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SUPPLEMENT 1 TO STANAG 4154 GENERAL CRITERIA AND COMMON PROCEDURES FOR SEAKEEPING PERFORMANCE ASSESSMENT FAST PATROL BOAT

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1. ANEP-15, FAST PATROL BOAT SUPPLEMENT 1 to STANAG 4154 - General Criteria and Common Procedures for Seakeeping Performance Assessment is a NATO UNCLASSIFIED publication.

2. ANEP-15 is effective NATO-wide upon receipt.

3. ANEP-15 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.

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Major General, POAF
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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 15 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

GENERAL CRITERIA AND COMMON PROCEDURES FOR SEAKEEPING PERFORMANCE ASSESSMENT - FAST PATROL BOAT 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 publication is to establish general criteria for the operability and habitability aspects of seakeeping and common procedures to be followed by participating nations in the assessment and evaluation of seakeeping characteristics, in order to ensure satisfactory seakeeping qualities in the design of fast patrol boats and to enhance the interoperability of such vessels in joint operations. Fast patrol boats in the understanding of this publication are primarily those of the monohull semi-displacement type with maximum speeds corresponding to Froude numbers of more than about 0.7.

General

2. This publication follows very closely the formulations of STANAG 4154. Modifications are limited to those which are dictated by the peculiar characteristics of fast patrol boats.

3. The seakeeping qualities of a vessel are established by attention to:

(a) Underwater Hull Form and Particulars including Appendages which largely determine vessel motions and bottom slamming characteristics.

(b) Abovewater Hull Form and Freeboard which largely determine wetness, spray and flare slamming characteristics.

(c) Stabilisation Devices which have significant impact on lateral motions, predominantly roll.

(d) Weight Distribution

(e) Arrangements

4. Annex A describes how the above-mentioned general parameters affect seakeeping. Annex B formulates general criteria for ship seakeeping which enable design decisions ensuring satisfactory seakeeping qualities under the present state-of-the-art. These criteria will in general depend upon the ship's missions, equipment sensitivity and structural characteristics. Annex C identifies recommended computational and experimental procedures for assessment of ship seakeeping characteristics in the design process. Annex D presents a worked example illustrating 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:

Breakdown of the Problems of Seakeeping

1. A modern fast patrol boat carries a larger number of complex, inter-related systems operated by the crew than was previously usual for this type of ship. The term "seakeeping" is used to describe the ability of the ship including her sub-systems and crew to successfully perform her task despite adverse environmental conditions due to wind and waves.

2. The two driving factors in Fig. A1 are the natural environment, notably the seaway, and the ship's mission. The seakeeping phenomena of primary concern are motions, shipped water/spray and slamming. Additional phenomena shown are reduced stability in waves, involuntary speed loss and broaching. The primary seakeeping phenomena adversely affect the crew, the hull structure and the ship's various sub-systems. These detrimental effects may be grouped under the following three headings:

(a) Crew - performance degradation, fatigue, motion sickness, work restrictions, injury, loss overboard, poor visibility due to spray.

(b) Structure - including hull and superstructure - hull damage from bottom and flare slamming, damage to superstructure, structural fatigue.

(c) Equipment - performance degradation of weapons and sensors, damage from inertial loads and green water, reduction of propulsive efficiency, propeller racing.

3. These effects could individually or collectively stimulate a decision to modify mission objectives (for example, reduce speed, change course or cancel a certain operation) such that acceptable levels of loads and/or performance are achieved. The aim of giving due consideration to seakeeping in the design process is to reduce the severity of these effects to such a level that the ship can carry out her missions over the required range of sea conditions.

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

5. In the design process, seakeeping characteristics are established by attention to:

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

(b) abovewater hull form and freeboard;

(c) stabilisation and metacentric height;

(d) weight distribution and radii of gyration;

(e) arrangements;

(f) overall and local structural strength,

(g) appendages, e.g. spray rails, stern flaps.

The designer has greater control on (a), (b), (c), and (g).

6. The designer may also have an option to distribute crew, weapons and equipments in such a way that they are least affected by the adverse effects of the environment and the ship responses.

7. The structural design of the ship must take account of the wave loads including the loads exerted by slamming and wave impact. Fast patrol boats encounter high or even limiting sea conditions more frequently than larger vessels. Structural design criteria for the overall as well as the local structure should be established dependent upon the intended mission profiles and the sea areas of operation and should consider maximum loads as well as fatigue.

8. In the design process, the aspects of seakeeping should be addressed by specifying environmental conditions up to which certain missions are to be performed and the sea areas of operation. Under the current state-of-the-art, the effects of seakeeping on crew, structure and equipment are addressed by specifying acceptable levels of ship motion, slamming and deck wetness as a function of the intended mission. A recommended set of specifications for fast patrol boat seakeeping should consider the following phenomena, grouped according to the major design parameters of paragraph 5:

(a): (1) bottom slamming frequency and severity;
(2) pitch;
(3) vertical accelerations at a number of locations;
(4) measures of ride quality which account for the effects of motions on crew performance;
(5) propeller emergence;

(b): (6) frequency and severity of deck wetness;
(7) frequency and severity of flare slamming;

(c): (8) roll (including effect of stabilisation, if relevant);
(9) lateral accelerations at a number of locations.

