DEPARTMENT OF THE ARMY TECHNICAL BULLETIN

TRANSPORTABILITY CRITERIA SHOCK AND VIBRATION

Headquarters, Department of the Army, Washington, D.C.
17 April 1964

1. Purpose. This bulletin sets forth the Department of the Army interim position as regards engineering considerations of shock and vibration environments induced by transportation. It also furnishes basic transportation engineering design parameters for research and development design usage in conjunction with transportability of military items.

2. Scope. The information contained in this bulletin is applicable to all Army cargoes and in particular for rail, air, sea, and highway modes of transport. Shocks and vibrations are illustrated as envelopes of data that enclose maximum accelerations.

3. General. a. Increased use of fragile, sensitive, and dangerous items and increased importance of such military items have established an urgent requirement for formal guidance as regards transportation environments. The increasing variety of both military cargoes and transport vehicles with their differing size, mass, and internal cushioning has complicated the process of establishing specific guidelines useable for a broad range of items and carriers.

b. Certain data can be established now in the field of transportation shock and vibration that will be extremely helpful for technical communications and as a tool for analytical comparison. The first step is to obtain and use acceleration inputs to a transportation system that are independent of the operational characteristics, such as the physical state of the right of way, impact speed, sea state, and landing rate. From this point, other factors can be presented that are determined wholly or in part by the mechanical makeup and operational characteristics of the transportation system, and that are peculiar to the specific system.

c. It is recognized that some combination of forces, accelerations, and frequencies that would classify and standardize the required strength of 8 broad range of cargoes would be a most useful tool. Work to date in this area has been accomplished on selected items. A complete scientific methodology requires a broad background of field studies designed specifically for this purpose. Considerable effort has been expended, and enough studies have been conducted to develop, empirically, certain shock and vibration producing factors. These factors are illustrated and published here to initiate a better interchange and comparison of transportation shock and vibration data; also, to increase utilization of existing data in initially establishing a methodology stated in mathematical and mechanical terminology.

d. The data and guidelines contained in this bulletin comprise the Department of the Army, Chief of Transportation interim position. Transportation Corps efforts will be continuous to keep up with technological advances; the basic factors will be adjusted as required, and additional findings will be included to extend toward the development of a definite analysis procedure.

4. Rail. a. The cargo and its restraining systems should be capable of withstanding a transportation shock environment simulated by three successive rail impacts in both car directions of 10-mile-per-hour severity for priority, high value, and sensitive cargoes and 8 miles per hour for general troop support cargoes. The striking (or the car moving before impact) must be either a fully loaded car having a minimum rail load of 169,000 pounds with a standard-travel draft gear, or the car containing the cargo being studied, whichever has the greater weight.

b. The stresses in the restraining members should be less than one-half the yield strength of the material in the static, or restrained condition. The combined static and dynamic stresses must not exceed the static yield strength* of the material in any restraining system component during the dynamic portion of the impact loading. Additional margins of safety may be required during design of the restraining systems because of the cargo's peculiar nature, train safety considerations, or accident effects considerations.

c. For design purposes, the shock environment contained herein should be treated as a definite loading produced by the environment. No safety factors are included in the environmental statements or data.

d. The cargo and its restraining system should be able to withstand without failure or impending failure, a transportation vibration environment equivalent to one produced by over-the-road movement in a 150-car train. The car transporting the cargo should have standard freight car suspension and draft gear, and should be considered for the end of the train car position. Vibrations, both intermittent and continuous, should be of a duration equivalent to the input from 3,000 miles of Class I railroads containing at least 50-percent long maximum grades.

c. Envelopes of the maximum environmental values recorded during Transportation Corps studies for both shock and vibration are shown in figure 1. These values were recorded while using standard commercial rail car impacted at 10 mph. The range of response of the recording instrumentation limits data frequencies; hence, higher frequency data were filtered before recording.

f. It is recommended that at least six applications of the maximum shock acceleration be applied consistent with three car impacts from each direction. It is recommended that a vibration time be consistent with a 3,000-mile trip, and that design increases for safety be made by increasing the time of vibration rather than by adjusting the amplitude or the frequency.

