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NATO NAVAL ARMAMENTS GROUP

NAVAL GROUP 6 ON SHIP DESIGN

NG/6 SUB-GROUP 7 ON SHIP COMBAT SURVIVABILITY

RATIFICATION DRAFT OF STANAG 4142 (Edition 3) - SHOCK RESISTANCE ANALYSIS OF EQUIPMENT FOR SURFACE SHIPS

Memorandum by the Assistant Secretary General for Defence Investment

(RATIFICATION REQUEST)

Reference: AC/141-D/751//AC/141(NG/6)D/35//AC/141(NG/6-SG/7)D/7 dated 19 July 2001

1. Naval Group 6 Sub-Group 7 approved the attached text of ratification draft of STANAG 4142 (Edition 3) on Shock Resistance Analysis of Equipment for Surface Ships. This edition is an update of Edition 2 which was distributed for ratification in 2001 in accordance with the reference. Edition 2 is hereby cancelled/

2. In line with the decision of the Group, the agreed text is herewith forwarded to delegations who are requested to obtain the national ratification by **14 November 2003** and to inform the Defence Investment Division of their national ratification references, together with a statement of the actual or forecast date by which national implementation is intended to be effective. Furthermore, the service or services within which the standard applies should be indicated or corrected (use form at page iii).

3. Most national Ministries of Defence contain a standardization office or standardization liaison officer who can give advice on the procedure to be adopted to obtain a formal ratification reference. It is recommended that contact be made with that office.

4. As soon as sufficient ratifications have been received, this STANAG will be forwarded to the Director, NATO Standardisation Agency for promulgation.

(Signed) Robert Bell

1 Annex

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ANNEX 1
AC/141-D/762
AC/141(NG/6)D/35
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NATO STANDARDISATION AGREEMENT (STANAG)

SHOCK RESISTANCE ANALYSIS OF EQUIPMENT FOR SURFACE SHIPS

Annex: Shock Resistance Analysis of Equipment for Surface Ships

Related documents: STANAG 4137
STANAG 4150
STANAG 4549

FOREWORD

It is essential that the philosophy and objectives of this STANAG and its related documents (see above) are fully understood before any one of the STANAGs is applied to a specific shock design problem or requirement and the results of that application are assessed.

STANAG 4137 applies for the Explosion Testing of Surface Ships and Craft and, as stated specifically in this STANAG, it defines a test, the severity of which is regarded as the minimum severity which a viable warship must withstand without significant loss of operational effectiveness. It is considered that modern warships should be able to withstand without operational impairment higher explosion severities than are specified herein.

STANAG 4549 describes the procedure for proof-testing equipment intended for installation in Naval Surface Ships, using shock testing machines to a specified shock severity. STANAG 4549 introduces a standard method for defining a NATO Standard shock level, and proposes 13 standard or preferred levels. In addition to the 13 standard shock spectra contained in the STANAG, STANAG 4549 enables alternative spectra to be specified and provides a set of rules for comparing spectra. This document was introduced as a replacement for STANAG 4141 which specified the actual test levels to be used for qualification. In general the STANAG 4141 levels were not accepted within NATO and hence the decision was made to replace it. Where nations wish to continue using the STANAG 4141 levels it is recommended that suitable equivalent levels are selected from STANAG 4549.

STANAG 4150 specifies the severity and describes the procedure to be adopted for the proof testing of heavy weight surface ship equipment on floating shock test barges.

STANAG 4142 describes the requirements for the numerical shock qualification of equipment. The STANAG 4142 procedures are aimed at giving confidence that equipment designed to this standard will meet the requirements of the shock test specified in accordance with STANAG 4549. The shock testing STANAGs 4549 and 4150 should be invoked in preference to STANAG 4142 whenever possible.

1. INTRODUCTION

1.1 When under attack by Non Contact Underwater Explosions, Naval ships run the risk of significant loss of operational effectiveness, mainly due to malfunctioning of systems caused by individual equipment failures. For that reason, qualification for shock by means of shock testing or by numerical analysis prior to installation onboard is generally considered essential by the Navies.

1.2 National specifications for shock qualification vary considerably. The previous issue of this STANAG attempted to specify minimum levels for equipment shock resistance that could be adopted throughout NATO. These minimum levels were not adopted universally across NATO, each nation preferring to specify its own national standards and practices. In recognition that this situation is unlikely to change, STANAG 4549 (covering shock testing) introduced a standard approach which enabled existing national practices to be retained whilst providing sufficient information to enable other nations to compare the levels achieved during a shock test against their own standards. This STANAG has adopted the same methods for shock analysis methods.

2. AIM

2.1 To supply unified procedures so that equipment installed aboard NATO surface naval vessels possess a recognised shock resistance.

2.2 The aim of this agreement is to define the requirements for the partial qualification by means of analysis of shipboard equipment as concerns its resistance to shock resulting from underwater non-contact explosions. This STANAG will facilitate :-

a) the procurement of shock qualified equipment for international projects.

b) easy identification of equipment as far as proven shock resistance is concerned.

3. AGREEMENT

3.1 Participating nations agree to adopt the procedures as defined at Annex. A participating nation agrees that the implementation will be as described in paragraph 4.

4. IMPLEMENTATION OF THE AGREEMENT

4.1 A nation ratifying this STANAG has the obligation to implement its contents. This is to be done by means of the following actions:

a) Its Navy produces for internal use a general and concise document which :

- States that this document is a valid document.
- Introduces qualification according to this STANAG to be an alternative to existing analysis requirements.
- States that the supplier is free to analyse equipment either in accordance with this STANAG or existing analysis requirements.
- Specifies which NATO STANDARDISED (NS) levels are required for the various shipbuilding projects.

b) The above document must be taken into account by project teams enabling them to set required NS levels for specific items of equipment.

