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STATIC AND DYNAMIC TESTING OF THE MHU-12/M TRAILER

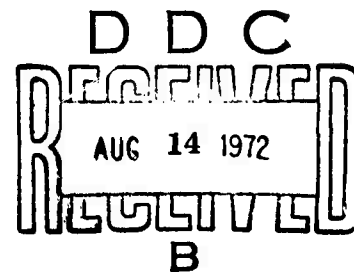
Frank T. Krek



AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base
New Mexico

TECHNICAL REPORT NO. AFSWC-TR-72-30

July 1972



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AFSWC-TR-72-30

STATIC AND DYNAMIC TESTING
OF THE MHU-12/M TRAILER

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FOREWORD

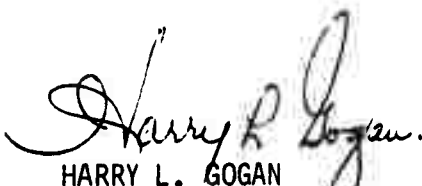
This research was performed under Program Element 41119F, Project 410A.

Inclusive dates of research were September 1970 through November 1971. The report was submitted 25 May 1972 by the Air Force Special Weapons Center Test Director, Mr. Frank T. Krek (FTSE). The Air Force Weapons Laboratory Project Officer was Mr. Lee W. Short (SEE).

This technical report has been reviewed and is approved.


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ABSTRACT

(Distribution Limitation Statement B)

Static and dynamic tests were performed on an MHU-12/M Munitions Handling Trailer for determining aircraft transport criteria. An existing tiedown configuration for air transport of the MHU-12/M trailer, without parking shoring, was established and tested. Dynamic tests, simulating flight conditions, performed with this tiedown configuration on an unshored trailer having soft springs and/or pneumatic tires revealed that a weapon-trailer combination can be excited to resonance. The developed tiedown configuration, test procedures, test data, notations of test observations and other pertinent information are presented.

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SECTION I

INTRODUCTION

1. GENERAL

The data and results of an investigation conducted to verify existing tiedown configurations for air transporting the MHU-12/M trailer in current cargo aircraft are presented. Static and dynamic tests were performed on an existing tiedown configuration of a weapon-trailer combination for the MHU-12/M Munitions Handling Trailer. All tests were performed without the parking shoring. Verified tiedown configurations for nuclear weapons and devices with their respective handling equipment are required as source data for inclusion in the -16-1 Technical Orders for cargo aircraft. Flexibility, required by aircraft load planners and loadmasters for obtaining more effective utilization of cargo aircraft, has dictated a need to determine the requirements for shoring when nuclear weapons are mounted on trailers which have soft springs and pneumatic tires. Tests, simulating flight conditions performed on other unshored trailers having soft springs and/or pneumatic tires, revealed that a weapon-trailer combination can present resonant frequency problems. Dynamic tests were performed with existing tiedown patterns for the MHU-12/M Munitions Handling Trailer to verify the possibility of resonant frequencies with the parking shoring removed. The authority for this work is contained in AF Form 111, Research and Development Management Report entitled "Nuclear Weapon Support," dated 6 August 1970. Earlier MHU-12/M trailer tests conducted were road transport tests of bolstered special weapons when secured to the trailer (reference: AFSWC-TR-69-16, Bolster Transport of Special Weapons on the MHU-12/M Trailer, by R. L. Posey, September 1969).

2. PURPOSE

The purpose of this investigation was to statically and dynamically test an existing tiedown configuration, without parking shoring, for the MHU-12/M Munitions Handling Trailer. These tests were to determine the loads on the tiedown devices and associated equipment. The loads were induced by a static or dynamic test environment on the fully loaded trailer through hydraulic cylinders reacting from a test frame.

SECTION II
SUMMARY OF TESTS

1. DESCRIPTION OF TEST ITEM

The MHU-12/M Munitions Handling Trailer is a four-wheeled pneumatic-tired, roadable vehicle which can be adapted to carry various nuclear weapons. The trailer is fabricated from aluminum and has eight 25,000-pound capacity tiedown rings, four on each side. This particular trailer (serial number 66HS-244) was manufactured in 1966. The trailer has a maximum width of 85 inches, a maximum length of 128 inches and a height of approximately 29 inches. The trailer weighed 1775 pounds (empty).

2. TEST REQUIREMENTS

The MHU-12/M trailer was required to be statically loaded to the following maximum simulated aircraft load acceleration conditions specified in AFSCM 122-1, "Nuclear Systems Safety Design Manual," and supplemented by the Air Force Weapons Laboratory (AFWL) Project Officer:

Forward	4.0 g
Aft	1.5 g
Side	1.5 g
Upward	3.7 g + TARE
Downward	4.5 g

Upward load requirements were established by the AFWL Project Officer from aircraft load reports based on operational data. The specified upward load is the ultimate load based on structural design criteria.

Tiedown patterns for the unshored MHU-12/M trailer were to be tested with two each BDU-8 practice bombs mounted on the trailer. Loads were to be introduced through the practice bombs as well as the trailer. The tiedown patterns were to be tested with MB-1 tiedown devices (10,000-pound capacity chains). These patterns were to withstand the above test loads, which simulate maximum accelerations that might be imposed by the aircraft. Deflection measurements, when applicable, were to be taken during the static tiedown tests.

With the same tiedown configuration, low frequency vibration tests were to be conducted on the unshored weapon-trailer combination. The input load was to be varied during the low-frequency vibration sweeps. Input loads were to be established at approximately 1000, 2000, and 3000 pounds.

3. GENERAL TEST METHODS

With the use of scale floor plan drawings of C-130, C-133, and C-141 aircraft and a scaled template of the BDU-8-MHU-12/M weapon-trailer combination, an existing tiedown pattern was established. The pattern and spacing of tiedown fittings is the same for the C-130, C-133, and C-141 aircraft; thus, only one tiedown configuration was necessary to meet the test loading requirement for these aircraft.

The trailer was placed in the static test frame and tied down in the configuration to be tested using the MB-1 tiedown devices. A strain link was inserted in each tiedown chain to monitor the restraining force transmitted to the tie points.

For the static load tests, the strain links were connected to monitoring indicators and the reactions were recorded for each static load increment. Reaction loads induced in the restraint devices as the result of the dynamic load tests (low-frequency vibration) were monitored by the same strain links and were recorded on instrumentation magnetic recording tape.

a. Static Load Testing

Chains and fixtures were attached to the test trailer and two BDU-8 bombs then connected through load cells to hydraulic cylinders that reacted from the static test frame to apply simulated inertial loads through the center of gravity of the test articles. The load cells were electrically wired to indicators on the hydraulic console from which the test loads were monitored and controlled. Lubricated steel plates were placed beneath the four trailer tires to simulate the reduced friction between the test article and aircraft deck during vibration. Figure 1 shows the typical test setup used for the static load tiedown testing.

The response of the trailer to loading, aside from tiedown restraint, was trailer movement and/or shifting. The amount of movement and/or shifting was monitored and recorded.

Simulated inertial loads were calculated using the weight of the MHU-12/M trailer and the weight of the BDU-8 bombs as 1.0 g and the acceleration criteria specified in paragraph 2. The test loads were applied through the trailer center of gravity and each of the BDU-8 bomb centers of gravity in increments of 25, 50, 66.67, 75, 85, 90, 95, and 100 percent of the required load. The load at each increment was held for at least 30 seconds. The test article was visually examined and all reaction loads (when applicable) were recorded during this holding period. A force equal to the weight of the test article was added to loads applied in an upward direction to compensate for gravity.

b. Dynamic Testing

The BDU-8-MHU-12/M weapon-trailer combination was secured in the tie-down configuration obtained from the static load tests. Two BDU-8 bombs were secured to the MHU-12/M trailer in the same manner as the static tiedown tests.

The weapon-trailer combination was secured in the static test frame on a floating floor plate which simulated the aircraft cargo deck. The plate was supported by tire inner tubes sandwiched between plywood. This arrangement created a very low natural frequency for the support structure. A 20,000-pound programmed Servoram (hydraulic cylinder) attached to the floor plate introduced the dynamic loads to the floating floor plate. Figure 2 shows the typical test setup used for the dynamic load testing and figure 3 shows the installation of the 20,000-pound input Servoram cylinder. The load was introduced to the floating floor plate through the Servoram at the bottom of the plate.

