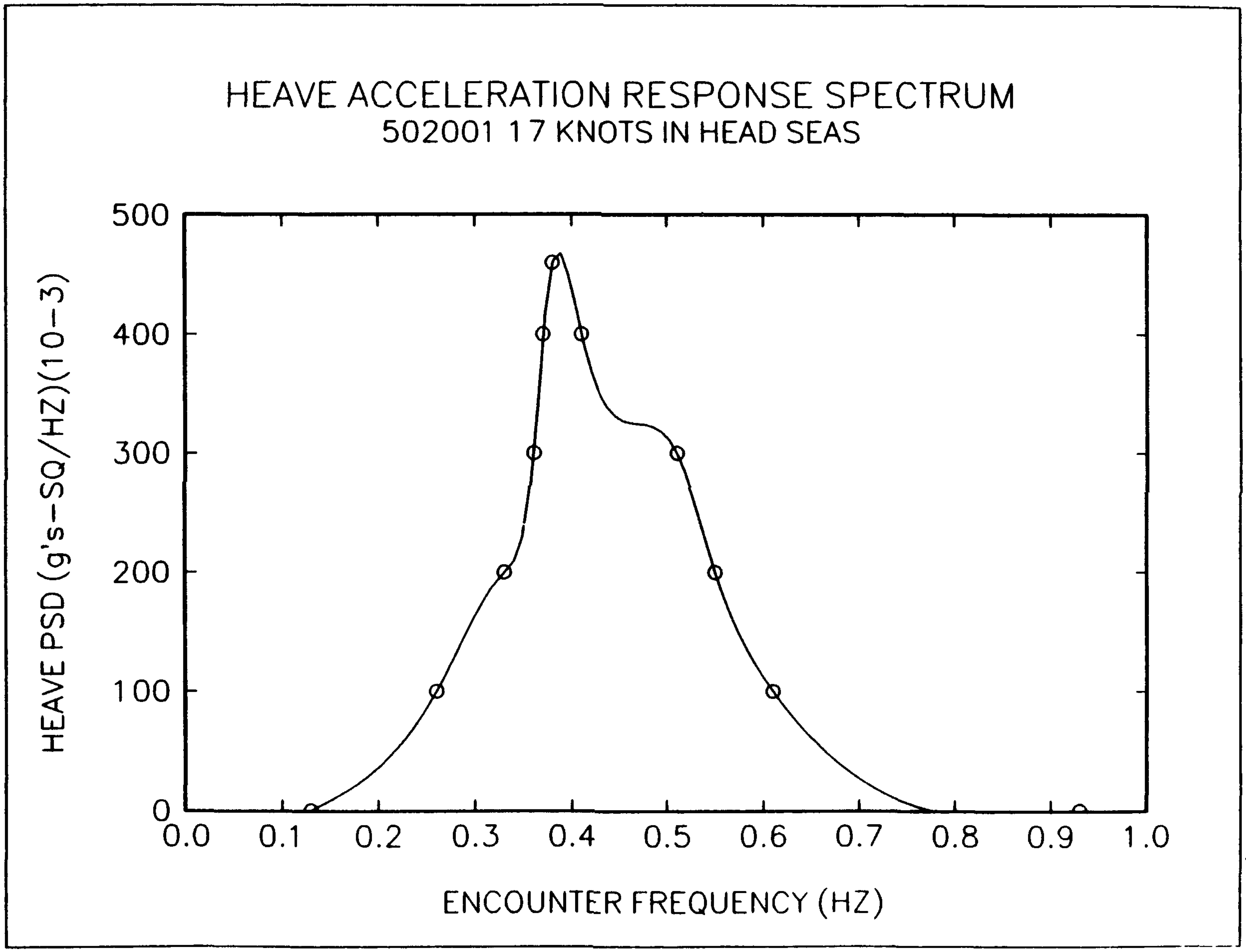


FIGURE C-18: 502001 Heave Response Spectrum at 17 Knots

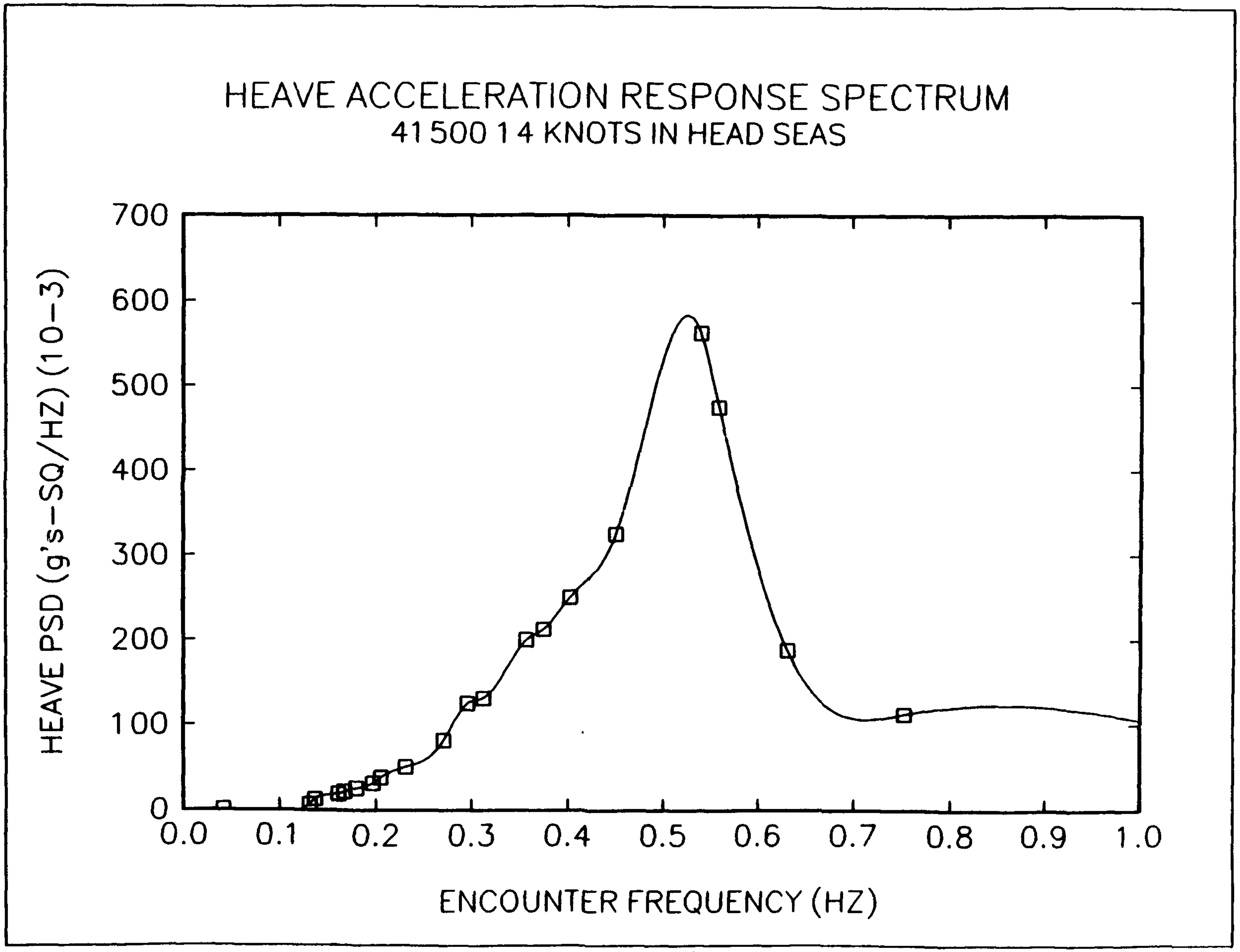