9. In addition to its function as a design tool, sea-keeping performance assessment can provide information for the Commanding Officer which assists to fully exploit the ship's capabilities without undue risk for crew, equipment and structure.

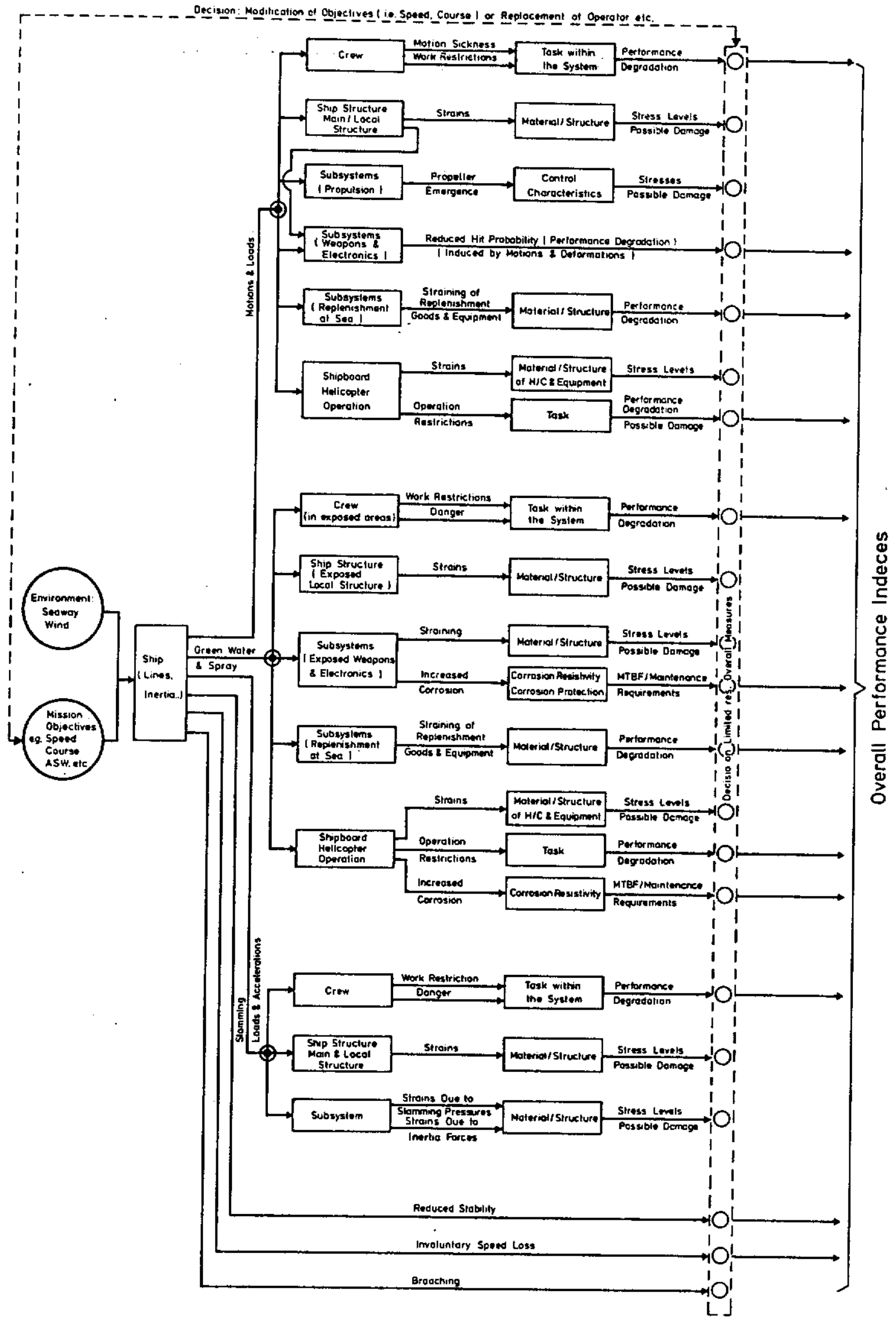

Figure A1: Effects of Seaway on Total Ship Performance

Annex B:

General Criteria for Fast Patrol Boat Seakeeping

1. The effects of seakeeping on crew, equipment and ship structure 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 limit values depend on the intended missions/tasks, on ship structure/material, and on equipment sensitivity. Design criteria should also consider the requirements of interoperability of ships which are expected to participate in joint NATO operations.

2. A recommended set of seakeeping phenomena which should be considered in the design process of fast patrol boats is given in paragraph 8 of Annex A. The factors governing definition of criteria for each of these aspects of seakeeping are listed below:

Phenomenon	Factors Governing Criteria and Definition
bottom and flare slamming	- strength of primary and local structure - material fatigue - crew tolerance to impacts - ability of equipment to withstand whipping accelerations
pitch, roll, vertical and lateral accelerations	- equipment specifications - specialised equipment handling
ride quality	- crew performance degradation - motion sickness and fatigue - work restrictions
propeller emergence	- propulsion machinery specifications
deck wetness	- visibility from bridge - strength of deck, superstructure and exposed equipment - requirement for crew to work on weather deck - loss of stability.

