IS 13633 : 1993

(Reaffirmed 1998)

भारतीय मानक

पोत निर्माण—पोत संरचना तथा उपस्कर के स्थानीय कम्पन आँकड़ों का मापन तथा रिपोर्टिंग

Indian Standard

SHIPBUILDING — MEASUREMENT AND REPORTING OF LOCAL VIBRATION DATA OF SHIP STRUCTURES AND EQUIPMENT — CODE OF PRACTICE

UDC 629 : 12 : 534·1·08

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group 5

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Shipbuilding Sectional Committee had been approved by the Transport Engineering Division Council.

The term ' local vibration ', as used in the shipbuilding industry, applies to the dynamic response of a structural element, an assembly of structural elements, machinery or equipment which vibrates at an amplitude significantly greater than that of the basic hull girder at the location. This vibration may occur at a frequency of the hull girder or of a machinery component. Typical examples include the vibration of parts of the superstructure, smokestack, mast, binnacle, turbine, pipe or deck plate. These local vibrations generally result from:

a) local flexibility of supporting structural elements; or

b) the vibratory characteristics of the machinery concerned.

In this standard, the term ' vibration severity ' is used to describe the vibration conditions in the ship and, based on long established practice in the industry, the peak value of vibration velocity has been chosen as the primary quantity of measurement; since, however, much data have been accumulated in terms of vibration acceleration and vibration displacement, a plotting sheet has been adopted on which data may easily be plotted using any of these quantities of measurement.

This standard establishes uniform procedures for gathering and presenting data on vibration of local structural elements or equipment in sea-going merchant ships. The procedures, where applicable, can also be used for inland ships and tug boats. Such data are necessary to establish uniformly the vibration characteristics present in various compartments on board ship and to provide a basis or design predictions, improvements and comparison against environmental vibration reference levels or criteria relative to reliability (of machines), safety (of structures) and habitability. The data are not intended to apply to the evaluation of the vibration of machines with respect to noise control or to the design of the machine or equipment under consideration. These latter cases will generally require specific diagnostic treatment and include a broader frequency range and more specialized instrumentation than is necessary for these general considerations.

Concern over local vibration may be caused by:

a) the stresses due to the vibration, for example, in the structure, in the equipment or attachments;

b) the necessity of maintaining trouble-free operation of a machine or other equipment which might be jeopardized by the malfunction or degradation of components;

c) the physical strain on man (habitability and performance);

d) the effects of the vibration on its environment, such as adjacent instruments, machines, equipment, etc.

This standard gives general principles of vibration measurement on board ships to improve vibration engineering. Therefore, in individual case, items to be measured may be selected or added to meet the aims of the vibration measurement of each ship.

In the preparation of this standard, considerable assistance has been derived from ISO 4868 : 1984 ' Code for the measurement and reporting of local vibration data of ship structures and equipment ', issued by the International Organization for Standardization (ISO)

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ' Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SHIPBUILDING — MEASUREMENT AND REPORTING OF LOCAL VIBRATION DATA OF SHIP STRUCTURES AND EQUIPMENT — CODE OF PRACTICE

1 SCOPE

1.1 This standard deals with local vibration measured on structural elements, superstructures, decks, bulkheads, masts, machines, foundations, equipment, etc, and only relates to the measurement and reporting of the local vibration of the structure or equipment mounted thereon.

The frequency range considered includes propulsion shaft rotational frequencies, rotational frequency of machines and other significant source frequencies, such as diesel firing, blade or vane passage etc.

2 REFERENCE

IS 13290 : 1992 'Shipbuilding — Measurement and reporting of shipboard vibration data — Code of practice' is a necessary adjunct to this standard.

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Free Route

That condition achieved when the ship is proceeding at a constant speed and course with minimum throttle or helm adjustment.

3.2 Hull Girder

The primary hull structure such as the shell plating and continuous strength decks contributing to flexural rigidity of the hull and the static and dynamic behaviour of which can be described by a free-free non-uniform beam approximation.

