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ABSTRACT

The NASA test airplane, B-52B-008, was a carrier for drop tests of the shuttle booster recovery parachute system. The Drop Test Vehicle was built for the George C. Marshall Space Flight Center by Martin Marietta-Denver. Testing of the new parachute system was done at the NASA Hugh L. Dryden Flight Research Facility and the Naval Weapons Center China Lake Facility.

The purpose of the test support by Boeing was to monitor the vertical loads on the pylon hooks. The hooks hold the Drop Test Vehicle to the B-52 pylon during drop test missions. The loads were monitored to assure the successful completion of the flight and the safety of the crew.

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1. SUMMARY

Full scale Solid Rocket Booster (SRB) parachute drop testing was conducted to verify the SRB parachute deployment and structural integrity. The NASA Test Airplane B-52B-008 was used again in the second series of tests to carry the Drop Test Vehicle (DTV) from Hugh L. Dryden Flight Research Facility (DFRF) to the drop site at China Lake Naval Air Station (NAS). Ground cameras at China Lake NAS would record the drop test sequence of events for later evaluation of new parachute system. This document presents the vertical loads on the forward and two aft hooks that attach the DTV to the pylon. The loads were recorded from start of taxi through the dropping of DTV. The loads are broken down into three conditions:

1. Taxi (Includes ground turns)
2. Takeoff
3. Climb and Cruise (includes aircraft maneuvering).

The recorders for the hook loads were stopped after the DTV was released. See Figure 1 for the sketch of the tested B-52B/DTV configuration. A sketch of the DTV is given in Figure 2.

This NASA test program was under direction of the George C. Marshall Space Flight Center (MSFC) with DFRC providing aircraft maintenance, flight crew and telemetry equipment to support the test effort. Martin Marietta-Denver provided the DTV including the appropriate parachute system for the given test. Boeing Military Airplane Company (BMAC) monitored the test to assure B-52B safety of flight. The BMAC effort was funded under NASA Contract Number NAS8-35016.

Flights in support of the new SRB parachute deployment and structural integrity were accomplished during the September 1983 through March 1985 time period. The first drop test was postponed due to failure of the two aft hooks while the airplane was being towed with the DTV attached to the pylon. Under a separate contract Boeing investigated the cause of failure of the aft hooks, also Boeing participated in proof tests of the forward hook. As a result of the proof tests, further restrictions were placed on the airplane. On the thirteenth drop test the parachute system failed. After Martin-Marietta-Denver corrected the problem, the extra drop test was scheduled as the fourteenth test.

Drop tests 7, 8, 9, and 10 had a 3-inch shim at the aft hooks. The shim thickness was reduced to two inches for the last four tests. The gross weight at time of engine start remained in the 300,000 to 336,000 pound range. The ground winds were none to light except for the third drop test which had gust up to 20 miles per hour. Atmospheric turbulence varied from none to light for all flights, except for the fourteenth drop which were heavy around 40,000 feet.

The B-52B-008 carrier aircraft and the pylon still is in the same configuration as the previous tests. The radial clearance between the DTV and B-52 wing is 3.00 and 1.59 inches for the three inch shim and two inch shim, respectively.

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Restrictions established during the first series of tests still applied during this series of tests with additional restrictions applied to the airplane as a result of the proof test of the forward hook. The previous restrictions are given in Reference 1. The additional restriction imposed by NASA/DFRF are as follows:

- o Airspeed restriction of 230 KCAS or Mach .70, whichever is less.
- o Elevator input restriction of 20 degrees per second and maximum deflection of plus or minus 10 degrees.
- o Smaller landing condition envelope which varies from 4.5 degrees pitch angle at zero feet per second sink rate to zero degree angle at 5.5 feet per second.

The design envelope is given in Figure 3. As a result of the proof test on the forward hook, the limit load was reduced to 36.0 kips.

In general the rescheduled drop test missions went as planned except the eleventh drop test which was aborted due to clouds over the drop stie. The eleventh drop test was rescheduled for the next day. On the fourth pass over the target area the DTV was dropped successfully the next day. On the thirteenth and last drop test the DTV was dropped successfully on the first pass over target area, but the parachute system failed. However, on the fourteenth drop test, which repeated the conditions of the thirteenth drop test, the parachute system worked successfully. Two changes were made between the thirteenth and fourteenth drop tests. One change is that the retrieval line and related hardware were deleted. The other change is not allowing the chute to inflate to second stage during very high dynamic pressure.

