DS-2728
MODEL SPECIFICATION
SATURN S-IVB-D STAGE

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PREPARED FOR:
NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
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ABSTRACT

DAC (Douglas Aircraft Company, Inc.) Model Specification DS-2728, Model Specification, Saturn S-IVB-D Stage, describes in general the design requirements for both the Saturn IB and Saturn V configurations of the S-IVB-D Stage and its associated subsystems. S-IVB-D is the designation given to the S-IVB Dynamics Stage.

The design requirement characteristics of the stage are divided according to function into the following main sections propulsion, electrical/electronic, and mechanical systems. Information pertinent to ordnance devices, weight, and launch safety provisions are also provided; quality assurance provisions, applicable documents, general requirements, etc., are also included.

PREFACE

This specification is prepared for NASA/MSFC (National Aeronautics and Space Administration/Marshall Space Flight Center) under Contract NAS7-101.

Appendix A to this specification lists applicable contract modifications, i.e., CCN's (Contract Change Notices), supplemental agreements, change orders, and contract letters, initiated through 26 September 1965 (reference Appendix A). Language changes associated with these modifications have been incorporated.

DOUGLAS

END ITEM CONFIGURATION CHART

SPECIFICATION NO DS-2728

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SPECIFICATION ISSUE	ECP'S	CONTRACT AUTHORITY	PRODUCTION EFFECTIVITY
NEW 1 December 1965	This issue of Model Specification DS-2728 reflects design/performance requirements for Saturn S-IVB-D Stage configuration required by Contract NAS7-101 inclusive of contractual documents issued through 31 March 1965.		S-IVB-D
NEW 1 February 1966	This issue of Model Specification DS-2728 reflects design/performance requirements for Saturn S-IVB-D Stage configuration required by Contract NAS7-101 inclusive of contractual documents issued through 26 September 1965.	Per Negotiations MSFC at DAC/HB (5-23-66 thru 5-26-66)	S-IVB-D

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1. INTRODUCTION

1.1. Scope - This specification defines the characteristics necessary to satisfy the S-IVB-D requirements for both the Saturn IB and Saturn V Dynamics Vehicle. Typical performance requirements, structural design criteria, and design and performance descriptions of the various associated subsystems are presented. DAC is developing the S-IVB-D Stage for NASA/MSFC.

The Saturn IB/S-IVB-D Stage is the second stage of the Saturn IB Dynamics Vehicle. The Saturn V/S-IVB-D is the third stage of the Saturn V Dynamics Vehicle.

1.2 Vehicle Description - The Saturn IB Dynamics Vehicle consists of the S-ID-D and S-IVB-D Stages and the S-IU-200D. The Saturn V Dynamics Vehicle consists of the S-IC-D, S-II-D, and S-IVB-D Stages and the S-IU-500D.

1.3 Mission Description - The primary mission of the S-IVB-D Stage will be to provide initial Saturn IB and Saturn V dynamic information. The testing will assure fit and handling capabilities, and structural and operational integrity under vibration, simulating, acoustical, and aerodynamic loadings.

2. APPLICABLE DOCUMENTS

2.1 General - The specifications, standards, publications, etc., applicable to the design and development of the S-IVB-D Stage will be in general accordance with the Specification and Deviation Document, SM-41411, dated 12 December 1964.

3. CONFIGURATION DESCRIPTION, S-IVB/S-IB

3.1 General - The S-IVB-D Stage shall not have flight capability, but will be used by MSFC for the purpose of determining the dynamic characteristics of both the Saturn IB and Saturn V Vehicles, as well as the S-IVB stage. The S-IVB-D Stage will be configured initially to the Saturn IB vehicle configuration, and converted to the Saturn V vehicle configuration upon completion of the Saturn IB dynamic tests.

The basic design criteria of the S-IVB-D Stage configuration will be to simulate the mass, center of gravity, structural dimensions, stiffness, and mass distribution of flight stages S-IVB/IB and S-IVB/V.