5. Sea. a. For sea transportation, cargo and its restraining system should be capable of sustaining an environment occasioned by a seaway-induced loading on a transport ship consequent to 20 days of Beauford Sea State Condition 12. During this condition, the components of the restraining system should not exhibit a combined static and dynamic stress in excess of 80 percent of the static yield strength of the materials. The static stresses occasioned by normal tie down procedures should not exceed 50 percent of the static yield strength* of the materials.

b. Particular emphasis must be placed on the effects of stacking cargo for shipboard transport. Stacking may subject the cargo, the cargo container, or the restraining system to severe loading conditions. As the dynamic and static loads are resisted by each succeeding lower unit of cargo in the stack, the cumulative effect on the bottom units must be considered in design. The same consideration as regards stacking and dynamic loading must be given in the horizontal plane, since longitudinal accelerations will also cause a load buildup on the end unit unless load dividing measures are taken. Effects of cargo stacking are most troublesome in sea transport because of relatively large cargo holds which accommodate excessive stacking.

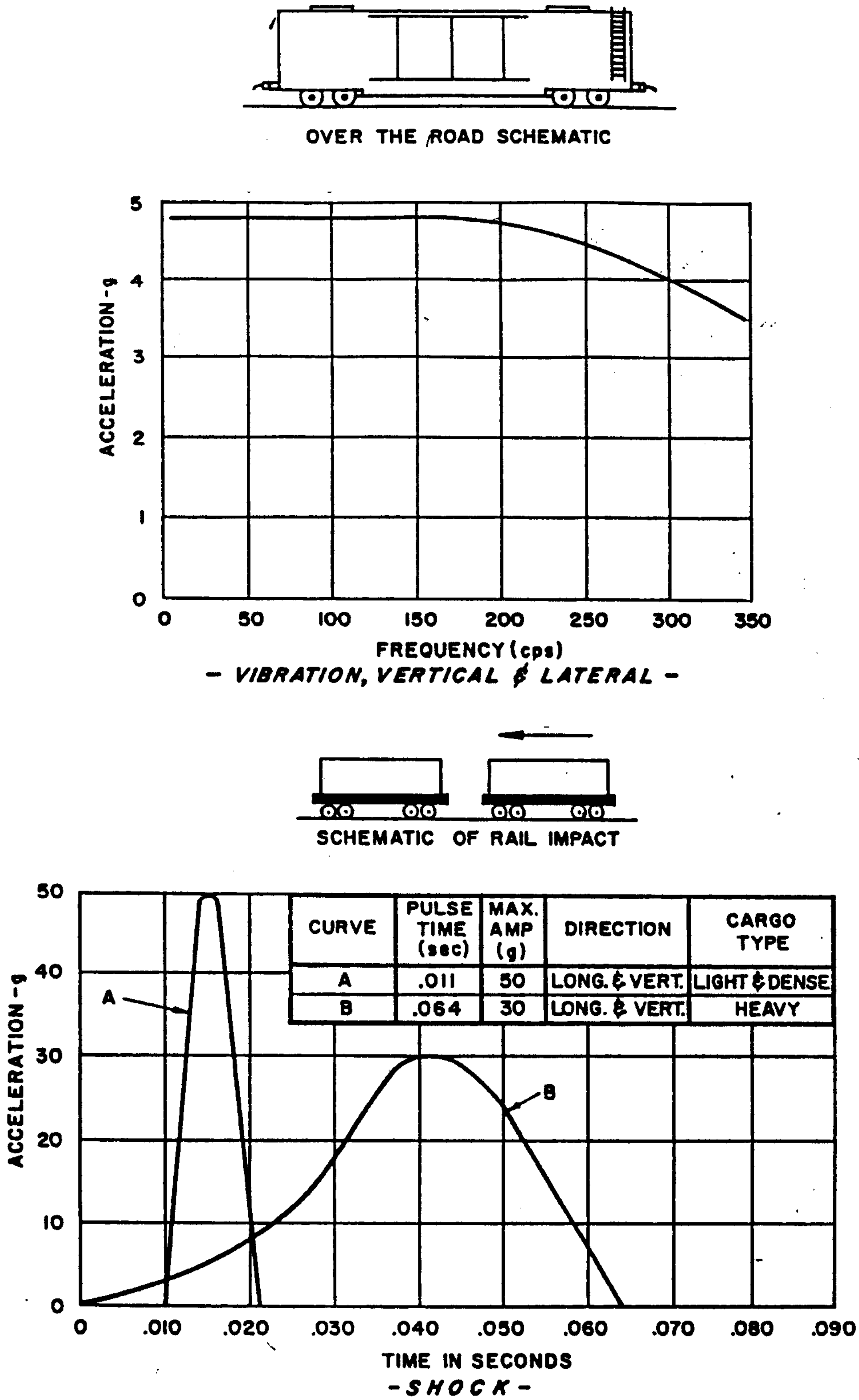
c. Figure 2 presents guidance as to the nature of the sea-induced accelerations on the cargo. The data are a plot of an envelope of the maximum values of the vibrations in the frequency range of 0 to 15 cycles/second. Also shown is a time-history envelope of the maximum shock environment measured.