FIGURE C-19: 41500 Heave Response Spectrum at 14 Knots

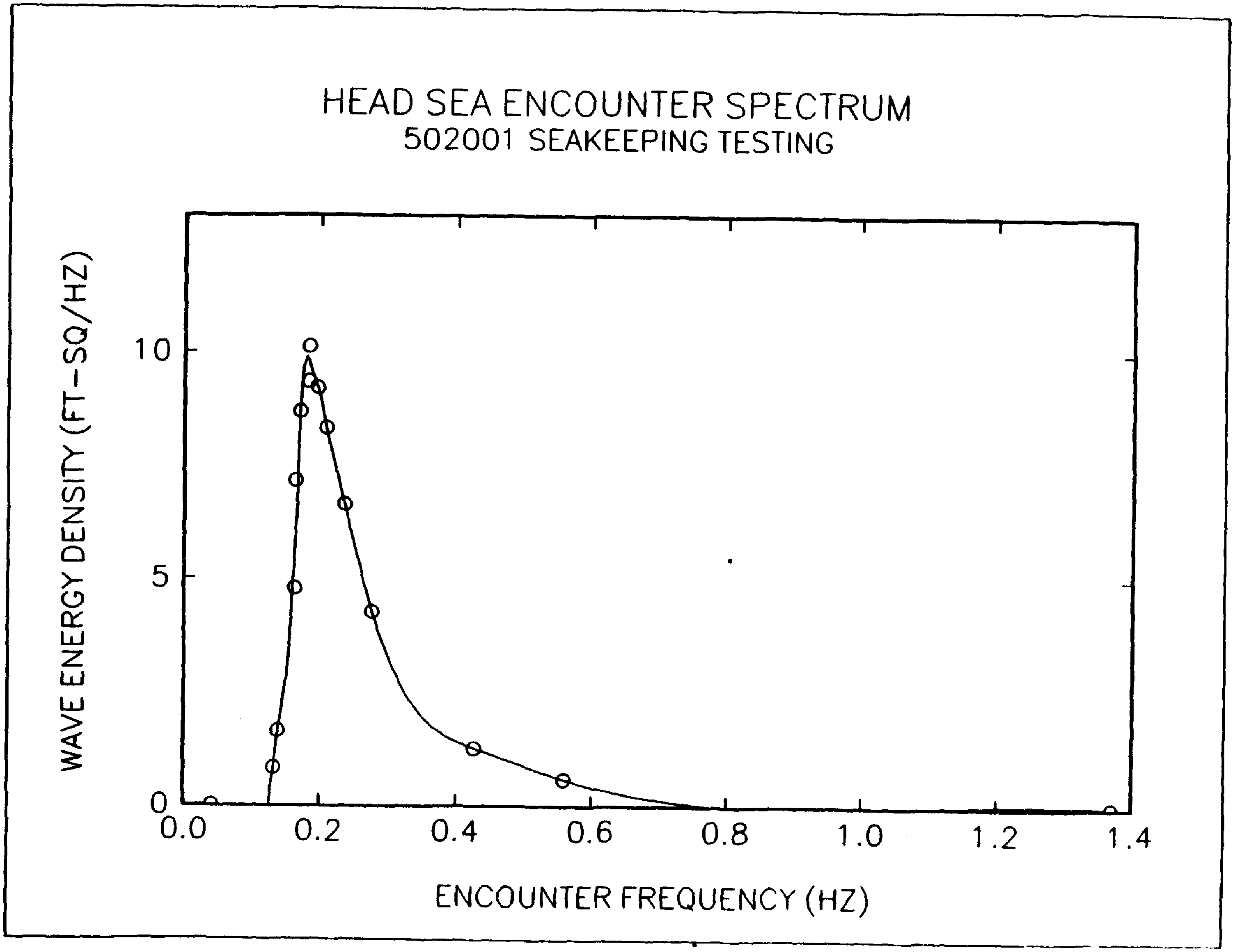


FIGURE C-20: 502001 Head Sea Encounter Spectrum at 17 Knots

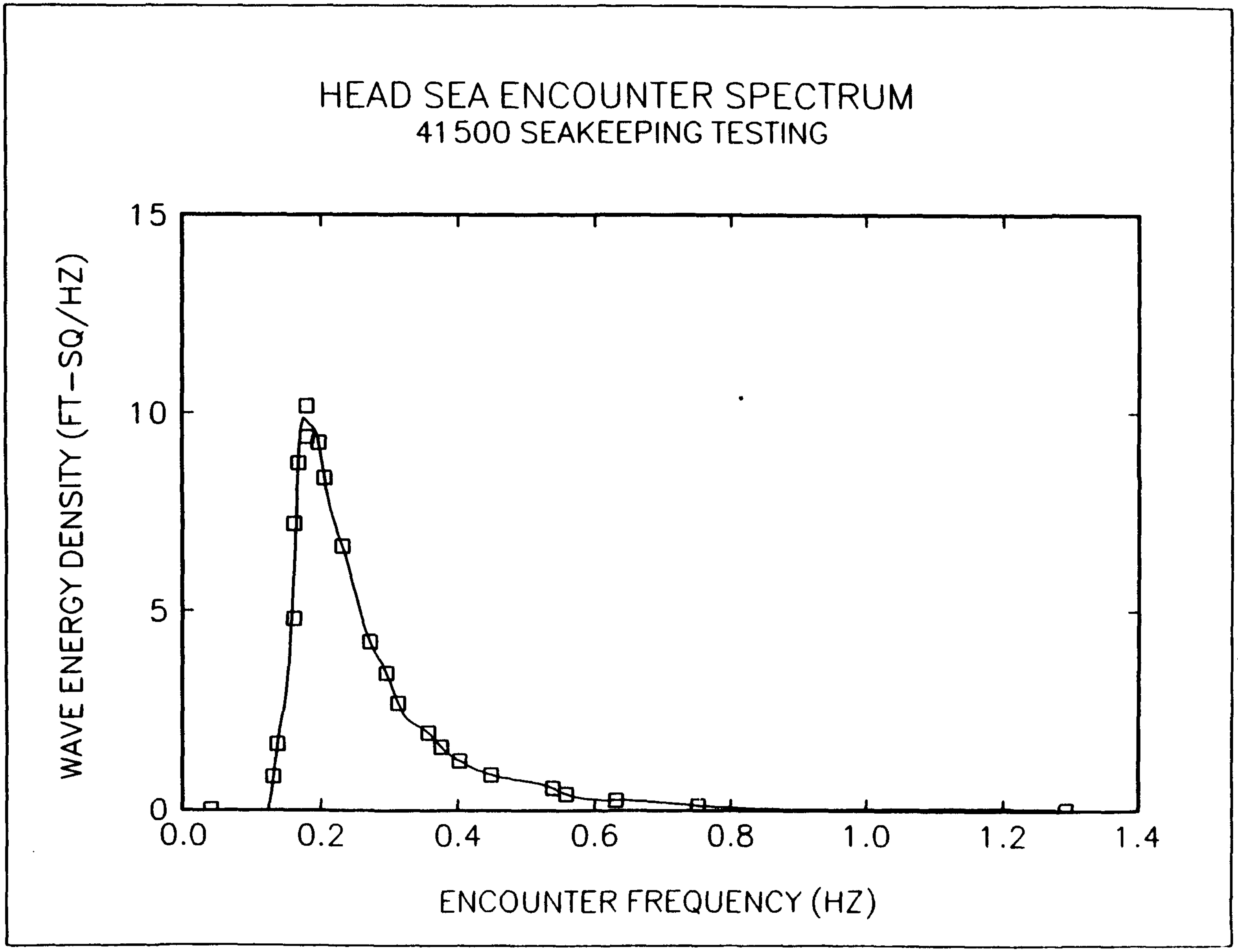


