MILITARY STANDARD

ENVIRONMENTAL TEST METHODS

TO ALL HOLDERS OF MIL-STD-810B:

1. The following pages of this standard have been revised and supersede the pages listed:

New pages	Date	Superseded Pages	Date
519.1-1 thru 519.1-17	18 Sep 70	519.1 thru 519.15	29 Sep 69

2. This notice forms a part of MIL-STD-810B dated 15 June 1967. The general requirements of MIL-STD-810B shall apply to any application of this notice.

3. THIS NOTICE IS NONCUMULATIVE, RETAIN AND INSERT BEFORE THE TABLE OF CONTENTS.

4. Holders of MIL-STD-810B will verify above addition has been entered. This issuance, together with appended pages is a separate publication. Each notice is to be retained by stocking points until the Military Standard is completely revised or canceled.

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Project No. MISC-0651

METHOD 519.1

GUNFIRE VIBRATION, AIRCRAFT

1. Purpose. The gunfire vibration test is conducted, in addition to the conventional vibration test, to simulate the relatively brief but very intense vibration fields resulting from blast pressure fields generated by repetitive firing guns mounted in, on, or near the aircraft structure. This method applies to gun pod configurations and, provided that appropriate gunfire vibration data is not available, may also be used for helicopter gunships.

2. Apparatus. Vibration equipment with required instrumentation.

3. Criteria for application. The most severe vibration field results from blast pressure pulses coupling to the aircraft structure and inducing vibration fields that are of maximum intensity near the gun muzzle region. This field, designated by curve A on figure 519.1-1, decreases in an inverse relationship to the distance as viewed in a forward direction from the gun muzzle. The vibration field, designated by curve B on figure 519.1-1, decays similar to the primary field beginning at the gun muzzle and extending in the aft direction. The B field, beyond the near field region of the muzzle, is of lower intensity. Guns, physical locations, and ballistic parameters should be carefully and accurately identified prior to application of this test method. In no case should this test method be substituted for conventional vibration tests. If the maximum test spectrum level of the gunfire configuration is equal to or less than .04 g^2/Hz, the gunfire method need not be conducted.

3.1 Sensitive equipment. Equipments found most susceptible to gunfire are those equipments that are usually located within a 3-foot radius of the gun muzzle and are mounted on the structural surface exposed to the gun blast. Prime examples are UHF antennas of the blade, V, and the flush-mounted configurations, including their bracketry, coaxial connectors, and lines. Next in order of failure susceptibility is equipment mounted on drop-down doors and access panels, equipment mounted in cavities adjacent to the aircraft surface, and finally, equipment located in the interior of the vehicle structure. Typical vulnerable equipments in these latter categories are auxiliary hydraulic and power units (including mounting bracketry), switches, relays, IR, photographic, communication and navigation equipment and radar systems, including items either shock or hard mounted.

3.2 Determination of test levels

3.2.1 Selection of the maximum test level. The maximum gunfire vibration level is defined by the following equation:

$$G_{max} = \frac{E_1}{E_0}\left(\frac{G_0}{r_0\ n_0}\right)(r_1\ \ n_1)\left(\frac{80}{W_E}\right)^2 \text{ ; in PSD units } (g^2/Hz)$$

where: $80/W_E$ = 1, for equipment weight $W_E \leq$ 80 pounds

and: $80/W_E$ = 1/4 for equipment weight $W_E \geq$ 160 pounds

The test level (G_{max}) is obtained from the basic normalized level (G_o/r_on_o) which is adjusted to the muzzle energy (E_1), the firing rate (r_1), and the number of guns (n_1) of the particular gun(s) under consideration. The normalizing energy (E_o) is equal to 39,600 foot-pounds. The last term ($80/W_E$) represents a mass adjustment factor and permits the reduction of G_{max} when the equipment weight is greater than 80 pounds. Table 519.1-I designates the muzzle energy adjustment factors, and the nominal firing rates of commonly used gun configurations. Figure 519.1-1 provides G_o/r_on_o as a function of the distance parameter (D). The mass adjustment factor is determined from figure 519.1-2. If it can be shown (from vibration data, structural analysis, or simulitude arguments) that the equipment support structural impedance is less than that of typical aircraft cargo decks, then the upper weight scale of figure 519.1-2 (beginning with 50 pounds) may be used in lieu of the lower scale (beginning with 80 pounds).

3.2.2 Determination of the distance parameter (D). The distance parameter represents the vector distance, measured (or estimated) from the gun muzzle to the mean distance between equipment support points. Where equipment support points are indeterminate, the equipment center of gravity shall represent the terminal point of D. The vector D is usually generated from the orthogonal distances referenced to the fuselage station, the water, and the butt line data. The D vector and the computation is shown on figure 519.1-3.

3.2.3 Multiple guns. For configurations involving multiple guns, the origin of D is determined from the centroidal point of the gun muzzles. Figure 519.1-4 shows the origin location for a typical four-gun staggered array.

Example No. 1 - A 2-pound UHF antenna, is to be flush mounted to the undersurface of the aircraft and located forward of the muzzle of four M-61 type cannons. The expected firing rate is 25 Hz (r_1 = 25). (If the firing rate is unknown, the maximum specified rate shall be used.) Since, in this configuration, each barrel fires independently and the number of guns is equal to four, then n_1 = 4 (see 1/).