The aft hook failures and the proof test of the forward hook are discussed in a separate report (Reference 2).

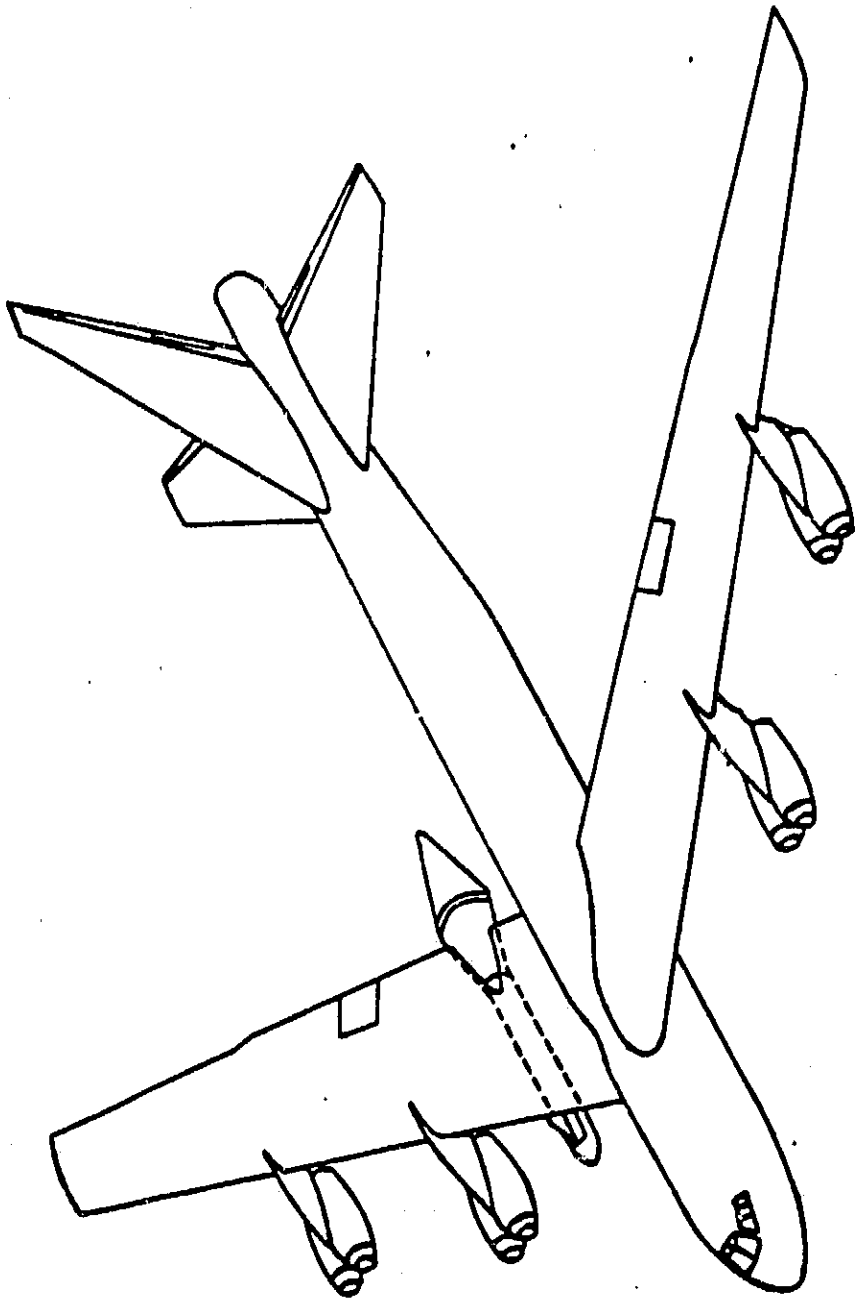


FIGURE 1
B-52B-008/DTV CONFIGURATION DESCRIPTION

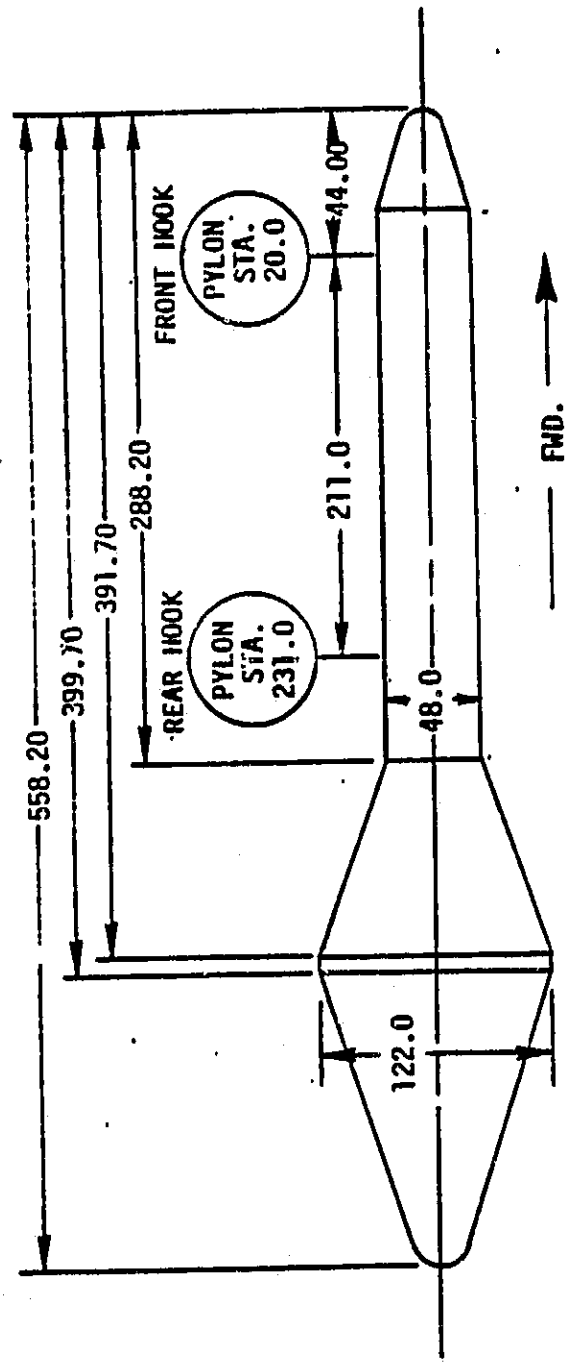


FIGURE 2

DTV CONFIGURATION DEFINITION

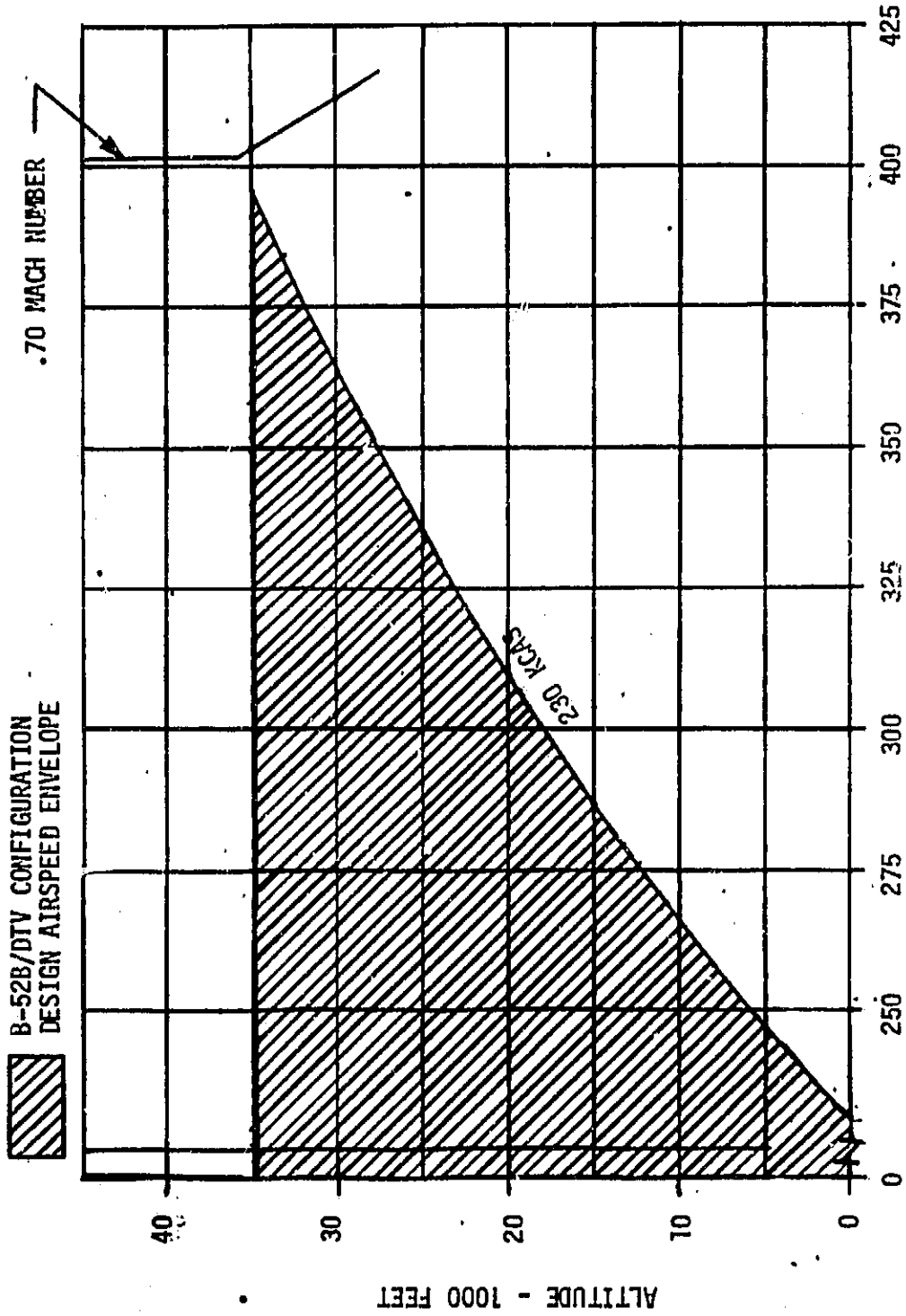


FIGURE 3
B-52B/DTV CONFIGURATION
DESIGN AIRSPEED ENVELOPE

CALC				SUBJECT:
CHECK				
REVISED				
REVISED			D500-10855-1	

2. DTV DROP TEST RESULTS

DTV drop tests took place from September 1983 to March 1985. The B-52B-008 is stationed at NASA facility which is located at Edwards Air Base. The DTV was dropped at China Lake NAS where ground cameras monitored the descent. The airplane gross weight varied from slightly over 300,000 pounds to less than 336,000 pounds. The DTV weight properties are given in Figure 4.

