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(WITH AND WITHOUT FINS) FLIGHT TEST RESULTS - CAPTIVE
FLIGHT AND DROP TEST MISSIONS

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ABSTRACT

This document was written to present the results of B-52B-008/Drop Test Vehicle (DTV) Configuration 1 (with and without fins) testing. The testing consisted of one takeoff roll to 60 KCAS, two captive flights to accomplish limited safety of flight flutter and structural demonstration testing, and seven drop test flights. Of the seven drop test missions, one flight was aborted due to the failure of the hook mechanism to release the DTV; but the other six flights successfully dropped the DTV.

The drop test vehicle (DTV) was designed and fabricated for the George C. Marshall Space Flight Center (MSFC) by Martin Marietta-Denver. The B-52B-008 carrier aircraft was in the "as modified" configuration previously used during the X-15 test program. Clearance for the carrier aircraft to perform the DTV drop mission was given based on the Reference 1 and 2 analysis results along with the captive flight test results.

Testing on the program was accomplished out of the NASA Edwards Hugh Dryden Flight Research Center (DFRC) with the actual DTV drops occurring at the National Parachute Test Range (NPTR). Key DFRC personnel assigned to support/direct the test effort were Mr. M. Groen, Test Director; Mr. F. Fulton, Chief Test Pilot; Mr. M. Tang, Load Evaluation; and Mr. W. Cazier, Flutter Evaluation.

Boeing Wichita test support at DFRC was provided under Contract NAS8-31805 with the George C. Marshall Space Flight Center. Technical contacts at MSFC were Mr. R. Mitchell and Mr. D. Kross.

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1.0 SUMMARY

Full scale solid rocket booster (SRB) parachute drop testing was required by the NASA to verify SRB parachute deployment and structural integrity. The NASA Test Airplane B-52B-008 was selected to carry the drop test vehicle (DTV) from Edwards Hugh Dryden Flight Research Center (DFRC) to the National Parachute Test Range (NPTR) where the DTV would be released and the parachute system evaluated. This document presents the flutter and load results obtained during the B-52B/DTV Configuration 1 (with and without fins) taxi, captive flight and drop testing. See Figures 1 and 2 for sketches of the B-52B/DTV configurations tested.

This NASA test program was under the direction of the George C. Marshall Space Flight Center (MSFC) with Edwards DFRC providing the necessary aircraft maintenance, flight crew and telemetry equipment to support the test effort; Martin Marietta-Denver providing the DTV including the appropriate parachute system for the given test; and the Boeing Wichita Company (BWC) monitoring the test results to ensure B-52B safety of flight. The BWC effort was funded under NASA Contract Number NAS8-31805.

Flights in support of the SRB parachute deployment and structural integrity evaluation were accomplished during the June 1977 through September 1978 time period. A total of nine flights were made with the first two flights used to demonstrate B-52B/DTV Configuration 1 (without fins) safety of flight and the other seven flights used in the actual drop testing of the DTV. The airplane gross weight for each of the nine test flights at the time of engine start was in the 300,000 to 336,000 pound range. The weather conditions at DFRC and NPTR along with the atmospheric turbulence encountered during the flights are given in Table I. A detailed description of the DTV mass and cg for each of the nine flights is given in Table III.