Steps

a. The antenna location determined from the aircraft spatial coordinates (see figure 519.1-3) is found to be 39 inches or D = 39 inches

b. Refer to figure 519.1-1. Select curve A and obtain the ordinate value of G_o/r_on_o for D = 39 inches. In this case, $G_o/r_on_o = 3.0 \times 10^{-2}$

c. From table 519.1-I, select E_1/E_o for the M-61 gun (see 2/). Here, $E_1/E_o = 1$

d. Since the antenna weight is less than 80 pounds, the mass adjustment factor becomes unity and a reduction of G_{max} is not allowed (see figure 519.1-2)

e. Determine the normalized level, G_1/r_1n_1, by adjusting G_o/r_on_o by E_1/E_o as follows: $G_1/r_1n_1 = E_1/E_o \ (G_o/r_on_o)$ or $G_1/r_1n_1 = (1)\ 3.0 \times 10^{-2}$

f. Multiply G_1/r_1n_1 by n_1r_1 to obtain the maximum test level, G_{max}:

$$G_{max} = G_1/r_1n_1 \ (r_1n_1)$$

$$G_{max} = 3.0 \times 10^{-2} \ (25) \ (4)$$

$$G_{max} = 3.0 \ g^2/Hz$$

g. Apply G_{max} to figure 519.1-5 to obtain the test spectrum.

Example No. 2 - An electronic equipment weighing 102 pounds is located in the aircraft nose section forward of the gun muzzle. The distance (D) is 45 inches. The firing rate of the revolving barrels of the cannon totals 100 Hz with $n_1 = 1$.

The muzzle energy (E_1) is 83,000 foot-pounds.

Steps

a. Repeating steps (a) and (b) as before:
$G_o/r_on_o = 1.9 \times 10^{-2}$

b. From note 2, divide E_1/E_o:
$83 \times 10^3/39.6 \times 10^3 = 2.1$

c. Adjusting for E_1/E_o:
$G_1/r_1n_1 = (2.1)\ (1.9 \times 10^{-2})$
or $G_1/r_1n_1 = 4.0 \times 10^{-2}$

d. Obtain G_{max} as before:
$G_{max} = 4.0 \times 10^{-2}\ (10^2)\ (1) = 4.0\ g^2/Hz$

e. Noting from 3.2.1 that $W_E > 80$ pounds and referring to figure 519.1-2, where the derated value (G'_{max}) is found to be 2 dB down (-2 dB) from 4.0 g^2/Hz

From dB power tables or from the right-hand scales of figure 519.1-2

$-2\ dB = 10\ Log_{10} G'_{max}/4.0$

or $G'_{max} = 2.5\ g^2/Hz$

f. Apply G'_{max} to figure 519.1-5 to obtain the test spectrum.

1/ Some gun configurations (see MK-IV, gun pod, table 519.1-I) feature two barrels per pod; firing simultaneously. In such a case, $n_1 = 2$ per pod.

2/ If E_1 is unknown, determine E_1 from ballistic data using $E_1 = m_1 v_1^2/2$ where: m_1 = the projectile mass and v_1 = muzzle velocity. Divide by E_o (see table 519.1-I) and proceed as in step (e).

3.2.4 Test level reduction due to gun standoff distance. A reduction of G_{max}, in accordance with the criteria of figure 519.1-8, shall be allowed for the case of gun configurations with muzzles mounted a perpendicular distance from the aircraft structure.

4. Test procedures. Test procedures used shall be as specified in the equipment specification or test plan.

4.1 Test item operation. Unless otherwise specified, the test item shall be operated during application of vibration so that functional effects caused by these tests may be evaluated. When a test item performance test is required during vibration and the time required for the performance is greater than the duration of the vibration test, the performance test shall be abbreviated accordingly. At the conclusion of the test, the test item shall be operated and the results compared with the data obtained in accordance with section 3, General Requirements, paragraph 3.2.1. The test item then shall be inspected in accordance with section 3, General Requirements, paragraph 3.2.4.

4.2 Mounting techniques. In accordance with section 3, General Requirements, paragraph 3.2.2, the test item shall be attached to the vibration exciter table by its normal mounting means or by means of a rigid fixture capable of transmitting the vibration conditions specified herein. Precautions shall be taken in the establishment of mechanical interfaces to minimize the introduction of undesirable responses in the test setup. Whenever possible, the test load shall be distributed uniformly on the vibration exciter table in order to minimize effects of unbalanced loads. Vibration amplitudes and frequencies shall be measured by techniques that will not significantly affect the test item input control or response. The input control accelerometer(s) shall be rigidly attached to the vibration table or to the intermediate structure, if used, at or as near as possible to the attachment point(s) of the test item.

5. Test procedures

5.1 Procedure I, Random vibration test. The test item shall be subjected to random vibration along each mutually perpendicular axis. Test times shall be in accordance with time schedule I from table 519.1-II. The instantaneous peaks of the random vibration acceleration may be limited to 2.5 times the rms acceleration level. The power spectral density of the test level control signal shall not deviate from the specified requirements by more than +40 -30 percent ($\pm$1.5 dB) below 500 Hz and +100 -50 percent ($\pm$3.0 dB) between 500 and 2,000 Hz, except that deviations as large as +300 -75 percent ($\pm$6 dB) shall be allowed over a cumulative bandwidth of 100 Hz between 1,000 and 2,000 Hz for equipment items whose weight is equal to or less than 60 pounds. For items weighing more than 60 pounds, the same deviation shall be allowed over the extended range from 500 to 2,000 Hz provided the cumulative bandwidth deviation does not apply to the swept bandwidth of noise as detailed in 5.3.1.2.

5.2 Procedure II, Single direction test. If the equipment item is mounted with the base peripherally attached to and in the plane of the aircraft skin, then the test direction may be restricted to the direction normal to the aircraft skin (see figure 519.1-6). The total test time in this case shall be as stated in time schedule II of table 519.1-II.

