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SANDIA SYSTEMATIC DECLASSIFICATION REVIEW

1st Review Date: 1-28-80
Authority: ☐ ADC ☒ ADD
Name: CCRP RR
2nd Review Date: 10-17-96
Authority: ADD
Name: W Layne

Determination (Circle Numbers):
1. Classification Retained
2. Classification Changed to: U
3. Contains No DOE Classified Information
4. Coordinate With
5. Contains UCNI?
6. Comments: unclassified

SC-TM 180-56-51

PARACHUTE-RETARDATION STUDIES FOR NEW CLASS B WEAPON

PART I - CONVENTIONAL PARACHUTE SYSTEM

PART II - LAYDOWN PARACHUTE SYSTEM

SANDIA SYSTEMATIC DECLASSIFICATION REVIEW
DOWNGRADING OR DECLASSIFICATION STAMP

CLASSIFICATION CHANGED TO: U
AUTHORITY: W. C. Layne
PERSON CHANGING CLASSIFICATION & DATE: Ernelda Seeph 10-24-96
RECORD ID: 97SN062
PERSON VERIFYING CHANGING & DATE: R. T. Duff 10/29/96
DATED: 10-17-96

Joseph Crompton

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ABSTRACT

Preliminary calculations, based on currently available data, present the design factors involved in the two types of parachute systems under study by the Class A and B Working Group to determine feasible parachute applications for the new Class B weapon.

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(13 pages)

Case No. 409.01

September 11, 1956

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PREFACE

This report presents the factors involved in development of parachute-retardation systems for the new Class B weapon. It is intended as a guide in the discussion and selection of feasible systems for more refined analysis by the Parachute Branch at WADC.

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PARACHUTE-RETARDATION STUDIES FOR
NEW CLASS B WEAPON

PART I -- CONVENTIONAL ESCAPE PARACHUTE

The following outline of factors involved in providing a retarded trajectory by means of a conventional escape parachute has been prepared for the A and B Working Group Feasibility Study.

INTRODUCTION

For purpose of this discussion, the conventional escape parachute is defined as being similar to the Mk 17/24 and Mk 21/36 parachutes which use static line deployment of a constant drag area to reduce the rate of descent to burst altitude. Variations to the conventional systems are also presented for discussion. No discussion of the "laydown" aspects is included since this type of application is presented in Part II.

PRELIMINARY DESIGN PARAMETERS

1. Bomb Weight: Bomb weight determines the drag area required for a specified time of fall. Military characteristics specify a 10,000-pound maximum. Variations in bomb weight will require changes in drag area to maintain the specified time of fall. Minor variations in drag area can be secured without change in nominal diameter of the parachute by reefing techniques.

2. Required Time of Fall: Time of fall is a function of degree of retardation required which depends on aircraft escape capabilities and weapon yield. Previous conventional escape parachutes have used a 40,000-foot release altitude and a 4000-foot burst altitude to specify the excursion zone of the trajectory. No official time of fall has been specified for the new Class B. For preliminary calculations, the 100-second requirement for the Mk 21 has been assumed for the new Class B study.

3. Drag Area Required: For 100 seconds downtime, from 40,000 feet to 4000 feet MSL, 107 square feet of drag area is required. This is equivalent to a 16.5-foot nominal diameter FIST ribbon parachute. However, a downtime tolerance of +6 per cent specified by SAC to insure a minimum of 100 seconds escape time establishes 106 seconds as the design goal for the parachute. Preliminary calculations indicate that a drag area of 127 square feet is required for 106 seconds time of fall.

4. Nominal Diameter of Parachute: A nominal diameter of 18 feet will provide 127 square feet drag area in a ribbon parachute.

5. Maximum Release Speed: Based on USN aircraft characteristics for P6M aircraft, Mach .9 is the maximum release speed. Release speed is a factor in determining the dynamic loading of the canopy.

6. Minimum Release Altitude: Based on SAC operational requirements for the Mk 21, 20,000 feet MSL has been assumed for the new Class B bomb.

7. Maximum Dynamic Pressure on Canopy: From the release speed and altitude in paragraphs 5 and 6 above, the dynamic pressure (q) is 540 pounds/square feet.