Restrictions on the B-52B airplane for all drop test flights are given in Section 1 of this document. Vertical loads on all three hooks were monitored from real time telemetered data. The maximum load on the fronk hook occurred on the aborted flight of eleventh drop test. This load of 25,500 pounds represented 71 percent of limit proof test on the front hook.

The summary of the results of the analyses that was published in Reference 3 is reprinted in Figure 5. A summary of the maximum loads of each hook per drop test in each of the four flight conditions is given in Figure 6 through 8. On drop tests thirteen and fourteen the vertical loads on the two aft hooks were not monitored. In place of the two aft hooks, the drag and side forces on the left pin were monitored. The maximum drag force was 6 kips which occurred soon after the plane was airborne. The maximum side force was three kips which occurred during takeoff. Because of the greater restrictions imposed during the drop test flight, the loads on the pylon hooks were within predictions. The greater restrictions were a result of the proof test on the hooks. The four conditions are as follows:

- Taxi (includes ground turns)
- Takeoff
- Climb and cruise (includes maneuvers)
- Landing

Location of the pylon hooks and pins are given in Figure 9. Vertical loads on pylon hooks are shown for the takeoff portion of the strip chart for Drop Test No. 12 in Figure 10.

COMPARISON OF DTV MASS PROPERTIES

DROP TEST	WEIGHT - LBS	X_{CG} PYLON	Y_{CG} STATION	Z_{CG} INCHES	PITCH MOMENT OF INERTIA (SLUG - FT^2)
1	47772	171.3	0.09	-26.62	399,228
2	48273	169.5	-0.01	-27.17	404,223
3	48570	170.7	-0.02	-27.17	406,995
4	48070	172.5	0.09	-26.80	401,995
5	48070	172.5	0.09	-26.80	401,995
6	47139	168.4	0.18	-26.84	399,228
7	48248	171.1	0.12	-26.03	295,551
8	48403	170.88	0.13	-25.82	298,625
9	48403	170.88	0.13	-25.82	298,625
10	48375	169.88	0.13	-26.02	295,020
11	47660	169.1	0.13	-25.61	308,840
12	48162	168.0	0.10	-26.60	310,359
13	48160	168.0	0.10	-26.60	310,359
14	48033	168.1	0.10	-26.80	313,018
CURRENT ANALYSIS	49000			-28.60	315,000

