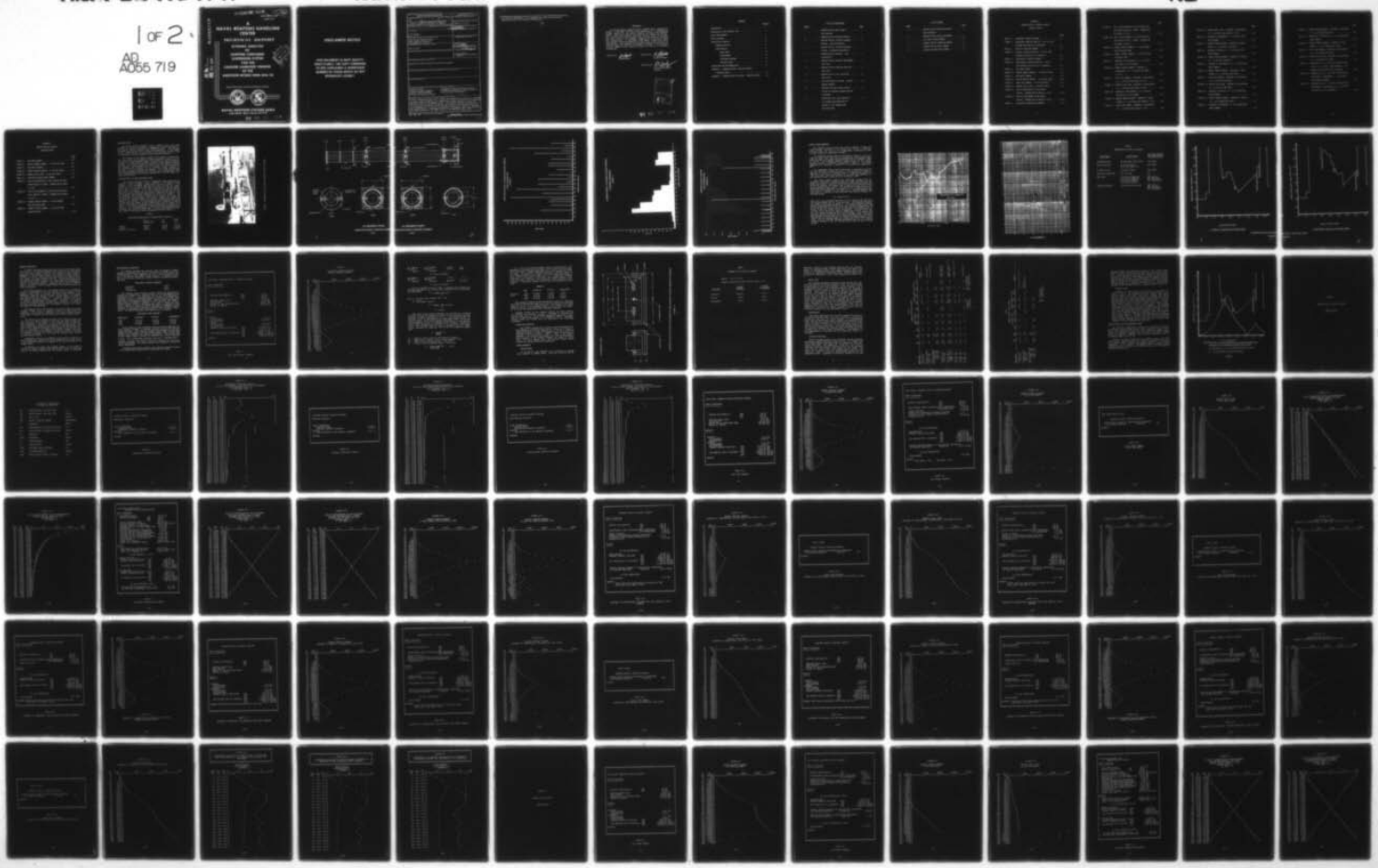
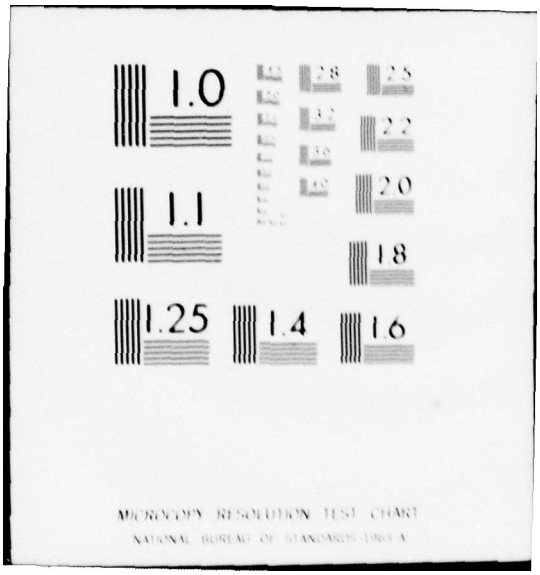
AD-A055 719 NAVAL WEAPONS HANDLING CENTER COLTS NECK N J F/G 13/4
DYNAMIC ANALYSIS OF SHIPPING CONTAINER SUSPENSION SYSTEM FOR TH--ETC(U)
APR 78 Y TRASK
UNCLASSIFIED NWHC-7760 NL

1 OF 2
AD
A055 719




1.0
1.1
1.25
1.4
2.8
2.5
2.2
2.0
1.8
1.6
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

FOR FURTHER TRAN

NWHC REPORT 7760

1 APRIL 1978

AD A055719

AD No.
DDC FILE COPY

A NAVAL WEAPONS HANDLING CENTER

TECHNICAL REPORT

DYNAMIC ANALYSIS OF SHIPPING CONTAINER SUSPENSION SYSTEM FOR THE CANISTER LAUNCHED VERSION OF THE HARPOON MISSILE RGM-84A-3A

DDC
JUN 26 1978
F

Approved for public release; distribution unlimited

NAVAL WEAPONS STATION EARLE
Colts Neck, New Jersey 07722

78 06 23 104

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DDC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 7760 (6)
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): Dynamic Analysis of Shipping Container Suspension System For the Canister Launched Version of the HARPOON Missile RGM-84A-3A
5. TYPE OF REPORT & PERIOD COVERED: (9) Final rept.,
6. PERFORMING ORG. REPORT NUMBER: (14) NWHC-7760
7. AUTHOR(s): (10) Y. Trask
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Naval Weapons Handling Center
Naval Weapons Station Earle
Colts Neck, N.J. 07722
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11. CONTROLLING OFFICE NAME AND ADDRESS:
Same as above
12. REPORT DATE: (11) 1 April 1978
13. NUMBER OF PAGES: (12) 97p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report):
Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Dynamic Analysis
Isolation Systems Parameters
Canister Launched HARPOON
Shipping and Storage Container
Packaging Configuration Using Isolators
Configuration adequately protects weapon in specified shock environments.
→ This center
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):
The Naval Weapons Handling Center, WPNSTA Earle, conducted an analysis to determine isolation system parameters for a shipping and storage container for the canister-launched version of the HARPOON missile. This report presents the details of the analysis and information concerning the predicted shock and vibration forces on the packaged item as well as the container caused by the hazards of handling and transportation. A packaging configuration is presented, which uses isolators previously approved for the ASROC version of the HARPOON missile. This → over
since

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

410 058 ✓ JRB

cont

configuration adequately protects the weapon in its specified shock vibration environments; therefore, it is recommended that ASROC-version approved isolators be used in the proposed configuration.

1473 B

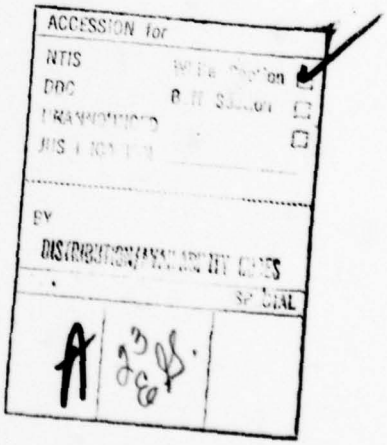
ABSTRACT

The Naval Weapons Handling Center, WPNSTA Earle, conducted an analysis to determine isolation system parameters for a shipping and storage container for the canister launched version of the HARPOON missile. This report presents the details of the analysis and information concerning the predicted shock and vibration forces on the packaged item as well as the container caused by the hazards of handling and transportation. A packaging configuration is presented, which uses isolators previously approved for the ASROC version of the HARPOON missile. This configuration adequately protects the weapon in its specified shock and vibration environments; therefore, it is recommended that ASROC version approved isolators be used in the proposed configuration.

Prepared by: J. Trask
J. TRASK
Mathematician

Reviewed by: C. Rinaldi
E. RINALDI
Analysis Branch

Approved by: R.E. Seely
R. E. SEELY
Test and Evaluation
Division



78 06 22 104

CONTENTS

	PAGE NO.
INTRODUCTION	1
DESCRIPTION OF THE PACKAGED ITEM	2
DESIGN REQUIREMENTS	7
DESIGN APPROACH	12
DISCUSSION OF RESULTS	13
VIBRATION RESULTS	17
SHOCK RESULTS	17
SHOCK LEVEL	20
DISPLACEMENT	20
STRUCTURAL RESPONSE	20
REACTION LOADS	23
CONCLUSIONS AND RECOMMENDATIONS	23
APPENDIX A. HARPOON MISSILE, CANISTER VERSION - COMPUTER OUTPUT	A-1
APPENDIX B. HARPOON MISSILE CANISTER - COMPUTER OUTPUT	B-1

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1	HARPOON MISSILE BEING LOADED INTO CANISTER	2
2,	HARPOON MISSILE/CANISTER ASSEMBLY	3
3	HARPOON MISSILE, CANISTER LAUNCHED VERSION - LOAD DISTRIBUTION	4
4	HARPOON MISSILE, CANISTER LAUNCHED VERSION - STIFFNESS DISTRIBUTION	5
5	HARPOON MISSILE CANISTER - LOAD DISTRIBUTION	6
6	HARPOON MISSILE VIBRATION ENVIRONMENT (XAS 2381)	8
7	HARPOON MISSILE VIBRATION FRAGILITY (XAS 3894)	9
8	HARPOON MISSILE LIMIT EQUIVALENT AXIAL LOAD	11
9	FLAT DROP ANALYSIS FAILURE - DYNAMIC BENDING MOMENTS	15
10	PROPOSED ISOLATION SYSTEM CONFIGURATION FOR CANISTER LAUNCHED VERSION OF HARPOON	18
11	EQUIVALENT AXIAL LOAD COMPARISON OF ALLOWABLE AND PREDICTED RESPONSE TO -20°F FORWARD EDGE ROTATIONAL DROP	24

LIST OF TABLES

TABLE		PAGE
1	HARPOON MISSILE/CANISTER ASSEMBLY - MASS PROPERTIES	1
2	HARPOON MISSILE SHOCK ENVIRONMENT	10
3	FLAT DROP FAILURE SUMMARY	14
4	HARPOON MISSILE VIBRATION SUMMARY	19
5	HARPOON MISSILE SHOCK SUMMARY	21
6	HARPOON CANISTER SHOCK SUMMARY	22

APPENDIX A

HARPOON MISSILE, CANISTER VERSION

COMPUTER OUTPUT

		PAGE
TABLE A-1.	TRANSVERSE VIBRATION SUMMARY	A-1
FIGURE A-1.	TRANSVERSE VIBRATION ANALYSIS - PLOT OF ITEM RESPONSE AND FRAGILITY VS FREQUENCY	A-2
TABLE A-2.	VERTICAL VIBRATION SUMMARY	A-3
FIGURE A-2.	VERTICAL VIBRATION ANALYSIS - PLOT OF ITEM RESPONSE AND FRAGILITY VS FREQUENCY	A-4
TABLE A-3.	LONGITUDINAL VIBRATION SUMMARY	A-5
FIGURE A-3.	LONGITUDINAL VIBRATION ANALYSIS - PLOT OF ITEM RESPONSE AND FRAGILITY VS FREQUENCY	A-6
TABLE A-4.	FLAT DROP SUMMARY	A-7
FIGURE A-4.	DYNAMIC BENDING MOMENTS - 18 INCH FLAT DROP	A-8
TABLE A-5.	END IMPACT SUMMARY	A-9
FIGURE A-5.	DYNAMIC BENDING MOMENTS - 10 FPS END IMPACT	A-10
TABLE A-6.	AXIAL LOAD SUMMARY - 10 FPS END IMPACT	A-11
FIGURE A-6.	DYNAMIC AXIAL LOADS - 10 FPS END IMPACT	A-12
FIGURE A-7.	PLOT OF DECELERATION VS HALF-MOUNT SPACING - FORWARD AND AFT DROPS AT -20°F	A-13
FIGURE A-8.	PLOT OF DISPLACEMENT VS HALF-MOUNT SPACING - FORWARD AND AFT DROPS AT 140°F	A-14
TABLE A-7.	ROTATIONAL EDGEWISE DROP SUMMARY	A-15

PAGE

FIGURE A-9. PLOT OF DECELERATION AT ITEM STATIONS FOR HALF-MOUNT SPACING 65 INCHES - FORWARD AND AFT DROPS AT -20°F..... A-16

FIGURE A-10. PLOT OF DISPLACEMENT AT ITEM STATIONS FOR HALF-MOUNT SPACING 65 INCHES - FORWARD AND AFT DROPS AT 140°F..... A-17

FIGURE A-11. DYNAMIC BENDING MOMENTS - 18 INCH FORWARD EDGE ROTATIONAL DROP..... A-18

FIGURE A-12. DYNAMIC BENDING MOMENTS - 18 INCH AFT EDGE ROTATIONAL DROP..... A-19

TABLE A-8. RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT 140°F SUMMARY..... A-20

FIGURE A-13. DYNAMIC BENDING MOMENTS - RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT 140°F..... A-21

TABLE A-9. AXIAL LOAD SUMMARY - RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT 140°F..... A-22

FIGURE A-14. DYNAMIC AXIAL LOADS - RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT 140°F..... A-23

TABLE A-10. RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT -20°F SUMMARY..... A-24

FIGURE A-15. DYNAMIC BENDING MOMENTS - RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT -20°F..... A-25

TABLE A-11. AXIAL LOAD SUMMARY - RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT -20°F..... A-26

PAGE

FIGURE A-16. DYNAMIC AXIAL LOADS - RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT -20°F..... A-27

TABLE A-12. RESPONSE TO TRANSVERSE 15 G, 18 MS HALF SINE SHOCK SUMMARY..... A-28

FIGURE A-17. DYNAMIC BENDING MOMENTS - RESPONSE TO TRANSVERSE 15 G, 18 MS HALF SINE SHOCK..... A-29

TABLE A-13. RESPONSE TO VERTICAL 15 G, 18 MS HALF SINE SHOCK SUMMARY..... A-30

FIGURE A-18. DYNAMIC BENDING MOMENTS - RESPONSE TO VERTICAL 15 G, 18 MS HALF SINE SHOCK..... A-31

TABLE A-14. RESPONSE TO LONGITUDINAL 15 G, 18 MS HALF SINE SHOCK SUMMARY..... A-32

FIGURE A-19. DYNAMIC BENDING MOMENTS - RESPONSE TO LONGITUDINAL 15 G, 18 MS HALF SINE SHOCK..... A-33

TABLE A-15. AXIAL LOAD SUMMARY - RESPONSE TO LONGITUDINAL 15 G, 18 MS HALF SINE SHOCK..... A-34

FIGURE A-20. DYNAMIC AXIAL LOADS - RESPONSE TO LONGITUDINAL 15 G, 18 MS HALF SINE SHOCK..... A-35

TABLE A-16. RESPONSE TO VERTICAL 15 G, 35 MS TRAPEZOIDAL SHOCK SUMMARY..... A-36

FIGURE A-21. DYNAMIC BENDING MOMENTS - RESPONSE TO VERTICAL 15 G, 35 MS TRAPEZOIDAL SHOCK..... A-37

TABLE A-17. RESPONSE TO TRANSVERSE 9 G, 35 MS TRAPEZOIDAL SHOCK SUMMARY..... A-38

PAGE

FIGURE A-22. DYNAMIC BENDING MOMENTS - RESPONSE TO TRANSVERSE 9 G, 35 MS TRAPEZOIDAL SHOCK..... A-39

TABLE A-18. RESPONSE TO LONGITUDINAL 6 G, 35 MS TRAPEZOIDAL SHOCK SUMMARY..... A-40

FIGURE A-23. DYNAMIC BENDING MOMENTS - RESPONSE TO LONGITUDINAL 6 G, 35 MS TRAPEZOIDAL SHOCK..... A-41

TABLE A-19. AXIAL LOAD SUMMARY - RESPONSE TO LONGITUDINAL 6 G, 35 MS TRAPEZOIDAL SHOCK..... A-42

FIGURE A-24. DYNAMIC AXIAL LOADS - RESPONSE TO LONGITUDINAL 6 G, 35 MS TRAPEZOIDAL SHOCK..... A-43

FIGURE A-25. COMPARISON OF 42 G, 25 MS TPS (SPECIFICATION) TO 19.09 G, 64 MS HALF SINE RESPONSE TO -20°F FORWARD EDGE ROTATIONAL DROP (RESPONSE)..... A-44

FIGURE A-26. COMPARISON OF 42 G, 25 MS TPS (SPECIFICATION) TO RESPONSE TO TRANSVERSE 9 G, 35 MS TRAPEZOIDAL SHOCK (RESPONSE)..... A-45

FIGURE A-27. COMPARISON OF 42 G, 25 MS TPS (SPECIFICATION) TO RESPONSE TO LONGITUDINAL 25 G, 25 MS HALF SINE SHOCK AT -20°F (RESPONSE)..... A-46

APPENDIX B

HARPOON MISSILE CANISTER

COMPUTER OUTPUT

		PAGE
TABLE B-1.	FLAT DROP SUMMARY	B-1
FIGURE B-1.	DYNAMIC BENDING MOMENTS - 18 INCH FLAT DROP	B-2
TABLE B-2.	END IMPACT SUMMARY	B-3
FIGURE B-2.	DYNAMIC BENDING MOMENTS - 10 FPS END IMPACT	B-4
FIGURE B-3.	DYNAMIC AXIAL LOADS - 10 FPS END IMPACT	B-5
TABLE B-3.	ROTATIONAL EDGEWISE DROP SUMMARY	B-6
FIGURE B-4.	PLOT OF DECELERATION AT ITEM STATIONS FOR HALF-MOUNT SPACING 65 INCHES - FORWARD AND AFT DROPS AT -20°F	B-7
FIGURE B-5.	PLOT OF DISPLACEMENT AT ITEM STATIONS FOR HALF-MOUNT SPACING 65 INCHES - FORWARD AND AFT DROPS AT 140°F	B-8
FIGURE B-6.	DYNAMIC BENDING MOMENTS - 18 INCH FORWARD EDGE ROTATIONAL DROP	B-9
FIGURE B-7.	DYNAMIC BENDING MOMENTS - 18 INCH AFT EDGE ROTATIONAL DROP	B-10

INTRODUCTION

The Naval Weapons Handling Center, WPNSTA Earle, has been assigned the task of developing a shipping and storage container for the canister launched version of the HARPOON missile. The principal technical sub-tasks involved in such a development are: (1) the design of the isolation system, (2) the design of the container structure, and (3) subsequent test and evaluation of the prototype container.

The design of the isolation system is the subject of this report. The output of the report consists of design parameters, which are to be used by shock mount manufacturers and container structural designers, presented as results from the NWHC container design computer program package. The design parameters presented are the natural frequency and damping of the isolation system, the location of shock mounts and the reaction loads developed by the isolation system's response to specified shock and vibration environments. The design specifications that these parameters address are contained in two specifications, XAS 2381 (HARPOON Missile Environment Specification) and XAS 3894 (Container Specification).

DESCRIPTION OF THE PACKAGED ITEM

The canister launched version of HARPOON being loaded into its canister is shown in Figure 1 and a schematic of the missile/canister assembly in the packaging configuration is shown in Figure 2. The missile air scoop is placed down and the wings and fins are folded. Three shoes are located on each side of the weapon at missile stations 88.12, 166.0, and 189.12. A fire thru restraint bolt and an explosive inadvertent fire restraint bolt are located at missile station 192.13. The missile weighs 1515.18 pounds distributed as illustrated in Figure 3 and has stiffness characteristics presented by the EI plot, Figure 4. The overall length of the missile is 182.2 inches, diameter 13.5 inches and the missile is supported within the canister on launch rails running the length of the canister. The forward missile and forward booster shoes interface with the canister at the stacking frames (CS 80.52, CS 158.39). The overall length of the canister is 189.5 inches and the diameter 23.50 inches. The canister weighs 490.30 pounds distributed as illustrated in Figure 5. The stacking frames are 25.90 inches high (excluding stacking guide pin) and 26.10 inches wide. The mass properties of the missile, canister and missile/canister assembly are listed in Table 1.

Table 1

HARPOON Missile/Canister Assembly Mass Properties

	I_{pitch} (in-lb-sec^2)	CG (MS)	Weight (lb)
Missile	10240.8	104.88	1515.18
Canister	4320.0	108.70	490.30
Missile in Canister	14575.8	105.82	2005.48

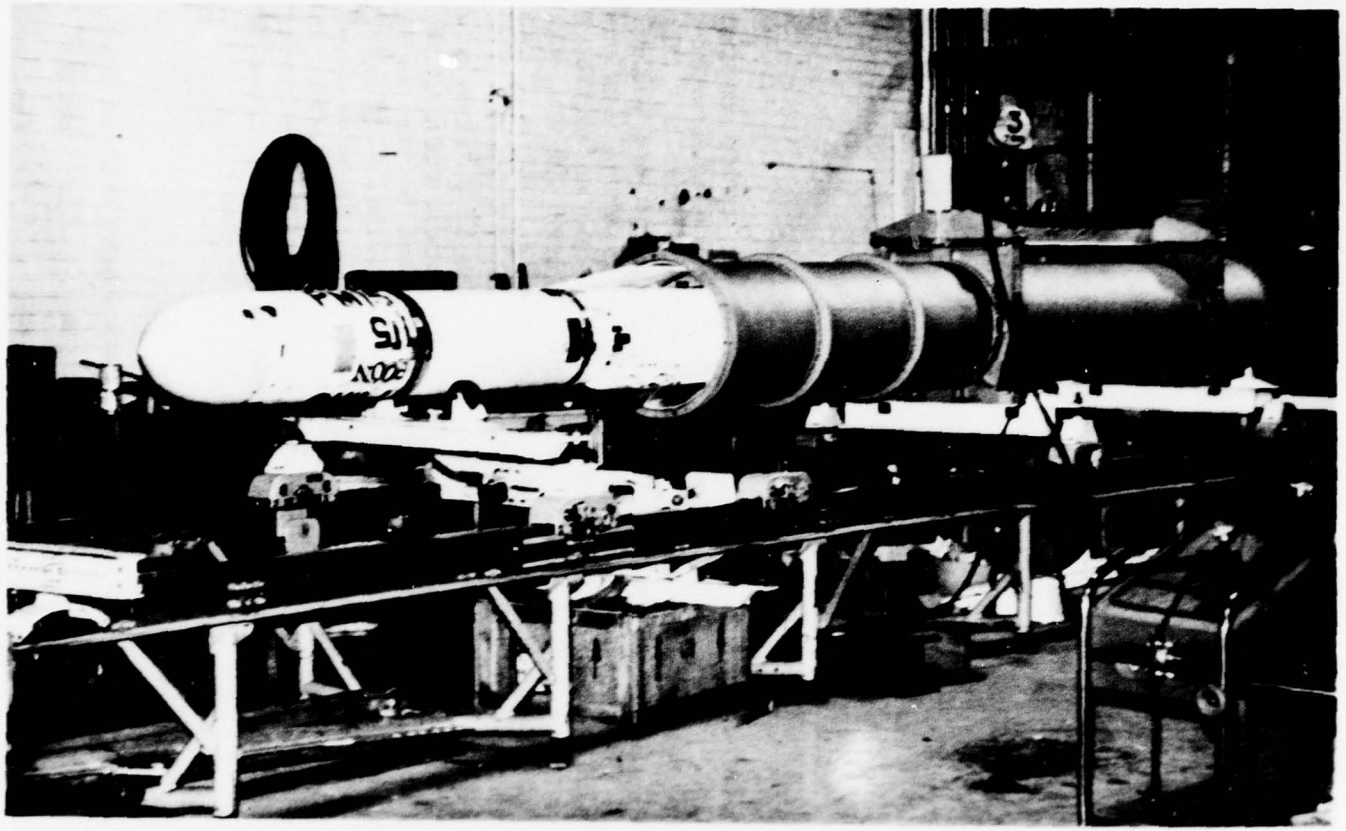
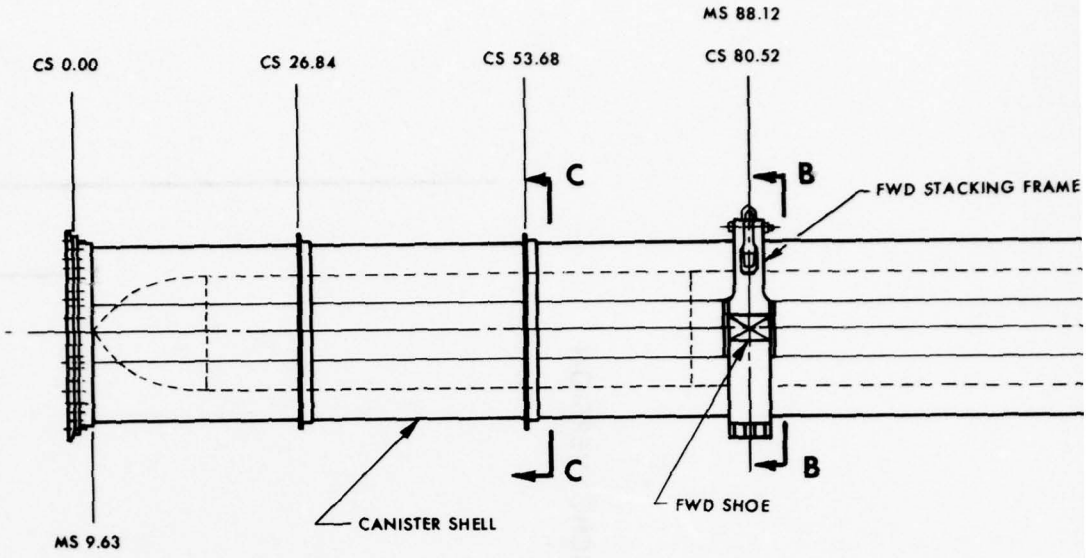
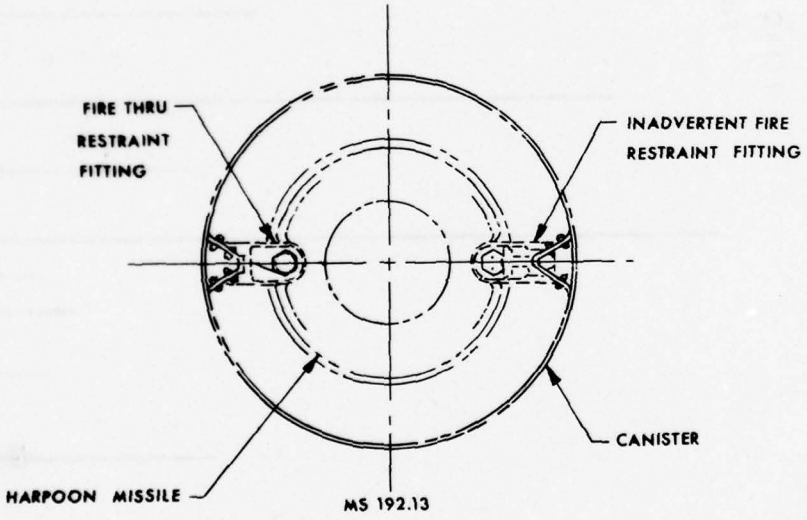
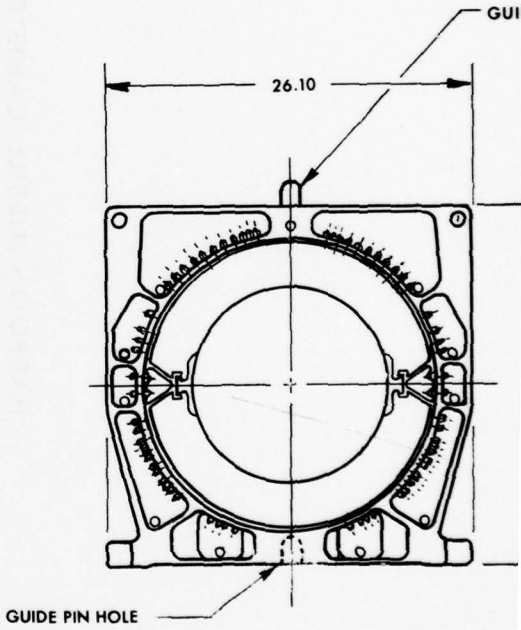


FIGURE 1. HARPOON MISSILE BEING LOADED INTO CANISTER





A-A

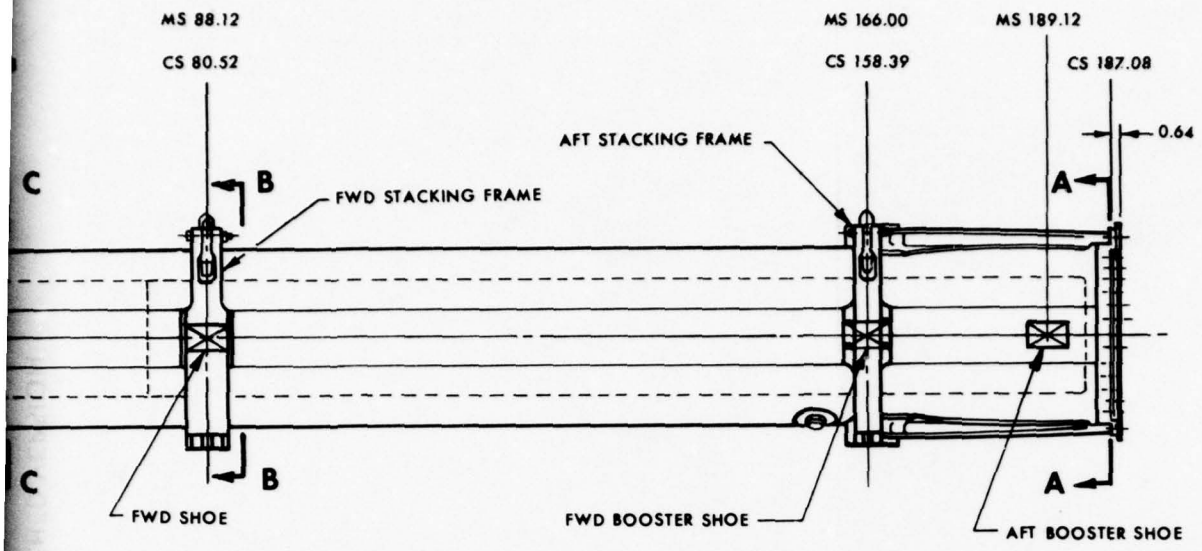


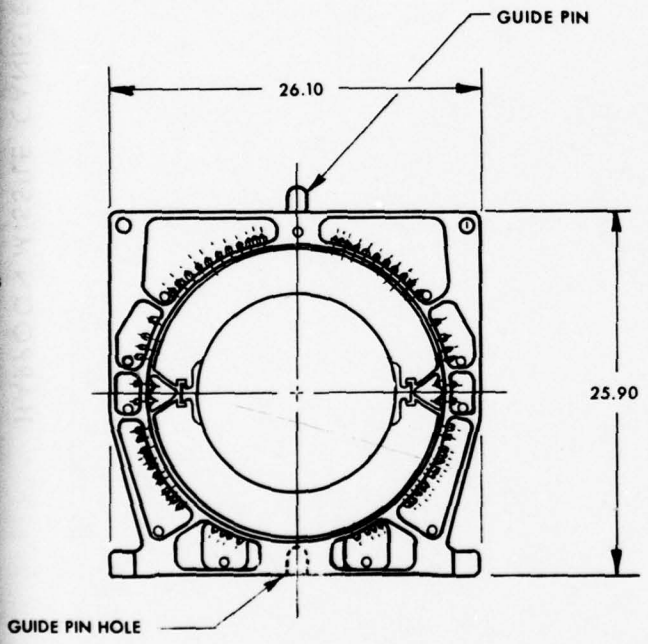
B-B

(ALL DIMENSIONS IN INCHES)

