NATO STANDARD

AMP-15

STANDARDS FOR NAVAL MINE WARFARE ACOUSTIC MEASUREMENTS

Edition (A) Version (1)

MAY 2013

NORTH ATLANTIC TREATY ORGANIZATION

ALLIED MINE WARFARE PUBLICATION

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NATO STANDARDIZATION AGENCY (NSA)

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May 2013

PUBLICATION NOTICE

1. AMP-15 (A)(1), STANDARDS FOR NAVAL MINE WARFARE ACOUSTIC MEASUREMENTS, is effective upon receipt. It supersedes AMP-15 Change 1.

2. Summary.

a. The title of this publication is amended from AMP 15, STANDARDS FOR MINE WARFARE ACOUSTIC MEASUREMENTS to AMP-15 Edition (A) Version (1), STANDARDS FOR NAVAL MINE WARFARE ACOUSTIC MEASUREMENTS.

b. This publication has been reformatted to meet the requirements set forth in AAP-3 Edition (J) Version (2). Changes agreed upon during the 2010 NATO Naval Mine Warfare Working Group have been incorporated and editorial corrections have been made throughout.

c. All references to “Mine Warfare,” “Mine Countermeasures,” and “mines” throughout this publication refer to “Naval Mine Warfare,” “Naval Mine Countermeasures,” and “sea mines”.

d. This edition clarifies terms related to the acoustic goal.

This notice will assist in providing information to cognizant personnel. It is not accountable.

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NORTH ATLANTIC TREATY ORGANIZATION (NATO)

NATO STANDARDIZATION AGENCY (NSA)

NATO LETTER OF PROMULGATION

7 May 2013

1. The enclosed Allied Tactical Publication AMP-15, Edition A, Version 1 - STANDARDS FOR NAVAL MINE WARFARE ACOUSTIC MEASUREMENTS, which has been approved by the nations in the Military Committee Maritime Standardization Board, is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 1418.

2. AMP-15, Edition A, Version 1 is effective upon receipt and supersedes AMP-15 which shall be destroyed in accordance with the local procedure for the destruction of documents.

3. No part of this publication may be reproduced, stored in a retrieval system, used commercially, adapted, or transmitted in any form or by any means, electronic, mechanical, photo-copying, recording or otherwise, without the prior permission of the publisher. With the exception of commercial sales, this does not apply to member nations and Partnership for Peace countries, or NATO commands and bodies.

4. This publication shall be handled in accordance with C-M(2002)60.

Dr. Cihangir AKSIT, TUR Civ
Director, NATO Standardization Agency

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATIONS BY NATIONS
1	
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General	LTU, TUR, USA

NOTE

THE RESERVATIONS LISTED ON THIS PAGE INCLUDE ONLY THOSE THAT WERE RECORDED AT TIME OF PROMULGATION AND MAY NOT BE COMPLETE. REFER TO THE NATO STANDARDIZATION DATABASE FOR THE COMPLETE LIST OF EXISTING RESERVATIONS.

RECORD OF RESERVATIONS

NATION	SPECIFIC RESERVATIONS
LTU	Due to the shortage of equipment LTU navy is not able to fully implement the standard for naval mine warfare acoustic measurements. The standard will be seen only as a guide for mine warfare planning.
TUR	Turkish Navy will not be able to implement this STANAG because of the non-availability of an Acoustic Measurement Centre; nevertheless, this STANAG will be used only for Mine Warfare planning purposes.
USA	US Navy implementation includes US Marine Corps.

NOTE

THE RESERVATIONS LISTED ON THIS PAGE INCLUDE ONLY THOSE THAT WERE RECORDED AT TIME OF PROMULGATION AND MAY NOT BE COMPLETE. REFER TO THE NATO STANDARDIZATION DATABASE FOR THE COMPLETE LIST OF EXISTING RESERVATIONS.

NATO NATIONS
EACH NATION SHOULD SUBSTITUTE ITS OWN
NATIONAL LETTER OF PROMULGATION IF REQUIRED

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CONVENTIONS USED IN THIS PUBLICATION

CHANGE SYMBOLS

Revised text in changes is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol indicates added or restated information. A change symbol in the margin adjacent to the chapter number and title indicates a new or completely revised chapter.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to warnings, cautions, and notes used in this manual:

WARNING

AN OPERATING PROCEDURE, PRACTICE, OR CONDITION THAT MAY RESULT IN INJURY OR DEATH IF NOT CAREFULLY OBSERVED OR FOLLOWED.

CAUTION

AN OPERATING PROCEDURE, PRACTICE, OR CONDITION THAT MAY RESULT IN DAMAGE TO EQUIPMENT IF NOT CAREFULLY OBSERVED OR FOLLOWED.

NOTE

AN OPERATING PROCEDURE, PRACTICE, OR CONDITION THAT REQUIRES EMPHASIS.

WORDING

Word usage and intended meaning throughout this publication is as follows:

“Shall” indicates the application of a procedure is mandatory.

“Should” indicates the application of a procedure is recommended.

“May” and “need not” indicates the application of a procedure is optional.

“Will” indicates future time. It never indicates any degree of requirement for application of a procedure.

PREFACE

1. Purpose.

The purpose of AMP-15 is to provide procedures for the measurement and reporting of acoustic signature information and for the establishment of acoustic signature goals to counter the naval sea mine threat to Allied and National Commands. AMP-15 is intended for application at all planning, operational and tactical levels.

2. Scope.

AMP-15 covers all aspects of measuring and reporting acoustic information and setting acoustic goals to counter the threat from acoustic naval sea mines to naval mine countermeasures vehicles, warships, merchantmen, naval mine countermeasures helicopters, divers, remotely operated vehicles and untethered unmanned vehicles.