8. Estimated Opening Shock: The magnitude of opening shock is contingent on the parachute "X" factor. Drop test data must be secured to determine the time-load history of canopy

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inflation. From the dynamic loading (q) and the drag area, opening shock calculations indicate a force of 100,000 pounds when the "X" factor is 1.5. This is equivalent to 10 g.

9. Parachute Design Load: To meet the opening shock of 100,000 pounds with a normal parachute safety factor of 2, as specified by WADC, the canopy design load will be 200,000 pounds.

10. Suspension Line Strength: Based on design of previous conventional parachutes, 9000-pound class line with a 20 per cent allowance for stitching and bending is assumed. The line/diameter ratio of 1.5 is normal for heavy-duty parachutes.

11. Developed Strength of Canopy: An 18-foot diameter parachute with a line diameter ratio of 1.5 will require 28 suspension lines. Developed strength of 28 lines at 9000 pounds breaking strength is 201,600 pounds.

12. Estimated Volume of Canopy and Lines: Based on estimates from WADC, the volume of the canopy and lines is 3.4 cubic feet.

13. Estimated Volume-Deployment System: Based on 20 per cent allowance for deployment system, .7 cubic foot is required.

14. Total Pack Volume: Total pack volume is 4.1 cubic feet with conventional packing techniques.

15. Total Pack Weight: Based on tentative information from WADC, total pack weight is 114 pounds.

DISCUSSION OF ADDITIONAL DESIGN REQUIREMENTS

1. Reliability: Maximum reliability is required. This requirement imposes obligation for correct design, manufacture, packing, and use.

2. Environmental Requirements: The parachute system must meet the environments of the stockpile-to-target sequence (SCS-5).

3. Compatibility: The parachute pack must be compatible with the bomb and the bomb bays of the carrier aircraft.

4. Trajectory: Conventional applications deploy the parachute on release and apply constant drag area over the full trajectory. (Two-stage deployment requires approximately 10 seconds.)

DROP TEST REQUIREMENTS

Conventional parachute systems have required approximately 20 drop tests for each pack configuration. Phase I, consisting of ten drop tests, provides data to prove the deployment, stability, opening shock, packing, and time of fall. Phase II, also consisting of ten drop tests, provides data on compatibility with aircraft types, reliability statistics, and proves the system for various release conditions. Phase II can be combined with F&F drop tests and also provides data for bombing tables.

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VARIATIONS FROM THE CONVENTIONAL PARACHUTE SYSTEM

Development programs for the conventional parachute systems for the Mk 17/24 and Mk 21 programs have disclosed possible variations from the conventional systems for evaluation in feasibility study for new programs.

External Pack Configurations: Previous parachute systems required internal stowage in the bomb afterbody. Smaller parachutes permit stowage in external packs for simplified assembly. Sealed metal containers externally mounted can be developed to protect the exposed pack from damage or deterioration during storage, assembly, and transit. Simplified assembly will permit interchange flexibility and simplified logistics.

Reduced Pack Volume: Pressure packing methods are being investigated at WADC to reduce pack volume.

Automatic Deployment System: Static line deployment presents problems in the areas of aircraft compatibility with the various types of controls installed by aircraft contractors. Interference with bomb-bay door operation and damage to the aircraft also present problems in static line development. Automatic deployment systems, actuated electrically through bomb or aircraft circuitry, present a closer approach to the "wooden bomb" concept. Aircraft compatibility with the bomb bays would be simplified. Preliminary information from Navy sources indicates that the rotary door of the P6M bomb bay cannot be used with a static line system.

In return for additional effort to develop a reliable system, would be the advantages in aircraft modification and simplified loading procedures. An external pack combined with a reliable automatic deployment system affords definite advantages for evaluation. Missile recovery systems afford precedent for automatic programmed deployment systems.

Alternate Trajectories: Development of programmed deployment systems would permit examination of alternate trajectories that cannot be exploited with static line systems. Free fall and retardation could be combined in the optimum balance indicated by vulnerability studies. Preliminary study of "laydown" aspects indicates that low-impact velocities are accompanied by low rates of descent that may not be compatible with vulnerability requirements.

General: The attached exhibits illustrate preliminary concepts of variations from the conventional systems that require evaluation. Division 1260 is investigating the problems involved in electrical actuation of deployment systems through aircraft or bomb circuitry.