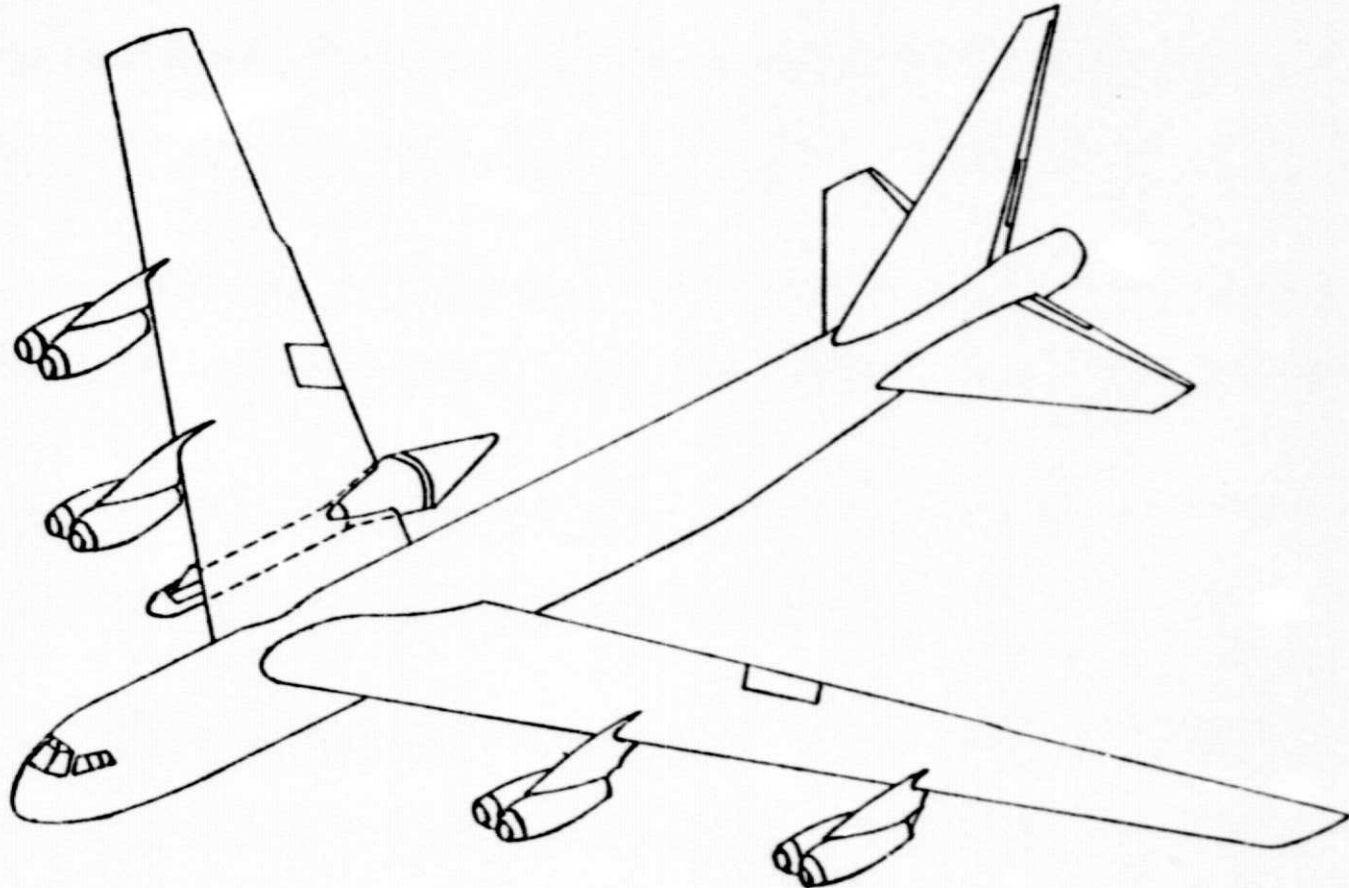
The B-52B-008 carrier aircraft was in the "as modified" configuration previously used during the X-15 program. Clearance for the carrier aircraft to perform the DTV Configuration 1 (without fins) drop mission was provided based on the results of the theoretical analyses given in Reference 1 and captive flight test results. The captive flight test showed the airplane free of flutter to the 260 KCAS (knots calibrated airspeed)/Mach .75, whichever is less, placard. In addition, pushover-pullup maneuvers demonstrated airframe structural integrity. However, captive flight testing did reveal DTV sensitivity to both elevator and landing impact excitation. This excitation of the DTV in a 1.9 to 2.0 hertz rocking motion relative to the pylon could cause airframe-pylon-hook loads which exceed structural capability. Based on this sensitivity and the resulting potential for a catastrophic failure, flight restrictions/guidelines were established to preclude excessive loading from atmospheric turbulence, abrupt control surface inputs and landing impact excitation.

Based on the results of the flight flutter and structural demonstration testing accomplished along with the analytical results presented in Reference 1, the airplane was cleared subject to the following restrictions/guidelines:

- Airspeed restriction of 260 KCAS or Mach .75, whichever is less.
- Maximum operational gross weight for the B-52B/DTV is 336,344 pounds.
- 1.8g limit maneuver load factor restriction for B-52B/DTV gross weights above 306,000 pounds.
- Drop test missions should be flown only when the forecasted turbulence in the test area is for calm or light turbulence expected.
- Pilot should avoid abrupt aileron, elevator or rudder inputs which excite the DTV rocking motion.
- If mission must be aborted, return to Edwards - minimize landing impact sink rates.

Clearance for the B-52B/DTV Configuration 1 (with fins) was given based on the Reference 2 analytical study results along with the DTV Configuration 1 (without fins) test results. The restrictions/guidelines established for the without fins configuration apply directly to this configuration.

All drop test missions from Edwards DFRC to NPTR went well except for Drop Test Flight 4-1. On this flight, the hooks failed to release the DTV. The mission was aborted with the airplane making a safe emergency landing at DFRC. Section 3.0 of this document elaborates more fully on this failure.

