

UNCLASSIFIED

AD NUMBER
AD910278
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; 31 DEC 1972. Other requests shall be referred to Naval Air Development Center, Warminster, PA 18974.
AUTHORITY
NADC ltr dtd 31 Oct 1973

THIS PAGE IS UNCLASSIFIED

NAVAL AIR DEVELOPMENT CENTER

WARMINSTER, PA. 18974

REPORT NO. NADC-72136-VT

31 Dec 1972

DETERMINATION OF THE LUG AND SWAY BRACE REACTIONS
FOR THE MAU-9/A BOMB RACK

FINAL REPORT

AIRTASK 532000004
Work Unit No. A53213-1

Distribution limited to U. S. Government agencies only;
Test and Evaluation; Report Issue Date. Other requests
for this document must be referred to COMNAVAIRDEVGEN
or COMNAVAIRSYSCOM.



D D C
REGISTERED
JUN 1 1973
C

AD-910 278



DEPARTMENT OF THE NAVY
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA 18974

AIR VEHICLE TECHNOLOGY DEPARTMENT

REPORT NO. NADC-72136-VT

31 Dec 1973

DETERMINATION OF THE LUG AND SWAY BRACE REACTIONS
FOR THE MAU-9/A BOMB RACK

FINAL REPORT

AIRTASK 532000004
Work Unit No. A53213-1

This report summarizes a series of static load tests which were conducted at NAVAIRDEVCCEN (Naval Air Development Center) to develop a method of calculating the lug and sway brace reactions for the MAU-9/A Bomb Rack.

Prepared by: E. Kenkelen
E. KENKELEN

W. Wieseemann
W. WIESEMANN

Reviewed by: W. J. Bollinger
W. J. BOLLINGER
Head, Search and Rescue Sec

Approved by: L. A. Fuchs
L. A. FUCHS
Supt, Aircraft Subsystems Div

Distribution limited to U. S. Government agencies only; Test and Evaluation; Report Issue Date. Other requests for this document must be referred to COMNAVAIRDEVCCEN or COMNAVAIRSYSCOM.

SUMMARY

This report presents the results of a test program designed to determine the distribution of yawing moment and side load reactions between the sway braces and the lugs on the MAU-9/A Bomb Rack. Reference (a) develops the general design criteria for airborne stores and suspension equipment. Experience with bomb racks, however, has led to the conclusion that some of the assumptions in the specification, particularly the assumption regarding yawing moment distribution, may be in error. Consequently, it is necessary to identify, analyze, test, and possibly revise some of the basic assumptions composing the present design standards.

The actual test program involved a MAU-9/A Bomb Rack subjected to simulated in-flight loads. Known loads were applied by means of hydraulic jacks, and the reactions of the rack were determined by means of strain gages and piezotron load cells installed at the 30-in. hooks and sway braces, respectively. Tests clearly demonstrate that some of the assumptions specified in reference (a) are not applicable to the MAU-9/A Bomb Rack or to other bomb racks with similar hook and sway brace configurations. The evaluation techniques employed and the resultant test data are presented for the MAU-9/A Bomb Rack. It is recommended for the MAU-9/A that for yawing moments less than 60,000 in.-lb, 50 percent be reacted by the sway braces and 50 percent by the lugs. For yawing moments greater than 60,000 in.-lb, 30,000 in.-lb should be reacted by the sway braces and the remainder by the lugs. It is also recommended that the side load distribution as presented in reference (a) remain unchanged. It is further recommended that effort be undertaken to revise reference (a) so that it will contain a more realistic, but still conservative, yawing moment distribution which will be applicable to all suspension equipment.

"PRECEDING PAGE BLANK-NOT FILMED."

TABLE OF CONTENTS

	<u>Page</u>
SUMMARY.	iii
LIST OF FIGURES.	v
LIST OF TABLES	vi
LIST OF SYMBOLS.	vii
SECTION I. INTRODUCTION	1
SECTION II. TEST CONFIGURATION.	2
SECTION III. OBJECTIVE.	9
SECTION IV. DISTRIBUTION TEST RESULTS	9
SECTION V. COMBINED LOADS TESTING	15
SECTION VI. CONCLUSIONS AND RECOMMENDATIONS	29
SECTION VII. ADDITIONAL INFORMATION	31
SECTION VIII. REFERENCES.	31

LIST OF FIGURES

<u>Figure No.</u>	<u>Description</u>	<u>Page</u>
1	MAU-9/A Bomb Rack Test Setup Showing Instrumentation.	3
2	MAU-9/A Bomb Rack Test Setup Showing Detail of Instrumentation	4
3	MAU-9/A Bomb Rack Test Setup.	5
4	MAU-9/A Bomb Rack Test Setup Showing Deflection Due to Yawing Moment.	6
5	MAU-9/A Bomb Rack Test Setup (Side View) Showing Strain Gage Instrumentation	7
6	MAU-9/A Bomb Rack Test Setup Showing Detail of a Load Cell	8
7	Average Yawing Moment Reaction at the Sway Braces .	10
8	Average Yawing Moment Reaction at the 30-In. Lugs . .	11
9	Average Percentage Side Load Reaction	14
10	Combined Loads Test No. 1 - Forward Left Brace . . .	18
11	Combined Loads Test No. 1 - Aft Left Brace.	19
12	Combined Loads Test No. 2 - Forward Left Brace. . . .	20
13	Combined Loads Test No. 2 - Aft Left Brace.	21
14	Combined Loads Test No. 2 - Aft Right Brace	22
15	Combined Loads Test No. 3 - Forward Left Brace. . . .	23
16	Combined Loads Test No. 3 - Forward Right Brace . . .	24
17	Combined Loads Test No. 3 - Aft Right Brace	25
18	Combined Loads Test No. 4 - Forward Left Brace. . . .	26
19	Combined Loads Test No. 4 - Forward Right Brace . . .	27
20	Combined Loads Test No. 4 - Aft Left Brace.	27
21	Combined Loads Test No. 4 - Aft Right Brace	28

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
I	Derivation of Yaw Trap and Sway Brace Design Reactions	13
II	Loads Applied in Combined Loads Testing	16
III	Combined Loads Test Results	17

LIST OF SYMBOLS

P_y	Total side load applied at store C.G.	lb
M_z	Total yawing moment applied (about the store's C.G.)	in.-lb
l	Fore-and-aft distance from store C.G. to lug	in.
$\bar{l}$	Fore-and-aft distance from store C.G. to sway brace	in.
θ	Angle between vertical plane and the line-of-action of sway braces in a fore-and-aft view	deg
R	Lug reaction	lb
$\bar{V}$	Vertical Component of each sway brace reaction	lb
a	Indicates that the quantity pertains to an aft lug or sway brace	
f	Indicates that the quantity pertains to a forward lug or sway brace	
x,y,z	Subscript indicating that the reaction "R" is a component acting in the direction indicated by the subscript	

I. INTRODUCTION

A. The test evaluation presented in this report investigates the validity of three basic assumptions stated in the appendix of reference (a). According to the specification, the assumptions are as follows:

1. The sway braces take compressive loads only. Lugs take only tensile loads in the vertical direction.

2. The two diagonally opposed sway braces react the torque induced by the yawing moment, M_z , or it may be reacted by differential action of the forward and aft sway braces on the same side.

3. In general, the lug and associated suspension structure are assumed to be very rigid with respect to the sway brace and strong-area structure.

B. By considering only the reactions to purely compressive loads, assumption (1) effectively ignores the tendency of a store to slip under the sway brace pad's surface. This tendency, however, is always present as a result of elastic deformations developed in both the rack (suspension structure) and the store, and the wedge-like effect provided by the sway brace pads. Any normal compressive force acting on the sway brace pad also generates a proportionate frictional shear force acting parallel to the surface of the pad. Assumption (1) completely eliminates such frictional effects in the load analysis. Assumption (1) also states that the lugs withstand only vertical tensile loads. However, experience in bomb rack testing has indicated that the hooks may be required to withstand side loads as well as down loads. Thus, any hooks designed to the present standard could prove to be structurally inadequate. The sway braces in the MAU-9/A Bomb Rack have been machined to provide an indentation which fits closely around the lug on the store. The purpose of this device, which has been designated a "yaw trap" is to relieve the hooks of the side load which would normally be imposed by the yawing moment.

C. Assumption (2) assumes that the sway braces alone react the entire applied yawing moment. This theory is questionable since definite lateral contact is likely to occur between the lugs and the side walls of the yaw traps due to the application of yawing moment. Therefore, it is highly probable that the yaw traps react a portion of the yawing moment. It is also expected that this portion is much greater than that reacted by the sway braces. Assumption (2) is conservative in regard to the sway braces, since it is unlikely that they react 100 percent of the applied yawing moment. Consequently, if the lugs and bomb rack are not designed for side load at their interface, the effects of a substantial yawing moment could be catastrophic.

D. According to assumption (3), the suspension structure is rigid with respect to the sway brace and strongback structure. Practical experience, however, does not seem to justify this theory. When subjected to

high flight loads, suspension structures may undergo large deflections. At the same time the sway braces are displaced by the action of the supporting structure and deflected by the action of the applied load. It is reasonable to assume that neither of these influences is negligible. Therefore, the relative rigidities of both the suspension structure and the sway brace structure should be equally considered.

II. TEST CONFIGURATION

A. The test setup (figures 1 and 2) was designed to accurately apply the forces and moments necessary for evaluating the validity of the previously stated assumptions. The MAU-9/A Bomb Rack (figure 3) was selected because of its relatively high sway brace strength and stiffness, and overall structural rigidity. This rack was expected to indicate a comparatively large sway brace reaction which would lead to conservative design criteria for the sway braces of less rigid bomb racks. Hydraulic jacks were employed for applying side load, vertical load, drag load, yawing moment and pitching moment directly to a simulated store. Strain gages were applied to the internal side walls of both 30-in. lugs in order to indicate the reactions at the yaw traps. These gages were calibrated for yawing moment (figure 4). The bomb rack 30-in. hooks were strain gaged and calibrated to read the hook reactions to vertical tension loads (figure 5). Semiconductor load cells were fitted on the sway brace pads (figure 6) and calibrated to read the normal reactions of the pads. Thus, with this test setup, the three reaction points in the rack (braces, yaw traps, and hooks) could be monitored for any type of loading.

B. Instrumentation

<u>Quantity</u>	<u>Type</u>
4	Kistler Instrument Corp Load Washers - Model Number 905A S/N 20175 S/N 20177 S/N 20176 S/N 20178
4	Kistler Instrument Corp. Universal Dial-Gain Charge Amplifiers - Model 504 S/N 129 S/N 458 S/N 130 S/N 1401
1	DC Micro-Volt-Ammeter MV-07C 62269 - USN 019383
1	Budd Instruments Div - Datran Digital Strain Indicator 62269 - USN 019136
4	Baldwin-Lima-Hamilton Corp SR-4 Strain Gages