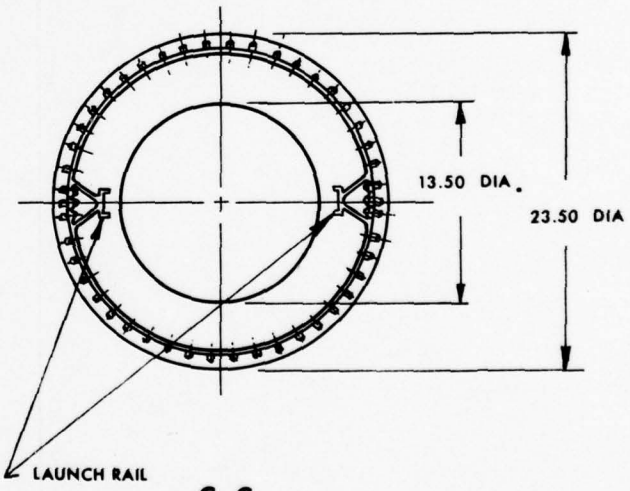
HARPOON MISSILE/CANISTER AS

FIGURE 2





B–B



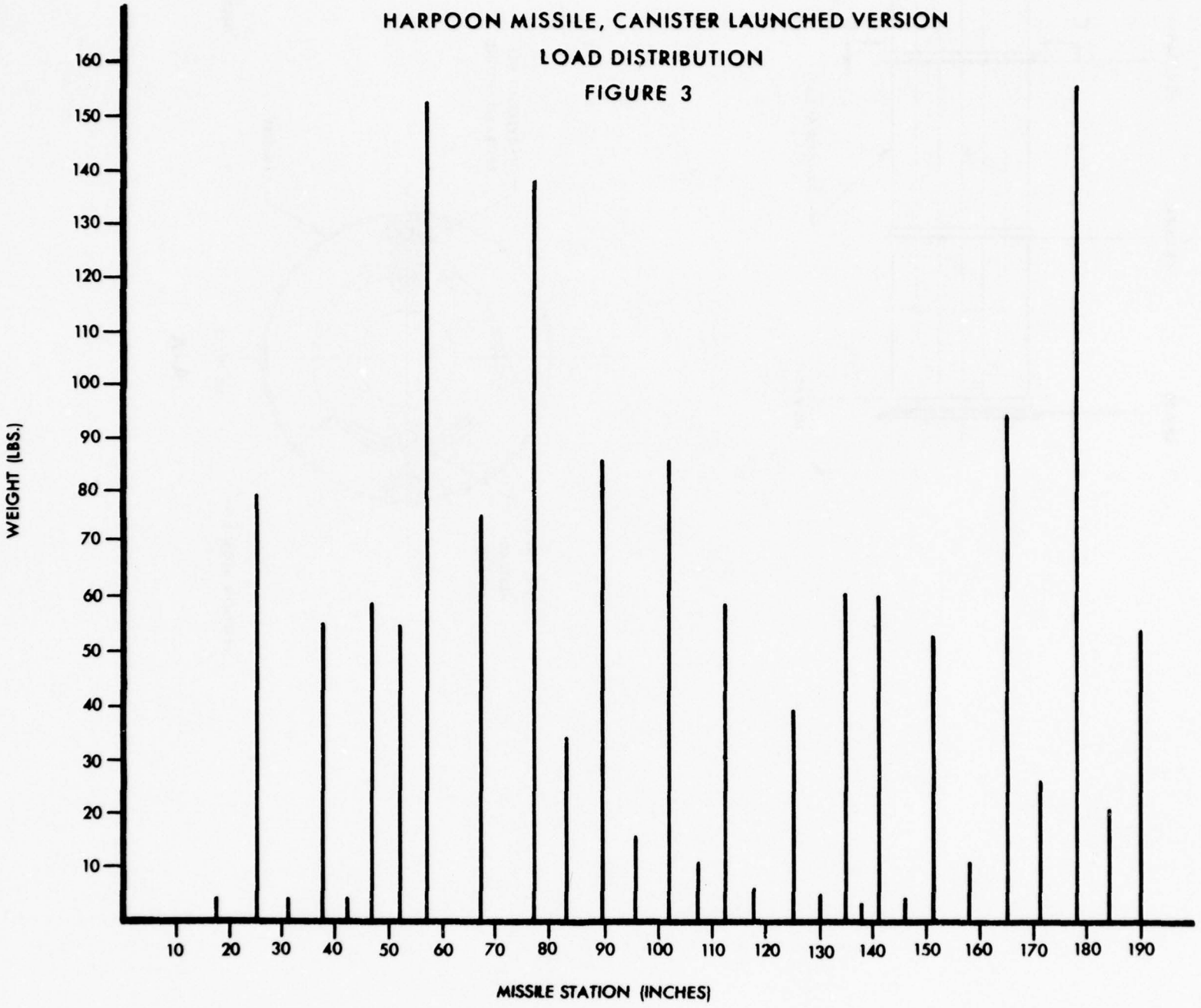
C-C

(ALL DIMENSIONS IN INCHES)

HARPOON MISSILE/CANISTER ASSEMBLY

FIGURE 2

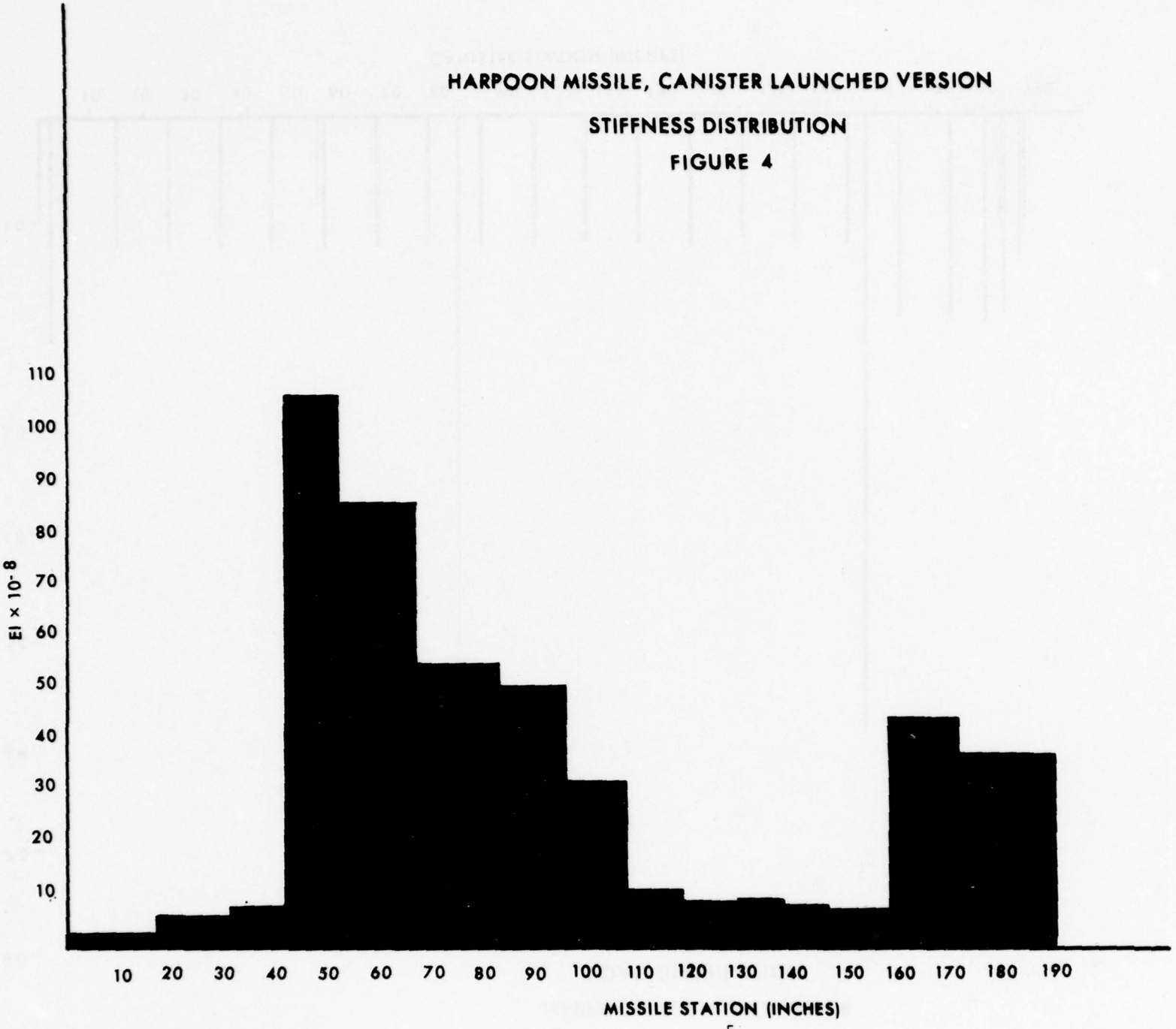
2


HARPOON MISSILE, CANISTER LAUNCHED VERSION
LOAD DISTRIBUTION
FIGURE 3
WEIGHT (LBS.)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190
MISSILE STATION (INCHES)

HARPOON MISSILE, CANISTER LAUNCHED VERSION

STIFFNESS DISTRIBUTION

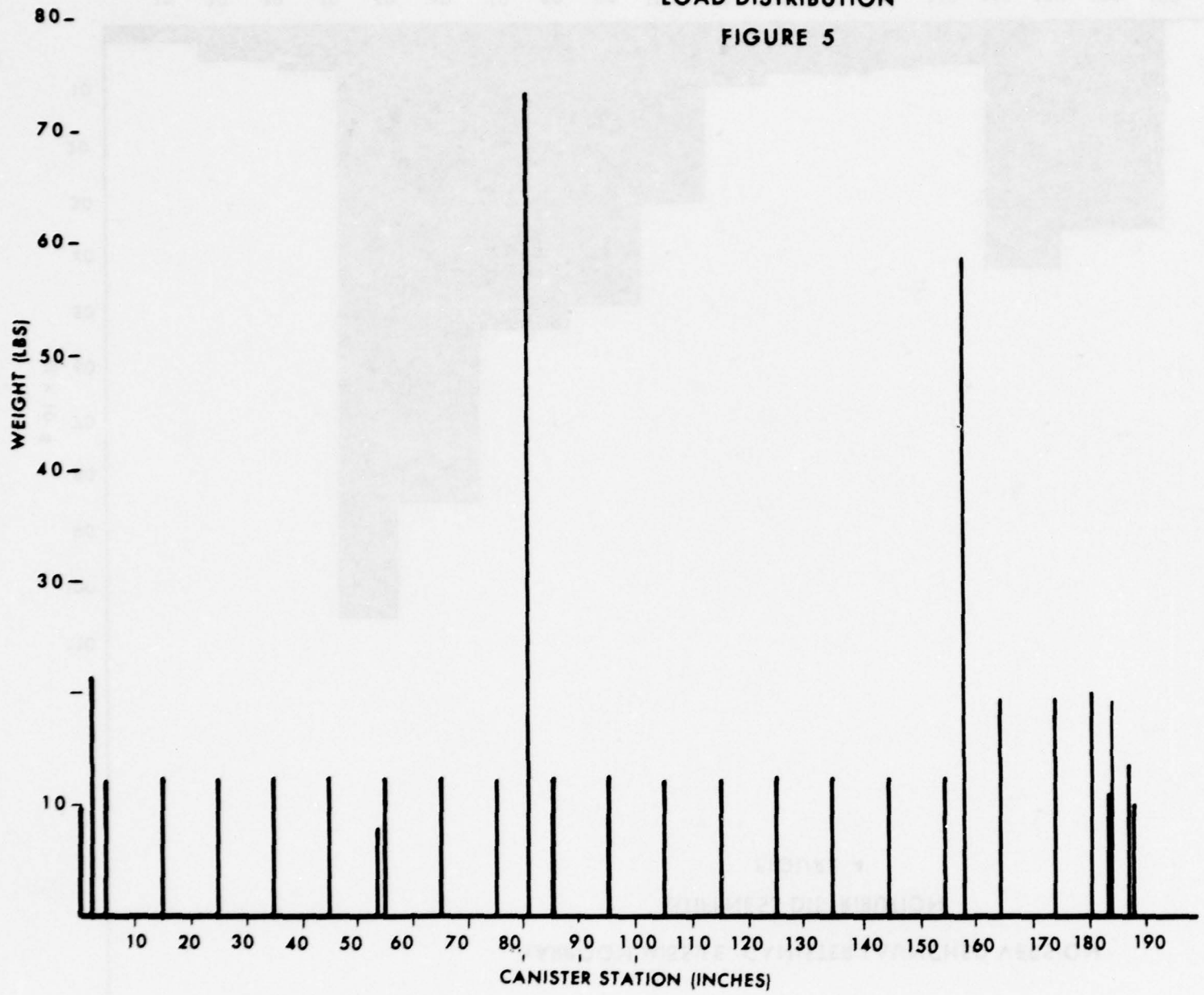
FIGURE 4



HARPOON MISSILE CANISTER

LOAD DISTRIBUTION

FIGURE 5



DESIGN REQUIREMENTS

The isolation system design must satisfy shipping, storage and rough handling requirements. The design must be able to withstand specified truck, rail, ship and air transportation environments as well as rough handling at temperature extremes.

The HARPOON missile vibration environment, Figure 6, is the envelope of truck, rail, ship and air transportation environments taken from XAS 2381, with agreed upon modifications in the frequency range of 5-12 Hz. The vibration fragility (design levels) for the canister launched version of HARPOON is presented in Figure 7. The design temperature for vibration is specified to be normal room temperature, 70°F.

The HARPOON missile shock environment as extracted from XAS 2381 and XAS 3894 is listed in Table 2. The containerized weapon is expected to survive the specified inputs at temperature extremes of -20°F and 140°F, with the exception of the near miss eligibility test and shipboard shocks, which are to be performed at 70°F.

The shock analysis utilizes the acceleration design levels for HARPOON components, bending moment and axial load limits for the missile and canister structures and interface reaction limits between the missile and canister, and canister and container as the survival criteria for the missile/canister system. The acceleration design level for the HARPOON missile components is specified as a 42 g terminal peak sawtooth shock of duration not less than 25 ms. Bending moments and axial loads are combined to yield equivalent axial loads according to the following formula:

$$PE = (2/R)\ M + PA$$

where PE is the equivalent axial load, R is the radius of the item, M is the bending moment and PA is the axial load. The allowable equivalent axial loads are presented in Figure 8. The vertical interface locations between the missile and canister are at the canister stacking frames, MS 88.12 and MS 166.0 and at MS 189.12 with specified allowable loads of 18,200; 15,600 and 12,800 pounds respectively. The inadvertent fire restraint bolt at MS 192.13, used for longitudinal restraint of the weapon, has a load carrying capacity of 23,200 pounds. The canister shell maximum allowable equivalent axial load is 244,000 pounds. The maximum allowable vertical loads for the canister/container interfaces at the forward and aft stacking frames are 101,600 and 24,400 pounds respectively, and the maximum allowable longitudinal load for the canister/container interface at the aft stacking frame guide pin hole is 45,000 pounds.

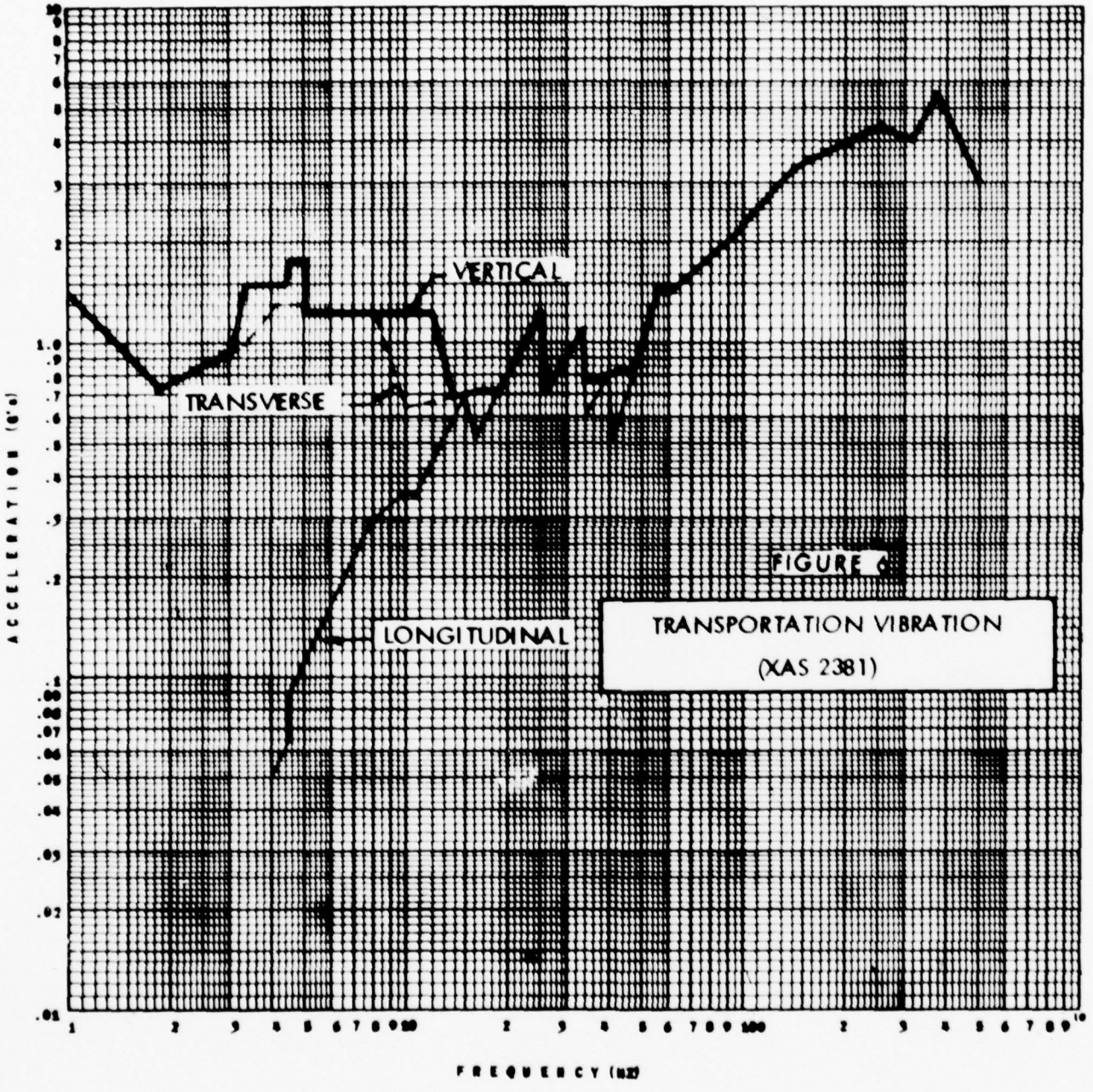


FIGURE 6

TRANSPORTATION VIBRATION

(XAS 2381)

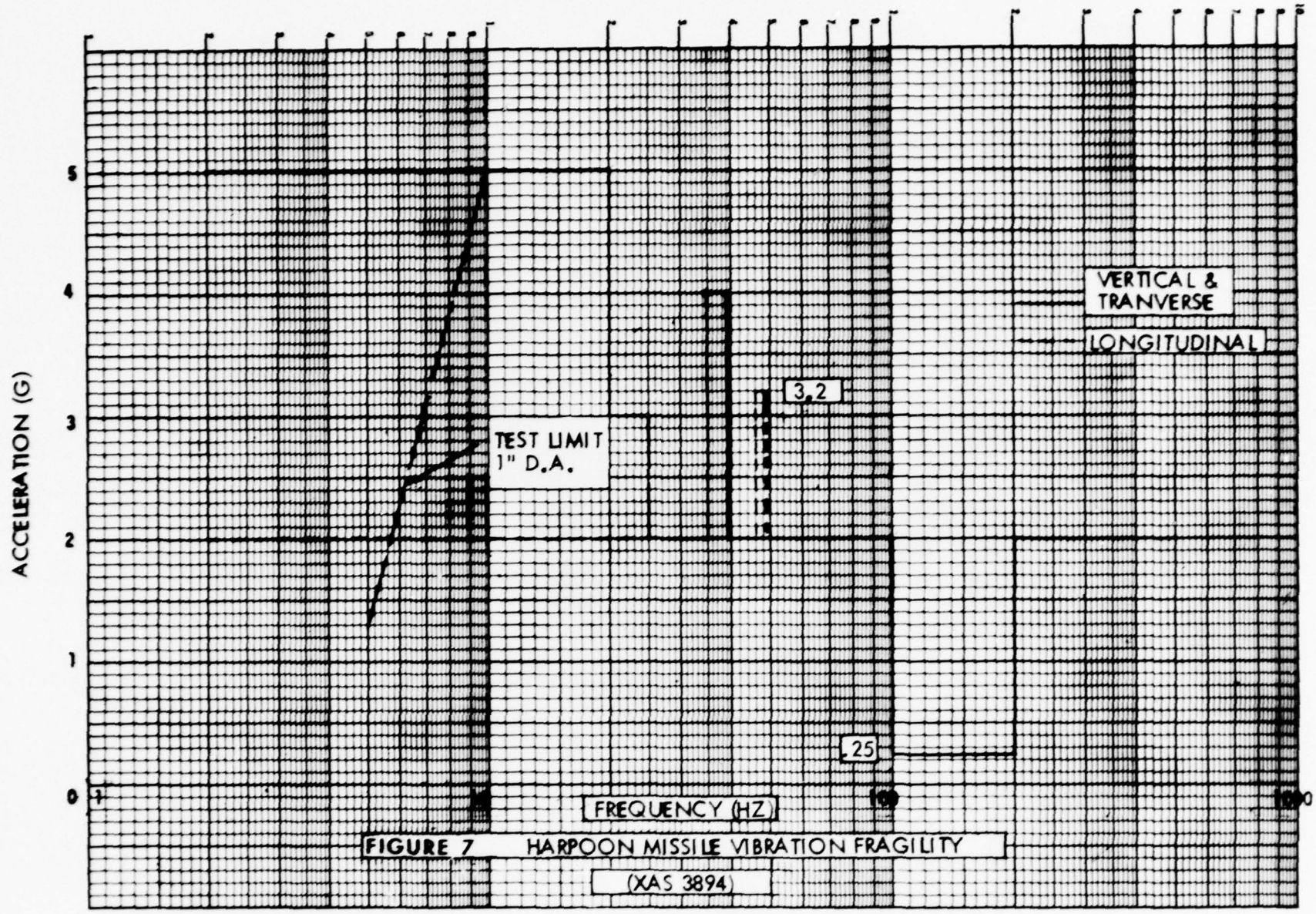


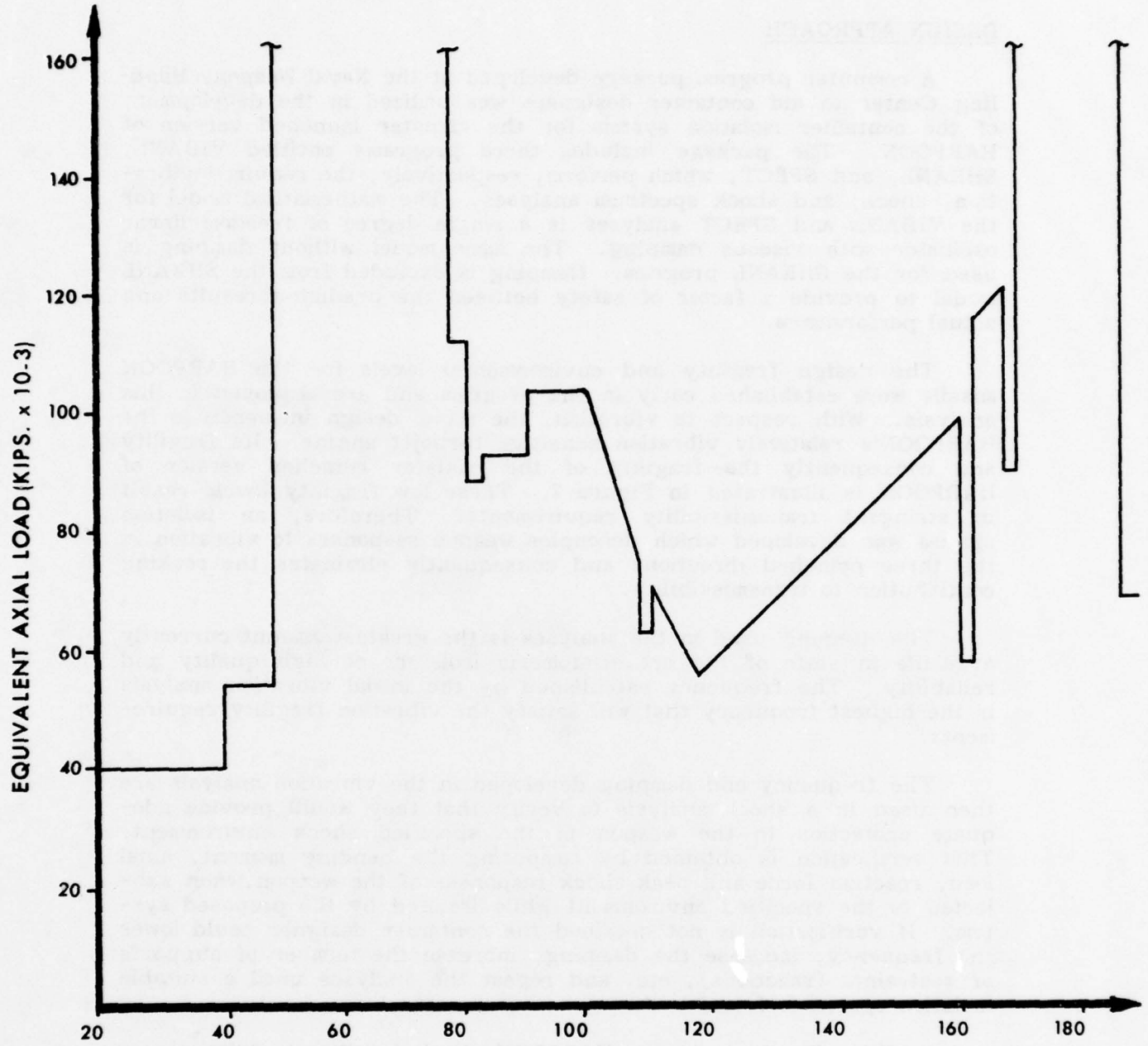
FIGURE 7 HARPOON MISSILE VIBRATION FRAGILITY

(XAS 3894)

TABLE 2

HARPOON Missile Shock Environment

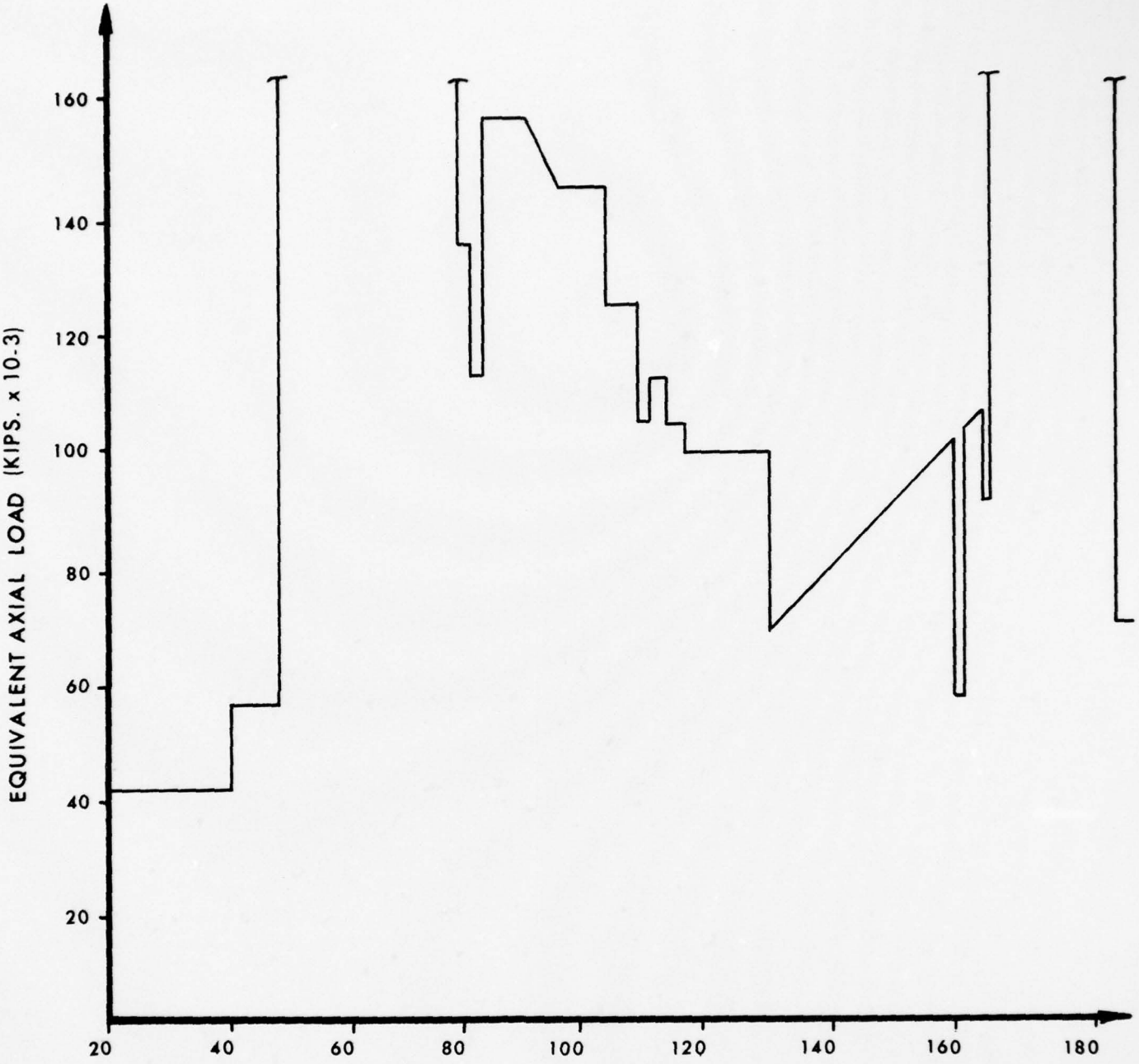
SHOCK EVENT	SPECIFICATION	APPLICABLE TEMPERATURE AND DIRECTION
Storage/Handling	18" Rotational Corner Drop	-20^{o}, $140^{o}F$
Railcar Coupling	10 fps End Impact 25 g, 25 ms half sine	-20^{o}, $140^{o}F$
Transfer at Sea	10 fps End Impact	-20^{o}, $140^{o}F$
Near Miss Eligibility	18" Flat Drop	$70^{o}F$
Ship Shock	15 g, 35 ms Trapezoid* 9 g, 35 ms Trapezoid* 6 g, 35 ms Trapezoid* *10 ms Rise & Decay	$70^{o}F$ Vertical $70^{o}F$ Transverse $70^{o}F$ Longitudinal
Shipboard Handling	15 g, 11-18 ms half sine	$70^{o}F$ Vertical $70^{o}F$ Transverse $70^{o}F$ Longitudinal



A. VERTICAL LOADING WITH SCOOP DOWN

HARPOON MISSILE LIMIT EQUIV

FIGURE 8



B. TRANSVERSE LOADING WITH SCOOP DOWN

MIT EQUIVALENT AXIAL LOAD

FIGURE 8

2

DESIGN APPROACH

A computer program package developed at the Naval Weapons Handling Center to aid container designers was utilized in the development of the container isolation system for the canister launched version of HARPOON. The package includes three programs entitled VIBANL, SHKANL, and SPECT, which perform, respectively, the required vibration, shock, and shock spectrum analyses. The mathematical model for the VIBANL and SPECT analyses is a single degree of freedom linear oscillator with viscous damping. The same model without damping is used for the SHKANL program. Damping is excluded from the SHKANL model to provide a factor of safety between the predicted results and actual performance.