3.3 Hull Girder Vibration

That component of vibration which exists at any particular transverse plane of the hull so that there is little or no relative motion between elements intersected by the plane.

3.4 Local Vibration

The dynamic response of a structural element, deck, bulkhead or piece of equipment which is significantly greater than that of the hull girder at that location.

3.5 Severity of Vibration

The peak value of vibration (velocity acceleration or displacement) during periods of steady-state vibration, representative of maximum repetitive behaviour, under the conditions defined in **4.2**.

When using autographic records, suitable lengths of record may easily be recognized.

When using electronic methods of recording and analysis, care shall be taken to use lengths of record, time constants and averaging times so that good approximation to the steady-state amplitude is obtained.

4 MEASUREMENT OF DATA

4.1 Instrumentation

4.1.1 Measurements shall preferably be made with an electronic system which produces a permanent record. The transducers may generate signals proportional to acceleration, velocity or displacement. Recording can be made either on magnetic tape, paper oscillographs, or a combination of both. Use of paper oscillographs during the tests means that the vibration traces can be inspected directly and is very helpful in evaluating existing vibration problems. When displacement rather than either velocity or acceleration is recorded, the desired low-frequency signals associated with significant vibratory motion are the major components of a recorded trace. Thus, they are readily evaluated since they overshadow possible higher frequency signals with low displacement amplitudes.

4.1.2 Provision shall be made for suitable attenuation control to enable the system to accommodate a wide range of amplitudes.

4.1.3 An event marker shall be provided on the propeller shaft. Its position with respect to top dead centre of cylinder No. 1 and a propeller blade shall be noted.

4.1.4 The complete measuring system shall be calibrated in the laboratory prior to the test and it is desirable to check the calibration of each recording channel before each stage of the test.

4.1.5 Portable electronic and mechanical instruments capable of single-point measurement may be used.

4.2 Preferable Test Conditions

4.2.1 The preferable test conditions shall be as follows:

a) The test shall be conducted in a depth of water not less than five times the draught of the ship, with machinery running under normal conditions, unless otherwise specified;

NOTE — For exploratory purposes, tests may be carried out at the quayside if there is no reason to suppose that shallow water will influence the results.

b) The test shall be conducted in a quiet sea [sea State 3 (equivalent to wind speed of 11 to 16 knots) or less];

c) The ship shall be ballasted to displacement as close as possible to the operating conditions within the ordinary ballasting capacity of the vessel. The draught aft shall ensure full immersion of the propeller;

d) During the free-route portion of the test, the rudder angle shall be restricted to about two degrees port or starboard (minimum rudder action is desired); and

e) Individual machines may be run in isolation as required to investigate particular problems.

4.2.2 Any divergence from these conditions shall be clearly stated in Table 4.

4.3 Transducer Locations

4.3.1 *Stern*

Vertical, athwartship and longitudinal measurements as close as possible to the centreline and the stern, to establish the hull girder vibration characteristics. The location shall be chosen so that the results are not influenced by local vibration effects.

4.3.2 *Superstructure*

Vertical, athwartship and longitudinal measurements on the superstructure front bulkhead, at a minimum of three different deck levels.

4.3.3 *Local Structures*

Vertical, athwartship and longitudinal measurements at any local structure where evidence of local vibration occurs.

4.3.4 *Local Deck Traverse*

Vertical, athwartship and longitudinal measurements at a sufficient number of points in the area of local vibration to determine the relative vibration with respect to the hull girder.

4.3.5 *Local Machinery and Equipment Vibration*

Vertical, athwartship and longitudinal vibration at the outside of machinery where there is evidence of large vibration amplitudes.

4.4 Quantities to be Measured

The quantities to be measured are as follows:

a) Any one of displacement, velocity, acceleration, pressure and strain;

b) Frequencies in cycles per second (Hz) or cycles per minute;

c) Shaft rotational frequency (speed) in revolutions per minute or revolutions per second; and

d) Phase, where appropriate.

4.5 Test Procedure

4.5.1 *Calibration of Recording Equipment*

Each channel shall be checked after completion of installation to ensure proper working condition, desired amplification setting and phasing. Checks shall be made at regular intervals. The calibration shall be recorded.