3.2 Structure - The S-IVB-D Stage will be a single-stage structure capable of withstanding all loads imposed during normal dynamic test operations. The stage will also have free-standing capability (1) when staged as a complete Saturn IB vehicle, (2) with the S-IVB-D and all upper stages empty or fully loaded, and (3) with the S-IVB-D pressurized or unpressurized. The stage will also be designed to withstand ground handling without pressurization when empty. The stage will substantially conform to flight configuration, except for those parameters not required for mission performance. Protruding flight equipment which is not required will be simulated. The basic S-IVB-D airframe will consist of the following major structural assemblies:

a. Forward skirt
b. Propellant tank assembly
c. Thrust structure
d. Simulated engine (mass)
e. Aft skirt
f. Aft interstage

Descriptions of these assemblies are given in the following paragraphs; all dimensions given are approximate.

3.2.1 Forward Skirt - Shall be low strength (pre-Change Order 146) production configuration, including the forward umbilical and hydrogen vent panel, less fittings and connectors: except that the forward frame shall have the flight stage hole pattern superimposed on the existing hole pattern (reference Supplemental Agreement 149). The flight stage pattern tooling and handlong holes shall not be drilled.

3.2.2 Propellant Tank Assembly - Shall be production configuration, and shall include the production-type items listed below. In addition, all exposed metal surfaces in the LOX and LH_2 tanks shall be coated with a durable water-resistant material.

3.2.2.1 Forward bulkhead and cover (the forward bulkhead will be pre-NPSH configuration and, therefore, the maximum internal LH_2 tank pressure shall be limited to 36 psia (21.3 psig).

3.2.2.2 Common bulkhead

3.2.2.3 Aft bulkhead and sump

3.2.2.4 Tunnel covers

3.2.2.5 LOX tank slosh baffles

3.2.2.6 Production-type insulation shall be applied to the LH_2 tank walls. Rubber sheets may be used on the forward dome and common bulkhead of the LH_2 tank.

3.2.2.7 Cold helium bottles shall be mass simulated by installing a dummy mass for each bottle. They will be installed in the hydrogen tank at the same location as flight bottles.

3.2.3 Thrust Structure - The thrust structure shall be of production configuration and shall include gimballing and hydraulic actuator attach point provisions to allow the simulated engine to be gimballed by flight-type actuators.

3.2.4 Aft Skirt - The aft skirt shall be low strength (pre-Change Order 146) production configuration and shall include a flight-type aft umbilical panel, less fittings and conductors.

3.2.5 Aft Interstage - The aft interstage shall be low strength (pre-Change Order 146) production configuration and shall include retro-rocket fairings. The aft interstage aerodynamic fairing shall be simulated by a distributed dummy mass with the center of the mass installed as close as practicable to the production location on the interstage.

4. PROPULSION SYSTEM

4.1 General - The S-IVB-D propulsion system will consist of the necessary equipment to safely accomplish tank pressurization. The pressurization system installed will be of production configuration, except as modified for performance of the S-IVB-D mission.

4.2 Engine - The main propulsion system J-2 engine will not be installed. Engine gimballing capability will be provided, and the engine-mounted heat exchanger will not be furnished. A dummy inert mass will be installed to simulate the J-2 engine mass. The engine actuators will not be installed or simulated. The engine feedlines will not be provided. The J-2 engine chilldown system will not be provided.

4.2.1 Redesigned J-2 Engine (Simulated Mass) - DAC will provide and install a kit after delivery of the Dynamics Vehicle to MSFC which will consist of:

4.2.1.1 A new dynamic dummy engine equipped with two blank flanges to simulate the inlet flanges to the turbopumps.

4.2.1.2 Two additional bellows blank flanges with one-inch pipe fittings and caps for subsequent connection to a facilities pressurization system.

4.2.2 LH_2 and LOX feed ducts and valves shall not be installed; however, blank closure flanges shall be installed on the LH_2 elbow and on the LOX sump to close off the tanks. The LOX and LH_2 closure flanges shall have a two-inch pipe fitting, hand valve, and cap to allow tank fill and drain from facility (domestic) water supply.