5.3 Procedure III, Composite or alternate test. For locations near the gun muzzle and for equipment weighing in the region of 60 pounds, the test levels may exceed the force capabilities of all but the largest shaker systems. For such cases, the following test method may be substituted provided the following criteria are met:

when: $G_{max} \geq 3.0\ g^2/Hz \geq 8.6 \times 10^{-4}\ (F_r/W_T)^2$

where: $W_E \geq 55$ pounds and: $W_J \leq 1.2\ W_E$

F_r = Maximum RMS shaker force output - pounds

$$W_T = W_E + W_A + W_J$$

W_E = Equipment weight - pounds

W_A = Armature weight - pounds

W_J = Test jig weight - pounds.

5.3.1 Selection of composite elements. A broad band, random vibration test level G_B shall be selected equal to $G_{max}/4$ (6 dB down). A random noise signal of 100 Hz bandwidth (3 dB down points) shall be superposed on G_B having a G_{max} equal to the original determined value. The composite spectrum is shown on figure 519.1-7.

5.3.1.2 Test procedure. The test shall be conducted in accordance with 5.1, except the narrow band noise shall be swept from 300 to 1,000 Hz, referenced to the narrow band center frequency. The sweep time shall be in accordance with time schedule III in table 519.1-II.

6. Test level overall rms. The overall rms test level shall be no less than the area enclosed by the solid curve of figure 519.1-5, -21 percent (-2dB). The overall rms is defined by the following equation.

$$OAR = (1163\ G_{max})^{1/2}$$

7. Summary. The following details shall be specified in the equipment specification or test plan:

a. Procedure number (see 5)

b. Pretest data required (section 3, General Requirements, paragraph 3.2.1)

c. Nonoperation of equipment during test, if desired (see 4.1)

d. Unique or special test considerations.