4.5.2 *Performance of Measurements*

The data in the following conditions shall be recorded:

a) In free route, at 3 to 10 rev/min increments from one-half to maximum speed. Additional runs at smaller increments are required in the vicinity of critical speeds and near service speed;

b) Free route runs at the operation speeds; and

c) Special runs at speeds reported to cause local vibrations, as needed.

NOTE — For free-route runs, permit the ship to steady on constant speed. Hold the speed for a sufficient time to permit recording of maximum and minimum vibration values (about 1 min). In multiple shaft ships, all shafts shall be run at, or as close as possible to, the same speed to determine total vibration levels. In certain instances it may be preferable to run with a single shaft for the determination of vibration modes.

5 ANALYSIS AND REPORTING OF DATA

5.1 Analysis

Analysis shall provide the following information for all runs:

a) Severity of vibration at the propeller shaft rotational frequency for hull girder transducers;

b) Severity of vibration at blade rate frequencies for hull girder and machinery transducers;

c) Severity of vibration of each detectable harmonic of shaft rotational frequency or blade rate for hull girder and machinery transducers;

d) Severity of local structural vibration at all measurement locations;

e) Mode shape of local vibrations. Use hull girder vibration as reference for the mode shape;

f) Severity of vibrations of local machinery or equipment at all measurement locations;

g) For additional optional measurements, if specified, *see* IS 13290 : 1992.

NOTE — The presence of beating effects, if any, shall be noted by recording maximum and minimum values of the amplitudes and the frequency of the beat.

5.2 Reporting of Data

Data reported shall include the following:

a) The principal ship design characteristics:

1) Complete Tables 1, 2, 3 and 4.

2) Provide a sketch of the inboard profile of hull and superstructure.

b) A sketch showing locations of hull girder and local transducers and their directions of measurement.

NOTE — For local vibration measurements, it is particularly important that the precise position of transducers shall be noted since very small changes in position can lead to large changes in measured amplitude.

c) Plots of displacement of velocity or acceleration amplitudes versus speed for shaft rotational frequency, blade rate or any harmonic thereof. Make use of forms of the kind shown in Fig. 1, using the rules given in Table 5. Linear plots may also be used;

d) Profiles of local deck vibration at each resonace from port to starboard and from the nearest aft to the nearest forward structural bulkhead;

e) Tables of all significant vibration severities and their location and frequency, for machinery excited vibration;

f) Hull girder natural frequencies identified from stern measurements and any unusual vibration condition encountered;

g) Results from manoeuvres tabulated as indicated in Tables 6 and 7;

h) Weather conditions during the measurements, including sea state and direction relative to the ship;

j) Method of analysis of results; and

k) Type of instrument used.

6 RULES FOR PRESENTATION OF VIBRATION TEST RESULTS

6.1 Use one graph each (*see* Fig. 1) for vertical, athwartship and longitudinal hull vibration at stern.

Identify severity of vibration for evaluation of habitability. Use ● for objectionable, ◑ for questionable, and ○ for acceptable vibrations.

6.2 Use one graph (*see* Fig. 1) each for all measuring points and directions of measurement.

6.3 Additional graphs shall be used to identify phasing relationships, etc.

6.4 The following marks shall be used throughout the report for easy identification:


Propeller shaft frequency


Blade rate


Twice blade rate


Three times blade rate


Higher frequencies (identify)


Engine frequency (identify predominant orders)

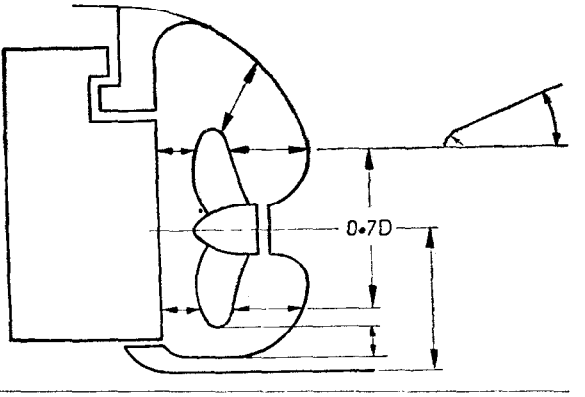
Table 1 Particulars of Test Ship

[*Clause* 5.2(a)]