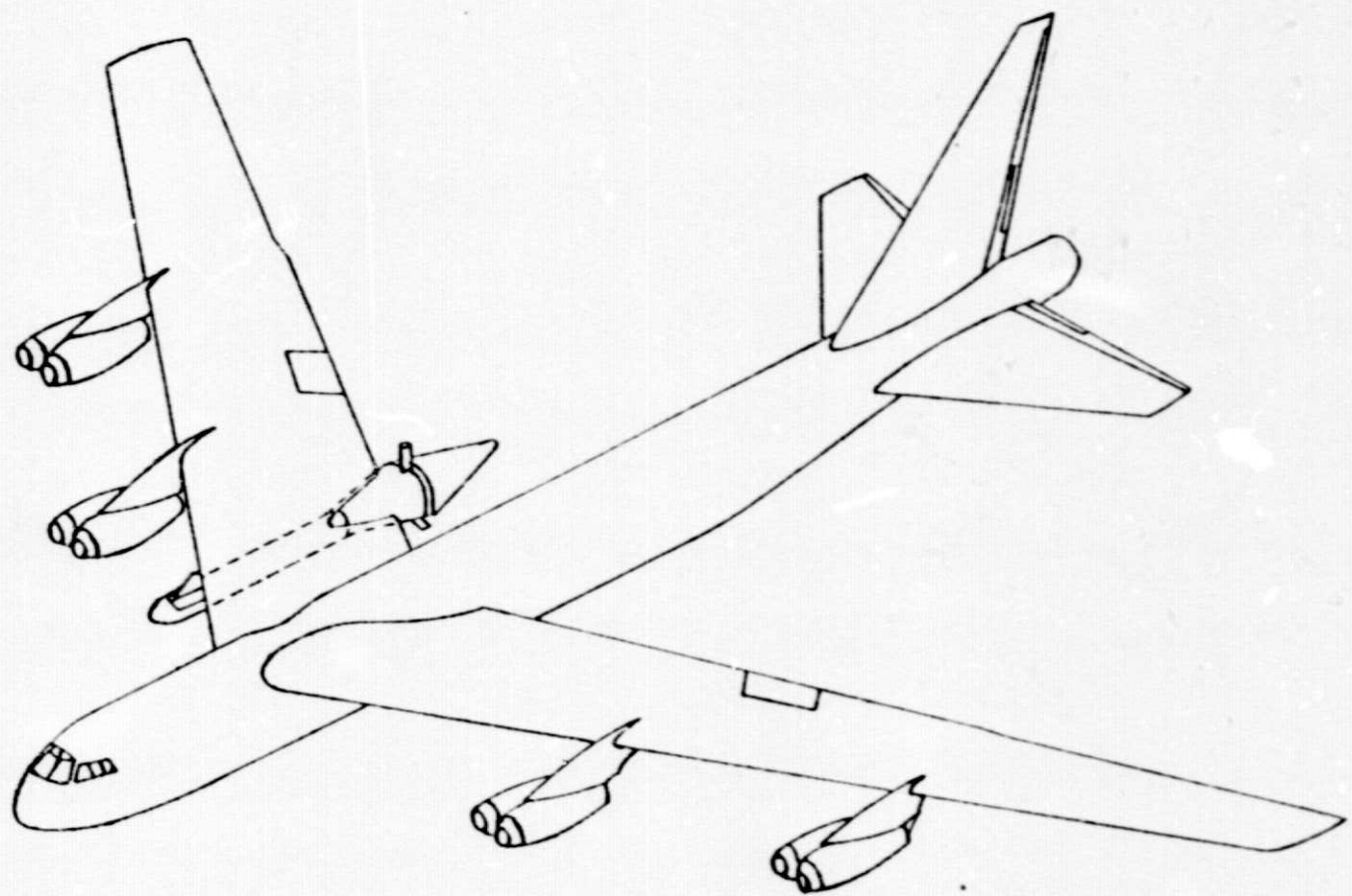


B-52B-008/DTV CONFIGURATION 1 (WITHOUT FINS) DESCRIPTION

FIGURE 1

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B-52B-008/DTV CONFIGURATION 1 (WITH FINS) DESCRIPTION

FIGURE 2

TABLE I
WEATHER CONDITIONS

DATE	FLIGHT	DTV (FINS)	DRYDEN FLIGHT RESEARCH CENTER	NATIONAL PARACHUTE TEST RANGE	ATMOSPHERIC TURBULENCE
CAPTIVE FLIGHTS					
06/10/77	1-1	WITHOUT	EXCELLENT	---	VERY LIGHT
06/10/77	1-2	WITHOUT	EXCELLENT	---	VERY LIGHT
DROP TEST FLIGHTS					
06/15/77	1	WITHOUT	EXCELLENT	EXCELLENT	VERY LIGHT
08/04/77	2	WITHOUT	EXCELLENT	EXCELLENT	VERY LIGHT
12/14/77	3	WITH	EXCELLENT	EXCELLENT	NONE
04/27/78	4-1	WITH	EXCELLENT	EXCELLENT	VERY LIGHT
05/23/78	4-2	WITH	FAIR	MARGINAL	LIGHT
07/26/78	5	WITH	EXCELLENT	EXCELLENT	VERY LIGHT
09/12/78	6	WITH	EXCELLENT	EXCELLENT	VERY LIGHT