3. Associated Allied Publications.

a. ATP-06, Volume I, Naval Mine Warfare Principles, is used at the operational level by personnel involved in minefield and naval mine countermeasures planning, sea mine threat, minelaying and naval mine countermeasures operations.

b. ATP-06, Volume II, Naval Mine Countermeasures Operations, Planning and Evaluation, is used at the operational level for planning, conducting and evaluating, naval mine countermeasures operations.

c. ATP-24, Volume I, Naval Mine Countermeasures Tactics and Execution, contains naval mine countermeasures information and guidance for operations at sea.

d. AEODP-1, Underwater Munition Disposal Procedures, is used by explosive ordnance disposal (EOD) personnel in underwater operations.

e. Other associated Allied Publications are:

1. AMP-12, Catalogue of Mine Warfare Computer Programs.

2. AMP-13, Volume I, Introduction and Definition of Terms for NATO Sea Mines.

3. AMP-13, Volume II, Characteristics of NATO Sea Mines.

4. AMP-13, Volume III, Characteristics of NATO Exercise and Training Mines.

4. International Units System.

a. The international units system (*Systeme International d'Unites*—short title "SI units") is the standard NATO system of measurement.

b. The acoustic sound pressure level (SPL) is expressed as the root mean square (RMS) magnitude of the sound pressure in decibels referenced to 1 micropascal (μ Pa) for a specific frequency band or specified line. Spectrum-level data is expressed as RMS magnitude referenced to 1 μ Pa per unit bandwidth (dB re 1 μ Pa/√Hz).

c. Unless otherwise stated, the following units of measurement are used in AMP-15.

Period (P)(seconds)	Time in seconds for a cyclic phenomenon to repeat itself.
Frequency (f)(cycles)(Hertz)	Repetitions per unit time 1/P (Hertz).
Bandwidth (w)	The difference between an upper frequency, f_u, and a lower frequency, f_l.
Band	The frequencies, f, between an upper, f_u, and lower limit, f_l.
Octave	The eighth full tone above a given tone having twice the frequency of the starting tone.
Octave Bands	Full Octave: $f_u/f_l = 2$ 1/3 Octave: $f_u/f_l = 2^{(1/3)}$ 1/10 Octave: $f_u/f_l = 2^{(1/10)}$
Linear Band	1 Hertz: $f_u - f_l = 1$.
Filter	An input output device which passes energy having frequencies between an upper and lower limit only.
Filter Center frequency	Defined generally as $f_c = \sqrt{(f_u f_l)}$
Length (meters)(m)	Unit of length.
Power (Watt)(w)	Energy per unit of time (Joules/second).
Acoustic Pressure (SPL)(dB re 1 μ Pa)	Sound Pressure Level (time varying component of the pressure).
Acoustic Pressure Spectral Density (PSL)(dB re 1 μ Pa/√Hz)	Pressure Spectrum Level (time varying component of the pressure at each frequency averaged for frequencies within √(1/2 Hz) of the frequency.
Acoustic Intensity (IL)(dB re 6.76 x 10^{-19} W/m^2)	Intensity Level (average power per unit area associated with the SPL. In water, a root mean square (RMS) pressure, SPL, of 1 μ Pa is equivalent to an IL of 6.4 x 10^{-12} W/m^2).
Acoustic Intensity Spectral Density (ISL)(dB re 6.76 x 10^{-19} W/m^2-Hz)	Intensity Spectrum Level (average power per unit area at each frequency averaged for all frequencies within 1/2 Hz of the center frequency).
Decibel (dB)	A unit used to describe sound levels. 10 $\log_{10}$ (ratio of two numbers).
Signal to Noise Ratio (S/N)	Ratio of the acoustic power generated by a source to the acoustic power of the ambient noise in a frequency band as measured by the sea mine fuze.
Detection Threshold (DT)	A specific sea mine fuze S/N providing a specified probability of detection and probability of a false detonation. (DT = 10 log[S/N]).
Transmission Loss (TL)	TL = 20 log (range) (re 1 meter) in the far field.
Reference Acoustic Goal (AGO)	A reference acoustic level corresponding to the actuation level of the existing potential acoustic sea mines.
Target Level	A PSL corresponding to the Reference Acoustic Goal (AGO).
Acceptable Risk	An interim margin added to AGO to set the Interim Level.
Supplementary Margin ($S_{up}M$)	A supplementary margin added to the Interim Level to set the Limited Level.
Safety Margin (SM)	A (negative) margin added to AGO to set the Acoustic Goal of Order 1 AG1.

d. For international use, units of measurement of the nation concerned may be used. Some equipment will be based on old systems until conversion to SI units is complete. Additionally, some data in this book may have been devised and collected in non-metric units of measurement. Where this is so, NATO agreed conversion factors are to be used. The following shows some agreed factors for conversion from cgs units (centimetre, gramme, second system) to SI units:

Quantity	cgs Units	SI Units	Conversion Factors
Force	dyne (dyn)	newton (N)	1 dyn = 10^{-5} N 1 N = 10^{5} dyn
Pressure	microbar (µbar) 1 µbar = 1 dyn/cm^2	pascal (Pa) 1 Pa = 1 N/m^2	1 µbar = 10^{-1} Pa 1 Pa = 10 µbar 1 µbar = 10^{5} µ Pa

e. When data is reported as dB (re 20 µ Pa/√Hz), it can be converted to dB (re 1 µ Pa/√Hz) by adding 26 dB. For example, 54 dB (re 20 µ Pa/√Hz) = 80 dB (re 1 µ Pa/√Hz).

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CHAPTER 1 Acoustic Goal for the Sea Mine Threat

0101 Introduction

This publication provides an acoustic goal or target for use in developing equipment for use by naval mine countermeasures (MCM) forces or for establishing operational constraints on existing equipment.

This publication also provides standards for measuring and reporting acoustic characteristics of ships, helicopters, underwater vehicles and MCM divers.

0102 Acoustic Goal Defined

1. An acoustic goal for MCM assets operating in the vicinity of acoustic sea mines is defined by the sensitivity threshold of the sea mine, the distance between the sea mine and the asset, the ambient noise level in the operating environment and the acceptable risk or desired safety margin (SM). Assets with lower radiated signatures or operating in noisy environments can operate closer to sea mines or operate in shallower water. If specific information is known concerning the characteristics of the sea mine fuze, specific operating parameters can be established.

This publication uses as a basis for establishing acoustic goals, the threat acoustic detection levels (DT). These levels are established by constraints placed on a naval sea mine developer in making tradeoffs between the probability of a false detection and the probability of failing to detect an appropriate target within the damage radius of the sea mine. In one case, an investment in delivering the sea mine is lost because the sea mine detonates or uses up battery power to make an “acoustic look”. In the other, the sea mine does not serve its intended purpose. In general, “acoustic only” sea mine fuzes fire on sure things, and sea mines with combination fuzes take an acoustic look only when a strong signal is present.