The design fragility and environmental levels for the HARPOON missile were established early in the program and are employed in this analysis. With respect to vibration, the major design influence is the HARPOON's relatively vibration sensitive turbojet engine. Its fragility and consequently the fragility of the canister launched version of HARPOON is illustrated in Figure 7. These low fragility levels result in stringent transmissibility requirements. Therefore, an isolation system was developed which decouples weapon responses to vibration in the three principal directions and consequently eliminates the rocking contribution to transmissibility.

The damping used in the analyses is the greatest amount currently available in state of the art elastomeric isolators of high quality and reliability. The frequency established by the initial vibration analysis is the highest frequency that will satisfy the vibration fragility requirements.

The frequency and damping developed in the vibration analysis are then used in a shock analysis to verify that they would provide adequate protection to the weapon in the specified shock environment. This verification is obtained by computing the bending moment, axial load, reaction force and peak shock responses of the weapon when subjected to the specified environment while isolated by the proposed system. If verification is not obtained the container designer could lower the frequency, increase the damping, increase the number of supports or restraints (reactions), etc. and repeat the analyses until a suitable isolation system is found.

Additionally, because the HARPOON shock fragility is defined as a shock having peak, duration and shape parameters, the shock spectra of the predicted responses are compared to the shock spectrum of the fragility shock.

Furthermore, for logistic and economic reasons, it was decided to develop an isolation system using isolators which would use the same mold as the isolator approved for the ASROC version of HARPOON.

DISCUSSION OF RESULTS

The VIBANL program was executed using the maximum available damping of economical shock mounts, 13 percent of critical, and a compression/tension to shear stiffness ratio of 4:1, which results from the use of the mold for the ASROC version isolators. A satisfactory solution to the vibration problem was found in which the predicted frequencies were:

PRELIMINARY VIBRATION FREQUENCY

Transverse	19 Hz
Vertical	10 Hz
Longitudinal	10 Hz

The isolation system natural vibration frequencies generated by VIBANL were divided by a conversion factor of 1.1 to approximate shock frequencies at 70°F. This adjustment accounts for the nonlinearity of elastomeric mounts of comparable elastomer, stiffness and shape when subjected to shock induced displacement. Several of the shock requirements apply to temperature extremes of -20°F and 140°F, see Table 2. Nominal thermal stiffness coefficients were used to modify the 70°F shock frequency to account for temperature effects on elastomeric shock mounts. The 70°F shock frequency is multiplied by coefficients of $\sqrt{1.3}$ and $\sqrt{0.9}$ to approximate shock frequencies at -20°F and 140°F, respectively. The shock frequencies were computed to be as follows:

PRELIMINARY SHOCK FREQUENCY

Temperature	Transverse	Vertical	Longitudinal
-20°F	19.69 Hz	10.36 Hz	10.36 Hz
70°F	17.27 Hz	9.09 Hz	9.09 Hz
140°F	16.38 Hz	8.62 Hz	8.62 Hz

These isolation system parameters were then used in SHKANL, the shock analysis program, to determine whether they provide adequate shock protection. The proposed isolation system failed the flat drop analysis in that reaction load and bending moment limits at the forward support were exceeded, see Table 3 and Figure 9. The reaction load at the forward support exceeded the allowable load by more than 5500 pounds. The corresponding equivalent axial load, $(.296)(388.6 \times 10^3) = 115.0 \times 10^3$, exceeded the 91.0×10^3 inch-pound allowable by more than 24,000 inch-pounds. The shock frequency was decreased to satisfy the shock requirements.

Assuming linear elastic deflection and using the computed results, a new vertical shock frequency for consideration was found.

FLAT DROP- HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
VERTICAL SHOCK FREQ		9.09 HZ
DROP HEIGHT		18.00 INS
WEIGHT OF THE CONTAINER SHELL		500.00 LBS
WEIGHT OF CRADLE		917.50 LBS

RESULTS

PRIMARY-		
DISPLACEMENT		2.19 INS
DECELERATION		18.45 G
REBOUND-		
DISPLACEMENT		0.37 INS
DECELERATION		3.15 G
DYNAMIC SUPPORT REACTIONS	FWD	23713.21 LBS
	CTR	-1719.87 LBS
	AFT	5967.17 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-388607.12 IN-LBS
	CTR	70692.14 IN-LBS
	AFT	-883.90 IN-LBS

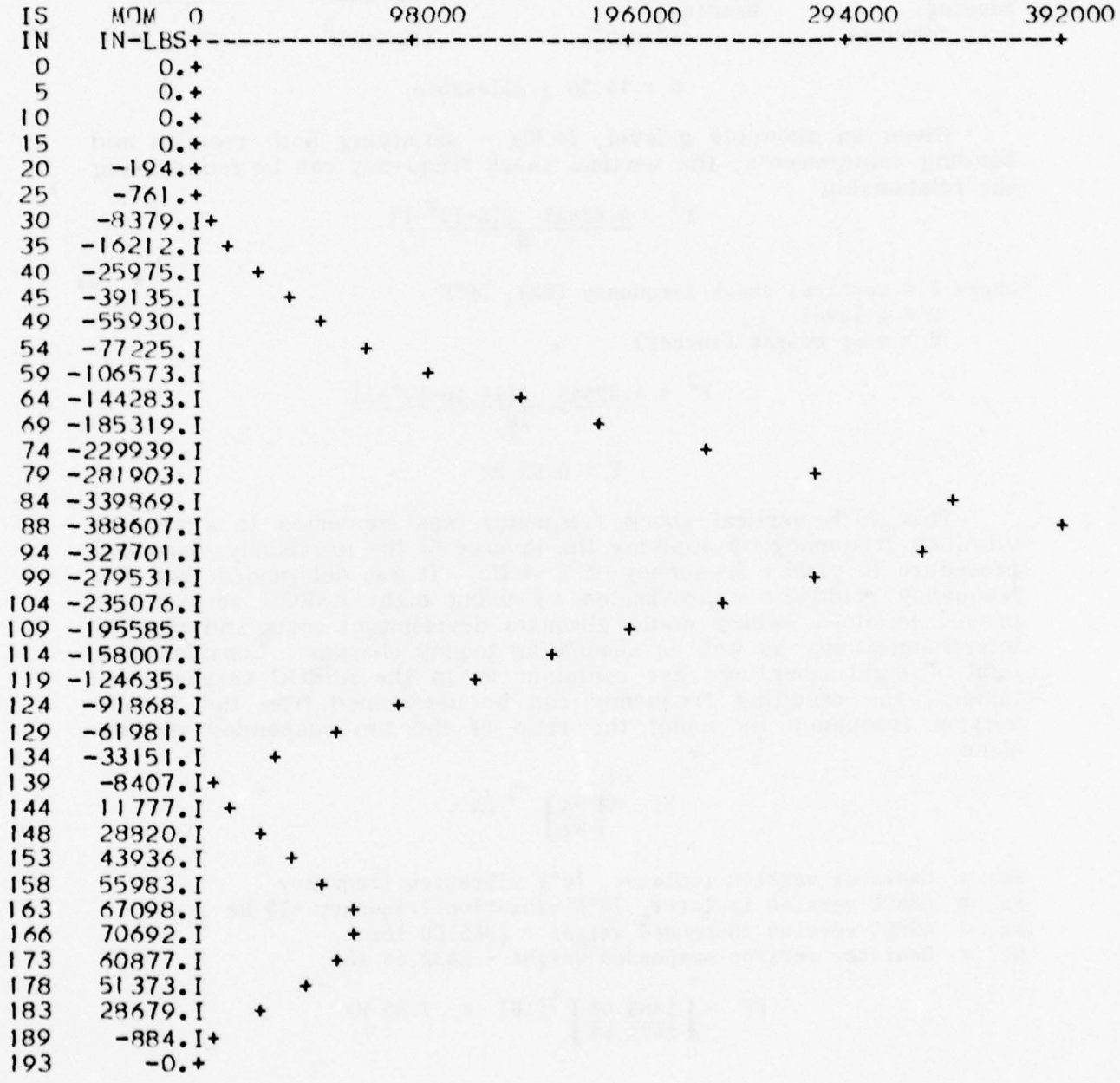
REMARKS

TABLE 3

FLAT DROP FAILURE SUMMARY

FIGURE 9

FLAT DROP ANALYSIS FAILURE
DYNAMIC BENDING MOMENTS



$$\frac{\text{g's computed}}{\text{reaction computed}} = \frac{\text{g's allowable}}{\text{reaction allowable}} \qquad \frac{18.45}{23713.21} = \frac{G}{18200}$$

$$G = 14.16 \text{ g allowable}$$

$$\frac{\text{g's computed}}{\text{bending computed}} = \frac{\text{g's allowable}}{\text{bending allowable}} \qquad \frac{18.45}{388.6 \times 10^3} = \frac{G}{307.4 \times 10^3}$$

$$G = 14.59 \text{ g allowable}$$

Given an allowable g-level, 14.16g - satisfying both reaction and bending requirements, the vertical shock frequency can be found using the relationship.

$$F^2 = \frac{4.89845 \quad [(G-1)^2-1]}{H}$$

where F = vertical shock frequency (Hz), 70°F
G = g-level
H = drop height (inches)

$$F^2 = \frac{4.89845 \quad [(14.16-1)^2-1]}{18}$$

$$F = 6.85 \text{ Hz}$$

This 70°F vertical shock frequency was converted to a vertical vibration frequency by applying the inverse of the previously discussed procedure to yield a frequency of 7.54 Hz. It was determined that this frequency could be approximated by using eight ASROC version approved isolators, which would eliminate development costs and provide interchangeability as well as eliminating tooling charges. Considering a total of eight mountings per container as in the ASROC version containers, the resulting frequency can be determined from the ASROC version frequency by using the ratio of the two suspended weights alone.

$$Fc = \left[\frac{Wa}{Wc}\right]^{\frac{1}{2}} Fa$$

Fc = Canister version isolator, 70°F vibration frequency
Fa = ASROC version isolator, 70°F vibration frequency -10 Hz
Wa = ASROC version suspended weight - 1365.08 lbs.
Wc = Canister version suspended weight - 2432.68 lbs.

$$Fc = \left[\frac{1365.08}{2432.68}\right]^{\frac{1}{2}}(10) = 7.49 \text{ Hz}$$

In a center of gravity mounting system as proposed here, the mountings are primarily loaded in shear in the vertical as well as longitudinal directions, yielding longitudinal and vertical frequencies which are equal. The transverse vibration frequency is directly related to the vertical frequency by the square root of the compression/tension to shear stiffness ratio which in this case is 4.0. Using these vibration frequencies, the vibration to shock factor and thermal stiffness coefficients previously presented, the appropriate shock frequencies were computed. A frequency summary for this second consideration is given below.

FREQUENCY

	Temp	Transverse	Vertical	Longitudinal
Vibration	70°F	14.98 Hz	7.49 Hz	7.49 Hz
Shock	-20°F	15.52 Hz	7.76 Hz	7.76 Hz
	70°F	13.62 Hz	6.81 Hz	6.81 Hz
	140°F	12.92 Hz	6.46 Hz	6.46 Hz

This proposed isolation system configuration, Figure 10, represents an isolation system having mount elastic centers located in the horizontal plane of the CG of the isolated element. The isolators are loaded primarily in shear in the longitudinal and vertical directions and primarily in tension and compression in the transverse direction.

Computer outputs for the complete vibration and shock analyses are presented in Appendices A and B. Appendix A represents the analysis with respect to the HARPOON missile and Appendix B represents the analysis with respect to the HARPOON canister. Significant analysis results and problem areas are discussed in the succeeding paragraphs:

VIBRATION RESULTS

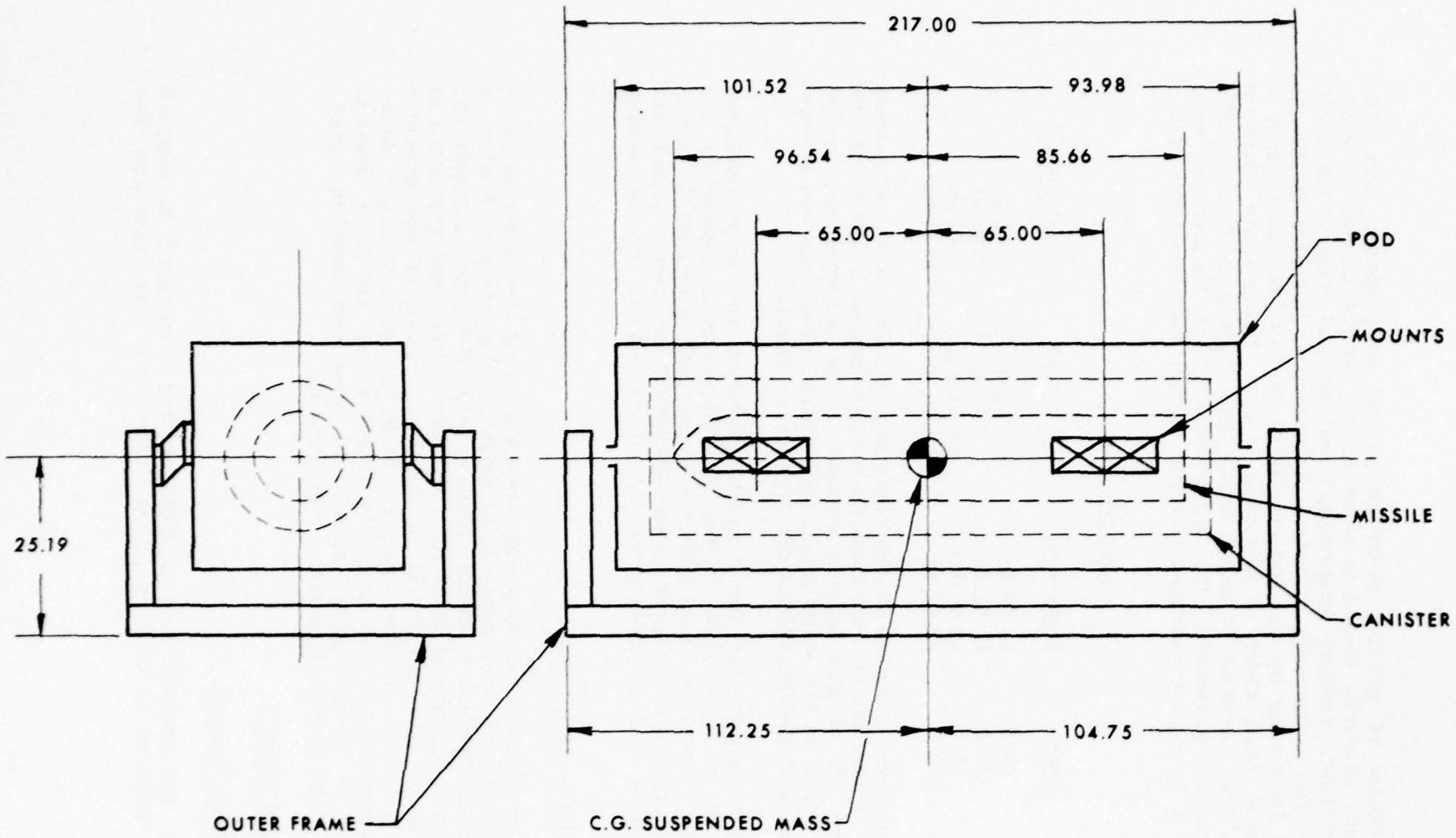
The VIBANL program was executed using the maximum available damping of economical shock mounts, 13 percent of critical, a compression/tension to shear stiffness ratio of 4:1 and a transverse vibration frequency of 14.98 Hz. VIBANL outputs are presented in Appendix A and are listed in Table 4. Plots of the weapon's response to the specified environment in the three principle directions compared to the weapon's fragility are shown in Figures A1-A3. As these figures show, the proposed isolation system satisfies the specified vibration requirements.

SHOCK RESULTS

Shock Results

At the present time SHKANL is not structured to compute shock response to uniform pulses. Note that structural and dis-

(ALL DIMENSIONS IN INCHES)



PROPOSED ISOLATION SYSTEM CONFIGURATION FOR CANISTER LAUNCHED VERSION OF HARPOON

FIGURE 10

TABLE 4

HARPOON Missile Vibration Summary

Damping = 13% of critical

Compression/Tension to Shear Stiffness Ratio = 4:1

DIRECTION	NATURAL FREQUENCY	RESPONSE AT RESONANCE
Transverse	14.98 Hz	2.78 g
Vertical	7.49 Hz	4.97 g
Longitudinal	7.49 Hz	1.03 g

placement responses to the specified uniform pulses are computed using the existing SHKANL routines (flat drop, side impact, end impact) by computing pseudo drop heights/velocities which would result in the appropriate deceleration levels. SHKANL outputs are presented in Appendices A and B and summarized in Tables 5 and 6.

Shock Level

The maximum predicted deceleration levels in the three primary directions are the 19.09 g response to the -20°F forward edge rotational drop in the vertical direction, 12.68 g response to the 9 g trapezoidal shock in the transverse direction and the 15.51 g response to the 25 g half sine shock at -20°F in the longitudinal direction. Shock spectra of these deceleration responses were generated and compared to the weapon's allowable shock spectrum (42 g, not less than 25 ms TPS) using the SPECT program. Velocity shocks (drops and impacts) were assumed to be half sine shocks having a duration equal to one-half the natural shock period of the isolation system in the applicable direction. Acceleration time histories were run for the responses to acceleration shocks (specified by half sine or trapezoidal shocks) and the digitized output was used in the SPECT program. The spectrum comparisons, presented as Figures A25-A27, indicate that the predicted responses are within specification levels.

Displacement

The largest displacements in the three primary directions are 3.14 inches vertically down, 0.51 inches vertically up, 3.06 inches forward and aft, and 0.67 inches laterally. The displacements result from the 140°F forward edge rotational drop (computed at MS 9.63), the 18 inch flat drop, the 25 g half sine shock in the longitudinal direction at 140°F and the 9 g trapezoidal shock in the transverse direction respectively. The mount spacing (130 inches) was selected to maintain the required sway space within the levels resulting from the other shock requirements. The magnitude of the displacements is reasonable for the configuration under consideration.

Structural Response

Weapon bending moments and axial loads are the structural response parameters addressed in this analysis. The design levels for bending moments and axial loads are combined as limit equivalent axial loads. The formula $PE = (2/R)\ M + PA$ is used to determine equivalent axial load response where PE is the equivalent axial load, R is the radius (6.75 inches for the missile, 11.75 inches for the canister), M is the bending moment and PA is the axial load. Figure 8 shows the design levels specified for the HARPOON Missile. Application of the above equation to the peak

TABLE 5

HARPOON MISSILE SHOCK SUMMARY

SHOCK EVENT	DEC (G)	DSP (IN)	REACTION (KIPS) MS 88.12	MS 166.0	MS 189.12	MS 192.13	BENDING MOMENTS (IN-KIPS) MS 88.12	MS 166.0	MS 189.12	MS 192.13	REMARKS
Flat Drop (18")											Rebound
6.41 Hz 70°F.	14.09	2.98	18.1	-1.3	4.6		-296.8	54.0	-0.7		2.40g, 0.51 in.
End Impact (10fps)											
6.46 Hz 140°F		2.96									
7.76 Hz -20°F	15.14	2.46	1.2	5.9	-5.7	22.9*	- 21.1	-0.5	131.9	131.9	*Axial Reaction
Rotational Edge Drop											130" Mount Spacing
(18") 6.46 Hz FWD		3.14									
140°F. AFT		3.07									
7.76 Hz FWD	19.09	3.11	17.5	-7.8	4.4		-321.7	96.3	- 0.0		
-20°F AFT	18.33	2.98	6.9	5.9	1.8		- 79.1	-22.4	- 0.9		
25g., 25ms ∩ , L											
6.46Hz 140°F	13.05	3.06	1.2	5.0	-4.8	19.8*	- 21.1	0.1	113.6	113.7	*Axial Reaction
7.76 Hz -20°F	15.51	2.52	1.2	6.0	-5.7	23.5*	- 21.1	-0.6	135.1	135.1	*Axial Reaction
15g, 11-18 ms ∩											
13.62Hz 70°F T	11.51	0.61	14.8	-1.1	3.7		-242.4	44.1	- 0.6		
6.81Hz 70°F V	6.01	1.27	7.7	-0.6	1.9		-126.6	23.0	- 0.3		Rebound 1.02g, 0.22 in.
6.81Hz 70°F L	6.01	1.27	1.3	2.3	-2.0	9.1*	- 21.1	2.1	52.3	52.4	*Axial Reaction
15g, 35ms ⌒											
6.81 Hz 70°F V	12.56	2.65	16.1	-1.2	4.1		-264.5	48.0	- 0.6		Rebound 2.14g, 0.45 in.
9g, 35ms ⌒											
13.62Hz 70°F T	12.68	0.67	16.3	-1.2	4.1		-267.0	48.6	- 0.6		
6g, 35ms ⌒											
6.81Hz 70°F L	5.02	1.06	1.3	1.9	-1.7	7.6*	- 21.1	2.4	43.7	43.7	*Axial Reaction

T - Transverse
V - Vertical
L - Longitudinal

DEC - Deceleration
DSP - Displacement
MS - Missile Station

TABLE 6

HARPOON CANISTER SHOCK SUMMARY

SHOCK EVENT	DEC (G)	DSP (IN)	REACTION (KIPS) CS 80.52	CS 158.39	CS 158.39*	BENDING MOMENTS (IN-KIPS) CS 80.52	CS 158.39	CS 158.39*	REMARKS
Flat Drop (18")									
6.41Hz 70°F.	14.09	2.98	21.4	6.8		-100.8	-139.0		Rebound 2.40g, 0.51 in.
End Impact (10fps)									
6.46Hz 140°F		2.96							*Guide Pin
7.76Hz -20°F	15.14	2.46	6.2	-4.2	30.4**	- 7.2	353.0	353.0	**Axial Reaction
Rotational Edge Drop									
(18") 6.46Hz FWD		3.16							
140°F AFT		3.05							
7.76Hz FWD	19.22	3.13	19.5	-1.0		-124.7	- 7.5		
-20°F AFT	18.20	2.96	9.3	10.0		- 11.5	-177.2		

DEC - Deceleration
DSP - Displacement
CS - Canister Station

bending moments and axial loads of Tables 5 and 6 indicates that only the -20°F forward edge rotational drop exceeds the design level. The limit equivalent axial load response to this shock is presented in Figure 11. Although the predicted equivalent axial load exceeds the allowable by a small amount from MS 86 to MS 90, damping would lower the predicted response to within the allowable limit as shown by the dashed peak in Figure 11. The canister equivalent axial loads computed from Table 6, were well under the 244,000 pounds allowable having a maximum value of 90.5 kips.

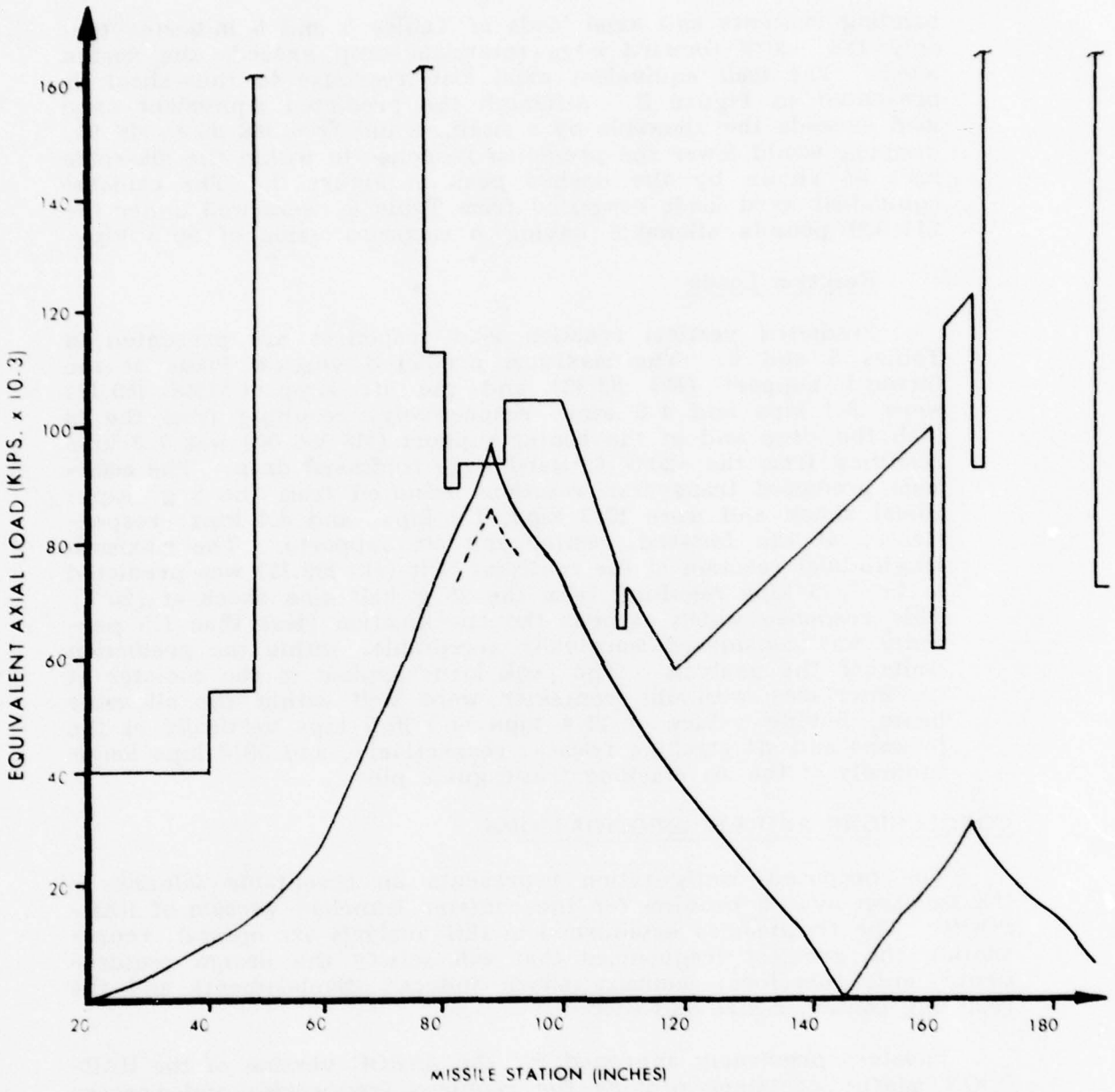
Reaction Loads

Predicted vertical reaction load responses are presented in Tables 5 and 6. The maximum predicted vertical loads at the forward support (MS 88.12) and the aft support (MS 189.12) were 18.1 kips and 4.6 kips, respectively, resulting from the 18 inch flat drop and at the center support (MS 166.00) was 7.8 kips resulting from the -20°F forward edge rotational drop. The maximum predicted transverse reactions resulted from the 9 g trapezoidal shock and were 16.3 kips, 1.2 kips, and 4.1 kips, respectively, at the forward, center and aft supports. The maximum longitudinal reaction at the restraint bolt (MS 192.13) was predicted to be 23.5 kips resulting from the 25 g half sine shock at -20°F. This response which exceeds the specification (less than 1.5 percent) was considered marginally acceptable, within the prediction limits of the analysis. The peak loads applied to the canister at its interfaces with the container were well within the allowable limits, having values of 21.4 kips and 10.0 kips vertically at the forward and aft stacking frames, respectively, and 30.4 kips longitudinally at the aft stacking frame guide pin.

CONCLUSIONS AND RECOMMENDATIONS

The proposed configuration represents an acceptable solution to the isolation system problem for the canister launched version of HARPOON. The frequencies established in this analysis are optimal, representing the greatest frequencies that will satisfy the design requirements and, therefore, minimize shock induced displacements and the resulting container size and cost.

Isolators previously approved for the ASROC version of the HARPOON missile container provide the required frequencies and possess the necessary shape, stiffness and thermal qualities for the proposed application. It is, therefore, recommended that two ASROC version approved isolators be used at each mount location in the configuration presented in this report.