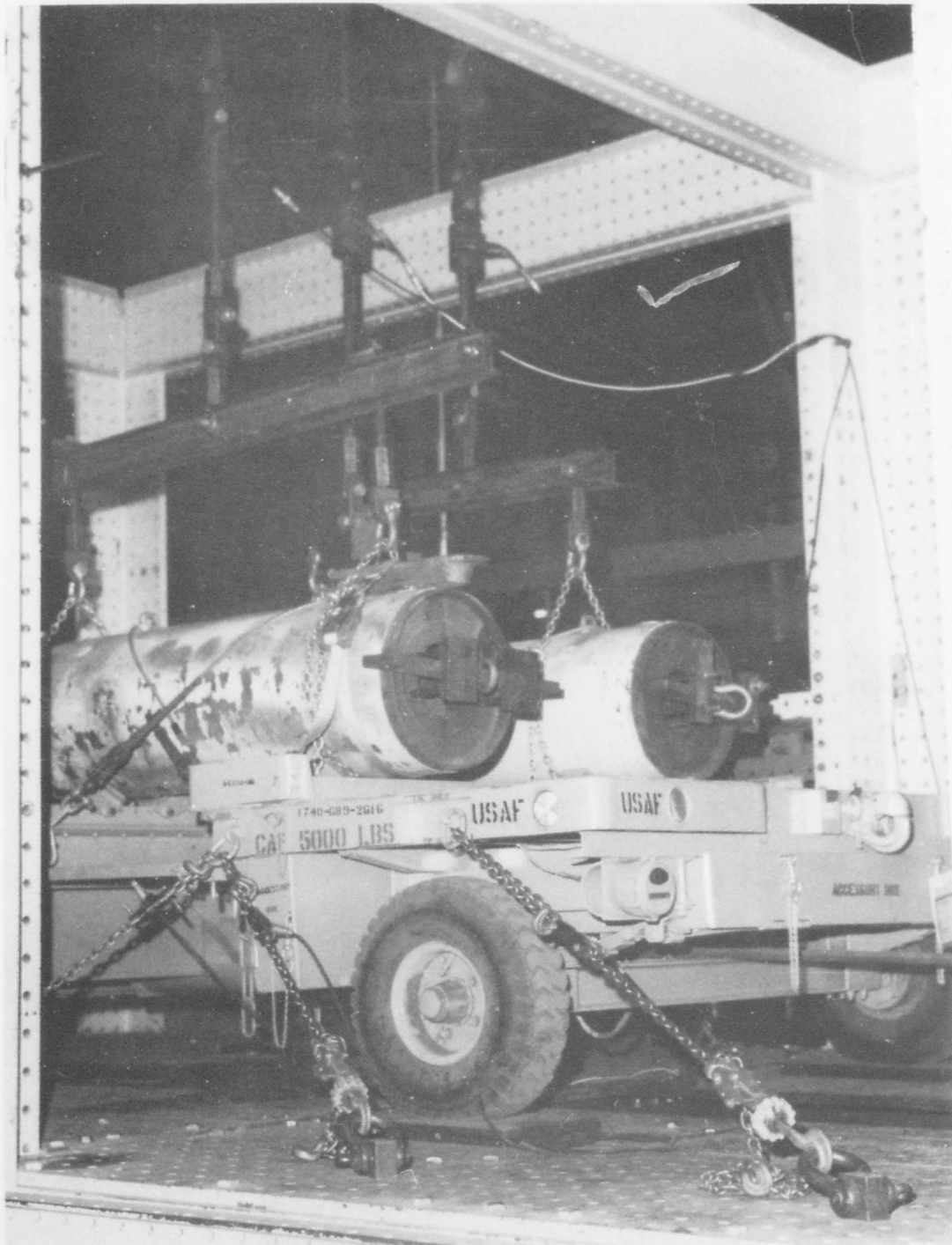


Figure 1. Static Load Tiedown Test Setup

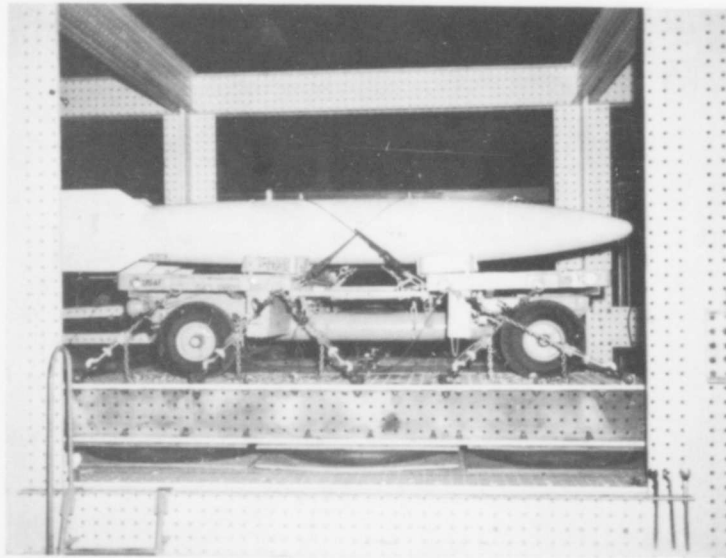


Figure 2. Test Setup for Dynamic Load Testing

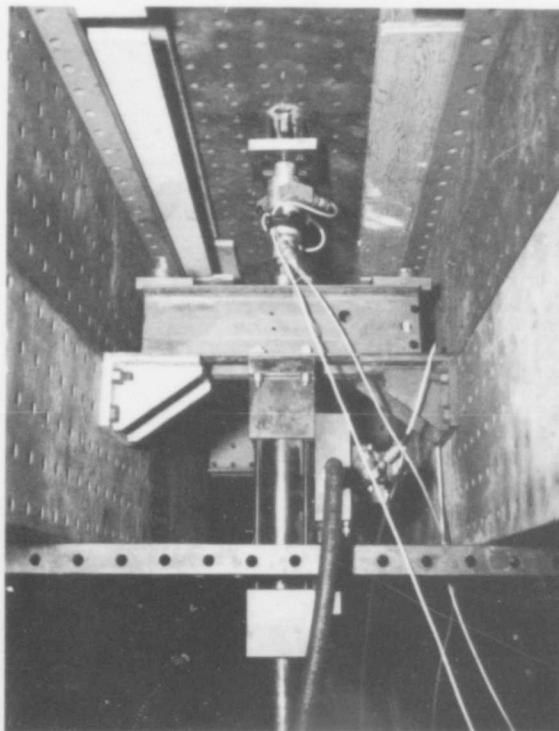


Figure 3. Twenty-Thousand-Pound Servoram Input Cylinder

SECTION III

TEST PROCEDURES AND TEST RESULTS

1. STATIC LOAD TESTING

The static load tiedown configuration with tiedown numbers 1 through 10 as shown in figure 4 proved satisfactory (by test) to the simulated acceleration (g) loads as outlined in the Test Requirements.

Table I presents the measured loads in each restraint device for each increment of load as the result of a 1.5-g aft loading condition. The trailer movement in the aft direction at 100 percent load was approximately 1 inch.

Table II represents the results from a 1.5-g side loading condition. Side trailer movement (in the same direction as the loading) at the 100 percent load was approximately 2-11/16 inches at the aft location of the trailer and approximately 2-3/8 inches at the forward location of the trailer.

Tables III, IV, and V present the measured loads in each tiedown for 3.7-g upward, 4.0-g forward, and 4.5-g downward loading conditions, respectively.

Table VI shows the MHU-12/M trailer displacement through the springs and pneumatic tires as the result of the 4.5-g downward loading condition.

2. DYNAMIC TESTING

The MHU-12/M trailer with the two BDU-8 bombs fully secured was tied down to the floating floor plate (without axle shoring) with the same 10 tiedowns as shown in figure 4. Figure 2 illustrates the typical test setup used for all of the dynamic load tests. The tiedown method was the same method as was used for the static load tests and the two BDU-8 bombs were secured to the trailer in the same manner.

After several dynamic (vibration) evaluation and demonstration test runs, the instrumentation data was checked, reduced, analyzed, and reviewed before a definite test procedure was established. A testing criteria was established wherein the force input to the floating floor plate would be held constant with a varying frequency. The purpose for this procedure was to determine resonance frequencies, i.e., the fundamental natural frequency or any harmonic of that frequency.

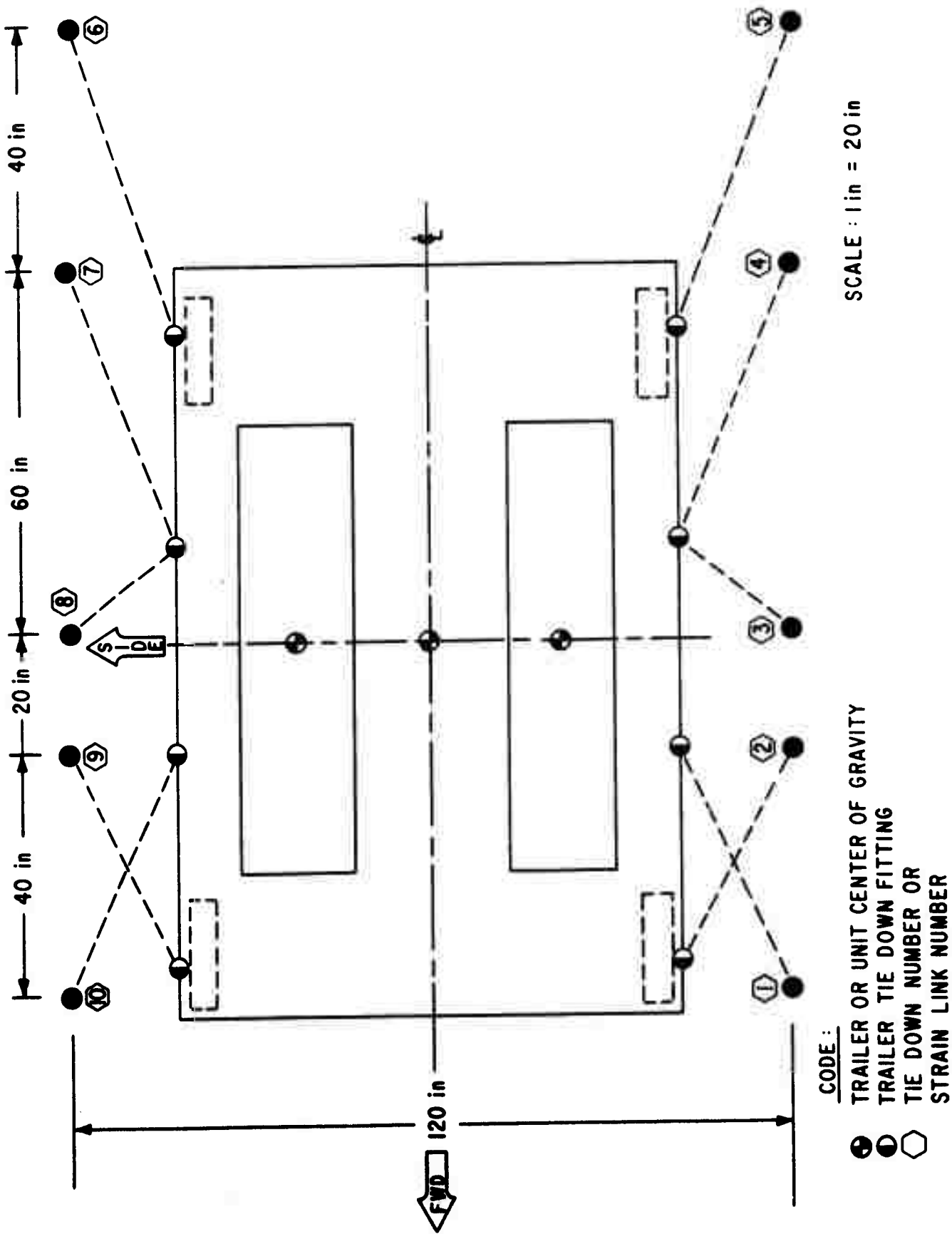


FIGURE 4. TYPICAL TIEDOWN DIAGRAM FOR MHU-12/M TRAILER

Table I

REACTION LOADS MEASURED IN RESTRAINT DEVICES UNDER
1.5 g AFT LOAD

Percent of load	Chain number									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Min	240	170	210	200	150	200	180	230	150	300
50.00	2430	0	410	0	0	0	0	490	0	2560
66.67	3190	0	550	0	0	0	0	600	0	3340
75.00	3600	0	610	0	0	0	0	680	0	3780
85.00	4070	0	710	0	0	0	0	740	0	4300
90.00	4310	0	750	0	0	0	0	770	0	4520
95.00	4560	0	800	0	0	0	0	800	0	4780
100.00	4800	0	850	0	0	0	0	850	0	5050
0.00	100	40	140	200	40	20	80	150	50	200

- NOTES:** 1. Aft movement at 100 percent load: 1 inch.
2. See figure 4 for location of tiedown chains.

Table II

REACTION LOADS MEASURED IN RESTRAINT DEVICES UNDER
1.5 g SIDE LOAD

Percent of load	Chain number									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Min	300	200	300	200	200	200	200	300	200	250
50.00	1390	1190	1700	740	1080	0	0	0	0	0
66.67	1970	1550	2480	1000	1600	0	0	0	0	0
75.00	2270	1800	2750	1120	1800	0	0	0	0	0
85.00	2570	1820	3370	1360	2250	0	0	0	0	0
90.00	2690	1930	3350	1400	2320	0	0	0	0	0
95.00	2830	2080	3550	1460	2400	0	0	0	0	0
100.00	2960	2200	3670	1530	2500	0	0	0	0	0
0.00	670	590	570	300	330	0	0	0	0	0

- NOTES:** 1. Side movement at 100 percent load: Fwd end 2-3/8 inches; Aft end 2-11/16 inches.
2. See figure 4 for location of tiedown chains.

Table III

REACTION LOADS MEASURED IN RESTRAINT DEVICES UNDER 3.7 g VERTICAL LOAD

Percent of load	Chain number									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Min	270	200	300	200	200	200	200	200	200	300
50.00	3140	2950	3980	2770	1300	800	3070	3530	2970	3280
66.67	3880	3480	4730	3410	1630	1060	3640	4230	3560	4120
75.00	4210	3720	5070	3700	1800	1180	3900	4600	3810	4500
85.00	4640	4070	5510	4070	2010	1350	4300	5040	4120	5000
90.00	4910	4210	5730	4230	2110	1450	4500	5250	4260	5220
95.00	5130	4380	5950	4400	2200	1550	4700	5480	4410	5460
100.00	5370	4520	6200	4610	2300	1650	4880	5730	4590	5720
0.00	490	320	320	200	330	100	200	200	260	480

- NOTES:**
1. Vertical movement at 100 percent load: BDU-8 units: Fwd end 1 inch; MHU-12/M trailer: Fwd end 1/16 inch, Center 1 inch, Aft end 1/16 inch.
 2. See figure 4 for location of tiedown chains.

Table IV

REACTION LOADS MEASURED IN RESTRAINT DEVICES UNDER 4.0 g FORWARD LOAD

Percent of load	Chain number									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Min	280	240	220	200	90	110	230	230	100	230
50.00	0	1870	0	1300	4220	4080	1560	0	1790	0
66.67	0	2400	0	1330	6030	5300	2180	0	2260	0
75.00	0	2600	0	1680	6800	5920	2510	0	2530	0
85.00	0	2830	0	2040	7630	6620	2920	0	2820	0
90.00	0	2980	0	2250	8080	7000	3130	0	3000	0
95.00	0	3080	0	2500	8440	7320	3350	0	3120	0
100.00	0	3220	0	2700	8800	7700	3500	0	3320	0
0.00	---	---	---	---	---	---	---	---	---	---

- NOTES:**
1. Forward movement at 100 percent load: 1-5/8 inches.
 2. Downward movement at 100 percent load: Right rear: 1-5/8 inches; Left rear: 1-3/4 inches; Right front: 1-1/4 inches; Left front: 3/4 inch.
 3. See figure 4 for location of tiedown chains.