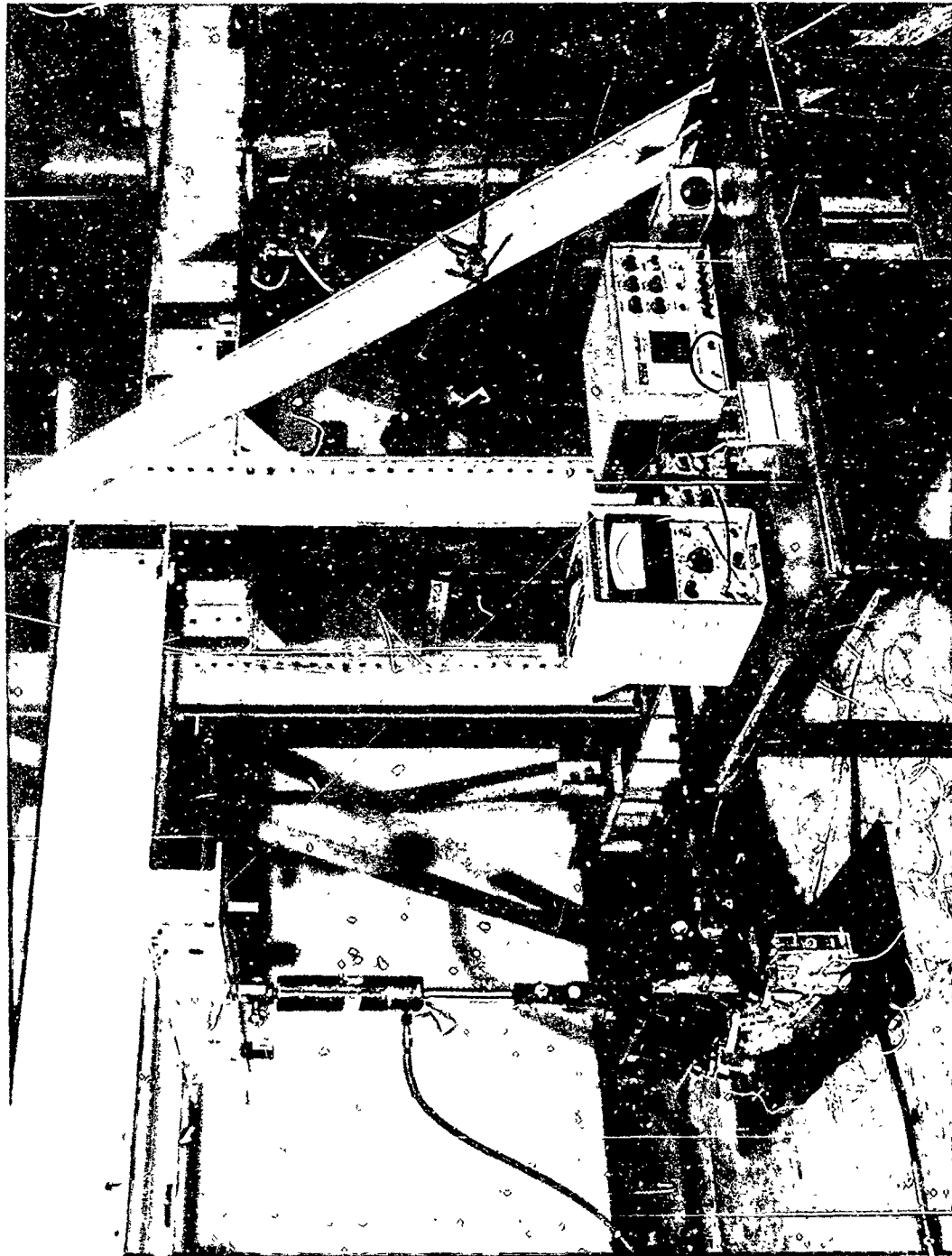


Figure 1. MAU-9/A Bomb Rack Test Setup Showing Instrumentation

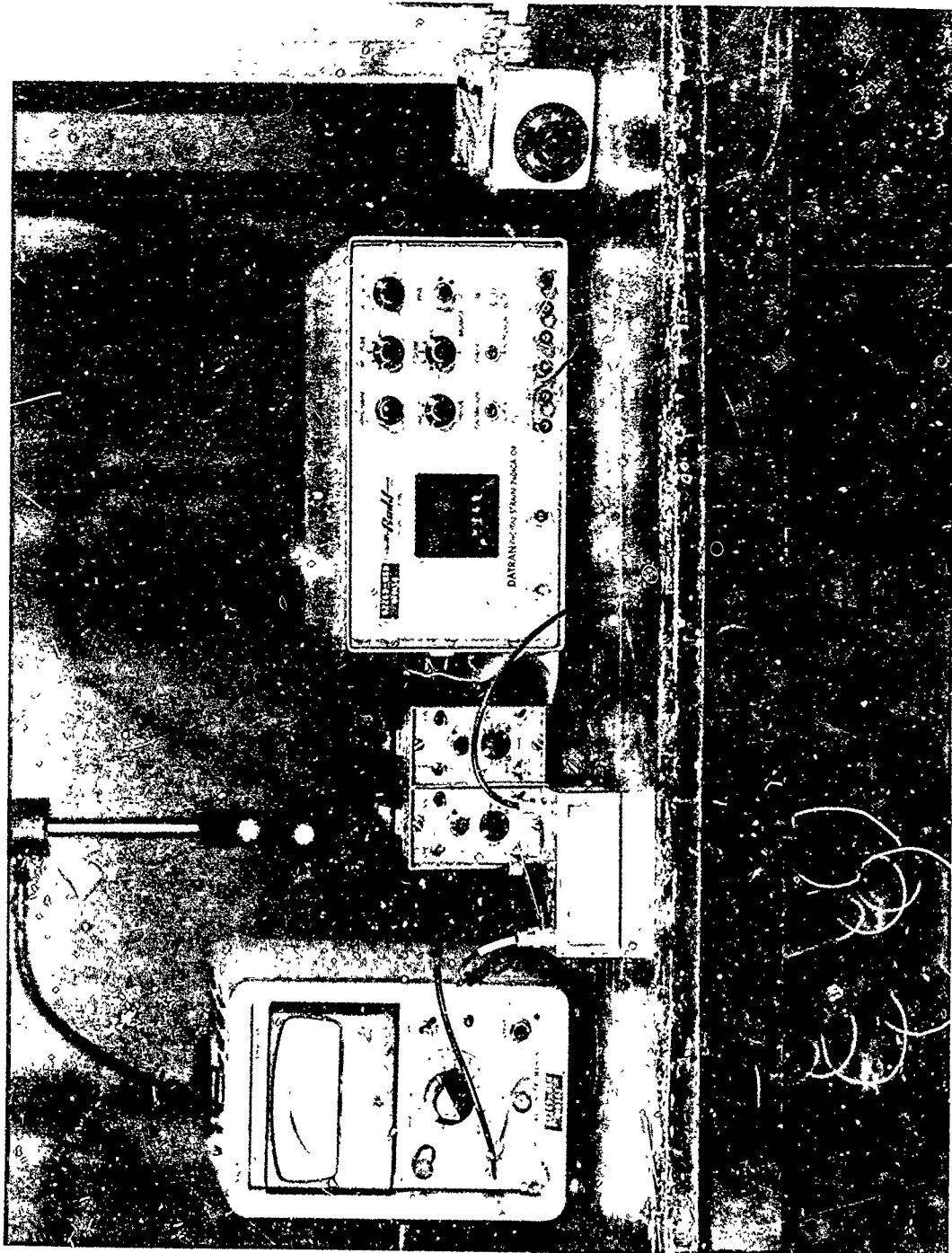


Figure 2. MAU-9/A Bomb Rack Test Setup Showing Detail of Instrumentation

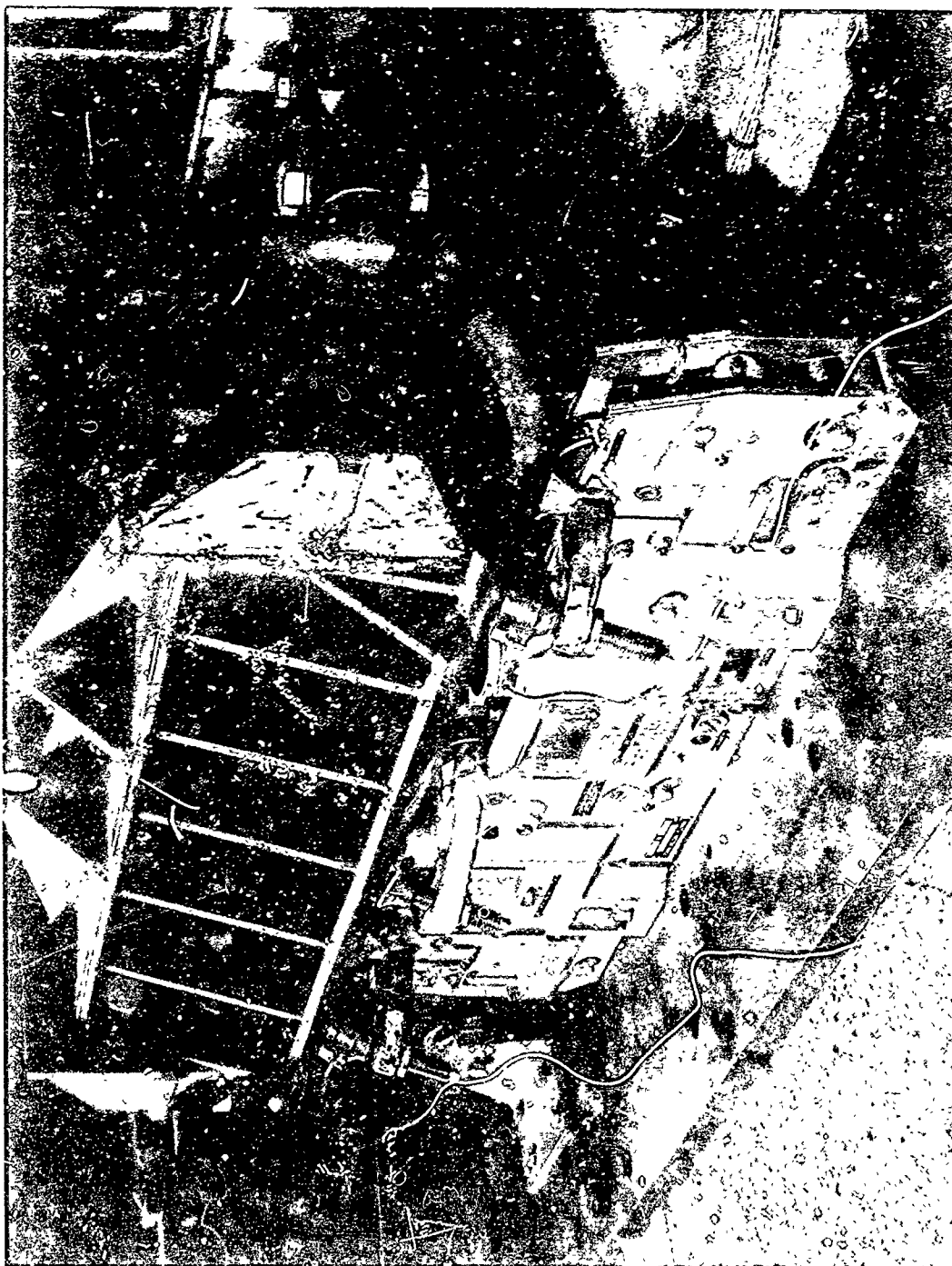


Figure 3. MAU-9/A Bomb Rack Test Setup

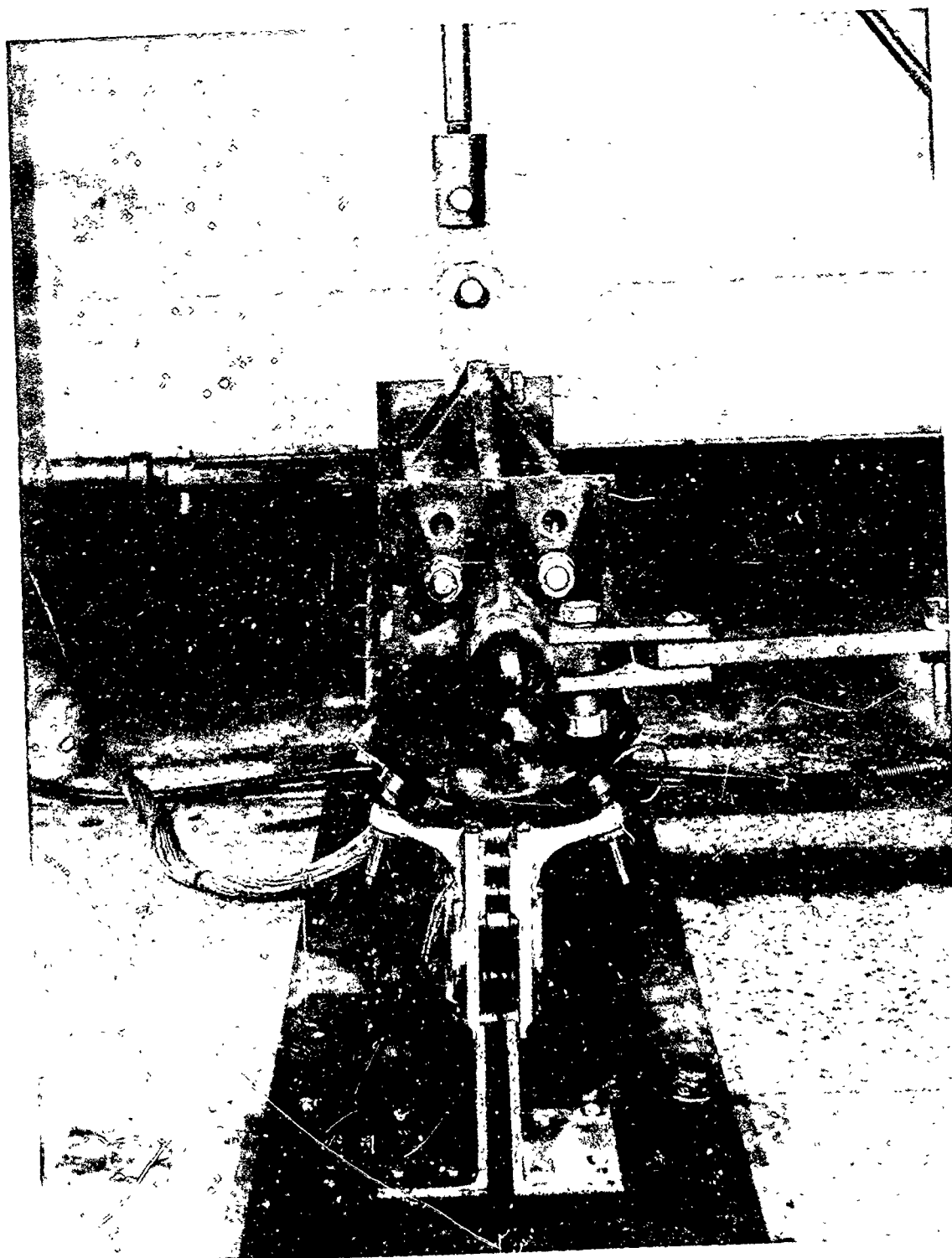


Figure 4. MAU-9/A Bomb Rack Test Setup Showing Deflection Due to Yawing Moment

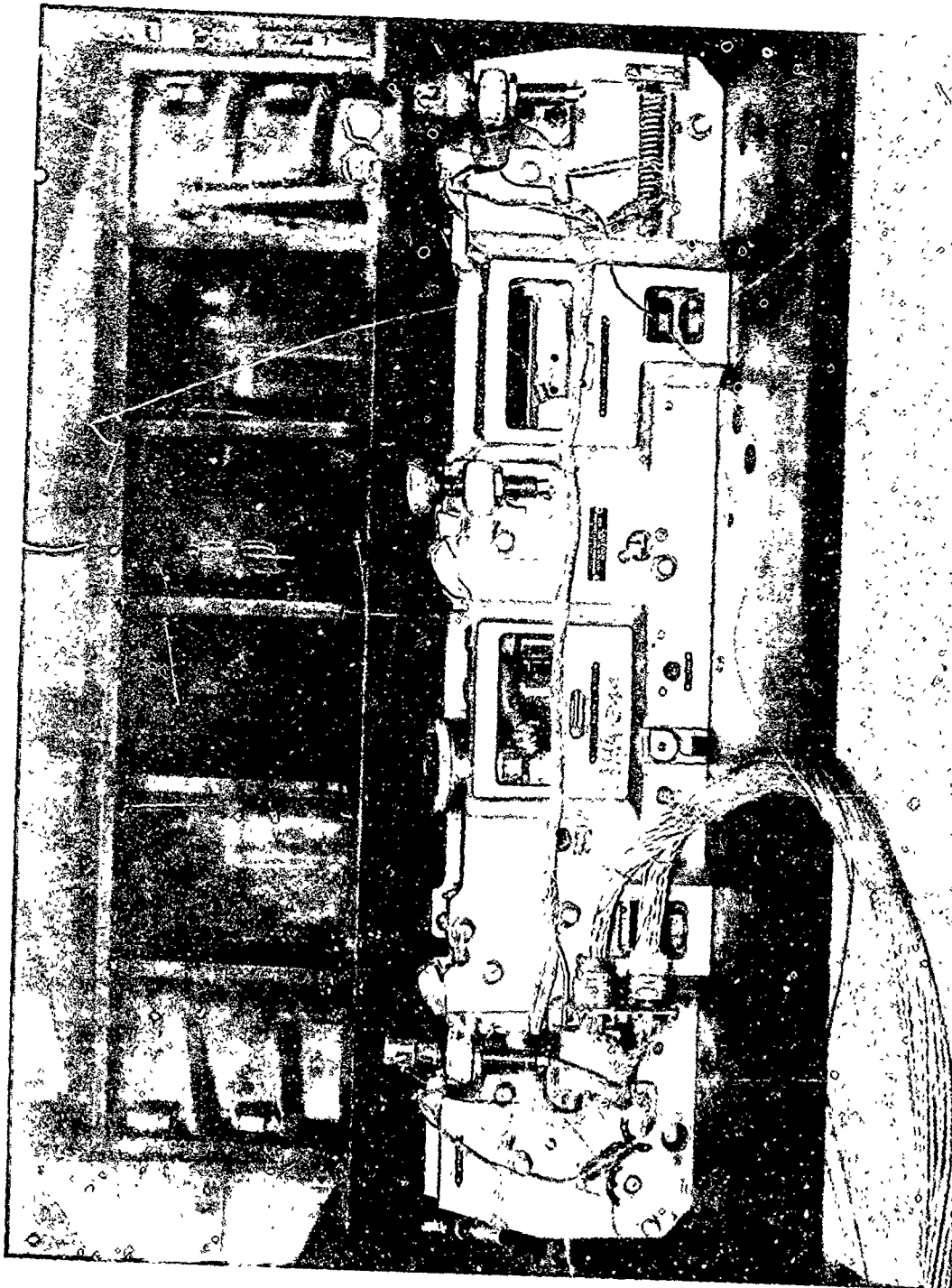


Figure 5. MAU-9/A Bomb Rack Test Setup (Side View) Showing Strain Gage Instrumentation

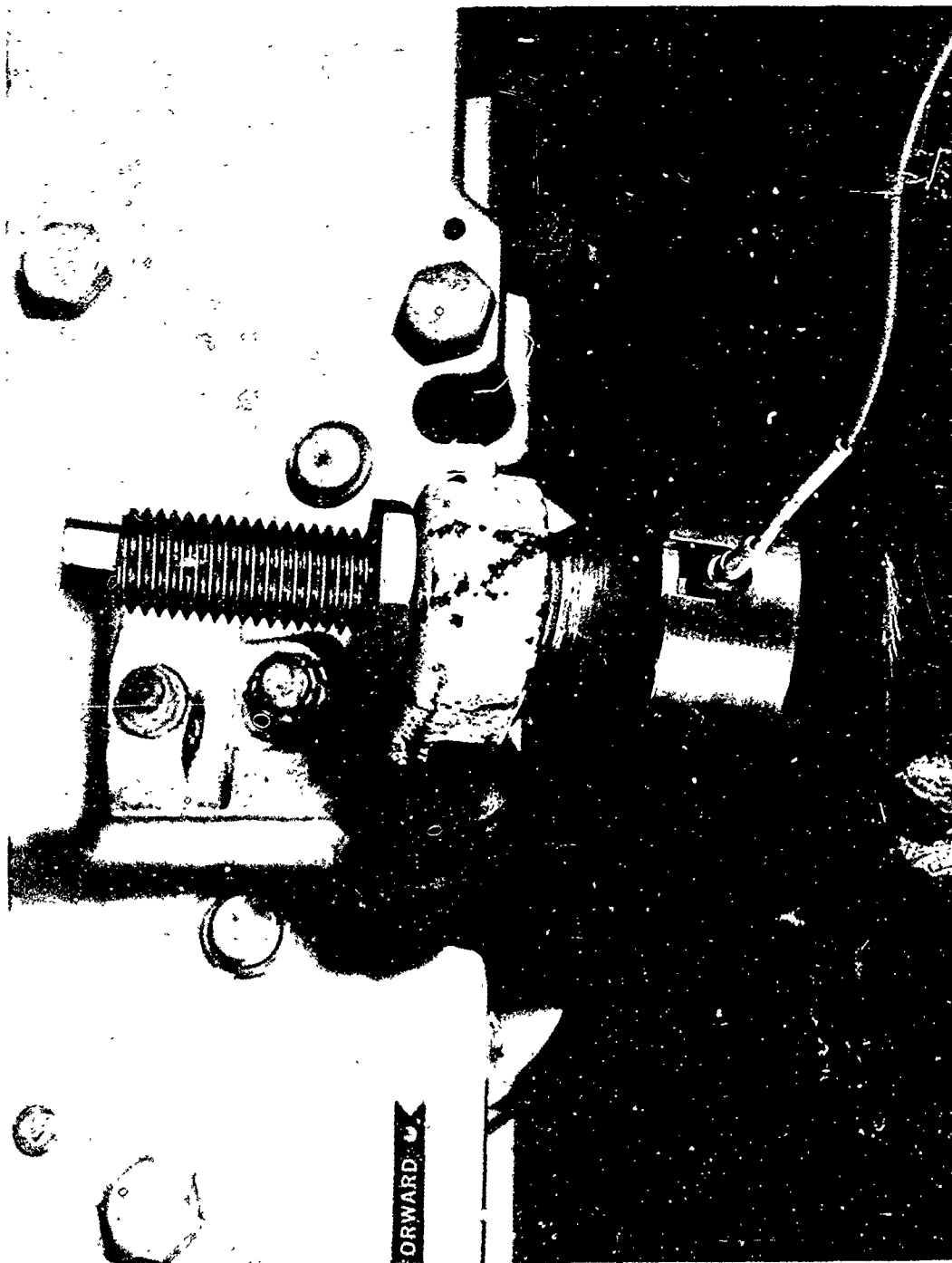


Figure 6. MAU-9/A Bomb Rack Test Setup Showing Detail of a Load Cell

III. OBJECTIVE

A. The primary objective of the test evaluation described in this report is to determine the distribution of yawing moment between the yaw traps and sway braces. The sway braces are expected to indicate an increase in reaction with an increase in yawing moment up to a certain level. At this level the braces should cease to exert any further increase in reaction, while the yaw traps provide the required increase in moment reaction. This could be the result of the structure's geometry and differential rigidities of the braces, yaw traps, and supporting structure. A second objective is to evaluate the loads experienced by the sway braces during the application of side load. In these tests, side load is applied at the center line of the store. Thus, there is an induced rolling moment (about the contact points of the sway brace pads) which will always accompany side load. It is expected that this rolling moment will increase the sway brace loads. Having calibrated the reaction points for each individual load, a reasonable prediction of the structure's reactions to a simultaneous application of all loads should be possible.