EQUIVALENT AXIAL LOAD COMPARISON OF ALLOWABLE AND PREDICTED RESPONSE TO -20°F FORWARD EDGE ROTATIONAL DROP

——— RESPONSE TO -20°F FORWARD EDGE ROTATIONAL DROP

– – – – ESTIMATED REDUCTION DUE TO DAMPING

FIGURE 11

APPENDIX A

HARPOON MISSILE, CANISTER VERSION

COMPUTER OUTPUT

GLOSSARY OF TERMS USED IN COMPUTER PRINTOUTS

ADC	DECELERATION- AFT EDGE DROP	G'S
ADS	DISPLACEMENT- AFT EDGE DROP	INCHES
AXL	AXIAL LOAD	POUNDS
DYM	DYNAMIC BENDING MOMENT	INCH-POUNDS
F	FREQUENCY	HERTZ
FDC	DECELERATION- FORWARD EDGE DROP	G'S
FDS	DISPLACEMENT- FORWARD EDGE DROP	INCHES
FR	FRAGILITY	G'S
FREQ	FREQUENCY	HERTZ
IR	ITEM RESPONSE	G'S
IS	ITEM STATION	INCHES
RESP	RESPONSE SHOCK SPECTRUM	G'S
SPAC	HALF-MOUNTSPACING	INCHES
SPEC	SPECIFICATION SHOCK SPECTRUM	G'S

HARPOON MISSILE CANISTER VERSION

TRANSVERSE ANALYSIS

INPUT PARAMETERS

DAMPING FACTOR	0.130
TRANSVERSE NATURAL FREQUENCY	14.98 HZ

RESULTS

ITEM RESPONSE AT THE NATURAL FREQUENCY	2.78 G

REMARKS

TABLE A-1

TRANSVERSE VIBRATION SUMMARY

FIGURE A-1

TRANSVERSE VIBRATION ANALYSIS
PLOT OF ITEM RESPONSE AND FRAGILITY VS FREQUENCY
ITEM RESPONSE (IR) = *
FRAGILITY (FR) = +

F HZ	FR G	IR G	0.0 ---------- 5.0
5.0	5.00	1.46	
6.0	5.00	1.49	
7.0	5.00	1.59	
8.0	5.00	1.73	
9.0	5.00	1.38	
10.0	5.00	1.14	
11.0	5.00	1.33	
12.0	5.00	1.60	
13.0	5.00	2.05	
14.0	5.00	2.63	
15.0	5.00	2.78	
16.0	5.00	2.40	
17.0	5.00	1.82	
18.0	5.00	1.39	
19.0	5.00	1.10	
20.0	3.00	0.99	
21.0	3.00	0.91	
22.0	3.00	0.83	
23.0	3.00	0.80	
24.0	3.00	0.77	
25.0	2.00	0.74	
26.0	2.00	0.37	
27.0	2.00	0.36	
28.0	2.00	0.35	
29.0	2.00	0.34	
30.0	2.00	0.33	
31.0	2.00	0.32	
32.0	2.00	0.33	
33.0	2.00	0.33	
34.0	2.00	0.21	
35.0	2.00	0.20	
36.0	2.00	0.19	
37.0	2.00	0.18	
38.0	2.00	0.18	
39.0	2.00	0.17	
40.0	2.00	0.16	
50.0	2.00	0.13	
60.0	2.00	0.13	
70.0	2.00	0.12	
80.0	2.00	0.11	
90.0	2.00	0.11	
100.0	0.25	0.10	
150.0	0.25	0.10	
200.0	0.25	0.08	
250.0	2.00	0.07	
300.0	2.00	0.05	
350.0	2.00	0.06	
400.0	2.00	0.05	
500.0	2.00	0.02	

HARPOON MISSILE CANISTER VERSION

VERTICAL ANALYSIS

INPUT PARAMETERS

DAMPING FACTOR	0.130
VERTICAL NATURAL FREQUENCY	7.49 HZ

RESULTS

ITEM RESPONSE AT THE NATURAL FREQUENCY	4.97 G

REMARKS

TABLE A-2

VERTICAL VIBRATION SUMMARY

FIGURE A-2

VERTICAL VIBRATION ANALYSIS
PLOT OF ITEM RESPONSE AND FRAGILITY VS FREQUENCY
ITEM RESPONSE (IR) = *
FRAGILITY (FR) = +

F HZ	FR G	IR G	0.0 ---------- 5.0
5.0	5.00	3.06	
6.0	5.00	3.08	
7.0	5.00	4.70	
8.0	5.00	4.17	
9.0	5.00	2.41	
10.0	5.00	1.55	
11.0	5.00	1.10	
12.0	5.00	0.84	
13.0	5.00	0.48	
14.0	5.00	0.31	
15.0	5.00	0.26	
16.0	5.00	0.23	
17.0	5.00	0.20	
18.0	5.00	0.18	
19.0	5.00	0.16	
20.0	3.00	0.16	
21.0	3.00	0.16	
22.0	3.00	0.16	
23.0	3.00	0.16	
24.0	3.00	0.16	
25.0	2.00	0.16	
26.0	2.00	0.09	
27.0	2.00	0.09	
28.0	2.00	0.09	
29.0	2.00	0.09	
30.0	2.00	0.09	
31.0	2.00	0.09	
32.0	2.00	0.09	
33.0	2.00	0.09	
34.0	2.00	0.06	
35.0	2.00	0.06	
36.0	2.00	0.06	
37.0	2.00	0.05	
38.0	2.00	0.05	
39.0	2.00	0.05	
40.0	2.00	0.05	
50.0	2.00	0.05	
60.0	2.00	0.05	
70.0	2.00	0.05	
80.0	2.00	0.05	
90.0	2.00	0.05	
100.0	0.25	0.05	
150.0	0.25	0.05	
200.0	0.25	0.04	
250.0	2.00	0.03	
300.0	2.00	0.03	
350.0	2.00	0.03	
400.0	2.00	0.02	
500.0	2.00	0.01	

HARPOON MISSILE CANISTER VERSION

LONGITUDINAL ANALYSIS

INPUT PARAMETERS

DAMPING FACTOR	0.130
LONGITUDINAL NATURAL FREQUENCY	7.49 HZ

RESULTS

ITEM RESPONSE AT THE NATURAL FREQUENCY	1.03 G

REMARKS

TABLE A-3

LONGITUDINAL VIBRATION SUMMARY

FIGURE A-3

LONGITUDINAL VIBRATION ANALYSIS
PLOT OF ITEM RESPONSE AND FRAGILITY VS FREQUENCY
ITEM RESPONSE (IR) = *
FRAGILITY (FR) = +

F HZ	FR G	IR G	0.0 ... 2.0
5.0	2.00	0.19	
6.0	2.00	0.39	
7.0	2.00	0.86	
8.0	2.00	1.00	
9.0	2.00	0.64	
10.0	2.00	0.45	
11.0	2.00	0.33	
12.0	2.00	0.30	
13.0	2.00	0.29	
14.0	2.00	0.26	
15.0	2.00	0.26	
16.0	2.00	0.16	
17.0	2.00	0.16	
18.0	2.00	0.16	
19.0	2.00	0.16	
20.0	2.00	0.16	
21.0	2.00	0.16	
22.0	2.00	0.16	
23.0	2.00	0.15	
24.0	2.00	0.16	
25.0	2.00	0.16	
26.0	2.00	0.09	
27.0	2.00	0.09	
28.0	2.00	0.09	
29.0	2.00	0.09	
30.0	2.00	0.09	
31.0	2.00	0.09	
32.0	2.00	0.09	
33.0	2.00	0.09	
34.0	2.00	0.05	
35.0	2.00	0.05	
36.0	2.00	0.05	
37.0	2.00	0.05	
38.0	2.00	0.05	
39.0	2.00	0.05	
40.0	2.00	0.05	
50.0	2.00	0.05	
60.0	2.00	0.05	
70.0	2.00	0.05	
80.0	2.00	0.05	
90.0	2.00	0.05	
100.0	0.25	0.05	
150.0	0.25	0.05	
200.0	0.25	0.04	
250.0	2.00	0.03	
300.0	2.00	0.03	
350.0	2.00	0.03	
400.0	2.00	0.02	
500.0	2.00	0.01	

FLAT DROP- HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
VERTICAL SHOCK FREQ		6.81 HZ
DROP HEIGHT		18.00 INS
WEIGHT OF THE CONTAINER SHELL		500.00 LBS
WEIGHT OF CRADLE		917.50 LBS

RESULTS

PRIMARY-		
DISPLACEMENT		2.98 INS
DECELERATION		14.09 G
REBOUND-		
DISPLACEMENT		0.51 INS
DECELERATION		2.40 G
DYNAMIC SUPPORT REACTIONS	FWD	18109.20 LBS
	CTR	-1313.42 LBS
	AFT	4556.98 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-296769.81 IN-LBS
	CTR	53985.87 IN-LBS
	AFT	-675.01 IN-LBS

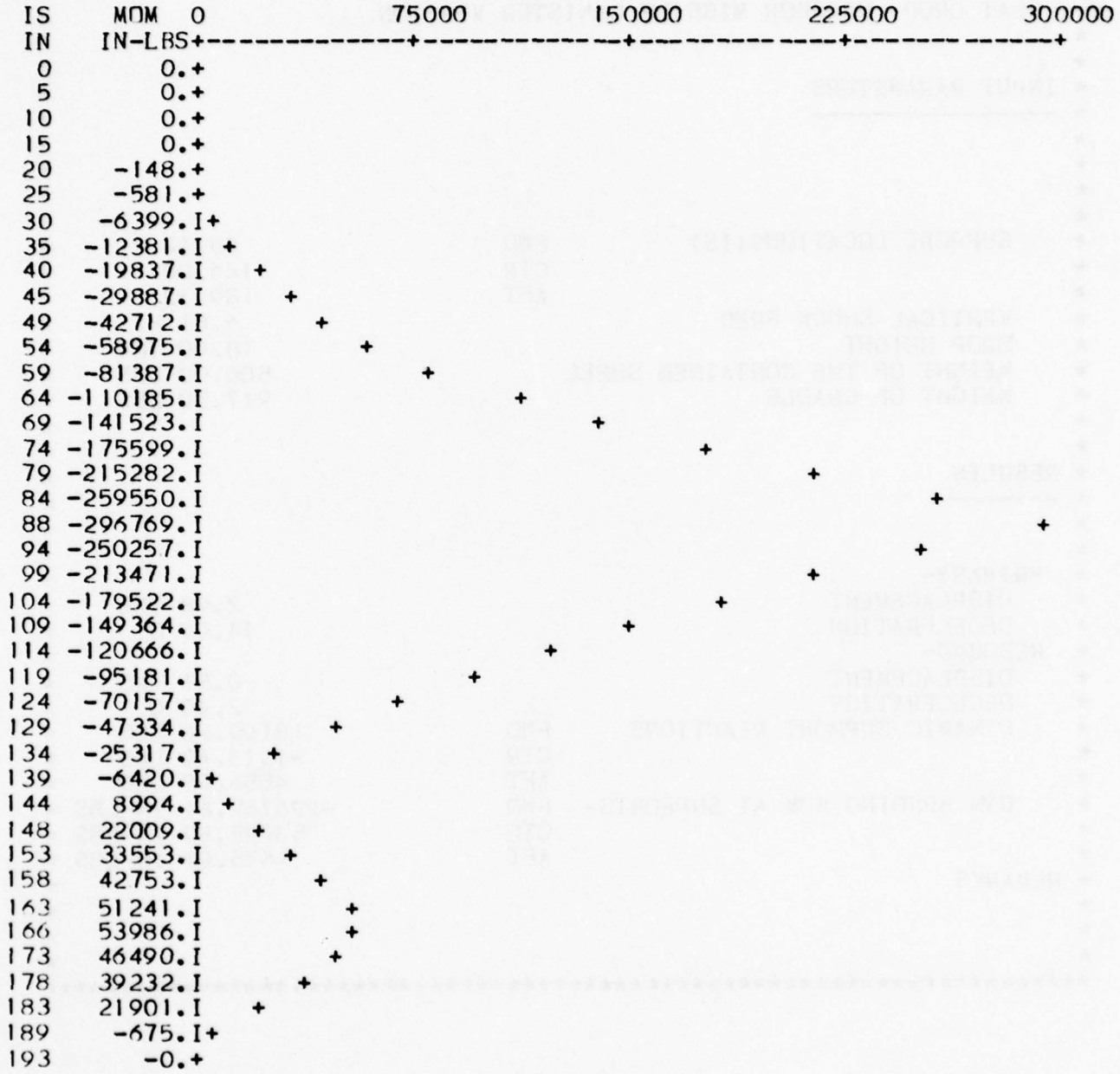
REMARKS

TABLE A-4

FLAT DROP SUMMARY

FIGURE A-4

DYNAMIC BENDING MOMENTS
18 INCH FLAT DROP



END IMPACT- HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12	
	CTR	166.00	
	AFT	189.12	
LONGITUDINAL SHOCK FREQUENCY-HIGH TEMPERATURE		6.46	HZ
	LOW TEMPERATURE	7.76	HZ
IMPACT VELOCITY		10.00	FPS
NUMBER OF LONGITUDINAL BEARING RESTAINTS		1	
LOCATION OF LONG BEARING RESTRAINTS(IS)		192.13	
ECCENTRICITIES		5.75	INS

RESULTS

AT LOW TEMPERATURE

DECELERATION		15.14	G
DYNAMIC SUPPORT REACTIONS	FWD	1229.64	LBS
	CTR	5853.83	LBS
	AFT	-5568.29	LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-21058.62	IN-LBS
	CTR	-482.24	IN-LBS
	AFT	131854.01	IN-LBS

DYNAMIC BENDING MOMENTS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	131901.90	-0.00	IN-LBS

AT HIGH TEMPERATURE

DISPLACEMENT		2.96	INS

REMARKS

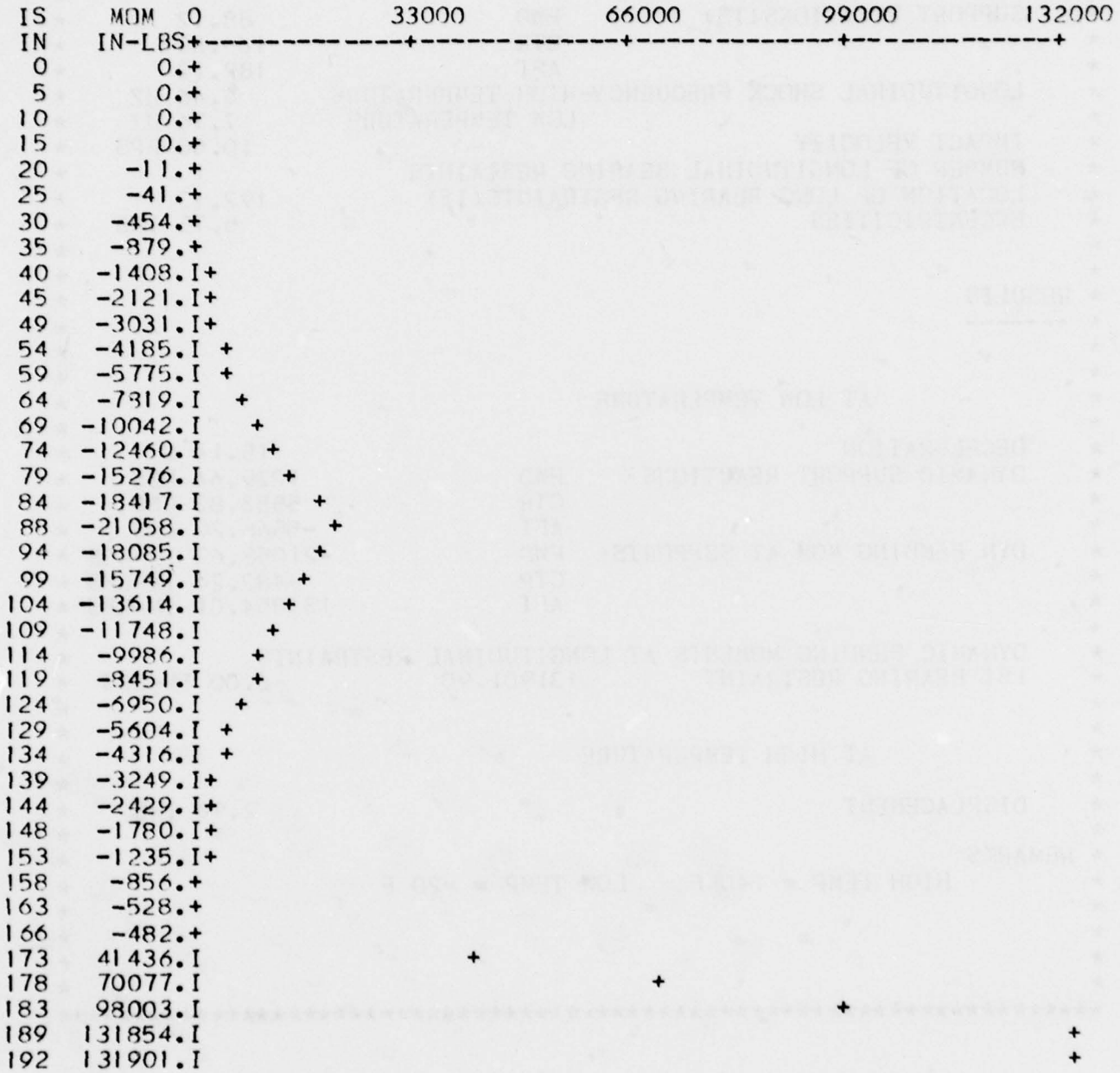
HIGH TEMP = 140 F LOW TEMP = -20 F

TABLE A-5

END IMPACT SUMMARY

FIGURE A-5

DYNAMIC BENDING MOMENTS
10 FPS END IMPACT



```
*****************************************************************
*                                                               *
*                                                               *
*                                                               *
*  END IMPACT-AXIAL LOADS                                       *
*                                                               *
*                                                               *
*          HARPOON MISSILE CANISTER VERSION                     *
*                                                               *
*    DYNAMIC AXIAL LOADS AT LONGITUDINAL RESTRAINTS             *
*     1ST BEARING RESTRAINT          22939.46          LBS      *
*                                                               *
* REMARKS                                                       *
*                                                               *
*                                                               *
*                                                               *
*                                                               *
*****************************************************************
```

TABLE A-6

AXIAL LOAD SUMMARY
10 FPS END IMPACT

FIGURE A-6

DYNAMIC AXIAL LOADS
10 FPS END IMPACT

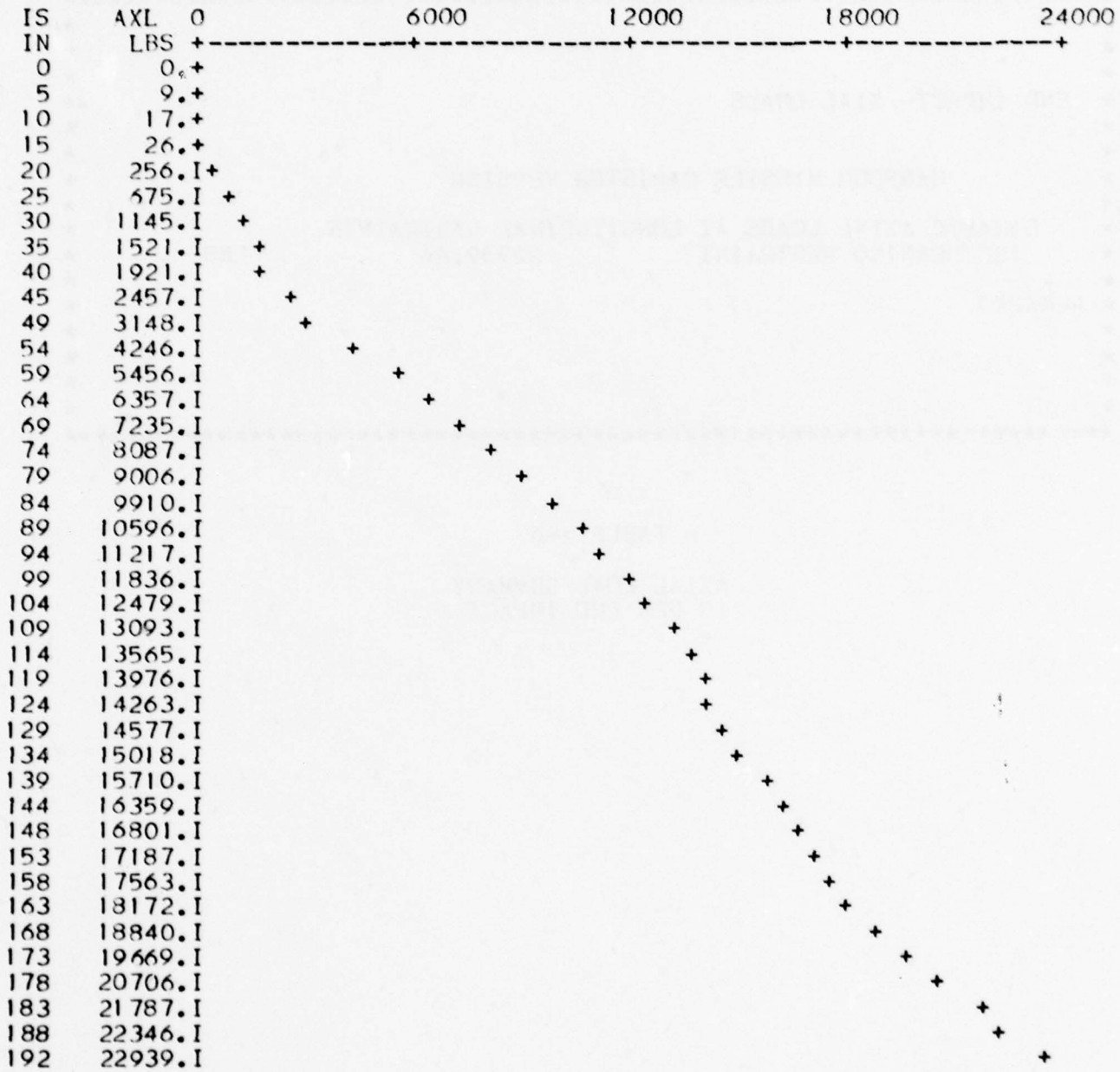


FIGURE A-7

PLOT OF DECELERATION VS HALF-MOUNTSPACING
FORWARD AND AFT DROPS AT -20°F
FORWARD DROP = +
AFT DROP = *

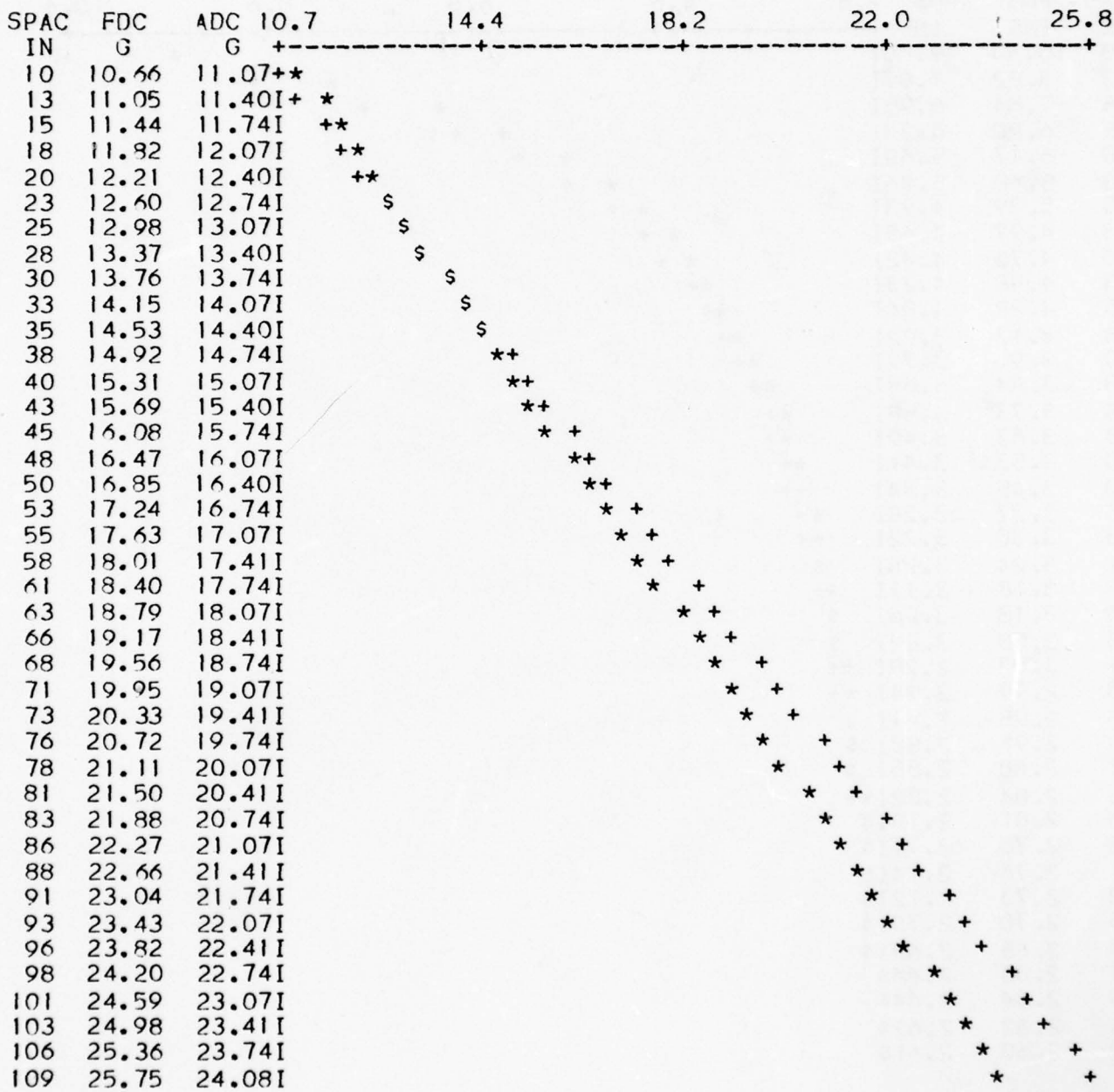
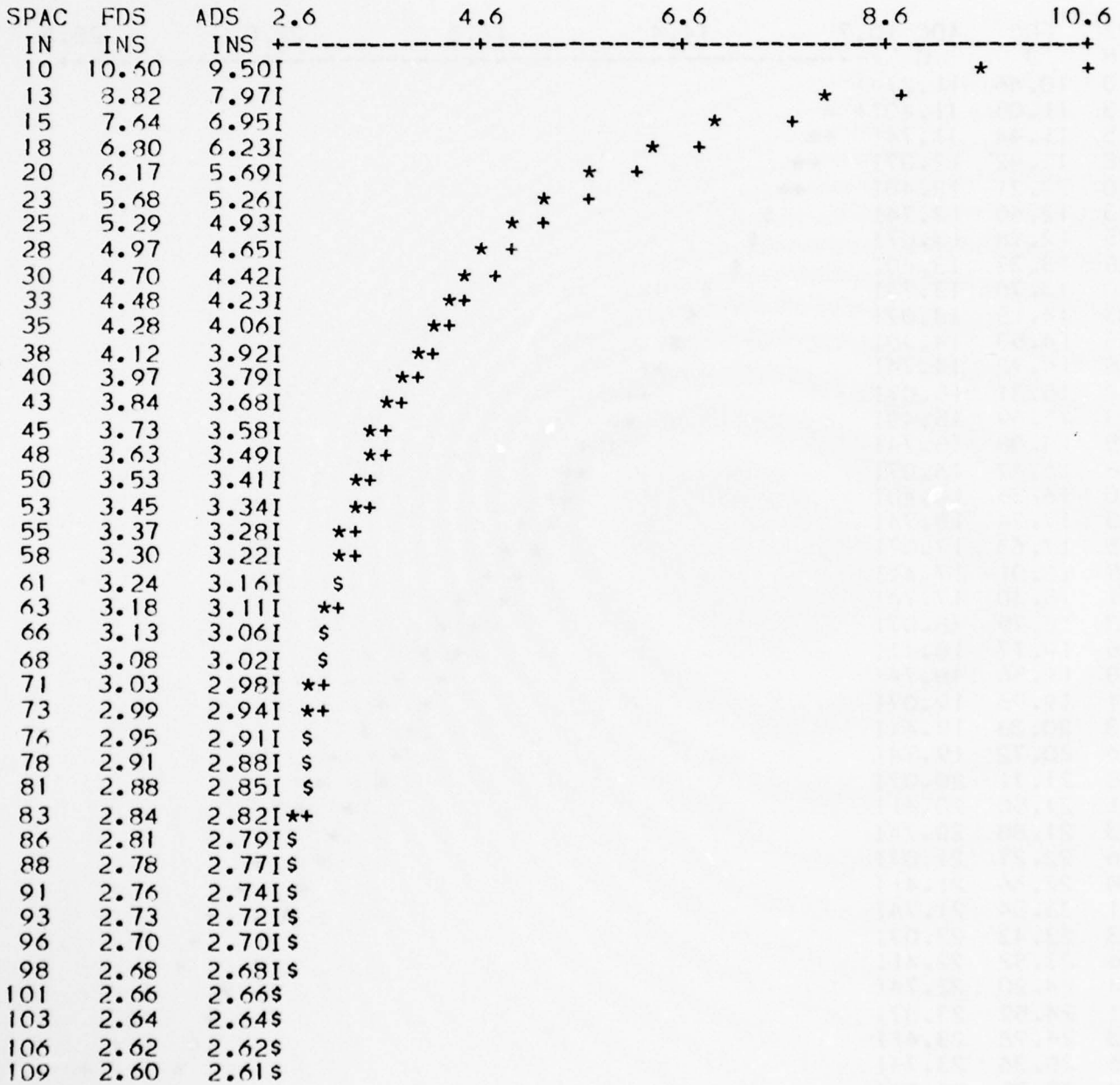