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

4. It is emphasised that seakeeping criteria must be given in a form which recognises the statistical nature of the problem. A specification of maximum values is insufficient as there is always a finite probability that a given value will be exceeded. Guidance is given in Reference 1. Examples are given in Annex D.

5. Usually a range of operational situations 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.

6. Bottom and Flare Slamming Criteria are derived from considerations of susceptibility to hull damage and operability. Criteria for limiting conditions arise from three sources:

(a) prevention of hull damage;

(b) ability of equipment and structure to withstand inertial loads due to whipping;

(c) crew tolerance to impact accelerations.

For fast patrol boats, slamming loads constitute one very important input to structural strength considerations. Therefore, the definition of acceptable limits of hull bending moments and bottom plating loads has to include the consideration that slamming must not cause damage of such severity to suspend operations or, in the extreme, to endanger the ship. The opposite approach could also be applied, i.e. requirements for hull girder and bottom strength are derived from the mission requirements. Under the present state-of-the-art, an estimate of hull bending moments in a given wave condition can be obtained by model tests or non-linear simulation as explained in Annex C. Since the non-linear simulation models are not fully consolidated criteria as well as limiting values may depend on the method used. Bottom-pressure criteria could be based on empirical formulations covered in Annex C. - An indirect approach based on estimates of slamming frequency is very customary for frigates and destroyers. Such an approach always implies certain assumptions on slamming severity. An example of such an application will be given in Annex D. -Criteria of type (b) may be formulated in much the same way as the hull damage criteria, with limits set on whipping acceleration amplitude or some other measure of structural response. Type (c) criteria for crew tolerance may be formulated by comparing the new design's slamming characteristics with a vessel known from operation experience to have superior slamming behaviour.

7. Pitch, Roll, Vertical and Lateral Acceleration Criteria are derived from operability considerations. Limits are set on response amplitudes (primarily pitch, roll motion and vertical and lateral accelerations) based on equipment specifications and requirements for specialised equipment handling including VERTREP.

8. Ride Quality Criteria are derived from operability and habitability considerations. Both motion severity and frequency content should be taken into account. With regard to vertical motions, the least complex criterion would take the form of limits on vertical accelerations at specified locations along the ship. The formulation of ride quality criteria should take into account that usually missions are shorter and response frequencies are higher than for frigates and destroyers. Criteria should also consider the differences in time history and spectrum shapes (Reference 2). Ride quality criteria for lateral motions may be formulated in a similar manner; however, for fast patrol boats, even roll is normally not considered to have a major separate impact on ride quality.

9. Propeller Emergence Criteria are derived from operation considerations for the propulsion machinery. This basically involves establishing a tolerance level for propeller racing and results in a limit on frequency of emergence.

10. Deck Wetness Criteria have the same level of importance as slamming criteria, because shipping of water may result in significant damage. Criteria are derived from the considerations of shipping of water at an adequate number of locations and on considerations of visibility from the bridge. It is also desirable to account for the severity of deck wetness, i.e. the amount of water on the deck and resulting forces on exposed personnel, structures and equipment. Criteria for reduced visibility which are not established at present, should be based on the formation and configuration of spray which is influenced by details of the hull form, viz. flare, knuckles, deflectors, spray rails, etc.

Annex C:

Recommended Computational and Experimental Procedures for Seakeeping Predictions for Fast Patrol Boats

1. This Annex identifies recommended computational procedures for prediction of fast patrol boat seakeeping qualities in the design process and for guidance on the capabilities of existing vessels. The reports of Seakeeping Committees of the various ITTCs recommend procedures and standards for model testing. It is emphasised that these are suggested procedures and that adoption of this publication does not preclude the use of alternative procedures providing these are of comparable or superior accuracy. This is an area of intense research and improved methods can be expected to appear in time.

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

(a) Specification of sea spectra;

(b) Ship motion response;

(c) Slamming;

(d) Propeller emergence;

(e) Deck wetness;

(f) Roll stabilisation;

(g) Involuntary speed loss;

(h) Ride quality.

3. Specification of Sea Spectra. Adequate description of the seaway environment is of high importance and must take into account the peculiarities of the envisaged sea areas of operation which are not normally the open ocean. A realistic range of wave spectra must be identified for each sea area of operation. Wave observation data may be obtained from references listed in STANAG 4194. For the North Sea hindcast data are given in Reference 3 and should preferably be used in identifying wave conditions. Satisfactory spectra formulations for sea areas of operation for fast patrol boats are:

(a) Measured wave spectra (see e.g. Reference 4);

(b) JONSWAP spectra formulation as recommended in STANAG 4194 for land-locked sea areas.