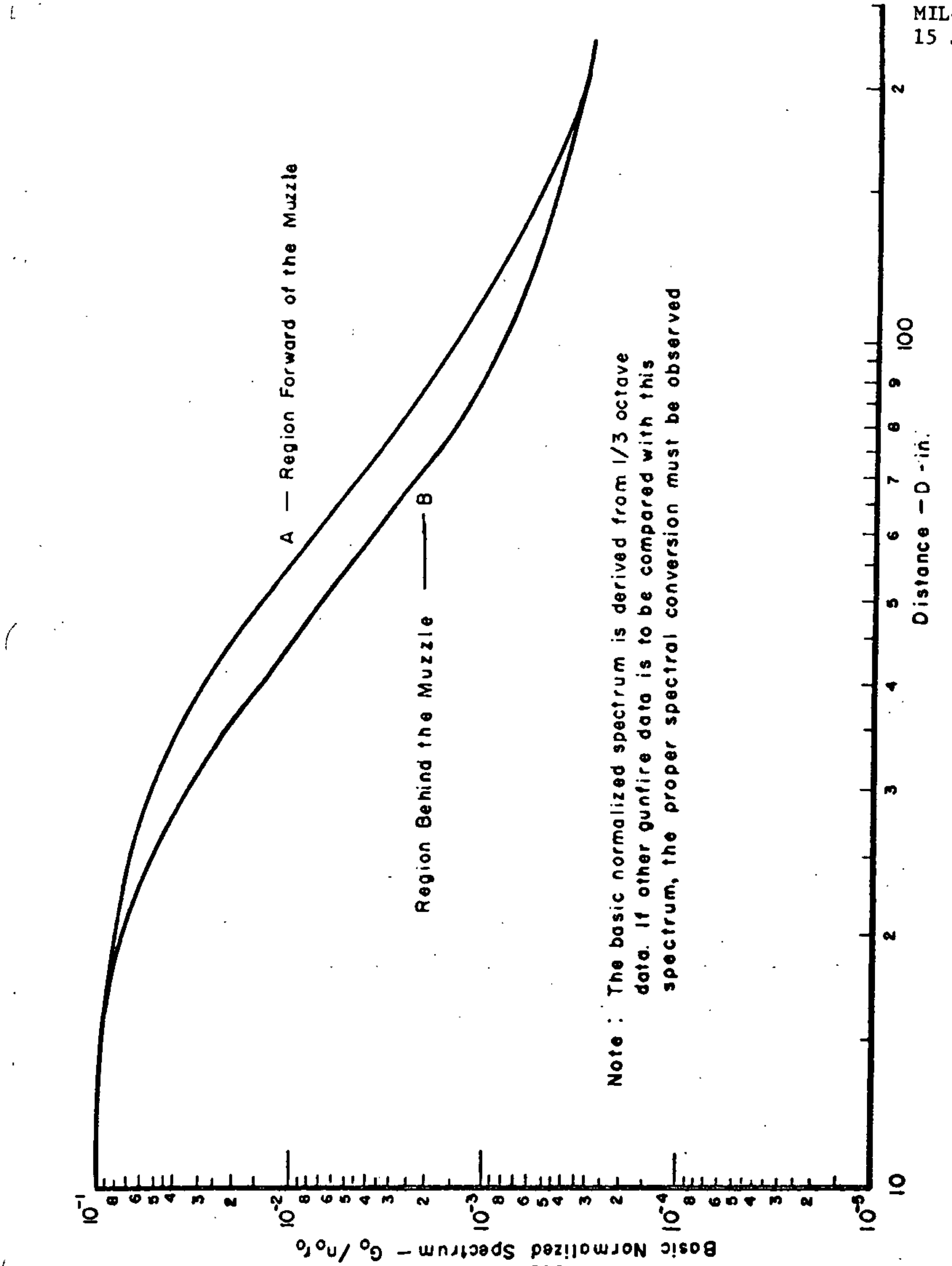


FIGURE 519.1-1. G_o/n_or_o vs. D

