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Viking '75 Project

PRE-TEST REPORT FOR FLEXIBLE DECELERATOR WIND TUNNEL TESTS AT AEDC PWT 16S

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PRE-TEST REPORT FOR FLEXIBLE DECELERATOR WIND TUNNEL TESTS AT AEDC PWT 16S

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

SUMMARY

An investigation to determine the drag performance of Disk-Gap-Band 10% scale model parachute assemblies behind the entry vehicle forebody has been planned at the AEDC PWT 16S facility.

The investigation will be conducted over a Mach number range $M \approx 1.7 - 3.0$ at dynamic pressures about 80 PSF. The tests will consist of variations of both parachute assembly trailing distance behind the entry vehicle and suspension line length ratio. Measurements will consist of utilization of load cells and a tensiometer to determine the parachute performance behind the EV.

This report presents the details of the investigation including installation, instrumentation, data reduction requirements and specifics concerning conduct of the test.

I. INTRODUCTION

A wind tunnel (PWT-16T) investigation of several 10% scale, flexible Disc-Gap-Band (DGB) parachute models behind the Viking Entry Vehicle (EV) and Lander and Base Cover (L+BC) forebodies was conducted over a range of Mach numbers of 1.4 - 0.2. This investigation was primarily concerned with variations of parachute assembly trailing distance and suspension line length to nominal parachute diameter ratio. Increased suspension line length provided for increased parachute performance during the investigation. Accordingly, it is required to determine the influence of both increased suspension line length and trailing distance upon parachute performance over the range of Mach numbers from 1.7 to 2.2; the latter Mach number is the present Viking decelerator system deployment Mach number while 1.7 is the anticipated lowest available Mach number in the PWT 16S facility. The major test objectives are:

1. Obtain the drag performance of DGB parachute assemblies at $X/d = 8.5$, $S/D_o = 1.73$ and $S/d = 6.5$, $S/D_o = 1.17$ over the Mach number range of 1.7 - 2.2;
2. Obtain the deployment shock loads at $M = 2.2$ for both assemblies noted above;
3. As a function of parachute assembly survivability, extend the Mach number range to $M = 3.0$;
4. Obtain "chute alone" performance data for a parachute assembly of $S/D_o = 1.73$; and,
5. Investigate the performance of other parachute assemblies if the allotted tunnel occupancy time permits.

This report presents the details of the investigation including model, instrumentation and data reduction requirements.

II. SYMBOLS AND NOMENCLATURE

A. Model Configuration Nomenclature

Symbol	Configuration
$A_{140}BC_6$	Entry vehicle configuration with 140^o cone forebody and spherically blunted nose (Figure 1(a)).
P	Parachute assembly - includes canopy, suspension lines, swivel, riser line (if necessary) and bridle.
d	Maximum diameter of Entry Vehicle (13.8 inches).
D_o	Uninflated (reference) diameter of parachute (5.3 ft.).
$R_{eff.}$	Effective length of riser line.
R_x	Longitudinal length of riser line as measured from bridle to chain link attachment to swivel.

II. SYMBOLS AND NOMENCLATURE (Continued)

A. Model Configuration Nomenclature (Continued)

Symbol	Configuration
S	Parachute suspension line length.
X	Longitudinal distance from maximum diameter of Entry Vehicle to parachute canopy inlet.
DGB	Disc-Gap-Band

B. Data Reduction Symbols

LC_t, LC_f	Load cell drag force (lbs) - t, measures total load of forebody and parachute; f, measures forebody load only.
T	Tensiometer drag force (lbs) - measures parachute axial force.
C_{D_P}	Parachute drag coefficient $\frac{(LC_t)}{q_{oo} S_{ref.}} - K$ or $\frac{T}{q_{oo} S_{ref.}}$
C_{P_B}	Base pressure coefficient $\frac{P_B - P_{oo}}{q_{oo}}$
K	Drag coefficient value to account for forebody drag coefficient based upon parachute reference area.
M	Tunnel Mach number.
q_{oo}	Free stream dynamic pressure.
$S_{ref.}$	Parachute reference area $\pi D_o^2/4 = 22.06 \text{ ft}^2$.
α	Angle of attack of forebody (degrees).
β	Angle between velocity vector and assumed parachute centerline through load cell (degrees).