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BRIEFING DOCUMENT

2.0 TAXI AND CAPTIVE FLIGHT TESTS

Taxi and captive flight testing of B-52B/DTV Configuration 1 (without fins) was accomplished at NASA Edwards DFRC on 10 June 1977. The purpose of the testing was to demonstrate B-52B/DTV flight safety. Due to the failure of a DTV transmitter during the captive flight testing, two flights were required to demonstrate this safety. Taxi weight for the first flight was 301,050 pounds while the second flight weight approached the maximum allowable of 336,344 pounds. The weight, cg location and pitch moment of inertia for the DTV during captive flight testing are shown in Table III. Data monitored during the flight were front hook loading (calibrated strain gage), DTV fore and aft acceleration (\ddot{x}), DTV lateral acceleration (\ddot{y}), DTV vertical acceleration (\ddot{z}), DTV roll rate ($\dot{\theta}_x$), DTV pitch rate ($\dot{\theta}_y$) and DTV yaw rate ($\dot{\theta}_z$).

The taxi testing consisted of a takeoff roll up to 60 KCAS (knots calibrated airspeed) with subsequent application of brakes until the B-52B/DTV system came to a complete stop. Post taxi inspection consisted of brake heating checks and visual checks of the B-52B/DTV system. No problems were discovered. In addition, telemetered front hook loading during the taxi testing was well within the design limit capability. However, some 1.9 to 2 hertz rocking motion of the DTV on the pylon was noted. Based on the airplane inspection checks and a cursory review of the telemetered data, the B-52B/DTV was cleared for takeoff.

The flaps up takeoffs went well with 9,500 to 10,000 feet of runway used during the ground rolls. The climbouts to the flutter and load testing altitude of 27,500 feet were routine. The only pilot comment during the climbouts was that the crew noted a slight DTV induced buffeting of the B-52B.

Captive flight flutter and loads testing were accomplished at 27,500 feet altitude. Flutter testing excitation consisted of elevator pulses, rudder kicks and roll inputs at airspeeds of 225, 240, 250 and 260 KCAS. Evaluation of the telemetered data showed the structural damping (g) of the B-52B/DTV Configuration 1 (without fins) to be well above .03. In addition, no discernible damping reduction trend was noted as airspeed was increased. However, elevator pulse excitation at 225 KCAS caused a front hook loading which reached 89 percent of the design limit as shown in Table II. Subsequent elevator pulse inputs at the 240, 250 and 260 knots calibrated airspeeds were reduced in magnitude (approximately 50 percent) to ensure no front hook overload. This large front hook load was due to the dynamic excitation of the DTV in a 1.9 to 2.0 Hertz rocking motion relative to the pylon. This DTV pitch acceleration in conjunction with the large DTV pitch moment of inertia ($I_{p\ddot{\theta}_y}$) can develop extremely large hook loadings. Similar dynamic effects were noted during B-52B/DTV landing impact as shown in Table II.

Front hook load capability was demonstrated by pushover-pullup maneuvers at the following load factor-airspeed conditions:

- 0.70 to 1.30g at 225 KCAS
- 0.50 to 1.50g at 225 KCAS
- 0.35 to 1.70g at 250 KCAS

The results of this testing along with analytically predicted loadings are presented in both Figure 1 and Table II. In all cases, the agreement between test and analytical front hook loading is excellent.

Based on the results of the flight flutter and structural demonstration testing along with the analytical results presented in Reference 1, the B-52B airplane was cleared to accomplish the drop test mission for DTV Configuration 1 (without fins). However, the following restrictions/guidelines were to be followed:

- Airspeed restriction of 260 KCAS or Mach .75, whichever is less.
- Maximum operational gross weight for the B-52B/DTV is 336,344 pounds.
- 1.8g limit maneuver load factor restriction for B-52B/DTV gross weights above 306,000 pounds.
- Drop test missions should be flown only when the forecasted turbulence in the test area is for calm or light turbulence expected.
- Pilot should avoid abrupt aileron, elevator or rudder inputs which excite the DTV rocking motion.
- If mission must be aborted, return to Edwards--minimize landing impact sink rate.