Particulars of Ship		
Ship Name		
Builder/Year Built		
Hull		
Kind and Type		
Class		
Construction		
Length L_{pp} between perdendiculars, m		
Breadth B moulded, m		
Depth D moulded, m		
Draught T (full load,) m		
Displacement Δ (full load), t		
Block coefficient C_B		
Dead weight, t		
Light weight, t		
Second moment of area of midship section, m^4	I_v	
	I_h	
Shear area of midship section, m^2	A_v	
	A_h	
Sketch of midship section		

Main engines		
No., kind and type		
Year Built		
Bore and stroke, mm		
No. of cylinders		
Power, kW		
Speed, rev/min		
Location*		
Unbalance couple†, N.m	M_{v1}	
	M_{v2}	
	M_h	
Propellers		
No. and type		
No. of blades		
Pitch ratio		
Expanded area ratio		
Skew in degrees		
Diameter D_p, m		
Speed, rev/min		
Type and number of rudders		

Sketch of screw aperture‡



Remarks :

*For diesel engines, the distance from the aft perpendicular to centre of engine. For turbine, the approximate location, for example, amidships, semi-aft or aft.

†In the case of an engine having unbalanced forces and/or any other excitation necessary to describe the vibratory phenomenon, the value shall be added in the 'Remarks' column.

‡Substitute appropriate sketch in multiple screw or ducted propeller ship.

Table 2 Particulars of Propulsion-Shaft System

[*Clause* 5.2(a)]

Particulars of Propulsion-Shaft System	
	Number of Shafts
	Maximum and Normal Speed, rev/min
	Type of Bushing Material
	Shaft Alignment (Straight or Rational)

Rotating Parts	Diameter mm	Length mm
1 Tail Shaft		
2 First intermediate shaft		
3 Second intermediate shaft		
4 Third intermediate shaft		
5 Fourth intermediate shaft		
6 Thurst shaft		

	Diameter mm	*Mass* *t*	*Mass polar moment of inertia* $t.m^2$
Second reduction gear			
First reduction gear			
Flywheel			

Aft part of the shafting	
Mass, *t*, and density, kg/m^3, of propeller	
Mass polar moment of inertia of propeller, $t.m^2$	

Stationary Parts	Diameter mm	C* mm	Support†
a) Stern tube aft bearing			
b) Stern tube forward bearing			
c) First intermediate bearing			
d) Second intermediate bearing			
e) Third intermediate bearing			
f) Fourth intermediate bearing			
g) Fifth intermediate bearing			
h) Sixth intermediate bearing			
j) Seventh intermediate bearing			
k) Eighth intermediate bearing			
m) Ninth intermediate bearing			
n) Thrust block			
p) Bull gearing aft bearing			
q) Bullgearing forward bearing			

	Stiffness N/m	*Distance* mm
Aft support of tail shaft		‡
Forward support of tail shaft		§
Intermediate bearing		

Natural frequency c/min	*Mode*	*Lateral*	*Forward whirl*	*Counter whirl*
	First			
	Second			

Sketch of thrust block and its foundation with major scantlings

Sketch of shaft system showing relative location of rotating and stationary parts. Indicate the length of aft bushing (L) and (L/D).

*Diametral clearance.

†For example, on double bottom, in propeller bossing.

‡Distance between the propeller centre of gravity and aft support of the tail shaft.

§Distance between two tail shaft supports.