IV. DISTRIBUTION TEST RESULTS

A. The test program was initiated to establish a load distribution for all suspension equipment which would reveal the inherent deficiencies of the assumptions made in reference (a). The MAU-9/A Bomb Rack was utilized as the suspension structure throughout the testing. The sway braces on this bomb rack were felt to be relatively strong and rigid compared to other racks. Thus, it was expected that the reactions provided by these sway braces would be greater than those provided by the braces of most other suspension equipment. Since the loads in these tests were relatively high, the resulting sway brace design criteria were considered to be conservative for most in-service racks. The yaw trap or lug reactions also proved to be of major significance during the test program. Consequently, the percentage load distribution between the braces and 30-in. lugs developed from this test data should affect any future suspension equipment design.

B. Yawing Moment Tests

1. Figures 7 and 8 depict results of the yawing moment and initial preload tests which were conducted on the MAU-9/A Bomb Rack. Since the yawing moment test data provides sufficient information to develop two reaction curves for every preload yawing moment combination only average values of all the data recorded are considered in all cases. Pure yawing moment tests with zero preload reveal that more than 90 percent of the applied moment is accounted for by gauges monitoring the yaw traps and sway brace reactions. The remaining 10 percent could easily be attributed to frictional effects between the store and sway brace pads and/or between the store lugs and bomb rack hooks.