The probability of a false detection derives from environmental noise. If DT is set too low, spurious noise will eventually remove the sea mine through a detonation of an acoustic only fuze or battery run down of a combination fuze, even where an adaptive filter is used.

A sea mine emplaced in the ocean, sea, or estuary must separate the signature of a target from the ambient noise at ranges within the damage radius of the sea mine. Therefore, an MCM asset need only to have the distance of closest approach, a radiated acoustic signature below the S/N ratio or DT required to activate the sea mine.

2. The representation of acoustic energy can be done in several ways. In the AMP, acoustic energy is described by the Fourier transform of the acoustic pressure, SPL, which is a continuous line on a graph and describes acoustic pressure spectrum lever (PSL), for a band 1 Hz wide, versus frequency.

3. Face to the threat represented by existing potential acoustic sea mines, the **reference acoustic goal (AGO)** is a reference acoustic level corresponding to the actuation level of such sea mines. **AGO** is represented by a curve made up of straight segments joining a number of points, as defined in **AMP-15 CONF SUPP Version (1) chapter 1**. See figure 1-1.

4. Noting that the lowest sea mine actuation level of current NATO mines is some higher than that represented by the AGO, an interim margin called **acceptable risk (AR_{MCM})** can be added to **the AGO**, to set a new reference line: the **interim level**.

$$\textbf{Interim Level} = \textbf{AGO} + AR_{MCM}$$

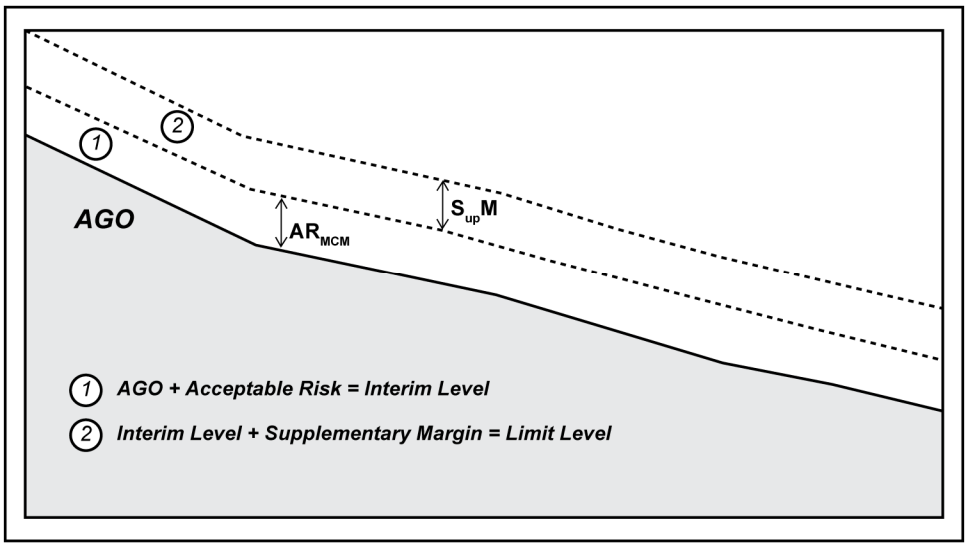


Figure 1-1. Illustration of Interim Level and Supplemental Margin

An **interim level** is a line generated by adding the $\mathbf{AR_{MCM}}$ to the curve defined by the above **AGO**.

Standardized values of the $\mathbf{AR_{MCM}}$ are contained in **AMP-15 CONF SUPP** chapter 2.

5. Besides the $\mathbf{AR_{MCM}}$, an additional **supplementary margin ($\mathbf{S_{up}M}$)** can be added, to set the **limit level**.

$$\textbf{Limit Level = Interim Level + } \mathbf{S_{up}M}$$

So a **limit level** is a line generated by adding the $\mathbf{S_{up}M}$ to the curve defined by the above **interim level**.

Standardized values of the $\mathbf{S_{up}M}$ are contained in **AMP-15 CONF SUPP** chapter 2.

6. To face the threat represented by future sea mines, that may have detection thresholds lower than current ones, a new negative margin called **safety margin (SM)** may also be added to the above **AGO**. The new line that is obtained by doing so is called the **acoustic goal of order 1 (AG1)**.

$$\textbf{AG1 = AGO – SM}$$

Specific **SM** are defined in **AMP-15 CONF SUPP** chapter 2 for MCMVs **($\mathbf{SM_{MCM}}$)** and Divers **($\mathbf{SM_{Divers}}$)** respectively. See figure 1-2.

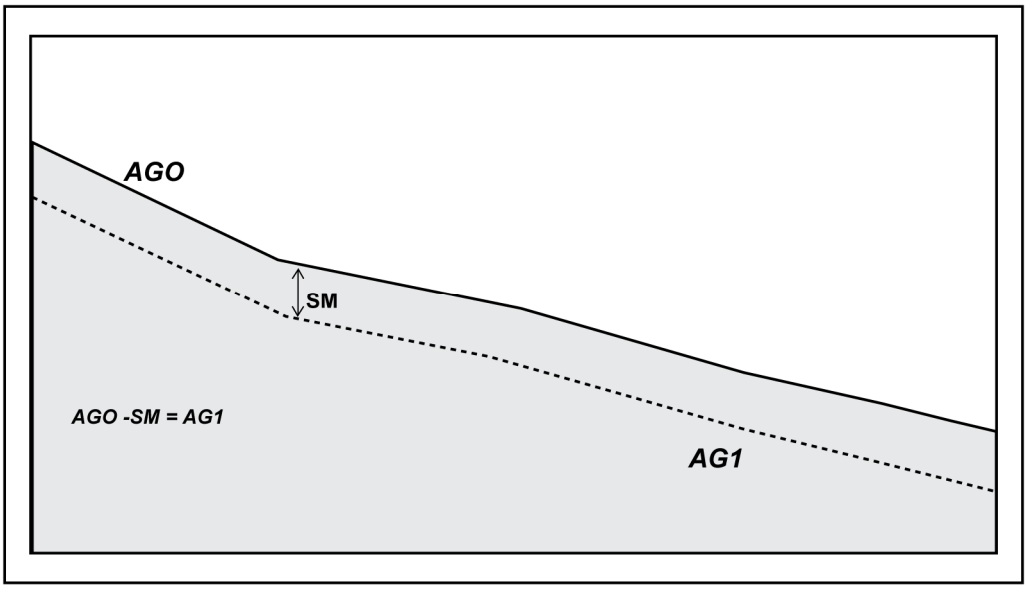


Figure 1-2. Illustration of Safety Margin and Acoustic Goal of Order

0103 Application of the Acoustic Goal (AGO)

1. The application of the goal is in the context of the threat from sea mines. Its use is twofold:

   a. As a target for the purposes of noise reduction.

   b. As a reference level for assessing the risk from acoustic sea mines set to the most sensitive actuation level.

   c. As a means for minimizing the SPL of a MCM vessel by modifying the operational configuration, that is by changing propeller pitch, shaft speed, operating water depth, modifying the operation of auxiliary equipment, etc.