III. MODEL INSTALLATION AND INSTRUMENTATION

A. Model

The 10% Entry Vehicle model (Figure 1) is identical to that previously utilized during the Reference 1 investigation.

B. Parachutes

The parachute canopies are of the DGB type. Table I presents the geometric properties of the parachute(s). Table II presents additional geometry for each parachute including the trailing distance values, lengths of "riser" required and effective riser lengths. The suspension lines are 200 lb. test braided nylon.

The parachute suspension lines are fitted to a 1.75 O.D. x .25 thick ring which is mated to a swivel design the details of which are presented in drawing SK837J81308. The swivel either mates with length of cable riser line or directly with a tensiometer. This is fitted to a length of 2 chain ovals which mates with the bridle assembly from the model. A rigging diagram is presented in drawing SK837J81309.

C. Installation

The model installation will essentially duplicate that utilized during the Reference 1 investigation. The parachute will be protected by being packaged in a tube mounted near the model support strut lower end and pneumatically deployed after the desired test condition has been established. The suspension lines will be led up the model strut trailing edge and tied with break cord which servers as the chute deploys.

D. Instrumentation

The test instrumentation will consist of the following:

For the Entry Vehicle models runs - 2 load cells and tensiometer

BLH C2M1 - 500 lb - measures EV load

BLH C2M1 - 2000 lb - measures EV + parachute load

SK837J81303 Detail 003 (Ref. 2 page 27) - measures parachute load

For parachute alone runs - 1 tensiometer

SK837J81303 detail 003 (Ref. 2 page 27) - measures parachute load

During EV model runs, base pressure in 3 locations will be obtained.

The photo coverage and camera speeds used during the Reference 1 investigation will be obtained. Temperature as recorded during the Reference 1 tests will also be obtained.

IV. TEST DESCRIPTION AND PROCEDURE

A. Tunnel Condition

The tunnel should be operated at the lowest practical dynamic pressure commensurate with efficient operation. A dynamic pressure $q \approx 80\text{-}100$ psf is desired. To enhance parachute survivability, dynamic pressure greater than 100 psf should be avoided. The following table represents a comparison of tunnel Reynolds numbers with flight Reynolds numbers.

Tunnel Reynolds number is based upon a constant tunnel dynamic pressure of 90 psf and tunnel $T_{tot} = 120^{o}F$. Flight Reynolds number is based upon the minimum surface density atmosphere over the Mach number range.

Mach Number	1.6	1.7	1.8	1.9	2.0	2.1	2.2
Tunnel Reynolds No. $\times 10^{-6}$	.485	.456	.451	.459	.469	.477	.487
Flight Reynolds No. $\times 10^{-6}$	.915	.940	.965	.995	1.03	1.05	1.09

The Reynolds numbers are based upon the maximum diameter of the EV.

B. Test Procedure

The parachute model canopy selected for the specific test run will be packed in a bag which will be furnished by Goodyear Aerospace Corporation for each test parachute. The parachute suspension lines will be bundled outside of the packed bag. The package will be placed within a 5" I.D. tube fixed to the model support strut and the suspension lines and riser line tied to the strut at its trailing edge with break cord at several vertical stations. A strapping arrangement will retain the chute bag within its cannister. A pneumatically operated styrofoam piston will eject the parachute-bag combination while the solenoid operated pin puller releases the tube cap straps. The deployment of the chute will sequentially sever the break cord which absorbs energy thereby minimizing the shock load at complete line stretch. Chute deployment will be initiated at peak Mach number and data will be obtained at specific Mach numbers as tunnel speed is progressively reduced. This will continue until a Mach number of about 1.7 is obtained. If the chute has survived data will then be obtained up to Mach number = 3.0 before tunnel shut down and model replacement.

