ANEP 16
Edition 1

ALLIED
NAVAL
ENGINEERING
PUBLICATION

SUPPLEMENT 2 TO STANAG 4154 GENERAL CRITERIA AND COMMON PROCEDURES FOR SEAKEEPING PERFORMANCE ASSESSMENT MINE COUNTER MEASURE VESSELS

APRIL 1989

NATO INTERNATIONAL STAFF - DEFENCE SUPPORT DIVISION

ANEP-16
Edition 1

NORTH ATLANTIC TREATY ORGANIZATION

MILITARY AGENCY FOR STANDARDIZATION (MAS)

NATO LETTER OF PROMULATION

April 1989

1. ANEP-16, Mine Countermeasure Vessels SUPPLEMENT 2 to STANAG 4154 - General Criteria and Common Procedures for Seakeeping Performance Assessment is a NATO UNCLASSIFIED publication.

2. ANEP-16 is effective NATO-wide upon receipt.

3. ANEP-16 contains only factual information. Changes to this publication are not subject to ratification procedures and will be promulgated as necessary by AC/141/(IEG/6)SG/5.

A.J.Melo CORREIA
Major General, POAF
Chairman

RECORD OF CHANGES

Change Date	Date Entered	Effective Date	By Whom Entered

FOREWORD

1. STANAG 4154 gives the agreed requirements for determining the General Criteria and Common Procedures for Seakeeping Performance Assessment.

2. STANAG 4194 is the agreed Standardized Wave and Wind Environments and Shipboard Reporting of Sea Conditions.

3. This Allied Naval Engineering Publication Number 16 has been prepared by AC/141(IEG/6)SG/5 on Seakeeping for use with STANAGs 4154 and 4194. It should be noted that this document is not an agreed standard, but is circulated for information and to provide guidance to those involved in ship design.

4. It should be noted that this is one of a series of ANEPs, to be used in conjunction with STANAG 4154.

TABLE OF CONTENTS

Item

GENERAL CRITERIA AND COMMON PROCEDURES FOR SEAKEEPING PERFORMANCE ASSESSMENT - MINE COUNTERMEASURE VESSELS SUPPLEMENT

Related Documents

1. STANAG 4154: General Criteria and Common Procedures for Seakeeping Performance Assessment.
2. International Towing Tank Conference (ITTC) Dictionary.
3. STANAG 4194: Standardized Wave and Wind Environments and Shipboard Reporting of Sea Conditions.

Aim

1. The aim of this Working Paper is to establish ad hoc criteria for the operability and habitability aspects of seakeeping of conventional type Mine Countermeasure Vessels (MCMVs) to be used in the assessment and evaluation of seakeeping qualities and to enhance the interoperability of such ships in joint MCM operations.

General

2. Annex A describes the general problems of MCM operations affecting seakeeping. Annex B formulates ad hoc criteria for MCMVs seakeeping which enable satisfactory design decisions under the present state-of-the-art. Annex C indentifies recommended computational and experimental procedures for assessment of ship seakeeping characteristics in the design process. Annex D shows examples which illustrate the application of the principles of Annex A and the general criteria of Annex B using procedures from Annex C. Definitions are given in Annex E, and references in Annex F.

ANNEX A

GENERAL PROBLEMS OF MCM OPERATIONS

1. Sea mines are a major weapon in naval warefare. They are cheap and simple devices, easy to manufacture and to deploy. Extensive coastal waters requires for all navies a capability to locate and destroy sea mines in order to minimize restriction and obtain a safe approach to sea terminals and establish the essential flow of traffic.

2. Mines can be contact or influence (magnetic, acoustic, pressure and others in any combinations). They can be moored (long or short tethered) or laying on the sea bottom (ground mines).

3. The different types of active MCM operations are:

- Mechanical: the sweeping of mines by devices designed to cut the mooring wire of moored mines.
- Influence: the activation of mines by the simulation of an influence signature (magnetic, acoustic, pressure) of a target vessel.
- Mine hunting: the detection of individual mines by sonar or other underwater locating devices and their subsequent disposal or recovery for mine investigation purposes by means of vehicles launched by the mother ship or of divers.
- Clearance diving: the location and disposal of mine using divers. This is restricted to shallow water depths.

4. Such active MCM operations can be effected by the following main methods:

- Exploratory operations: the initial investigation of an area or route to determine the presence or absence of mines. Minehunting is the most efficient technique for these operations.
- Clearing operations: use either minehunting or minesweeping techniques and are designed to achieve the clearance or reduction of mines from a specific area to a specific percentage.
- Attrition operations: are an extention of clearance operations and become necessary when mine replenishment or delayed arming mechnism make continued operations essential to maintain a low risk to shipping.

5. Localization and detection of mines is usually accomplished at low ship's speed (3-6 knots). Mechanical sweeping and transfer missions are performed at higher speeds.

Classification and neutralization is accomplished at very low and zero speed, at a close distance from the mine (150-200 meters). A continuous slow speed drive with fully controllable stopping, manoeuvring and station keeping capabilities is required for minehunting vessels. A dynamic positioning system is generally required, therefore auxiliary propulsion units have to be installed on board.

The nature of mines requires minimization of acoustic, magnetic and pressure signature. Magnetic signature is also influenced by eddy currents induced by roll and pitch motions and conductive components, therefore imposing limited roll and pitch velocities.

6. The seakeeping phenomena of concern are motions, course and station keeping and reduced stability. The seakeeping phenomena influence adversely the crew and the ship's various sytems. These detrimental effects may be grouped under two main headings:

(a) Crew: performance degradation, fatigue, motion sickness, work restriction, injury, loss overboard;

(b) Equipment: performance degradation of weapons and sensors, inability to launch/recover underwater vehicles and/or towed systems, damage from inertial loads, loss of towed systems, strain and damage of MCM equipment, increased corrosion, stabilization system and dynamic positioning system degradation.

7. These effects could individually or collectively stimulate a decision to cancel operations. The aim of giving due consideration to seakeeping in the design process is to reduce the severity of these effects to an acceptable level so that the ship can carry out her mission over a sufficient range of sea conditions.