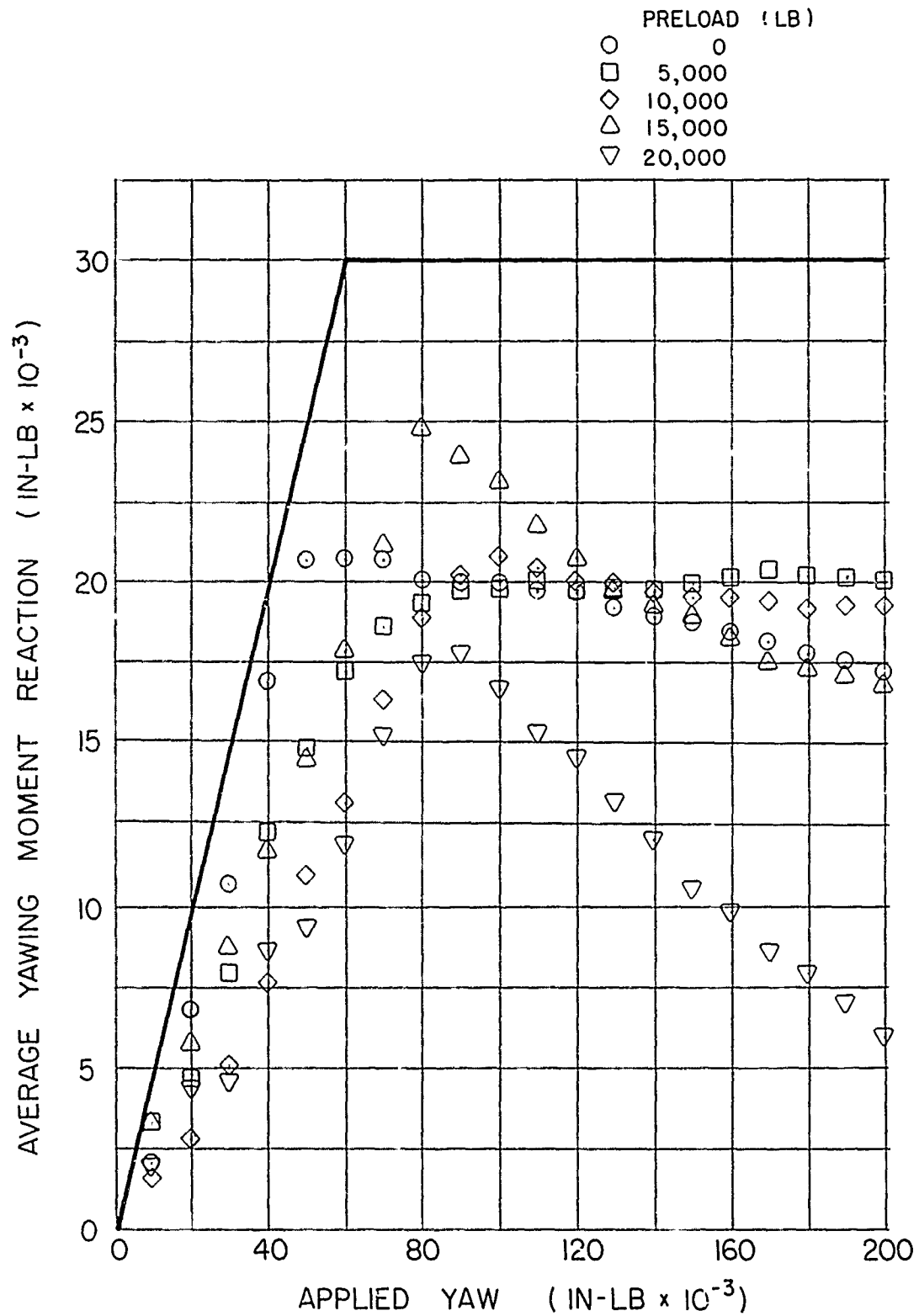


FIGURE 7. AVERAGE YAWING MOMENT REACTION AT THE SWAY BRACES

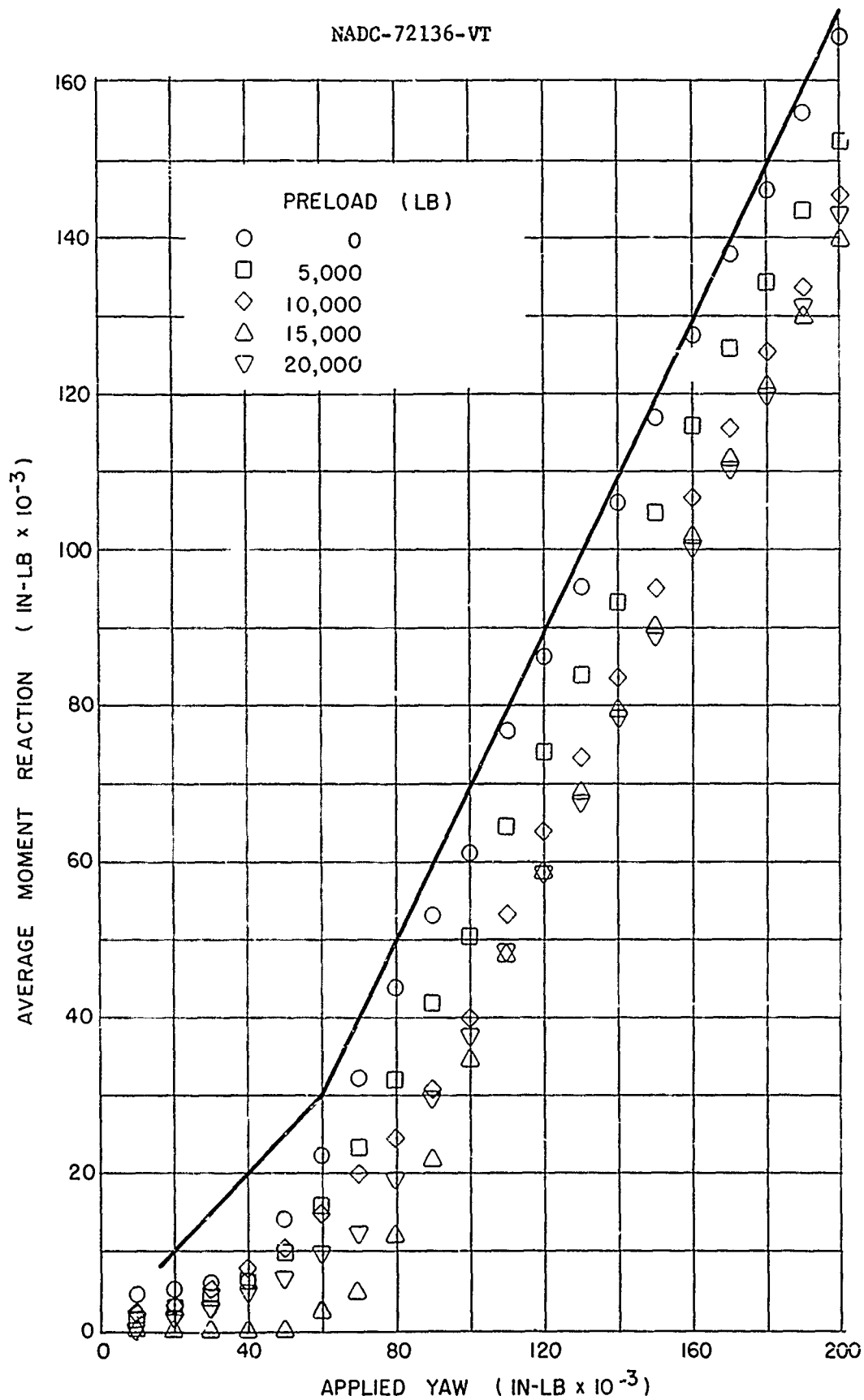


FIGURE 8. AVERAGE YAWING MOMENT REACTION AT THE 30 INCH LUGS

2. The tests involving 5000-, 10,000-, 15,000- and 20,000-lb preloads indicated a steady decrease of accountable reaction from the applied yawing moment as the initial preload was increased. The increase in preload apparently caused a corresponding increase in frictional effects which could not be monitored during the tests. At the maximum preload (20,000 lb) approximately 73 percent of the applied yawing moment was recorded on the instrumentation. It was possible to analytically demonstrate that the difference could be accounted for by friction at the hook and brace interfaces. Consequently, it can be concluded that friction forces can be quite significant at high preloads. However, the preload range selected for these tests, to demonstrate the influence of friction, was of a much higher magnitude than that normally encountered in service. Since more representative values of preload are on the order of 5000 lb, at which level frictional forces are not as significant, the interpretation of data will be limited to preloads at and below this magnitude.

3. The general trend in the range of 0 to 60,000 in.-lb of applied yawing moment, as can be observed from the curves, is for the sway braces, at a given preload, to increase uniformly in reaction while the yaw trap reactions remain in the relatively low range. In the upper applied moment range the converse occurs, and the yaw trap reactions steadily increase while the sway brace reactions remain relatively constant. This latter effect is a definite indication of the inability of the sway braces to provide reactions to significant yawing moments. When the lugs make contact with the side walls of the yaw traps, the sway braces essentially cease to resist any further increase in yawing moment.

4. A conservative design curve, independent of preload, was derived from the data by assuming that friction between the brace/store and the lug/yaw trap interface imposed a moment equal to the difference between the applied and measured moments. As indicated in Table I, the maximum recorded sway brace and yaw trap reactions selected from the acceptable preload range, were summed and subtracted from the applied moment to yield the moment induced by friction. This friction moment was then divided equally between the sway brace and yaw trap reactions to identify coordinates of the design curves. Figures 7 and 8 show the respective design curves and illustrate the magnitude of reaction attributable to friction. Several other distributions were assigned to fit the test data, but the best correlation with the combined load tests (Section V) was obtained using the recommended values.

C. Side Load Test

1. Figure 9, illustrating data from side load tests (10,000 lb max at zero preload), indicates that the sway brace readings account for essentially all of the reaction to the applied side load and accompanying rolling moment. Consequently, little frictional effect is experienced. The percentage reaction of the braces is scattered in the low load range

TABLE I
DERIVATION OF YAW TRAP AND SWAY BRACE DESIGN REACTIONS

Applied Yawing Moment	Test Range of Moment Reacted by Yaw Traps		Test Range of Moment Reacted by Sway Braces		Sum of Maximum Reactions		Friction Moment	Maximum Yaw Trap Reaction + $\frac{1}{2}$ Friction		Maximum Sway Brace Reaction + $\frac{1}{2}$ Friction	
	Zero		Zero		Zero			Approx Design Coordinate		Approx Design Coordinate	
	Preload	5000 Preload	Preload	5000 Preload	Preload	5000 Preload					
0	0	0	0	0	0	0	0	0	0	0	0
10	4.2	1.2	2	3.2	6.2	4.4	3.8	6	5	11	5
20	5	2	7	5	12	7	8	9			
30	6	4	11	8	17	12	13	12			
40	6	6	17	12	23	18	17	14			
50	14	10	21	15	35	25	15	21			
60	22	16	21	17	43	33	17	30			
80	43	32	20	19	63	51	17	51			
100	61	50	20	20	81	70	19	70			
120	86	74	20	20	106	94	14	93			
140	106	93	19	20	125	113	15	113			
160	127	116	18	20	145	136	15	134			
180	146	134	18	20	164	154	16	154			
200	166	153	17	20	183	173	17	174			

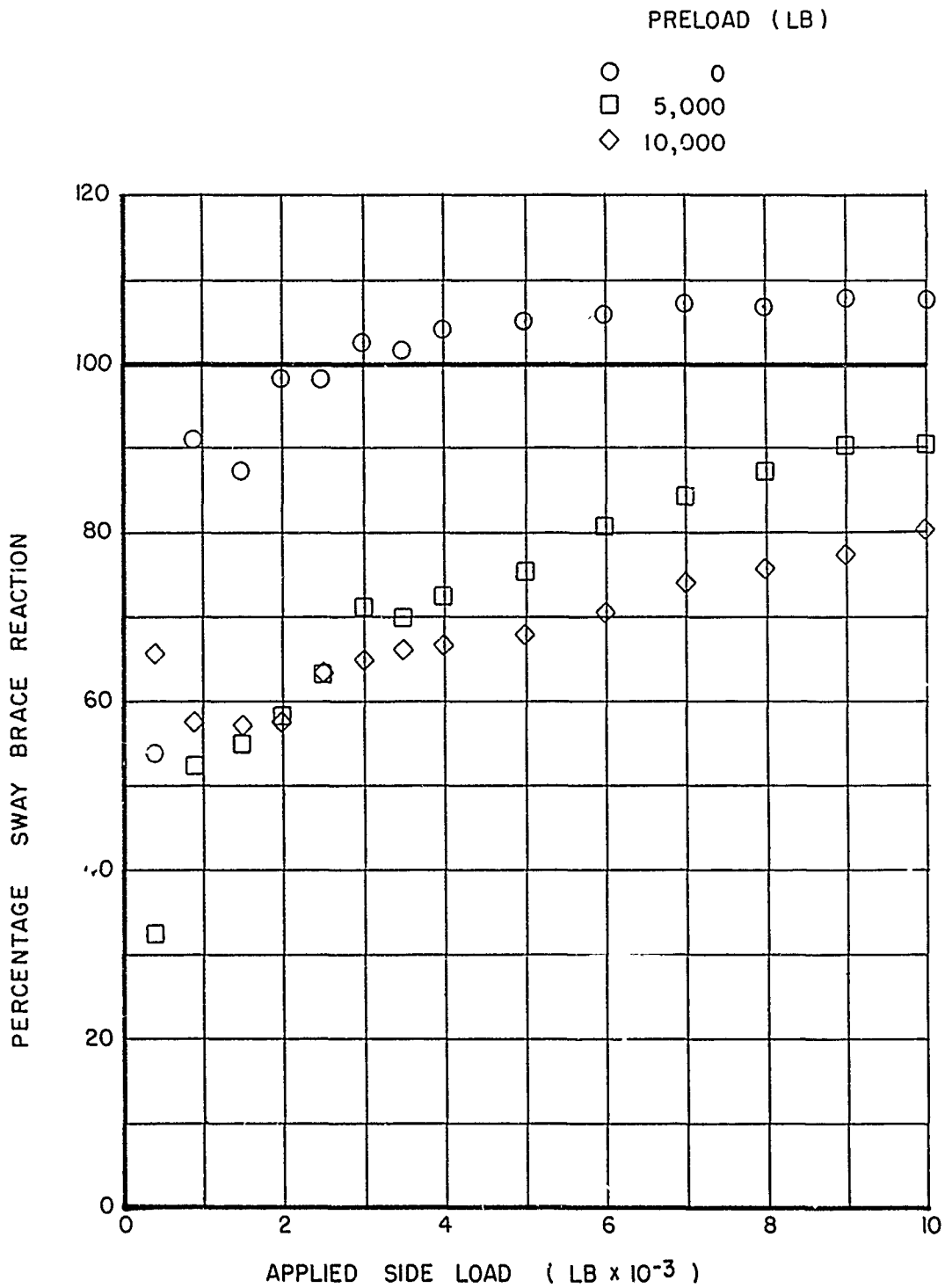


FIGURE 9. AVERAGE PERCENTAGE SIDE LOAD REACTION

(0 - 2000 lb), but rapidly levels off to a value between 100-110 percent of applied load in the high side load range (2000-10,000 lb).

2. The final side load tests involving 5000- and 10,000-lb preloads provide less satisfactory, but acceptable, data. With an increase in initial preload, less side load reaction is accounted for by the sway braces. This is caused by the fact that the increasing side load relieves the preload on the opposite side braces. However, in each case, the same general trend of sway brace reaction is observed. The percentage brace reactions in the respective trials are found to be scattered in the low side load range, but approach a magnitude of approximately 80-100 percent of applied load in the upper range.

V. COMBINED LOADS TESTING

A. Combined loads tests under simulated flight load conditions were conducted at NAVAIRDEVCON to investigate the validity of a proposed distribution of yawing moment reaction different from that given in reference (a). The loads applied in the combined loads tests are shown in table II. The results of these combined loads tests are presented in table III and in figures 10 to 21, inclusive. These plots show the sway brace loads taken from the average test results and those calculated from unmodified reference (a) calculations. Also shown are sway brace reaction predictions of two modified yawing moment distributions considered for recommendation. It can be seen that all of the sway brace predictions were affected significantly by redistributing the yawing moment. It should be noted that in some cases the modified predictions were higher on certain sway braces than the unmodified predictions. This is due to the absence of the subtracting effect of yawing moment and side load. In every test, however, the maximum sway brace load determined by distributing the yawing moment is lower than the maximum sway brace load calculated by the method in reference (a).

B. Figure 11 is an extreme example of this phenomenon. The loading on the aft sway braces of Test No. 1 is due only to side load and yawing moment, with side load tending to load the left brace and yawing moment loading the right-hand brace. By assuming that all of the yaw is reacted at the sway braces, the yawing moment dominates the side load in this case and the aft right sway brace loads, while the aft left brace feels zero load. With the revised prediction, however, only a small percentage of the yawing moment reacts at the sway braces. In this particular case the side load actually dominates, and the aft left sway brace should feel load rather than the aft right. The actual testing verified the fact that the aft left brace is loaded and not the aft right. Figure 19 is another such case where the reference (a) prediction errs in the same manner.