4. It is emphasised that a minimum of two parameters (significant wave height and characteristic wave period) must be used in specifying wave spectra. Further, at a given wave height, it is important to cover a realistic range of characteristic wave periods as some aspects of seakeeping, for example slamming, deck wetness or roll are sensitive to wave period. Source documents, as References 3 and 5 should be consulted to obtain the proper statistical distribution of wave period with wave height for sea areas of operational interest. It should also be recognised that seas are usually short-crested to some degree; the spreading should be selected for this purpose in accordance with ITTC recommendations.

5. Ship Motion Response. Satisfactory prediction of motion responses may be accomplished, in many cases, by regarding the ship as a linear system and employing the superposition principle to obtain motions in irregular seas. It should be considered that fast patrol boats may come in a wide variety of hull forms. In many cases FPBs are designed with full-width transom sterns. In such instances it may be advantageous to include the end-effect speed terms. The accuracy of the linear approaches is generally less satisfactory for large motions. Prediction of motion responses in regular waves may be divided into two separate problems:

(a) Vertical plane motions - surge, heave, pitch;

(b) Lateral plane motions - sway, roll, yaw.

These will be considered separately.

6. Of the vertical plane motions, surge is of concern only under specific conditions such as broaching. Towed systems are normally not relevant for fast patrol boats. For heave and pitch it can be said (see Reference 6) that existing linear strip methods are less accurate for fast patrol boats than for usual frigates and destroyers; but for round-bilge semi-displacement monohull fast patrol boats the accuracy can be considered fair at least up to Froude numbers of 0.7. A comparison of measured and calculated responses is published in Ref. 26. Non-linear extensions of the strip method promise improved accuracy, but existing approaches (as in References 7 and 8) show only marginal improvement. In summary, the following procedures are recommended for heave and pitch prediction:

(a) (linear) strip theory based computer programs, such as those listed in Reference 9 or provided with Reference 10, for fast patrol boats with round-bilge semi-displacement monohulls;

(b) Non-linear extensions of the strip theory, as in References 7 and 8, with a somewhat better accuracy than (a);

(c) Model tests in regular and irregular waves; these are the only realistic means for less well-behaved hull forms.

7. Trim and sinkage, as well as the effect of the bow wave profile, of wave distortion, and of dynamic swell-up, should be taken into account in predictions of relative motions and of emergence and deck wetness probabilities. Guidance could be derived from experimental data published in Reference 11. More reliable predictions may require model tests. It should be noted that full scale trials indicate that in a seaway trim is heading dependent.

8. Of the lateral plane motions, roll is by far the most important. Prediction of roll is complicated by the fact that roll damping has a significant non-linear component arising from viscous effects; this is usually accounted for by the technique of equivalent linearisation (Ref. 12). Based largely on the approach of Reference 13 and extensive recent work in Japan (see Reference 14) roll damping can be predicted with reasonable accuracy for normal hulls. These approaches developed for larger and slower vessels could also be useful for fast patrol boats.

The following procedures are recommended for roll prediction:

(a) Strip theory based computer programs, such as References 10 and 13 which take account of both dynamic lift on appendages and hull, and viscous effects in roll damping;

(b) Model tests in regular and irregular waves.

9. Slamming. Investigations into the seakeeping behaviour of fast patrol boats (Reference 15) confirmed that, for fast patrol boats, bottom and flare slamming is one of the primary speed limiting factors. Slamming is characterised by impact and whipping accelerations, hull girder bending moments and local impact pressures.

10. Computational methods are presented in Reference 16 for predicting slamming characteristics and hull response using only the ship lines; these methods were developed for larger ships but may also be used for fast patrol boats (as in the example in Annex D), but it should be noted that validation even for frigates and destroyers is incomplete. The following factors must be noted:

(i) Trim, sinkage and dynamic distortion should be included in calculating probability of keel emergence and relative velocity;

(ii) The form coefficients given in Reference 16 for calculation of slamming pressures may not be appropriate, especially for V-shaped bows. For hull sections of high deadrise and for higher forward speeds, the formulation of Reference 17 may be more adequate.

Data on relative motions and slamming pressures in irregular seas may also be obtained from model tests.

11. References 7 and 8 present alternate procedures to predict hull girder response to slamming which are based on an extension of the linear strip theory. Methods were specifically developed for predicting slamming characteristics (bottom as well as flare slamming) and hull girder response of fast patrol boats. Typical results include the rigid-body hull accelerations and bending moments as well as the whipping contributions to both. Reference 8 includes the prediction of bottom pressures based on Reference 17. Validation of these procedures is incomplete.

12. Relative motions to be used for the prediction of bottom pressures may either be obtained from linear or non-linear strip method calculations; the accuracy of the linear calculation appears sufficient for this purpose. Pressure coefficients should be based on Reference 17.

13. Yet another procedure is given in Reference 18 aimed at determining the whipping response of the hull in limiting conditions.

14. Propeller Emergence. Probability of propeller emergence on a given wave encounter may be estimated by standard methods proposed for larger ships, see for example Reference 1. References 18 and 20 present criteria. Results may be very sensitive to ship hull-wave interaction effects which cannot be treated with adequate accuracy at this time.