8. Under the present state-of-the-art, it is impossible to evaluate rigorously performance degradation of the crew and the ship's systems, and hence formulate an overall performance index as a function of ship's motions. Present knowledge does, however, allow the formulation of ad hoc criteria for the seakeeping phenomena. Furthermore, these criteria are compatible with existing procedures for predicting seakeeping behaviour, and are therefore suitable for use in the design process.

9. In the design process, seakeeping qualities are established by attention to:

(a) underwater hull form and leading particulars; (displacement, length, beam, draft)

(b) above-water hull and freeboard;

(c) stabilization and metacentric height;

(d) dynamic positioning system;

(e) weight distribution and radii of gyration;

(f) arrangements.

10. The designer may also have the option to distribute crew, weapons and equipments so that they are in favourable parts of the ship which do not suffer unduly from the adverse effects of the environment.

11. Under the current state-of-the-art, the effects of seakeeping on crew, structure and equipment are addressed in the design process by specifying acceptable levels of the ship motion as a function of the sea state and the intended missions, and designing to meet these limits. A minimum set of specifications is, grouped according to the major design parameters of paragraph 9:

(a) (1) pitch;

(2) vertical displacement, velocity and/or acceleration at a number of locations;

(3) a measure of ride quality which accounts for the effect of vertical motions on crew performance;

(4) relative motions;

(5) frequency and severity of bottom slamming;

(6) propeller/thruster emergence;

(b) (1) frequency and severity of deck wetness;

(2) frequency and severity of flare slamming;

(c) (1) roll;

(2) lateral displacement, velocity and/or acceleration at a number of locations;

(3) a measure of the ride quality which accounts for the effect of lateral motions on crew performance;

(4) stabilizer activity;

(d) (1) surge;

(2) sway;

(3) yaw;

(4) auxiliary propulsion units activity;

12. Formulation of ad hoc criteria and guidelines for each of the above aspects of seakeeping is discussed in Annex B.

ANNEX B

AD HOC CRITERIA FOR MCMV'S SEAKEEPING

1. For MCM operations the evaluation of ride qualities, ship motions, stabilizer's and auxiliary propulsion effectiveness for the assessment of seakeeping performances ought to be made only with the use of a specified spectra which takes account of the possible presence either of landlocked water (for instance JONSWAP spectra), or shallow water.

The effects of ship's motions on crew and equipment are addressed in the design process by specifying acceptable levels of ship motions and related phenomena for specified environmental and operational conditions, and designing to meet these limits. Criteria and limits depend on the intended missions/tasks and equipment sensitivity. Design criteria should also consider the requirements of inoperability of ships which are expected to participate in joint NATO MCM operations.

2. A minimum set of seakeeping phenomena which must be considered in a MCMV design process, with regard to MCM operations is given in paragraph 11 of Annex A. The factors governing definition of criteria for each of these aspects of seakeeping are listed below:

Phenomenon	Factors governing criteria
Ride quality	- crew performance degradation - fatigue and motion sickness - work restrictions - injury - loss overboard
Pitch, roll, vertical, lateral motions and surge	- underwater vehicles and divers operations - launch-recovery/on-deck movement - towed systems operations - equipment specifications - eddy current generation
Stabilizer performance	- for active and semi-active tanks: . loss of stability . saturation
Deck wetness	- requirements for crew to work on weather deck - equipment specifications - loss of stability

Propeller/thruster emergency	- main and auxiliary propulsion system specifications
Surge, sway, yaw and auxiliary propulsion units acitivity	- course and station keeping - loss of operational accuracy - loss of remotely operated vehicles
Course and station keeping	- operational accuracy
Bottom and flare slamming	- strengh of primary and local structure - material fatigue - crew tolerance to impact - equipment specifications
Relative motions	- equipment launching and/or recovery limitations

3. General criteria for each of the above seakeeping phenomena are described below.

4. Ride Quality Criteria are derived from operability and habitability considerations of the crew, taking into account the human body behaviour in the presence of ship motions. The formulation of ride quality criteria should consider the shorter duration of MCM missions and higher response frequencies than those of frigate and destroyers.

5. Pitch, Roll, Vertical, Lateral Motion and Surge Criteria are derived from operability considerations. Limits are set on the motion amplitudes. The most important sources of motion limits are the requirements to deploy and to conduct underwater vehicles/sensors and/or divers and/or towed systems operations, during station keeping and/or low speed operations.

6. Stabilizer Performance Criteria are naturally dependent on stabilizer type. For passive and semi-active tank systems statistical limits are derived from considerations of saturation, loss of metacentric height, added weight and resistance increase.

7. Deck wetness criteria are formulated on the basis of deck wetness probability for an adequate number of longitudinal stations. The effect of shipping water on equipment, personnel and visibility should be considered.

8. Propeller/thruster emergence criteria are derived from operating considerations for the main and auxiliary machinery. This basically involves establishing tolerance levels for propeller and thruster racing and results in a limit on the frequency of emergence.

9. Surge, sway, yaw and auxiliary propulsion units activity criteria are derived from the requirements for station keeping and low speed manoeuvring. The effect of wind on the superstructure can be of paramount importance.

10. Course and station keeping are dependent on ship's hull and ship's superstructure as well. Steering devices and propulsion plant system must be designed in order to give the necessary accuracy to navigation. The effect of wind on the superstructure can be of paramount importance.

11. Bottom and flare slamming are strongly dependent on ship speed. For a MCMV they are a minor input considering the anti-shock hull design and the low speed of these vessels. They can occur during MCM operations because of the limited size of the ship and the low wave period of coastal waters. The importance of these seakeeping phenomena is thus related mainly to operability and habitability consideration.

12. The operability of a MCMV highly depends on the capability to launch or recover equipment from the ship. Relative motions criteria must be derived from the directions for use of the devices to be deployed at sea. They are strongly dependent on the wave direction and the type of the seaway, i.e. short-crested or long-crested.

13. Usually a range of operational situation must be considered, which are defined by:

Ship condition - displacement, metacentric height, trim, stabilisation mode;

Environment - wave and wind conditions;

Mission objectives - task, speed, heading to waves and wind;

14. In assigning seakeeping criteria it is important to recognize the stochastic nature of the wave environment. For example, a limit on the roll angle can be expressed as a limit on the significant single amplitude of roll, but not as a limit on the maximum roll angle.