FIGURE C-21: 41500 Head Sea Encounter Spectrum at 14 Knots

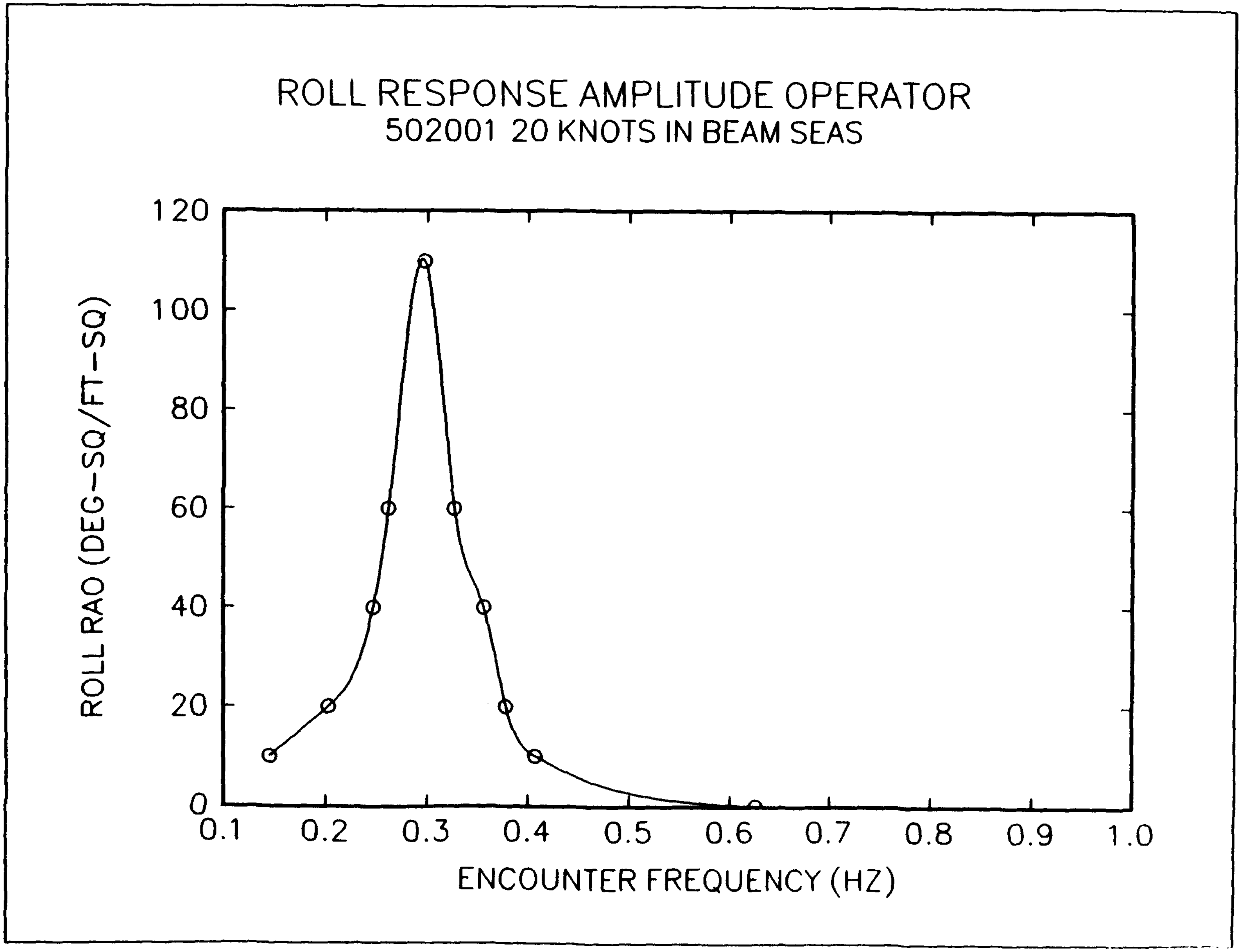


FIGURE C-22: 502001 Roll Response Amplitude Operator at 20 Knots