2. The target may be applied to present and future ships, vessels, craft and equipment. Examples specific to naval mine countermeasures are:

   a. Naval mine countermeasures vessels (MCMV).

   b. Helicopters, hydrofoils and other novel MCM craft.

   c. Surface and underwater sea mine disposal vehicles.

   d. Sea mine clearance divers (MCD).

   e. Remotely operated vehicles and untethered unmanned vehicles.

3. Each reference distance from the acoustic source to the point of the sea mine at which the comparison with the target is to be made is stipulated by the specific operational requirement. For example:

a. In the application of the target to MCMV, the acoustic levels must first be corrected from the conventional reporting distance of 1 metre (1 m) to a point on the seabed beneath the ship when it is operating in its required minimum water depth (a ground mine is assumed). Comparison may then be made with the goal.

b. Similarily for the underwater noise from a helicopter.

c. For the underwater sea mine disposal vehicle, the application is similar, but the acoustic levels reported at 1 m are first corrected to the nearest approach distance which is expected during the positioning of the disposal weapon with respect to the sea mine.

d. The goal may also be applied to the noise from a diver (e.g., a sea mine clearance diver (MCD)). The acoustic levels of the diver or his equipment would first be corrected from the 1 m reporting distance (from a stated reference point), to a distance representative of the diver when operating on the sea mine.

4. As an alternative to applying theoretical corrections to report acoustic signatures at a standard distance, the acoustic signature units can use either the distance at which the measurement was made or the operational distance of closest approach. For example, the acoustic level of a remotely operated vehicle could be reported as **dB (re 1 µ Pa/√Hz) at 2 m**.

0104 General Conditions of Applicability

1. When referring the goal specifically to MCMV, the following general conditions apply:

a. Speed—All normal operating speeds.

b. Tow—All normal towing conditions.

c. Manoeuvres—All normal manoeuvres used in minehunting.

d. Depth of Water—Minimum sweeping or hunting depth for class of ship.

2. When referring the goal to MCM helicopters the following general conditions apply:

a. Speed—All normal operating speeds.

b. Tow—All normal towing conditions.

c. Depth of Water—Minimum sweeping or hunting depth for type of helicopter.

d. Altitude—The minimum altitude for the type of craft and the operation.

CHAPTER 2 Standards for Use When Measuring and Reporting Acoustic Characteristics for Sea Mine Vulnerability

0201 General

This and subsequent chapters cite standards for use when measuring and reporting the acoustic characteristics of naval mine countermeasures vessels (MCMV) and naval mine countermeasures helicopters. The standards also apply to acoustic characteristics of warships and merchantmen in relation to sea mine risk. The units, reference values, forms and methods set forth herein are to be used.

0202 Acoustic Units and Reference Value

1. The unit of sound pressure will be the micropascal **(μ Pa)**.

2. Sound pressure level will be quoted in **dB** with reference to the **μ Pa**, that is 20 log P/P_o

where P = rms sound pressure in μ Pa
P_o = 1 μ Pa

3. Specifically, reported acoustic characteristic will be mean pressure levels in decibels referenced to 1 micropascal at a reference distance of 1 metre. Thus, the reporting units are:

Continuous Spectra: **dB (re 1 μ Pa/√Hz) at 1 m**
Band or Line Levels: **dB (re 1 μ Pa) at 1 m**

0203 Frequency

1. Frequency shall be reported in Hertz (Hz).

2. The range of frequency shall be 1 to 100,000 Hz.

0204 Bandwidth

1. Analysis will, where possible, be based on the Fourier transform of the SPL. The frequency of the Fourier analysis is inversely proportional to the measurement time, that is a time segment of 0.5 seconds gives a possible resolution of greater than 2 Hz. This resolution can only be achieved if the signal is almost stationary during the measurement period, therefore the time that the signal is nearly stationary gives an upper limit to the resolution which can be achieved. If Fourier analysis is not possible, analysis shall be in narrow bands (a bandwidth of 1.5%, 1/47 octave, is acceptable) so as to expose the absolute level of prominent spectral lines. These lines shall be reported separately when the level is from 0 dB to 3 dB below the total level in the corresponding third octave band, or alternatively 0 dB to 6 dB below the level in the corresponding octave band.

2. In addition, analysis shall be in 1/3 octave bands centred on the following frequencies and decimal multiples thereof:

1.00, 1.25, 1.60, 2.00, 2.50, 3.15, 4.00, 5.0, 6.30, 8.00 Hz

Results shall be reported as mean spectrum level at the geometric centre of the band by subtracting **10 Log (Bandwidth in Hz)** from the band level.

If measurements cannot be made in this manner, for example if they are made in octave bands or in 1/3 octave bands in a different series of band centres, the bandwidth and centre frequencies used shall be displayed on the signature form.

3. Filter characteristics shall, in general, be in accordance with the specification contained in **I.E.C. No. 225** and should give an error of less than **1 dB** when reporting the mean spectrum level of a continuous noise having a slope lying between **0 dB** and **-12 dB** per octave.