ANNEX C

RECOMMENDED COMPUTATIONAL AND EXPERIMENTAL PROCEDURE FOR SEAKEEPING PERFORMANCE PREDICTIONS

1. This Annex identifies recommended computational and experimental procedures for the prediction of MCMV seakeeping qualities during MCM operations in the design process and for guidance on the capabilities of existing vessels. It is emphasized that these are suggested procedures and that adoption of alternative procedures which are of comparable or superior accuracy is not precluded. This is an area of intense research and improved methods can be expected to appear in the near future.

2. The procedures are grouped into nine categories which will be addressed individually:

(a) Specification of sea spectra;

(b) Ship motion response;

(c) Slamming;

(d) Deck wetness;

(e) Course and station keeping;

(f) Roll stabilization;

(g) Ride quality;

(h) Relative motions;

(i) Propeller and thruster emergence.

3. Specification of Sea Spectra. Adequate description of the seaway environment is of paramount importance. As MCM operations are generally performed near harbours, channels, and so on, wave spectra which takes into account the presence of landlocked areas or shallow water must be used. For the former case the JONSWAP spectra is recommended, while for the latter it will be necessary to use either data derived from seaway measurements or data predicted by a suitable formulation. See for guidance related document 3 and its associated source documents; reference 3, 24, 26 contain further information.

It is emphasized that a minimum of two parameters (significant wave height and wave modal period) must be used in specifying seaway spectra. Further, at a given height, it is important to cover a realistic range of characteristic wave periods as some aspects of seakeeping, e.g. pitch and roll, are sensitive to wave period. Documents should be consulted to obtain the proper statistical distribution of wave period with wave height for the areas of operational interest. It should also be recognized that seas are usually short crested to some degree, and therefore a spreading function should be selected for this purpose.

4. Ship Motion Response. Satisfactory prediction of ship motions may be accomplished by the use of a ship motion computer program. References 14, 15, 20 are widely used. For the vertical plane motions, i.e. surge, heave and pitch, the prediction has a greater accuracy than the lateral plane motions, i.e. sway, roll and yaw; see ref. 10, 17 for more detailed investigation on the latter motions. In MCM operations all the motions are of considerable importance considering the need of equipment and sensor deployment and towing. References 5, 8, 13, 16, 18, 19, 25 contain useful information and methods on ship motions prediction. The following procedures are recommended for motion prediction in the design stage:

(a) Strip theory-based computer program for ships with fairly normal hull form, which takes account of both dynamic lift on appendages and hull, and viscous effects in estimating roll damping.

(b) Model tests in regular and irregular waves.

5. Slamming. Slamming phenomena are of paramount importance at high speed in rough sea. For MCM operation slamming can occur in shallow water in the presence of waves having a very short period and a relatively high significant height. Computer programs have the possibility to calculate figures on slamming phenomena: ref. 14, 15. Reference 19 contains information about both bottom and flare slamming which can occur on a conventional hull form; their probability can be established, although the validation is not complete, with the following procedures:

(a) Computational or experimental methods for bottom slamming.

(b) Experimental methods for flare slamming.

6. Deck Wetness. Probability of deck wetness may be predicted by standard methods given in the seakeeping literature. Methods for estimating the severity of deck wetness are given in reference 33. Model and full scale tests are the only reliable source of information on the dynamic pressure caused by green water crashing on deck. MCM operations are usually conducted from the weather deck aft of the superstructure. Particular attention to wetness in this

area is required since freeboard is low to permit launch/recovery of underwater vehicles.

7. Course and Station Keeping. Both course and station keeping capability are essential for MCM operations. Several methods have been developed to predict the behaviour of a ship under the wind and wave effect, but generally only boundaries can be defined, therefore enhancing the difficulty of an assessment process. Detailed information can be found in reference 1, 2, 30, 34, 35, 36, 37, 38. Furthermore, the presence of auxiliary propulsion devices adds uncertainties in the prediction of the ship manoeuvrability in rough sea, see ref. 27, 28, 29, 31, 32. It is therefore recommended to perform investigations both in rough and in calm sea in order to have a better knowledge of the ship performance. In manoeuvring studies the mathematical model is usually based on the coupled equations of surge, sway, yaw, roll and propeller revolution, and the effects of hydrodynamic drag, propeller thrust, wind, current, wave drift, lateral thruster, miscellaneous towed drag and active controls are included in the model as external disturbances. The computed results give satisfactory agreements with the results of the full scale trials in calm and deep water, in shallow water and regular waves. However, methods for stimulating ship steering in seaways are still in the formative stage. The recommended procedures for course and station keeping prediction are as follows:

(a) computational methods with mathematical models which use hydrodynamic coefficients derived by captive model tests (rotating arm and planar motion mechanism);

(b) free running model tests in calm water, regular and irregular waves.

8. Roll Stabilization. A roll stabilization system is always required for the type of vessels of concern. Furthermore, it has to be effective at low or zero speed; this constraint leads the designer to install antiroll tanks and large bilge keels. The roll reduction achieved by using the antiroll tanks, either active or passive type, is not well predicted by existing theories, therefore the preferred method is simulation tests with a large model tank mounted on a special activated table. References 4, 9, 11 provide information on passive roll stabilizer tanks and ref. 6, 7 give a description of the forces involved. Care must be paid to the bilge keels design considering the effectiveness which can be lost with these cheap and simple devices when they are not properly designed. Recommended procedures are as follows:

(a) tank model test with activated bench for antiroll tanks;

(b) roll damping evaluation test for bilge keels.

9. Ride Quality. Methods for quantitative assessment of ride quality of naval vehicles are still in the formative stage. The methods which can be used

are not completely exhaustive and reliable. They ought to consider one or more parameters deriving from the ship motions or accelerations and their resulting effects on the crew working capability. References 12, 21, 22, 23, 41 provide guidance and information on this topic.