4.2.3 The chilldown systems shall not be installed. Therefore, the tank ports must be closed by suitable blank cover flanges.

4.2.4 Propellant utilization system shall not be installed. Therefore, the tank ports must be closed by suitable blank cover flanges.

4.2.5 The LH_2 propellant tank pressurization system shall include only the following items: a production relief valve vented to the outside of the skirt, and a pressurization line routed from the LOX tank to the aft umbilical. LOX tank pressurization shall be accomplished from a GFE-controlled ground source.

4.2.6 The LOX propellant tank pressurization system shall include only the following items: a production relief valve vented to the outside of the skirt, and a pressurization line routed from the LOX tank to the aft umbilical. LOX tank pressurization shall be accomplished from a GFE-controlled ground source.

4.2.7 Each APS module and each ullage rocket shall consist of a dummy mass installed on the production attach points located on the aft skirt. Fairings are not required.

4.2.8 S-IB Stage retro-rockets shall consist of dummy masses with provisions for installation in the aft interstage at the production mounting locations. However, they shall not be installed during interstage transportation.

4.2.9 Propulsion leak detection systems shall not be installed.

5. HYDRAULIC SYSTEM

5.1 General - The hydraulic system shall be designed to operate at 3650 psi. Production flight-type J-2 engine actuators and accumulator reservoirs shall be installed and shall be interconnected so as to allow engine gimballing. The high-pressure and low-pressure service quick-disconnects shall be installed to allow direct connection of the ground hydraulic supply. Engine-driven and auxiliary-electrical hydraulic pumps shall not be installed.

6. ELECTRICAL/ELECTRONIC SYSTEMS

6.1 Hydraulic System - The hydraulic system actuator control and piston position feedback wiring receptacles, which are mounted on the actuators, shall be utilized by the Customer for control and actuator position readouts.

6.2 Dummy Mass Plates - Dummy mass plates shall be installed at each of the production locations in the aft skirt.

6.3 Batteries - Batteries shall be mass simulated and installed in the production locations.

7. MECHANICAL SYSTEMS

7.1 General - Production-type forward thermoconditioning panels shall not be installed. Equal-weight, identical-size dummy mass panels shall be installed at each of the sixteen production locations in the forward skirt.

8. STAGE EXTERIOR FINISH

8.1 General - The stage exterior finish paint and marking shall be in accordance with production flight-type requirements.

9. DUMMY MASSES

9.1 General - A detailed description of each dummy mass follows (physical characteristics of the dummy masses other than those noted below shall not be a primary consideration of their design).

9.2 J-2 Engine -

9.2.1 Initial Dummy J-2 Engine - Shall comply to within 5%: weight 3400 pounds; CG location: Y = 29.8, X = -.4, Z = 1.0 inches; I_{yy} = 400, $I_{xx} = I_{zz}$ = 1420 slug-feet^2.

9.2.2 New Dummy J-2 Engine - Shall comply to within 5%: weight: (J-2 engine wet weight at burnout) = 3578 pounds; CG location: Y = 26.9, X = 0, Z = 0, I_{yy} = 422, moment of inertia about the centerline of propellant feed inlet = 873 slug-feet^2, and the moment of inertia normal to propellant feed inlet = 948 slug-feet^2.

9.3 Main Tunnel Area - Shall contain a distributed mass weighing 400 ± 5% pounds and shall allow for the hydrogen tank pressurization line.

9.4 Cold Helium Tanks - Shall be individually simulated and located at the production locations. They shall each weigh 70 ± 10% pounds.

9.5 Ullage Rockets - Shall each weigh 135 ± 5% pounds.

9.6 Retro-rockets - Shall each weigh 450 ± 5% pounds.

9.7 APS Modules - Shall be made of two easily-separated flat plates; one representing an empty APS module of 345 ± 5% pounds, and two together representing a fully-fueled APS module of 405 ± 5% pounds.

9.8 Forward Panels - The panels shall weigh 105 ± 5% pounds, and shall be designed so as to permit easy incremental weight adjustments after installation.