It is recognized that incorporation of any variations from the conventional parachute system will extend development time scales to produce a reliable system. Increased coordination with USAF parachute development will be required.

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SUMMARY SHEET
PRELIMINARY DESIGN PARAMETERS
PART I -- CONVENTIONAL ESCAPE PARACHUTE
CLASS B FEASIBILITY STUDY

(1) Bomb weight (lbs)	(2) Req'd time of fall (sec)	(3) Drag area req'd (sq ft)	(4) Nominal diam chute (ft)	(5) Max release speed (fps)	(6) Min release alt (msl)	(7) Max dynamic pressure (lbs/ft^2)	(8) Est open shock (lbs)	(9) Canopy design load	(10) Line class	(11) No. lines req'd	(12) Dev str of canopy	(13) Estimated Volume: Canopy & lines (cu ft)	(14) Estimated Volume: Deploy (20%) (cu ft)	(15) Estimated Volume: Total pack (cu ft)	(16) Total pack weight (lbs)
10,000	100	127	18	920	20,000	540	100,000	200,000#	9000#	28	201,000#	3.4	.7	4.1	114

Source:
1. Maximum weight of Class B by military characteristics
2. Specified by USAF for TX-21. Assumed for Class B
3. Preliminary calculations - Sandia Corporation, 5144
4. Preliminary calculations - Sandia Corporation, 5144
5. USN - aircraft performance for P6M of Mach .9
6. USAF specifications for TX-21. Assumed for Class B
7. Preliminary calculations - Sandia Corporation, 5144
8. Preliminary information - WADC
9. Based on WADC factor of safety of 2
10. Based on design of TX-21 parachute
11. Preliminary calculations - Sandia Corporation, 5144
12. Preliminary calculations - Sandia Corporation, 5144
13. Based on tentative information from WADC
14. Based on WADC estimates
15. Based on WADC information
16. Based on tentative information - WADC

Additional Design Requirements:
a. Maximum reliability
b. Environmental requirement of stockpile-to-target sequence (SCS-5)
c. Compatibility w/bomb and bomb bays of each aircraft type
d. Deployment system

Estimated Drop Test Requirements:
Phase I: 10 drops for development and design refinement
Phase II: 10 drops for proof and ABM (combined w/F&F drops)
Total: 20

Possible Variations from Conventional System:
a. External pack configuration
b. Pressure packing for reduced volume
c. Automatic or programmed deployment
d. Alternate trajectory combinations

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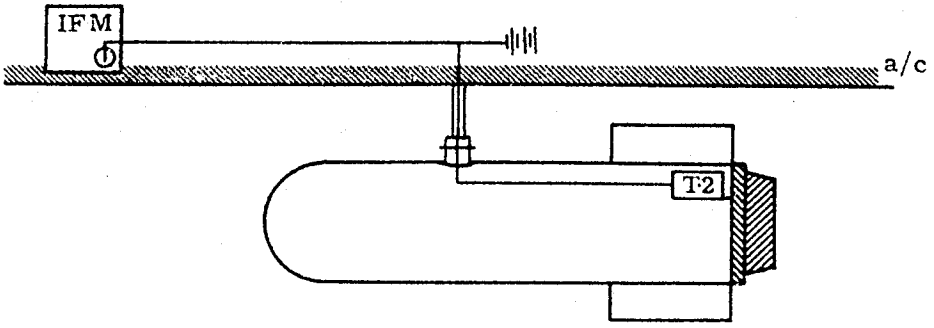
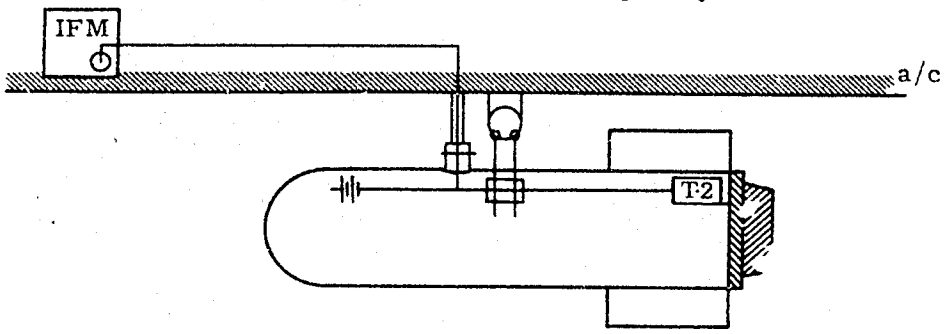
DEPLOYMENT SYSTEMS CONCEPTS