4. Spectrum levels derived from measurements in one series of frequency bands may be converted to those derived from another series in the following manner.

a. The reported spectrum level is converted to a band **(W)** level by adding **10 Log W**.

b. The reported spectral lines occurring within the band are removed from the total band level by successive energy subtraction.

c. The remaining continuous sound pressure level is converted to a new mean spectrum level by subtracting **10 Log W**. This is repeated successively for each frequency band over the whole frequency range, and a new curve of continuous level versus frequency plotted, the spectrum level being plotted at the geometric mean of the band **W**.

d. From the curve derived in subparagraph c above, a mean spectrum level at the geometric mean frequency of the new band **W**' is obtained. A total band level is then calculated by adding **10 Log W**'.

e. The reported spectral lines still occurring within the new band **W**' are now added by successive energy addition.

f. The mean spectrum level is derived by subtracting **10 Log W'** from the value obtained in subparagraph e.

g. This value is plotted for each band at the geometric mean of the band **W'** and a standard acoustic signature in the new form obtained.

0205 Sound Pressure Level

1. Pressure levels shall be reported in decibels **(dB)** with a reference pressure of 1 micropascal **(1 µ Pa)**.

2. When reporting ship acoustic signatures, the reported level shall be the maximum recorded in each band during a passage of the ship over a hydrophone using an exponential averaging time constant of about 2 seconds at frequencies greater than **5 Hz**. At closest approach, the distance from the ship's centerline to a point directly over the hydrophone shall be less than one-half the water depth.

3. The level shall be corrected if the measured signal is within **10 dB** of ambient noise.

4. The background noise shall be measured before and after the measurement of the ship's SPL.

0206 Bottom Conditions

1. No correction shall be made for varying bottom conditions of the ranging site.

2. Note shall be made of the bottom composition in three broad categories as follows:

   a. Recent sedimentary deposits to an appreciable depth.

   b. Soft consolidated sedimentary deposits lying close to the seabed (perhaps **6 m**).

   c. Hard rock lying close to the seabed (perhaps **6 m**).

0207 Format

1. The format for reporting the acoustic signature shall conform insofar as possible to the sample provided by figure 2-1. The grid spacings of graph paper will be as shown, that is, **40 mm** per decade of frequency and **20 mm** per 10 divisions of **dB**, but variation in the actual size of the overall graph sheet will be permitted to accommodate different report sizes and methods of plotting. Format data and graph may occupy two pages if required.

2. It may be desirable to compare acoustic characteristics of vessels one with another, and also with the noise requirements, which can be derived from the acoustic goal expressed in chapter 1. For this purpose, a reference curve may be drawn on the format graph as explained in the following:

   a. Historically, acoustic signature levels were corrected to a reference depth of **9 m**, that being a representative value for the minimum operational water depth for MCMV. Thus, the acoustic goal of chapter 1 could be directly compared to the standard acoustic signatures.

   b. A reference curve, or weighting line, adjusted for comparison with sound ranging is referred to **1 m** for a minimum operational depth of **9 m** and for a draught of **1.8 m**, is formed by adding the correction term **17 dB** to the curve defined by the Acoustic Goal.

   c. Similarly, an exact correction may be applied for ships or types if the specified draught is known.

NATO UNCLASSIFIED
(When completed: NATO CONFIDENTIAL)
NATO STANDARD ACOUSTIC SIGNATURE

Noise Range: _____ Bottom Conditions: _____

Platform: _____ Date Ranged: _____

Class: _____ Range Officer: _____

1. Platform

Speed: _____ Last Docking: _____

Engine rpm: _____ State of Hull: _____

Propeller rpm: _____ Condition of Tow: _____

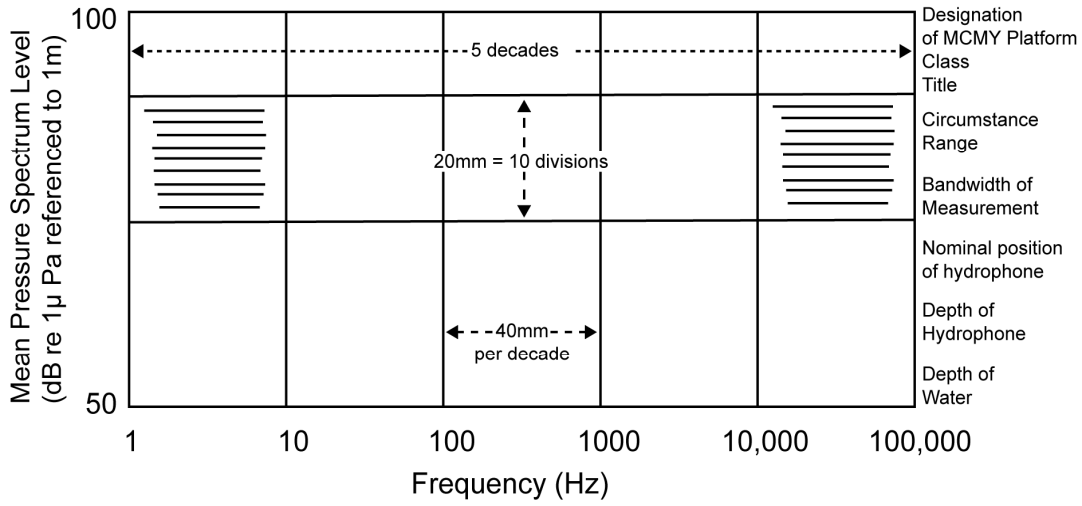
Pitch Setting: _____ Noise Reduction Devices: _____

Auxiliary Engines rpm: _____ Helicopter Altitude: _____

Other Acoustically Important Conditions: _____

2. Acoustic Signature:

a. Radiated Noise Report



b. Spectral Lines:

Speed/ Prop RPM	Frequency (Hz)	Line Level (dB re 1 µ Pa at 1 m)	Remarks

3. Remarks by Range Officer:

Date Plotted

Figure 2-1. Standard Acoustic Signature Format

CHAPTER 3 Measuring and Reporting Acoustic Characteristics of Naval Mine Countermeasures Vessels

0301 General

When noise characteristics of naval mine countermeasures vessels (MCMV) are determined, they should be measured, recorded, and reported in accordance with chapter 2. Matters specific to MCMV are covered in this chapter.

0302 Depth

1. Acoustic measurements shall be made with hydrophone depth between **9 m** and **36 m**.

2. Measurements shall be corrected to and reported at a reference distance of **1 m**.

3. The standard correction shall assume spherical spreading where the distance to be corrected is that from the source to the hydrophone.

4. If the hydrophone is not at the seabed (free field conditions), pressure levels shall be corrected for the absence of the bottom by adding **3 dB**.