10. Relative Motions. The launching and/or recovery of equipment, e.g.: sonar equipment, inflatable boats, etc. is strongly affected by the motion magnitude of the deck relative to the water surface. By using computational methods, ref. 15 for example, it is possible to predict the distance of the sea surface from a specified point, with the limitation that these methods cannot take into account the wave distortion due to the presence of the hull. The methods which can be used to have a measure of relative motions are:

(a) computational method for relative motion calculation;

(b) model tests.

11. Propeller and Thruster Emergence. Probability of propeller/thruster emergence may be estimated using standard methods given in the seakeeping literature, see for example ref. 33. References 39 and 40 present criteria for these phenomena.

12. Examples illustrating the use of the above procedures, in conjunction with the general criteria of Annex B, are given in Annex D.

ANNEX D

EXAMPLES OF PROCEDURES FOR SEAKEEPING PREDICTIONS DURING MCM OPERATIONS

1. This Annex provides examples of the procedures described in Annex C. Postulated criteria are used pending development of the STANAG on criteria. Two examples are worked out in detail. These are based upon the ship comparison procedure described below in paragraph 2.

2. Ship Comparisons. The compatibility of NATO ships in joint operations can be assessed by the following procedures:

(a) Specify an operational scenario including the mission to be performed and the range of conditions (seaway, wind and other relevant environmental factors, ship speeds, and ship-to-wave relative headings) under which the mission has to be performed.

(b) Specify the ships which will perform the mission; and in accord with Annex B, the seakeeping-related criteria applicable to these ships for the mission. (Ships and criteria must be jointly specified because criteria can be ship dependent).

(c) Determine the relevant seakeeping characteristics of each ship considered in accord with the procedure outline in the Annex. These characteristics shoud be determined for the range of conditions specified in (a) and expressed in terms of the criteria from (b).

(d) For each ship compare the results of (c) with the criteria specified in (b). Thus, identify the subset of the conditions specified in (a) under which each ship can perform the mission being considered.

(e) Compare the results of (d) for the ships evaluated. This comparison assesses the relative abilities of the ships to perform successfully in the operational scenario specified in (a).

3. Ship Comparison Example for Exploratory Operation

Following paragraph 2 this example is specified as follows:

(a) Operational Scenario:

(i) exploratory operation: i.e. speed 4 knots, active sonar in search mode;

(ii) long-crested seas representative of the North Sea in winter;

(iii) ship-wave relative heading: port bow, starboard quartering.

(b) Ships:

(i) Ship A: 48.7 m * 6.10 m * 2.35 m, 380 tonnes;

(ii) Ship B: 61.3 m * 7.9 m * 2.95 m, 750 tonnes;

(c) Criteria:

(i) low probability of sonar emergence, less than 0.01 per cycle;

(ii) significant single amplitude of absolute vertical acceleration less than 0.2 g at the bridge;

(iii) significant single amplitude of roll less than 5.0 deg.

4. Transfer function for heave, roll and the associated kinematic responses of both ships in regular waves, having the aforesaid relative headings, were predicted using a strip theory computer program. The computations were performed for 4 knots and 45/135 deg.

5. The antiroll tank effect was taken into account by decreasing the roll angle significant amplitude.

6. Linear superposition was applied to obtain the significant single amplitudes of ship response in unit significant height JONSWAP wave spectra with modal wave period covering the relevant range of wave conditions. These statistics were used to compute the limiting significant wave heights associated with each of the three criteria specified in paragraph 3.

7. The ultimate limiting wave heights from paragraph 6 were drawn as illustrated, for example, in figure D1 for the bow sea condition. This figure applies to ships A and B at 4 knots. Given the postulated criteria, the figure D1 indicates that ship A can sustain 4 knots in bow sea of about 1.9 m significant wave height; the corresponding limit for ship B is about 2.3 m. These limits refer to the most adverse wave period. For both ships roll angle is the limiting criterion.

8. The information obtained with the method which has been shown can be used directly when a simple comparison has to be done. If the investigation must be thoroughly exhaustive, a more elaborate method like that one which is described at page D3 of related document 1 can be used.

9. Ship Comparison Example for Mine Hunting Operation

Following paragraph 2 this example is specified as follows:

(a) Operational Scenario;

- (i) mine hunting operation, i.e. the ship is hovering at a close distance from the target to be neutralized and is deploying devices at sea;
- (ii) short-crested sea representative of the Gulf of Taranto in January;
- (iii) 30 knots wave-associated wind;

(b) Ships:

- (i) Ship A: same leading particulars as paragraph 3, fully steerable auxiliary propeller unit forward and aft, twin shaft with Controllable Pitch Propeller (CPP);
- (ii) Ship B: same leading particulars as paragraph 3, fully steerable auxiliary propeller units forward, two fully steerable auxiliary propeller units aft, one shaft with CPP;

(c) Criteria:

- (i) power required by the auxiliary units not exceeding 80% of MCP;
- (ii) significant single amplitude vertical acceleration at the crane top when positioned for submersible device deploying, not exceeding 1.5 g.

10. Transfer functions for kinematic responses of concern for both ships in regular seas were obtained with the use of a strip theory computer program. The computations were performed at 0 knots and for all the relative ship-wave directions. A + 90 deg cosine squared spreading function was used.

11. By using suitable formulae and algorithms which took into account the performance degradation due to the ship motions, the power required for station keeping was computed for both ships.

12. Linear superposition was applied to obtain the significant single amplitudes of vertical acceleration at the crane top in unit significant height Gulf of Taranto wave spectra in January, and motions concerning the auxiliary units performance degradation as well. The computations were performed with three periods corresponding to the three most probable periods. By these statistics it was possible to obtain the polar diagrams drawn in fig. D2 (a)-(b) which represent the limiting wave heights associated with each of the two criteria specified in paragraph 9.

13. The information obtained can be used directly. If a more exhaustive investigation must be done, it is possible to perform the calculations described at page D3 of related document 1.

14. Other Examples. Procedures of Annex C not addressed in the foregoing are:

(a) slamming;

(b) course and station keeping;

(c) roll stabilization;

(d) ride quality.

Each of these areas is addressed individually in the following paragraphs.

15. Slamming. As noted in Annex C, computational methods can only be applied to bottom slamming phenomena, because the state of the art of flare slamming prediction is reliable only under idealised conditions. For this latter phenomena, model experiments may be the only way to assess oblique flare impact in confused seas.