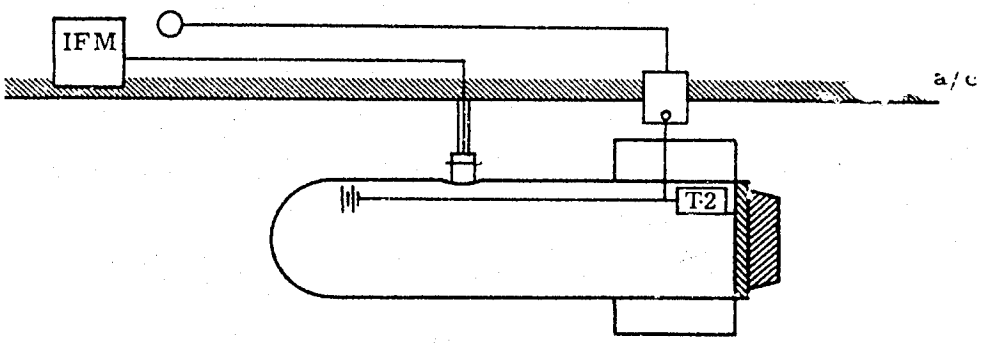
SYSTEM A: Utilize T-249, IFM, System With Parachute Option Switch. Actuate By A/C Power To T-2 Squib:



SYSTEM B: Utilize T-249, IFM, To Provide Option But Actuate By Weapon Power To T-2 Squib By Pullout Wires:



SYSTEM C: Utilize Arming Control For Option, F[illegible] Electrically Actuate Delay Squib By Weapon Powe[illegible] [illegible] Wire On Release:



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PARACHUTE-RETARDATION STUDIES FOR NEW CLASS B WEAPON

PART II -- LAYDOWN PARACHUTE SYSTEM

The following outline of factors involved in the development of a laydown parachute system has been prepared for the A and B Working Group Feasibility Study.

INTRODUCTION

A laydown parachute system differs from a conventional escape parachute in that the size of canopy is governed by the allowable impact velocity rather than time of fall. Conventional escape parachutes impact at approximately 280 fps; whereas, laydown parachutes are expected to impact at 125 fps. This reduction in impact velocity quadruples parachute drag area and pack bulk, and presents formidable problems in bomb and aircraft compatibility.

For purpose of this preliminary study, only high-altitude laydown factors are considered. The ultimate goal of a low-level laydown capability for the Class B cannot be attained until the design parameters of a high-altitude system are met.

PRELIMINARY DESIGN PARAMETERS

A. Parachute Size

1. Bomb Weight: As in the conventional systems, bomb weight determines the drag area required for a specified impact velocity. Military Characteristics specify a maximum weight of 10,000 pounds for the new Class B weapon.

2. Required Impact Velocity: Allowable impact velocity is governed by bomb case and component design, combined with the effectiveness and amount of cushioning material. Preliminary study has indicated that weapon design will permit impact velocities of 125 fps. Higher impact will overtax the cushioning, and lower impacts appear prohibited by pack bulk requirements.

3. Drag Area Required: For an impact velocity at sea level of 125 fps, with a 10,000-pound bomb, 550 square feet of drag area is required. For comparison, impact velocities of 100 fps and 150 fps require 900 square feet and 400 square feet of drag area, respectively.

4. Nominal Diameter of Parachute:

   a. 100 fps requires 900 square feet or 48-foot diameter.
   b. 125 fps requires 550 square feet or 38-foot diameter.
   c. 150 fps requires 400 square feet or 32-foot diameter.

Diameter calculations are based on a FIST ribbon parachute as used for conventional escape parachute systems.

B. Canopy Design Loading

5. Design Class: The major factor in pack bulk is design strength of canopy. Six design classes have been selected for study. Higher design strength permits greater operational flexibility but increases pack bulk. For example, a 38-foot diameter canopy, with a first-stage drag area of 192 square feet, designed to 120 pounds per square foot will require

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approximately 7.0 cubic feet, whereas the same canopy, designed to 725 pounds per square foot will require 20 cubic feet for stowage.