FIGURE A-8

PLOT OF DISPLACEMENT VS HALF-MOUNTSPACING
FORWARD AND AFT DROPS AT 140°F
FORWARD DROP = +
AFT DROP = *



```
*****************************************************************
*                                                               *
*  ROTATIONAL EDGEWISE DROP                                     *
*          HARPOON MISSILE CANISTER VERSION                     *
*                                                               *
* INPUT PARAMETERS                                              *
* ---------------                                               *
*    HALF MOUNT SPACING                        65.00 INS        *
*    SUPPORT LOCATIONS(IS)        FWD          88.12            *
*                                 CTR         166.00            *
*                                 AFT         189.12            *
*    OVERALL CONTAINER LENGTH                 217.00 INS        *
*    ITEM PITCH MOMENT OF INERTIA           10240.80 IN-LB-SECSQ*
*    DISTANCE ITEM C.G. TO CONT BASE          25.19 INS         *
*    DISTANCE ITEM C.G. TO CONT FORWARD END   112.25 INS        *
*    DROP HEIGHT                              18.00 INS         *
*    VERTICAL FREQUENCY-LOW TEMPERATURE        7.76 HZ          *
*    VERTICAL FREQUENCY-HIGH TEMPERATURE       6.46 HZ          *
*    LOCATION FOR DEC CALCULATIONS-FORWARD     9.63 (IS)        *
*    LOCATION FOR DEC CALCULATIONS-AFT       191.83 (IS)        *
*    LOCATION FOR DSPL CALCULATIONS-FORWARD    9.63 (IS)        *
*    LOCATION FOR DSPL CALCULATIONS-AFT      191.83 (IS)        *
*    CRADLE WEIGHT                           917.50 LBS         *
*    CRADLE C.G. LOCATION                    108.70 (IS)        *
*    CRADLE PITCH MOMENT OF INERTIA         8330.40 IN-LB-SECSQ *
*                                                               *
* RESULTS                                                       *
* -------                                                       *
*    TOTAL WEIGHT OF ITEM AND CRADLE        2432.68 LBS         *
*    TOTAL PITCH MOMENT OF INERTIA         18592.75 IN-LB-SECSQ *
*    TOTAL C.G. IS LOCATED AT                106.32 (IS)        *
*                                                               *
*              AT LOW TEMPERATURE (-20°F)                       *
*                                                               *
*  FORWARD EDGE DROP                                            *
*    MAXIMUM DECELERATION AT(IS)   9.63          19.09 G        *
*    DYNAMIC SUPPORT REACTIONS     FWD        17495.64 LBS      *
*                                  CTR        -7801.59 LBS      *
*                                  AFT         4366.75 LBS      *
*    DYN BENDING MOM AT SUPPORTS-  FWD      -321743.39 IN-LBS   *
*                                  CTR        96276.13 IN-LBS   *
*                                  AFT          -24.71 IN-LBS   *
*  AFT EDGE DROP                                                *
*    MAXIMUM DECELERATION AT(IS) 191.83          18.33 G        *
*    DYNAMIC SUPPORT REACTIONS     FWD         6910.65 LBS      *
*                                  CTR         5867.20 LBS      *
*                                  AFT         1773.92 LBS      *
*    DYN BENDING MOM AT SUPPORTS-  FWD       -79102.40 IN-LBS   *
*                                  CTR       -22408.55 IN-LBS   *
*                                  AFT         -869.24 IN-LBS   *
*                                                               *
*              AT HIGH TEMPERATURE (140°F)                      *
*                                                               *
*    FWD EDGE DROP DISPLACEMENT AT(IS)  9.63       3.14 INS     *
*    AFT EDGE DROP DISPLACEMENT AT(IS)191.83       3.07 INS     *
*                                                               *
*                                                               *
*****************************************************************
```

TABLE A-7

ROTATIONAL EDGEWISE DROP SUMMARY

FIGURE A-9

PLOT OF DECELERATION AT ITEM STATIONS
FOR HALF-MOUNTSPACING 65 INCHES
FORWARD AND AFT DROPS AT -20°F
FORWARD DROP = +
AFT DROP = *

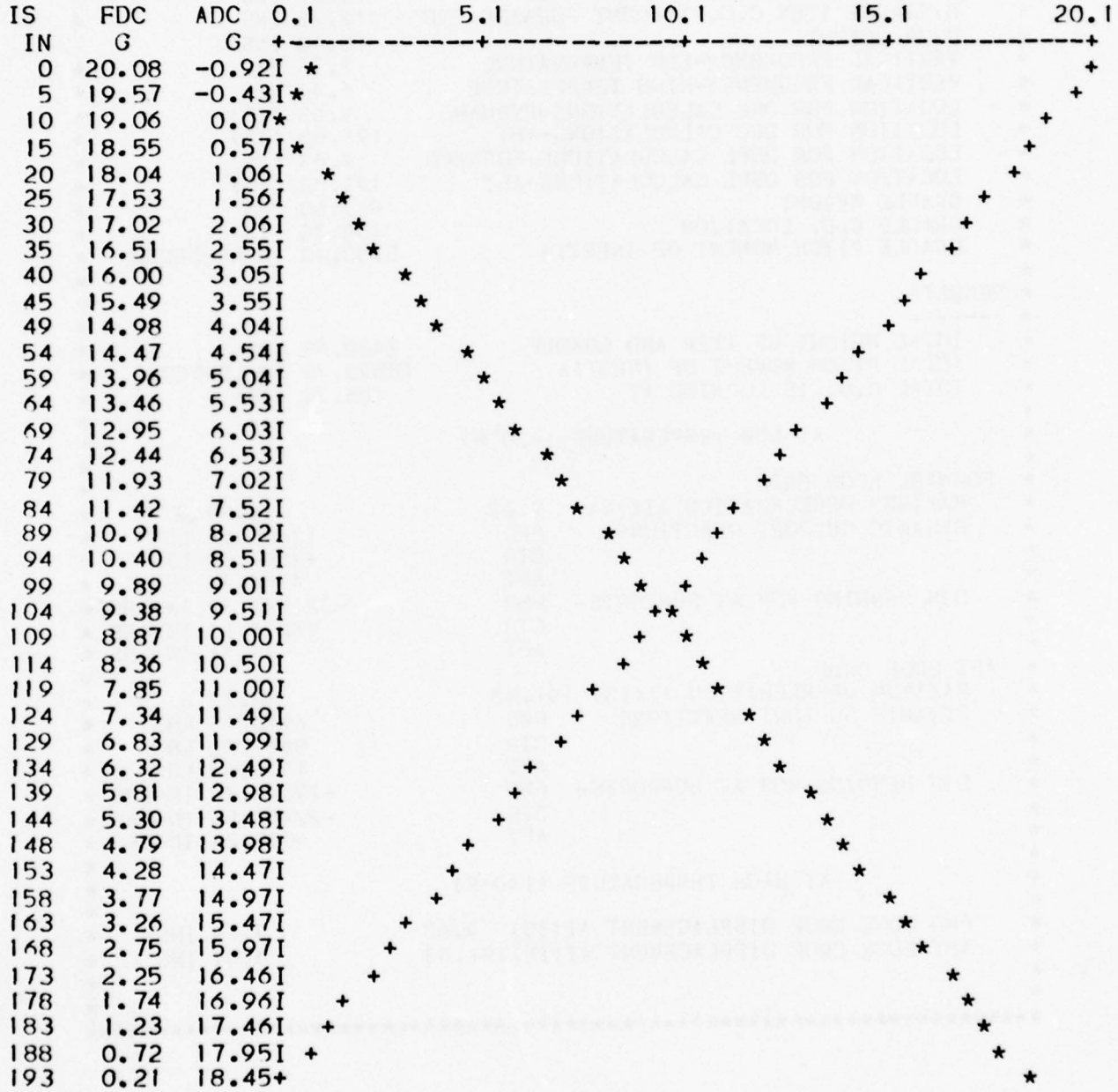


FIGURE A-10

PLOT OF DISPLACEMENT AT ITEM STATIONS
FOR HALF-MOUNTSPACING 65 INCHES
FORWARD AND AFT DROPS AT 140°F
FORWARD DROP = +
AFT DROP = *

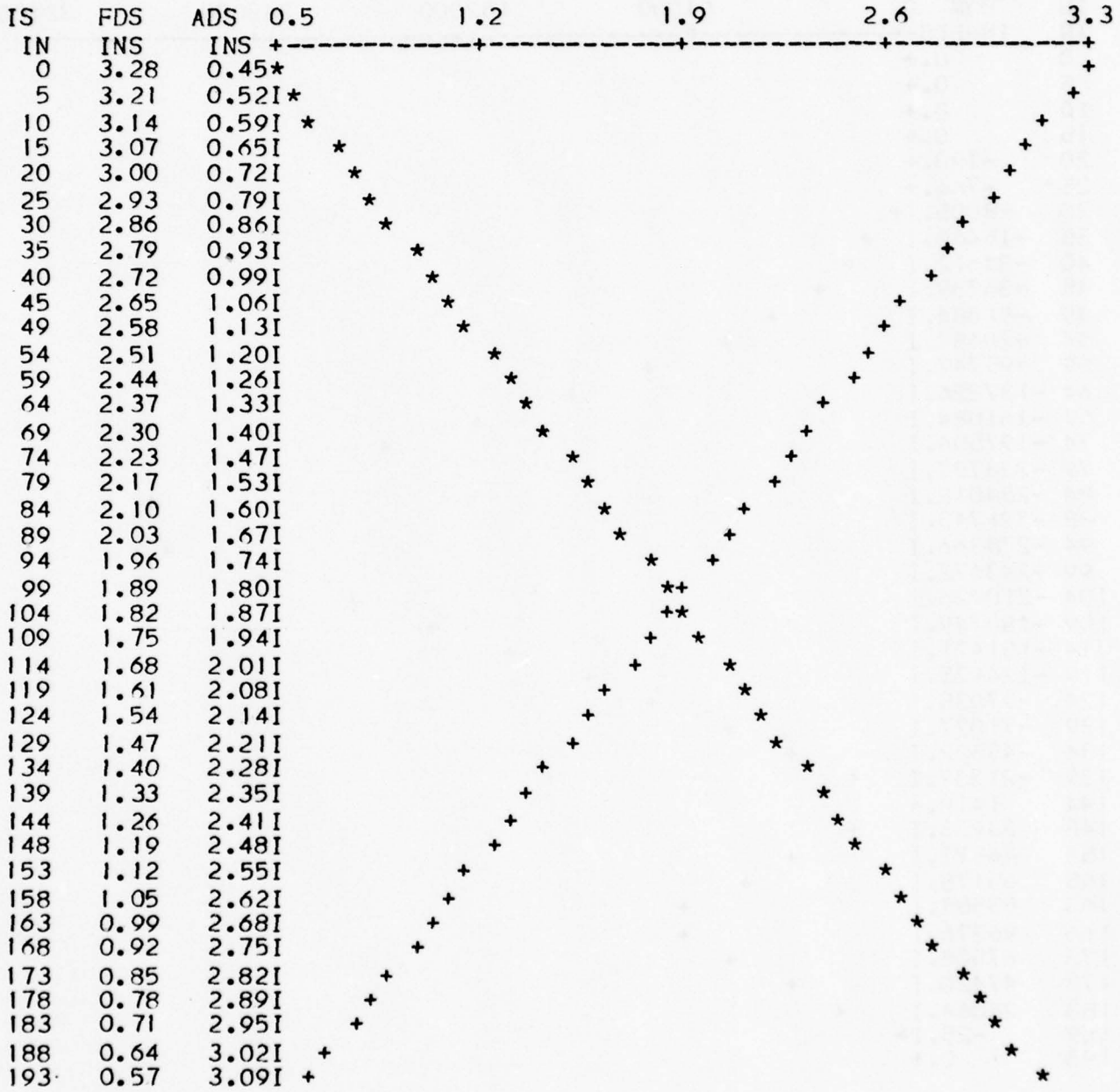


FIGURE A-11

DYNAMIC BENDING MOMENTS
18 INCH FORWARD EDGE ROTATIONAL DROP

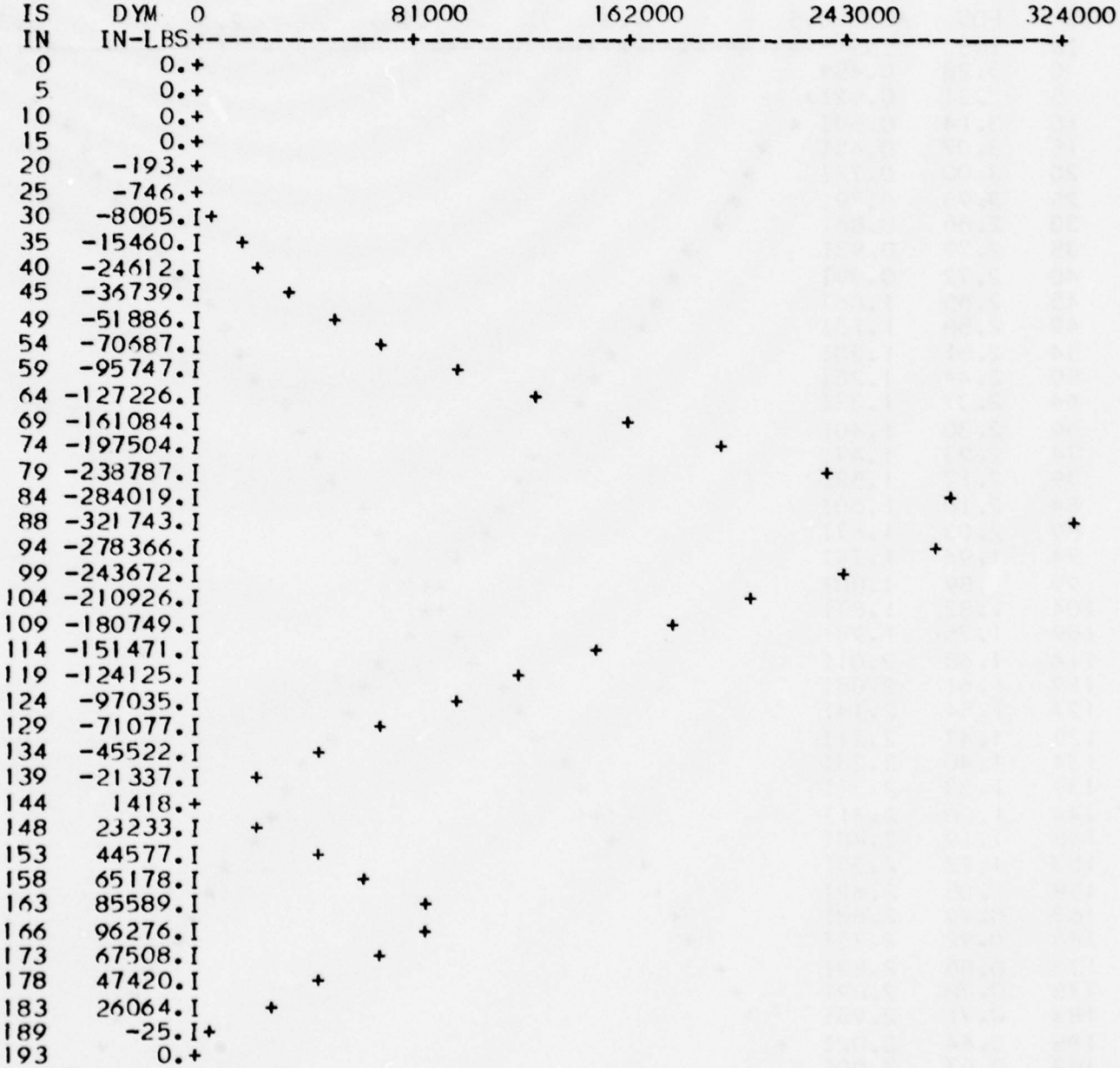
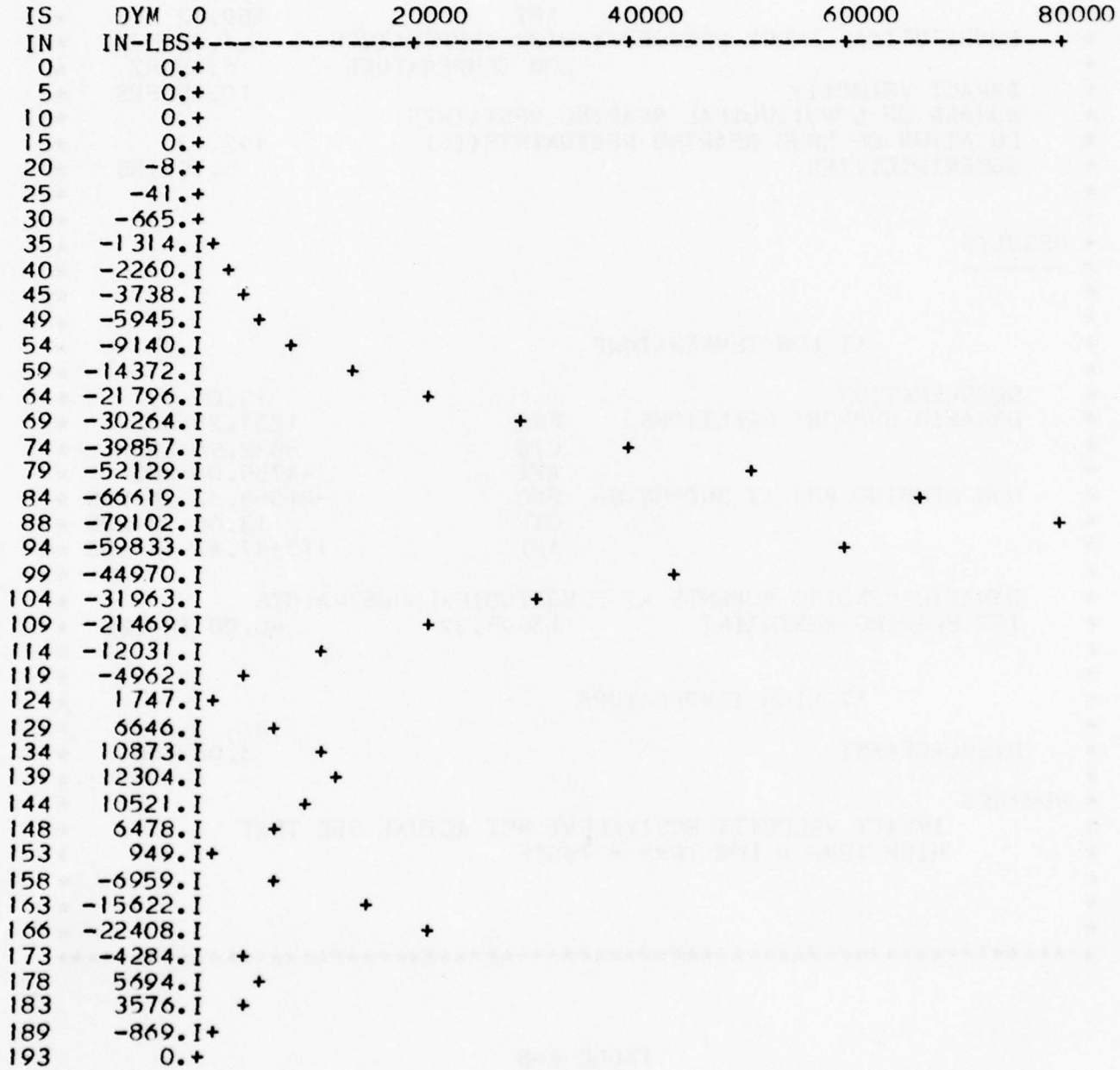


FIGURE A-12

DYNAMIC BENDING MOMENTS
18 INCH AFT EDGE ROTATIONAL DROP



HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
LONGITUDINAL SHOCK FREQUENCY-HIGH TEMPERATURE		6.46 HZ
	LOW TEMPERATURE	6.46 HZ
IMPACT VELOCITY		10.35 FPS
NUMBER OF LONGITUDINAL BEARING RESTAINTS		1
LOCATION OF LONG BEARING RESTRAINTS(IS)		192.13
ECCENTRICITIES		5.75 INS

RESULTS

AT LOW TEMPERATURE

DECELERATION		13.05 G
DYNAMIC SUPPORT REACTIONS	FWD	1237.28 LBS
	CTR	5032.96 LBS
	AFT	-4755.06 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-21058.62 IN-LBS
	CTR	113.09 IN-LBS
	AFT	113647.42 IN-LBS

DYNAMIC BENDING MOMENTS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	113695.32	-0.00 IN-LBS

AT HIGH TEMPERATURE

DISPLACEMENT	3.06 INS

REMARKS

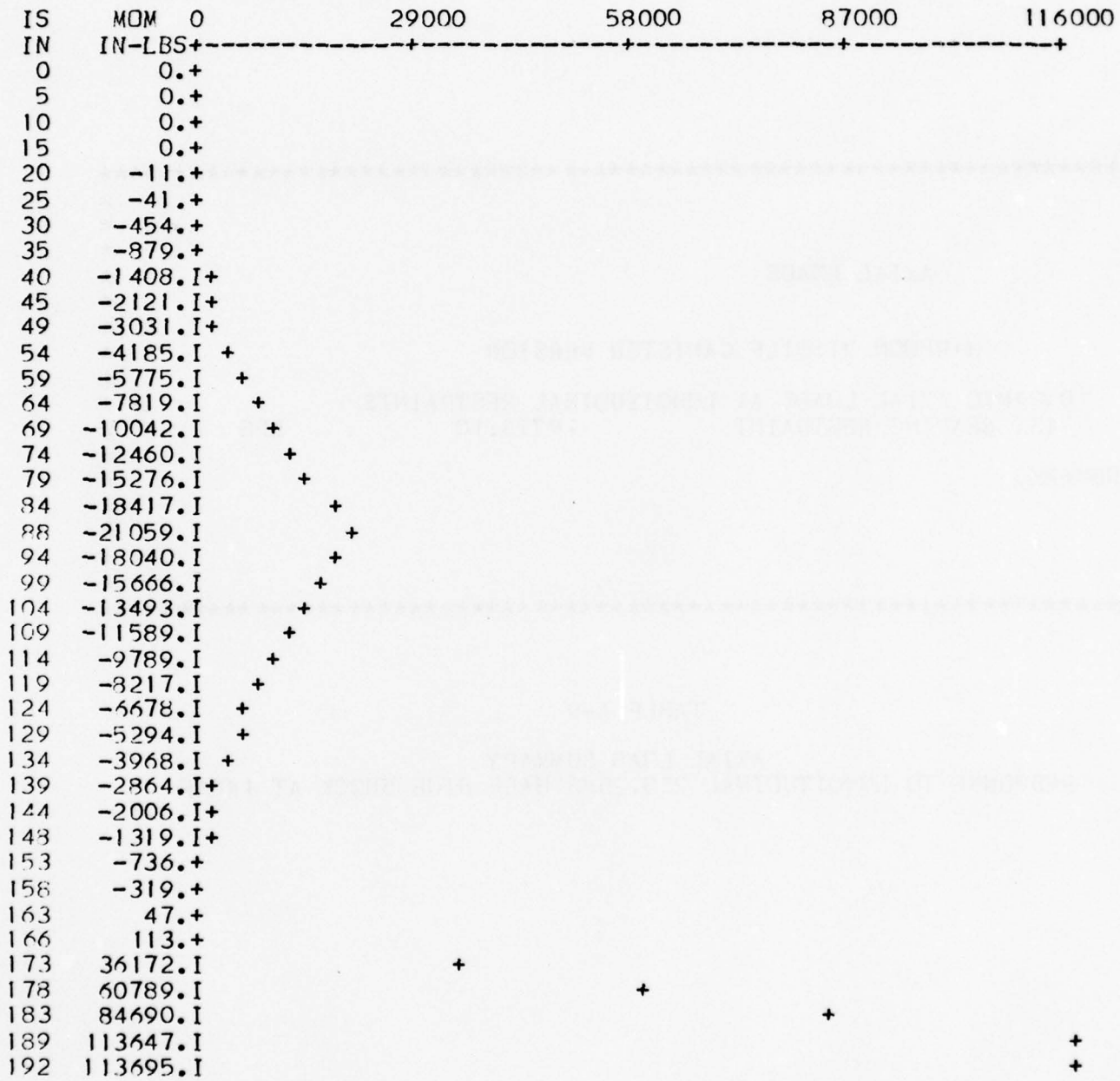
IMPACT VELOCITY EQUIVALENT NOT ACTUAL SEE TEXT
HIGH TEMP = LOW TEMP = 140°F

TABLE A-8

RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT 140°F
SUMMARY

FIGURE A-13

DYNAMIC BENDING MOMENTS
RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT 140°F



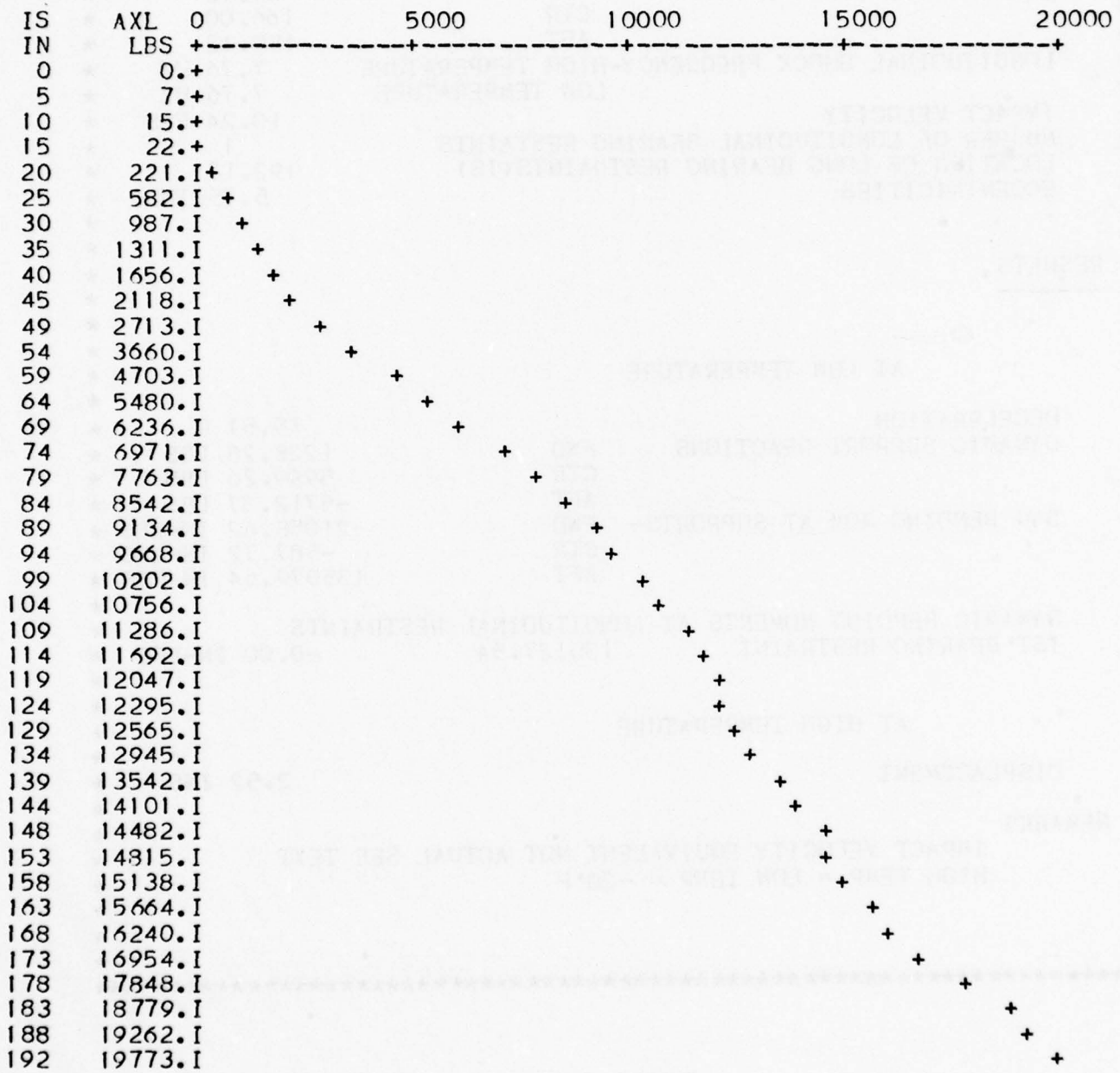
```
**********************************************************************
*                                                                    *
*                                                                    *
*                                                                    *
*              AXIAL LOADS                                           *
*                                                                    *
*                                                                    *
*           HARPOON MISSILE CANISTER VERSION                         *
*                                                                    *
*     DYNAMIC AXIAL LOADS AT LONGITUDINAL RESTRAINTS                 *
*       1ST BEARING RESTRAINT          19773.10          LBS         *
*                                                                    *
* REMARKS                                                            *
*                                                                    *
*                                                                    *
*                                                                    *
*                                                                    *
**********************************************************************
```

TABLE A-9

AXIAL LOAD SUMMARY
RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT 140°F

FIGURE A-14

DYNAMIC AXIAL LOADS
RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT 140°F



HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
LONGITUDINAL SHOCK FREQUENCY-HIGH TEMPERATURE		7.76 HZ
	LOW TEMPERATURE	7.76 HZ
IMPACT VELOCITY		10.24 FPS
NUMBER OF LONGITUDINAL BEARING RESTAINTS		1
LOCATION OF LONG BEARING RESTRAINTS(IS)		192.13
ECCENTRICITIES		5.75 INS

RESULTS

AT LOW TEMPERATURE

DECELERATION		15.51 G
DYNAMIC SUPPORT REACTIONS	FWD	1228.28 LBS
	CTR	5999.26 LBS
	AFT	-5712.37 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-21058.62 IN-LBS
	CTR	-587.72 IN-LBS
	AFT	135079.64 IN-LBS

DYNAMIC BENDING MOMENTS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	135127.54	-0.00 IN-LBS