ANNEX to
STANAG 4142
(Edition 3)

SHOCK RESISTANCE ANALYSIS OF EQUIPMENT FOR SURFACE SHIPS

CONTENTS

SHOCK RESISTANCE ANALYSIS OF EQUIPMENT FOR SURFACE SHIPS

1. GENERAL

1.1 Definitions

1.1.1 Equipment

1.1.1.1 Equipment. Any item which is independently attached to a ship structure (eventually by means of intermediate structures, such as sub-bases, resilient mounts, etc.) and which does not constitute a part of the ship's structure. Examples: a diesel generating set, a propulsion turbine, an electronic cabinet, etc.

When an item is attached to the ship's structure by means of an intermediate structure (such as a sub-base, a resilient mounts system, etc.) the latter is considered as being a component part of equipment.

Seatings, i.e. those extensions of the ship's structure expressly built to support equipment and its intermediate structures, are not to be considered as part of equipment.

1.1.1.2 Equipment Foundation or Seating (or simply 'Foundation' or 'Seating'). The ship's structure to which equipment is attached.

1.1.1.3 General Purpose Equipment. Equipment that may be used to fulfil different functions on board the same ship, and on board ships of different type, and that, for this reason, cannot be associated with a uniquely defined ship type or location on board. (Examples: pumping sets, fans etc.)

1.1.1.4 Principal Equipment Directions. Any set of three orthogonal axes that can be easily related to the constructional design of equipment (e.g. the axis of rotation and the axes orthogonal to it passing through the centre of gravity of a diesel engine).

1.1.1.5 Theoretical Model of Equipment. A numerical model which simulates the dynamic behaviour of equipment under shock, in the sense that corresponding points in the model and in equipment are estimated to exhibit approximately the same motion for the same shock excitation. The level of complexity of the model may vary from a simple lumped mass representation of the equipment to a complicated finite element model.

1.1.2 Shock

1.1.2.1 Shock. The sudden displacement of the foundation of the equipment caused by a non-contact underwater explosion or other similar loadings. The expression 'shock' is here understood to be not only a generic denotation of the motion of a structure of the ship, but also a quantitative description of this motion. A shock is therefore 'given' or 'described' when a convenient, correct and complete quantitative description thereof is available.

1.1.2.2 Shock Severity. On account of the quantitative characterisation given above to the term 'shock', the expression 'shock severity' (as well as 'shock intensity') is to be considered as being synonymous with 'shock', even if it makes more explicit reference to the quantitative importance of the motion of the foundation.

1.1.2.3 Shock Description. Any quantitative characterisation of a shock, correct and sufficient to carry out a valid analysis of the shock motion of equipment. The shock descriptions considered here as equivalent from the point of view of the information on the shock damage potential are two, namely:

1.1.2.3.1 Shock Time History. The function: foundation acceleration (or velocity or displacement) versus time.

1.1.2.3.2 Shock Response Spectra (SRS). A plot of the maximum response of a family of massless oscillators (fictitious single degree of freedom linear 1% critically damped systems) having a range of natural frequencies, to a given shock motion at the base.

1.1.2.4 Shock Direction. Three mutually independent shocks acting along the three principal directions, vertical, transverse and longitudinal respectively, are associated with any given ship's structure.

1.1.2.5 Shock Parameters. The kinematic quantities acceleration, velocity and displacement.

1.1.3 Shock Motion of Equipment

1.1.3.1 Shock Motion of Equipment. The motion (in the sense of kinematics) of the various parts of equipment excited by a shock.

Synonyms: Shock response of equipment.

1.1.3.2 Equipment Shock Analysis. Any valid mathematical analysis aimed at determining quantitatively the shock response of equipment.

1.1.4 Shock Resistance of Equipment

1.1.4.1 Equipment Shock Failure Criteria. The set of rules and procedures by which it is judged whether the equipment motion excited by a given shock will cause physical damage and/or functional impairment of equipment.

1.1.4.2 Shock Resistance of Equipment. The shock which equipment can withstand without loss of function and without damage, or with the amount of damage (not impairing function) accepted as the chosen failure criteria.

The shock resistance is an intrinsic characteristic of equipment given it by its constructional design, and includes the use of shock attenuating devices, such as flexible mounts, where these are used.

Synonyms: Hardness of equipment, protection level of equipment.

1.1.4.3 Equipment Shock Resistance Analysis. The complete procedure by which equipment shock resistance is assessed.

The three elements necessary and sufficient to carry out an equipment shock resistance analysis are the following:

a) A specified shock.
b) An equipment shock analysis method.
c) A failure criterion.

1.1.4.4 Design Shock Resistance of Equipment. The shock resistance of equipment as assessed by means of an equipment shock resistance analysis and by an inspection of the equipment constructional design.

1.2 Scope

1.2.1 This standard covers requirements for the partial assessment of the design shock resistance of equipment for installation on board naval surface ships using analysis methods.

1.2.2 This standard should be mandated where the acceptance authority has agreed that the equipment cannot otherwise be qualified by test, for example because of its size and weight.

1.3 Origin

1.3.1 This standard has been formulated by Sub-Group 7 of the NATO Naval Armaments Group on Combat Survivability (NG 6).

2. SHOCK RESISTANCE OF EQUIPMENT

2.1 NATO Design Shock Requirements

2.1.1 This STANAG does not specify a minimum level of shock resistance required for equipment. The choice of level of shock resistance is left to individual nations. Not only do different nations specify different levels, but it is also common practice for different levels to be specified for each class of ship and for different equipment in a ship. The actual level chosen will depend upon the function of the equipment and the location of the equipment within the vessel.

2.1.2 This STANAG and STANAG 4549 however define a standard method for describing and comparing shock levels (Section 4) . Where this method is used, the resulting level is known as a NATO STANDARDISED LEVEL or NS LEVEL.