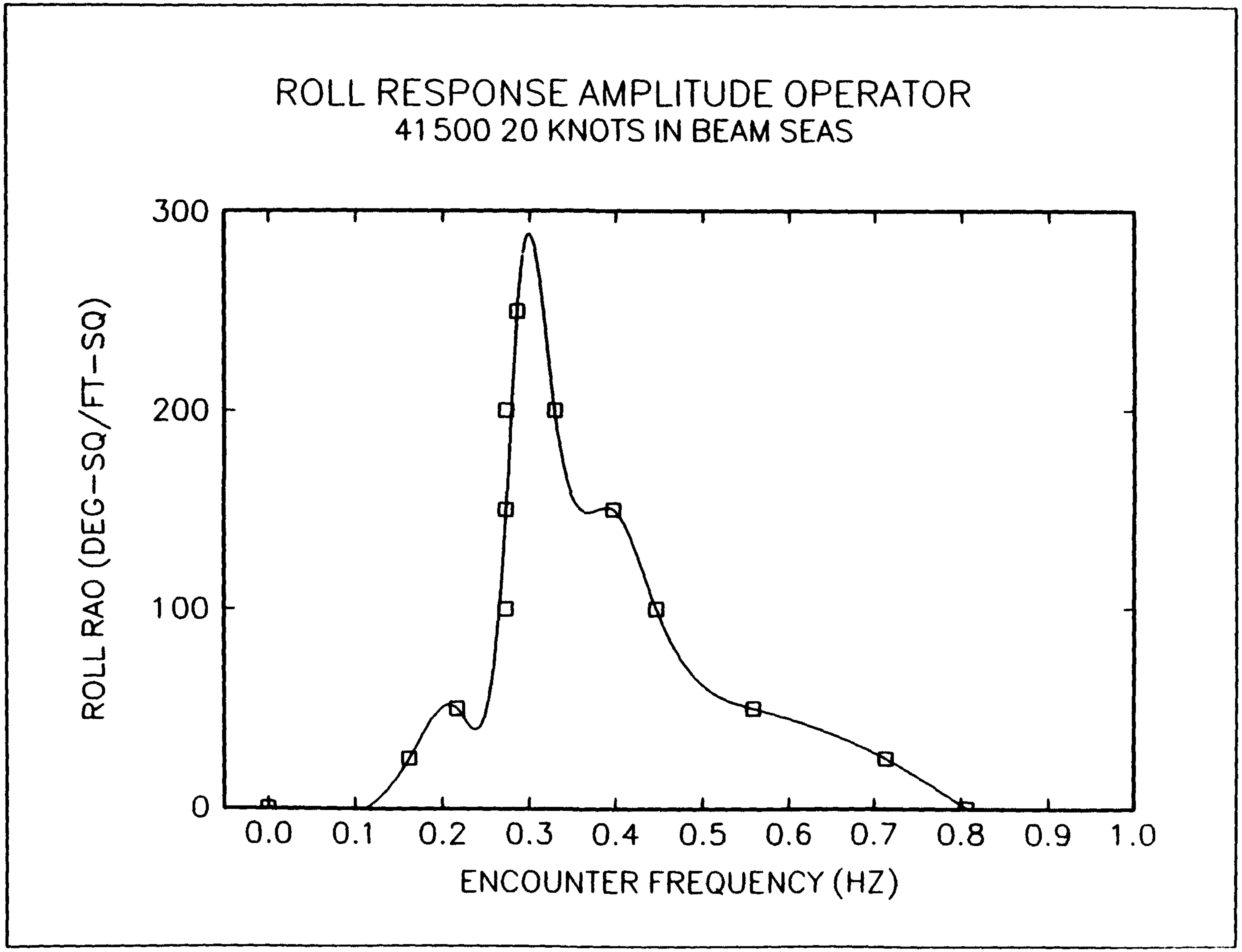


FIGURE C-23: 41500 Roll Response Amplitude Operator at 20 Knots

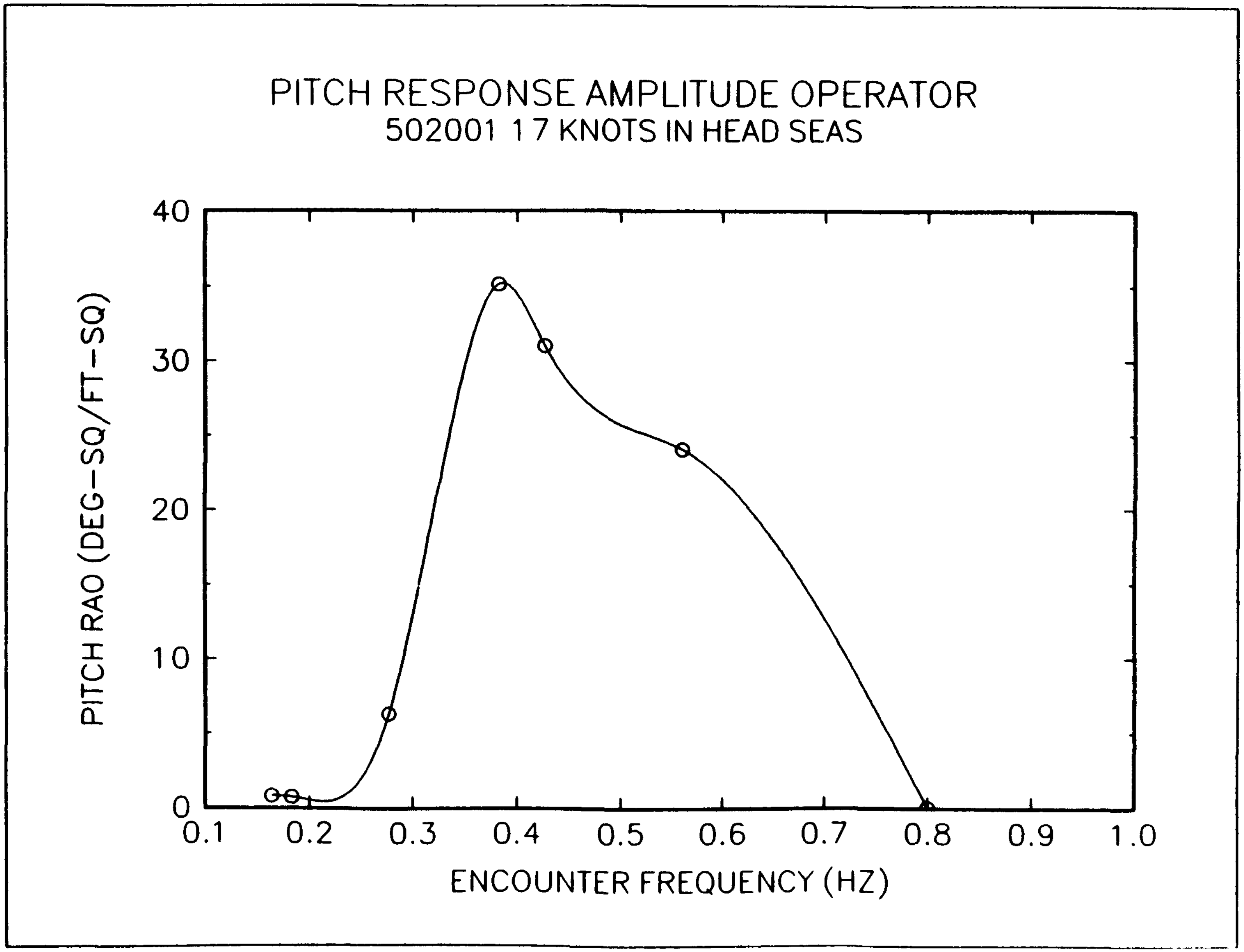