6. Number of Lines: Canopy strength is a function of number of lines and strength per line. Increased strength is attained by increasing the number of lines and/or increasing the strength of lines. Normal lines/diameter ratios have been used for study.

7. Unit Design Load: For purpose of study the unit design load has been calculated for six appropriate design classes ranging from 240 pounds/square foot to 1450 pounds/square foot.

8. Unit Working Load: Normal parachute safety factor of 2 has been used to establish safe unit working loads.

9. Load Factor: For guidance in bomb design, parachute load factors have been calculated for each strength class. Load factors range from 3.4 to 20.8.

C. Parachute Pack Bulk

10. Pack Weight: Pack weight for the six design classes ranges from 175 pounds to 500 pounds. An allowance of 25 per cent has been included for deployment accessories.

11. Pack Volume: Pack volume for the six design classes ranges from 7.0 cubic feet to 20.0 cubic feet. An allowance of 25 per cent has been included for deployment accessories. Pressure packing methods are being investigated at WADC and may reduce pack volume considerably.

D. Operational Flexibility

For purpose of study, unit working loads for each parachute design class have been converted to operational speeds and altitudes to demonstrate the limitations on bomb release conditions imposed by canopy strength.

Refer to Exhibit A.

E. Time of Fall

"Laydown" parachute applications selected on basis of impact velocity reduce time of fall to a secondary parameter. Time of fall for three impact velocities is approximately:

Impact Velocity fps	Time of Fall 40,000' to S. L.
100	325 Seconds
125	260 Seconds
150	220 Seconds

Vulnerability studies will be required to determine the effect of increasing time of fall. If the above times are considered excessive, alternate trajectories in which the parachute is deployed after a free-fall interval may be developed.

F. Additional Design Requirements

1. Reliability: Maximum reliability is required, which imposes obligations for correct design, manufacture, packing and use.

SUMMARY SHEET 2
PRELIMINARY DESIGN PARAMETERS
PART II "LAYDOWN" PARACHUTE
CLASS B FEASIBILITY STUDY

A. PARACHUTE SIZE				B. CANOPY DESIGN LOADING					C. PARACHUTE BULK		D. OPERATIONAL FLEXIBILITY				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
											Maximum Release Speed at Alt. (fps)				
Bomb Weight (lbs)	Req'd Impact Velocity (fps)	Drag Areas Req'd (sq ft)	Nominal Chute Diameter (ft)	Design Class	No. Lines	Unit Design Load (lbs/ft^2)	Unit Working Load (lbs/ft^2)	Load Factor (g's)	Pack Weight (lbs)	Pack Volume (cu ft)	5000' (msl)	10000' (msl)	20000' (msl)	30000' (msl)	40000' (msl)
10,000	100	315/900	48*												
	125	192/550	38 --------	C	38	240	120	3.4	175	7.0	342	370	420	520	640
	150	140/400	32*	D	46	540	270	7.8	200	9.0	510	555	655	780	960
				E	46	770	385	11.0	237	11.0	610	660	775	930	1150
				F	58	970	485	14.0	325	13.0	666	740	875	1040	1290
				G	46	1150	575	16.5	400	16.0	750	810	950	1135	1400
				H	58	1450	725	20.8	500	20.0	840	908	1070	1275	1575

(1) Maximum Weight of Class B by Military Characteristics
(2) Selected for Preliminary Study
(3) Preliminary Calculations, Sandia Corporation - 5144
(4) Preliminary Calculations, Sandia Corporation - 5144
(5) Selected for Study from Preliminary Data from WADC
(6) Based on Normal Line/Diameter Ratios from WADC
(7) Preliminary Calculations, Sandia Corporation - 5144
(8) Based on WADC Factor of Safety of 2
(9) Preliminary Calculations, Sandia Corporation - 5144
(10) Based on Tentative Information from WADC
(11) Based on Tentative Information from WADC

* Included for Comparison Only.