The precise order of runs has not been established as of this writing. Table II, however, identifies the six (6) available parachutes and the intended test parameter geometry for each parachute.

V. DATA REDUCTION

Of primary importance is the drag performance of the parachute in the wake of the forebody. The data reduction procedures established as per the reference 1 investigation will be followed for these tests.

AEDC will furnish the following specific items:

1. Reduced forebody drag coefficient from Load Cell #1 - drag coefficient based on $S_{ref} = 22.06\ ft^2$ and also $S_{ref} = 1.04\ ft^2$.

2. Reduced total drag coefficient from Load Cell #2 - coefficient based on $S_{ref} = 22.06\ ft^2$.

3. Reduced parachute drag coefficient based upon Load Cell #2 and Load Cell #1 values or Load Cell #2 and an estimate of forebody drag coefficient furnished by Martin Marietta Corporation.

4. Reduced parachute drag coefficient based upon Tensiometer values - coefficient based on $S_{ref} = 22.06\ ft^2$.

NOTE: Data reduced for 1-4 above based upon FAMROS time averaged values.

5. Base pressure coefficient values for 3 static pressures in model base region.

6. Load cell thermocouple data when applicable.

7. Listout of all pertinent tunnel test conditions.

8. Motion pictures from 5 cameras; 70 mm still photos.

9. Analog tape of all loads and pressure data.

NOTE: IRIG time mark on film and tape.

On-line data will consist of reduced drag coefficient based on FAMROS readings; oscillograph, TV screen and Tunnel condition listout will also be provided.

VI. REFERENCES

1. S. Steinberg, Pre-Test Report for Flexible Decelerator Wind Tunnel Tests at AEDC PWT 16T (Phase 2), Martin Marietta Corporation Report TP-3720157, June 1971, Denver, Colorado.

TABLE I - GEOMETRIC PROPERTIES OF PARACHUTE

ITEM	RELATIVE VALUE	VALUE
Nominal Diameter	D_o	5.3 ft
Total Area (S_o)*	$\pi D_o^2/4$	22.06 ft^2
Geometric Porosity**	0.125 S_o	2.76 ft^2
Disk Area***	0.53 S_o	11.69 ft^2
Disk Diameter	0.726 D_o	3.85 ft
Gap Area	0.12 S_o	2.65 ft^2
Gap Width	0.042 D_o	.223 ft
Band Area	0.35 S_o	7.72 ft
Band Width	0.121 D_o	.641 ft
Vent Area	0.005 S_o	.110 ft^2
Vent Diameter	0.07 D_o	.371 ft
Number of Suspension Lines	----	48
Thickness of Suspension Lines	0.00011 D_o (FS)	.07 inch
Thickness of Suspension Lines Actually Tested	0.00157 D_o (model)+	0.100 inch
Suspension Line Lengths	1.16 D_o	6.148 ft
	1.52 D_o	8.056 ft
	1.85 D_o	9.805 ft
	2.26 D_o	11.980 ft