Clearance for the B-52B to accomplish the DTV Configuration 1 (with fins) drop test mission was given based on the analytical studies of Reference 2 and the agreement shown between analytical and test results of B-52B/DTV Configuration 1 (without fins). The restrictions/guidelines given for DTV Configuration 1 (without fins) are directly applicable to the with fins DTV Configuration 1. The analytically predicted front hook loading for DTV Configuration 1 (with fins) is given in Figure 2.

TABLE II
FRONT HOOK LOADS - CAPTIVE FLIGHT TEST

SPEED	MANEUVER	LOAD FACTOR	HOOK LOAD		PERCENT OF LIMIT LOAD (TEST)
			CALCULATED	TEST	
KCAS	TYPE	g's	POUNDS	POUNDS	PERCENT
225	POPU	1.30	19,166	18,000	48
225	POPU	1.50	21,982	22,000	58
250	POPU	1.70	24,983	24,000	64
250	POPU	.35	5,951	5,000	13
225	ELEVATOR PULSE (1/4 THROW)	---	---	33,400	89
165	LANDING	---	---	28,500	76

GENERAL NOTES:

- Front hook limit load capability is 37,700 pounds
- POPU - Pushover-pullup maneuver

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⊙ CAPTIVE FLIGHT TEST RESULTS,
10 JUNE 1977

LIMIT FRONT HOOK LOADING - 37,700 POUNDS

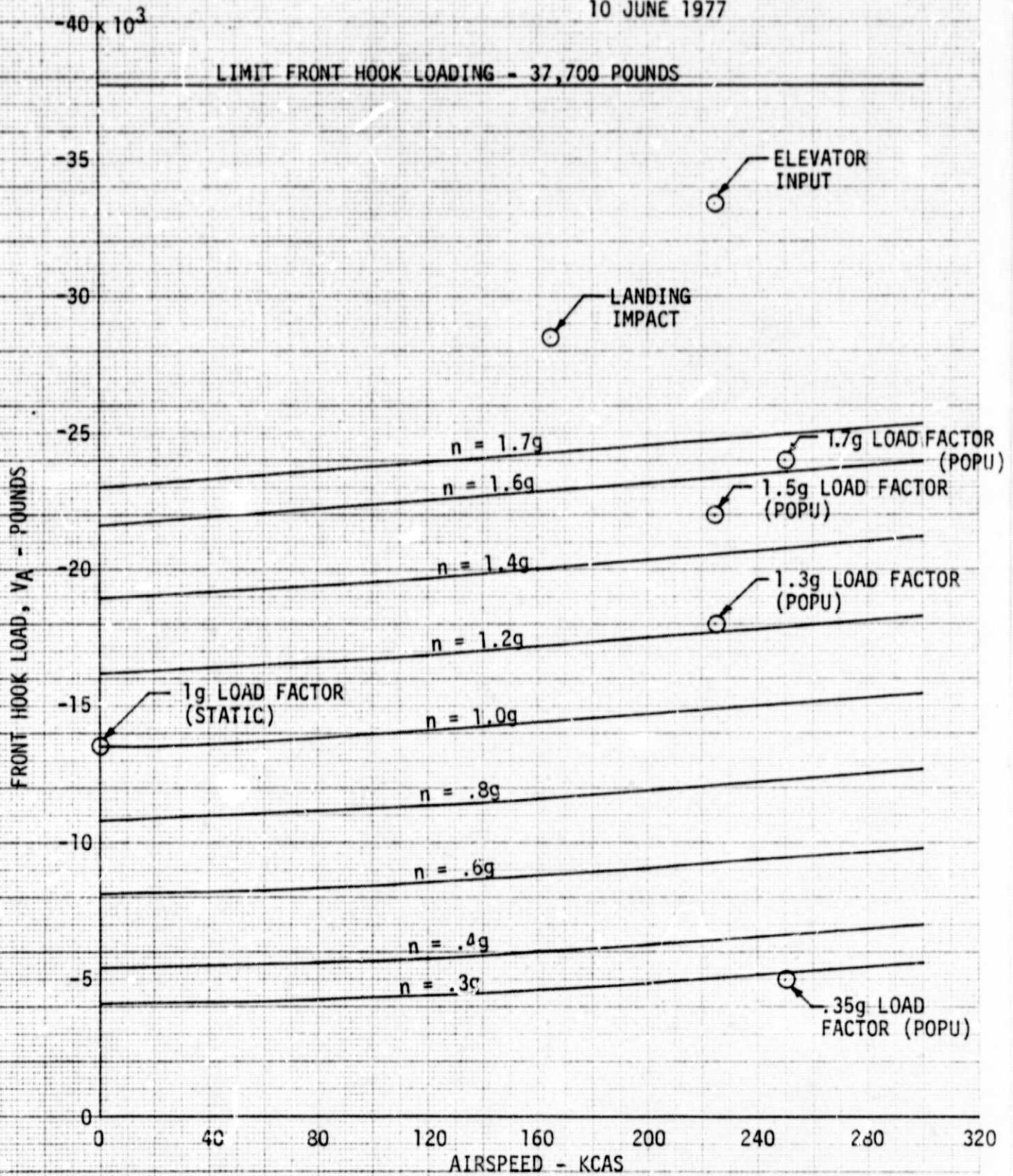


FIGURE 3:

CALC	<i>[Signature]</i>	—	REVISED	DATE	FRONT HOOK LOAD (V_A) VS. AIRSPEED (METHOD 1 & 2 STIFFNESS) B-52B/DTV CONFIGURATION 1 (W/O FINS)
CHECK	<i>[Signature]</i>	—			
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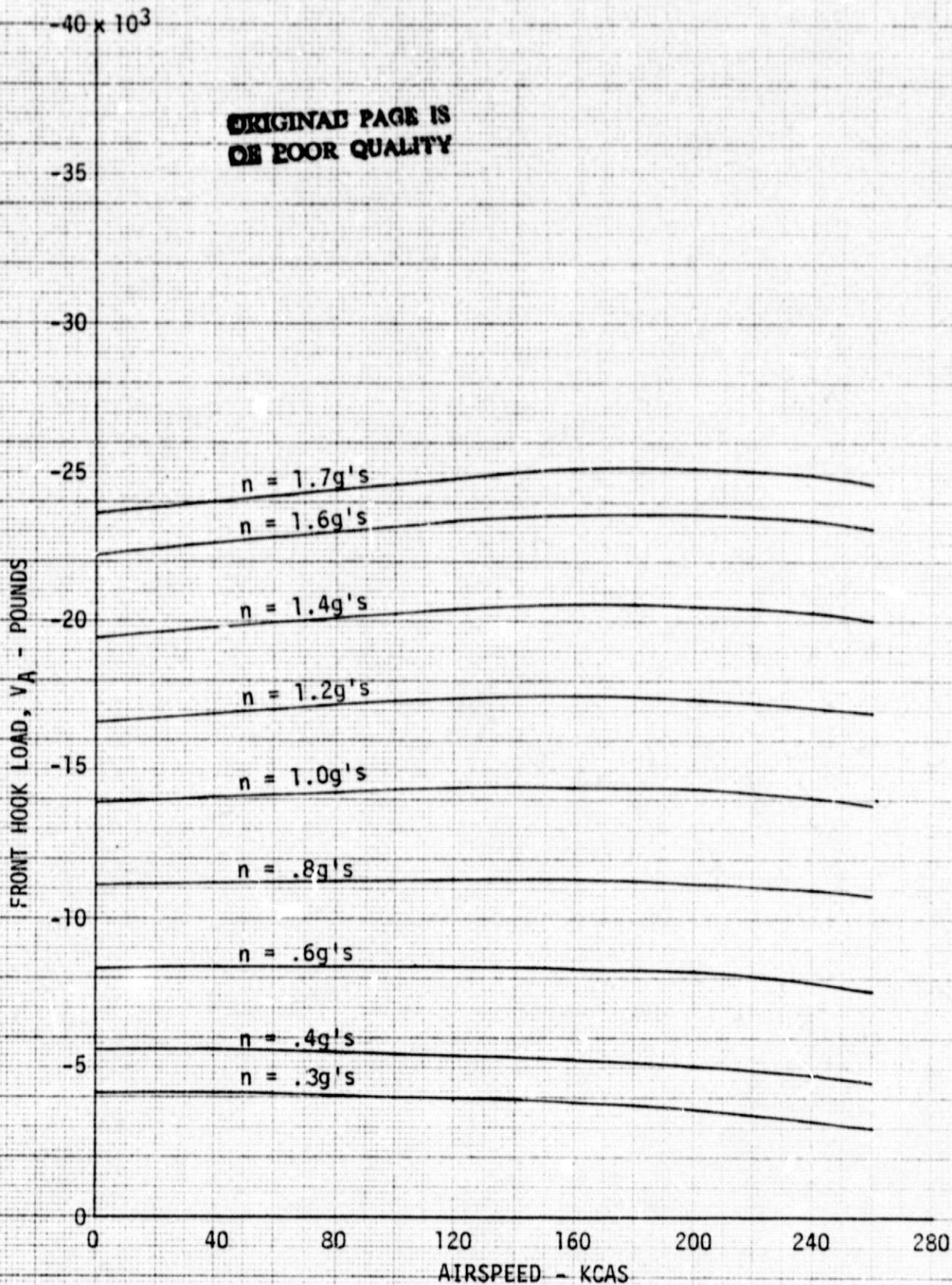