5. Where bottom hydrophones are used, the hydrophone shall be no more than **1 m** from the bottom.

6. If the acoustic source depth/location are unknown, the bottom of the hull at the engine room shall be used as the source for tonals.

0303 Operating Data

1. Speed. Speed shall be reported as speed through the water (STW).

2. Tow. A description of the type of tow shall be included when appropriate.

3. Machinery. The state of machinery important from an acoustical standpoint shall be stated for each particular condition of ranging. This should include the mode of propulsion (main or auxiliary) and propeller pitch where appropriate.

4. Mine Hunting Sonar. Mine Hunting SONAR should be secured (off) to eliminate transient sonar signals from the baseline measurement.

5. Conditions. Conditions for ranging should be in accordance with all applicable portions of figure 3-1.

6. Routine Data. Routine data, including the ship's time out of dock, shall be reported.

Condition	Actual Speed Through the Water (STW)	Gear Streamed
Passage	Normal passage speed of the class as authorized by national authorities	Nil
Wire Sweeping	Normal maximum wire sweeping speed for the class, less 1 knot	Single Oropesa type sweep plus audio-acoustic sweep at normal operating depth and position
Influence Sweeping	Normal maximum magnetic sweeping speed for the class, less 1 knot	Normal magnetic sweep plus audio and low frequency sweeps as normally rigged
Minehunting	Standard minehunting speed using main or auxiliary propulsion according to normal practice	Full equipment for a minehunting operation (including acoustic sweep if it is standard practice)

Note:
1. Where it is not possible to manoeuvre with wire or magnetic sweep or minehunter gear streamed, a drogue having an equivalent drag is to be used, and appropriate auxiliaries should be used.
2. Acoustic sweeps are not to be energized and need not be streamed at their standard operating depth if there is any question of fouling the range.
3. When magnetic sweeps are streamed, they are to be pulsed at full current with the normal operational pulse cycle.
4. All normal auxiliaries should be running and be loaded appropriately if practicable.
5. Mine Hunting SONAR should be secured (off) to eliminate transient sonar signals from the baseline measurement.

Figure 3-1. Ranging Parameters

0304 Format

1. The format for reporting the acoustic signature of MCMV shall conform insofar as possible to the sample provided by figure 2-1.

2. If it is desired to compare acoustic characteristics of MCMV one with another, the procedure and example in chapter 2 should be used. See paragraph 0306 for safety qualitative comparisons.

0305 Calculation of the Acoustic Conditions of Naval Mine Countermeasures Vessels

1. The Reference Signature. Standard acoustic signatures of individual MCMV will be used to establish a Reference Signature for each of the different classes of MCMV in each operating condition appropriate to the class. The reference signature is the mean level of noise observed among ships of the class, increased at every point by one standard deviation of the individual results at the point in question. The mean is the arithmetic mean of **dB** values. The standard deviation is the root mean square of the differences between individual results and the mean at each frequency. A minimum of 10 rangings should be applied to establish the reference signature and when established it should be drawn, together with the current standard acoustic signature, on the signature forms.

2. Extreme Actuation Depth. For each class and condition an "extreme actuation depth" will be established using the formula:

antilog (Δ/20) metres

Where Δ is the maximum difference between the final acoustic goal of chapter 1 referred to **1 m** and the reference signature at **1 m**. This procedure will be adopted when the reference signature is drawn through 1/3 octave measurements, and equally when drawn through 1 octave measurements; but it is essential that statements on extreme actuation depth should state the basis of derivation. In both cases, the extreme actuation depth as derived above strictly refers to actuation depth in relation to a sea mine whose bandwidth is small compared with the bandwidth of noise measurement, and assuming that noise within the measuring band has a continuous spectrum. With these limitations the derived extreme actuation depth is the depth beyond which approximately 85% of ships of the class will be safe against sea mines of sensitivity equal to the goal level. Ultimately, a ship's acoustic signature must be evaluated with respect to sea mines of specific frequency response, either representative or actual, with due allowance for the influence of discrete lines on sea mine response. This is one purpose of the table of discrete lines on the signature form. Detailed recommendations on this matter are deferred until more experience has been gained. Figures for extreme actuation depth will not be included in routine ranging forms.

3. Extreme actuation depths when calculated for MCMV as they now stand, will be operationally meaningless and may remain so during the life of existing ships. A more meaningful guide on actuation depth may be calculated by noting that the lowest sea mine actuation level of current NATO sea mines is some **12 dB** higher than that quoted in chapter 1, that is:

Interim extreme actuation depth = antilog (Δ-12)/20 m

Figures for interim actuation depth will not be included in routine ranging forms.

4. Whenever the standard signature of an individual ship is found to exceed the reference signature for the class and condition of operation, the extent to which it does so should be expressed as a percentage increase of actuation depth as applicable to the frequency band in which the divergence is found. This percentage will be calculated by the formula:

100 (antilog(δ/20)-1)

Where δ is the difference in **dB** between the individual signature and the reference signature in the band which the divergence is seen to occur. In some cases the divergence observed will produce an increase in the extreme actuation depth. When this is so, the percentage increase in extreme actuation depth of the particular ship or the class as a whole should be calculated. It is permissible to draw attention to the abnormally noisy character of the particular ship by quoting in the signature form the percentage increase of actuation depth of the ship over its class within defined frequency bands, or the percentage increase of extreme actuation depth compared with the class when this is applied.

0306 Establishment of Relative Safety Among Naval Mine Countermeasures Vessels

1. Qualitative comparison between individual MCMV or MCMV of different classes can be made in the following way:

Determine by measurement (or observation) the maximum difference α in **dB** between the signature and the "weight line" which appears on the format. The figure α, called the "acoustic merit index," gives a very rough indication of the relative safety of the ship or class.

2. A small value of α indicates a probability of actuating a smaller number of acoustic sea mines during the MCMV's passage through a minefield. Differences between one α and another of less than
5 dB are not significant. But the figure must not be treated in any sense as a quantitative measure of relative risk to the MCMV or class; it does scarcely more than place ships or classes in a general order of acoustic merit.

3. If it is known that sweeping is to be restricted to only a part of the whole frequency range of the signature, the same procedure can be carried out with attention restricted to the relevant part of the spectrum to determine α.