Table V

REACTION LOADS MEASURED IN RESTRAINT DEVICES UNDER
4.5 g DOWNWARD LOAD

Percent of load	Chain number									
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
Min	230	180	200	190	190	200	190	200	200	230
25.00	0	0	0	0	0	0	0	0	0	0
50.00	0	0	0	0	0	0	0	0	0	0
66.67	0	0	0	0	0	0	0	0	0	0
75.00	0	0	0	0	0	0	0	0	0	0
85.00	0	0	0	0	0	0	0	0	0	0
90.00	0	0	0	0	0	0	0	0	0	0
95.00	0	0	0	0	0	0	0	0	0	0
100.00	0	0	0	0	0	0	0	0	0	0
0.00	90	0	0	0	0	0	0	20	0	80

NOTE: See figure 4 for location of tiedown chains.

Table VI

TRAILER DISPLACEMENT (IN INCHES) THROUGH SPRINGS
AND/OR PNEUMATIC TIRES UNDER 4.5 g DOWNWARD LOAD

Percent of load	<u>MHU-12/M trailer location</u>			
	<u>Right front</u>	<u>Left front</u>	<u>Right rear</u>	<u>Left rear</u>
Min	0	0	0	0
25.00	1	3/4	1/2	1/2
50.00	2	1-7/8	1-3/8	1-1/4
66.67	2-1/4	2-1/4	2-1/2	1-7/8
75.00	2-3/8	2-1/2	2-1/8	2
85.00	2-1/2	2-1/2	2-1/4	2
90.00	2-5/8	2-5/8	2-3/8	2-1/8
95.00	2-3/4	2-3/4	2-7/16	2-3/16
100.00	2-3/4	2-7/8	2-7/16	2-3/16
0.00	3/16	3/8	1/2	3/8

Tests were conducted with sine wave load inputs of 1000, 2000, and 3000 pounds at frequencies of 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 16, 18, and 20 Hz. The sine wave load input and frequency input was controlled from a Servac Programmer and Control Console. The energy was supplied by a 3000-psi, 100-gpm hydraulic console. Figure 5 shows the system which provided the inputs.

Data was monitored during the dynamic (vibration) tests from the 10 MB-1 tiedowns (load in pounds) SL-1 (strain link) through SL-10, from two accelerometers (acceleration in g) A-2 and A-3, the input acceleration from A-1 and the input load (in pounds) from the input Servoram cylinder. The general location of these transducers is shown in figure 6. Figure 7 shows the method used for installing accelerometer A-2 at the aft end of the MHU-12/M trailer. Accelerometer A-3 was installed in the same manner at the forward end of the trailer. Figure 8 shows the input accelerometer, A-1, installation which was located on the floating floor plate.

Data from the various transducers was routed through bridge balance systems and was then impressed on a 14-track magnetic tape recorder by the use of voltage controlled oscillators. The resulting data tapes were then reduced into oscillograph records. The oscillograph records were reviewed, evaluated, and reduced into engineering units for plotting.

Figures 9 through 18 present the plotted loads versus frequency for each tiedown at the three different load inputs. The ordinate represents the normalized load factor at a certain frequency (the abscissa) for the particular tiedown. The normalized load factor was obtained by dividing the output of the particular tiedown strain link by the measured input load. Both loads are taken at the same time reference.

The input acceleration (location A-1, figure 6) versus frequency for the 1000-pound input dynamic load is plotted in figure 19 and figure 20 shows the output accelerations (locations A-2 and A-3, figure 6) versus frequency for the 1000-pound load. Similar information is plotted in figures 21 and 22 for the 2000-pound input load while figures 23 and 24 show the information from the 3000-pound input load.