Table 3 Particulars of Main Diesel Engines or Turbine Driven Plants

[*Clause* 5.2(a)]

Particulars of Main Engine

Manufacturer		
Kind		
Type		
	Maximum	Normal
Output, kW Brake :		
Shaft :		
Rotational frequency, rev/min		

Natural frequency of shafting and crankshaft or gearing and turbines, c/min*

Mode	Longitudinal	Torsional
First		
Second		
Third		

Main diesel engine

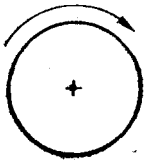
Number of cylinders	
Cylinder bore	
Cylinder stroke	

Mass and position in longitudinal and vertical direction of centre of gravity relative to crankshaft axis

Firing order

Indicate angle and cylinder No., Propeller blade and event marker

FORWARD RUNNING
(LOOKING FORWARD)



Mass polar moment of inertia with respect to crankshaft axis

Stiffness values of thrust block, N/m

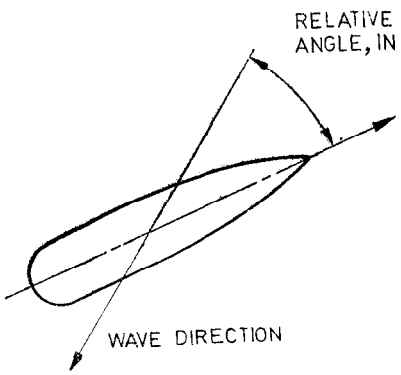
	Order	*Force* N	*Couple* N.m
Free forces and couples due to unbalance	First		
	Second		
Guide forces (H) and couples (X)			

Sketch of crankshaft or reduction gear system showing its major scantlings.

*Give details of balances, detuners, dampers, etc, which could influence vibration.

Table 4 Conditions During Vibration Measurements

[*Clauses* 4.2.2 *and* 5.2 (a)]

Test Conditions		Date
		Place
Sea state (Beaufort No.)		Type and characteristics of measuring instruments
Height of swell, m		
		
Depth of water, m		
Draught forward, m		
Draught aft, m		
Mean draught, m		
Test displacement Δ, t		
Propeller immersion from shaft centre-line to water surface, m		

Loading Plan

Table 5 Results of Vibration Measurements

[*Clause* 5.2 (c)]

Listing of Location of Measurements (Refer to Sketch)				Shaft Speed rev/min	Peak Amplitude* and Frequency Hz						
					Vertical		Athwartship		Longitudinal		Remarks
Station	Frame	Item	Transducers Location		†	Hz	†	Hz	†	Hz	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

Ship :..... Test date :.....

*Indicate whether velocity, acceleration or displacement amplitudes are reported.

†Enter the following units accordingly:

mm for displacement
mm/s for velocity (preferred)
mm/s^2 for acceleration.

Table 6 Results of Vibration Measurements During Manoeuvres (Optional)

[*Clause* 5.2 (g)]

Manoeuvres	Initial Shaft Speed rev/min	Order* BR, 2 × BR	Frequency, Hz, and Maximum Amplitude†					
			Stern			Other Selected Location identify		
			Vertical	Athwartship	Longitudinal	Vertical	Athwartship	Longitudinal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Hard turn to port								
Hard turn to starboard								
Crashback								

Notes:

Ship: ..... Test date: .....

*After order number, identify blade rate (BR) or twice blade rate (2 × BR).

†Indicate whether velocity, acceleration or displacement amplitudes reported and enter the following unite accordingly:

mm for displacement

mm/s for velocity (preferred)

mm/s² for acceleration.

Table 7 Longitudinal Vibration of the Propulsion System During Manoeuvres (Optional)

[*Clause* 5.2 (g)]

Manoeuvres	Run No.	Intitial Shaft Speed rev/min	Frequency, Hz, and Maximum Amplitudes*							
			Thrust Bearing Housing	Thrust Bearing Foundation	Bull Gear Shaft	Gear Case Foundation	Gear Case Top	HP Turbine	HP Turbine	Condenser
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Hard turn to port										
Hard turn to starboard										
Crashback										

Notes:

Ship: ..... Test date: .....

*Indicate whether velocity, acceleration or displacement amplitudes are reported and enter the following units accordingly:

mm for displacement

mm/s for velocity (preferred)

mm/s² for acceleration.