d. The time recommended for application of the vibration is 20 days. It is recommended that 100 shock applications be considered the minimum requirement.

6. Air. a. Induced shock and vibration environments for air transportation are normally considered the least severe as regards loading of the cargo and its restraining system. Factors of plane safety, cost of cargo, and military value of the cargo dictate the highest degree of reliability for the strength of cargo and its restraining systems. Many strength safety factors are employed both in design and operation for restraining systems involving air transport, with consequent multiplication factors applied to the basic environmental data. The basic data should be especially accurate in order to minimize cumulative error on the inaccurate portion of the data that is proportioned or multiplied for safety or design reasons.

b. For air transport, the cargo and its restraining system should be capable of withstanding all the aircraft vibrations occasioned for a time period consistent with the maximum range of the aircraft. It is considered important that the amplitude and

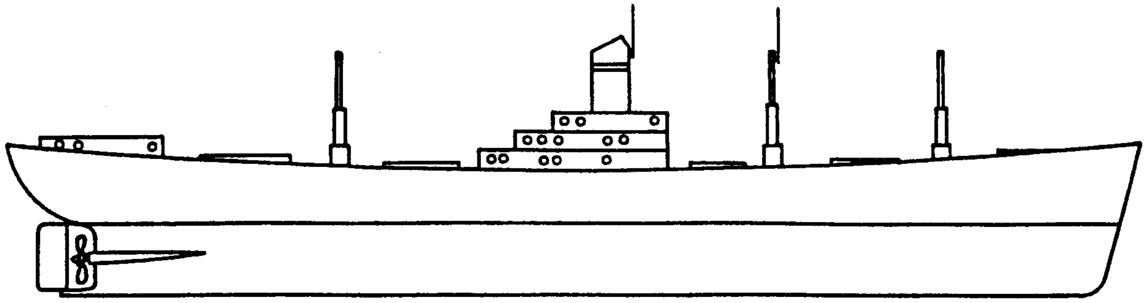
* As published by the American Society for Testing Materials (ASTM).



CURVE	PULSE TIME (sec)	MAX. AMP (g)	DIRECTION	CARGO TYPE
A	.011	50	LONG. & VERT.	LIGHT & DENSE
B	.064	30	LONG. & VERT.	HEAVY

CARGO ENVIRONMENTS FOR RAIL TRANSPORT

Figure 1.