2.1.3 Equipment is said to possess a certain NS Level of shock resistance if the equipment has been shock qualified. Equipment is qualified if the equipment is found to be capable of withstanding the motion induced by the shock characterising the chosen NS Level without damage or impairment of function. Shock qualification can only be obtained:

a) by shock testing according to STANAG 4549 or STANAG 4150.

b) if shock testing of the equipment as a hole not possible or practical (e.g. due to size or mass), agreed parts may be qualified by analysis according to STANAG 4142, section 3 (Equipment Shock Resistance Analysis) and other parts by dedicated shock-testing.

2.1.4 Occasionally the required NS LEVEL values may not be readily available. For instance when the initiative for shock qualification is from the supplier and/or the equipment is to be delivered to several navies. For such cases one of the default values given in Appendix 1 may be considered.

2.2 Qualification

2.2.1 Specification of NS Shock Level and approval of compliance rests with the purchasing authority and is generally valid only with respect to that authority. Adherence to this procedure will however assist the process of obtaining wider acceptance since it will ensure that the analysis report is issued in a format that is acceptable to other nations and will facilitate comparison with national shock requirements.

2.3 Limitations Of Shock Qualification By Analysis

2.3.1 Although this STANAG addresses the shock qualification of equipment by analysis, analytical methods are not to be considered as an alternative of equal value to shock testing.

2.3.2 Approval must be obtained from the relevant acceptance authority to adopt a qualification by analysis method instead of shock testing.

2.3.3 Whenever practical shock testing of the whole equipment should be undertaken. In particular it should be noted that analytical methods used in isolation can not be used to shock qualify the performance of electronic components and are severely limited in their application to visco elastic materials, brittle materials and materials whose characteristics are loading rate dependent.

2.3.4 When it is considered impractical to shock test the whole equipment, a combined analytical and experimental approach should be adopted for the equipment validation. For example:-

- It is required to shock qualify a large winch. The winch consists of a frame supporting a drum, a mechanism for handling the cable, a motor and a control system. With the exception of the motor and the control system the rest of the winch is made of steel. The winch is too large to be tested on either a suitable land based shock machine or in a floating barge.

A suitable method of shock qualification may be to numerically model the steel components to a) confirm that the shock performance of these components is acceptable and then b) to use the response of these components to determine the input to the components that can not be modelled satisfactorily namely the motor and control system. These components can then be tested separately on a suitable machine.

3. EQUIPMENT SHOCK RESISTANCE ANALYSIS

3.1 Shock

3.1.1 Each NS Level is a set of three independent shocks acting along the principal ship directions, vertical, transverse and longitudinal.

3.1.2 Use of the NATO Standardised Shock Levels

3.1.2.1 Equipment is said to have been analysed in accordance with a certain NS Level when the latter has been used as the basis for the equipment shock resistance analysis.

3.1.2.2 The three shock directions constituting a NS Level are to be considered independently, and their effects on equipment shall not be superimposed.

3.1.2.3 If the orientation of equipment on board is known in advance (for example a propulsion engine) then it shall be assumed in performing the equipment shock analysis, that such equipment is excited by all three shocks of the chosen NS Level, each acting independently along its appropriate direction with respect to equipment.

3.1.2.4 If equipment possesses a vertical direction that remains such after installation on board, while its horizontal orientation with respect to the ship may be different from case to case, then it shall be assumed, in performing the equipment shock analysis, that such equipment is excited by the vertical shock in the vertical direction, and by the transverse shock in the horizontal directions.

3.1.2.5 For equipment that can be installed on board in any orientation, it shall be assumed, in performing the equipment shock analysis, that such equipment is excited by the vertical shock along the three principal equipment axes.

3.2 Equipment Shock Analysis

3.2.1. Modelling of Equipment.

3.2.1.1 The development of the appropriate theoretical model of equipment to be analysed rests with the supplier of equipment. The equipment supplier is responsible for ensuring that the model satisfies the requirements of the acceptance authority for the equipment (i.e. MOD/DOD).

3.2.1.2 While every effort should be made to reduce the complexity of the model, it must however reproduce the essential spatial distribution of masses and flexibilities of the equipment necessary for a credible assessment of its overall shock resistance.

3.2.1.3 Equipment may be simulated by different models for the different directions of shocks.

3.2.2 Equipment Shock Analysis Method.

3.2.2.1 The choice of the equipment shock analysis method rests with the supplier of the equipment. The method chosen shall however be a valid one, i.e. one satisfying the following requirements:

a) it shall be theoretically correct and consistent with the chosen shock description;

b) it has taken into account the dynamic reaction of equipment on the foundation motion (see also paragraph 4.2.1.5);

c) all the assumptions made to simplify the analysis procedure shall be clearly stated and justified on the basis of experimental or theoretical evidence;

d) the numerical procedures used in carrying out the analyses shall be well established ones.

e) must satisfy the requirements of the acceptance authority of the equipment.

3.3 Failure Criteria

3.3.1 General Requirements.

3.3.1.1 The necessary conditions to be fulfilled if the equipment is to be considered as capable of withstanding successfully the shock motion represented by a given standard shock are the following:

a) the calculated maximum stresses induced by the shock in the various points of equipment shall not exceed the permissible stresses dealt with at 3.3.3;

b) the relative movements of adjacent parts of equipment shall not be such as to endanger the equipment function (e.g. contacts between rotating and stationary components of rotating machinery);

c) there are not other shock effects which cause malfunction of the equipment e.g. a transient motion of a component which causes an unacceptable interruption of vital supplies.

3.3.2 Evaluation of the Maximum Stresses

3.3.2.1 When the analysis method is such as to yield the actual response of the oscillating system, either completely as a time history (as in the case of dynamic analyses in the time domain) or more simply in the form of response maxima (as in the case of simplified analyses such as the 'quasi-static' methods, the 'g' method, etc.), then the calculated stresses must not exceed the permissible stresses given in 3.3.3. Stresses are to be compared on the basis of a currently accepted yield criterion, such as Tresca's, Hencky-von Mises, maximum principal stress criterion, etc. The analysis report is to state what criteria was used.

3.3.2.2 If a modal superposition method is used, sufficient modes should be included to account for at least 95% of the modal mass.