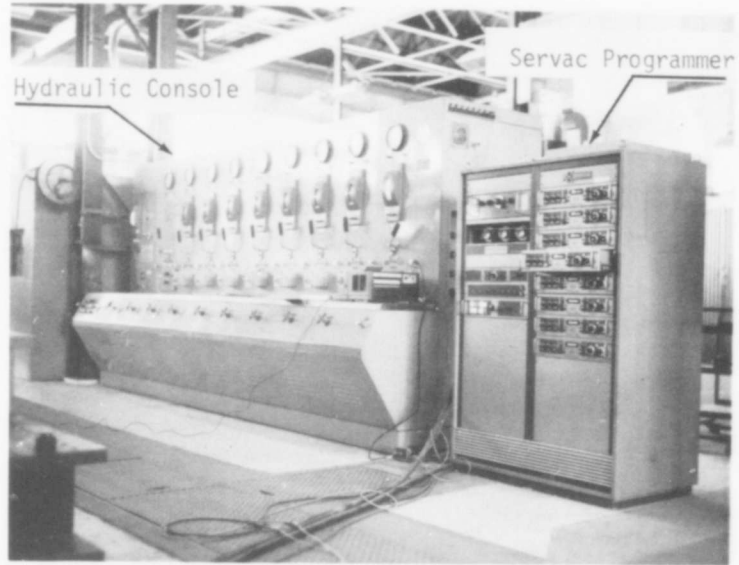


Figure 5. Servac Programmer and Hydraulic Console

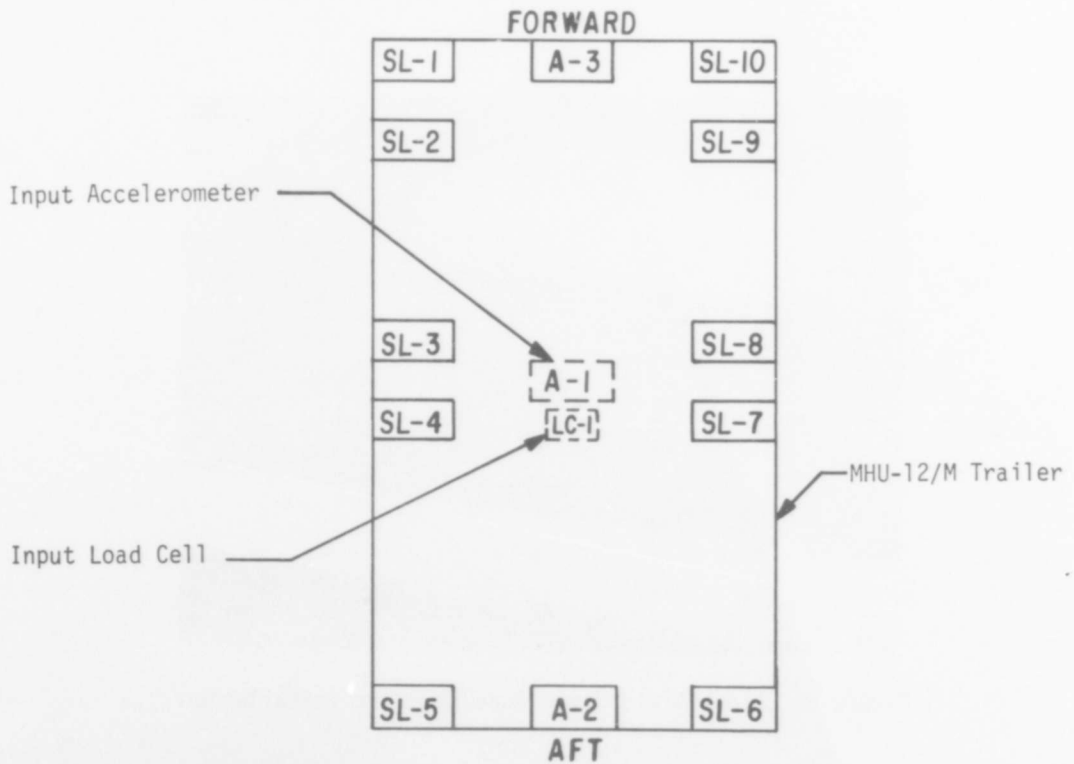


Figure 6. Vibration Test Transducer Locations

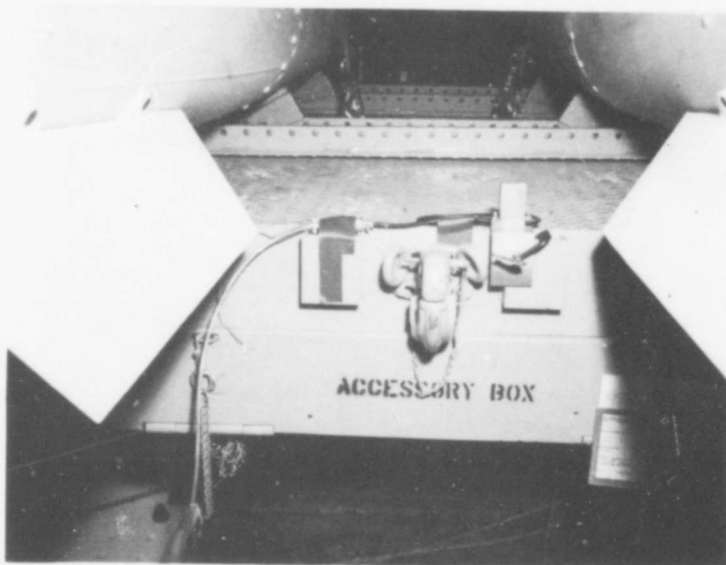


Figure 7. Trailer Accelerometer Installation

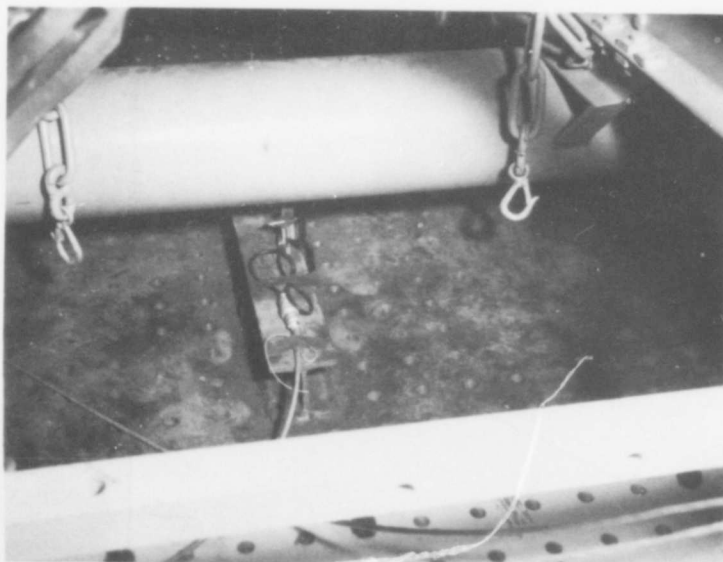


Figure 8. Floor Plate Input Accelerometer Installation

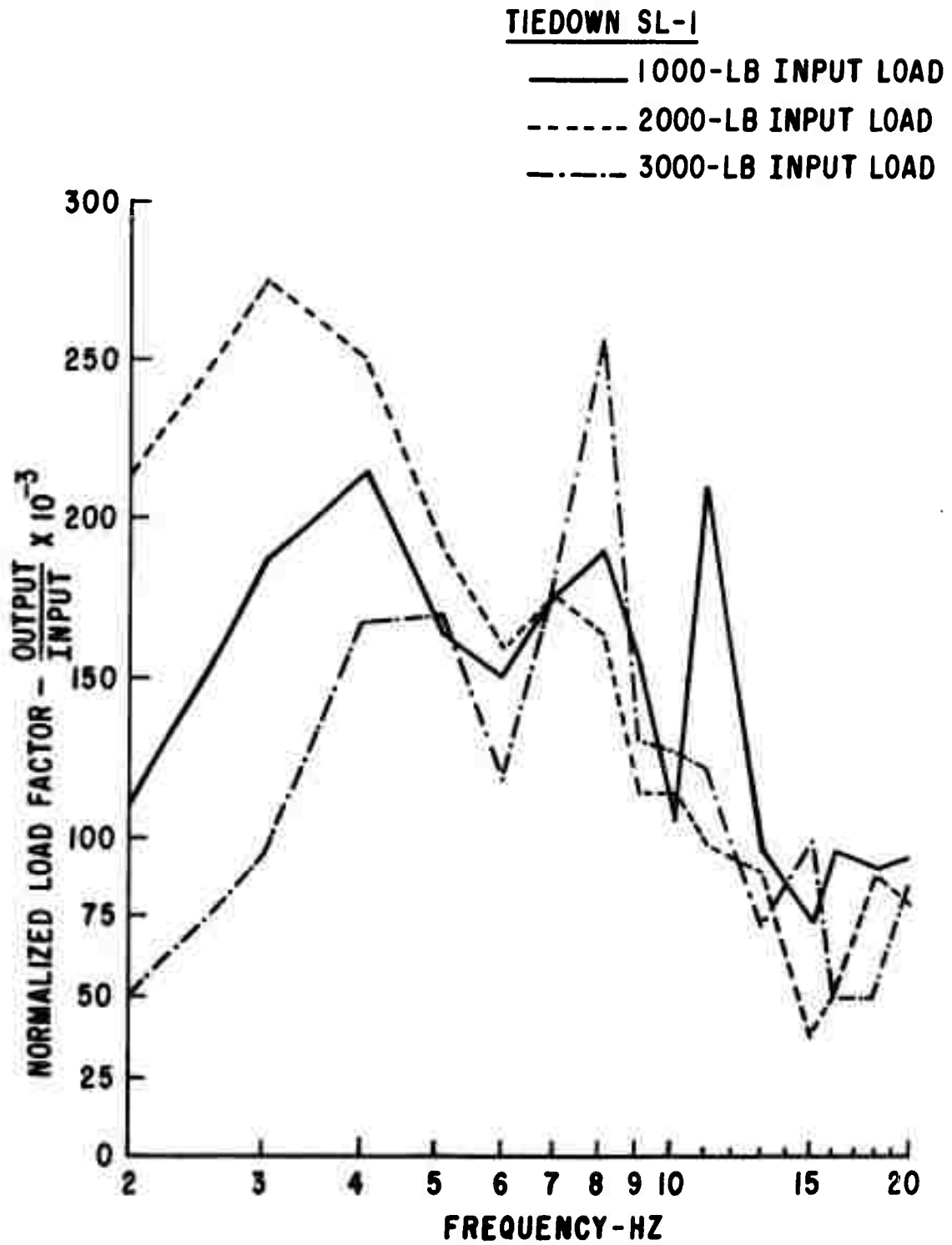


Figure 9. Tiedown SL-1 Normalized Load Factor versus Frequency

TIEDOWN SL-2

- 1000-LB INPUT LOAD
- - - - 2000-LB INPUT LOAD
- · - · - 3000-LB INPUT LOAD

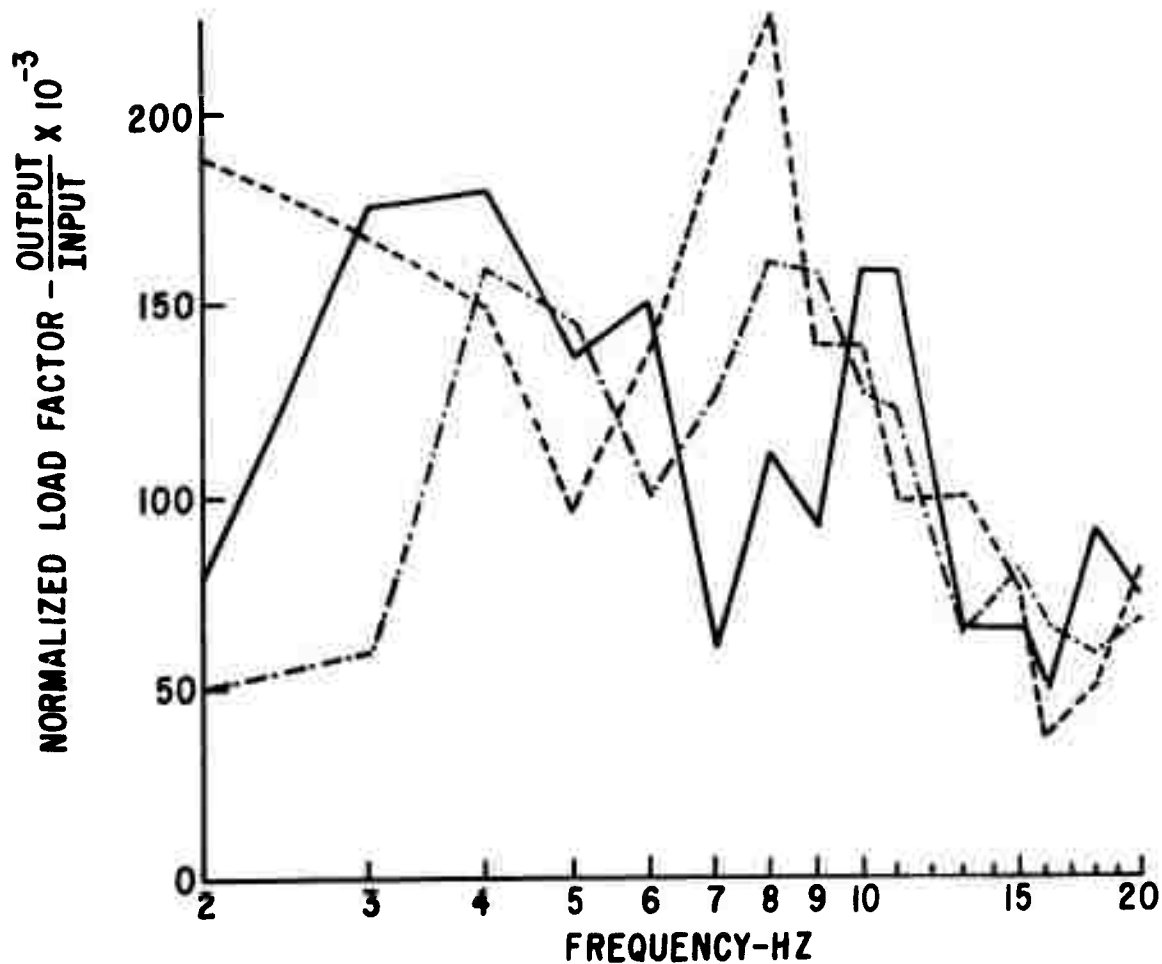


Figure 10. Tiedown SL-2 Normalized Load Factor versus Frequency

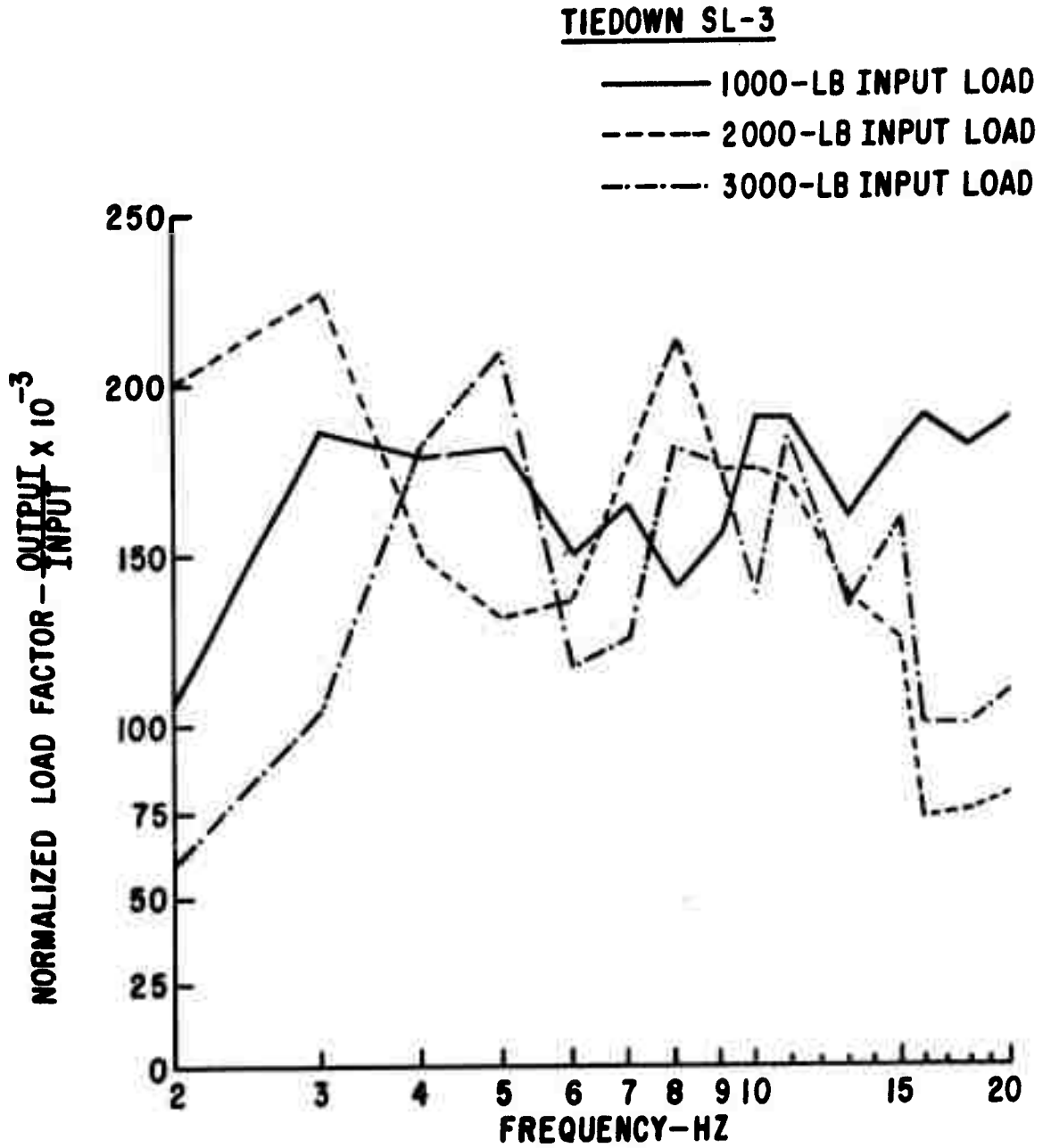