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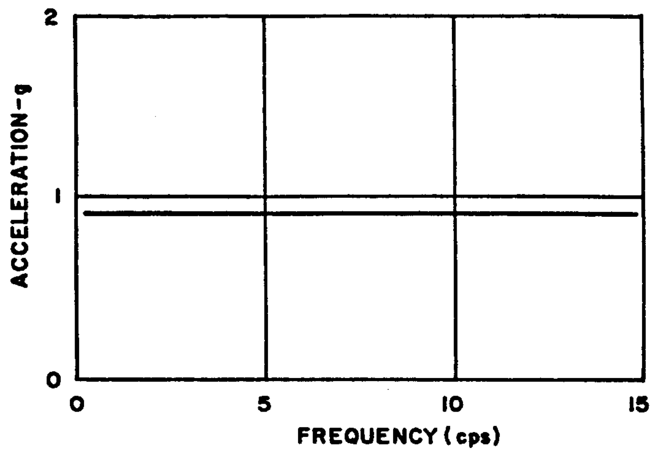
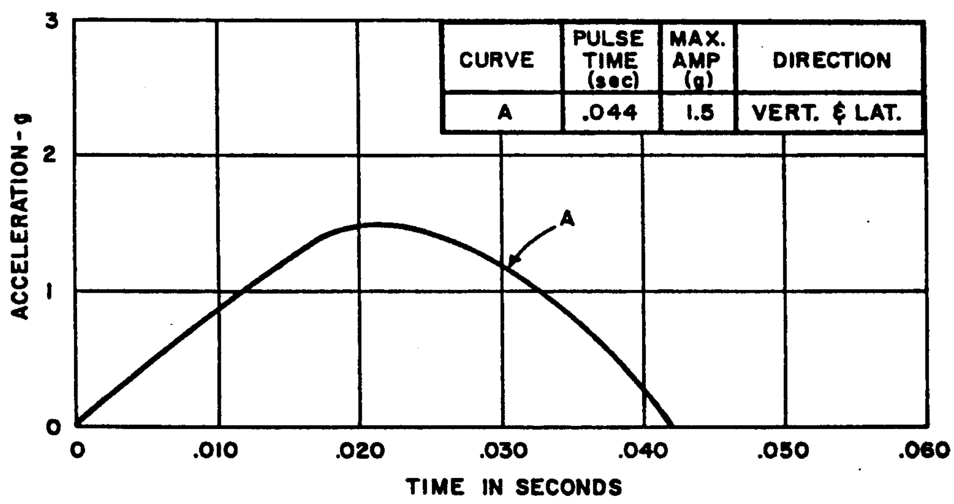


—VIBRATION, VERTICAL & LATERAL—



— SHOCK —

CARGO ENVIRONMENTS FOR SEA TRANSPORT

Figure 2.

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frequency of the vibrations be accurately duplicated and that safety factors be applied in terms of the length of the vibration. It is recommended that the restraining system be designed to sustain the vibration for a period three times as long as would be anticipated based on the mission of the aircraft.

c. The shock acceleration normally occasioned by landing should be based on a velocity at touchdown for the aircraft of 10 feet per second. Again, any safety factors should be applied by increasing the number of shocks rather than the severity. It is recommended that the restraining system be capable of withstanding 20 landing shocks with no signs of failure or impending failure to any of the components.

d. Envelopes of the maximum data recorded in the Transportation Corps field studies thus far are shown in figure 3. These data are from tests in which short recording periods were used and where high input loadings were simulated consistent with test safety. It is anticipated that with the inclusion of data taken under emergency conditions, the accelerations will be somewhat higher.

7. Highway. a. For highway transportation, the cargo and its restraining system should he capable of sustaining the loadings incident to a 1,000-mile road trip over a paved highway in a condition described by AASHO*--PSI** index 1. For all shocks and vibrations, the stresses in the restraining system should not exceed the yield strength*** of the material, nor should they exceed one-half the yield strength*** of the material under static load conditions.

b. Envelopes of maximum values recorded during Transportation Corps field studies for both shock and vibration are shown in figure 4. It is recommended that the vibration time for design purposes be consistent with a 5,000-mile trip and that design safety factors, if any, be applied by increasing the time of vibration. For design purposes, it is recommended that the restraining items be designed to withstand 30 shock applications.