AT HIGH TEMPERATURE

DISPLACEMENT	2.52 INS

REMARKS

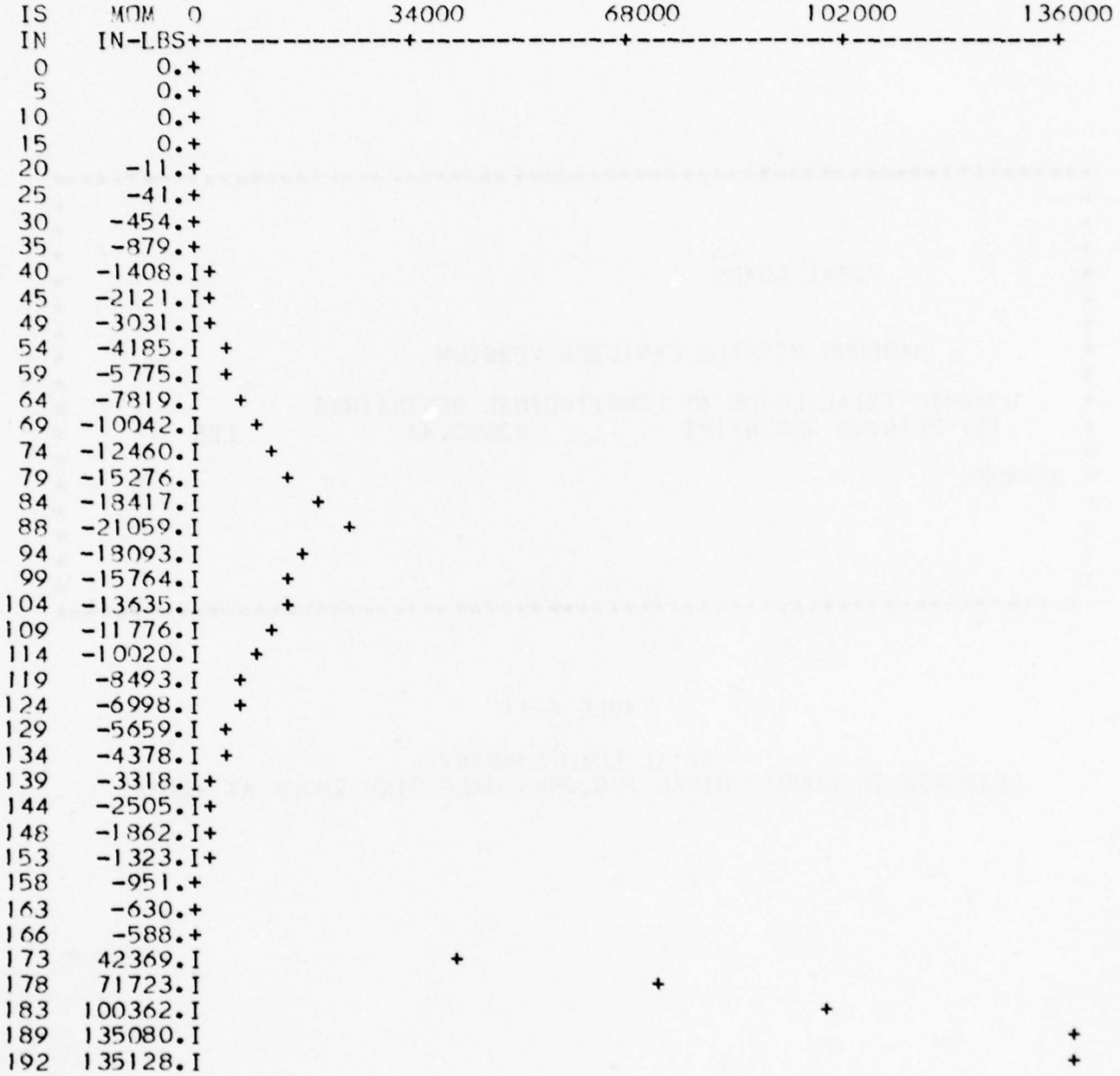
IMPACT VELOCITY EQUIVALENT NOT ACTUAL SEE TEXT
HIGH TEMP = LOW TEMP = -20°F

TABLE A-10

RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT -20°F
SUMMARY

FIGURE A-15

DYNAMIC BENDING MOMENTS
RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT -20°F



AXIAL LOADS

HARPOON MISSILE CANISTER VERSION

DYNAMIC AXIAL LOADS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	23500.44	LBS

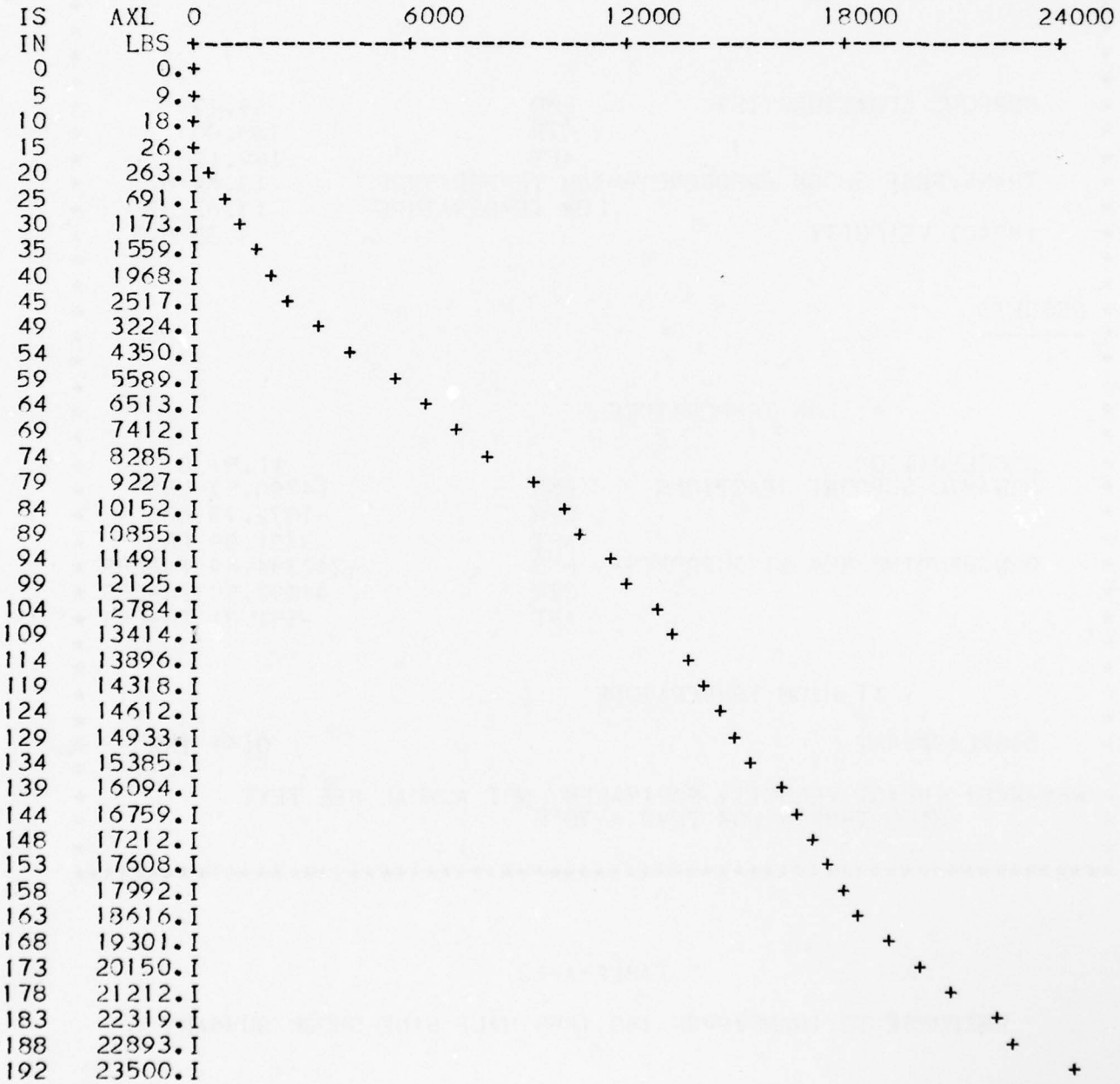
REMARKS

TABLE A-11

AXIAL LOAD SUMMARY
RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT -20°F

FIGURE A-16

DYNAMIC AXIAL LOADS
RESPONSE TO LONGITUDINAL 25G, 25MS HALF SINE SHOCK AT -20°F



```
*****************************************************************
*                                                               *
*                                                               *
*                                                               *
*              HARPOON MISSILE CANISTER VERSION                 *
* INPUT PARAMETERS                                              *
* ----------------                                              *
*                                                               *
*                                                               *
*                                                               *
*                                                               *
*    SUPPORT LOCATIONS(IS)          FWD          88.12         *
*                                   CTR         166.00         *
*                                   AFT         189.12         *
*    TRANSVERSE SHOCK FREQUENCY-HIGH TEMPERATURE  13.62 HZ     *
*                               LOW TEMPERATURE   13.62 HZ     *
*    IMPACT VELOCITY                               4.33 FPS    *
*                                                               *
*                                                               *
* RESULTS                                                       *
* -------                                                       *
*                                                               *
*                                                               *
*              AT LOW TEMPERATURE                               *
*                                                               *
*    DECELERATION                                  11.51 G     *
*    DYNAMIC SUPPORT REACTIONS      FWD        14790.57 LBS    *
*                                   CTR        -1072.73 LBS    *
*                                   AFT         3721.88 LBS    *
*    DYN BENDING MOM AT SUPPORTS-   FWD      -242384.69 IN-LBS *
*                                   CTR        44092.59 IN-LBS *
*                                   AFT         -551.31 IN-LBS *
*                                                               *
*                                                               *
*              AT HIGH TEMPERATURE                              *
*                                                               *
*    DISPLACEMENT                                  0.61 INS    *
*                                                               *
* REMARKS: IMPACT VELOCITY EQUIVALENT NOT ACTUAL SEE TEXT       *
*          HIGH TEMP = LOW TEMP = 70°F                          *
*                                                               *
*****************************************************************
```

TABLE A-12

RESPONSE TO TRANSVERSE 15G, 18MS HALF SINE SHOCK SUMMARY

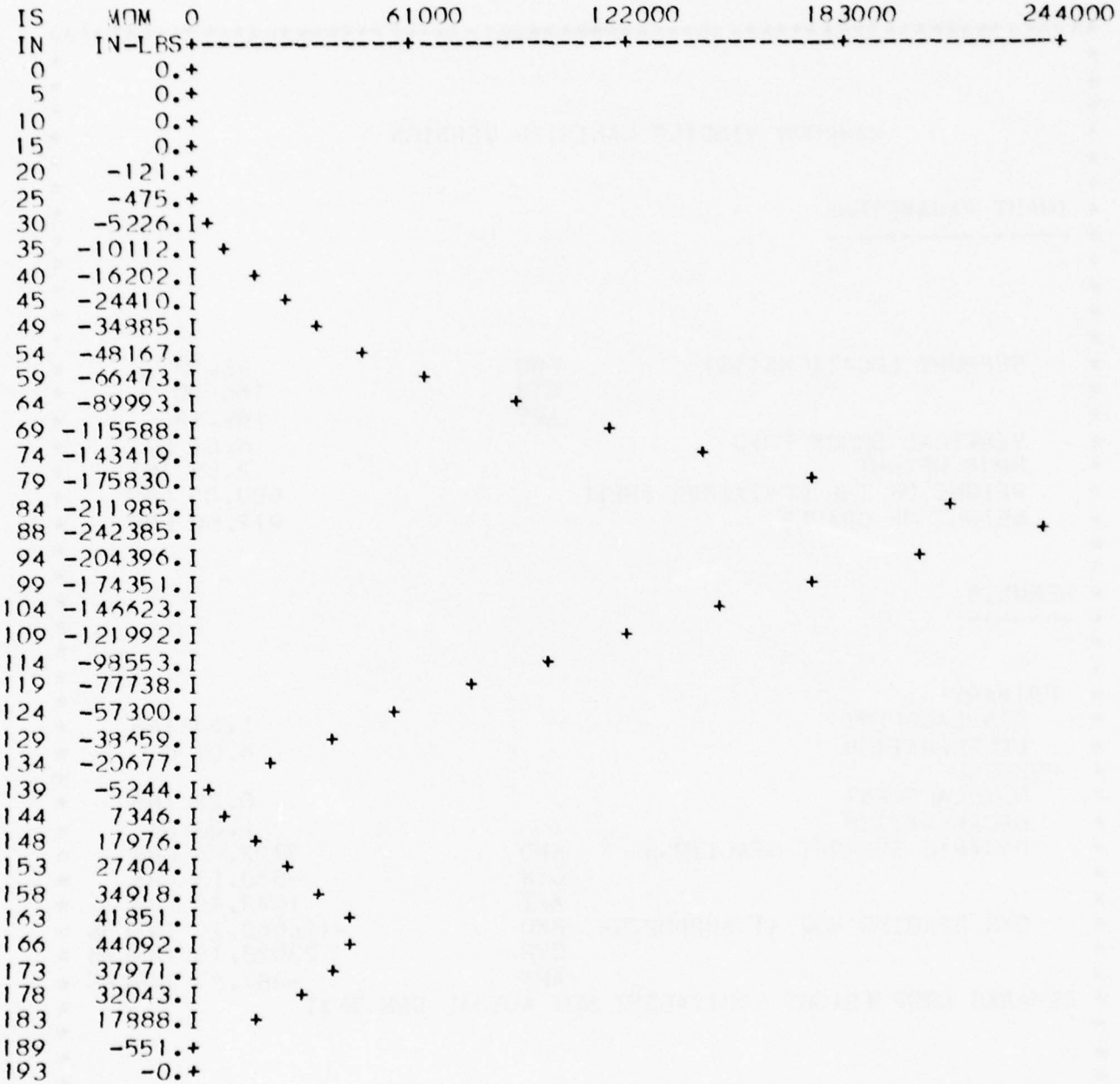


FIGURE A-17

RESPONSE TO TRANSVERSE 15G,18MS HALF SINE SHOCK
DYNAMIC BENDING MOMENTS

HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
VERTICAL SHOCK FREQ		6.81 HZ
DROP HEIGHT		2.55 INS
WEIGHT OF THE CONTAINER SHELL		500.00 LBS
WEIGHT OF CRADLE		917.50 LBS

RESULTS

PRIMARY-		
DISPLACEMENT		1.27 INS
DECELERATION		6.01 G
REBOUND-		
DISPLACEMENT		0.22 INS
DECELERATION		1.02 G
DYNAMIC SUPPORT REACTIONS	FWD	7722.96 LBS
	CTR	-560.13 LBS
	AFT	1943.40 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-126562.29 IN-LBS
	CTR	23023.15 IN-LBS
	AFT	-287.87 IN-LBS

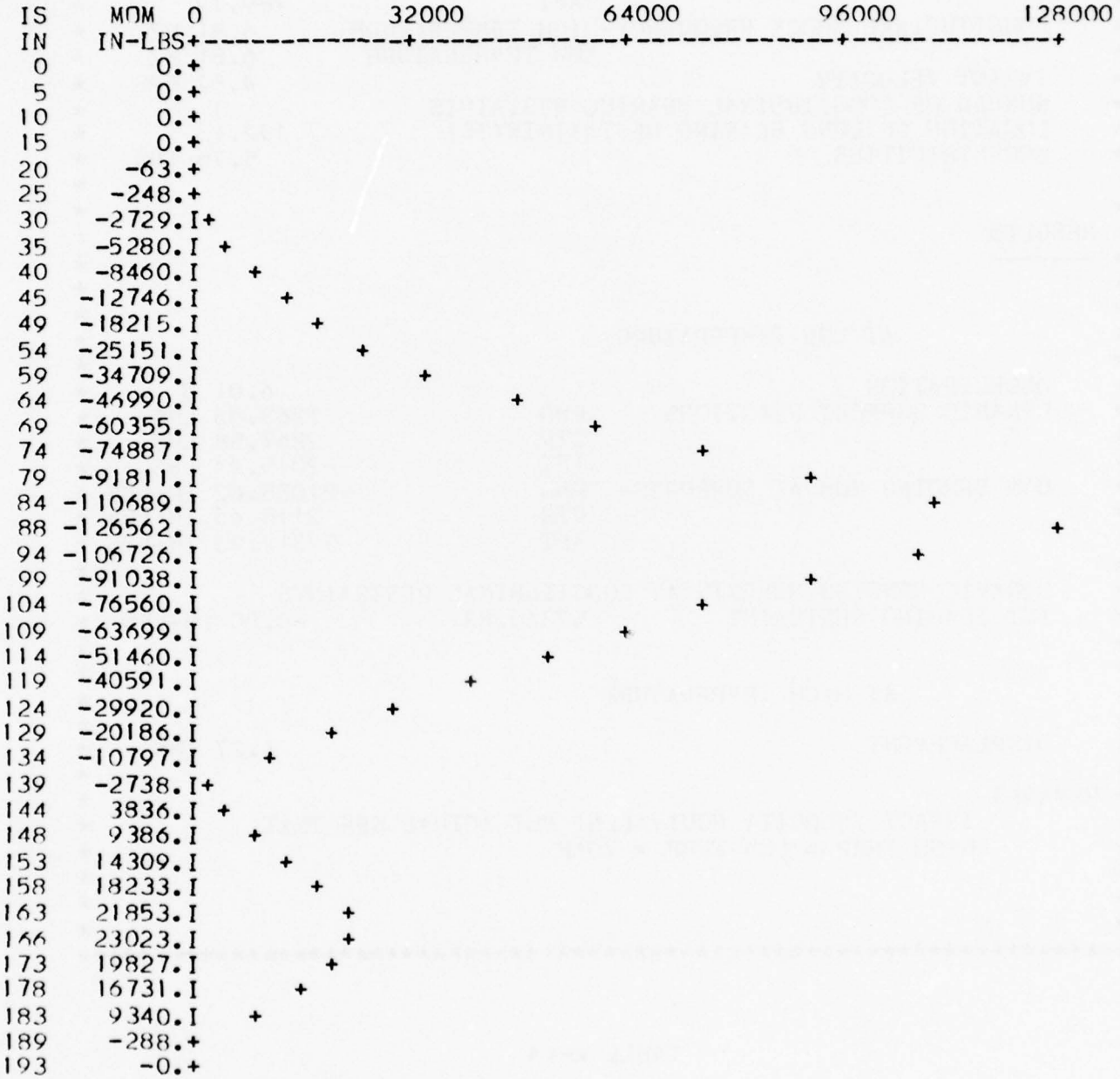
REMARKS DROP HEIGHT EQUIVALENT NOT ACTUAL SEE TEXT

TABLE A-13

RESPONSE TO VERTICAL 15G,18MS HALF SINE SHOCK SUMMARY

FIGURE A-18

DYNAMIC BENDING MOMENTS
RESPONSE TO VERTICAL 15G,18MS HALF SINE SHOCK



HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12	
	CTR	166.00	
	AFT	189.12	
LONGITUDINAL SHOCK FREQUENCY-HIGH TEMPERATURE		6.81	HZ
	LOW TEMPERATURE	6.81	HZ
IMPACT VELOCITY		4.52	FPS
NUMBER OF LONGITUDINAL BEARING RESTAINTS		1	
LOCATION OF LONG BEARING RESTRAINTS(IS)		192.13	
ECCENTRICITIES		5.75	INS

RESULTS

AT LOW TEMPERATURE

DECELERATION		6.01	G
DYNAMIC SUPPORT REACTIONS	FWD	1263.03	LBS
	CTR	2267.58	LBS
	AFT	-2015.44	LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-21058.62	IN-LBS
	CTR	2118.66	IN-LBS
	AFT	52312.93	IN-LBS
DYNAMIC BENDING MOMENTS AT LONGITUDINAL RESTRAINTS			
1ST BEARING RESTRAINT	52360.83	-0.00	IN-LBS

AT HIGH TEMPERATURE

DISPLACEMENT		1.27	INS

REMARKS

IMPACT VELOCITY EQUIVALENT NOT ACTUAL SEE TEXT

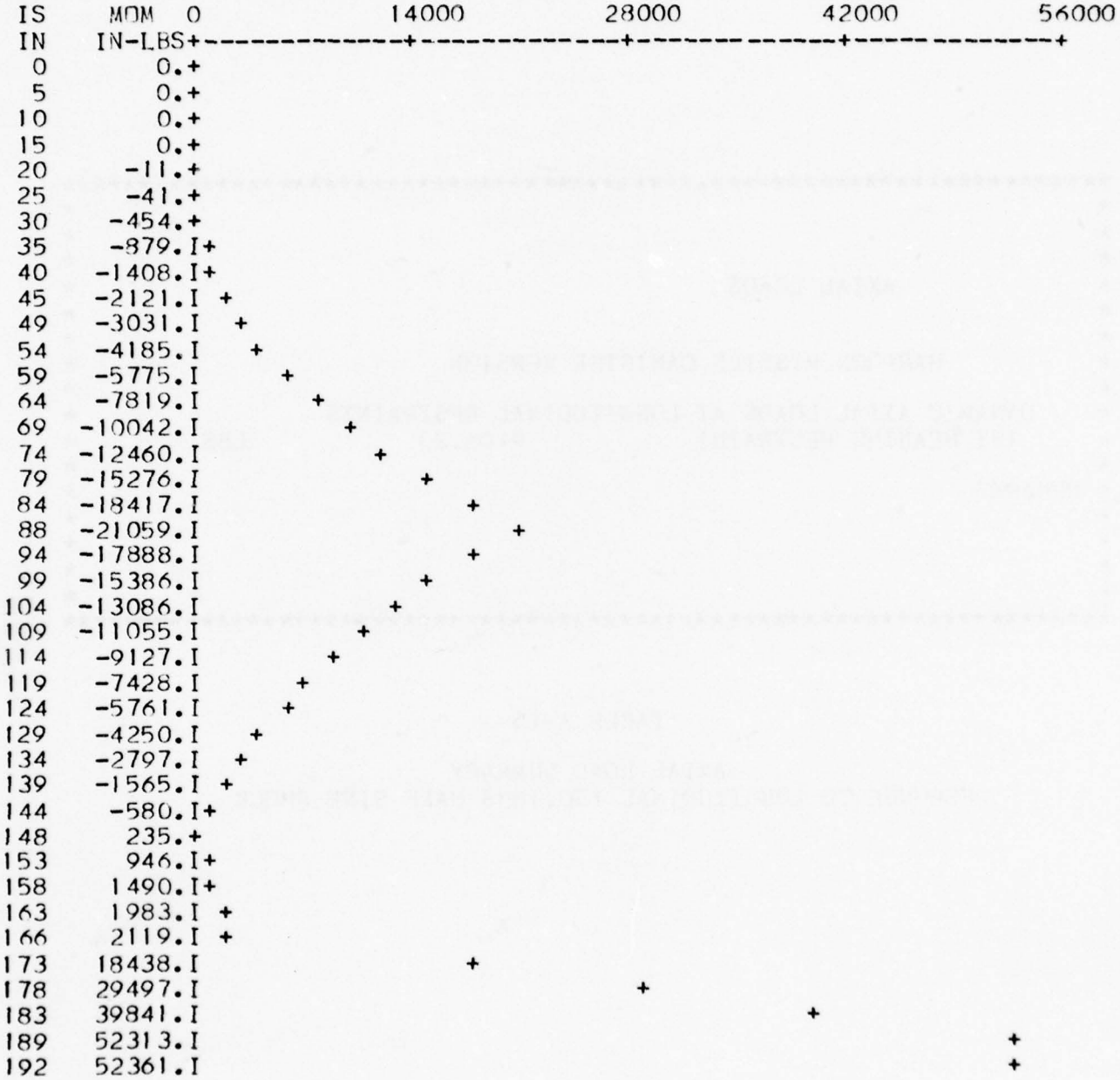
HIGH TEMP = LOW TEMP = 70°F

TABLE A-14

RESPONSE TO LONGITUDINAL 15G, 18MS HALF SINE SHOCK SUMMARY

FIGURE A-19

DYNAMIC BENDING MOMENTS
RESPONSE TO LONGITUDINAL 15G, 18MS HALF SINE SHOCK



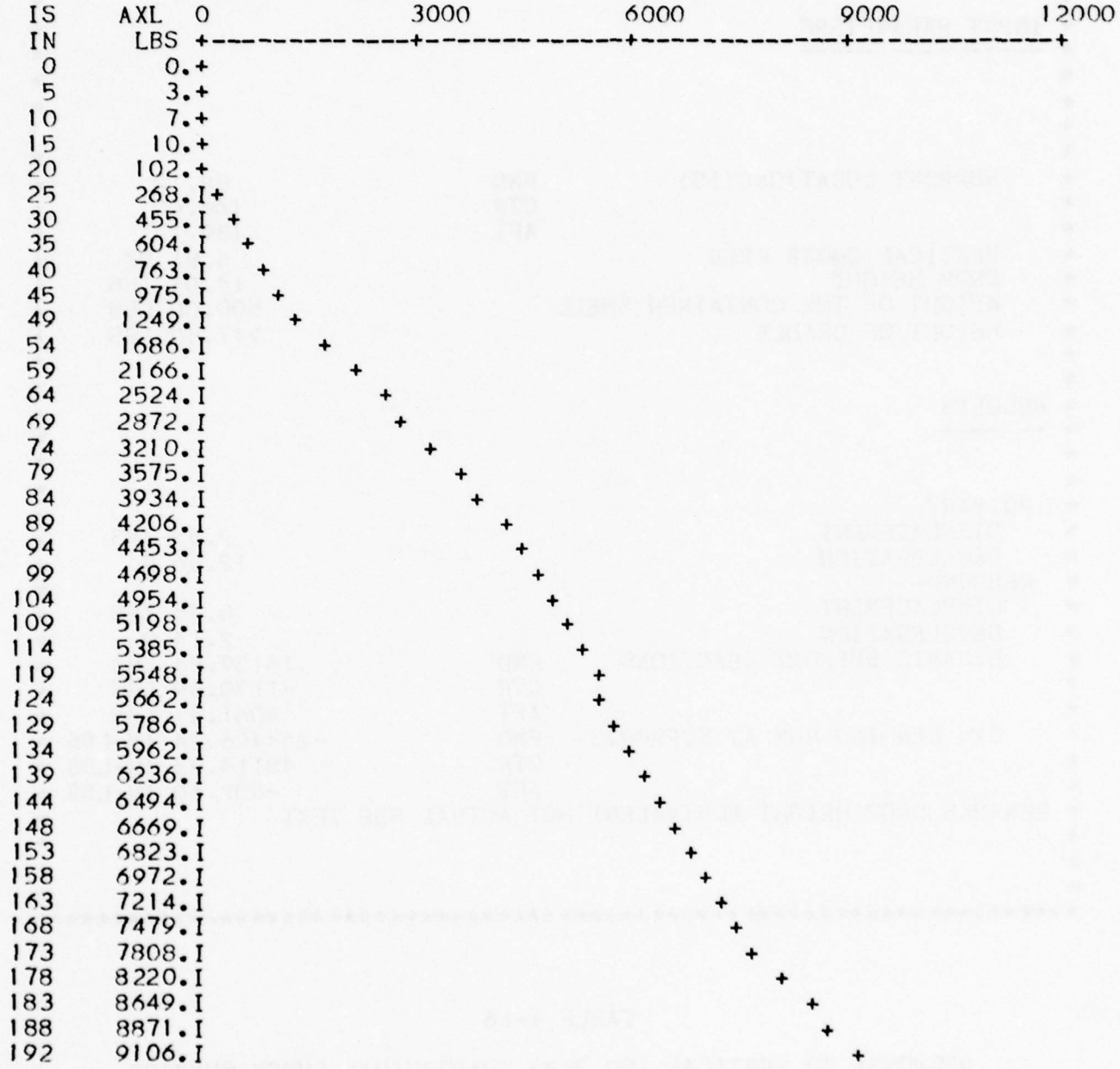
```
**************************************************************
*                                                            *
*                                                            *
*                                                            *
*              AXIAL LOADS                                   *
*                                                            *
*                                                            *
*           HARPOON MISSILE CANISTER VERSION                 *
*                                                            *
*     DYNAMIC AXIAL LOADS AT LONGITUDINAL RESTRAINTS         *
*       1ST BEARING RESTRAINT          9106.23      LBS      *
*                                                            *
* REMARKS                                                    *
*                                                            *
*                                                            *
*                                                            *
*                                                            *
**************************************************************
```

TABLE A-15

AXIAL LOAD SUMMARY
RESPONSE TO LONGITUDINAL 15G,18MS HALF SINE SHOCK

FIGURE A-20

DYNAMIC AXIAL LOADS
RESPONSE TO LONGITUDINAL 15G,18MS HALF SINE SHOCK



HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
VERTICAL SHOCK FREQ		6.81 HZ
DROP HEIGHT		14.01 INS
WEIGHT OF THE CONTAINER SHELL		500.00 LBS
WEIGHT OF CRADLE		917.50 LBS

RESULTS

PRIMARY-		
DISPLACEMENT		2.65 INS
DECELERATION		12.56 G
REBOUND-		
DISPLACEMENT		0.45 INS
DECELERATION		2.14 G
DYNAMIC SUPPORT REACTIONS	FWD	16139.84 LBS
	CTR	-1170.59 LBS
	AFT	4061.41 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-264496.24 IN-LBS
	CTR	48114.93 IN-LBS
	AFT	-601.60 IN-LBS

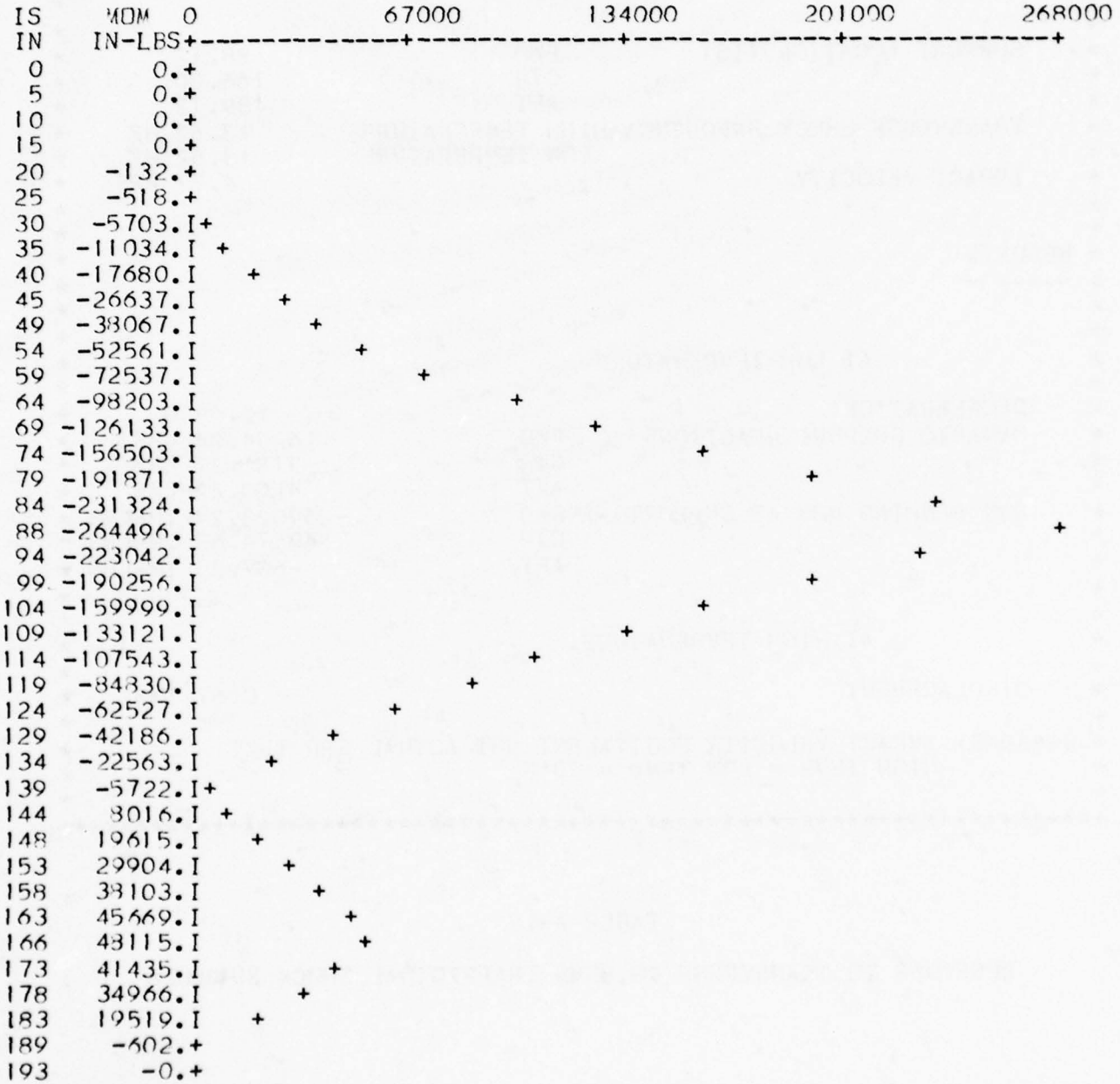
REMARKS DROP HEIGHT EQUIVALENT NOT ACTUAL SEE TEXT

TABLE A-16

RESPONSE TO VERTICAL 15G, 35MS TRAPEZOIDAL SHOCK SUMMARY

FIGURE A-21

DYNAMIC BENDING MOMENTS
RESPONSE TO VERTICAL 15G,35MS TRAPEZOIDAL SHOCK



HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
TRANSVERSE SHOCK FREQUENCY-HIGH TEMPERATURE		13.62 HZ
LOW TEMPERATURE		13.62 HZ
IMPACT VELOCITY		4.77 FPS