15. Deck Wetness. Reference 15 shows that deck wetness, in particular in the form of green water, is a major concern for Commanding Officers of fast patrol boats. Forebody sections of fast patrol boats show at least one of the following features: flare, knuckles, spray deflectors, hard chines. The influence of such features on the formation of spray and on green water may be considerable and may change the effective freeboard. It is highly desirable that prediction methods include these effects. None of the existing computational approaches seems to be able to include these effects. On the other hand, model tests may suffer from scale effects. As regards the probability and severity of deck wetness, methods for a rough estimate are given in Reference 20 which could also be applied to fast patrol boats.

16. Roll Stabilisation. A roll stabilisation system may be required to meet roll criteria specified. If a stabiliser is necessary, the choice of type is dependent on the ship's mission. Common practice is to install:

(i) bilge keels for low speed roll stabilisation;

(ii) active fins if special requirements are to be met at medium or high speeds.

17. Theory is adequate to predict the effectiveness of active fins. Allowance must be made for the effect of ship motions, hull boundary layer and fin-bilge keel interference on fin performance (see Reference 21).

18. Involuntary Speed Loss. Involuntary speed loss is rarely a factor in assessment of mobility for fast patrol boats in a seaway compared to voluntary speed reduction due to motions and other seakeeping phenomena.

19. Ride Quality. Methods for quantitative assessment of ride quality of naval vehicles are still in the formative stage. The methods given in References 22, 23 and 24 are in use pending the appearance of more complete and reliable procedures.

Annex D:

Examples of Procedures for Seakeeping Predictions

1. This Annex provides examples of the procedures described in Annex C. Postulated criteria are used pending development of a STANAG on seakeeping criteria. The examples are based upon the ship comparison procedure described below in paragraph 2. Those Annex C procedures which are not illustrated in the examples are then briefly treated.

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

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

(b) Specify the ships which will perform the mission 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, for the range of conditions specified in accordance with (a) and expressed in terms of the criteria variables from (b).

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

(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 a Transit Mission

Following paragraph 2 this example is specified as follows:

(a) Operational Scenario

(i) Transit Mission, i.e. all systems are fully operational from start to end of the transit,

(ii) short-crested head seas representative of the North Sea in winter,

(iii) Ship speed attainable in the context of voluntary speed reduction considerations.

(b) Ships

(i) Ship A - 54.4 m * 6.98 m * 2.40 m, 390 tonnes, 3.15 m freeboard at forward perpendicular (FP)

(ii) Ship B - 44.0 m * 6.60 m * 2.00 m, 265 tonnes, 2.75 m freeboard at FP.

(c) Criteria

(i) Bottom slamming probability of 4% at a location 15% of ship length (L) aft of FP,

(ii) Severe deck wetness probability of 7% at any location from the stem to 0,3L aft of the FP,

(ii) Significant single amplitude of absolute vertical acceleration equal to 0,55 g at the FP.

4. short-crested waves were used in this example because they tend to provide the more realistic conditions in head seas.

5. Transfer functions for pitch, heave and the associated vertical-plane kinematic responses of both ships in regular head waves were predicted using the strip theory computer program described in Reference 10. The computations were performed for ship speeds from 10 to 35 knots in 5-knots increments. The radius of gyration in pitch was taken to be 0,28 L for either ship.

6. Relative motions for use in the deck wetness computation were empirically corrected to account for bow wave effects based on the calm water bow wave. Such correction was not made in the case of slamming.

7. Linear superposition was applied to obtain the significant single amplitudes of ship response in unit significant height JONSWAP wave spectra (Ref. 3 or 5) with modal wave periods covering the relevant range of wave conditions shown in Fig D1. These statistics were used to compute the limiting significant wave heights associated with each of the three criteria specified in paragraph 3. For slamming and wetness computations, draft and freeboard were empirically corrected to account for change of level, i.e. for trim and sinkage.

8. The ultimate limiting wave heights from paragraph 6 were drawn as illustrated in Figure D1. This figure applies to ships A and B and 20 knots. Given the postulated criteria, Figure D1 indicates that ship A can sustain speeds of 20 knots in head seas of about 1.5 m significant wave height; the corresponding limit for ship B is about 1.35 m. These limits refer to the most adverse wave period.

9. The information can be used to derive a 'limiting speed' presentation via interpolation over ship speed. Figure D2 illustrates the results for ships A and B in waves of 1.5 m significant height. It can be concluded that in this case ship A is limited to speeds of about 23 knots and ship B to speeds of about 15 knots. In both cases the limiting criterion is the vertical acceleration at the forward perpendicular.

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

(a) Roll

(b) Flare Slamming

(c) Propeller Emergence

(d) Involuntary Speed Loss

(e) Ride Quality.

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

11. Roll. 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 condition (significant wave height and modal wave period) as parameter of the diagram. Again, short-crested seas were used (see figure D3).

In fig. D3 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.)

12. Flare Slamming. As noted in Annex C, computational methods can be applied to flare slamming under idealised conditions. Model experiments may be the only reliable means of assessing oblique flare impact in confused seas.

13. Propeller Emergence. The computational procedure for the phenomenon is essentially the same as involved in the bottom slamming and deck wetness computations. Present computational means are not very reliable because the hull-wave interaction is not included in a satisfactory way. No example is shown.