3.3.3 Permissible Stresses

3.3.3.1 Certain materials have rate dependent characteristics. Under shock loading, the strength of these materials can be enhanced or degraded. The degree of change being effected by the loading time and by the loading mechanism (i.e. bending, tension or shear). Whilst this STANAG does not preclude the use of any particular material, composites materials, viscoelastic materials and any materials having less than 10% elongation shall not be used unless dynamic material properties at the appropriate strain rate are available or the stresses can be proved acceptable by experiment.

3.3.3.2 For metals that have elongation of greater that 10% and where dynamic material properties are not available the following stresses are permissible.

Normal Stress The maximum permissible normal stress σ shall be the 0.2% offset static yield strength for materials giving an elongation of more than 10% before rupture.

Shear Stress. The maximum permissible shear stress shall be 60% of the maximum permissible normal stress σ or some other experimentally proved value.

3.3.3.3 Permissible plastic yield. If the stress distribution in some component part of the equipment is such that appreciable areas within the material are lightly stressed (e.g. a beam of circular cross section stressed in pure bending) and if small plastic deformations of this component part do not impair the function of equipment, then a certain amount of plastic yield may be assumed. The supplier must satisfy the purchasing authority that the amount of plastic deformation assumed is acceptable.

4. SHOCK DATA

4.1 Symbols, Abbreviations and Nomenclature

Throughout Section 4 the abbreviation SRS stands for Shock Response Spectrum (or Spectra)

a	=	absolute acceleration	m/s^2
a_o	=	constant value of the acceleration	m/s^2
f	=	frequency	Hz
f_i	=	lower transition frequency (see fig 1)	Hz
f_s	=	upper transition (or 'cut-off') frequency	Hz
d	=	relative displacement	m
d_o	=	constant value of the relative displacement	m
v	=	spectral (or 'pseudo') velocity $v = 2 \pi f . d$	m/s
v_o	=	constant value of the spectra velocity	m/s

SRS parameters = the quantities d_o, v_o and a_o characterising a given NS Level

4.2 Shock Description

4.2.1 Spectral Description

4.2.1.1 NS LEVEL SRS Composition. For a given equipment mass, shock direction and NS Shock Level, the Shock Response Spectrum (SRS) is composed by three distinct curves, each valid in a certain frequency interval, namely:

for $f < f_i$ by a constant relative displacement curve, i.e. d_o = const

for $f_i < f < f_s$ by a constant spectral velocity curve, i.e. v_o = const

for $f > f_s$ by a constant absolute acceleration curve, i.e. a_o = const.

In a logarithmic plotting with the frequencies as abscissas a NS Level SRS is a polynomial, the vertexes of which correspond to the lower (f_i) and upper (f_s) transition frequencies (fig 1).

4.2.1.2 Direction of the Shock. A NS Level is a set of three shocks, each acting along a principal ship direction, namely:

- a vertical shock
- a transverse (i.e. athwartships) shock, and
- a longitudinal (i.e. fore and aft) shock.

4.2.1.3 NATO STANDARDISED Levels The NS Level is fully defined by numerical values for $d_{o,}$ (m), v_o (m/s) and a_o (m/s^2). In this sequence and using the units specified, the numerical values are presented between parenthesis after the letters NS.

Example: NS(0.035;3.5;1250) means a NATO standard level of :-

35mm relative displacement between 4.0 and 15.9 Hz.
3.5 m/s pseudo velocity between 15.9 Hz and 56.8 Hz and
1250 m/s^2 absolute acceleration between 56.8Hz and 400 Hz

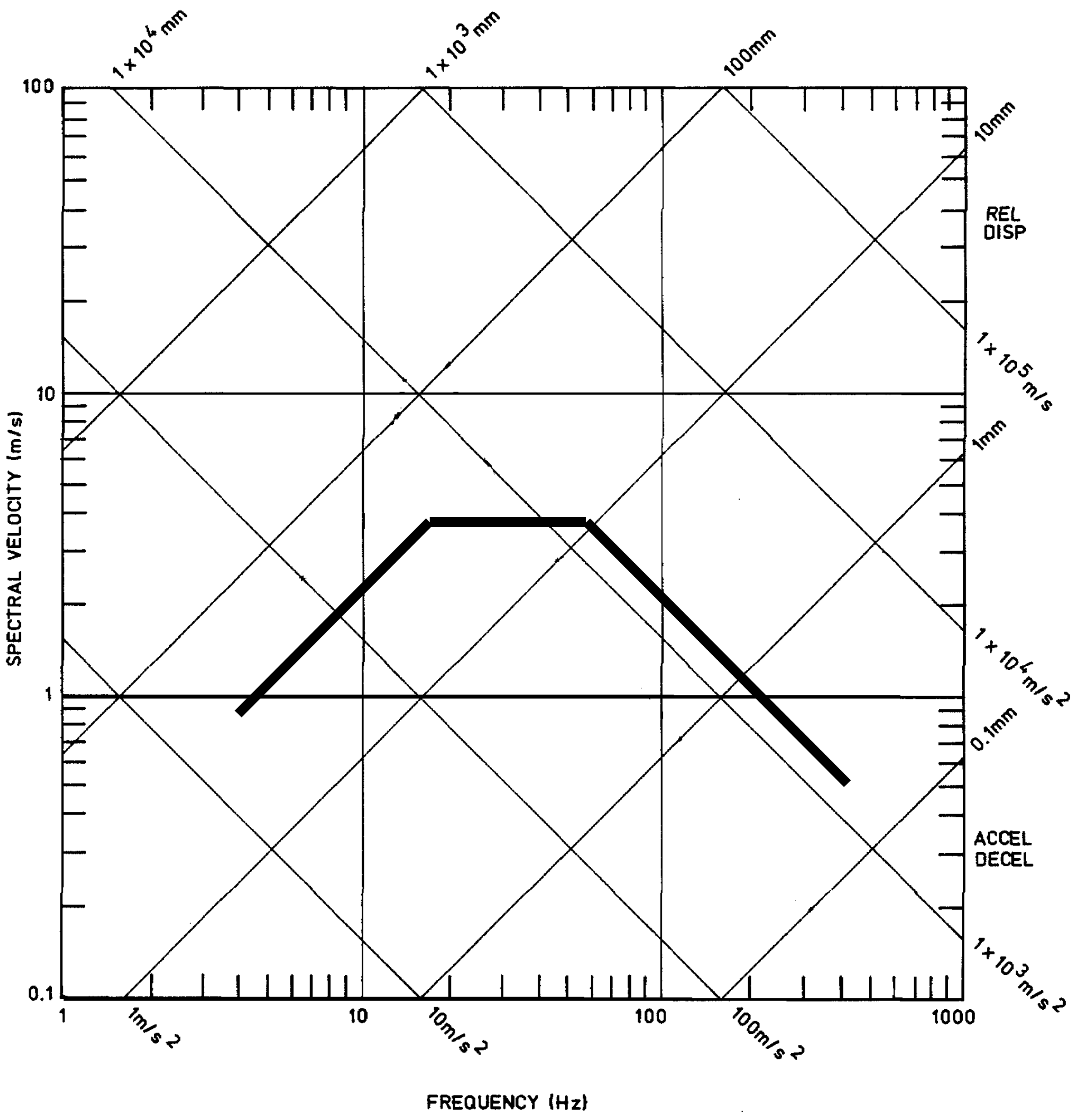
The SRS parameters d_o , v_o and a_o given above refer to a vertical shock. The DRS parameters d_o , v_o and a_o of the transverse shock are obtained by multiplying the corresponding vertical shock SRS parameters by 0.5. The SRS parameters $d_{o\,,}$ v_o and a_o of the longitudinal shock are obtained by multiplying the corresponding vertical shock DRS parameters by 0.25.