RESULTS

AT LOW TEMPERATURE

DECELERATION		12.68 G
DYNAMIC SUPPORT REACTIONS	FWD	16294.04 LBS
	CTR	-1181.77 LBS
	AFT	4100.22 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-267023.27 IN-LBS
	CTR	48574.63 IN-LBS
	AFT	-607.35 IN-LBS

AT HIGH TEMPERATURE

DISPLACEMENT	0.67 INS

REMARKS: IMPACT VELOCITY EQUIVALENT NOT ACTUAL SEE TEXT
HIGH TEMP = LOW TEMP = 70°F

TABLE A-17

RESPONSE TO TRANSVERSE 9G, 35MS TRAPEZOIDAL SHOCK SUMMARY

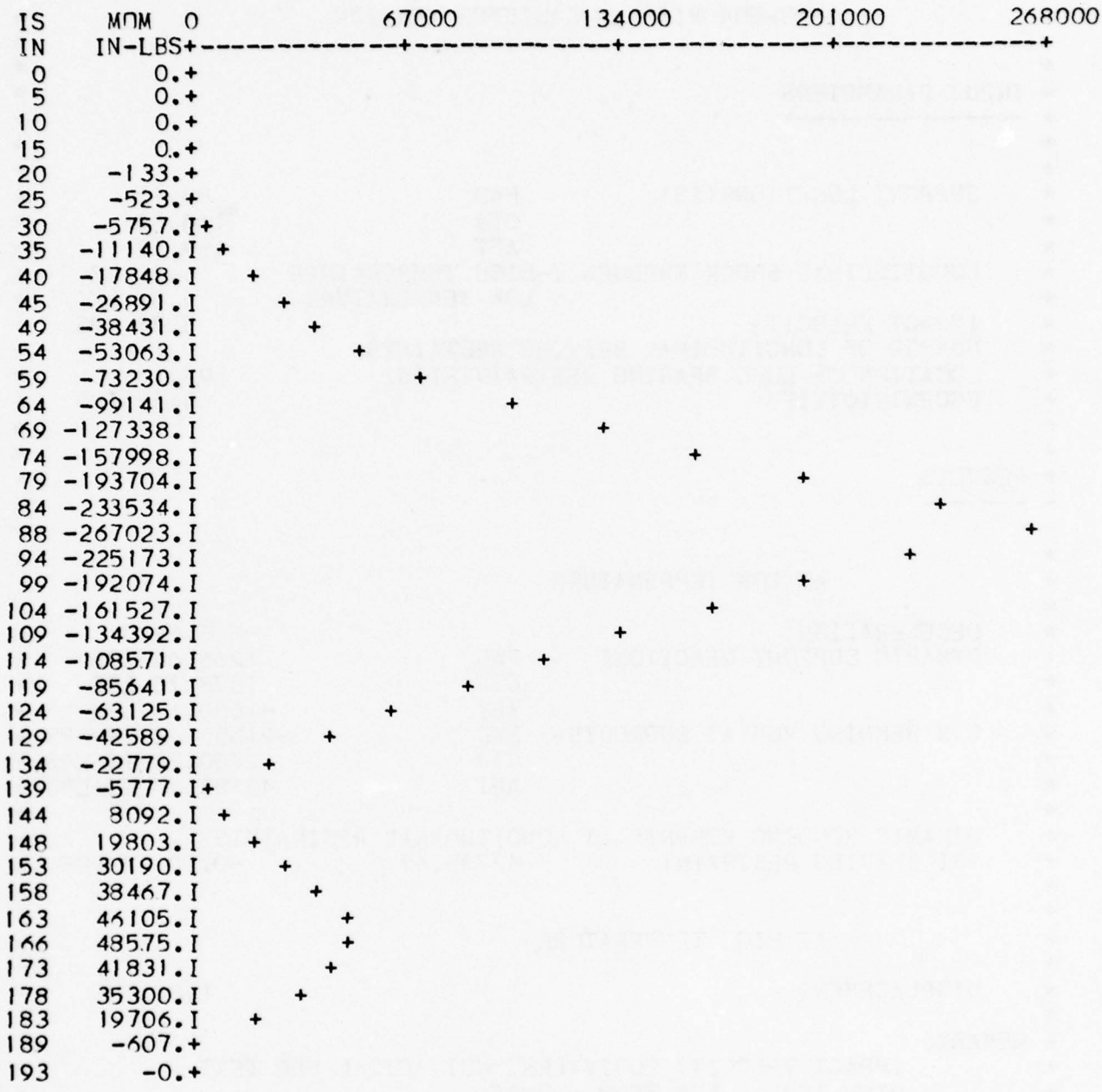


FIGURE A-22

RESPONSE TO TRANSVERSE 9G,35MS TRAPEZIODAL SHOCK
DYNAMIC BENDING MOMENTS

HARPOON MISSILE CANISTER VERSION

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	88.12
	CTR	166.00
	AFT	189.12
LONGITUDINAL SHOCK FREQUENCY-HIGH TEMPERATURE		6.81 HZ
LOW TEMPERATURE		6.81 HZ
IMPACT VELOCITY		3.78 FPS
NUMBER OF LONGITUDINAL BEARING RESTAINTS		1
LOCATION OF LONG BEARING RESTRAINTS(IS)		192.13
ECCENTRICITIES		5.75 INS

RESULTS

AT LOW TEMPERATURE

DECELERATION		5.02 G
DYNAMIC SUPPORT REACTIONS	FWD	1266.66 LBS
	CTR	1878.70 LBS
	AFT	-1630.18 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-21058.62 IN-LBS
	CTR	2400.70 IN-LBS
	AFT	43687.77 IN-LBS
DYNAMIC BENDING MOMENTS AT LONGITUDINAL RESTRAINTS		
1ST BEARING RESTRAINT	43735.67	-0.00 IN-LBS

AT HIGH TEMPERATURE

DISPLACEMENT	1.06 INS

REMARKS

IMPACT VELOCITY EQUIVALENT NOT ACTUAL SEE TEXT

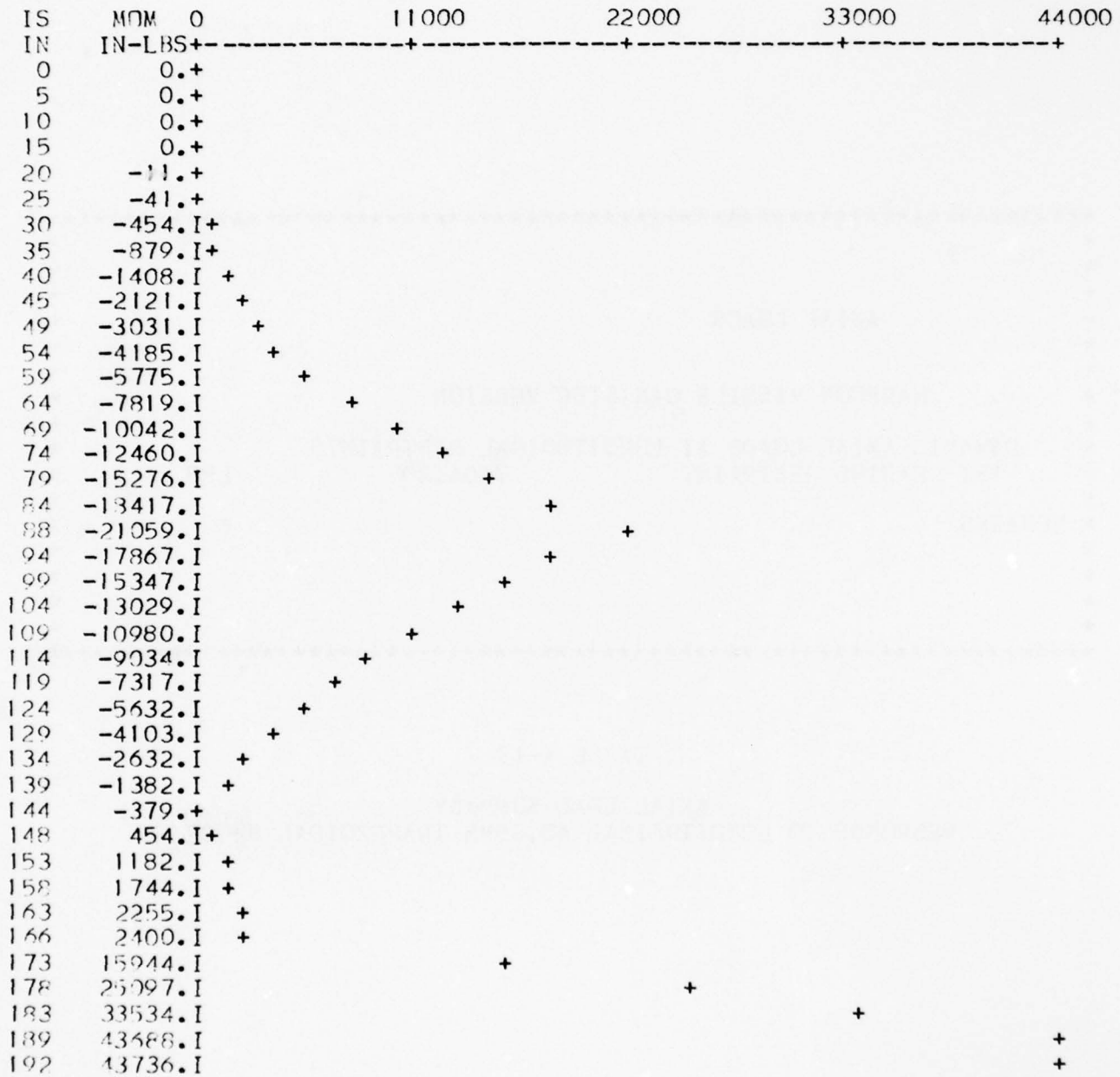
HIGH TEMP = LOW TEMP = 70°F

TABLE A-18

RESPONSE TO LONGITUDINAL 6G,35MS TRAPEZOIDAL SHOCK SUMMARY

FIGURE A-23

DYNAMIC BENDING MOMENTS
RESPONSE TO LONGITUDINAL 6G,35MS TRAPEZOIDAL SHOCK



AXIAL LOADS

HARPOON MISSILE CANISTER VERSION

DYNAMIC AXIAL LOADS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	7606.20	LBS

REMARKS

TABLE A-19

AXIAL LOAD SUMMARY
RESPONSE TO LONGITUDINAL 6G,35MS TRAPEZOIDAL SHOCK

FIGURE A-24

DYNAMIC AXIAL LOADS
RESPONSE TO LONGITUDINAL 6G, 35MS TRAPEZOIDAL SHOCK

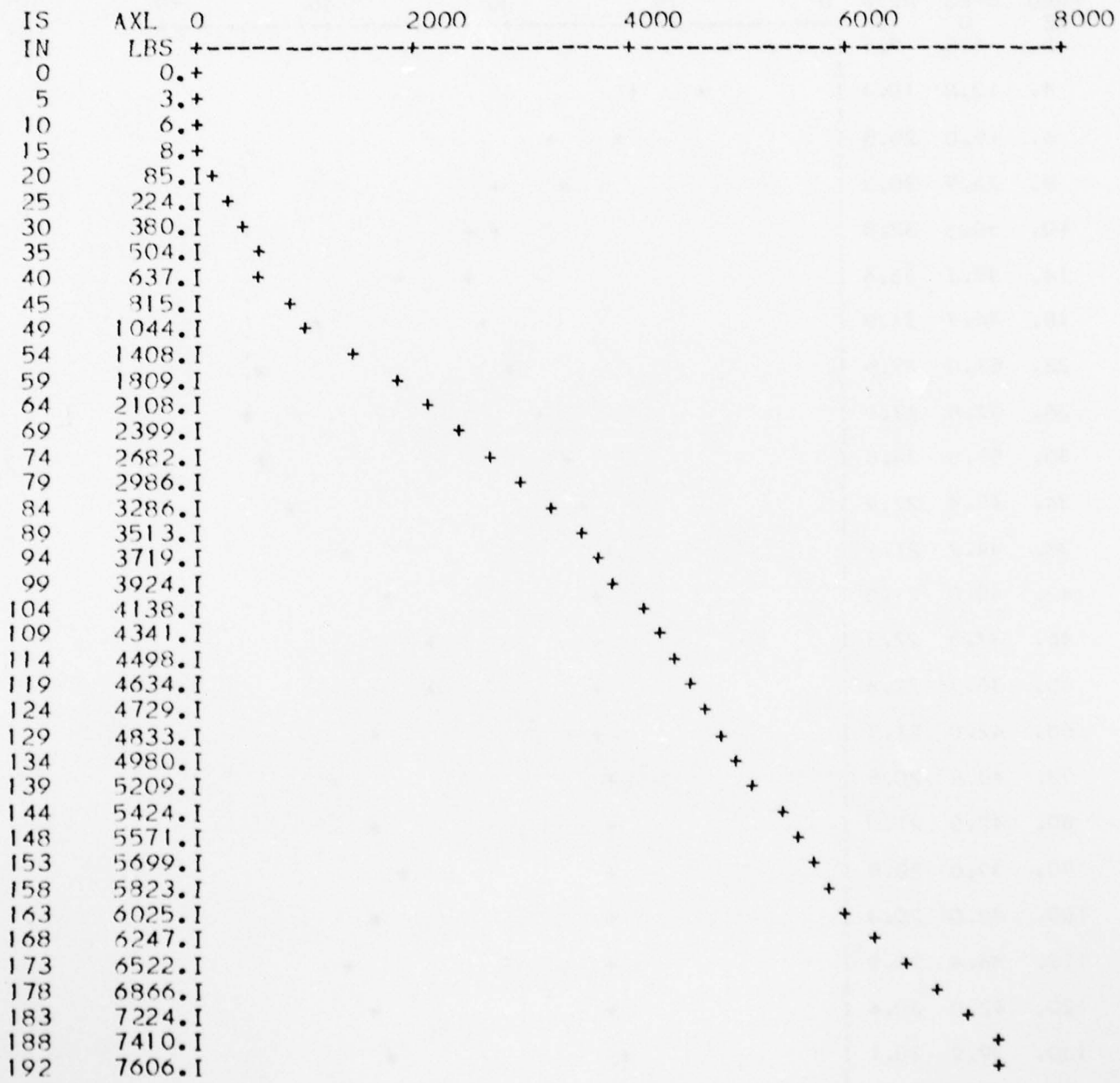


FIGURE A-25

COMPARISON OF 42G,25MS TPS (SPECIFICATION) TO 19.09G,64MS HALF SINE RESPONSE TO -20°F FORWARD EDGE ROTATIONAL DROP (RESPONSE)

SHOCK SPECTRUM
SPECIFICATION = *
RESPONSE = +

FREQ HZ	SPEC G	RESP G
2.	6.5	9.6
4.	12.8	18.4
6.	19.0	25.5
8.	24.9	30.3
10.	30.3	32.8
14.	39.7	33.6
18.	46.7	31.9
22.	51.0	29.5
26.	52.5	27.1
30.	51.8	24.8
34.	48.4	22.9
38.	44.2	21.1
42.	40.0	21.6
46.	37.3	22.3
50.	36.7	22.4
60.	42.0	21.7
70.	45.8	20.5
80.	42.0	21.0
90.	39.0	20.8
100.	42.0	20.3
110.	44.4	20.5
120.	42.0	20.4
130.	39.9	20.1
140.	42.0	20.1
150.	43.7	20.1

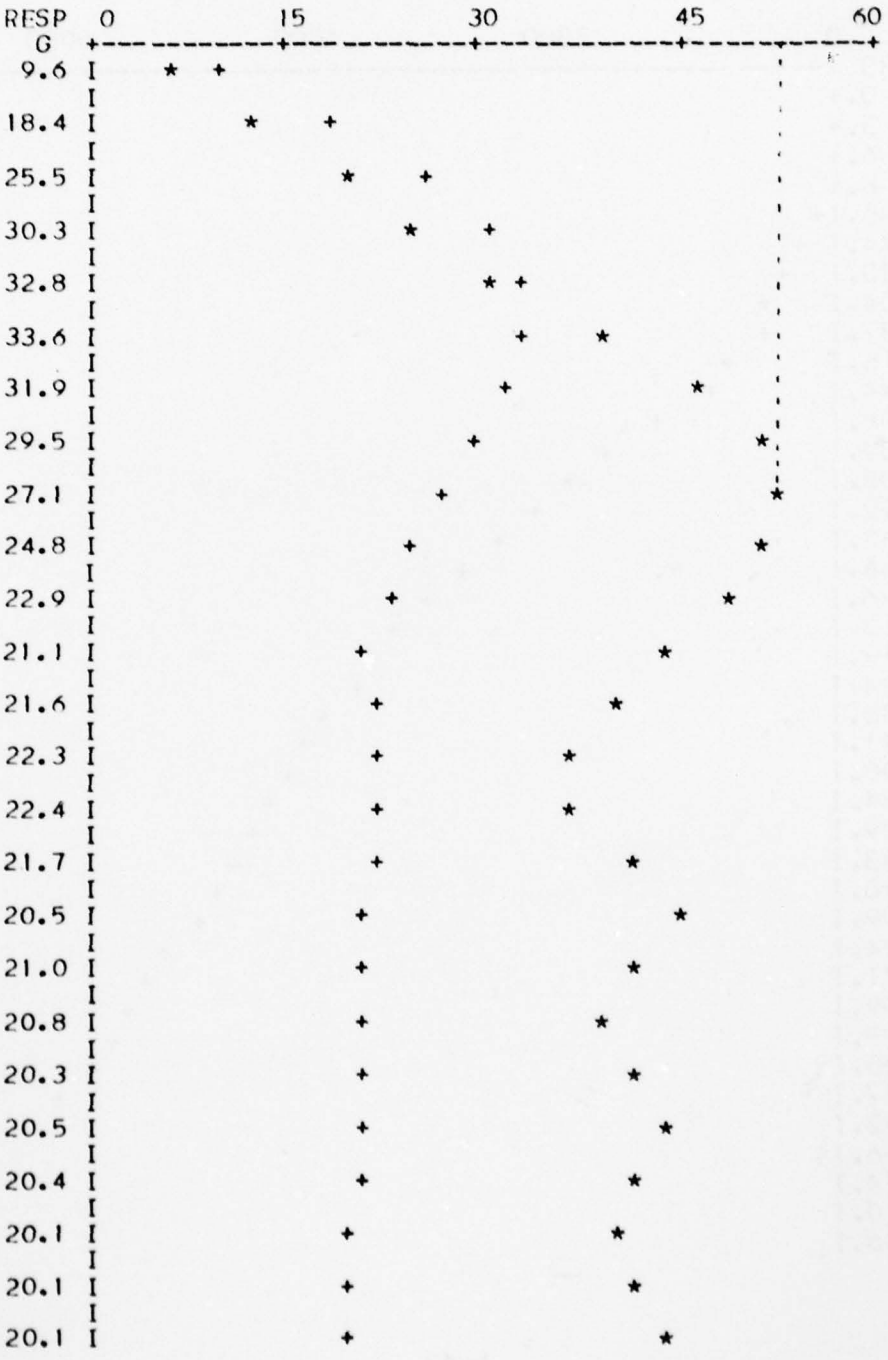


FIGURE A-26

COMPARISON OF 42G,25MS TPS (SPECIFICATION) TO RESPONSE TO TRANSVERSE 9G,35MS TRAPEZOIDAL SHOCK (RESPONSE)

SHOCK SPECTRUM
SPECIFICATION = *
RESPONSE = +

FREQ HZ	SPEC G	RESP G
2.	6.5	4.3
4.	12.8	8.4
6.	19.0	12.1
8.	24.9	15.2
10.	30.3	17.7
14.	39.7	20.4
18.	46.7	20.9
22.	51.0	20.1
26.	52.5	18.8
30.	51.8	17.3
34.	48.4	16.0
38.	44.2	14.8
42.	40.0	13.9
46.	37.3	13.4
50.	36.7	13.4
60.	42.0	13.7
70.	45.8	13.3
80.	42.0	13.1
90.	39.0	13.0
100.	42.0	12.9
110.	44.4	12.8
120.	42.0	12.8
130.	39.9	12.8
140.	42.0	12.8
150.	43.7	12.8

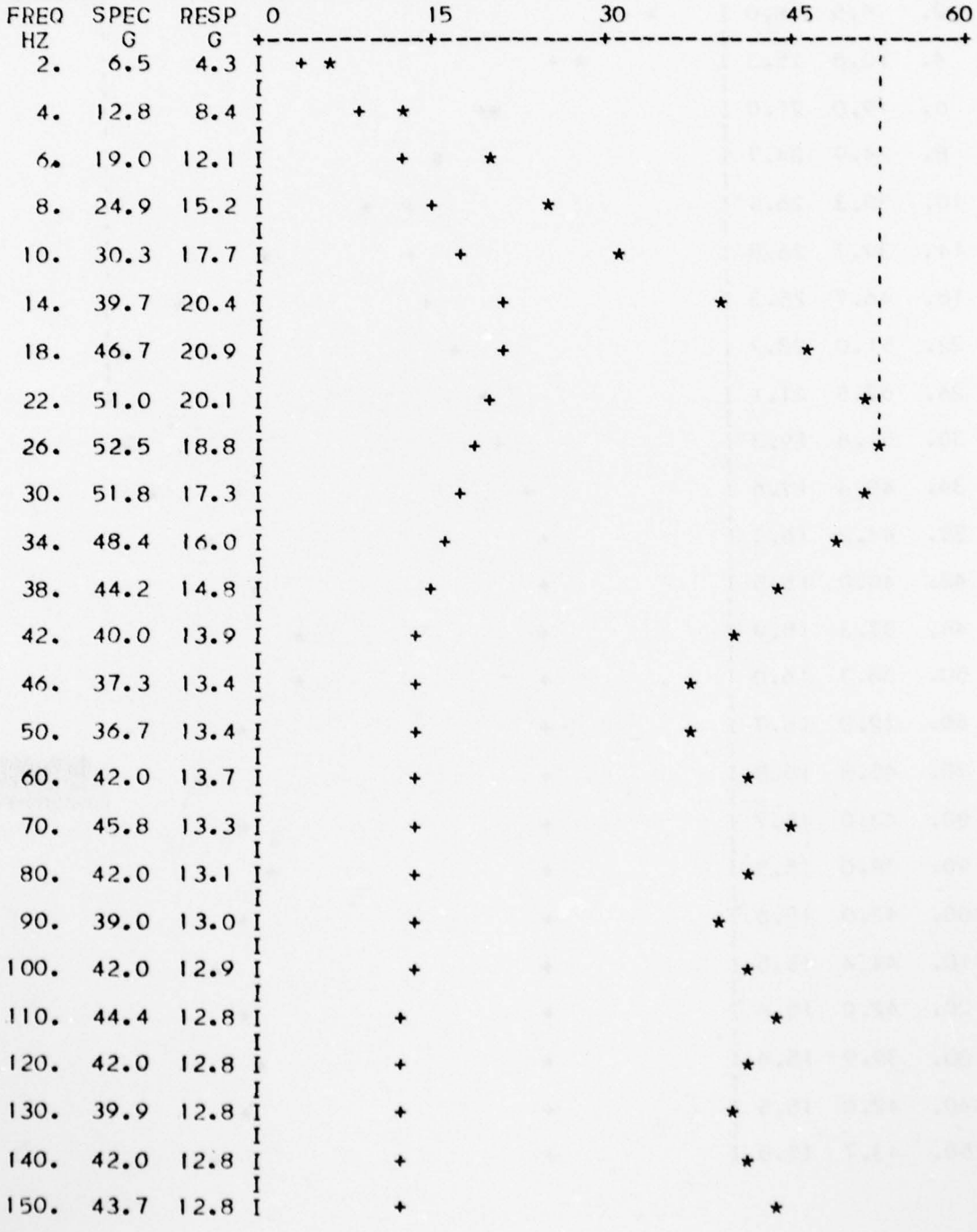
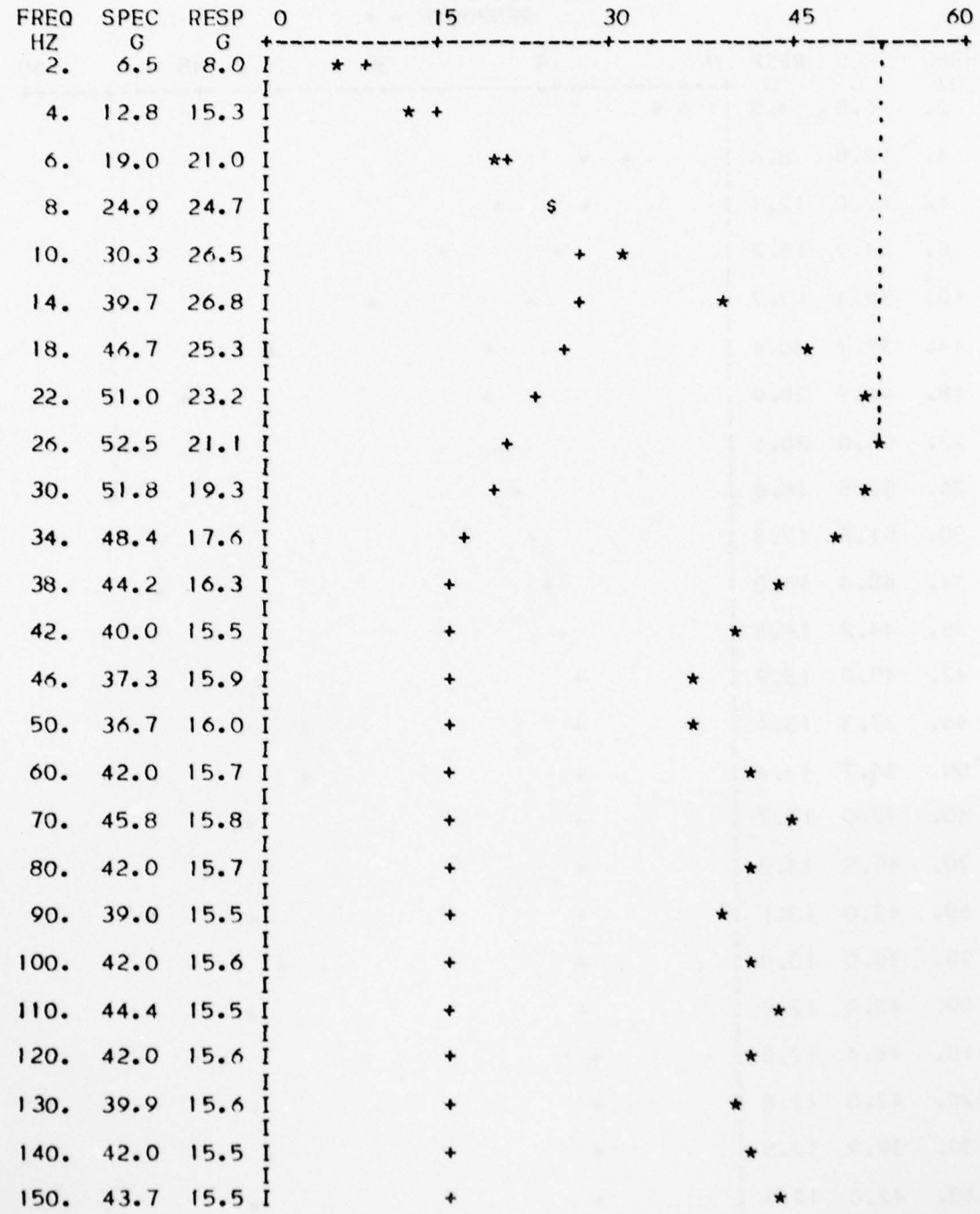


FIGURE A-27

COMPARISON OF 42G,25MS TPS (SPECIFICATION) TO RESPONSE TO LONGITUDINAL 25G,25MS HALF SINE SHOCK AT -20°F (RESPONSE)

SHOCK SPECTRUM
SPECIFICATION = *
RESPONSE = +

FREQ HZ	SPEC G	RESP G
2.	6.5	8.0
4.	12.8	15.3
6.	19.0	21.0
8.	24.9	24.7
10.	30.3	26.5
14.	39.7	26.8
18.	46.7	25.3
22.	51.0	23.2
26.	52.5	21.1
30.	51.8	19.3
34.	48.4	17.6
38.	44.2	16.3
42.	40.0	15.5
46.	37.3	15.9
50.	36.7	16.0
60.	42.0	15.7
70.	45.8	15.8
80.	42.0	15.7
90.	39.0	15.5
100.	42.0	15.6
110.	44.4	15.5
120.	42.0	15.6
130.	39.9	15.6
140.	42.0	15.5
150.	43.7	15.5



APPENDIX B

HARPOON MISSILE CANISTER

COMPUTER OUTPUT

FLAT DROP- HARPOON MISSILE CANISTER

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	80.52
	AFT	158.39
VERTICAL SHOCK FREQ		6.81 HZ
DROP HEIGHT		18.00 INS
WEIGHT OF THE CONTAINER SHELL		500.00 LBS
WEIGHT OF CRADLE		427.20 LBS

RESULTS

PRIMARY-		
DISPLACEMENT		2.98 INS
DECELERATION		14.09 G
REBOUND-		
DISPLACEMENT		0.51 INS
DECELERATION		2.40 G
DYNAMIC SUPPORT REACTIONS	FWD	21418.74 LBS
	AFT	6842.48 LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-100807.82 IN-LBS
	AFT	-139045.27 IN-LBS