* Disk + Gap + Band

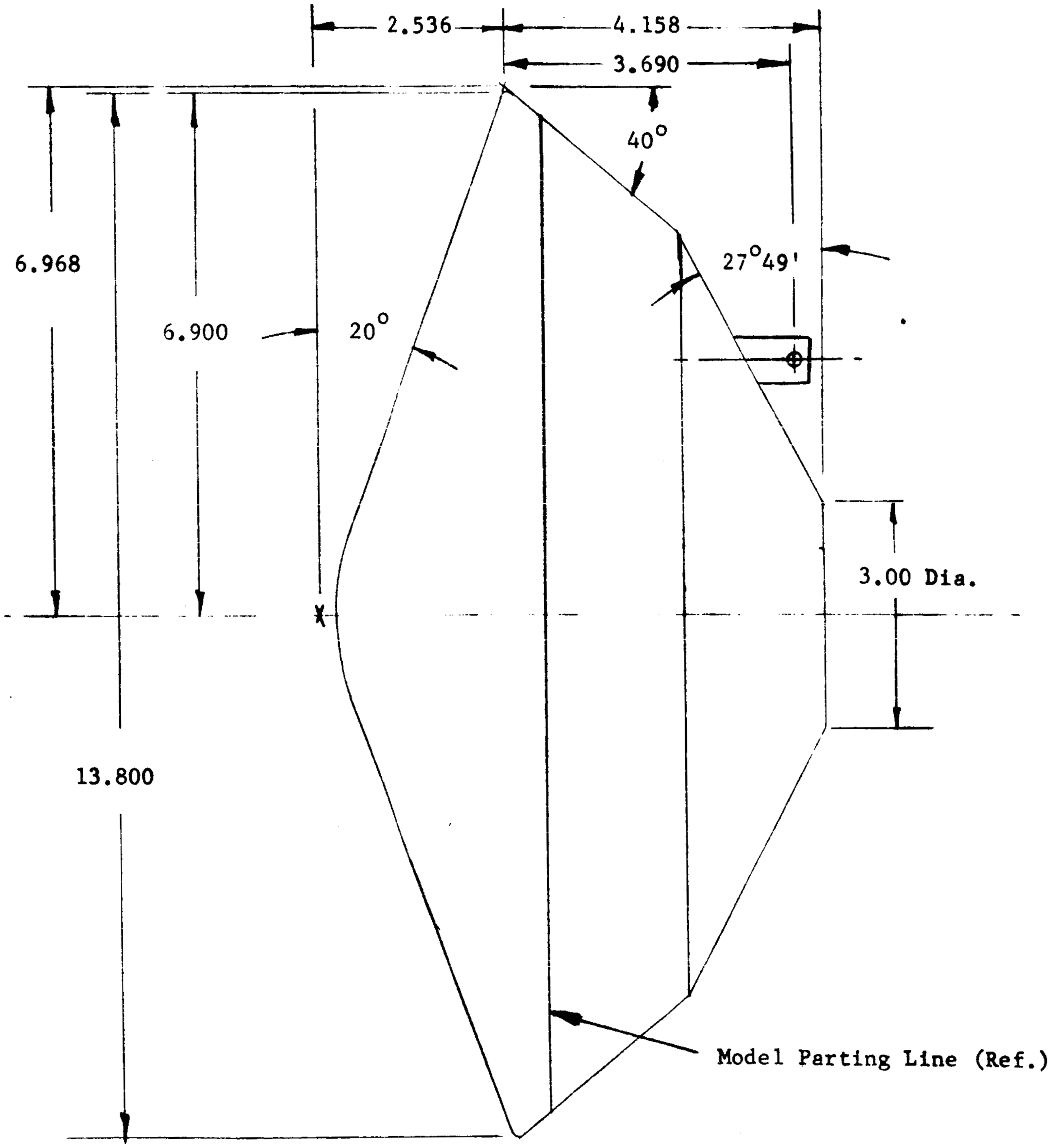
** Gap + Vent provide 12.5 percent geometric porosity

*** Includes Vent

\+ Based on wide edge dimension

TABLE II PARACHUTE TEST PARAMETER GEOMETRY

Serial No.	S/D_o	X/D	Finished S (in)	Reff (in)	Rx (in)
6A	1.73	8.53	105.5	.63	--
7A	1.16	6.5	70.5	37.29	35.7
5A	1.73	8.53	105.5	.63	--
3A	1.85	9.14	113.5	.30	--
2A	1.73	8.53	105.5	.63	--
7	1.16	8.5	70.5	37.29	35.7



NOTE: ALL DIMENSIONS IN INCHES

Fig. 1

ENTRY VEHICLE MODEL GEOMETRY