14. Involuntary Speed Loss. Involuntary speed loss is usually of less concern than voluntary speed reduction.

15. Ride Quality. Annex C notes that ride quality is not well defined at the present state-of-the-art. Therefore no example is presented.

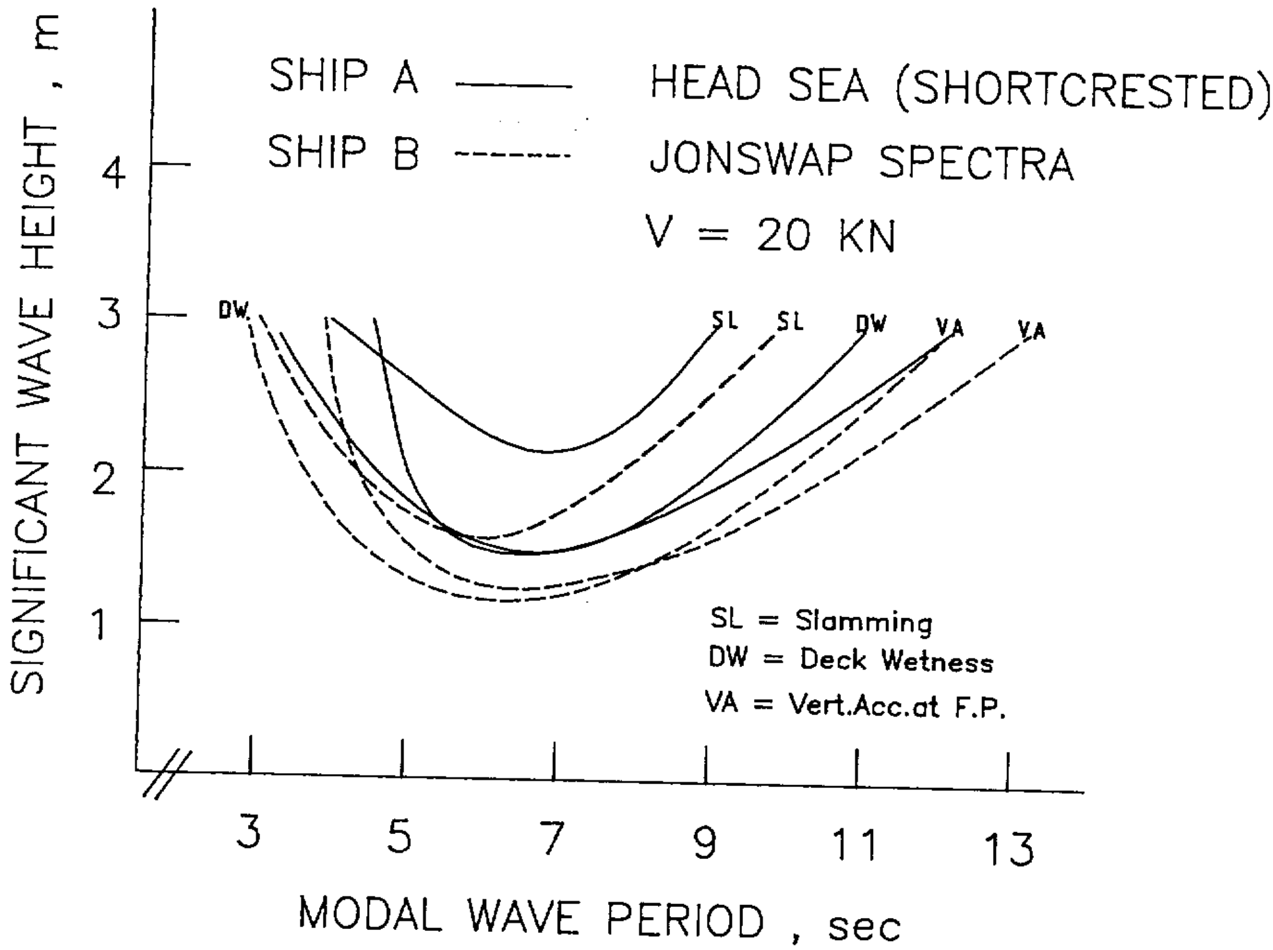

Figure D1: Representative Illustration of Limiting Condition Plots for the Transit Mission