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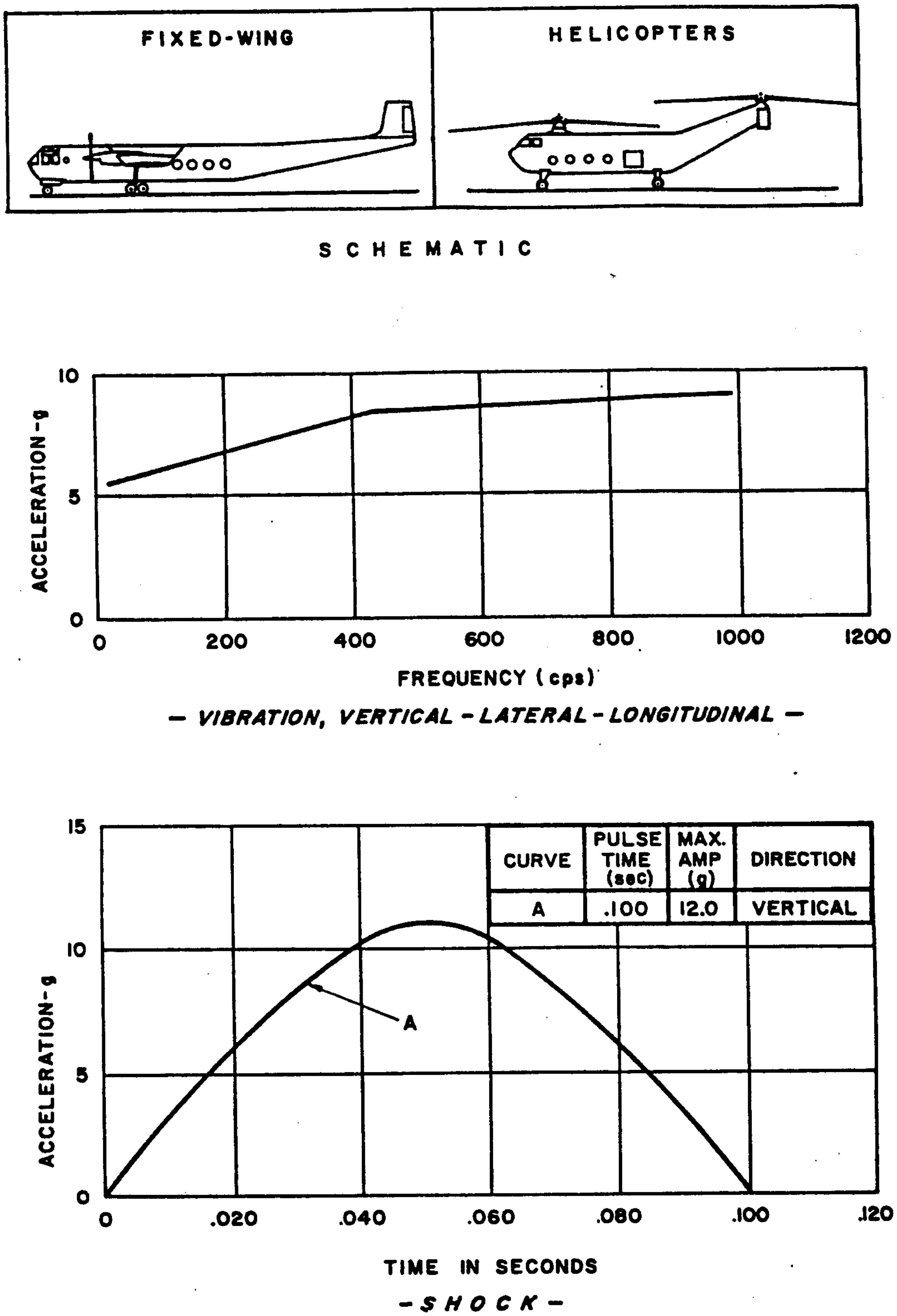
*AASHO - American Association of State Highway Officials.

**PSI - Present Serviceability Index, reference: Highway Research Board Special Report, No. 61-C.

***As published by the American Society for Testing Materials (ASTM).



CARGO ENVIRONMENTS FOR AIR TRANSPORT

Figure 3.