C. The combined loads tests were chosen so that with the revised yawing moment distribution there would be one test for each of the four possible loading cases in reference (a). Figures 10, 14, 15, 17, and 21

TABLE II
LOADS APPLIED IN COMBINED LOADS TESTING

	P_x (LB X 10^{-3})	P_y (LB X 10^{-3})	P_z (LB X 10^{-3})	M_y (IN.-LB X 10^{-3})	M_z (IN.-LB X 10^{-3})
TEST 1					
20% Limit	0.67	1.33	-0.33	16.67	26.67
40% Limit	1.33	2.67	-0.67	33.33	53.33
60% Limit	2.00	4.00	-1.00	50.00	80.00
80% Limit	2.67	5.33	-1.33	66.67	106.67
100% Limit	3.33	6.67	-1.67	83.33	133.33
TEST 2					
20% Limit	0.67	1.33	2.33	-23.33	26.67
40% Limit	1.33	2.67	4.67	-46.67	53.33
60% Limit	2.00	4.00	7.00	-70.00	80.00
80% Limit	2.67	5.33	9.33	-93.33	106.67
100% Limit	3.33	6.67	11.67	-116.67	133.33
TEST 3					
20% Limit	0.67	-0.67	1.40	40.00	26.67
40% Limit	1.33	-1.33	2.80	80.00	53.33
60% Limit	2.00	-2.00	4.20	120.00	80.00
80% Limit	2.67	-2.67	5.60	160.00	106.67
100% Limit	3.33	-3.33	7.00	200.00	133.33
TEST 4					
20% Limit	0.67	0.67	3.33	6.67	26.67
40% Limit	1.33	1.33	6.67	13.33	53.33
60% Limit	2.00	2.00	10.00	20.00	80.00
80% Limit	2.67	2.67	13.33	26.67	106.67
100% Limit	3.33	3.33	16.67	33.33	133.33

TABLE III
COMBINED LOUS TEST RESULTS

	FWD - LEFT BRACE			FWD - RIGHT BRACE			AFT - LEFT BRACE			AFT - RIGHT BRACE		
	Ref (a) Predictions	25% Up to 60,000 in.-lb Modification Prediction	Average Test Results	Ref (a) Predictions	25% Up to 60,000 in.-lb Modification Prediction	Average Test Results	Ref (a) Predictions	25% Up to 60,000 in.-lb Modification Prediction	Average Test Results	Ref (a) Predictions	25% Up to 60,000 in.-lb Modification Prediction	Average Test Results
TEST NO. 1												
20% Limit	3228	1894	1192	0	0	0	0	772	462	561	0	0
40% Limit	6455	3788	3000	0	0	0	0	1545	788	1122	0	0
60% Limit	9683	6349	4508	0	0	0	0	2317	1250	1683	0	0
80% Limit	12910	7132	6565	0	0	0	0	3534	1638	2244	0	0
100% Limit	16138	8582	8529	0	0	0	0	4751	2694	2804	0	0
TEST NO. 2												
20% Limit	3228	1894	2723	0	0	0	838	1532	638	1389	760	185
40% Limit	6455	3788	5451	0	0	0	1677	2405	1700	2798	1521	785
60% Limit	9683	6349	7829	0	0	0	2513	4599	3323	4198	2281	1416
80% Limit	12910	7132	9400	0	0	0	3353	6512	5517	5597	2829	2700
100% Limit	16138	8582	10768	0	0	0	4192	8127	9067	6996	3376	3184
TEST NO. 3												
20% Limit	1688	991	647	635	1271	800	0	0	0	2386	1053	739
40% Limit	3375	1981	1147	1270	2542	1998	0	0	0	4772	2106	1069
60% Limit	5063	2972	1757	1905	3813	3220	0	0	0	7159	3129	1577
80% Limit	6751	4079	2576	2576	5183	4600	0	0	0	11391	4276	1935
100% Limit	8439	4468	3240	3174	6179	6600	0	0	0	11391	4276	1935
TEST NO. 4												
20% Limit	2503	1644	1948	0	474	118	273	947	550	1442	783	516
40% Limit	5005	3288	4058	0	949	518	545	1895	1006	2884	1567	716
60% Limit	7508	4931	6605	0	1423	1441	818	2842	2011	4326	2350	1231
80% Limit	10011	6353	7800	0	2120	1715	1091	4012	3468	5768	2911	1431
100% Limit	12513	7774	9077	0	2817	1993	1363	5181	5396	7110	3472	2066

NOTE: All values are in lb.