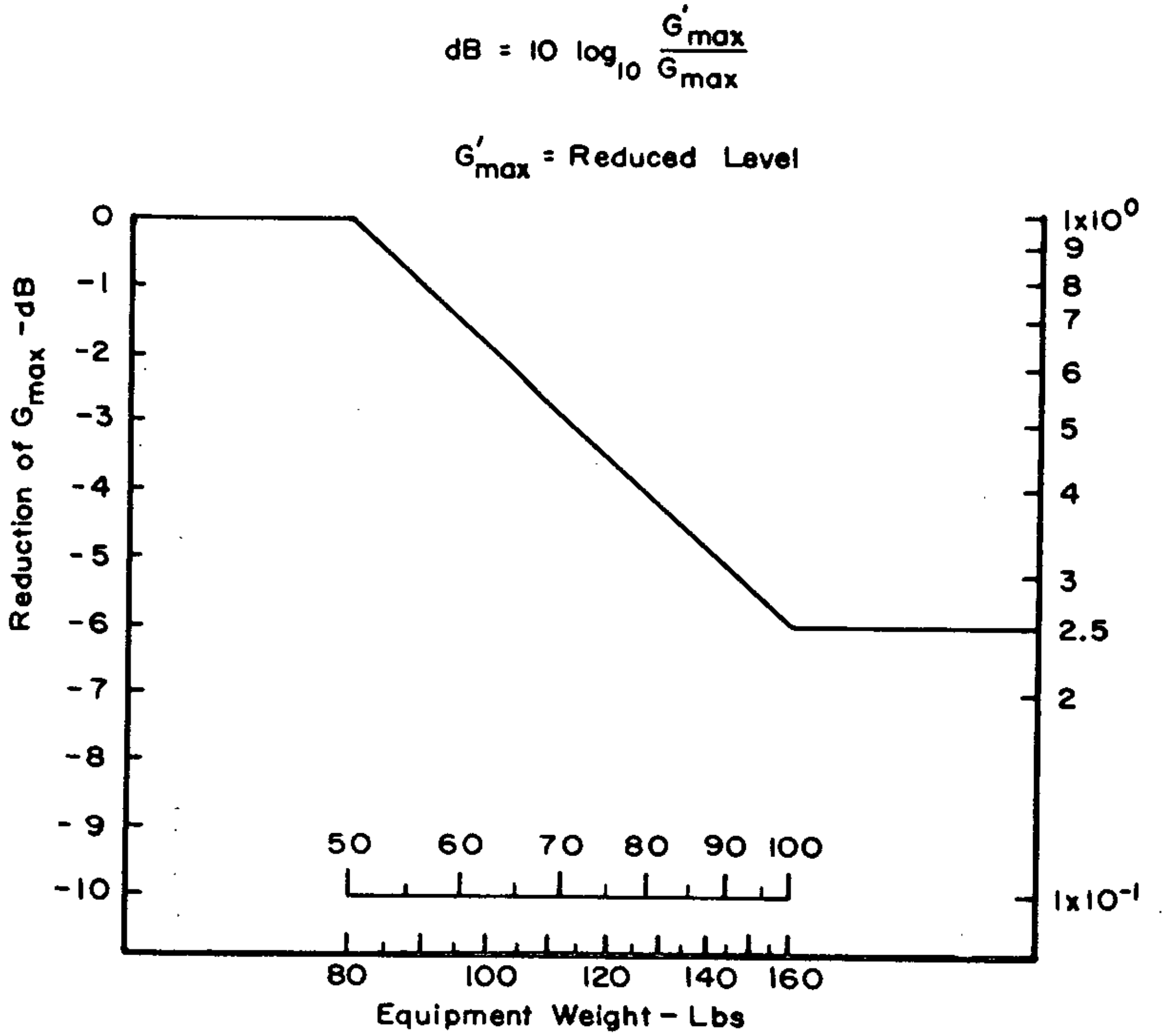
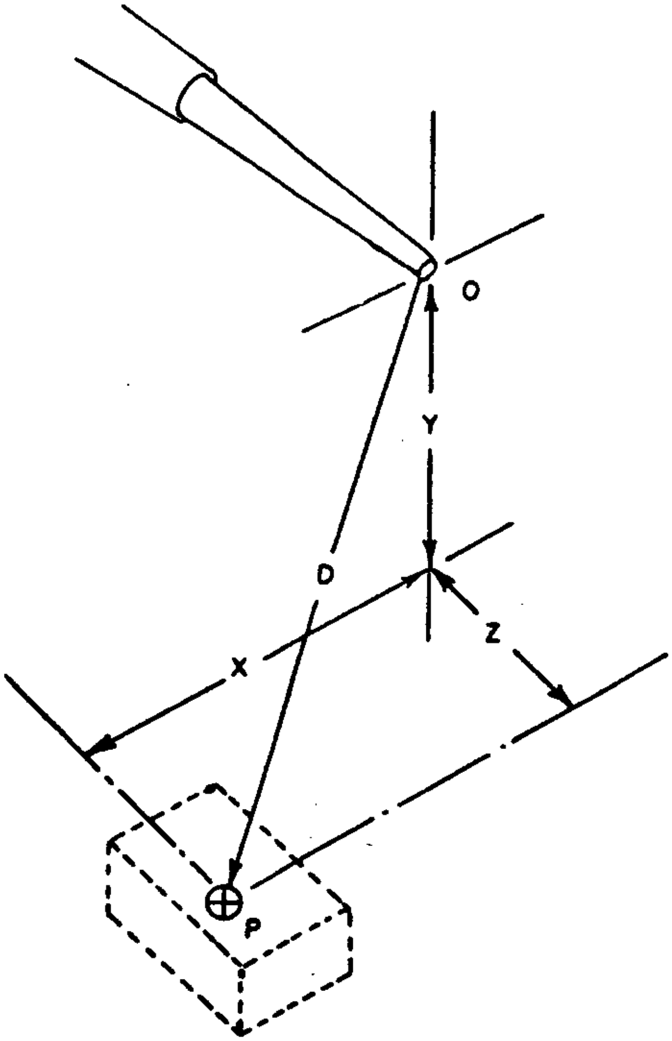