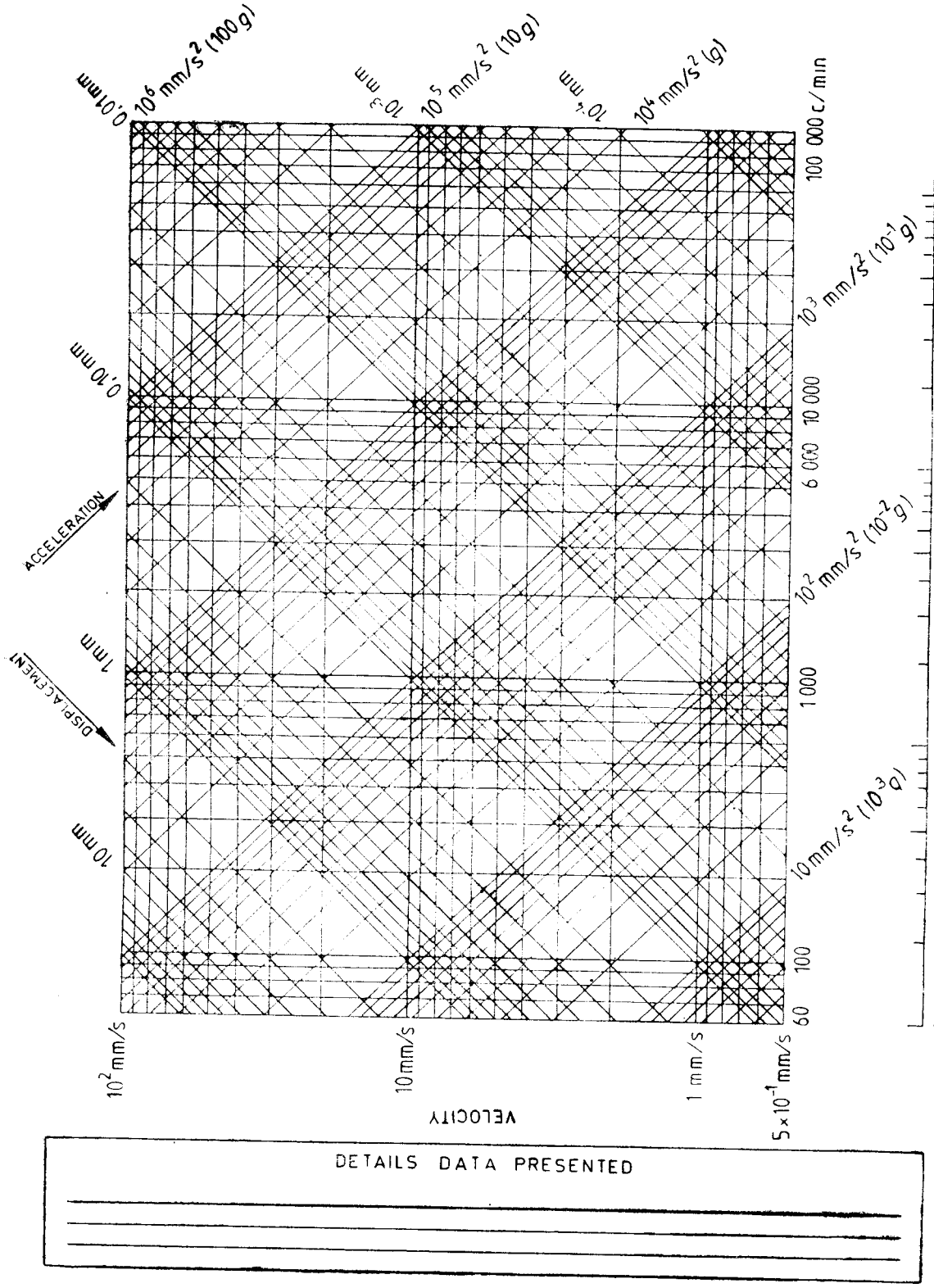


FIG. 1 LOCAL VIBRATION DATA

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