Figure 11. Tiedown SL-3 Normalized Load Factor versus Frequency

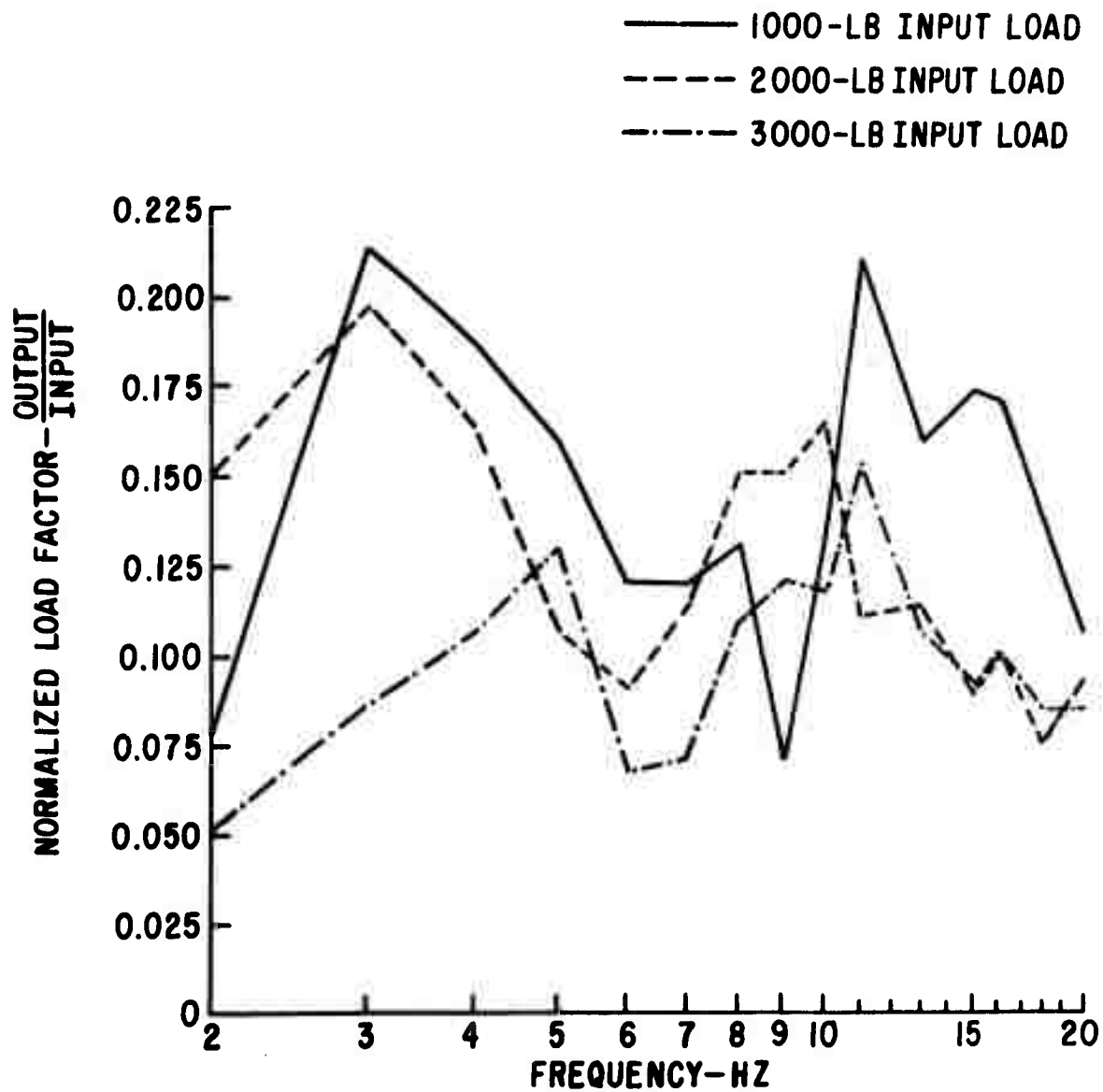
TIEDOWN SL-4

Figure 12. Tiedown SL-4 Normalized Load Factor versus Frequency

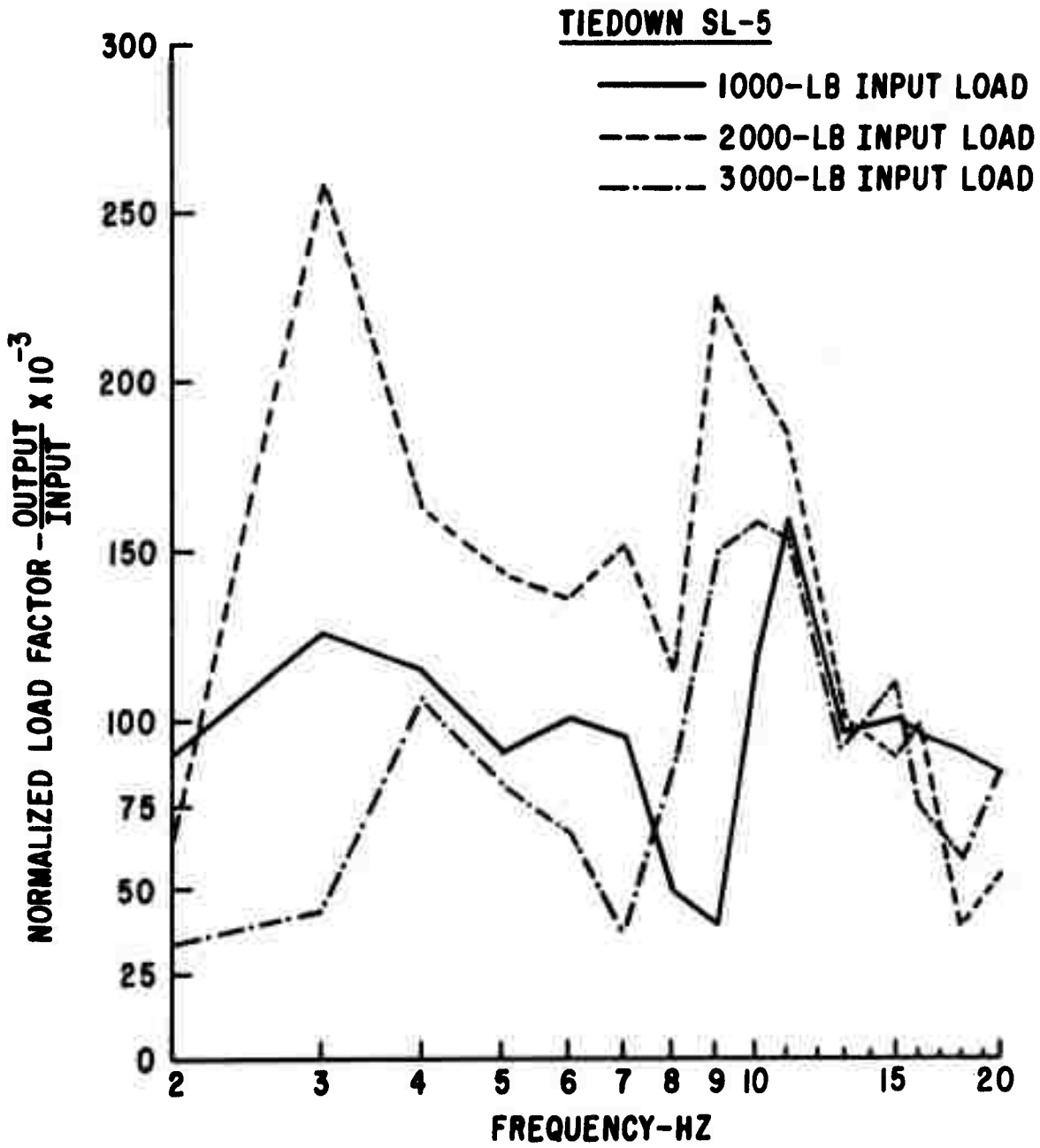


Figure 13. Tiedown SL-5 Normalized Load Factor versus Frequency

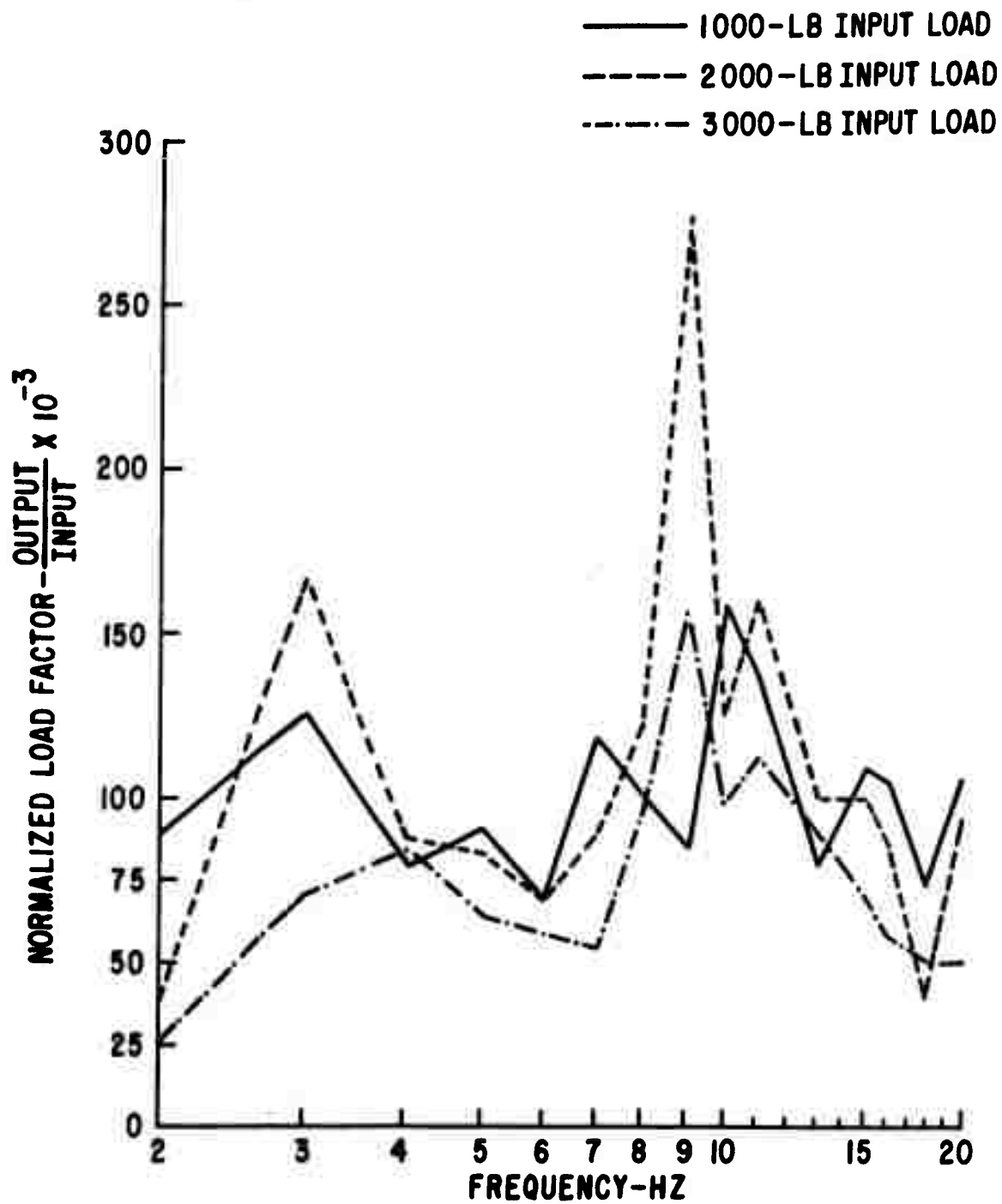
TIEDOWN SL-6

Figure 14. Tiedown SL-6 Normalized Load Factor versus Frequency

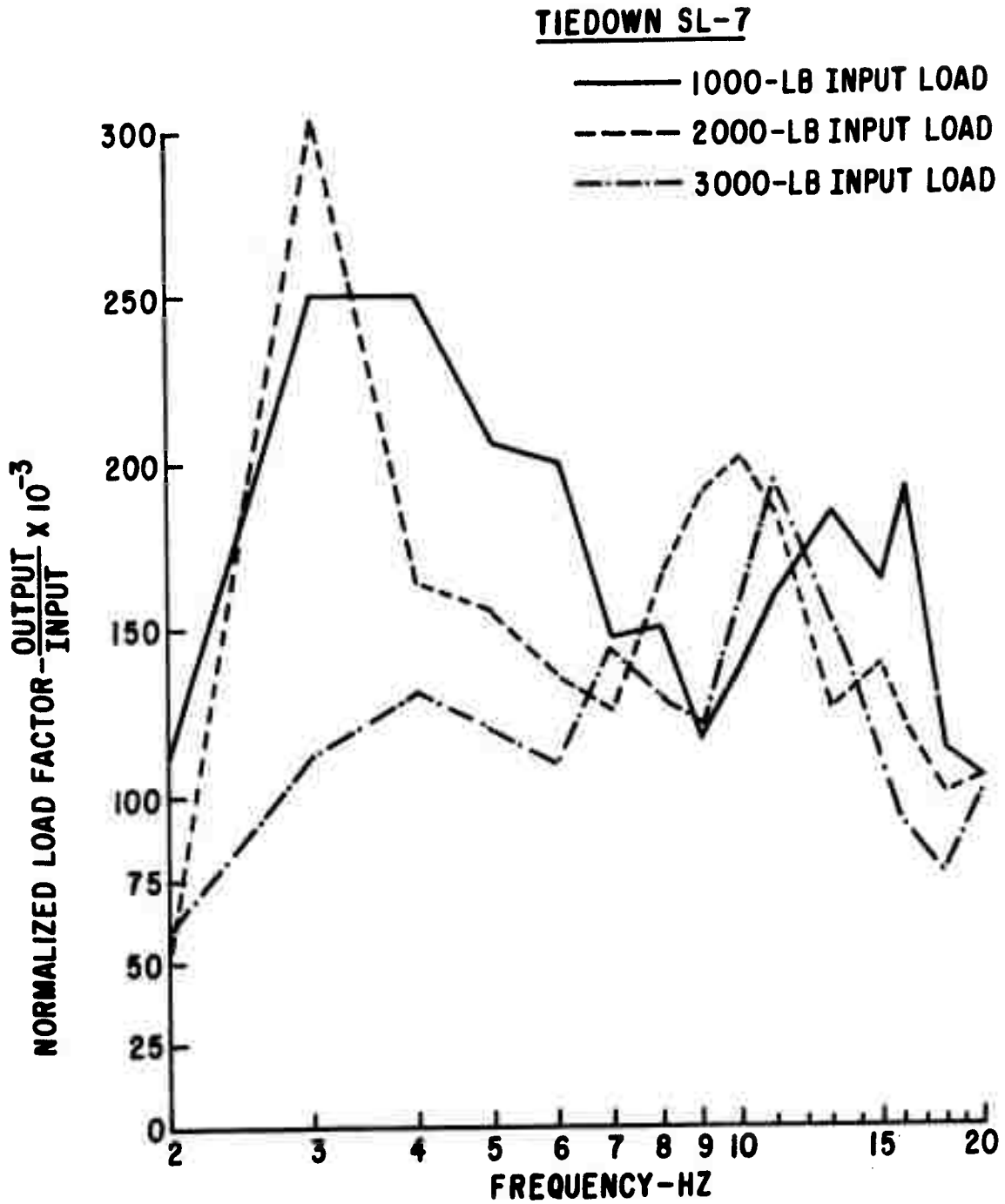


Figure 15. Tiedown SL-7 Normalized Load Factor versus Frequency

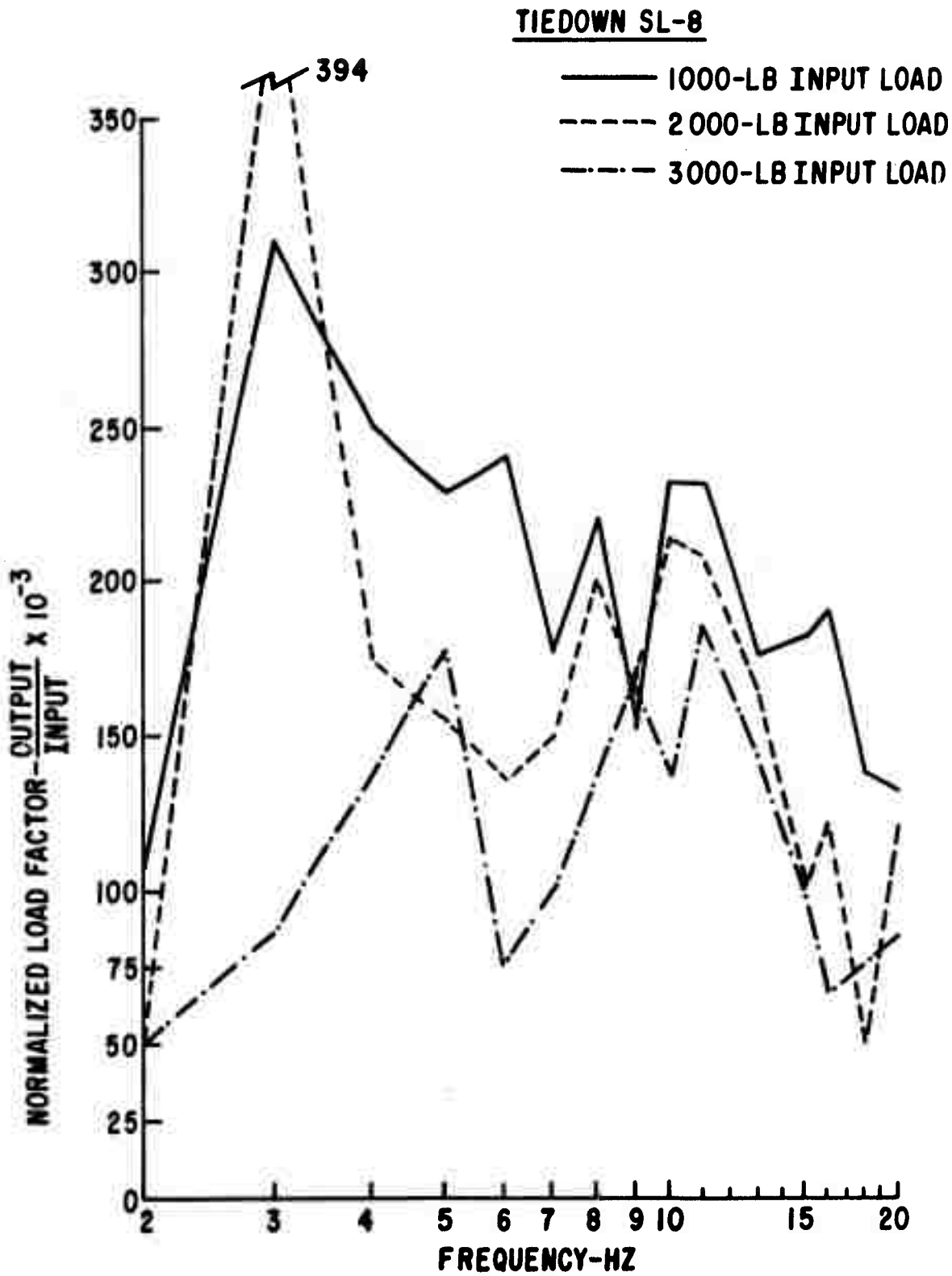


Figure 16. Tiedown SL-8 Normalized Load Factor versus Frequency

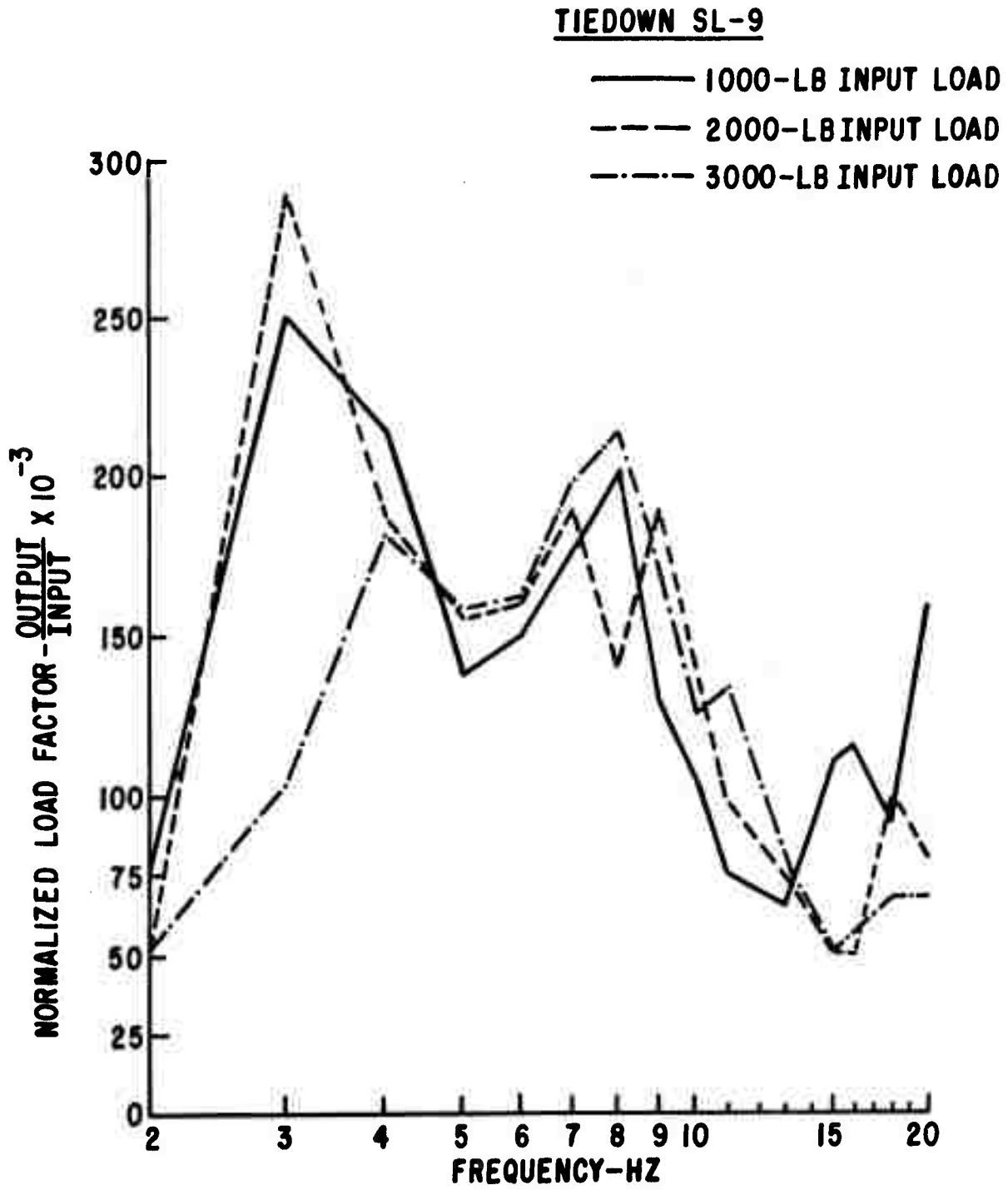


Figure 17. Tiedown SL-9 Normalized Load Factor versus Frequency