FIGURE 4

CALC	<i>2/16/73</i>	-	REVISED	DATE	FRONT HOOK LOAD (VA) VS. AIRSPEED (METHOD 1 & 2 STIFFNESS) B-52B/DTV CONFIGURATION 1 (W/FINS)
CHECK	<i>2/16/73</i>	-			
APPD					
APPD					

3.0 DTV DROP TESTS

Flights in support of solid rocket booster (SRB) parachute deployment and integrity evaluation using carrier aircraft B-52B-008 were accomplished during the June 1977 through September 1978 time period. These test flights consisted of B-52B/DTV takeoff from Edwards, flight to the National Parachute Test Range (NPTR), DTV drop at NPTR and B-52B return to Edwards. The airplane gross weight for each of the seven drop test flights at the time of engine start was approximately 336,000 pounds, with 100,000 pounds of this being fuel weight. The DTV weight and configuration (with and without fins) for each of the flights are shown in Table III.

All drop test flights were flown using the restrictions/guidelines (Reference Sections 1.0 and 2.0 of this document) developed during the captive flight test and subsequent data evaluation effort. Following the first drop test mission, a decision was made to monitor front hook loading on subsequent drop test flights to ensure that overload conditions were not encountered during the flight to NPTR. Real time telemetered data were monitored on all subsequent flights except Drop Test Flights 5 and 6, which were not monitored due to the failure of an amplifier in the strain gage circuitry. The maximum front hook loading experienced on each of the test flights is shown in Table IV. In all cases, the maximum load experienced occurred during taxi, takeoff or landing operations. The maximum load experienced during the drop test missions occurred during a taxi turn on Drop Test Flight 3. This loading of 29,800 pounds represented 79 percent of the front hook design limit load capability. Dynamic excitation of the DTV in the 1.9 to 2.0 hertz rocking mode due to either abrupt maneuvers or atmospheric turbulence was minimized because of the flight restrictions/guidelines imposed as a result of the captive flight test effort; therefore, no large front hook flight loads were experienced during the flights to NPTR.

Drop Test Flight 4-1 was aborted due to the failure of the hook mechanism to release the DTV. An emergency landing was made at Edwards with the hooks in an unsafe condition. Subsequent evaluation of the hook mechanism showed that a 3050 psi ram hydraulic pressure was required to open the hooks when a 1g DTV loading was applied to the hooks. The maximum hydraulic operating pressure for the ram is 3000 psi. The results of the drop mechanism checkout are given in Table V. Hook locations are defined in Figure 5. Following the test check, the release mechanism was reworked and another test check made to ensure proper hook release under a 1g DTV loading. Drop Test Flights 4-2, 5 and 6 were made without further hook release problems.

TABLE III
DTV CONFIGURATION 1 WEIGHT AND CG LOCATION

TEST	DTV CONF. 1 (FINS)	WEIGHT (POUNDS)	PYLON STATION	PYLON BUTTOCK LINE	PYLON WATERLINE	PITCH MOMENT OF INERTIA (SLUG-FT ²)
CAPTIVE FLIGHTS						
1-1	WITHOUT	47,772	171.34	0.09	-26.63	399,228
1-2	WITHOUT	47,772	171.34	0.09	-26.63	399,228
DROP TEST FLIGHTS						
1	WITHOUT	47,772	171.34	0.09	-26.63	399,228
2	WITHOUT	48,272	169.50	-0.01	-27.17	404,223
3	WITH	48,571	170.70	-0.02	-27.17	406,995
4-1	WITH	48,071	172.49	-0.09	-26.80	401,995
4-2	WITH	48,071	172.49	-0.09	-26.80	401,995
5	WITH	48,086	172.60	-0.09	-26.80	402,511
6	WITH	47,139	168.30	0.08	-27.19	395,000

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TABLE IV
FRONT HOOK LOADS - DTV DROP FLIGHTS

DATE	FLIGHT	MAXIMUM FRONT HOOK LOAD	PERCENT OF LIMIT LOAD	CONDITION DURING WHICH MAXIMUM HOOK LOAD EXPERIENCED
---	NO.	POUNDS	PERCENT	COMMENTS
06/15/77	1	N/A	N/A	N/A
08/04/77	2	26,200	69	TAKEOFF
12/14/77	3	29,800	79	GROUND TURN
04/27/78	4-1	25,600	68	LANDING
05/23/78	4-2	25,000	66	BRAKING
07/26/78	5	N/A	N/A	N/A
09/12/78	6	N/A	N/A	N/A
<p>GENERAL NOTES</p> <ul style="list-style-type: none"> ● Front hook loading capability is 37,700 lbs. limit (57,271 lbs. ultimate). ● N/A - not available 				