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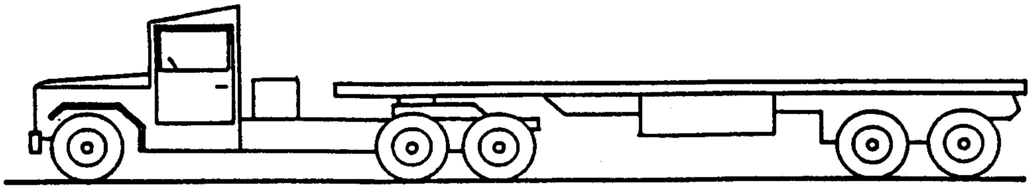

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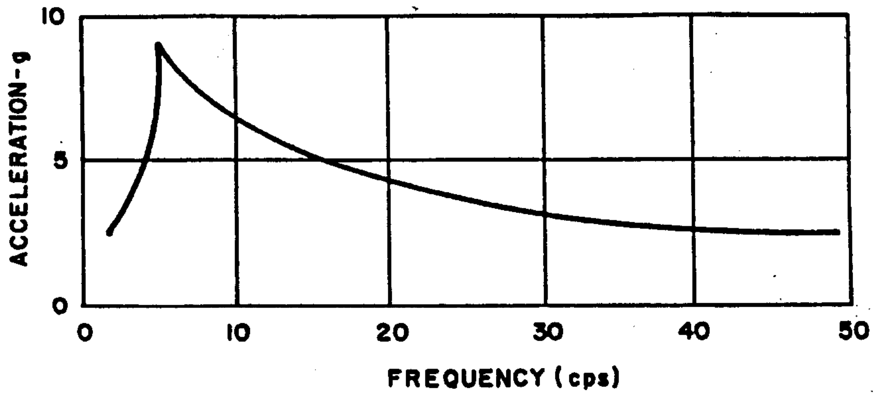
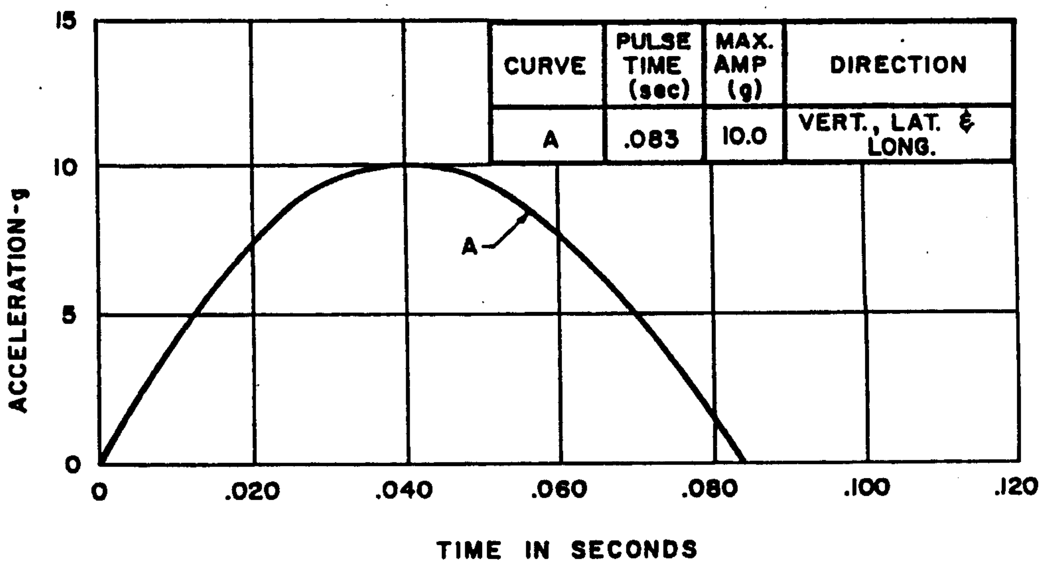


– *VIBRATION, VERTICAL* –



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CARGO ENVIRONMENTS FOR HIGHWAY TRANSPORT

Figure 4.

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