CHAPTER 4 Measuring and Reporting Acoustic Characteristics for Sea Mine Vulnerability of Ships Other Than MCMV

0401 General

When the noise characteristics of warships and merchantmen are determined, they should be measured, recorded, and reported in accordance with the general requirements in chapter 2. Some of the requirements in chapter 3 pertinent to MCMV are also germane. Matters specific to ships other than MCMV are covered below.

0402 Operating Data

1. Acoustic levels should be reported:

   a. For normal passage or normal cruising speed.

   b. For a "quiet" speed, which is defined as a speed specified class-by-class by national authorities such as to ensure the minimum sea mine risk consistent with effective navigation.

2. The state of machinery important from the point of view of radiated noise is to be reported, including a statement of propeller pitch setting where appropriate.

3. Routine data, including time out of deck, is to be reported.

0403 Reference Signature

It is probable that there will be insufficient basis for any reference signature for merchant ships. However, it should be possible to derive reference signatures for classes of warship. Where this is the case, the reference signature should be included in reports.

0404 Weighting Line

When reporting on merchant ships and warships, the weighting line on the format (chapter 2, figure 2-1) should be omitted.

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CHAPTER 5 Measuring and Reporting Acoustic Characteristics of Naval Mine Countermeasures Helicopters

0501 General

The methods of measuring and reporting acoustic fields for naval mine countermeasures helicopters should follow, insofar as applicable, the nomenclature, methods, and procedures laid down in chapter 2. Some aspects of chapter 3 relative to MCMV may also be germane. Matters specific to helicopters are covered in this chapter.

0502 Definitions, Terms and Notations

1. Altitude.

a. The altitude is the height in metres of a reference point on the helicopter above the water surface.

b. The vertical reference pin on helicopters having one main rotor system shall be a point midway between the blade axis at the rotor hub and the longitudinal centreline of the major exhaust system.

c. The vertical reference point on helicopters having multiple main rotor systems shall be a point midway between the average height of the blade axis at the rotor hubs and the longitudinal centreline of the major exhaust system.

2. Reference Distance. The sound pressure levels will be quoted with respect to the standard reference distance of **1 m**.

0503 Sound Pressure Level Measurement of Naval Mine Countermeasures Helicopters

1. Sound pressure level measurements shall be made with the helicopter at an altitude no lower than the rotor blade diameter. The helicopter shall pass close enough to the hydrophone to place it within the rotor blade circle radius. If this is not practical, estimates of miss distance must be made for later analysis. In any case, the miss distance must be less than one-half of the water depth.

2. Sound pressure level measurements shall be made with a hydrophone depth between **9 m** and **36 m**. If the hydrophone is not at the seabed, the sound pressure levels shall be corrected for the absence of the bottom by adding **3 dB**.

3. Sound pressure level measurements shall be made with the helicopter operating maximum gross weight under each of the conditions specified in figure 5-1.

Condition	Altitude	Ground Speed	Gear Streamed
Hover	1. 4.5 to 9 m (within the ground cushion region) 2. 15 to 30 m (above the ground cushion region)	Zero (0)	None
Free Route	Normal altitude as authorized by national authorities	Normal speed of helicopter as authorized by national authorities	None
Wire Sweeping	Normal operational altitude for wire sweeping	Normal maximum wire sweeping speed	Double Oropesa type sweep
Wire-Acoustic Sweeping	Normal operational altitude for wire-acoustic sweeping	Normal sustained sweeping speed for the helicopter	Oropesa type sweep plus acoustic sweep at normal operating depth and positions
Magnetic-Acoustic Sweeping	Normal operational altitude for magnetic-acoustic sweeping	Normal sustained sweeping speed for the helicopter	Normal magnetic sweep plus acoustic sweep as normally rigged

Note:
1. Where it is not possible to manoeuvre with wire or magnetic sweeps streamed, a drogue having an equivalent drag is to be used.
2. Acoustic sweeps are not to be energized and need not be streamed at their normal operating depth if there is danger of fouling the range.
3. Acoustic sweeps that operate by propulsive power are not to be streamed. A drogue having an equivalent drag is to be used.
4. When magnetic sweeps are streamed, they are to be operated at full current with normal operational pulse cycle.
5. All auxiliaries on the helicopter should be running and loaded if practicable.

Figure 5-1. Ranging Parameters for Naval Mine Countermeasures Helicopters

0504 Reporting Standard Acoustic Signatures of Naval Mine Countermeasures Helicopters

1. Format. The format for reporting the standard acoustic signature of naval mine countermeasures helicopters for various conditions shall conform to the sample given in figure 2-1.

2. In correcting measurements at the depth of the range hydrophone to figures at the reference distance of **1 m**, a procedure as in chapter 3, paragraph 0302, can be followed by use of the equation:

$$\mathbf{L_s = L_p + 7 + 20 \log (d + 0.226h)}$$

Where,
- L_s = helicopter source level
- L_p = level measured at the hydrophone
- d = hydrophone depth in metres
- h = helicopter reference altitude in metres (see paragraph 0502)

3. Conversion. Conversion of helicopter rangings referred to a water depth of **9 m** to the new reference distance of **1 m** may be obtained by adding **19 dB (20 log 9)** to the sound pressure levels.

Alternatively, for measurements in other water depths, the correction to **1 m** is:

[20 log (hydrophone depth in metres)] dB

4. Spectral Lines. Prominent spectral lines in the acoustic signature of the helicopter shall be reported in a like manner as directed in chapter 2.

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CHAPTER 6 Measuring and Reporting Acoustic Characteristics of Divers and Their Equipment

0601 General

When measuring and reporting acoustic characteristics of divers and their equipment, the standards contained in this chapter will be used. Use of these standards will facilitate the initial phases of laying down quietness standards and developing safe procedures. Details and application shall be in accordance with chapter 2, with refinements as contained in the following paragraphs.

0602 Measurement Conditions

Measurement conditions are as follows for an individual diver and his equipment:

1. Water depth:

   9 m +/− 1 m for mixed gas equipment

   6 m +/− 1 m for pure oxygen equipment

2. Measurement site: bottom of lake, bay or sea (not on a stage or platform unless it is impossible to make measurements otherwise).

3. Hydrophone location: **0.5 to 1 m** above the bottom.

4. Diver position and location with respect to hydrophone: diver in kneeling position facing the hydrophone with diver's mouth bit **30 cm** from hydrophone.