9.9 Aft Plates - The plates shall weigh 1400 ± 5% pounds total, with the weight per plate varied proportionately to the plate size and shall be designed so as to permit easy incremental weight adjustment after installation.

9.10 Batteries - Dummy mass as required to simulate flight battery mass of 192 ± 5% pounds.

9.11 Forward Skirt Ballast - 550 ± 5% pounds shall be installed as additional distributed mass.

9.12 Aft Ballast - A total of 2350 ± 5% pounds shall be installed as additional ballast on the aft skirt, and thrust structure as distributed mass.

9.13 Aft Interstage Aerodynamic Fairing - Dummy mass as required to simulate mass of 450 ± 5% pounds.

9.14 Bracketry - Flight-type brackets shall be used at all positions where rate gyros and accelerometers are located.

10. WEIGHT AND CENTER OF GRAVITY

10.1 Stage and Aft Interstage - The Dynamics Stage shall be weighed at Huntington Beach. A weight and balance report shall be written by the Analytical Branch to include mass distribution, total weight, calculated center of gravity locations, and calculated moments about all three major axes.

The aft interstage shall be weighed (and center of gravity determined) in a separate operation. The mass distrubution and calculated moments about all three major axes shall be determined analytically.

S E C T I O N I I

SATURN S-IVB/S-V

3. SATURN V DYNAMICS STAGE CONFIGURATION

3.1 General - The S-IVB-D Stage will be modified by DAC at MSFC from the Saturn IB to the Saturn V configuration at the completion of the MSFC/IB dynamic testing program. The S-IVB-D/IB configuration will be used as the S-IVB-D/V except as noted in the following paragraphs.

3.2 Structural Systems

3.2.1 Forward Skirt - The Saturn IB forward skirt and all of its installations shall be completely removed and replaced by a Saturn V-type production forward skirt, which shall include a flight-type forward umbilical panel, less fittings and connectors. The forward flange shall have the flight stage bolt hole pattern.

3.2.2 Propellant Tank Assembly - No change.

3.2.3 Thrust Structure - No change. Simulated ambient helium bottles shall be added by installing an individual dummy mass at each production bottle location.

3.2.4 Aft Skirt - The Saturn IB aft skirt and all of its installations shall be completely removed and replaced by a Saturn V-type production aft skirt, which shall include flight-type aft umbilical panel, less fittings and connectors.

3.2.5 Aft Interstage - The Saturn IB aft interstage and simulated aerodynamic fairing shall be completely removed and replaced by a Saturn V-type aft interstage which shall include retro-rocket fairings.

4. PROPULSION SYSTEM

4.1 J-2 Engine - No change

4.2 LH_2 and LOX Feed Ducts and Valves - No change.

4.3 Chilldown System - No change.

4.4 Propellant Utilization System - No change.

4.5 LH_2 Propellant Tank Pressurization System - No change.

4.6 LOX Propellant Tank Pressurization System - No change.

4.7 APS Modules - Saturn IB APS Dummy Modules shall be replaced by Saturn V APS Dummy Modules.

4.8 S-II Stage Retro-rockets - Shall consist of dummy masses with provisions for installation in the aft interstage at the production mounting locations. However, they shall not be installed during interstage transportation.

4.9 Propulsion Leak Detection System - No change.

5. HYDRAULIC SYSTEM - No change

6. ELECTRICAL/ELECTRONIC SYSTEMS

6.1 Hydraulic System Wiring - No change.

6.2 Aft Skirt Plates - No change. Saturn IB aft skirt plates shall be re-installed on Saturn V.

6.3 Batteries - Dummy masses shall be changed as required to compensate for differences in battery weights.

7. MECHANICAL SYSTEMS

7.1 Forward Thermoconditioning Panels - No change. Saturn IB forward skirt thermoconditioning panels shall be re-installed on Saturn V.