FIGURE C-24: 502001 Pitch Response Amplitude Operator at 17 Knots

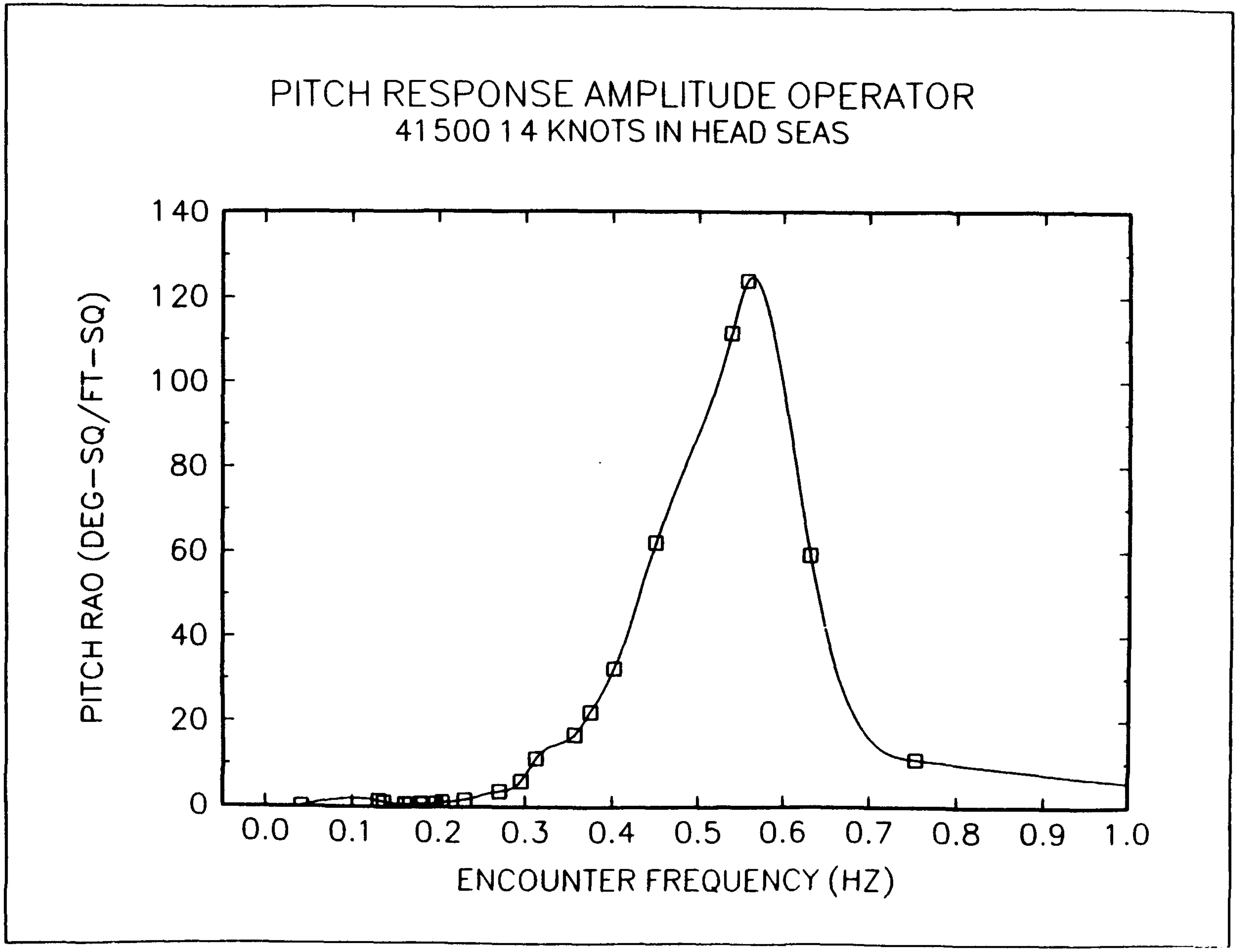


FIGURE C-25: 41500 Pitch Response Amplitude Operator at 14 Knots