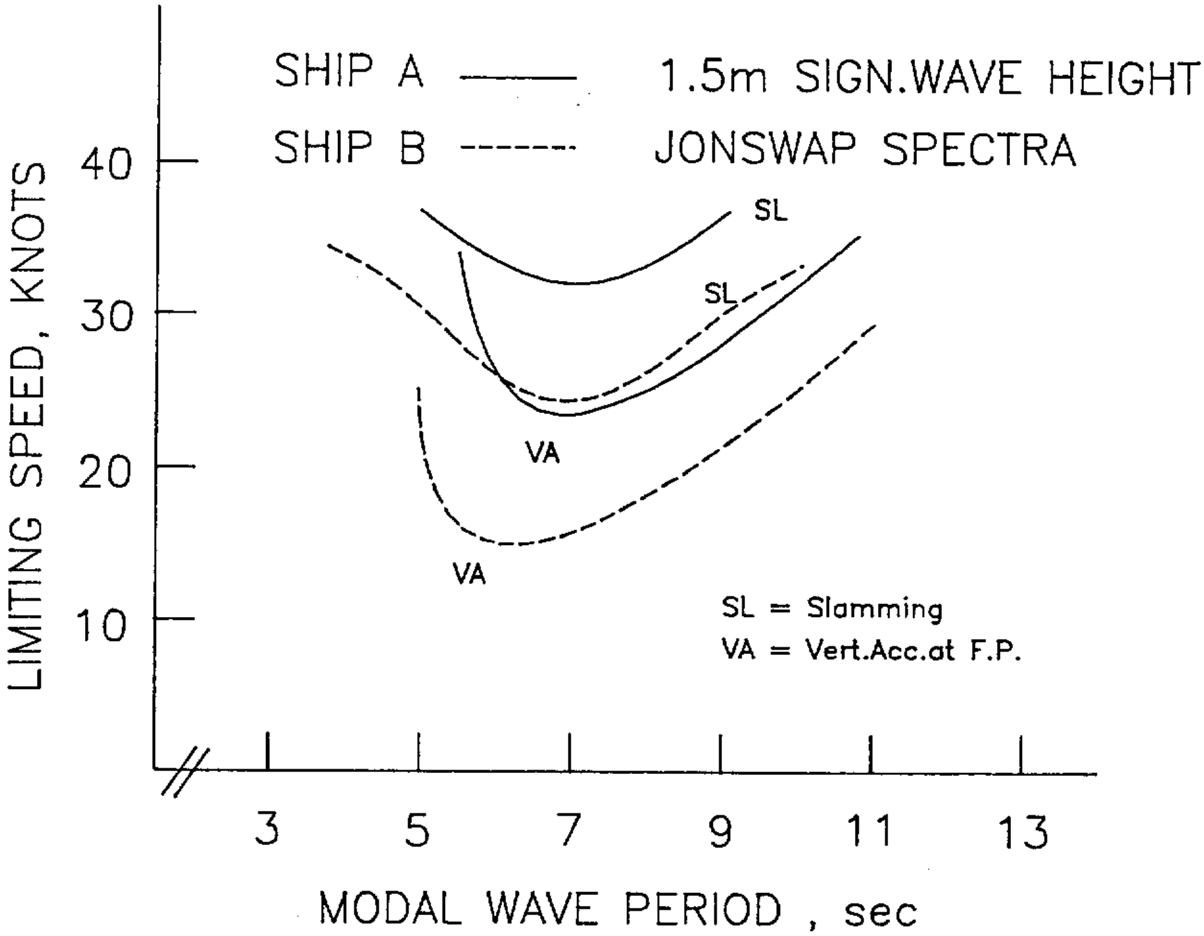

Figure D2: Transit Mission Limiting Speed Comparisons

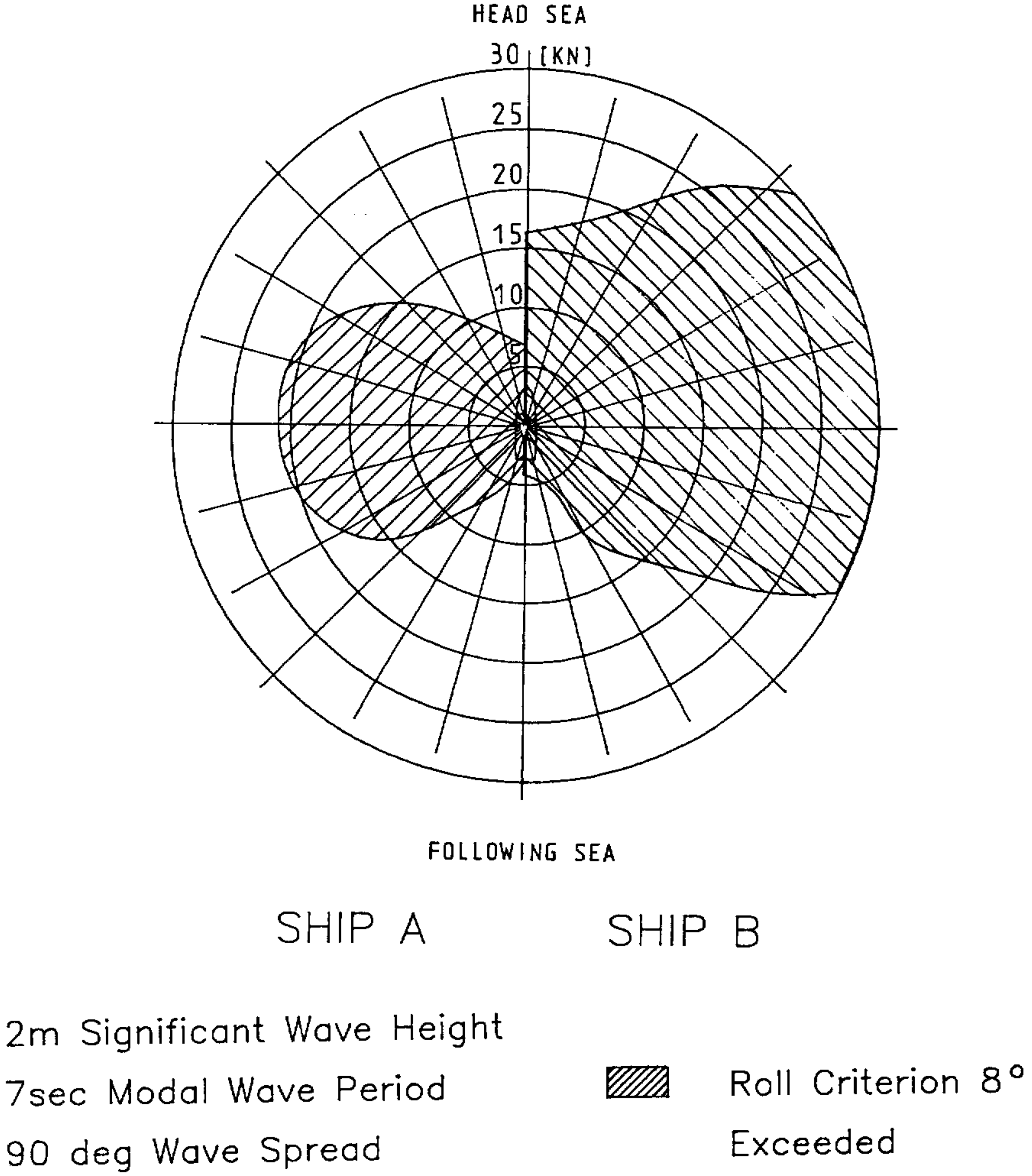

Figure D3: Representative Illustration of Limiting Condition Plots for Roll Motions

Annex E:

DEFINITIONS

Added resistance	In calm water at a given speed a certain resistance to forward motion is experienced by the ship. In waves this resistance increases and the difference is termed added resistance.
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.
Broaching	In following and quartering seas a ship may become difficult to steer. If control is lost the ship will swing violently onto a beam sea heading with a very large roll motion. This is called broaching.
Deck wetness	In ship motion calculations, the condition arising where the deck edge drops below the water surface; this is also referred to as "green water". The term "spray" is used to describe a non-severe type of deck wetness due to wind-blown broken water.
Freeboard	The height of the deck edge above the undisturbed waterline.
Forward perpendicular	The vertical line intersecting the stem at the undisturbed waterline.
Fin	Active roll stabilisation lifting surface mounted on hull.
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

Heave	Oscillatory vertical motion of ship's centre of gravity.
Hydrostatics	Relationship between buoyancy, righting moment, etc. and draught and trim.
Involuntary speed loss	For a given output of engine power, a ship achieves a lower speed in a seaway than in calm water. This reduction in speed is the involuntary speed loss.
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 multi-directional, 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 structure	The hull structure close to the part of the hull which suffers from slamming.
Metacentric height	The vertical distance between the centre of gravity and the metacentre: the parameter which governs the "stiffness" of the ship in roll.
Motions	General term describing the motions of the ship in rough weather.
Pitch	Oscillatory angular motion about a lateral horizontal axis.
Primary structure	The main structure of the hull.
Propeller emergence	Emergence of part of the propeller from the water.