4.2.1.4 Direction Of the Acceleration**.** The parameter a_o represents both a maximum acceleration and deceleration.

4.2.1.5 Mass dependencies. The values of the spectrum parameters d_o v_o and $a_{o-}$and those of the lower (f_i) and upper (f_s) transition frequencies, may vary as a function of the equipment mass. If this is the case, guidance on the variation will be provided by the acceptance authority.

Figure 1; Typical NATO Shock Spectra

NS(0.035, 3.5,1250)



4.2.2 Time - Domain Description

4.2.2.1 The choice of the analytical equations describing the equipment foundation motion is left with the supplier. For a given NS Level, equipment mass and shock direction, the severity of the excitation described in the form of a time history of the foundation motion shall be such that the shock response spectrum over the frequency range 4 - 400 Hz. satisfies the following requirements.

Condition 1 The spectrum used for the design (the derived spectrum) is not to fall below the required value by more than 30% of this value at any frequency.

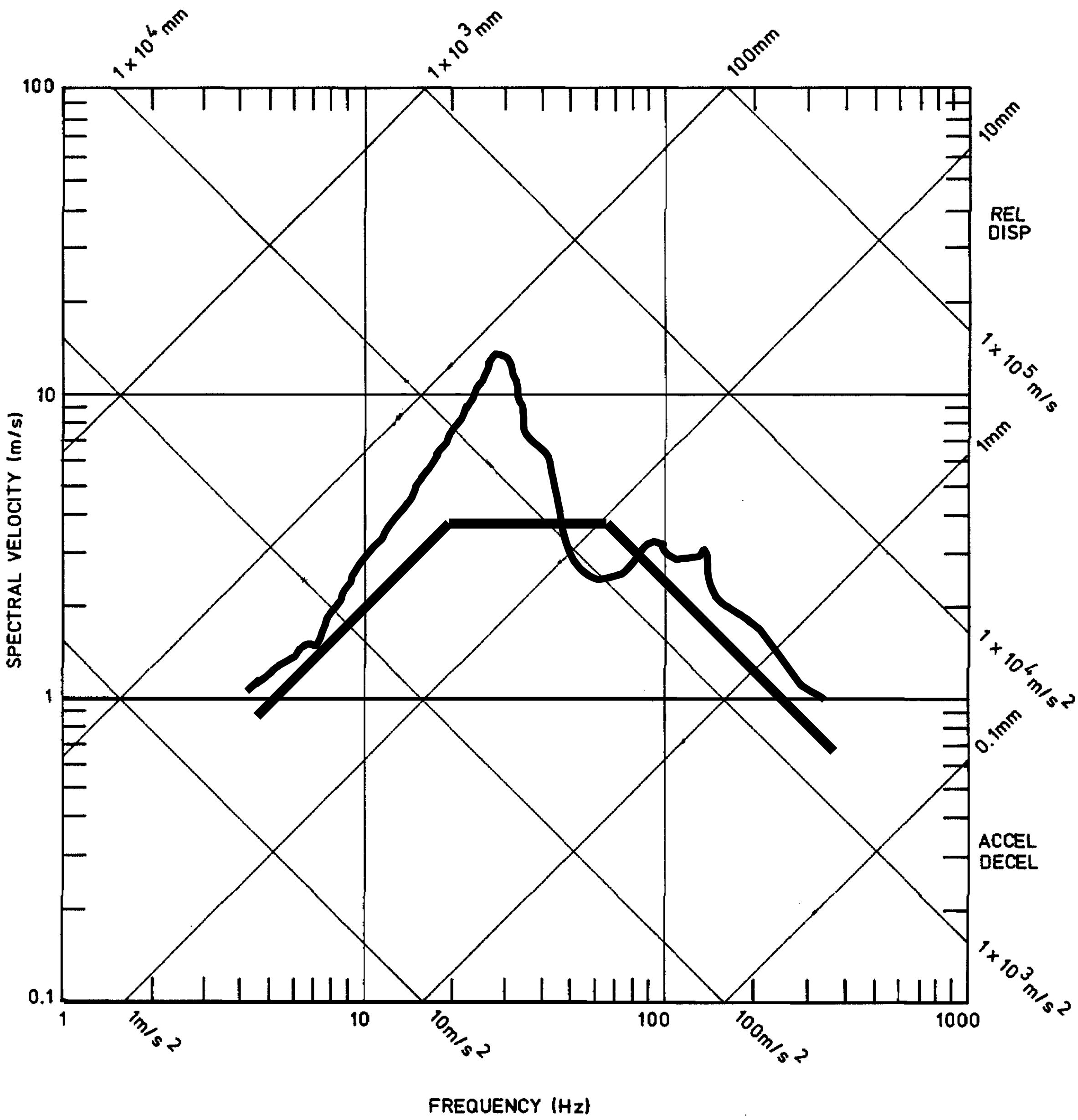
Condition 2 For each area where the derived spectrum lies below the required spectrum, there is to be no more than one frequency octave separating the points at which the derived spectrum crosses the required spectrum.