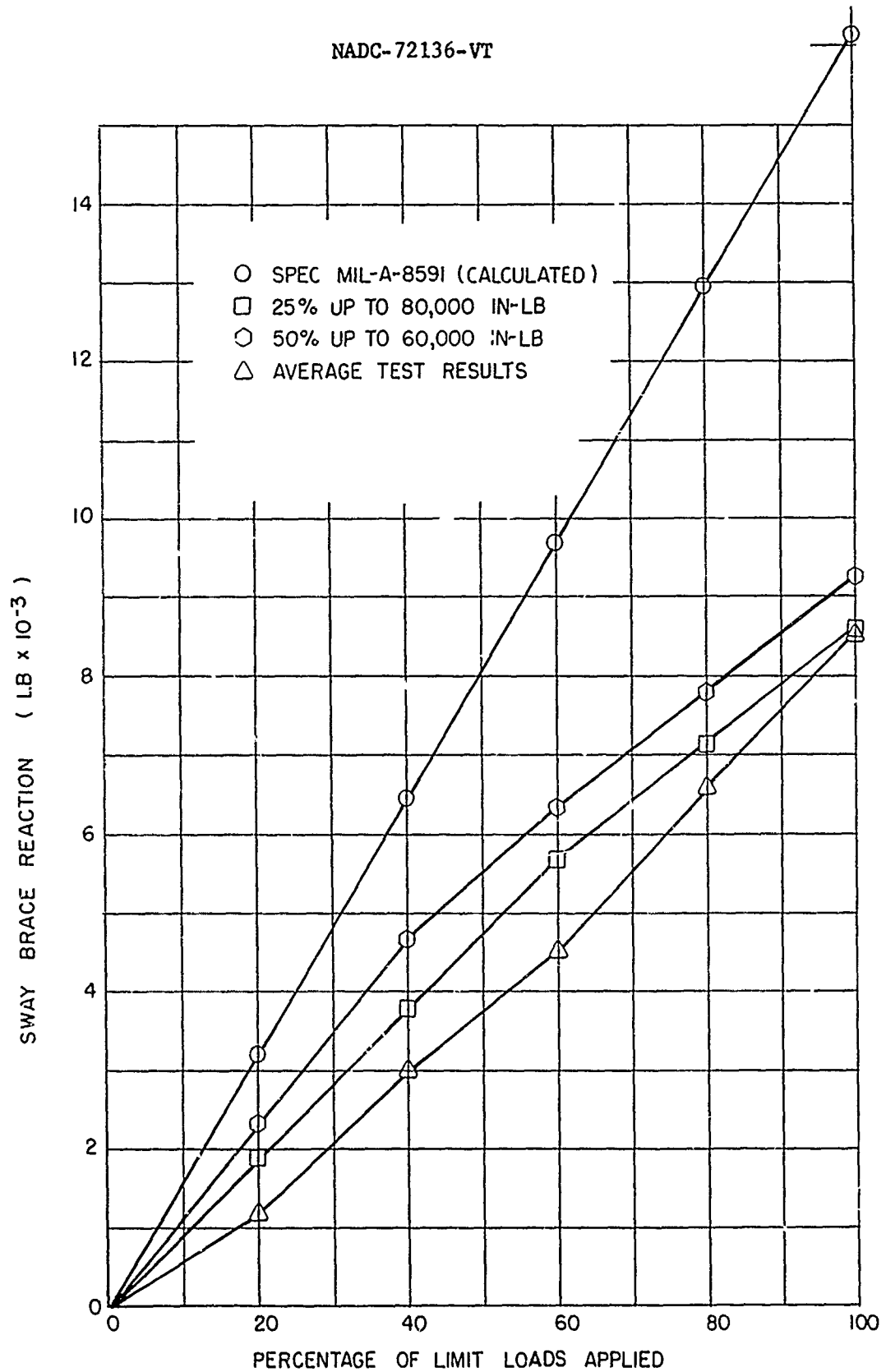


FIGURE 10. COMBINED LOADS TEST NO. 1 FORWARD LEFT BRACE

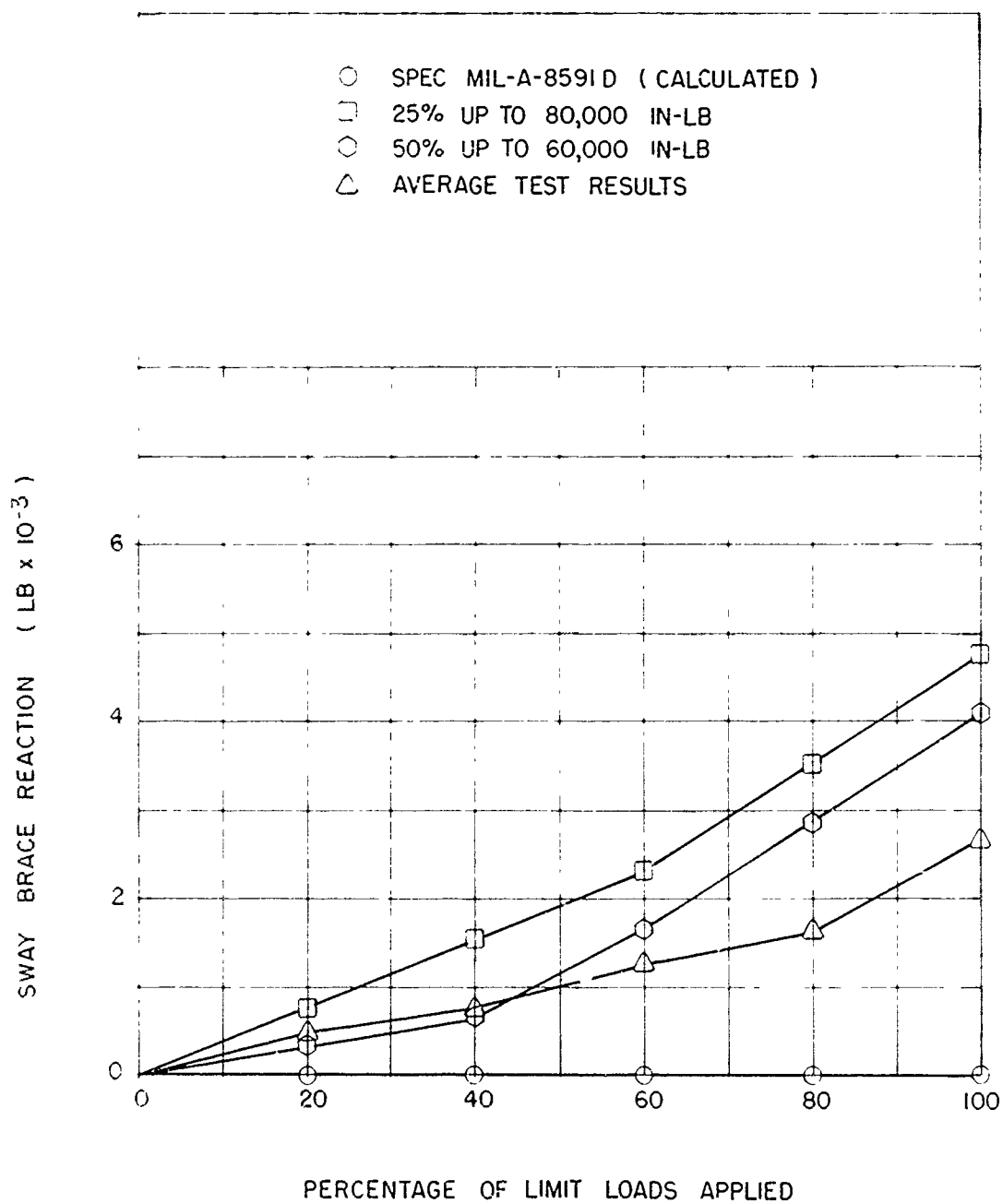


FIGURE II. COMBINED LOADS TEST NO.1 AFT LEFT BRACE

NADC-72136-VT

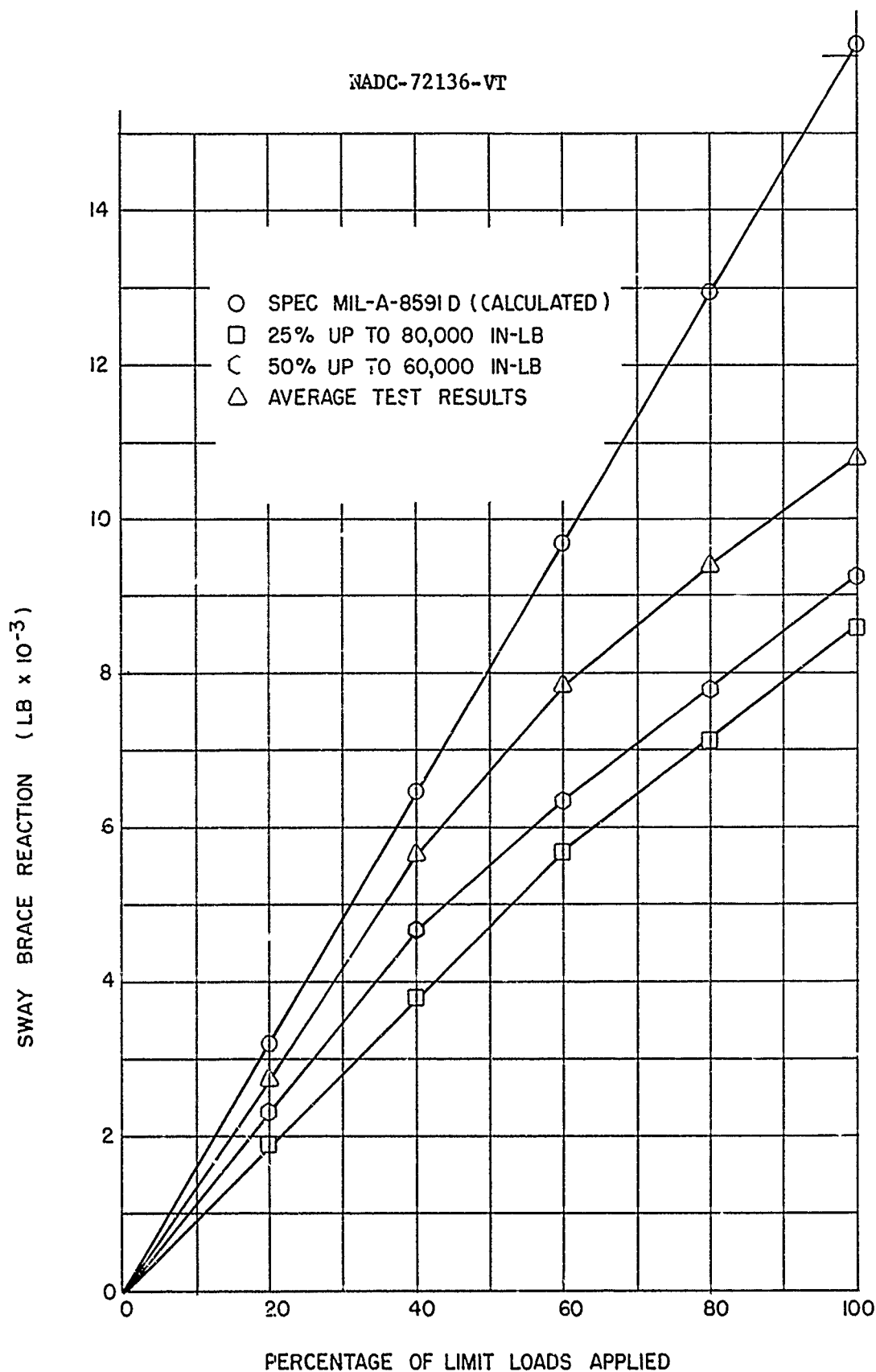


FIGURE 12. COMBINED LOADS TEST NO. 2 FORWARD LEFT BRACE

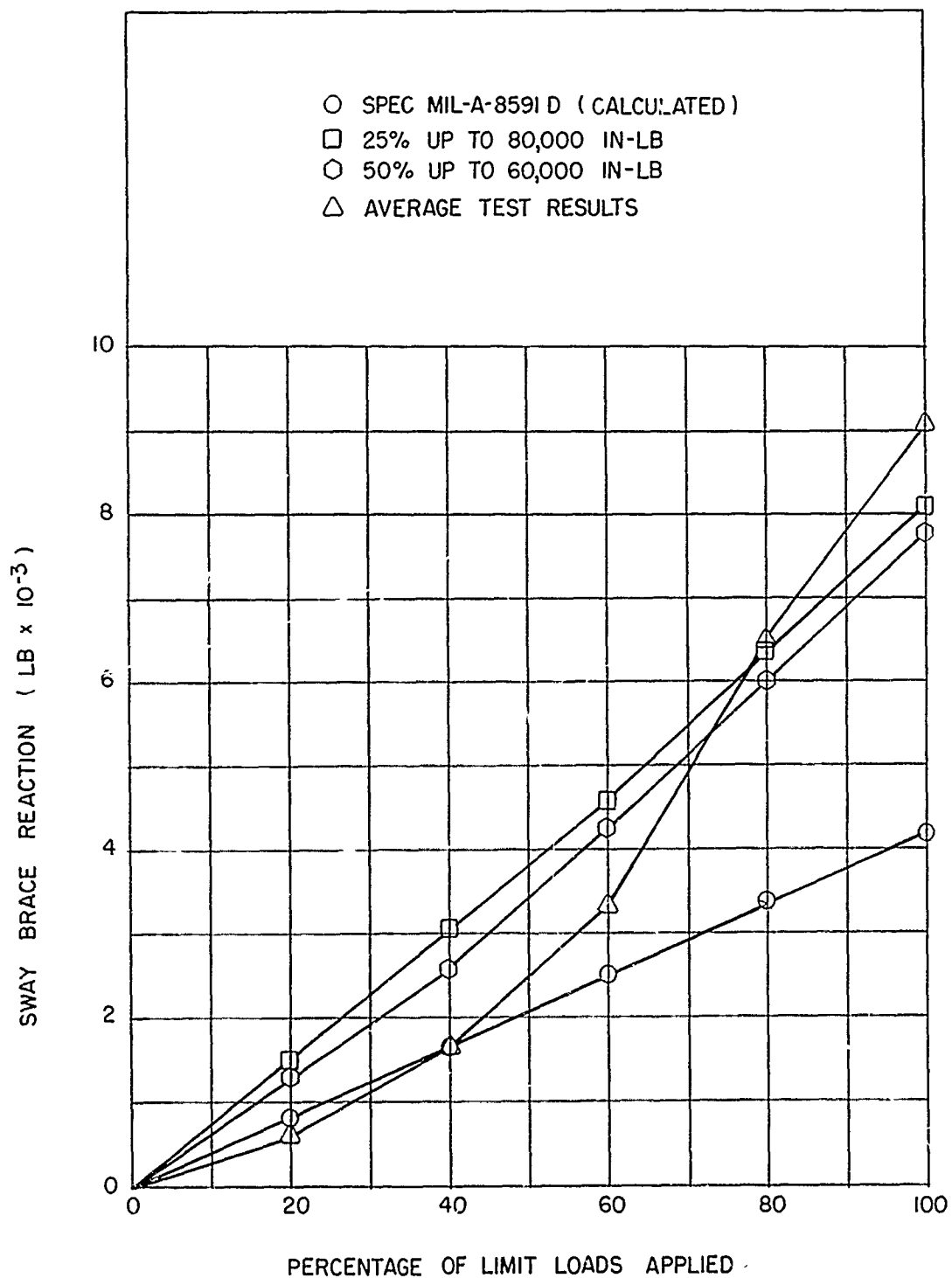


FIGURE 13. COMBINED LOADS TEST NO. 2 AFT LEFT BRACE

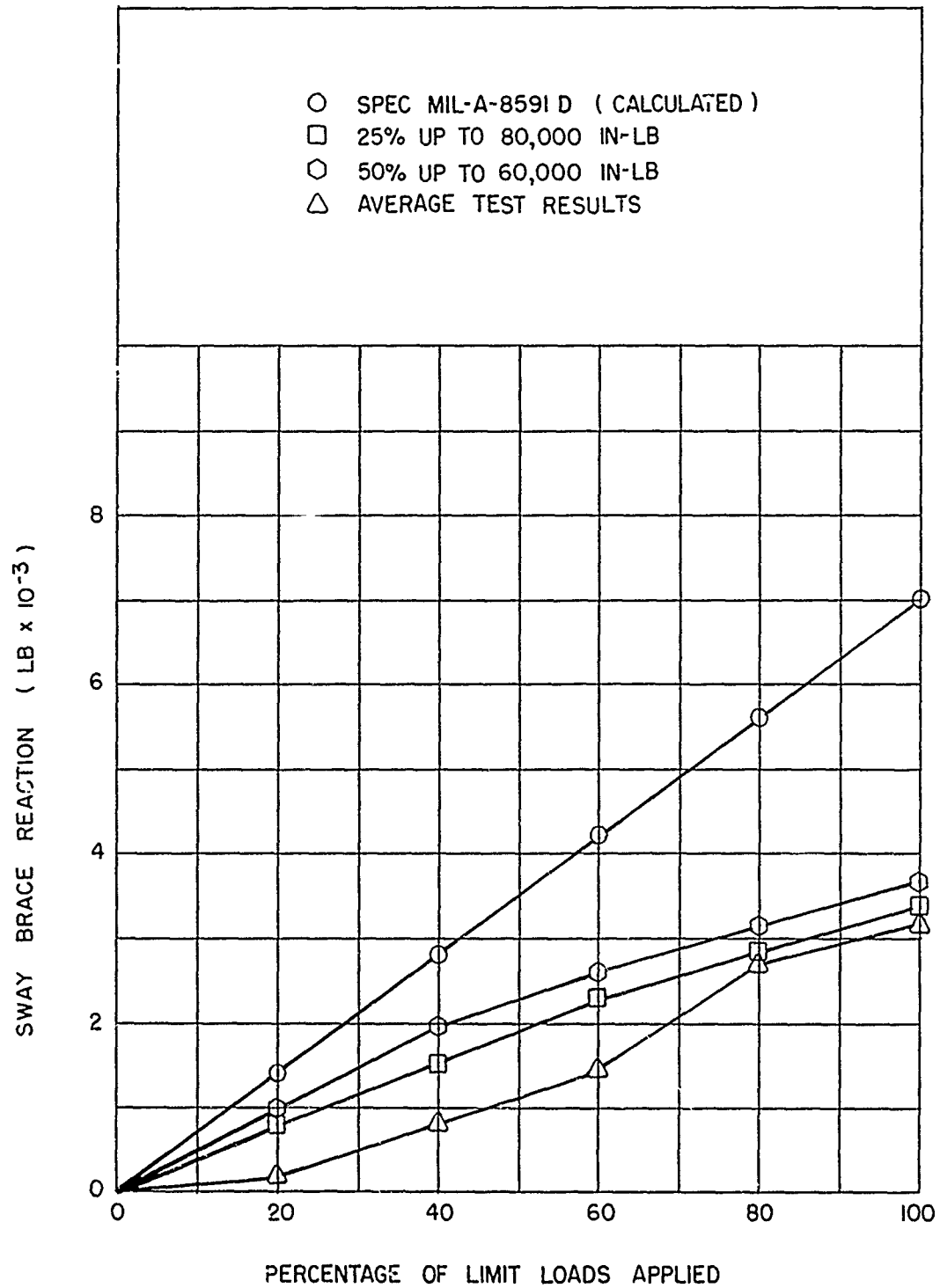


FIGURE 14. COMBINED LOADS TEST NO. 2 AFT RIGHT BRACE

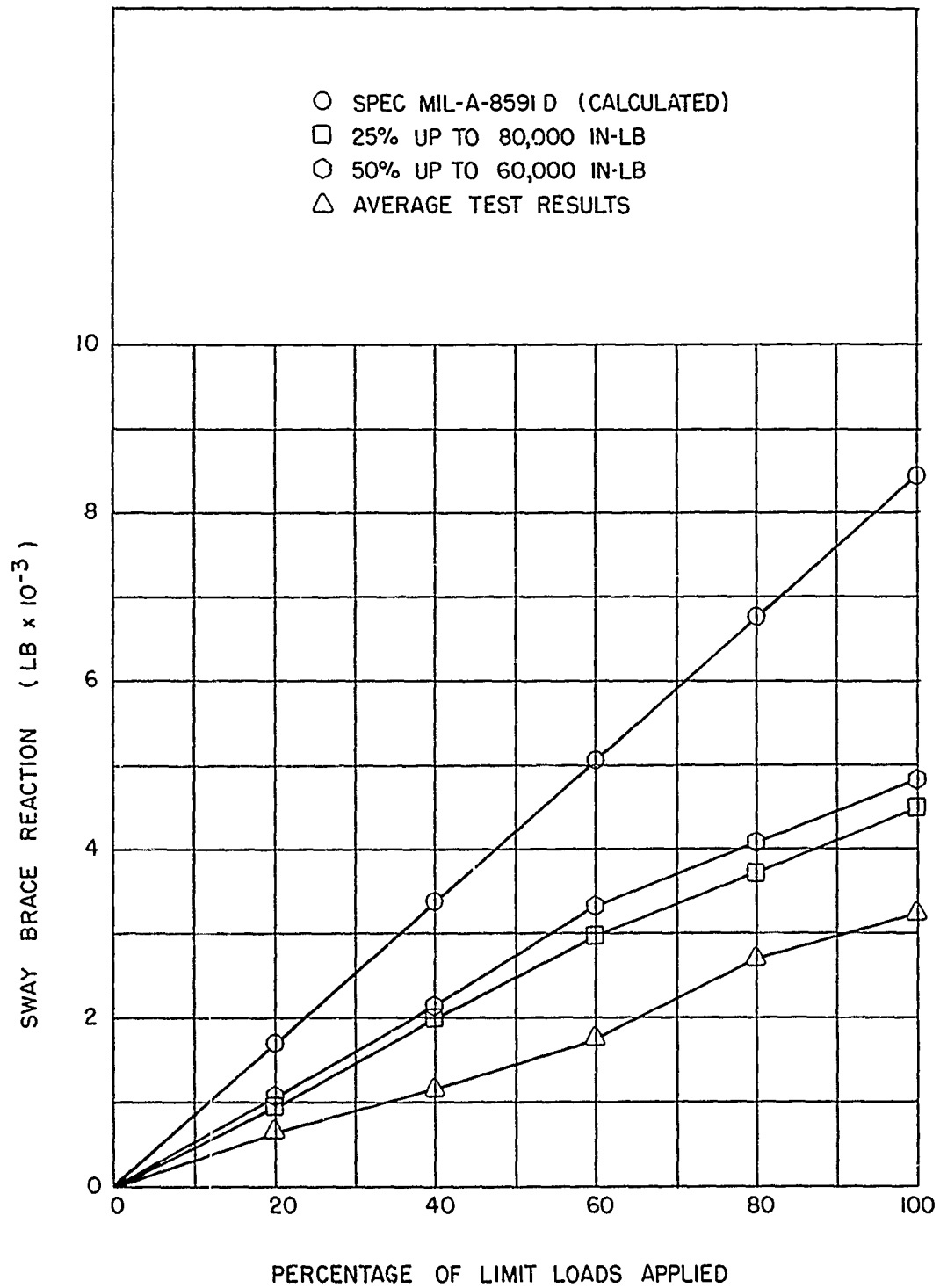


FIGURE 15. COMBINED LOADS TEST NO. 3 FORWARD LEFT BRACE

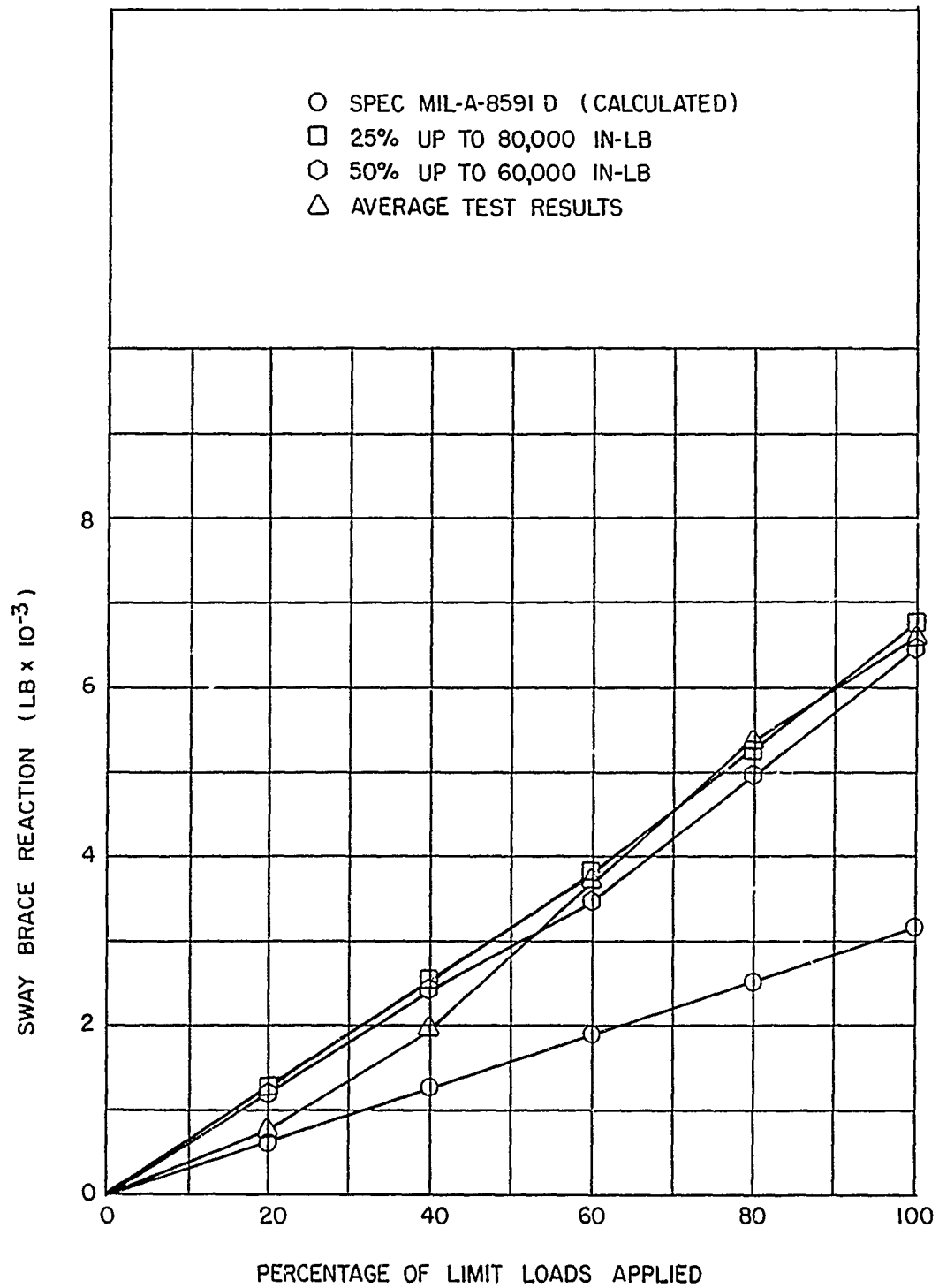


FIGURE 16. COMBINED LOADS TEST NO. 3 FORWARD. RIGHT BRACE

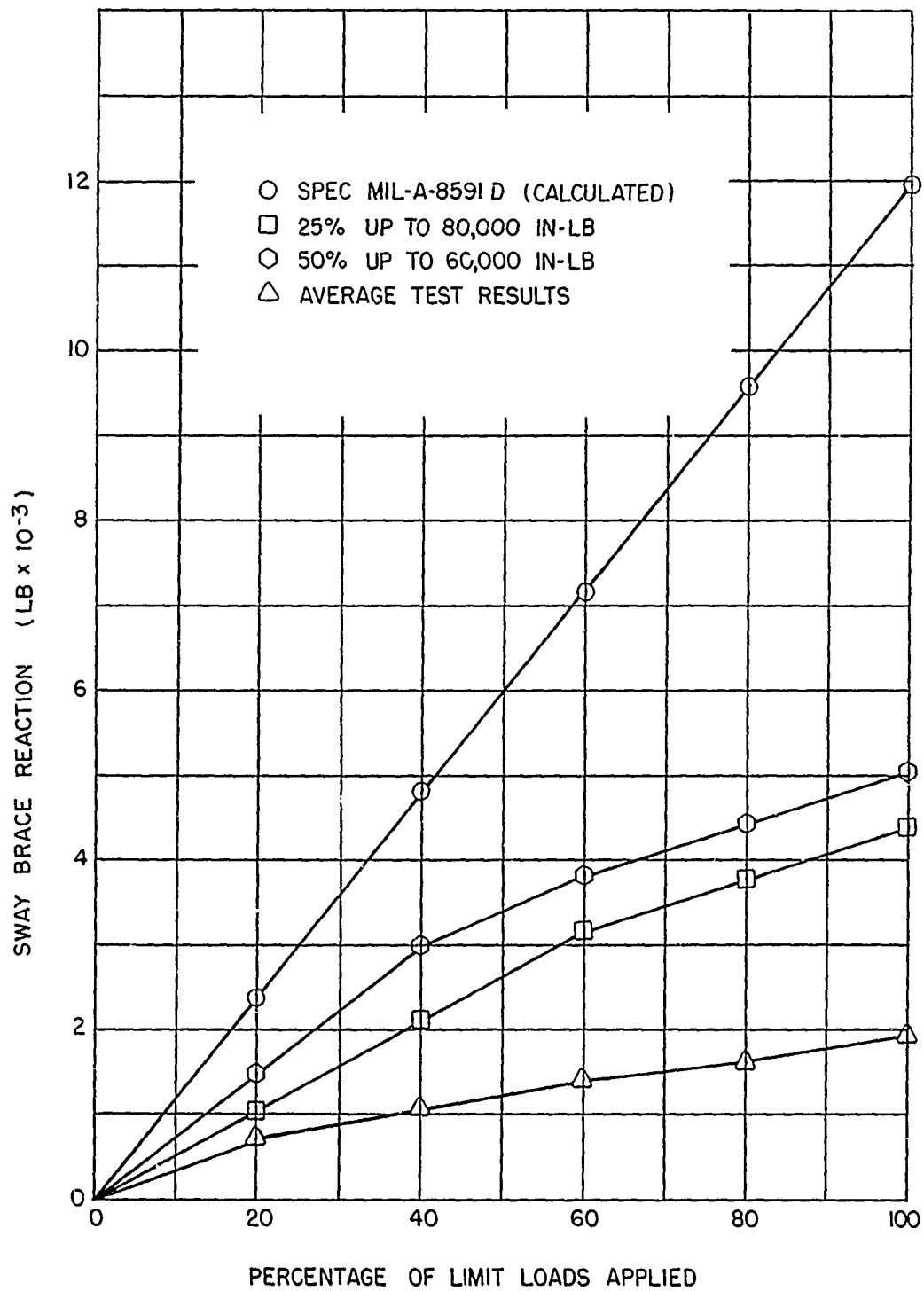


FIGURE 17. COMBINED LOADS TEST NO.3 AFT RIGHT BRACE

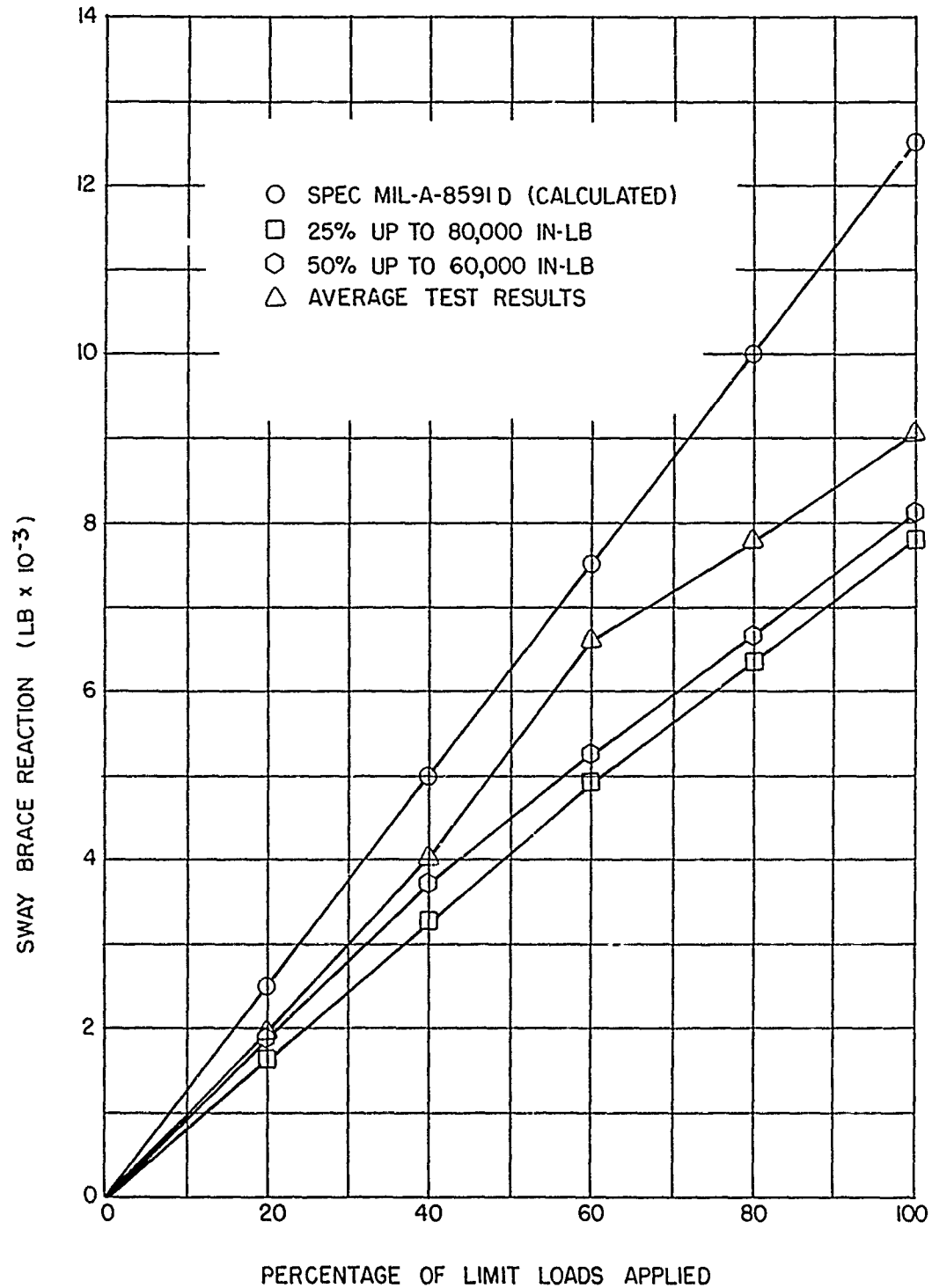


FIGURE 18. COMBINED LOADS TEST NO. 4 FORWARD LEFT BRACE

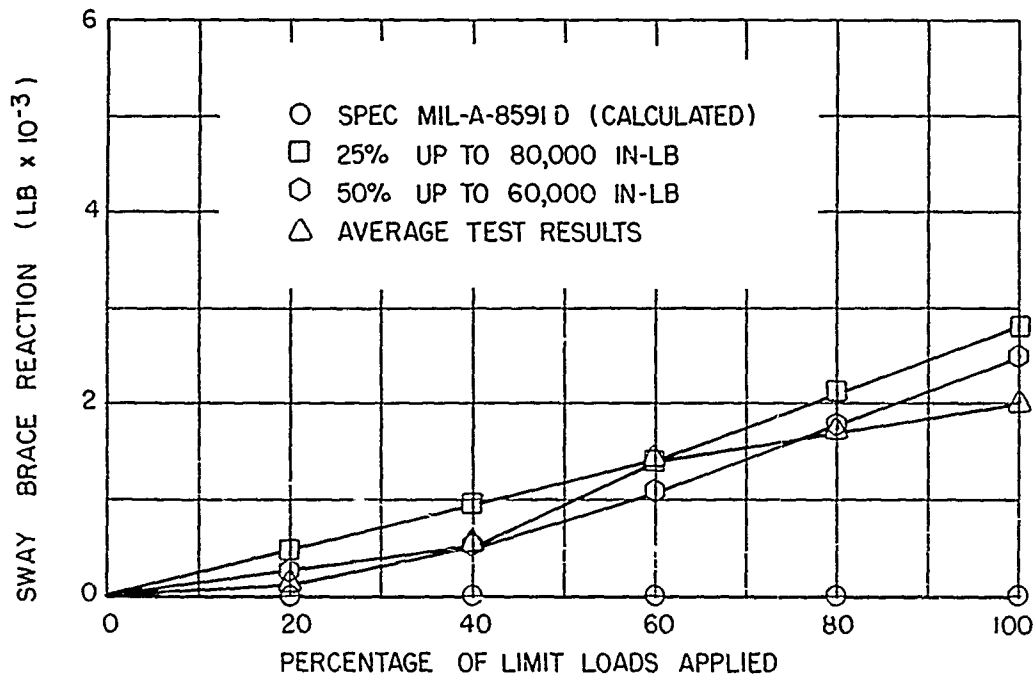


FIGURE 19. COMBINED LOADS TEST NO 4. FORWARD RIGHT BRACE

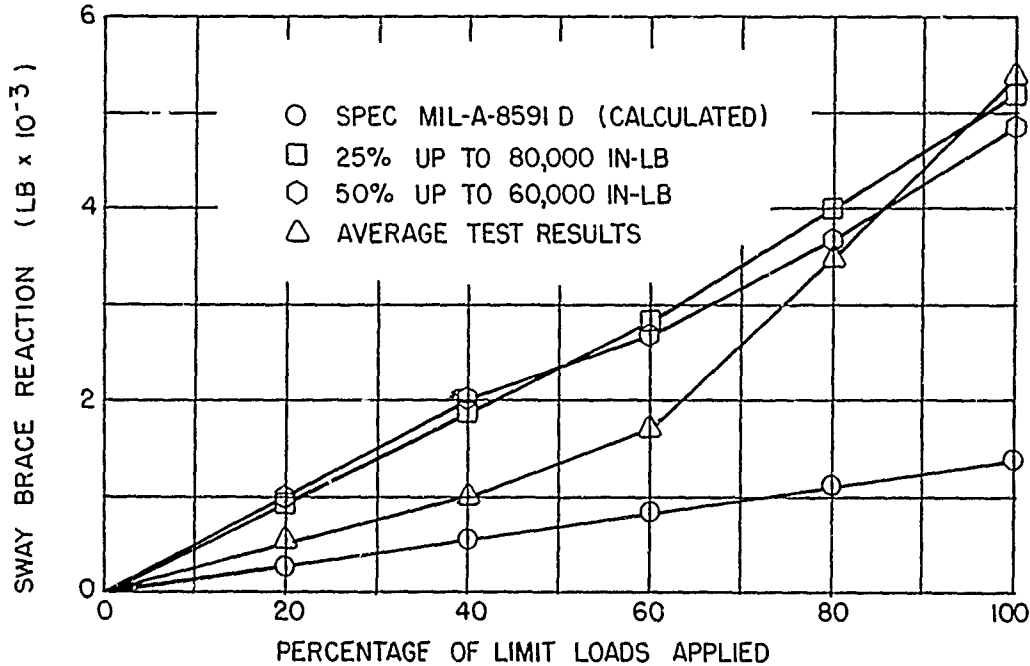


FIGURE 20. COMBINED LOADS TEST NO. 4 AFT LEFT BRACE

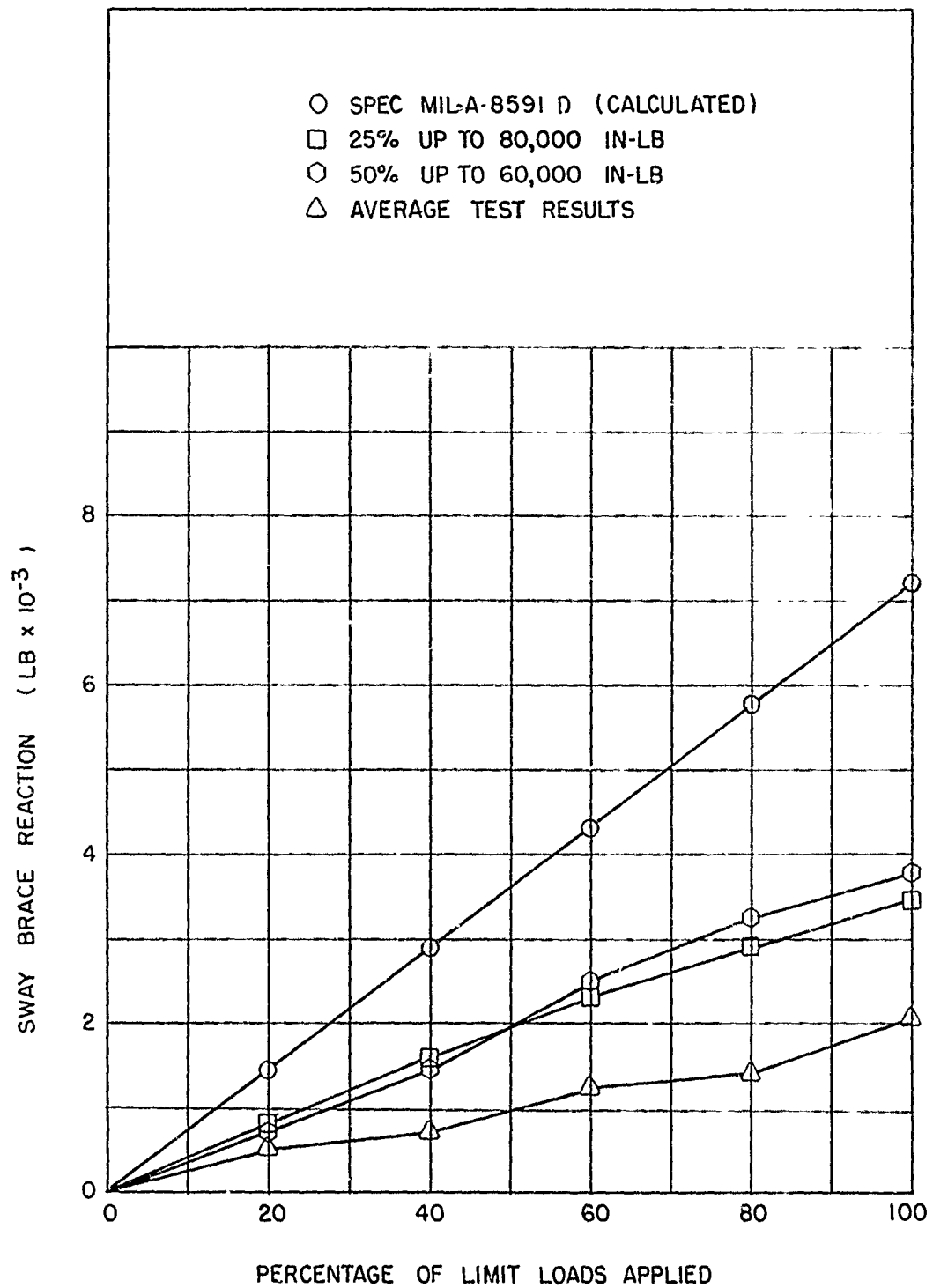


FIGURE 21. COMBINED LOADS TEST NO. 4 AFT RIGHT BRACE

indicate that the reference (a) predictions are at least twice the test values. On each graph the reference (a) predictions are conservative, but excessive when compared to the test values. The two modified predictions considered are still conservative in every case, but much more realistic. In these five sway brace loadings the reference (a) predictions deviate considerably from test data, while the modified predictions show an excellent correlation.

D. Figures 11 and 19 show that the unmodified predictions are zero, while the test results indicated load. Figures 13, 16, and 20 illustrate the same phenomenon to a lesser degree. In each of these graphs the original reference (a) predictions are less than half the experimental values. Both modified predictions again are a significant improvement in each case.

E. Figures 12 and 18 show the reference (a) predictions to be up to 40 percent above the test values. The revised predictions are a maximum of 2000 lbs unconservative on these plots. Thus, in these two examples the modified predictions are more accurate than the original predictions, but less conservative. Consequently, in the particular cases noted above for these sway braces, another yawing moment assumption would be advisable in order to avoid insubstantial designs. During the preparation of this report a number of distribution assumptions were evaluated. However, the one recommended in this report proved to be the best modification from the overall standpoint, considering both conservatism and realism.