FIGURE 519.1-2. Reduction Factor for Mass Loading



$$D = \overline{OP} = (X^2 + Y^2 + Z^2)^{1/2}$$

FIGURE 519.1-3. Determination of the D Vector

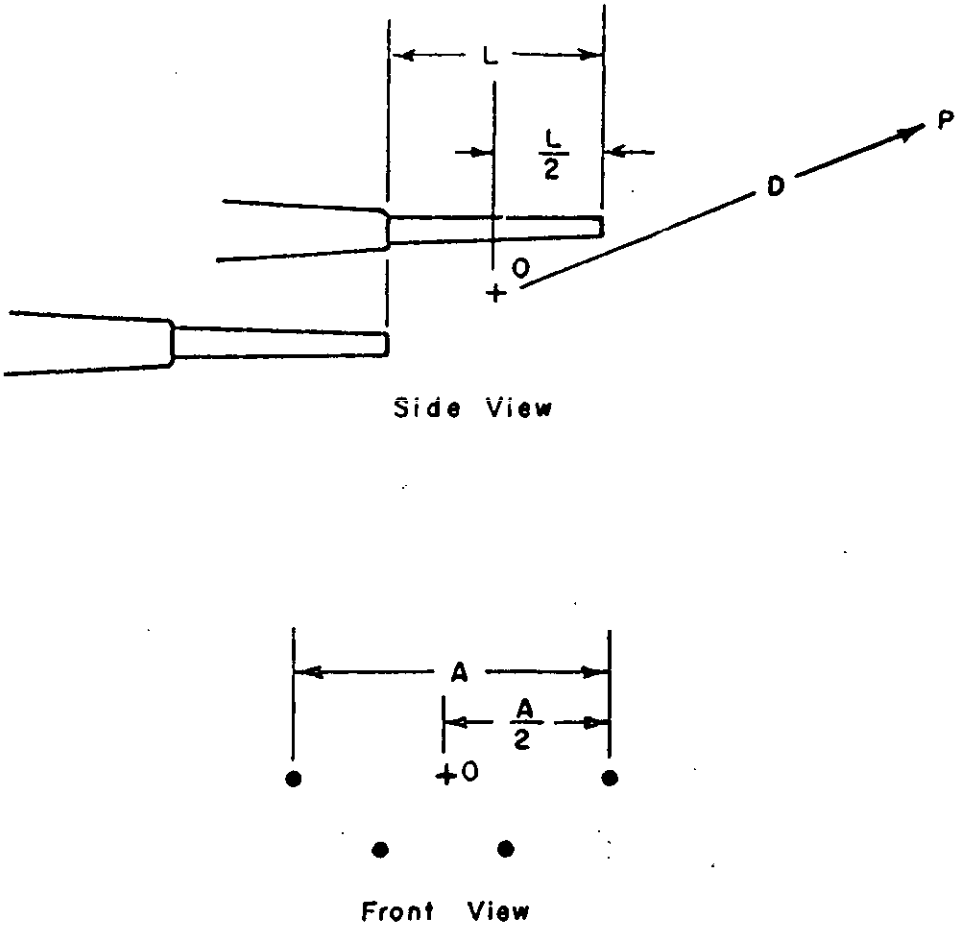


FIGURE 519.1-4. Origin of the D Vector for Multigun, Staggered Array

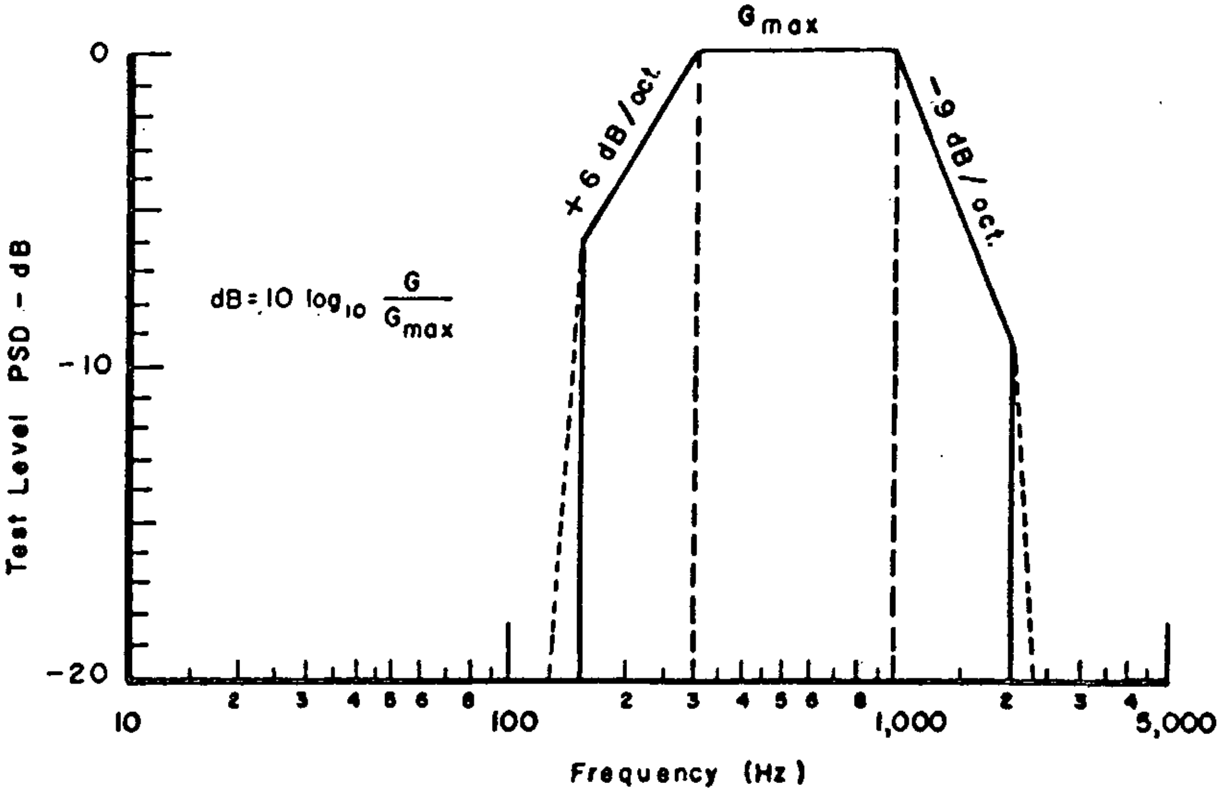


FIGURE 519.1-5. Random Vibration Test Curve

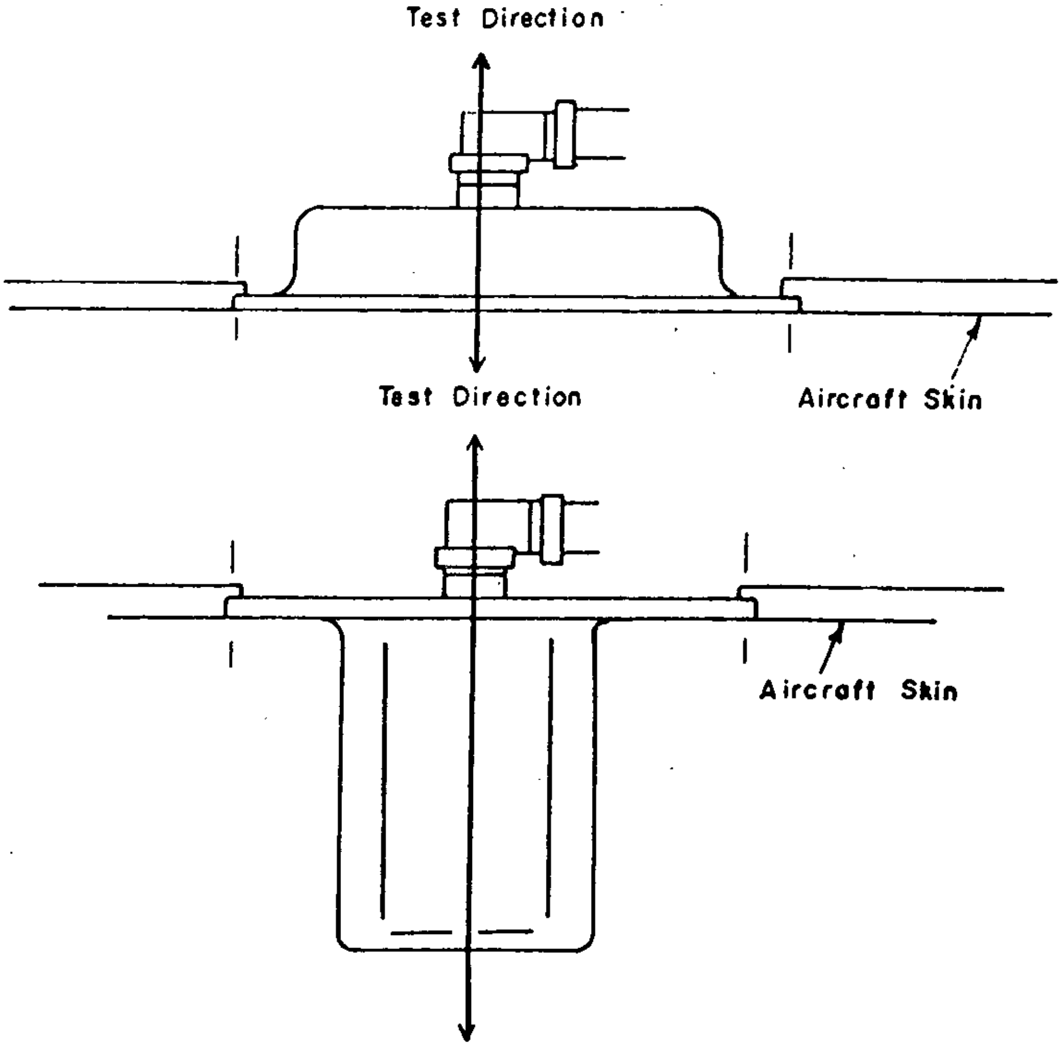


FIGURE 519.1-6. Peripherally Mounted Item

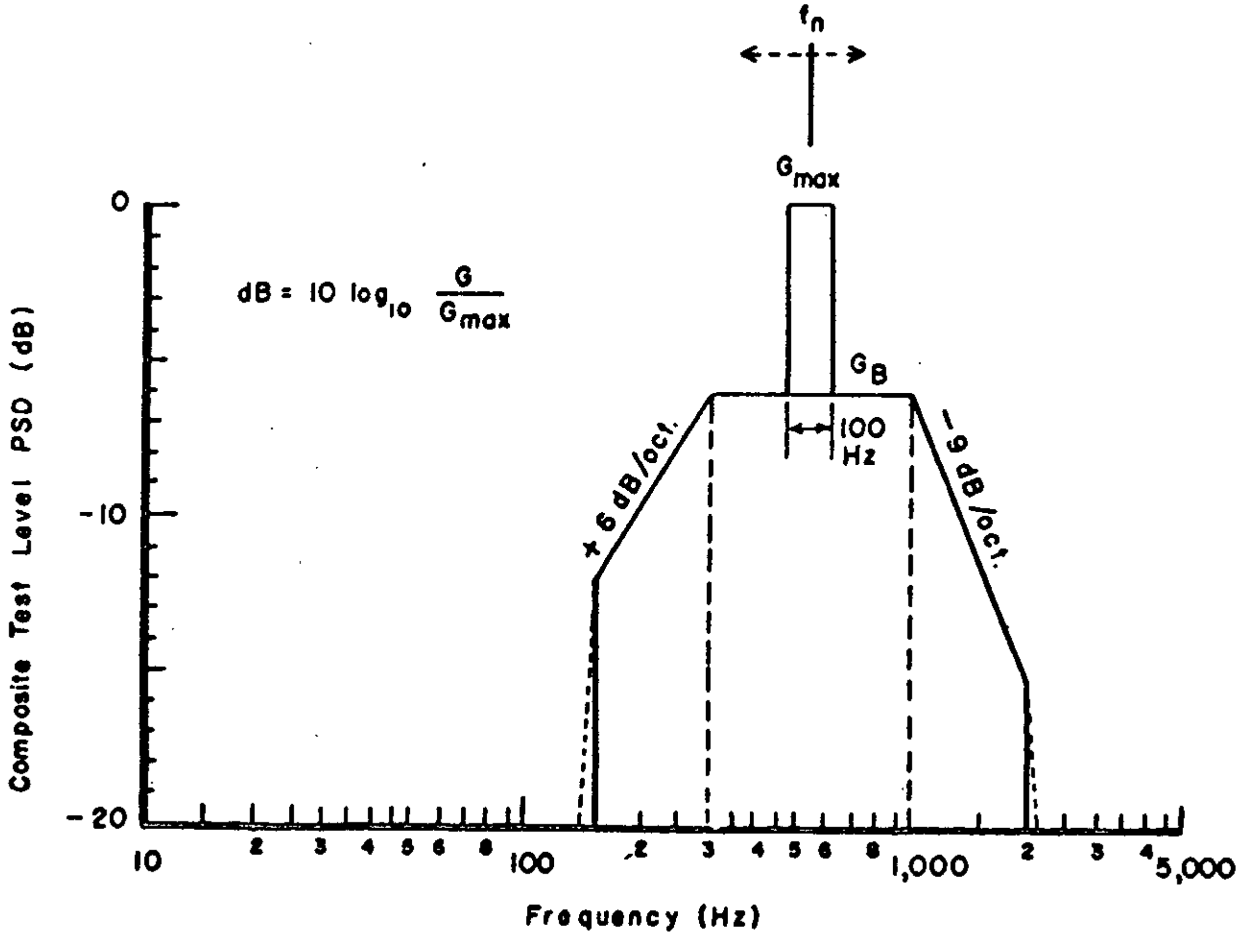


FIGURE 519.1-7. Swept Random Vibration Test Curve

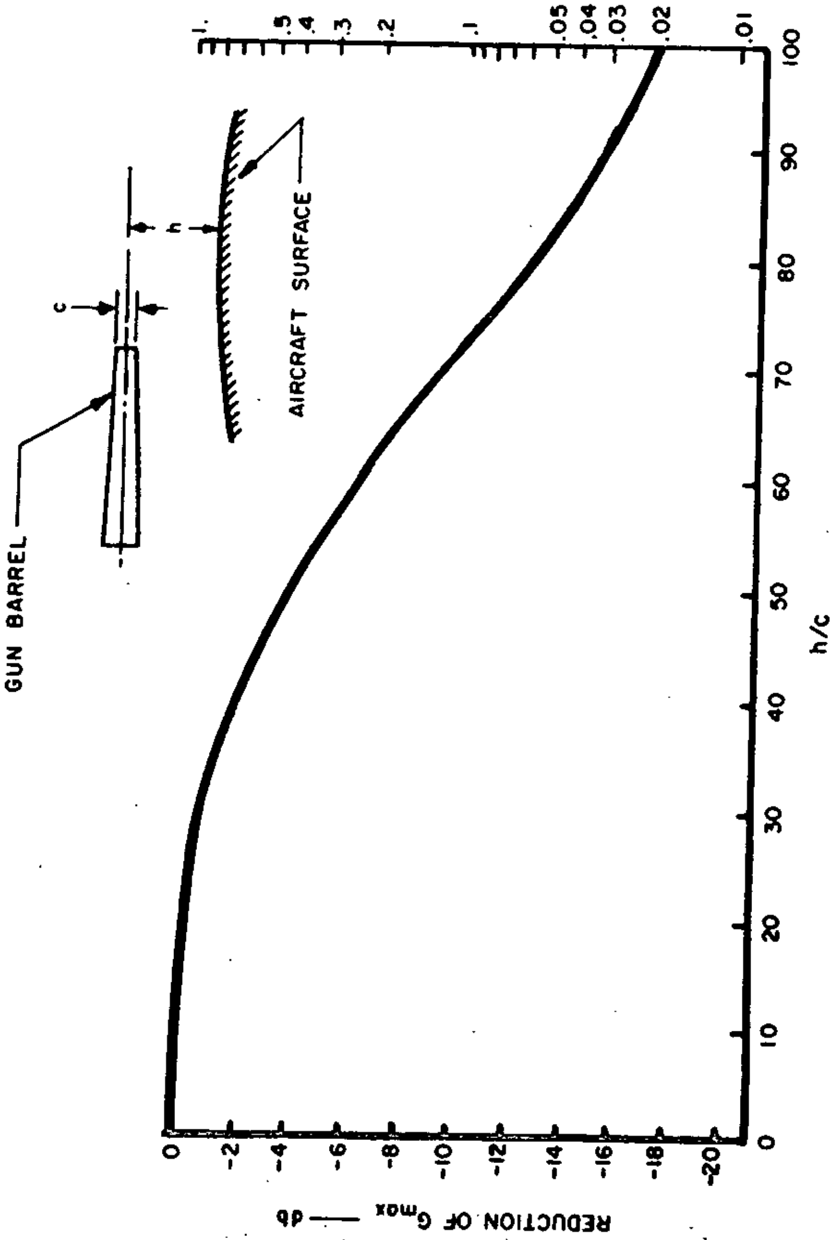


FIGURE 519.1-8. Reduction of G_{max} vs Distance Parameter h/c

TABLE 519.1-I. Ballistic Table

Gun Config-uration	Aircraft	Installation (Typical)	Gun Caliber (mm)	Gun Caliber (in)	Projectile weight (gr)	Projectile weight (lbs)	Firing Rate (r_1) Rds/min Hz/min	Firing Rate (r_1) Rds/sec Hz/sec	Muzzle Velocity (V_1) (ft/sec)	Muzzle Energy (E_1) (ft-lbs)	Muzzle Energy of M-61 (E_o) (ft-lbs)	Energy Adjust-ment factor (E_1/E_o)