16. Course and Station Keeping. Standard methods for assessing stability characteristics are the best means of comparing different designs. Reference 34 outlines several basic manoeuvring qualities (course keeping, turning, checking of turns, stopping and operation of the engine at acceptably low speeds) which could be evaluated in the design stage to compare different designs.

17. Roll Stabilization. Ship speed and relative heading combinations causing a roll criterion (or a combination with other criteria) to be met can be plotted in speed polar format with wave conditions (significant wave height and modal wave period) as parameters of the diagram (see example in fig. D3).

Here the concentric circles are contours of constant ship speed, and the radial lines are contours of constant ship heading relative to the predominant direction of the incident waves. (Relative heading is taken to increase clockwise from zero in following waves.)

18. Ride Quality. Annex C notes that ride quality is not well defined at the present state-of-the-art. Various criteria can be applied to have a measure of the ride quality of the ship, e.g.: Lateral Force Estimator, Motion Sickness Incidence, but none of them has yet been fully developed.

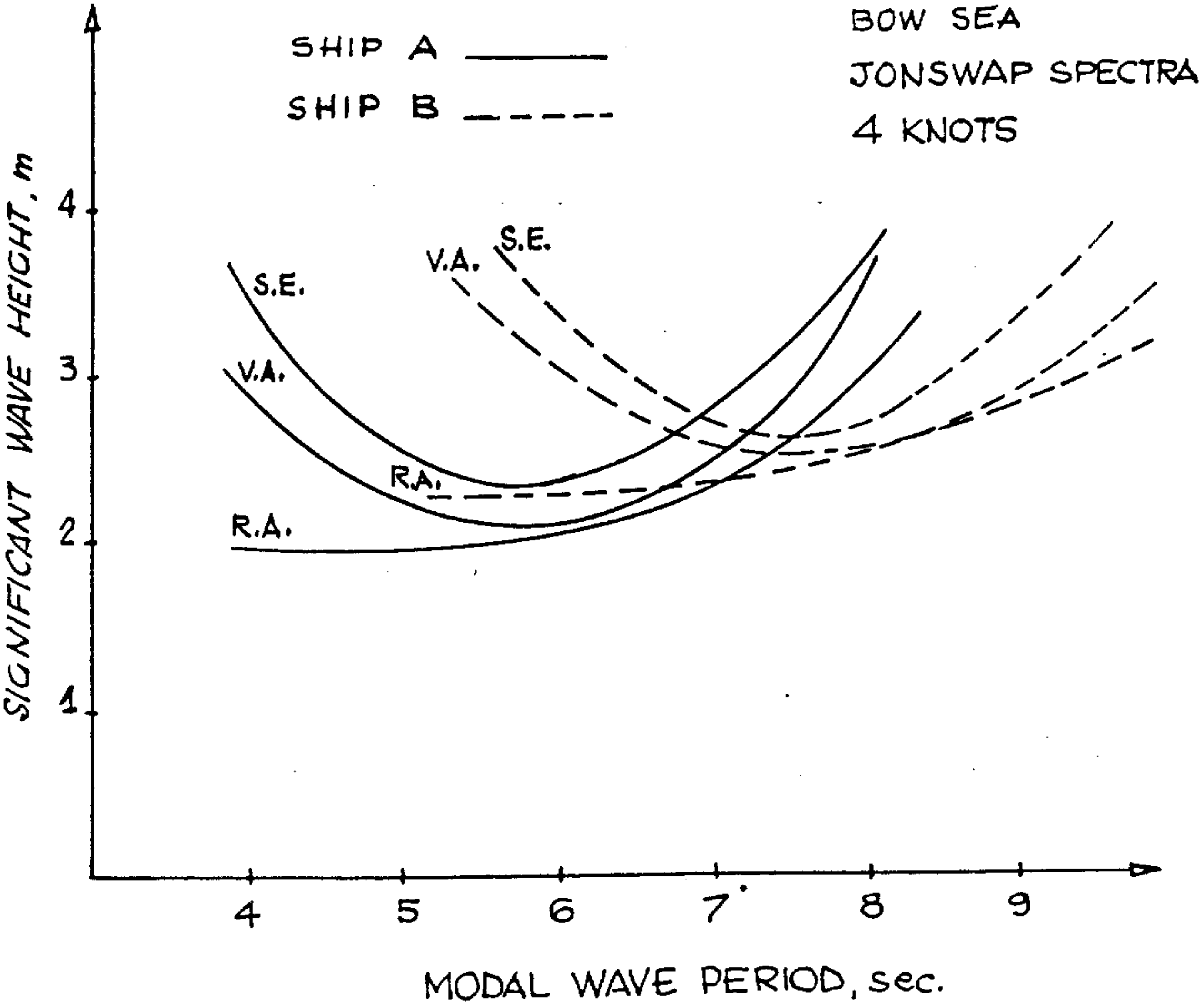
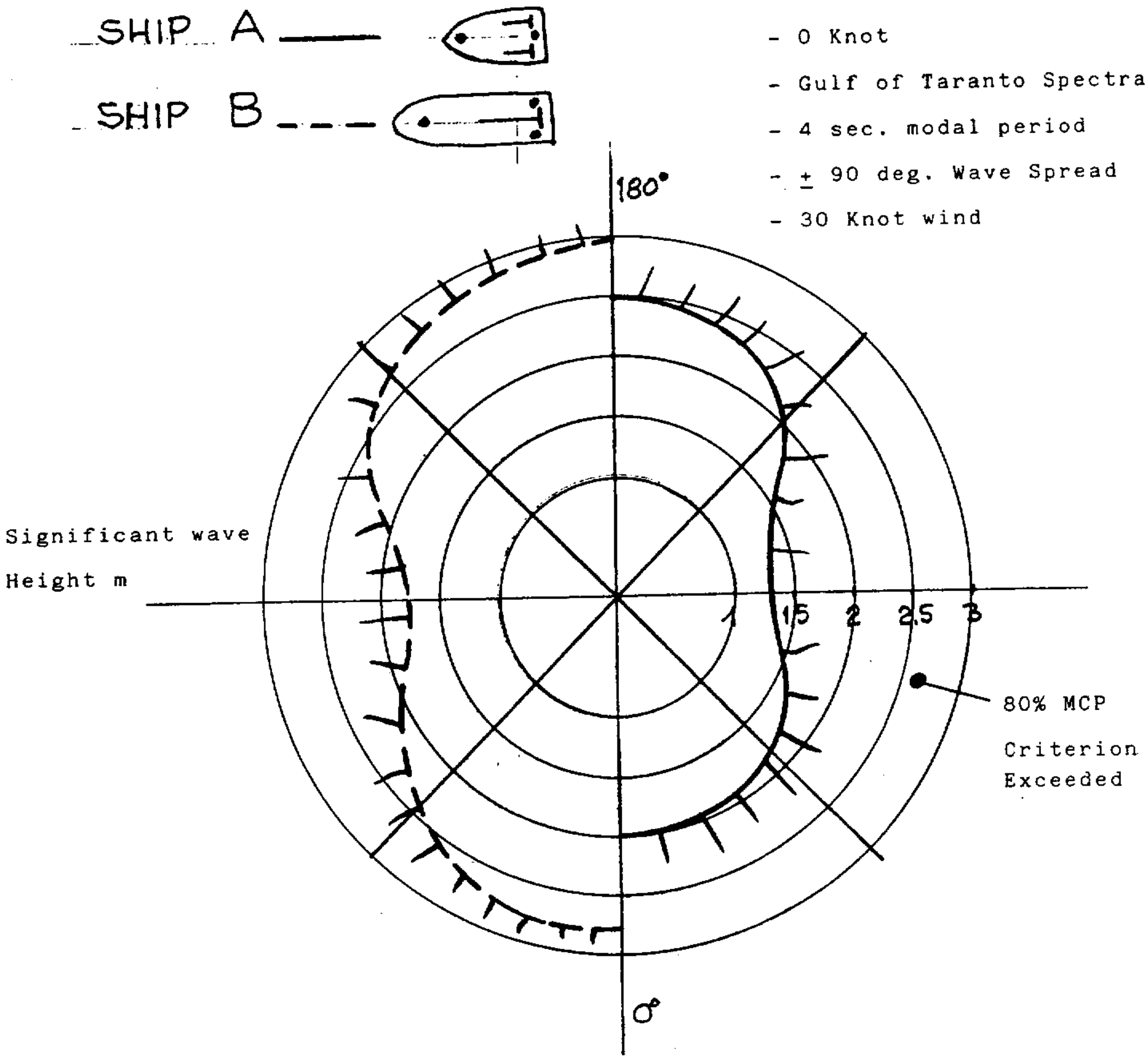