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. It has been concluded from the results of this program that modifications are required in the load analysis given in reference (a) to produce an acceptable correlation with the loads derived by extensive testing of an instrumented MAU-9/A Bomb Rack. It is assumed that this correlation will prove conservative in the design of other bomb racks because of the relative rigidity of the MAU-9/A Rack and the attendant high sway brace loads which were used to establish the recommended design criteria.

B. Figures 7 and 8 graphically illustrate the conclusion that the applied yawing moment is only partially, rather than totally, reacted by the sway braces as assumed in reference (a). The yawing moment also produces a very significant reaction in the lateral (Y) direction at the yaw traps, which is not considered in the specification. The conservative correlation with test data derived in Table I shows on figure 7 that the sway brace reactions vary linearly from 0 to 30,000 in.-lb over a yawing moment range of 60,000 in.-lb, which is equivalent to a 50 percent slope. For higher yawing moments a constant 30,000 in.-lb sway brace reaction is shown. In each case the 30-in. yaw traps simultaneously react the absolute value of the applied yawing moment minus the portion attributed to the sway braces. This is shown in figure 8.

C. Figure 9 illustrates the conclusion that side load applied at the center of gravity of the store, and consequently accompanied by a rolling moment, is totally reacted by the sway braces. This conclusion is in agreement with the parallel assumption employed in reference (a).

D. The validity of these correlations, as demonstrated by results of the combined loads tests, is concluded to be sufficiently accurate to justify revision of current loads analysis techniques. Consequently, it is recommended that the loads analysis published in reference (a), Section 20.5.2.2 be revised by introducing the following equations to be used for stores carried on the 30-in. hooks of the MAU-9/A Bomb Rack:

If $|M_z| < 60,000$ in.-lb

$$V_{P_y, M_z}^f = \frac{P_y \bar{l}_a + 0.5 M_z}{\tan \beta_f (\bar{l}_a + \bar{l}_f)}$$

$$V_{P_y, M_z}^a = \frac{P_y \bar{l}_f - 0.5 M_z}{\tan \beta (\bar{l}_a + \bar{l}_f)}$$

$$R_y^f = \frac{0.5 M_z}{l_a + l_f}$$

(R_y represents the fore or aft lateral yaw trap reaction)

$$R_y^a = \frac{0.5 M_z}{l_a + l_f}$$

If $|M_z| \geq 60,000$ in.-lb

$$V_{P_y, M_z}^f = \frac{P_y \bar{l}_a + 30,000}{\tan \beta_f (\bar{l}_a + \bar{l}_f)}$$

$$V_{P_y, M_z}^a = \frac{P_y \bar{l}_f - 30,000}{\tan \beta_f (\bar{l}_a + \bar{l}_f)}$$