Condition 3 With the derived spectrum plotted as a graph on top of the required spectrum. The area between the spectra below the required spectrum is not to exceed the area between the spectra above the required spectrum. These areas must be calculated as a geometrical area on the log/log graph and not from the actual physical values.

Examples of these conditions 1, 2 and 3 are shown in figures 2,3 and 4 respectively.

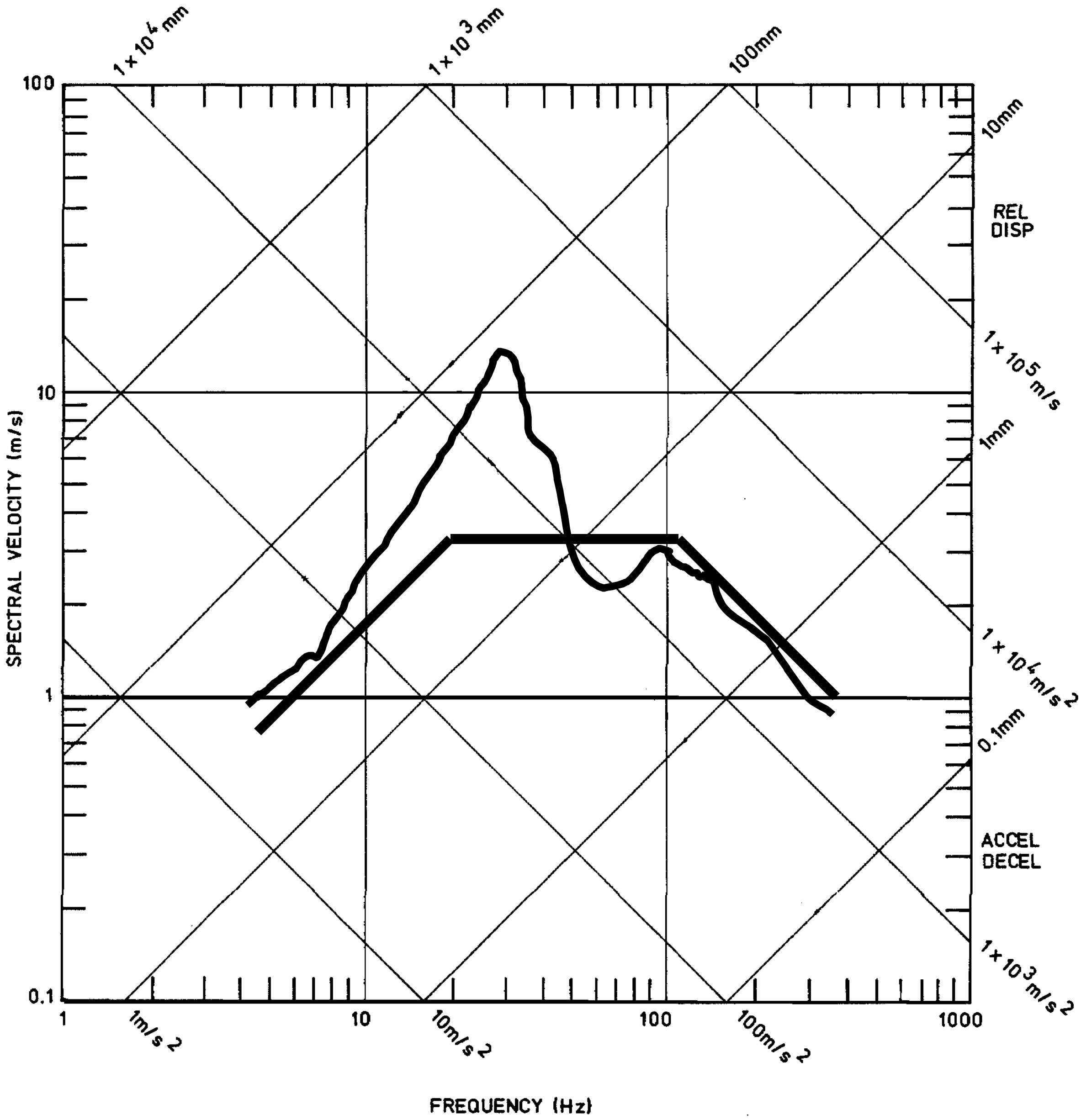
4.2.2.2 Since the shock spectra herein are not intended to be representative of a single typical shipboard shock motion but developed to envelope the motions of various types of surface ships, it may prove impossible to satisfy the preceding requirements with one foundation motion time history; in this case the analysis is to be carried out on the basis of two or more different foundation motions, so that the envelope of their SRS satisfies the conditions specified above. Since this method may underestimate the cumulative effects of different vibration modes care must be taken when selecting the different foundation motions. A justification for this approach must be provided to the acceptance authority