SHIP A
SHIP B
BOW SEA
JONSWAP SPECTRA
4 KNOTS
SIGNIFICANT WAVE HEIGHT, m
1
2
3
4
S.E.
V.A.
R.A.
S.E.
V.A.
R.A.
4
5
6
7
8
9
MODAL WAVE PERIOD, sec.

Figure D1



- 0 Knot
- Gulf of Taranto Spectra
- 4 sec. modal period
- ± 90 deg. Wave Spread
- 30 Knot wind

Fig. D 2 (a) Representative Illustration of Limiting Conditions Plot for Required Power.

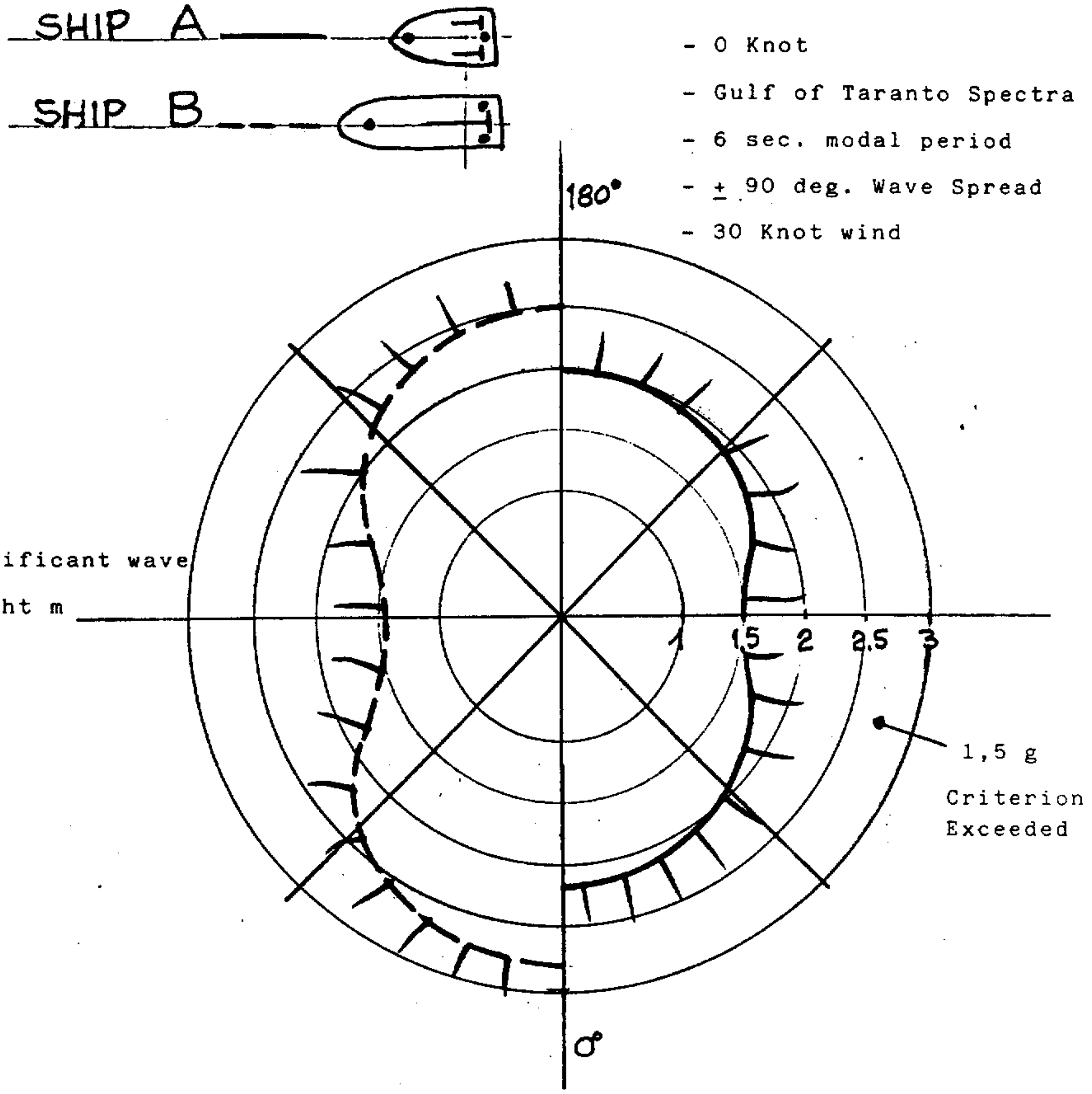
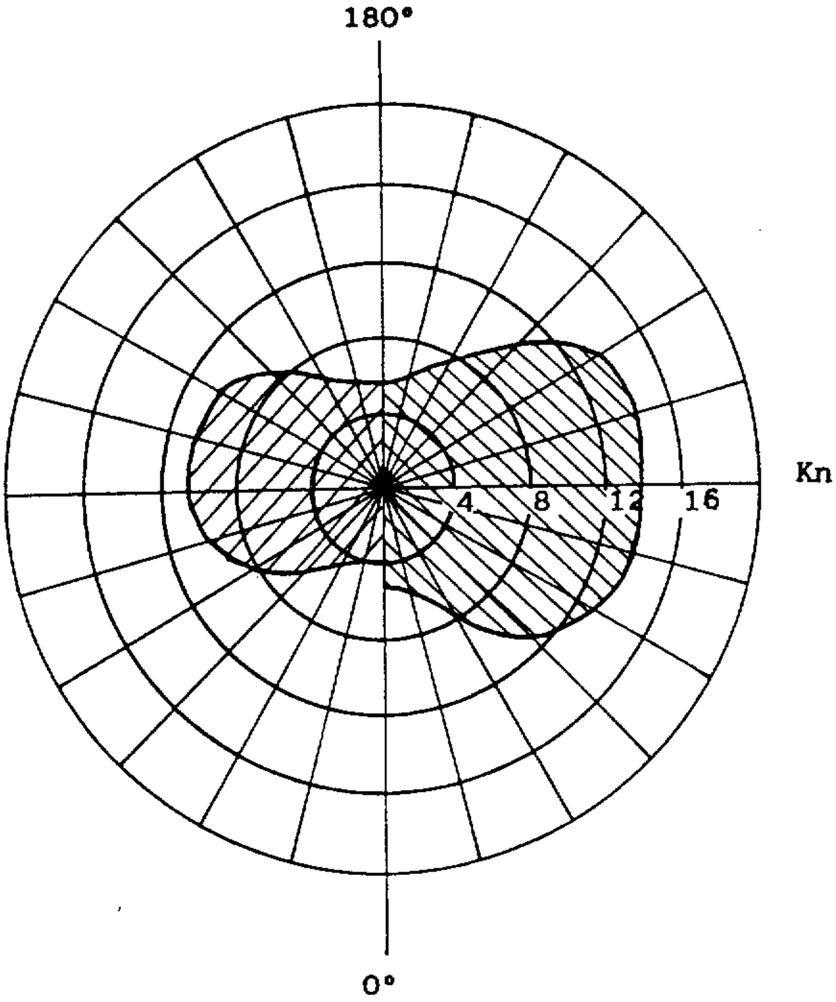


Fig. D 2 (b) Representative Illustration of Limiting Conditions Plot for Crane Top Vertical Acceleration.

NOTE : The graphs refer to the worst responses: Crane position opposite to incoming wave.



SHIP A **SHIP B**

2m Significant Wave Height
7sec Modal Wave Period
± 90 deg Wave Spread

▨ Roll Criterion 8° Exceeded

Figure D3: Representative Illustration of Limiting Condition Plot for Roll Motion.

ANNEX E

DEFINITIONS

Amplitude	The difference between the mean value and individual peak (or trough) of an oscillatory record.
Bilge keel	A fixed surface mounted on the hull to provide additional roll damping.
Course keeping	The ability of the ship to maintain a straight course under external disturbances. It can be specified quantitatively in terms of the stability index, of the characteristics of Dieudonne Spiral Manoeuvre, etc.
Dynamic positioning	The capability of the ship to maintain position and heading, under the presence of external disturbances, by using her propulsion devices only.
Heading	Ship's course relative to predominant direction of travel of waves or wind. 0 degrees = following 45 degrees = quartering 90 degrees = beam 135 degrees = bow 180 degrees = head