$$R_y^f = \frac{|M_z| - 30,000}{l_a + l_f}$$

$$R_y^a = \frac{|M_z| - 30,000}{l_a + l_f}$$

(If M_z is positive R_y^f will act in the negative and R_y^a in the positive direction.)

The remainder of the calculations in reference (a) would remain unchanged. Application of these results to other than the 30-in. hooks of the MAU-9/A Bomb Rack is considered to be a good approximation, but has not been proven by test.

VII. ADDITIONAL INFORMATION

The material presented in this report represents a considerable effort in time and test preparation and voluminous conduct of testing. The test values recorded were obtained by repeated testing at each of 25 different yawing moment and side load test conditions, but only the average values are given herein. Likewise, the combined load verification tests were repeated to establish consistency with the average values shown in the report. Complete and detailed test data and additional details of the test program are available at this Center.

VIII. REFERENCES

- (a) MIL-A-8591D, Airborne Stores and Associated Suspension Equipment;
General Design Criteria for

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Air Vehicle Technology Department Naval Air Development Center Warminster, Pennsylvania 18974		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP -	
3. REPORT TITLE DETERMINATION OF THE LUG AND SWAY BRACE REACTIONS FOR THE MAU-9/A BOMB RACK			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report			
5. AUTHOR(S) (First name, middle initial, last name) Edward Kenkelen and William Wiesemann			
6. REPORT DATE 31 Dec 1973		7a. TOTAL NO OF PAGES 40	7b. NO OF REFS 1
7a. CONTRACT OR GRANT NO.		9a. ORIGINATOR'S REPORT NUMBER(S) NADC-72136-VT	
b. PROJECT NO. AIRTASK 532000004 Work Unit No. A53213-1		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) None	
10. DISTRIBUTION STATEMENT Distribution limited to U. S. Government agencies only; Test and Evaluation; Report Issue Date. Other requests for this document must be referred to COMNAVAIRDEVCON or COMNAVAIRSYSCOM.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Naval Air Systems Command Headquarters Washington, D. C. 20360	
13. ABSTRACT This report summarizes a series of static load tests which were conducted at NAVAIRDEVCON (Naval Air Development Center) to develop a method of calculating the lug and sway brace reactions for the MAU-9/A Bomb Rack.			

DD FORM 1 NOV 65 1473 (PAGE 1)
0102 014 6600UNCLASSIFIED
Security Classification

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aircraft equipment Bomb racks Mechanics						

DD FORM 1473 (BACK)
NOV 65
(PAGE 2)

UNCLASSIFIED
Security Classification