M61	F-104 F-105 F-111 F-4 F-100 B-58 B-52 A-7	Various Fixed (For-ward Bomb Bay) SUU-16, on racks, tail turrets	20	.79	1,560 (avg)	.223 (avg)	6,000 (nom) 1,000 (min)	100 (max) 17 (min)	3,380 (nom) 3,250 to 3,450	39,600	39,600	1.0
M39	F-5 F-100 F-101 B-57 B-52	2 or 4 in nose or back of nose or tail turret	20	.79	1,560 (avg)	.223 (avg)	1,500	25	3,380 (nom) 3,250 to 3,450	39,600		1.0
MK11	A-4 F-4 A-7 A-6	MK4 C.L. POD inboard wing, etc.	20	.79	1,700	.243	4,000 (max) 750 (min)	67 (max) 12.5 (min)	3,300	41,200		1.04
MK12	A-4	1 at each wing root	20	.79	1,700	.243	1,000	16.68	3,300	41,200		1.04
M3	A-1E	2 each wing	20	.79	2,000	.286	800	13.33	2,700	33,400		.844
M24	B-52 F-86	Tail turret 4 or 6 nose	20	.79	2,000	.286	800	13.33	2,700	33,400		.844
M2		obsolete	12.7	.50	800	.114	750	12	2,800	13,900		.351
M3	B-52 B-26 B-57 F-86 HH-53 A-1	Tail turret up to 6 in nose	12.7	.50	709	.114	1,200 (nom)	20	2,810	12,430		.314

TABLE 519.1-I. Ballistic Table (Continued)