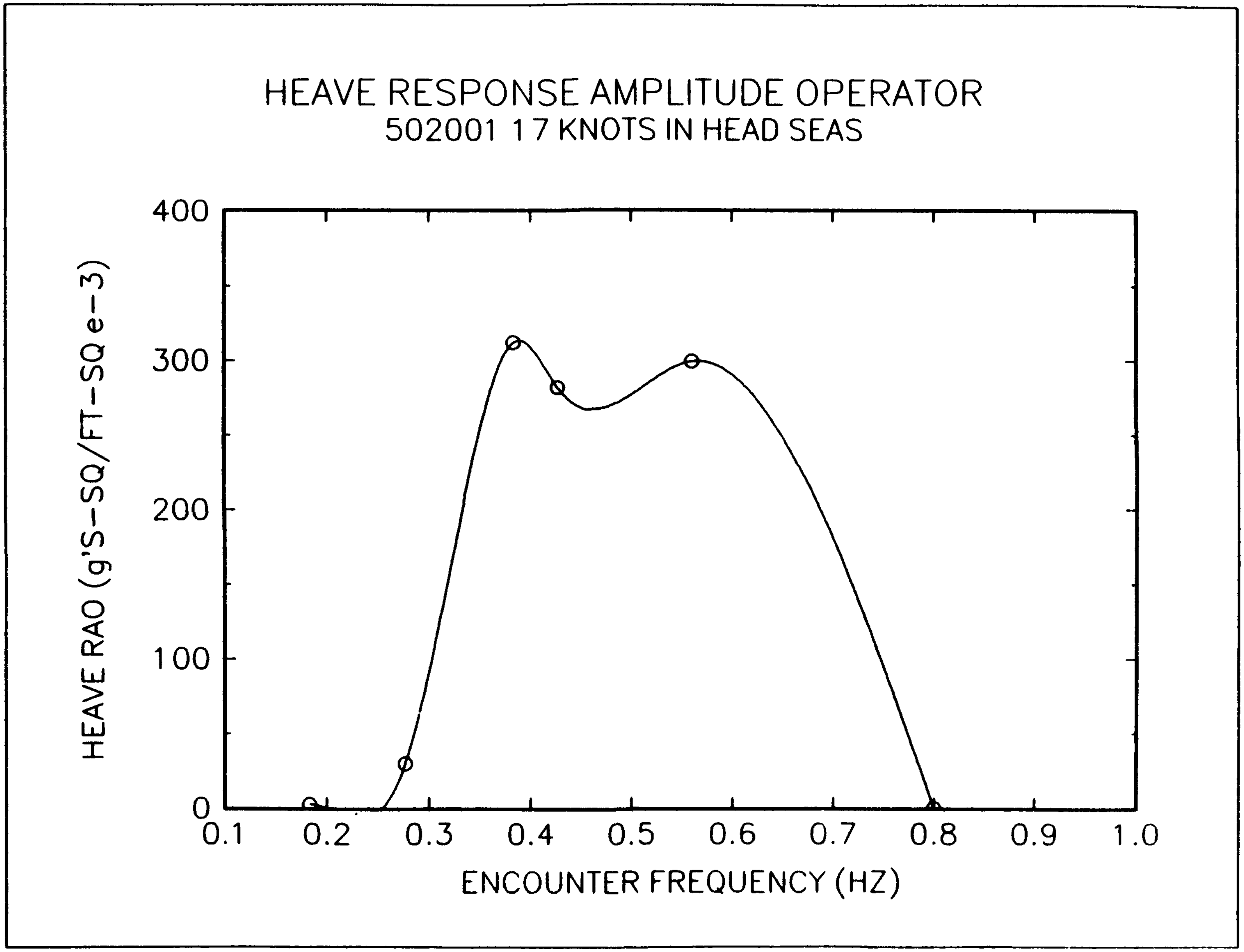


FIGURE C-26: 502001 Heave Response Amplitude Operator at 17 Knots

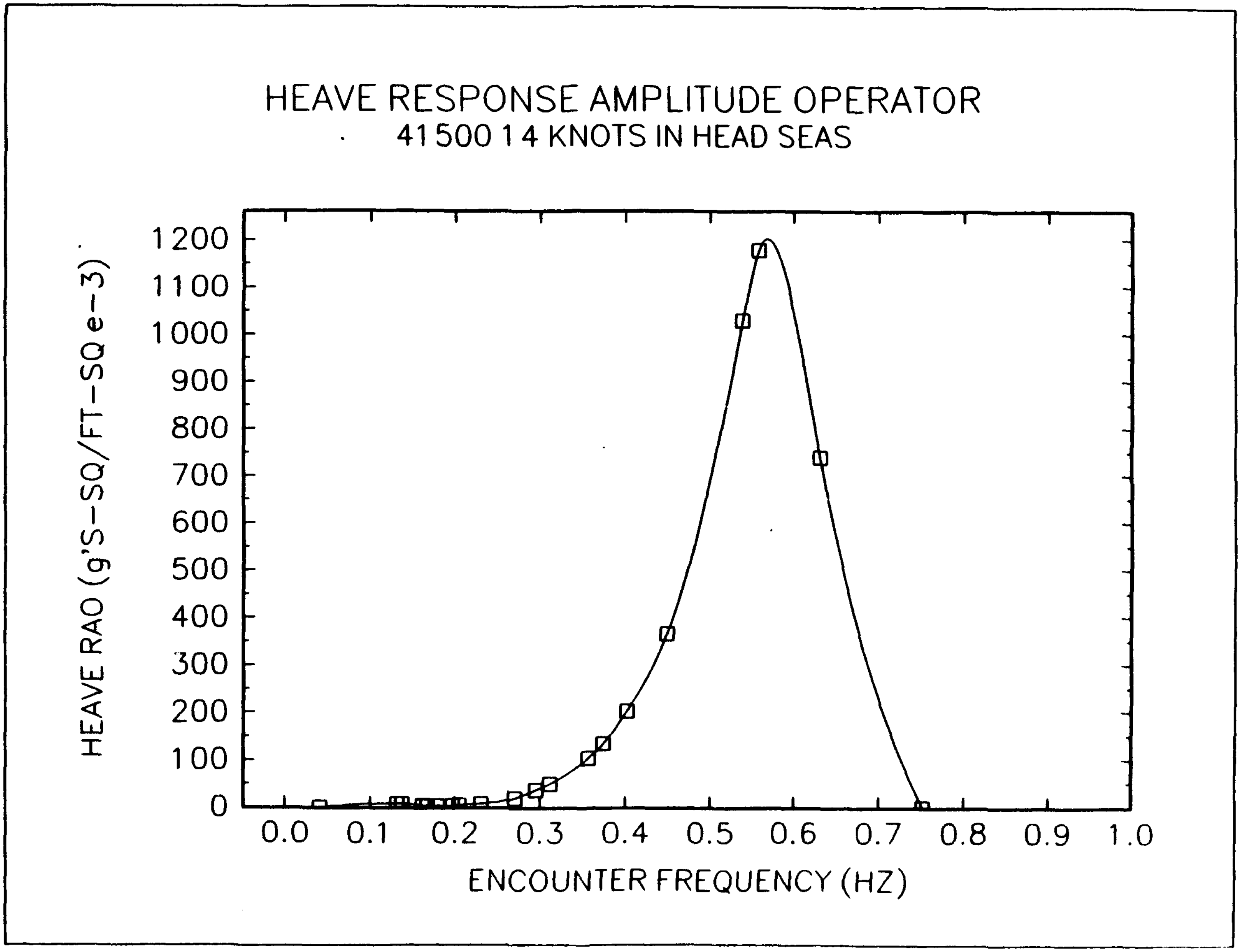