NOTE: 1. DROPS 7 AND UP USE SHORTENED DTV

2. ICD ENVELOPE X_{CG} = 167.49 TO 172.79

$Y_{CG} = \pm 0.65$

Z_{CG} = 27.35 LOWER LIMIT

FIGURE 4

DTV WEIGHT PROPERTIES OF ALL FOURTEEN

DROP TEST VEHICLES

BOEING

LOAD COMPONENT	X-15 ANALYSIS		1.5 MAXIMUM REVISED DROP TEST VEHICLE LOAD					
	ULTIMATE LOAD (LBS)	MARGIN	25 FT/SEC VERT. GUST (TRUE AIRSPEED) (LBS)	ELEV. INPUT ¼ MAX. DEF'L (LBS)	LANDING 6°NOSE UP 3 FPS S.R. (LBS)	LANDING 3°NOSE UP 3 FPS S.R. (LBS)	LANDING 0°NOSE UP 3 FPS S.R. (LBS)	LANDING 3°NOSE UP 6 FPS S.R. (LBS)
FWD HOOK VERTICAL	-56624	.01*	52350	35900	34370	34100	26480	41290
FWD HOOK LATERAL	13002	.27**	14400	1860	2310	1980	2280	3050
AFT LEFT HOOK VERTICAL	-86456	.06*	45600	39400	34920	33920	33340	34460
AFT RIGHT HOOK VERTICAL	-78599	.17*	45750	39150	34050	35390	31220	34270
AFT LEFT PIN FORE & AFT	46702	.12*	12600	4350	6130	5490	3720	6570
AFT RIGHT PIN FORE & AFT	43705	.29*	12820	2850	4600	4790	5710	6250
AFT LEFT PIN LATERAL	-36751	.51*	8850	3380	4570	6384	7040	7160

* REFERENCE TFD 66-431

** REFERENCE TFD 63-876

FIGURE 5

RELATIVE CRITICALITY OF B-52/REVISED DTV LOADS

BOEING

DROP TEST NO.	DATE OF DROP TEST	FLIGHT LOADS CONDITION			
		TAXI AND GROUND TURN (KIPS)	TAKEOFF (KIPS)	CLIMB AND CRUISE (KIPS)	LANDING (KIPS)
7	9/23/83	18.5	20.0	15.5	-
8	11/22/83	18.0	19.0	17.0	-
9	12/13/83	19.0	19.0	18.0	-
10	3/30/84	18.0	20.0	20.5	-
11	7/19/84* 7/20/84	19.5 18.5	20.0 20.0	20.0 20.0	25.5 -
12	10/30/84	19.0	20.5	20.0	-
13	1/17/85	18.0	20.2	20.0	-
14	3/20/85	19.2	24.0	22.3	-

FIGURE 6
MAXIMUM VERTICAL FRONT HOOK FLIGHT LOADS

* ABORTED FLIGHT

BOEING

DROP TEST NO.	DATE OF DROP TEST	FLIGHT LOADS CONDITION			
		TAXI AND GROUND TURN (KIPS)	TAKEOFF (KIPS)	CLIMB AND CRUISE (KIPS)	LANDING (KIPS)
7	9/23/83	25.0	26.5	23.0	-
8	11/22/83	23.0	26.0	22.5	-
9	12/13/83	23.0	23.0	23.0	-
10	3/30/84	27.0	27.0	28.0	-
11	7/19/84* 7/20/84	26.0 25.0	28.5 28.5	25.0 27.0	29.5 -
12	10/30/84	30.5	31.5	31.5	-
13**	1/17/85	-	-	-	-
14**	3/20/85	-	-	-	-