Gun Configuration	Aircraft	Installation (Typical)	Gun Caliber (mm)	Gun Caliber (in)	Projectile weight (gr)	Projectile weight (lbs)	Firing Rate (r_1) Rds/min Hz/min	Firing Rate (r_1) Rds/sec Hz/sec	Muzzle Velocity (V_1) (ft/sec)	Muzzle Energy (E_1) (ft-lbs)	Muzzle Energy of M-61 (E_o) (ft-lbs)	Energy Adjustment factor (E_1/E_o)
GAU-2B/A	AC-47 AC-130 A-37 UH-1 CH-3	side-looking, nose, and up to 8 PODS	7.62	.30	150	.021	6,000 (nom) 1,500 (min)	100 25 (min)	2,750	2,520		.0636
GAU-4/A	F-4	POD, inboard, wing	20	.79	1,560 (avg)	.223 (avg)	6,000 (nom) 1,000 (min)	100 (max) 17 (min)	3,380 (nom) 3,250 to 3,450	39,600		1.0

TABLE 519.1-II. Random Vibration Test Time

TIME SCHEDULE	CYCLING TIME PER AXIS 1/ (MIN)	RANDOM TIME PER AXIS 1/ (MIN)	SWEEP TIME (MIN) 1/ 300-1,000-300 (Hz)
I	—	15	—
II	—	30	—
III	90	—	5

1/ The total test period may be subdivided into sequential vibration bursts -- between which cooling intervals are allowed. The burst time shall be no less than 60 seconds.

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