Irregular waves	A wave system having heights and periods which are not constant. It is "long" or "short" crested depending on whether the wave energy is unidirectional or multidirectional, respectively.
Linear system	A system in which the response is proportional to the input. In the present context a ship in which motion amplitudes are proportional to wave amplitudes.
Local struture	The hull structure close to the part of the hull which suffers from slamming.
Primary structure	The main structure of the hull.

Regular waves	Waves with constant height and period. Such waves exist only in theory and towing tanks.
Ride quality	A measure of ship motions in terms of the comfort of the ship's crew and their capability to maintain calm sea performance levels. Also known as human factors.
Rms	In the seakeeping context, the Root Mean Square is used for standard deviation of a signal abouts its mean value. This is only precisely correct for signal of zero mean.
Significant wave height	If all the wave heights (peak to trough) of a wave record are measured, the significant wave height is the mean value of the highest one-third of all the wave heights. It is approximately equal to the wave height estimated by an observer.
Slamming	When the ship's bottom re-enters the sea following emergence in rough weather an impact occurs and high pressures may be generated. The resulting impulse is called bottom slamming. Similar effects can occur under a heavily flared form: flare slamming.
Sonar dome emergence	Emergence of part of the sonar dome from the sea so that sonar transmission and reception is impaired.
Station keeping	The capability of the ship to maintain her position under the presence of external disturbances.