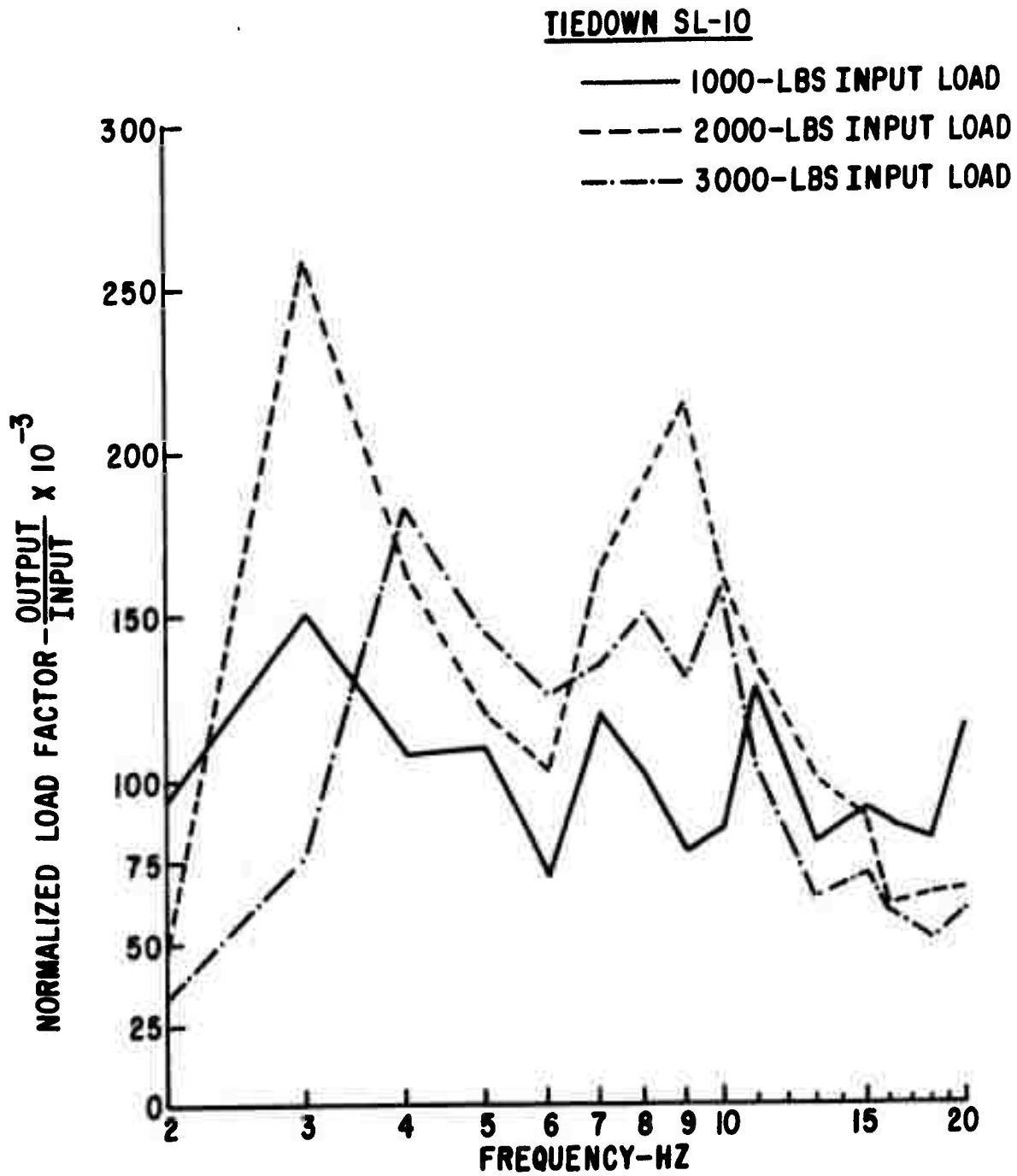


Figure 18. Tiedown SL-10 Normalized Load Factor versus Frequency

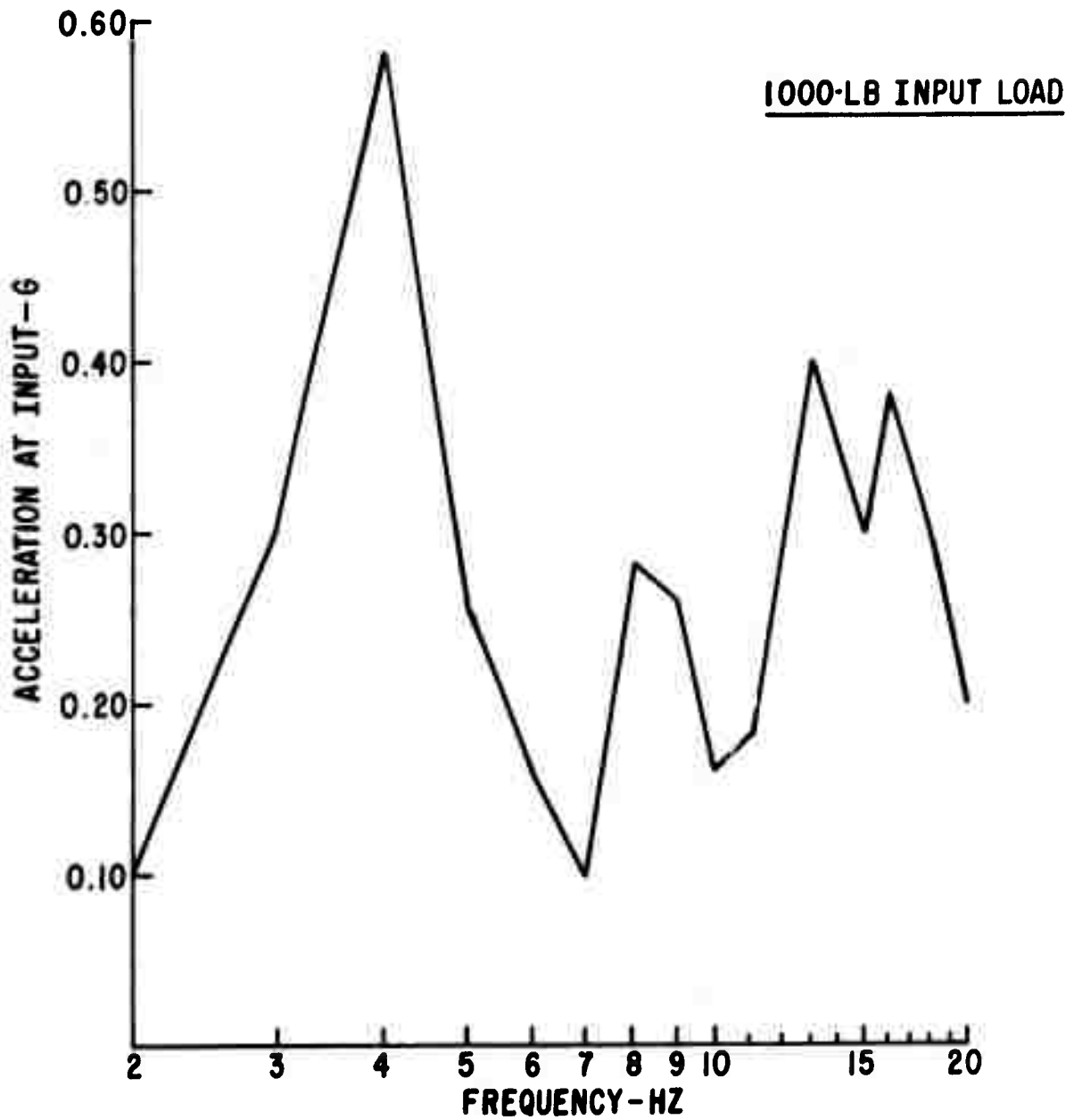


Figure 19. Input Acceleration versus Frequency for 1000-Pound Load

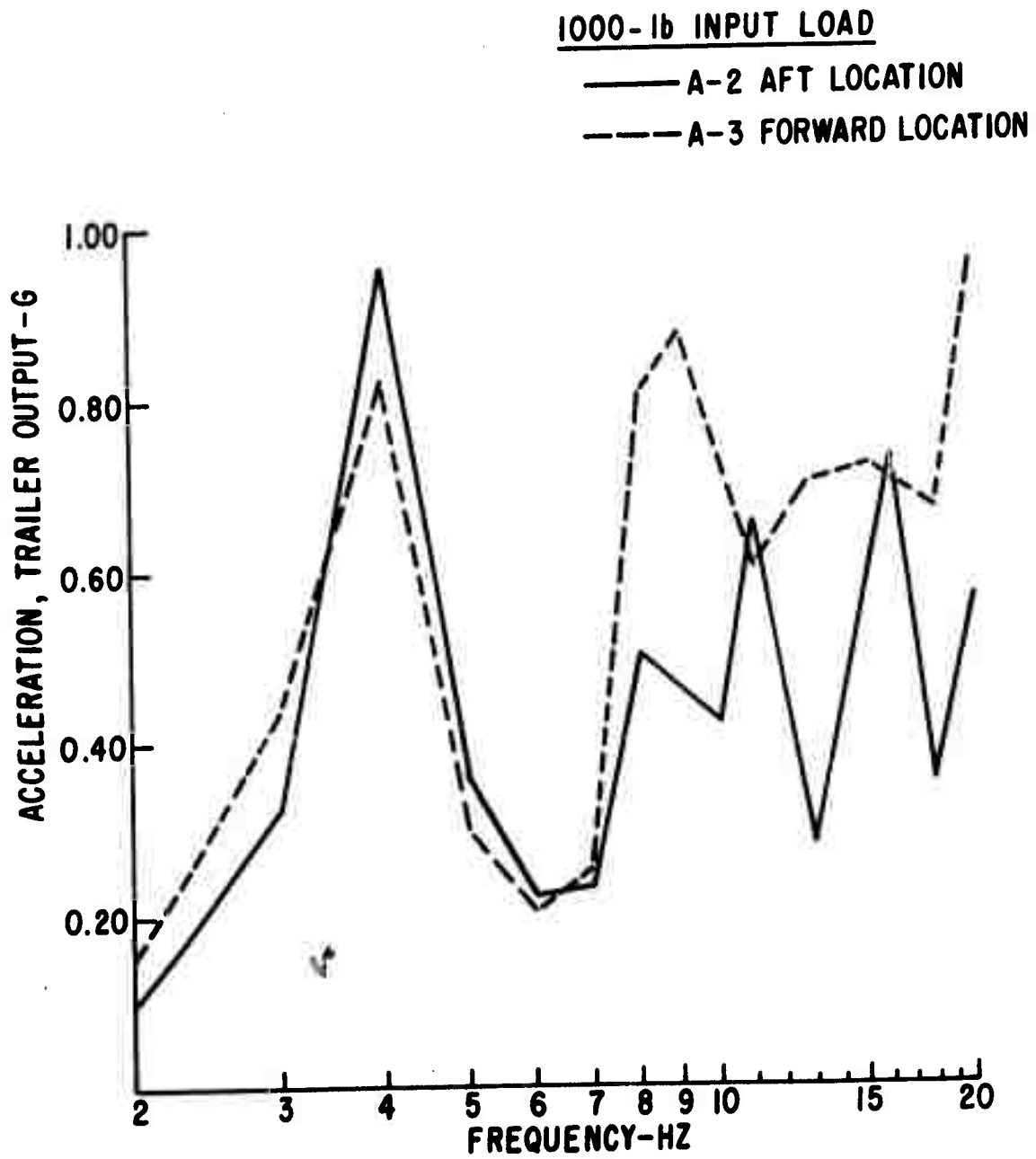


Figure 20. Output Accelerations versus Frequency for 1000-Pound Load

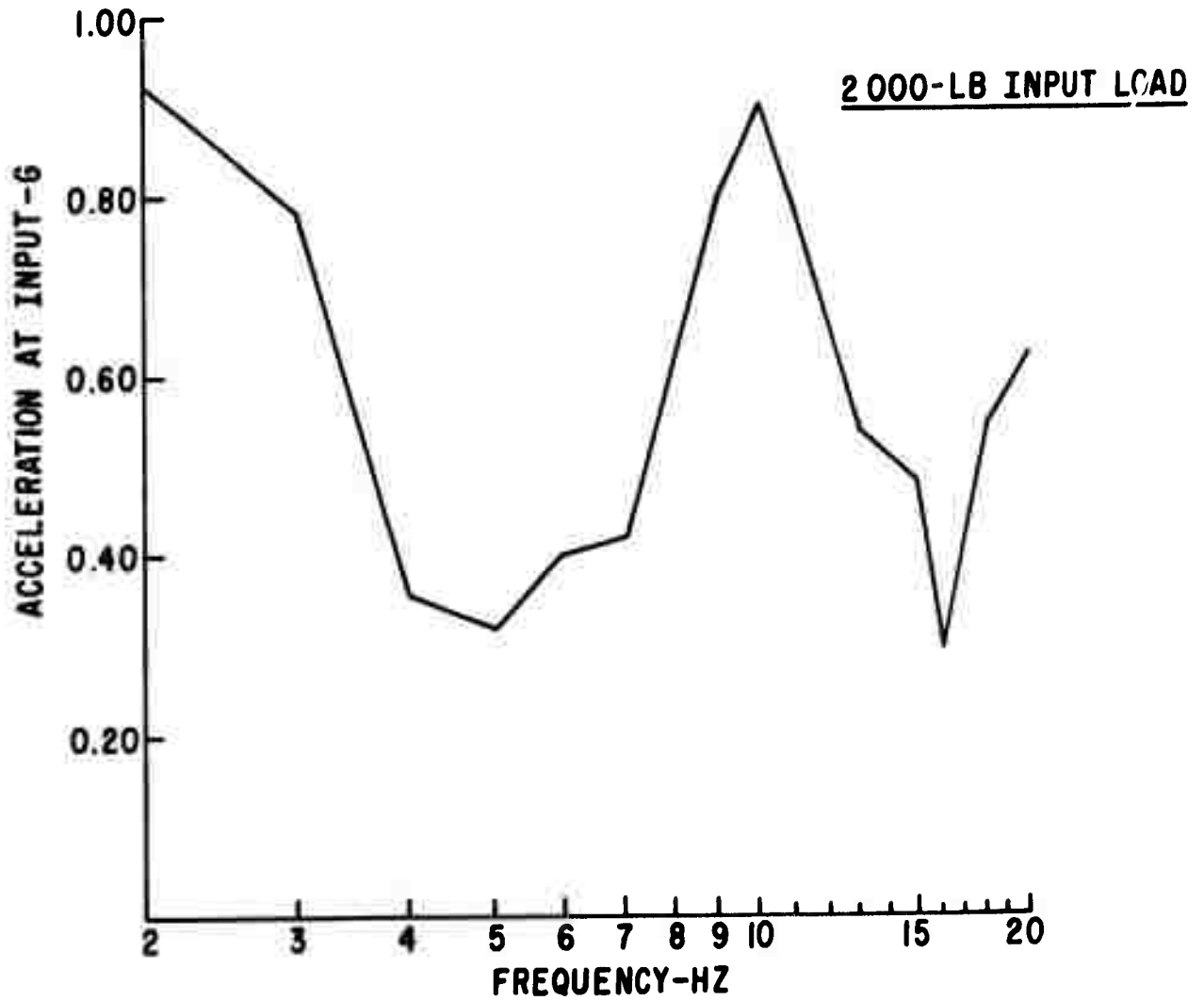


Figure 21. Input Acceleration versus Frequency for 2000-Pound Load

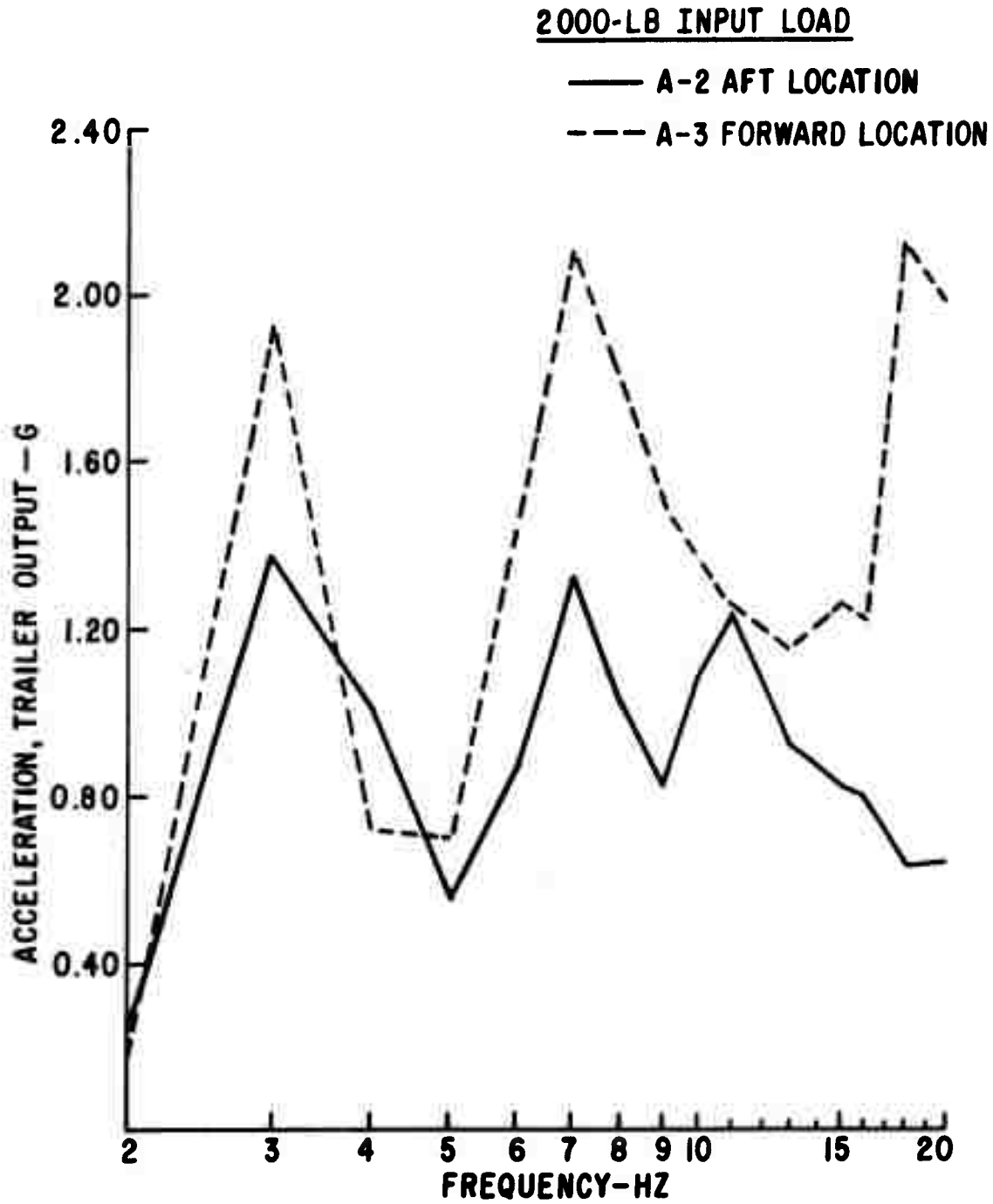


Figure 22. Output Accelerations versus Frequency for 2000-Pound Load

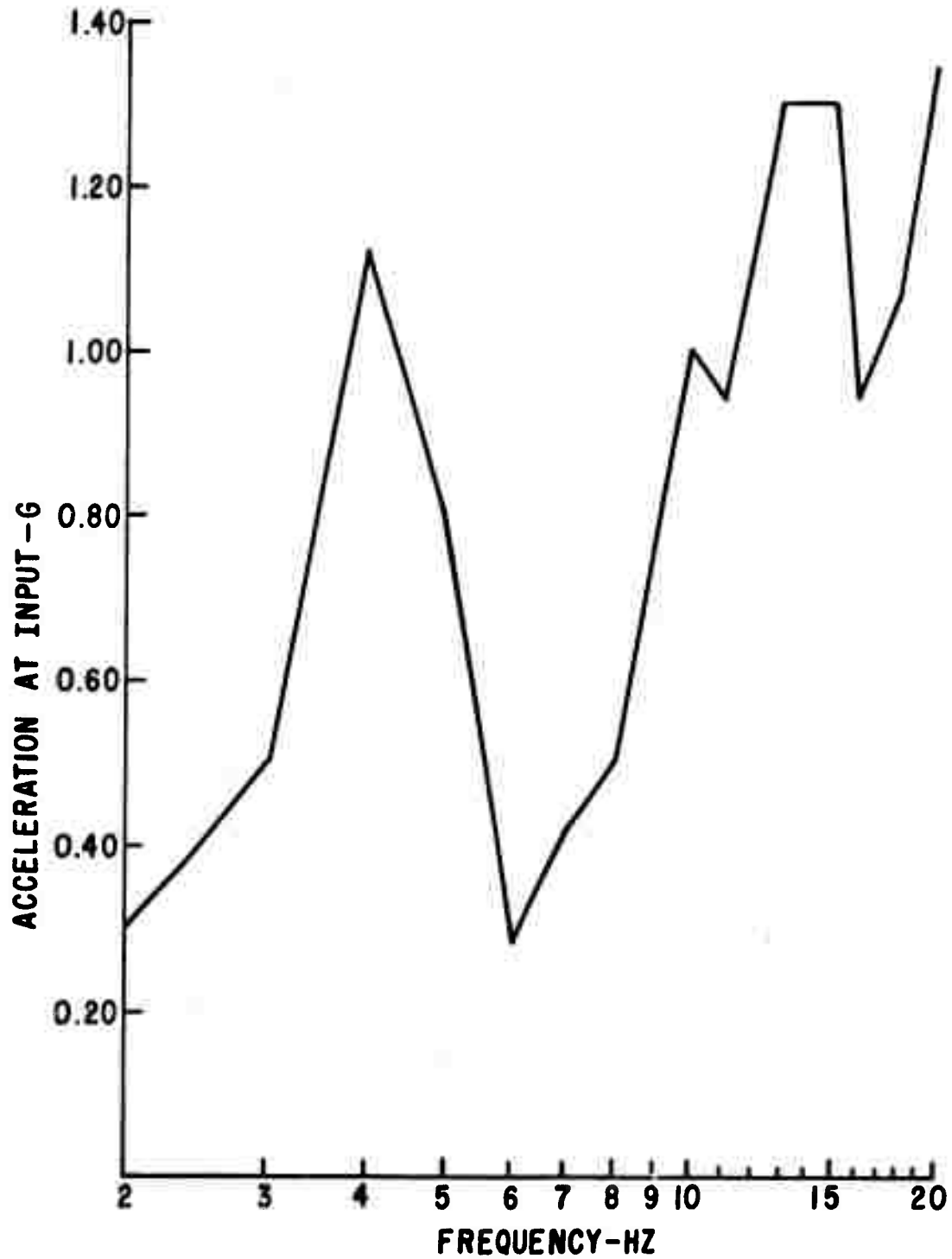
3 000 LB INPUT LOAD

Figure 23. Input Acceleration versus Frequency for 3000-Pound Load

3000 LB INPUT LOAD

— A-2 AFT LOCATION