Note: *This position is most representative of a diver's position relative to a sea mine during a diver-mine encounter.*

5. Diver breathing rate: Two breathing rates are desirable:

   a. A normal breathing rate representing the performance of a trained sea mine clearance diver or US EOD Diver who is not over-breathing the equipment or the situation.

   b. A higher than normal breathing rate simulating energy consumption necessary to maintain position against a strong current. When available, an ergometer shall be used to provide a work load equivalent to the 20 minute exhaustion level. At this work level, the diver will work for 6 minutes then stop working. Measurements will be made immediately.

6. Range of frequencies covered: **1 to 100,000 Hz**.

0603 Reporting Conditions

The following conditions pertain to the reporting of acoustic characteristics and their equipment as measured in accordance with the preceding paragraph:

1. State the reference distance observed. If the major source of noise was other than the mouth bit, describe the position of the major source and the reference distance to the hydrophone.

2. Describe special test conditions in detail.

3. Provide the measured ambient background analyses.

4. Present spectrum levels in **dB** reference pressures of **1 µ Pa** (Meter-Kilogram System (MKS)) and **1 µbar** (centimeter-gram system (cgs)) at a reference distance of **1 m**.

Note: *Since measurements are made at **0.3 m** measurement distance, the levels must be corrected to a **1 m** distance for reporting purposes using spherical spreading. If measurements are made at other than **0.3 m**, correct to **1 m** using spherical spreading (**6 dB** per distance doubled) and state the actual measurement distance from which distance corrections were made.*

5. Describe the nature of the analyses from whence the spectrum levels were derived (e.g., spectrum levels derived from 1/3 octave band analyses, etc.).

6. Noise levels of divers and their equipment are erratic with time. This is particularly true of semi-closed equipment, which may vent from time to time. SPL should be measured with equipment having sample rates greater than at least 25 kHz. Sections of the record should be searched for peak signals.

7. Reference Curve. On each reported diagram or figure giving PSL for divers and their equipment, include the acoustic goal reference curve based on adding the

SM_{divers} Confidential Supplement

to the curve defined by

AGO, Confidential Supplement.

8. Conditions of Diver and Equipment. For each reported measurement, identify the diver's equipment, gas mixture, gas flow rate (liters per minute at STP), ambient water temperature, and any modifications to the equipment from its standard configuration.

9. Peak levels in addition to those levels of sub-paragraph f. above should also be reported.

10. Characteristics of any spectral lines appearing in the noise output of the equipment should be reported.

11. Describe in the test or the report any unusual characteristics or noteworthy noise sources observed.

0604 Statistical Reliability

In order to assure statistical reliability of the acoustic characteristics of divers and their equipment, a sufficient number of divers should be used to eliminate bias by individual divers. For planning purposes, a minimum of 3 divers duplicating each test will assure reasonably accurate data. The mean values obtained are then taken as the final result for representing equipment characteristics only.

0605 Dynamic or Movement Noise

Dynamic or movement noise measurements are not covered in this chapter pending further study. The same conditions described in paragraphs 0602 and 0603 should apply, but the technique necessary to separate movement noise from equipment noise is not definable at this time.

CHAPTER 7 Parametric Analysis of Naval MCM Vessel Sound Pressure Levels

0701 General

Where appropriate PSL should be determined for naval MCM assets as a function of operational criteria which can be varied by the operator.

0702 Example

The form in use by GE for determining the optimum for respect to PSL for a vessel is shown in figure 7-1.

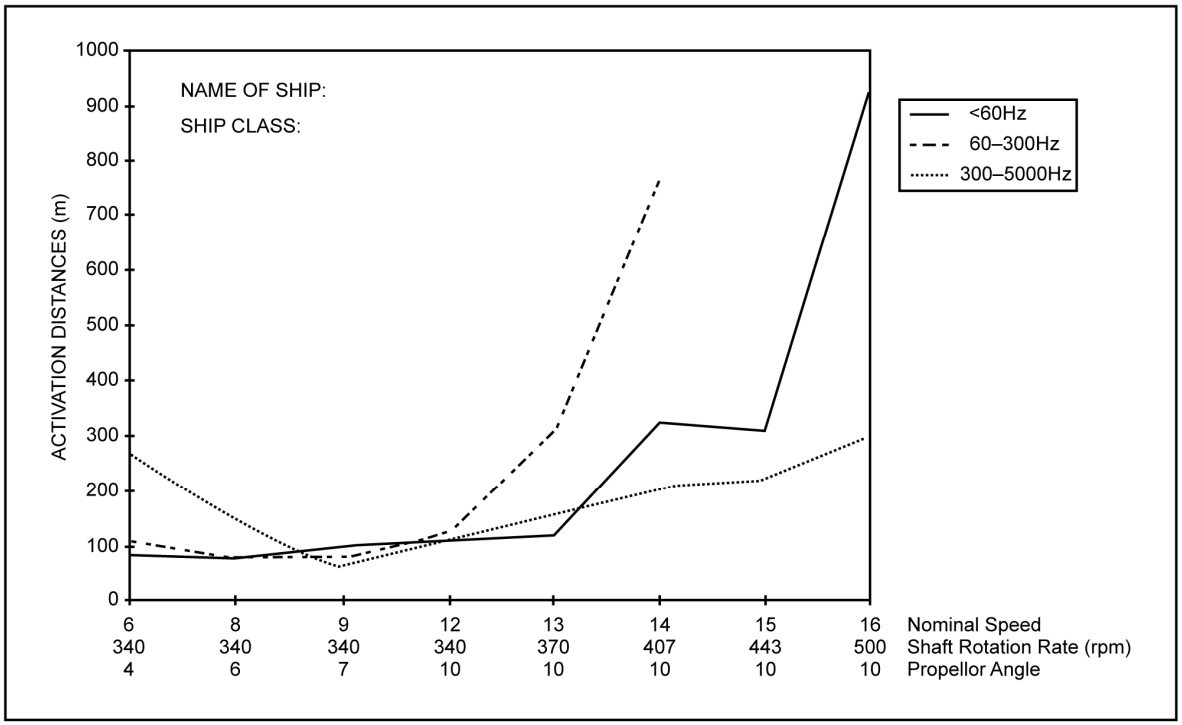

Figure 7-1. Activation Distances vs. Acoustic Mine Fuzes

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