Figure 2 Comparison of shock spectra - Condition 1 Failure



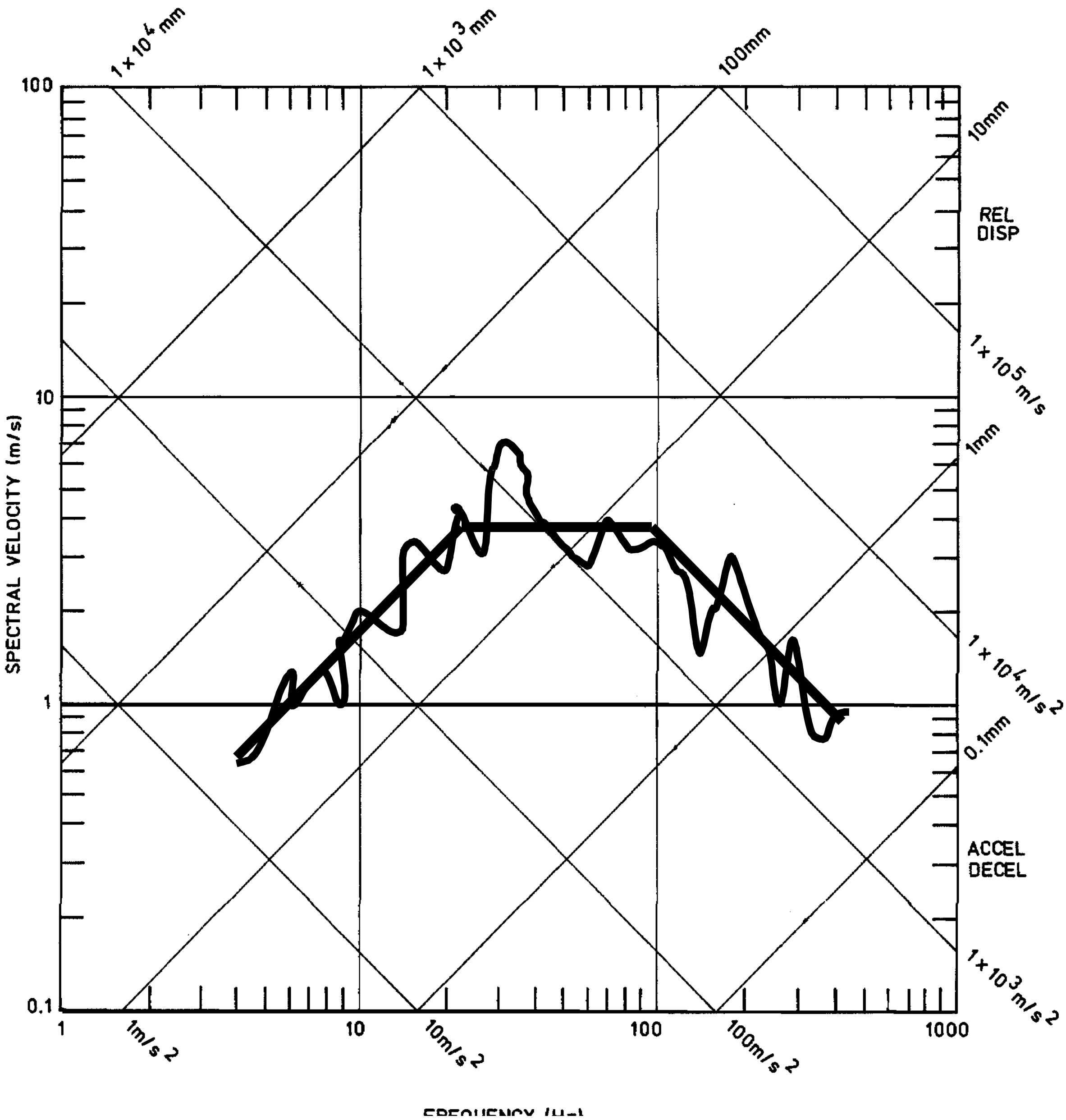
The comparison failed on condition 1 because the derived spectra dropped below 70% of the requirement at approximately 45Hz

Figure 3 Comparison of shock spectra - Condition 2 Failure



The comparison failed on condition 2 because the derived spectra dropped below the requirement at 45Hz and did not rise above it again. If the derived spectra had crossed again between 45Hz and 90Hz, condition 2 would have been satisfied.

Figure 4 Comparison of shock spectra - Condition 3 Failure



The comparison failed on condition 3 because there is a greater area between the derived spectra and the requirement below the requirement than there is above the requirement.

5. ANALYSIS REPORT

5.1 In applying for the shock resistance qualification of a piece of equipment, the supplier shall submit to the purchasing authority a full report on the equipment shock analyses carried out on equipment. This report shall contain:

5.1.1 A statement that the analysis was carried out in accordance with STANAG 4142.

5.1.2 The NS Level(s) used for the analysis and any other information relevant to the design requirement and the equipment's performance/acceptance requirements.

5.1.3 The description of the model (or models) shall be completed with an account of the criteria followed in deducing it (or them) from the actual constructional design of equipment (e.g. criteria at the basis of the choice of the spatial distribution of the masses and moments of inertia of the inertial components, coefficients of influence or stiffness of the resilient component, fractions of the critical damping of the eventual dissipative components etc.).

5.1.4 A description of the dynamic analysis method used including:

(a) the theoretical background for the analytical method;

(b) the critical assumptions, if any, made for simplifying the analysis, together with their theoretical and/or experimental justification;

(c) the procedure used for taking account of the dynamic reaction of the oscillating equipment on the foundation motion, together with its theoretical and/or experimental basis where applicable;

(d) an account of the numerical procedures used for calculating the response of equipment, with reference to the computer programmes (if any) used in connection with those procedures;

(e) a complete quantitative description of the basis of the analysis showing that all the relevant design requirements are satisfied;

(f) the results of the actual shock motion calculations carried out on the equipment model (or models) on the basis of the chosen NS shock Level;

(g) the results of the actual calculation of the stresses induced in the various equipment parts by its shock motion, together with the criterion used for determining the 'equivalent' stresses to be compared with the permissible ones. The assumptions made in these calculations, as concerns the stress raisers, the eventual design into the plastic field (according to point 3.3.3.3), etc. must be clearly stated and justified;

(h) a summary sheet of calculated values compared with permissible values. Calculated values that are greater than 75% of the permissible values should be identified.