FIGURE 7
MAXIMUM VERTICAL LEFT AFT HOOK FLIGHT LOADS

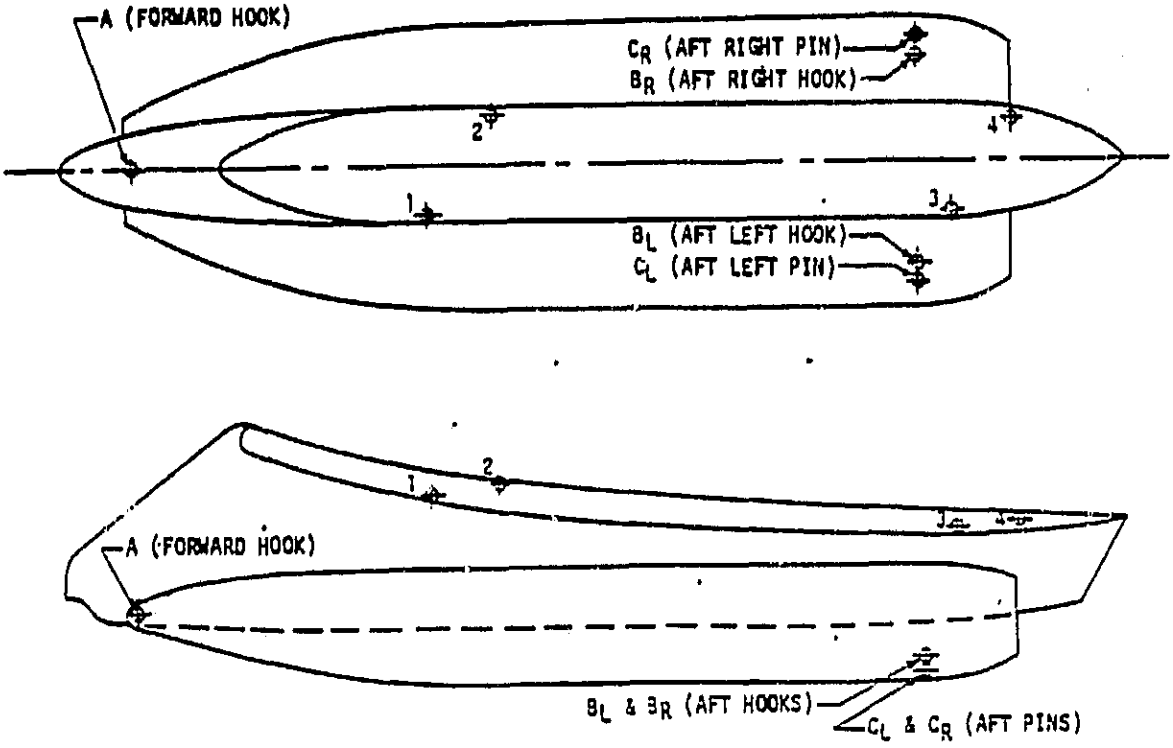
* ABORTED FLIGHT
** HOOK LOADS NOT MONITORED

BOEING

DROP TEST NO.	DATE OF DROP TEST	FLIGHT LOADS CONDITION			
		TAXI AND GROUND TURN (KIPS)	TAKEOFF (KIPS)	CLIMB AND CRUISE (KIPS)	LANDING (KIPS)
7	9/23/83	25.0	27.0	23.0	-
8	11/22/83	21.5	23.5	21.5	-
9	12/13/83	26.0	25.0	25.0	-
10	3/30/84	25.5	25.0	26.0	-
11	7/19/84* 7/20/84	26.0 25.0	26.0 28.0	25.0 25.0	26.0 -
12	10/30/84	27.5	28.0	28.0	-
13**	1/17/85	-	-	-	-
14**	3/20/85	-	-	-	-

FIGURE 8
MAXIMUM VERTICAL FIGHT AFT HOOK FLIGHT LOADS

* ABORTED FLIGHT
** HOOK LOADS NOT MONITORED



PYLON LOCATION	PYLON STATION	PYLON BUTTOCK LINE	PYLON WATER-LINE
A	20.000	0.000	-1.1875
B_L	231.000	-26.437	-15.1870
B_R	231.000	26.437	-15.1870
C_L	231.000	-31.312	-17.5000
C_R	231.000	31.312	-17.5000
1	98.500	-13.500	28.7930
2	115.625	13.500	29.5210
3	236.342	-13.093	18.9440
4	251.813	11.750	19.2910