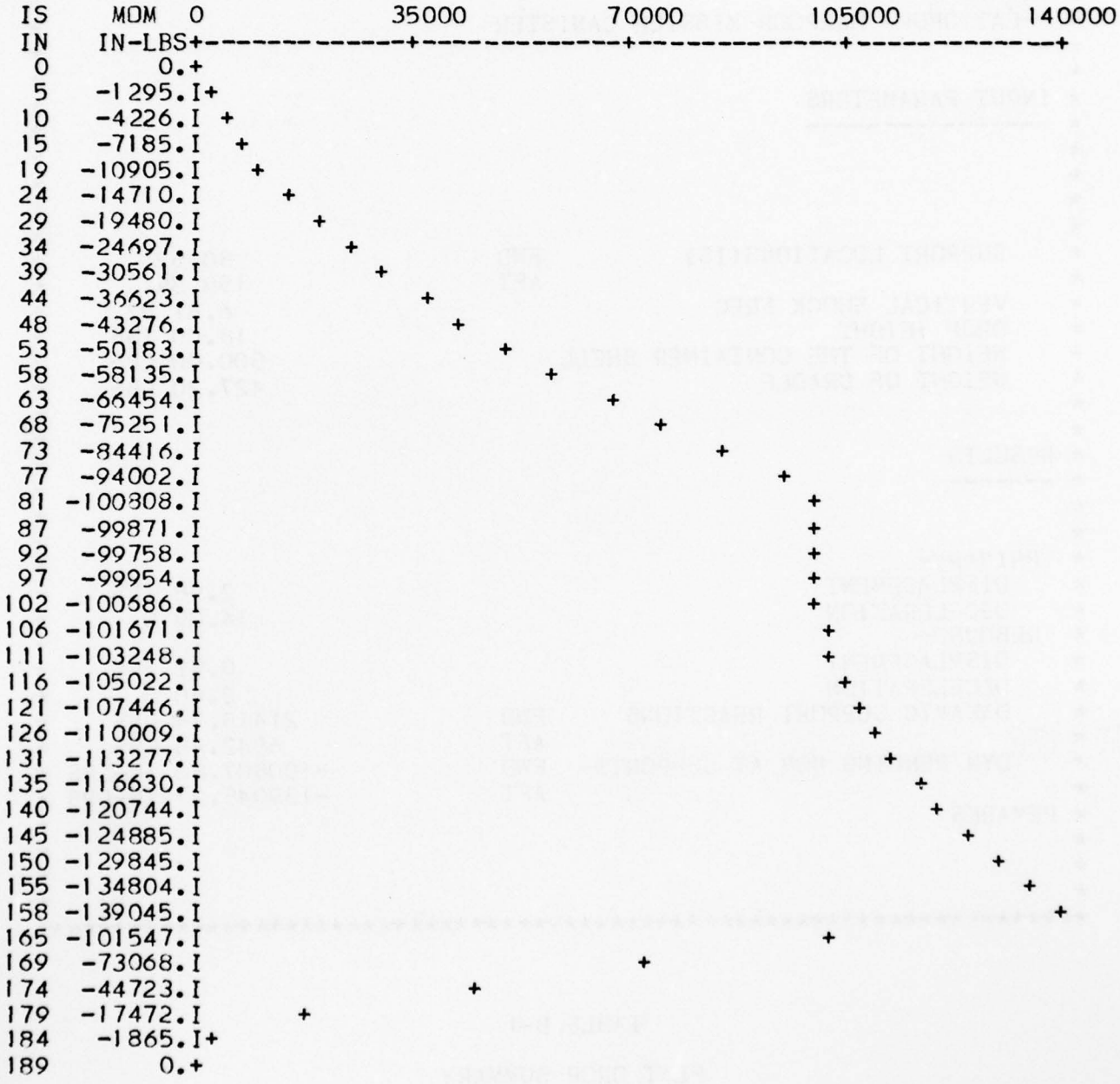
REMARKS

TABLE B-1

FLAT DROP SUMMARY

FIGURE B-1

DYNAMIC BENDING MOMENTS
18 INCH FLAT DROP



END IMPACT- HARPOON MISSILE CANISTER

INPUT PARAMETERS

SUPPORT LOCATIONS(IS)	FWD	80.52
	AFT	158.39
LONGITUDINAL SHOCK FREQUENCY-HIGH TEMPERATURE		6.46 HZ
	LOW TEMPERATURE	7.76 HZ
IMPACT VELOCITY		10.00 FPS
NUMBER OF LONGITUDINAL BEARING RESTAINTS		1
LOCATION OF LONG BEARING RESTRAINTS(IS)		158.39
ECCENTRICITIES		11.95 INS

RESULTS

AT LOW TEMPERATURE (-20°F)

DECELERATION		15.14	G
DYNAMIC SUPPORT REACTIONS	FWD	6179.13	LBS
	AFT	-4173.73	LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-7153.27	IN-LBS
	AFT	352950.66	IN-LBS

DYNAMIC BENDING MOMENTS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	352950.66	IN-LBS

DYNAMIC AXIAL LOADS AT LONGITUDINAL RESTRAINTS

1ST BEARING RESTRAINT	30356.89	LBS

AT HIGH TEMPERATURE (140°F)

DISPLACEMENT	2.96	INS

REMARKS

TABLE B-2

END IMPACT SUMMARY

FIGURE B-2

DYNAMIC BENDING MOMENTS
10 FPS END IMPACT

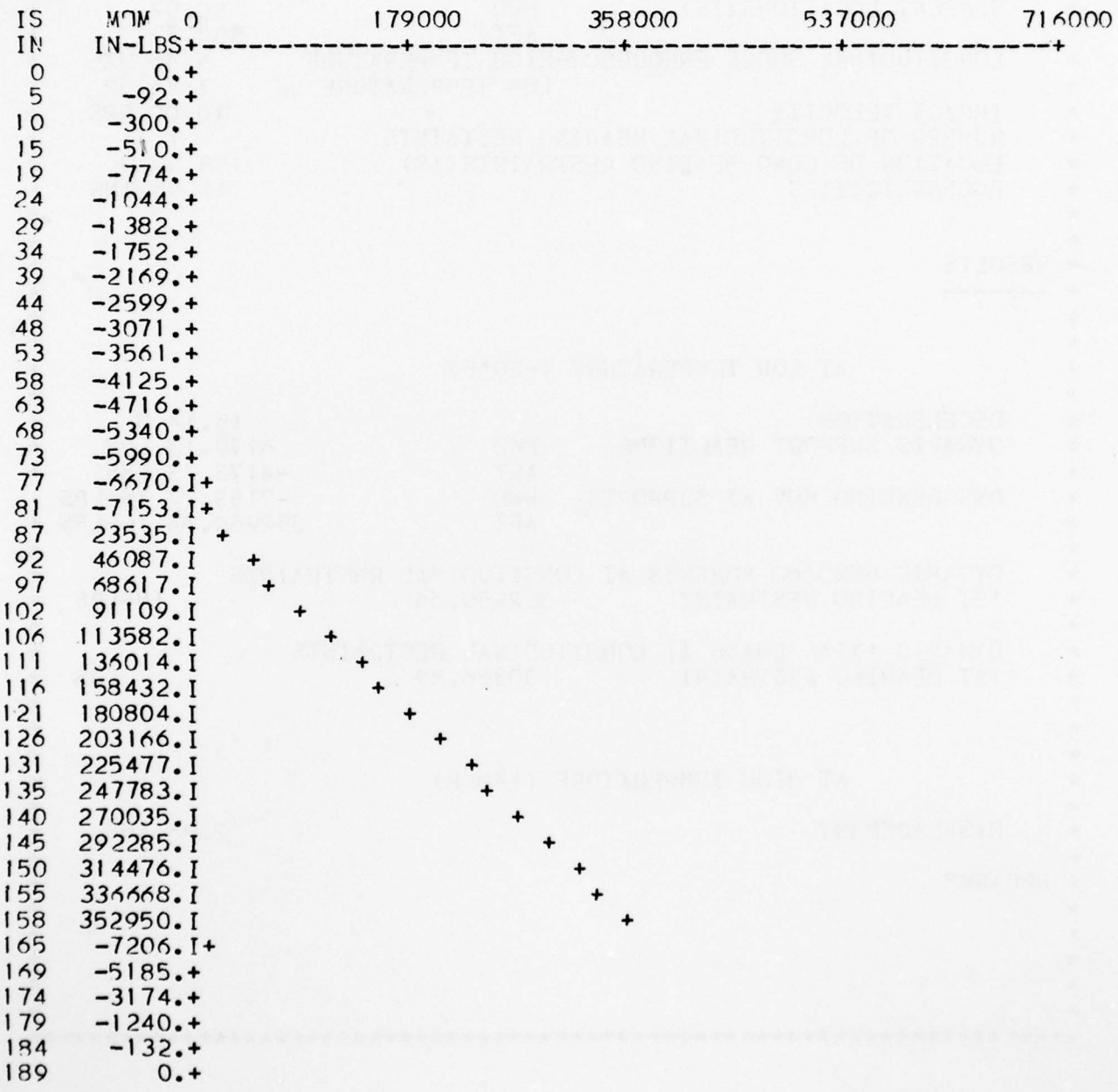
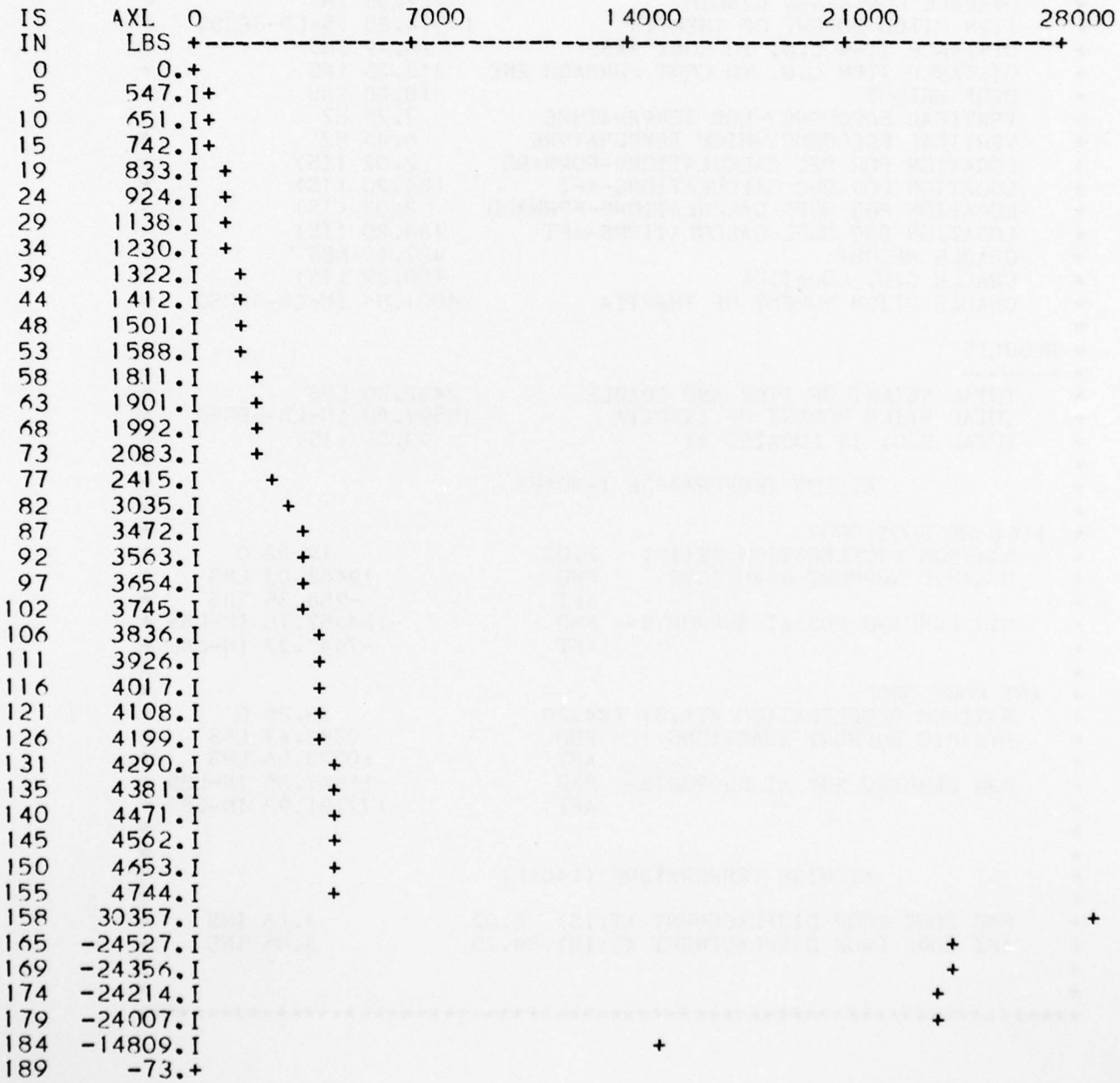


FIGURE B-3

DYNAMIC AXIAL LOADS
10 FPS END IMPACT



ROTATIONAL EDGEWISE DROP
HARPOON MISSILE CANISTER

INPUT PARAMETERS

HALF MOUNT SPACING	65.00	INS
SUPPORT LOCATIONS(IS) FWD	80.52	
AFT	158.39	
OVERALL CONTAINER LENGTH	217.00	INS
ITEM PITCH MOMENT OF INERTIA	14574.80	IN-LB-SECSQ
DISTANCE ITEM C.G. TO CONT BASE	25.19	INS
DISTANCE ITEM C.G. TO CONT FORWARD END	112.25	INS
DROP HEIGHT	18.00	INS
VERTICAL FREQUENCY-LOW TEMPERATURE	7.76	HZ
VERTICAL FREQUENCY-HIGH TEMPERATURE	6.46	HZ
LOCATION FOR DEC CALCULATIONS-FORWARD	2.02	(IS)
LOCATION FOR DEC CALCULATIONS-AFT	184.20	(IS)
LOCATION FOR DSPL CALCULATIONS-FORWARD	2.02	(IS)
LOCATION FOR DSPL CALCULATIONS-AFT	184.20	(IS)
CRADLE WEIGHT	427.10	LBS
CRADLE C.G. LOCATION	100.39	(IS)
CRADLE PITCH MOMENT OF INERTIA	4021.86	IN-LB-SECSQ

RESULTS

TOTAL WEIGHT OF ITEM AND CRADLE		2432.50	LBS
TOTAL PITCH MOMENT OF INERTIA		18597.60	IN-LB-SECSQ
TOTAL C.G. IS LOCATED AT		99.55	(IS)

AT LOW TEMPERATURE (-20°F)

FORWARD EDGE DROP

MAXIMUM DECELERATION AT(IS)	2.02	19.22	G
DYNAMIC SUPPORT REACTIONS	FWD	19462.03	LBS
	AFT	-958.35	LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-124657.70	IN-LBS
	AFT	-7547.32	IN-LBS

AFT EDGE DROP

MAXIMUM DECELERATION AT(IS)	184.20	18.20	G
DYNAMIC SUPPORT REACTIONS	FWD	9343.47	LBS
	AFT	10023.56	LBS
DYN BENDING MOM AT SUPPORTS-	FWD	-11547.55	IN-LBS
	AFT	-177181.93	IN-LBS

AT HIGH TEMPERATURE (140°F)

FWD EDGE DROP DISPLACEMENT AT(IS)	2.02	3.16	INS
AFT EDGE DROP DISPLACEMENT AT(IS)	184.20	3.05	INS

TABLE B-3

ROTATIONAL EDGEWISE DROP SUMMARY

FIGURE B-4

PLOT OF DECELERATION AT ITEM STATIONS
FOR HALF-MOUNTSPACING 65 INCHES
FORWARD AND AFT DROPS AT -20°F
FORWARD DROP = +
AFT DROP = *

IS IN	FDC G	ADC G
0	19.43	-0.35
5	18.93	0.14
10	18.43	0.63
15	17.94	1.11
19	17.44	1.60
24	16.94	2.09
29	16.45	2.58
34	15.95	3.06
39	15.45	3.55
44	14.96	4.04
48	14.46	4.52
53	13.96	5.01
58	13.47	5.50
63	12.97	5.99
68	12.47	6.47
73	11.98	6.96
77	11.48	7.45
82	10.98	7.93
87	10.49	8.42
92	9.99	8.91
97	9.49	9.40
102	9.00	9.88
106	8.50	10.37
111	8.00	10.86
116	7.51	11.34
121	7.01	11.83
126	6.51	12.32
131	6.02	12.80
135	5.52	13.29
140	5.02	13.78
145	4.53	14.27
150	4.03	14.75
155	3.54	15.24
160	3.04	15.73
165	2.54	16.21
169	2.05	16.70
174	1.55	17.19
179	1.05	17.68
184	0.56	18.16
189	0.06	18.65

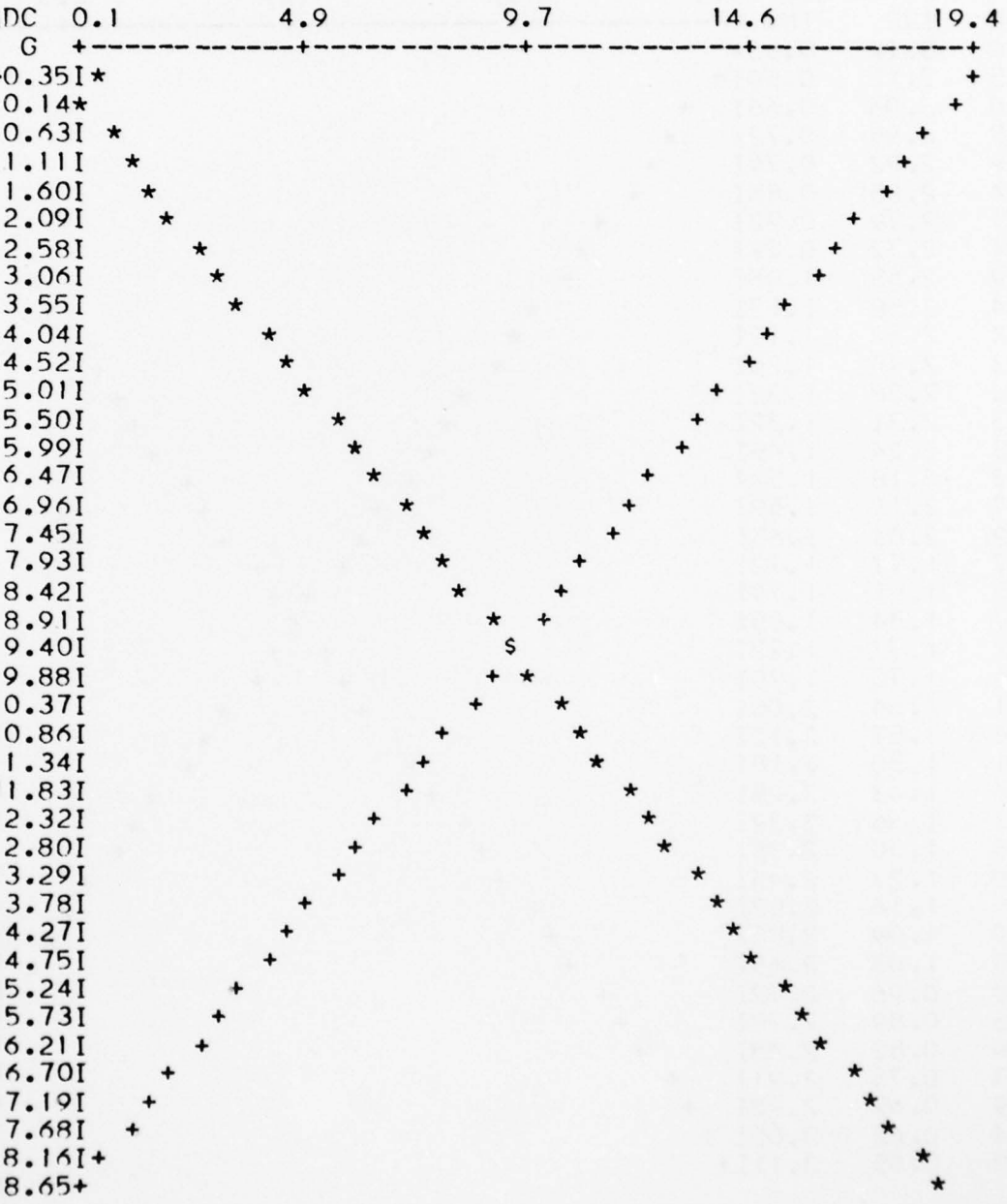
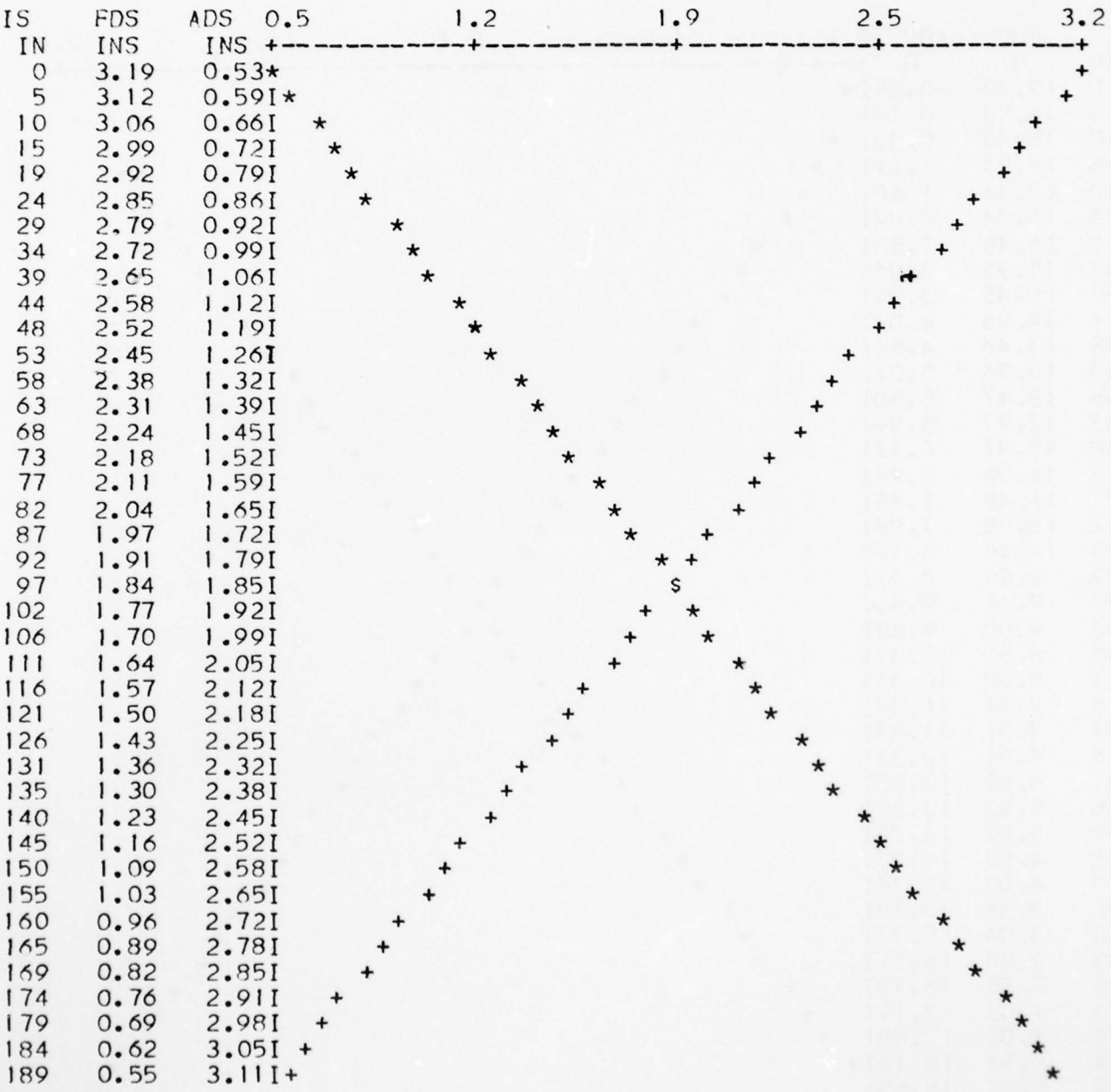


FIGURE B-5

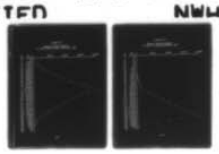
PLOT OF DISPLACEMENT AT ITEM STATIONS
FOR HALF-MOUNTSPACING 65 INCHES
FORWARD AND AFT DROPS AT 140°F
FORWARD DROP = +
AFT DROP = *

IS IN	FDS INS	ADS INS
0	3.19	0.53
5	3.12	0.59
10	3.06	0.66
15	2.99	0.72
19	2.92	0.79
24	2.85	0.86
29	2.79	0.92
34	2.72	0.99
39	2.65	1.06
44	2.58	1.12
48	2.52	1.19
53	2.45	1.26
58	2.38	1.32
63	2.31	1.39
68	2.24	1.45
73	2.18	1.52
77	2.11	1.59
82	2.04	1.65
87	1.97	1.72
92	1.91	1.79
97	1.84	1.85
102	1.77	1.92
106	1.70	1.99
111	1.64	2.05
116	1.57	2.12
121	1.50	2.18
126	1.43	2.25
131	1.36	2.32
135	1.30	2.38
140	1.23	2.45
145	1.16	2.52
150	1.09	2.58
155	1.03	2.65
160	0.96	2.72
165	0.89	2.78
169	0.82	2.85
174	0.76	2.91
179	0.69	2.98
184	0.62	3.05
189	0.55	3.11



AD-A055 719 NAVAL WEAPONS HANDLING CENTER COLTS NECK N J F/G 13/4
DYNAMIC ANALYSIS OF SHIPPING CONTAINER SUSPENSION SYSTEM FOR TH--ETC(U)
APR 78 Y TRASK
UNCLASSIFIED NWHC-7760 NL

2 OF 2
AD A055 719



END
DATE FILMED
8-78
DDC

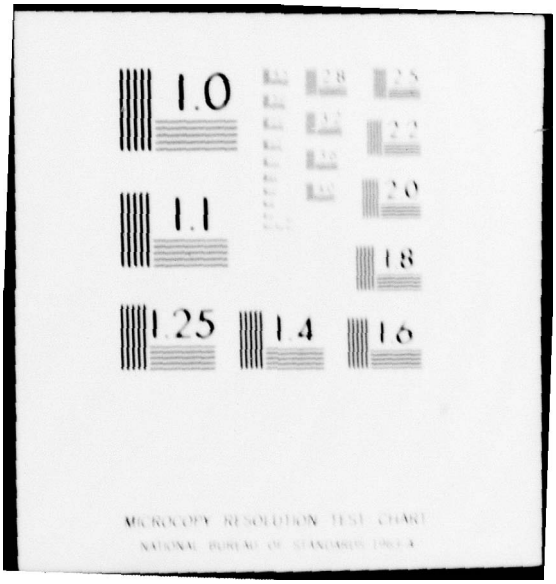

1.0
1.1
1.25
1.4
1.6
2.8
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

FIGURE B-6

DYNAMIC BENDING MOMENTS
18 INCH FORWARD EDGE ROTATIONAL DROP

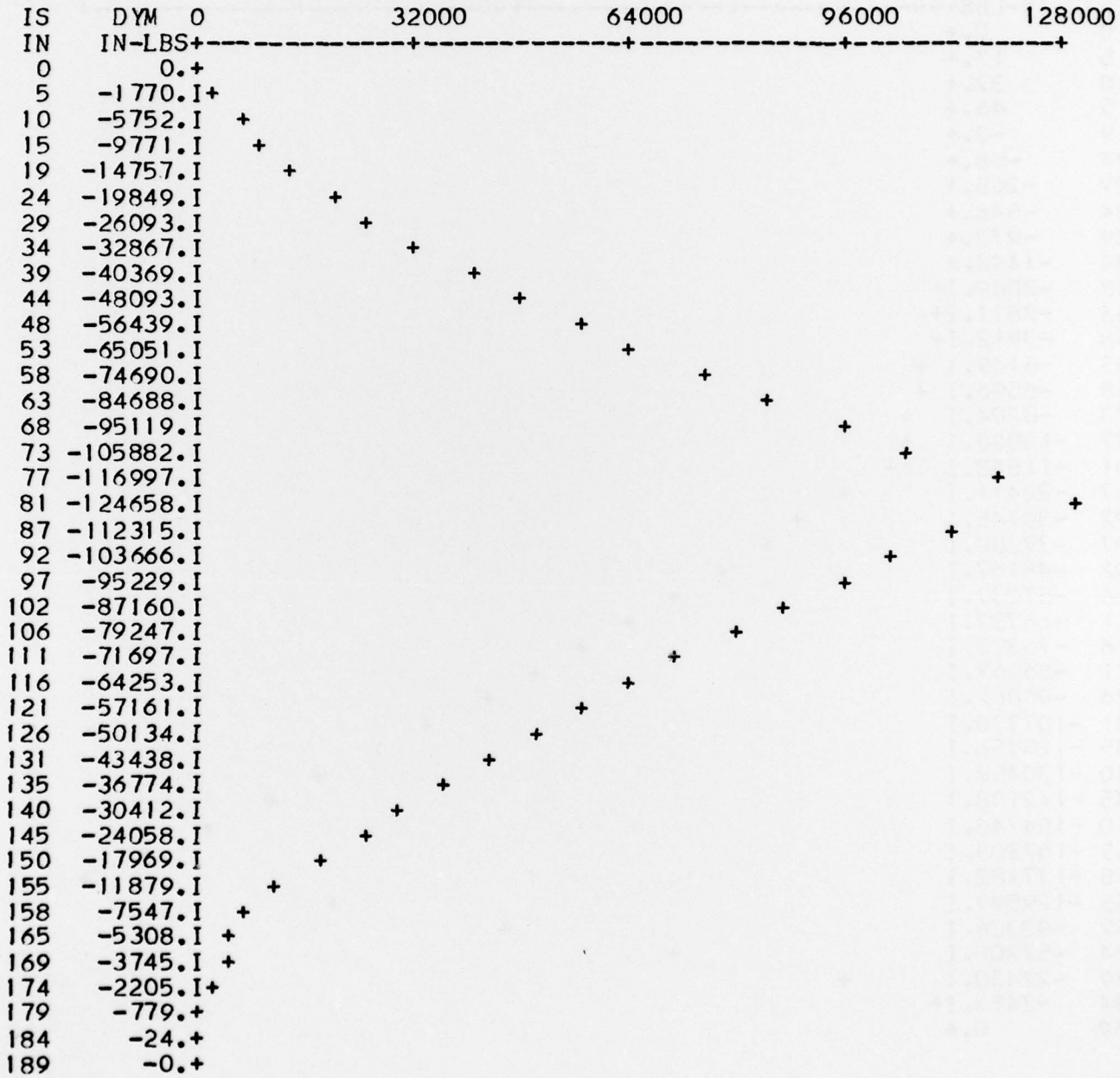


FIGURE B-7

DYNAMIC BENDING MOMENTS
18 INCH AFT EDGE ROTATIONAL DROP