FIGURE C-27: 41500 Heave Response Amplitude Operator at 14 Knots

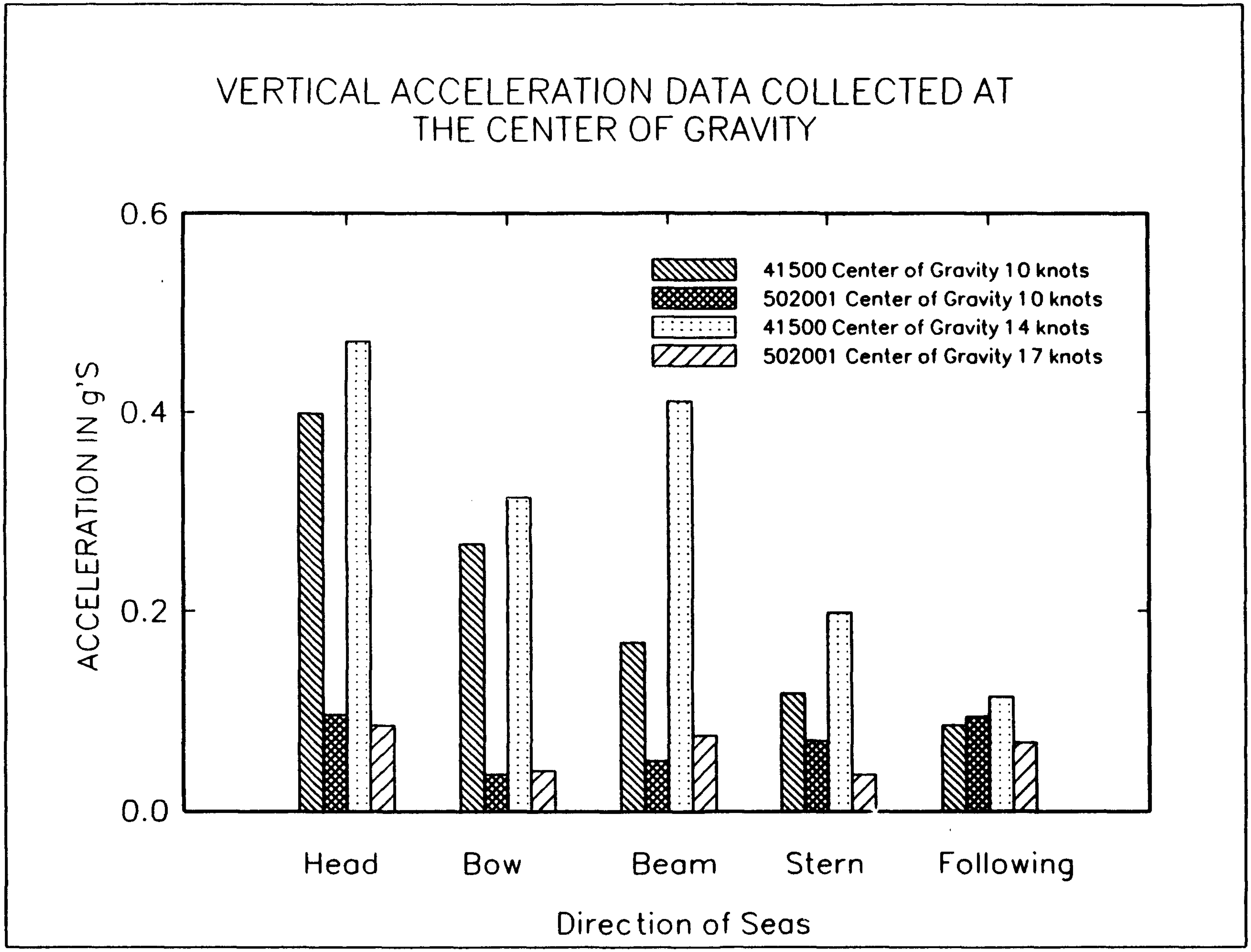


FIGURE C-28: **41500 and 502001 RMS Acceleration Data