- - - A-3 FORWARD LOCATION

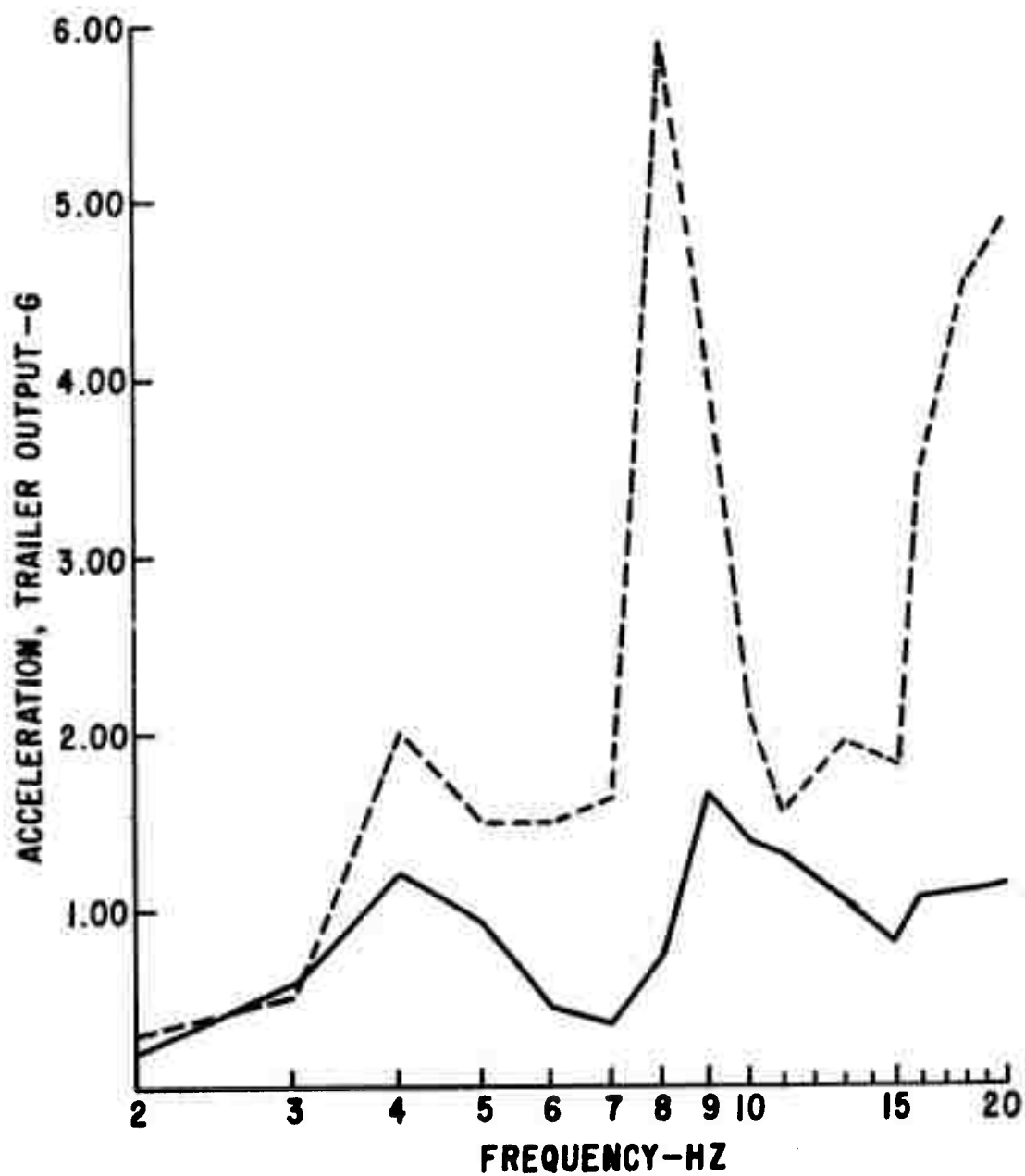


Figure 24. Output Accelerations versus Frequency for 3000-Pound Load

SECTION IV

CONCLUSIONS

1. All test program requirements were met and no visible failures occurred during the course of testing.
2. Dynamic testing indicated that the BDU-8-MHU-12/M weapon-trailer system has an initial resonant frequency between 3 and 4 Hz at the 1000-, 2000-, and 3000-pound input load to the simulated aircraft deck. A second resonant frequency occurred between 8 and 10 Hz.

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13. ABSTRACT (Distribution Limitation Statement B) Static and dynamic tests were performed on an MHU-12/M Munitions Handling Trailer for determining aircraft transport criteria. An existing tiedown configuration for air transport of the MHU-12/M trailer, without parking shoring, was established and tested. Dynamic tests, simulating flight conditions, performed with this tiedown configuration on an unshored trailer having soft springs and/or pneumatic tires revealed that a weapon-trailer combination can be excited to resonance. The developed tiedown configuration, test procedures, test data, notations of test observations and other pertinent information are presented.			

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KEY WORDS

LINK A

LINK B

LINK C

ROLE

WT

ROLE

WT

ROLE

WT

MHU-12/M trailer
BDU-8
Static tiedown tests
Dynamic tiedown tests