Propeller racing	Sudden increase in propeller revolutions following propeller emergence.
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 context of seakeeping, RMS (root mean square) is used for standard deviation of a signal relative to its mean value. This is only precisely correct for signals of zero mean.
Roll	Oscillatory angular motion about a horizontal longitudinal axis.
Sea state	Generic term describing the roughness of the sea. It has no precise definition but scales of sea state number and significant wave height have been proposed.
Significant waveheight	If all the waveheights (peak to trough) of a wave record are measured the significant waveheight is the mean value of the highest one-third of all the waveheights. It is approximately equal to the waveheight estimated by an observer.
Slamming	When the ships bottom re-enters the sea following emergence in rough weather an impact occurs and high pressure may be generated. The resulting impulse is called bottom slamming. Similar effects can occur under a heavily flared form and this is called flare slamming.
Sonar dome emergence	Emergence of part of the sonar dome from the sea so that sonar transmission and reception is impaired.
Spectrum	A function defining the relationship between the amplitude and frequency of a process, such as the energy in an irregular wave system, or the ship response thereto.
Stability	Generic term indicating the ship's resistance to capsize.
Stabilization mode	Indicating whether roll stabilizers are in use or not.

Station number	System of identifying a longitudinal location in ship.
Superposition	The mathematical process of calculating the response of a linear system in irregular waves.
Superstructure	The part of the ship above the main hull.
Surge	Oscillatory horizontal longitudinal motion of the ship's centre of gravity.
Sway	Ocillatory horizontal lateral motion of the ship's centre of gravity.
Whipping	The vibration of the ship's structure following slamming.
Worst heading	The heading on which the worst motion occurs. This will depend on the motion considered.
Yaw	Oscillatory angular motion about a vertical axis.

Annex F:

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