8. STAGE EXTERIOR FINISH - No change.

9. DUMMY MASSES

9.1 General - A detailed description of each dummy mass follows. (Physical characteristics of the dummy masses other than those noted below shall not be a primary consideration of their design.)

9.2 J-2 Engine - No change.

9.3 Main Tunnel Area - No change.

9.4 Cold Helium Bottles - No change.

9.5 Ambient Helium Bottles - Shall be individually simulated and attached at the production locations. They shall each weigh 150 ± 5% pounds.

9.6 Ullage Rockets - Install two of the Saturn IB ullage rocket dummy masses on Saturn V bracketry.

9.7 Retro-rockets - Install Saturn IB retro-rocket dummy masses on Saturn V bracketry.

9.8 APS Modules - Each APS module dummy mass shall consist of two easily-separated masses. One mass shall simulate an empty APS module of 250 ± 5% pounds. The combined weight of both masses shall simulate a fully-fueled APS module of 500 ± 5% pounds.

9.9 Forward Thermoconditioning Panels - No change. Saturn IB simulated panels shall be re-installed.

9.10 Aft Plates - No change. Saturn IB plates shall be re-installed.

9.11 Batteries - Dummy masses are required to simulate flight batteries of 575 ± 5% pounds.

9.12 Forward Skirt Ballast - 500 ± 5% pounds shall be installed as additional distributed mass.

9.13 Aft Ballast - A total of 3030 ± 5% pounds shall be installed as additional ballast on the aft skirt and thrust structure as distributed mass.

9.14 Aft Interstage Aerodynamic Fairing- Not applicable.

9.15 Rate Gyro and Accelerometer Bracketry - No change.

10. STAGE AND AFT INTERSTAGE WEIGHT AND CENTER OF GRAVITY

10.1 General - After the Dynamics Stage is modified, it shall be weighed by the Customer at MSFC. A weight and balance report shall be written by the Analytical Branch to include mass distribution, total weight, calculated center of gravity locations, and calculated moments about all three axes. Data for this report shall be provided by MSFC.

The aft interstage shall be weighed (and center of gravity determined) in a separate operation at Huntington Beach by DAC. The mass distribution and calculated moments shall be determined analytically.

APPENDIX A

APPENDIX A

Tabulated below are all contractually binding CCN's, supplemental agreements, change orders, and contract letters initiated through Supplement Agreement 380, which have an effect upon the S-IVB-D Stage design and development.

Modification	Scope Change	Nomenclature	Configuration S-IB	Configuration S-V
C.O. 95, 98	1011B	S-II Retro-rockets on S-IVB (Dummy)		X
C.O. 29	1016B	Deletes S-IVB Retro Provisions	X	X
C.O. 23	1024	Turbo Pump Warm Helium Purge		X
C.O. 229	1030A	Revised Stage Transportation Plan (non-hdw)	X	X
C.O. 118, S.A. 350	1045B	Thermoconditioning System (non-hardware), Forward Skirt Elect. (dummy plates)	X	X
C.O. 80	1060	Increase length of Aft Interstage		X
C.O. 35, 42	1075B	Redesign - Propellant Tanks (partial - See Scope Change 1304)	X	X
C.O. 293, 310	1092A	Aft Interstage Rework - Access Kit		X
C.O. 25	1096	Removal of Heat Barriers	X	X
C.O. 107, 346	1098B	S-IB Aft Interstage - Adds Aerodynamic Fairing	X	
C.O. 114	1102A	S-IB Retro-rockets on S-IVB Stage	X	
C.O. 113, 154 235, 356	1151	Hydraulic System Design Changes	X	X
C.O. 330, C/L 64-89; C.O. 136, 176	1187	Provisions for Control Accelerometer and Rate Gyros	X	X
C.O. 173	1205	Additional Interface Connectors (str. mods only)		X
C.O. 210	1221	Redesign APS for Ullage System		X
MSFC ltr. I-CO-SD-L-1321 (TAN 10259 Mgmt Risk)	1411	Redrilling Dynamics Forward Skirt	X	X
S.A. 380	ECP X015	Dynamics Stage Description	X	X