Collected at the Center of Gravity**

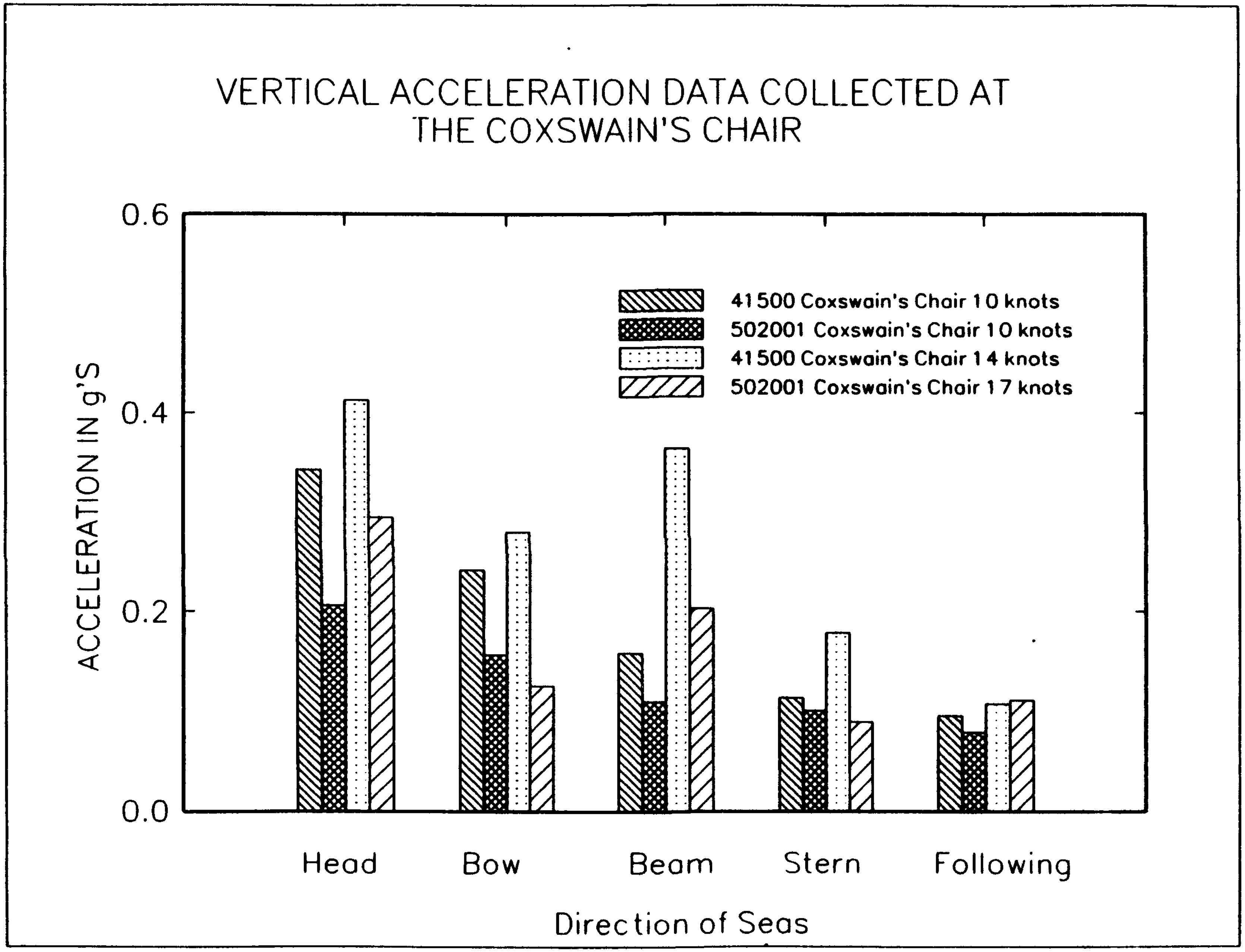


FIGURE C-29: 41500 and 502001 RMS Acceleration Data Collected at the Coxswain's Chair