(i) Evidence to support the chosen material properties

(j) Justification for not shock testing the equipment

5.1.5 The evidence required by (a), (b), (c) and (d) above can be dispensed with if full documentary material is already available for example in the form of technical reports describing the dynamic analysis method used for the specific equipment considered, national standards, etc. In this case the analysis report shall contain a complete list of this background material, and, if so requested by the purchasing authority, a copy of the relevant technical documents shall be annexed to the report.

Appendix 1 to Annex A of STANAG 4142

DEFAULT SPECTRAL VALUES

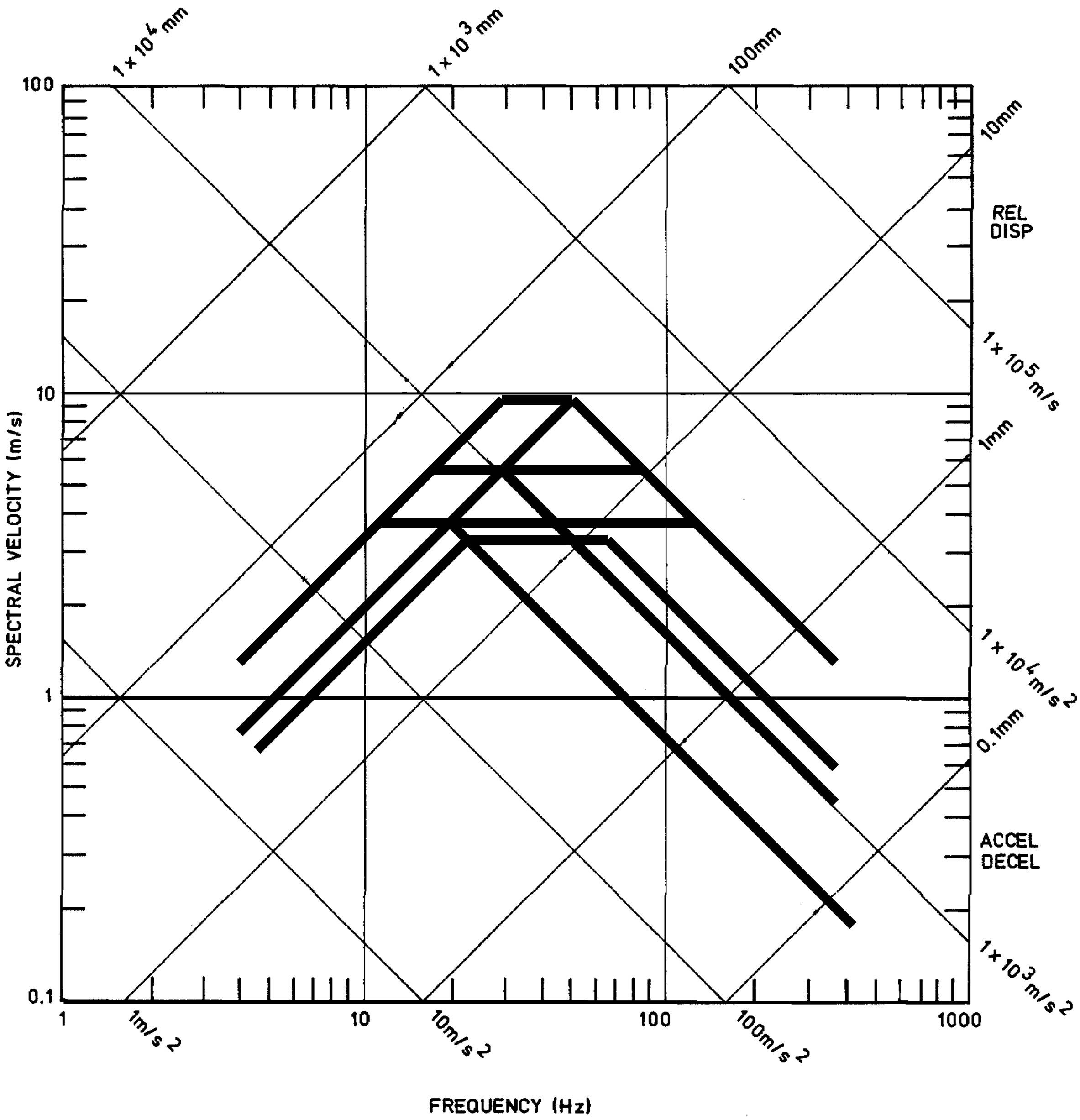
1. Where possible and under the circumstances described in paragraph 2.1.4 consideration should be given to selecting the shock parameters d_0 v_0 and a_0 from the following preferred values.

Relative Displacement	d_o =0.04 and 0.063	(m)
Spectral Velocity	v_o = 4.0, 6.3 and 10	(m/s)
Absolute Acceleration	a_o = 400, 1000 and 2500	(m/s^2)

2. The 12 spectra composed from these default values are shown in Figure A1.1.

3. In addition to the 12 levels described above, there is a 13th preferred level which equates to the NATO Standard Shock Grade 1 (NSSG1) specified in the previous issue of this STANAG. This additional NS level is defined as NS(0.035, 3.5, 1250).

FIGURE A1.1 - The Default NS Levels



Default NS Levels

NS(0.040;4.0;400)	NS(0.063;4.0;400)
NS(0.040;4.0;1000)	NS(0.063;4.0;1000)
NS(0.040;4.0;2500)	NS(0.063;4.0;2500)
NS(0.040;6.3;1000)	NS(0.063;6.3;1000)
NS(0.040;6.3;2500)	NS(0.063;6.3;2500)
NS(0.040;10.0;2500)	NS(0.063;10.0;2500)
	NS(0.035;3.5;1250)