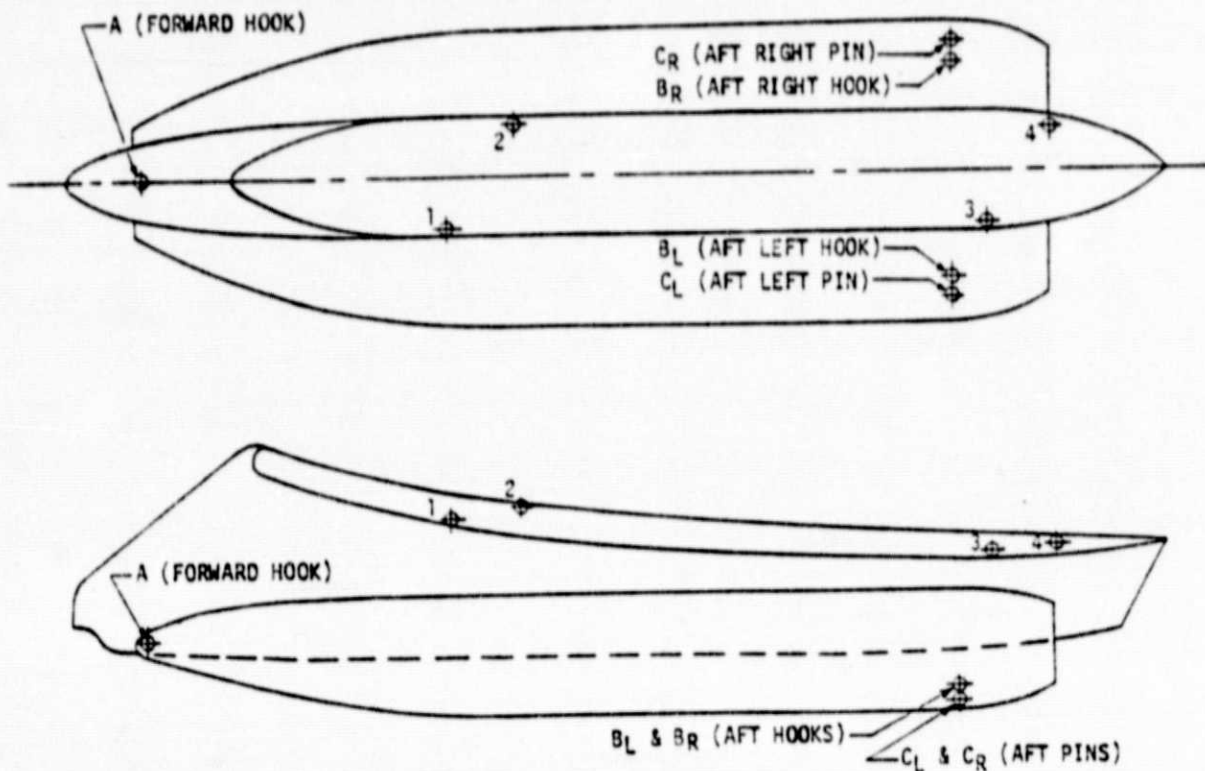
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TABLE V
DROP MECHANISM CHECKOUT FOLLOWING INFLIGHT FAILURE

CONDITION	APPLIED HOOK CHECKOUT LOAD (POUNDS)			HYDRAULIC RAM PRESSURE (PSI)	
	FRONT HOOK (V _A)	LEFT REAR HOOK (V _{BL})	RIGHT REAR HOOK (V _{BR})	TRY 1	TRY 2
C1	0	0	0	1100	---
C2	2000	3400	3400	2100	1950
C3	3400	8700	8700	2600	---
C4	13300	17500	17500	3050	---
MAXIMUM HYDRAULIC RAM PRESSURE - 3000 PSI					



PYLON LOCATION	PYLON STATION	PYLON BUTTOCK LINE	PYLON WATER-LINE
A	20.000	0.000	-1.1875
BL	231.000	-26.437	-15.1870
BR	231.000	26.437	-15.1870
CL	231.000	-31.312	-17.5000
CR	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 5

4.0 REFERENCES

1. Boeing Document D3-11220-1, Volumes I through IV, "Load and Dynamic Assessment of B-52B-008 Carrier Aircraft for Configuration 1 and 2 Space Shuttle Solid Rocket Booster Decelerator Subsystem Drop Test Vehicles", dated 24 October 1977.
2. Boeing Document D3-11220-2, Volumes I through IV, "Load and Dynamic Assessment of B-52B-008 Carrier Aircraft for Finned Configuration 1 Space Shuttle Solid Rocket Booster Decelerator Subsystem Drop Test Vehicle", dated 6 October 1978.