D. Operational Flexibility: Refer to Exhibit A

E. Time of Fall:

Impact Velocity:	100 fps;	Time of fall:	325 sec. 40/SL.
	125		260
	150		220

F. Additional Design Requirements
1. Maximum Reliability
2. Environments of Stockpile-to-Target Sequence
3. Compatibility with Bomb and with Bomb Bays

G. Drop Test Program: No Data

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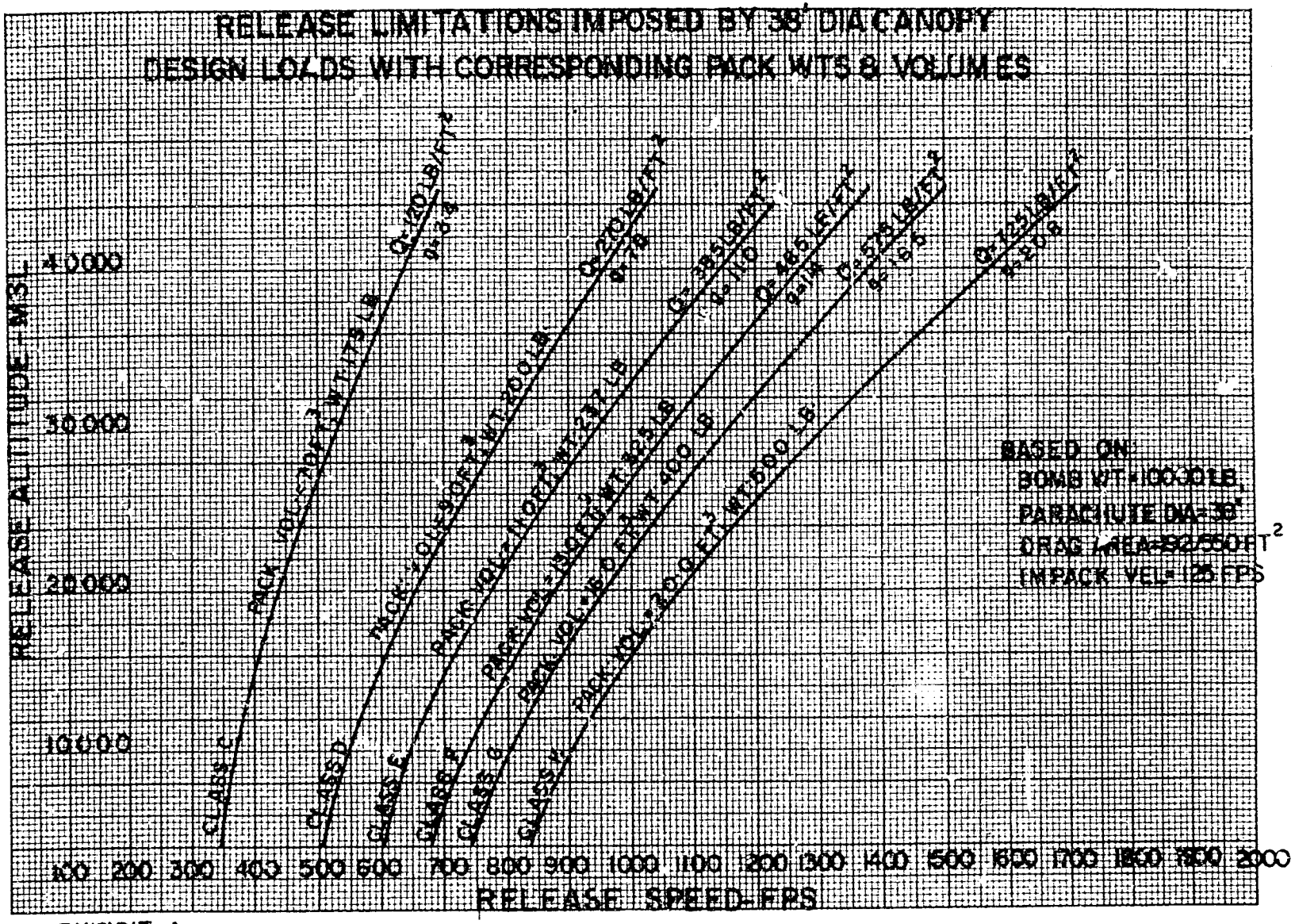

EXHIBIT A

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2. Environmental Requirements: The parachute system must meet the environments of the Stockpile-to-Target Sequence.. (SCS-5).

3. Compatibility: The parachute pack must be compatible with the bomb and with the bomb bays of the carrier aircraft.

JOSEPH CROMPTON - 5144

Case No. 409.01
September 11, 1956

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