PYLON GEOMETRY

FIGURE 9

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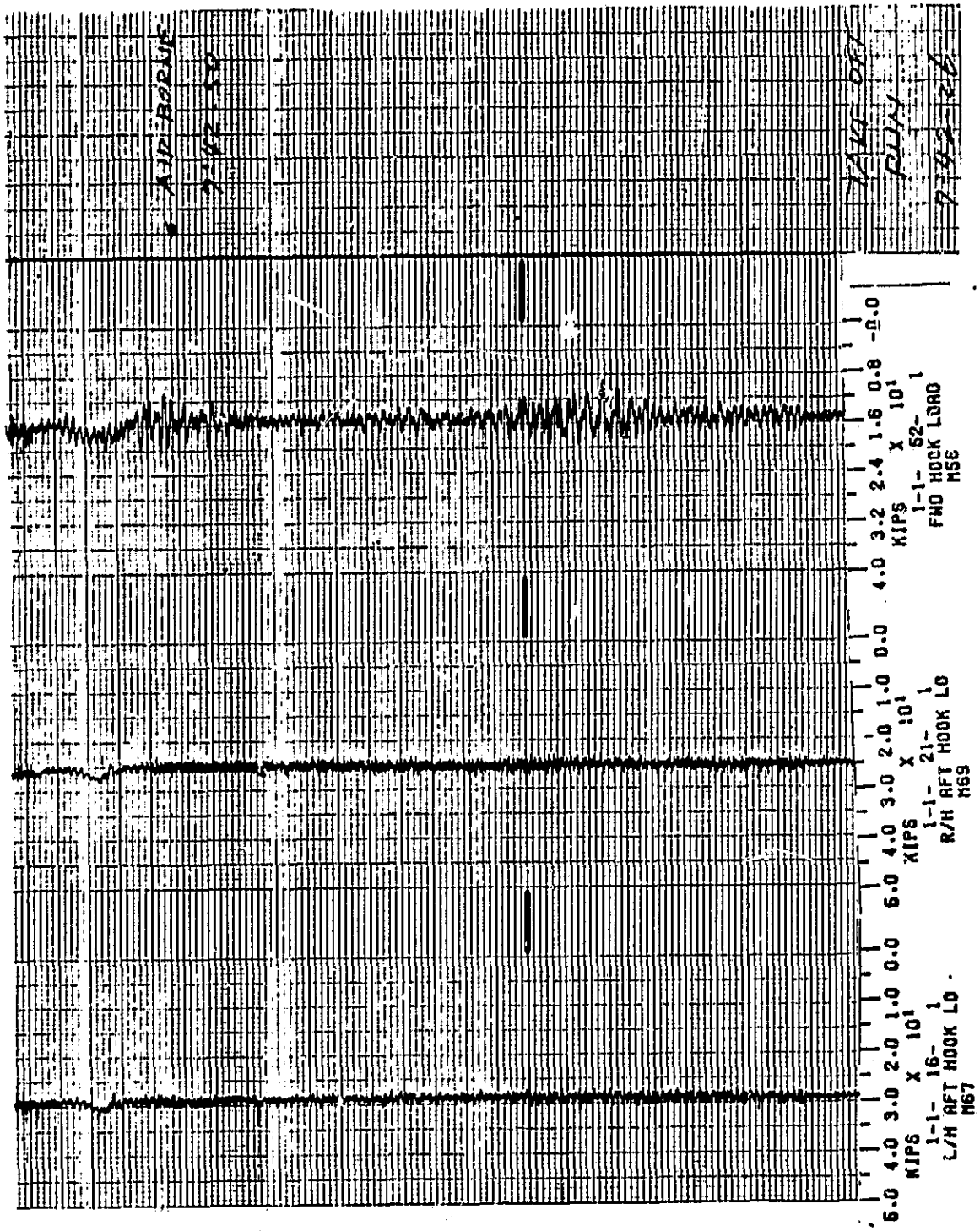

FIGURE 10
VERTICAL LOADS ON HOOKS DURING TAKEOFF
FOR DROP TEST NO. 12

3. REFERENCES

1. Boeing Document D3-11220-3, "B-52B-008/DTV (Drop Test Vehicle) Configuration 1 (With and Without Fins) Flight Test Results -- Captive Flight and Drop Test Missions", dated 29 September 1978.

2. Boeing Document D500-10854-1, "B-52B/SRB Drop Test Vehicle Loads and Aeroelastic Analysis -- Pylon Hook Failure", dated 22 January 1985.

3. Boeing Document D500-10379-1, "Dynamic Assessment of B-52B-008 Carrier Aircraft for the Revised Space Shuttle Solid Rocket Booster Decelerator Subsystem Drop Test Vehicle", dated 17 October 1983.

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ACTIVE SHEET RECORD

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