ANNEX F

REFERENCES

1. L.L. Martin "Ship manoeuvring and control in wind"
Trans. SNAME, vol. 88, 1980.

2. H. Eda "Directional stability and control of ships in restricted channels"
Trans SNAME, 1971

3. M.K. Ochi, W. Wang "Prediction of wave height of wind generated seas in finite water depth"
DTIC report, September 1984

4. A.R. Lloyd "HMS Fawn evaluation of passive roll stabilizer tank"
AEW Report No 25/71 1971

5. D.A. Walden "Practical methods for assessing seakeeping performance"
DTNSRDC report SPD-1089-01, August 1983

6. A. Cardo, A. Francescutto, R. Nabergoy "On damping models in free and forced rolling motion"
Ocean engineering, vol 9, 1982

7. A. Cardo, G. Michelacci "A stochastic model for the effect of wind on the roll of a ship"
International Shipbuilding Progress, vol. 29, June 1982

8. D.A. Walden, P. Grundmann "Methods for designing hull forms with reduced motions and dry decks"
Naval Engineers Journal, May 1985

9. N.E. Michelis, J.K. Miller, K.V. Taylor "Sloshing in partially filled liquid tanks and its effect on ship motions: numerical simulation and experimental verification"
Trans. RINA, 1984

10. R.T. Schmitke "Ship sway, roll, and yaw motions in oblique seas"
Trans. SNAME, vol 86, 1978

11. G.G. Cox, A.R. Lloyd "Hydrodynamic design basis for Navy ship roll motion stabilization"
Trans. SNAME, vol. 85, 1977

12. W.E. Farris "Ride quality criteria and assessment for advanced marine vehicles"
AIAA 8th Advanced Marine Systems Conference, September 1986, San Diego

13. M.K. Ochi, W.E. Bolton "Statistics for prediction of ship performance in a seaway"
International Shipbuilding Progress, vol. 20, 1973

14. A.E. Baitis "Validation of the Standard Ship Motion Program, SMP: Ship Motion Transfer Function Prediction"
DTNSRDC Report SPD-0936-03, July 1981

15. W.G. Meyers "User's manual for the Standard Ship Motion Program, SMP"
DTNSRDC Report SPD-0936-01, September 1981
(Software documentation to be requested from the US)

16. ITTC Standard for seakeeping model tests.

17. R.T. Schmitke "Prediction of ship roll, sway and yaw motions in oblique seas"
DREA Report 77/4, September 1977

18. Seakeeping Committee Reports, Proc. 15th and 16th ITTC, 1978 and 1981

19. M.K. Ochi, L.E. Motter "Prediction of slamming characteristics and hull responses for ship design"
Trans. SNAME, vol 81, 1973

20. M. Mackay, R.T. Schmitke "PHHS, a FORTRAN program for ship pitch, heave and seakeeping prediction"
DREA Technical Memorandum 78/A, February 1978

21. P.R. Payne "On quantizing ride comfort and allowable accelerations"
AIAA/SNAME Advanced Marine Vehicles Conference, September 1976

22. R.W. Shoenberger, "Subjective responses to very low frequency vibration"
Aerospace Medical Association Annual Meeting, May 1975

23. O'Hanlon, S. James, McCauley "Motion sickness incidence as a function of the frequency and acceleration of vertical sinusoidal motion"
Aerospace Medicine, April 1974

24. N. Hogben, Dacunha, Olliver "Global Wave Statistics"
BMT Ltd 1986

25. M.St. Denis, W.J. Pierson "On the motion of ships in confused seas"
Trans. SNAME, vol 61, 1953

26. "Estuary and coastline hydrodynamics", edited by A.T. Ippen, Mc Graw Hill, Inc, "Wave generation by wind in deep and shallow water", (C.L. Bretschneider), pp. 133-196, 1966

27. W.R. Mc Creight "Drift force investigation for a mine countermeasure ship"
DTNSRDC Report SPD-0854-04, 1979
(distribution limited)

28. W.R. McCreight "Equations and algorithms for estimating ship station keeping ability"
DTNSRDC Report SPD-1203-02, 1987
(distribution limited)

29. W.R. McCreight "MHC-51 Postion keeping evaluation"
DTNSRDC Report SHD-1242-02, 1987
(distribution limited)

30. J.N. Newman "The drift force and moment on ship in waves"
Journal Ship Research, vol 11, 1967

31. Norrby, Ridley "Notes on thrusters for ship manoeuvring and dynamic positioning"
Trans. SNAME, vol 88, 1980

32. M.S. Chislett, O. Bjorheden "Influence of ship speed on the effectiveness of a lateral-thrust unit"
Hydro-og Aerodynamisk Laboratories report HY-8, Lyngby, April 1966

33. M.K. Ochi "Prediction of occurrence and severity of ship slamming at sea"
Fifth Symposium on Naval Hydrodynamics, Office of Naval Research, 1964.

34. N.E. Michelis "A procedure for the prediction of ship manoeuvring response for initial design"
Computer Applications in the Automation of Shipyard Operation and Ship Design 5th, 1985

35. M. Hirano et al. "Manoeuvring Motion Prediction by Computer in Ship Design"
Computer Applications in the Automation of Shipyard Operations and Ship Design 4th, 1982

36. J. Daidola et al. "A Simulation program for Vessels' Manoeuvring at Slow Speeds"
SNAME STAR Symposium, Portland, Oregon, May 1986

37. C. Alexander et al. "Design and Verification for Adequate Ship Manoeuvrability"
Trans. SNAME vol. 91, 1983

38. IMD (International Maritime Organization) "Interim Guidelines for Estimating Manoeuvring Performance in Ship Design"
January 1985

39. A.R. Lloyd "A New Criterion for Acceptable Ship Motion (U)"
AEW-TR-77031, June 1977, CONFIDENTIAL

40. A.R. Lloyd, R.N. Andrew "Criteria for Ship Speed in Rough Weather"
18th ATTC, August 1977

41. A. Lawther, M.J. Griffin "Prediction of the incidence of motion sickness from the magnitude, frequency, and duration of vertical oscillation"
Journal Acoustical Society of America, September 1987