GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

Mr. Haggard/876-1862

TO I-V-S-IVB, Mr. Godfrey

DATE October 14, 1964

R-P&VE-XJ-64-659

FROM S-IVB Secretary, Vehicle Mechanical Design Integration Working Group, R-P&VE-XJ

SUBJECT Minutes of the Vehicle Mechanical Design Integration Working Group Meeting No. 6, S-IVB Stage (Saturn IB/V)

REFERENCE Memorandum R-P&VE-DIR(J)-64-529, dated September 2, 1964, Subject: "Action Items from the Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 6, August 26-27, 1964 (Saturn IB/V)"

1. The sixth meeting of the Vehicle Mechanical Design Integration Working Group (VMDIWG), S-IVB Stage convened at the Douglas Aircraft Company, Inc. (DAC) Huntington Beach facility, August 26-27, 1964. The meeting agenda, reference memorandum, and the meeting minutes (including appendices A thru CC) are enclosed for information transmittal to DAC.

2. The paragraph headings in the minutes are the same as the headings listed in the agenda. The 219 page DAC document, prepared for the meeting, is listed as appendix A. Other appendices received during or after the meeting have been inserted in appendix A to correspond with the agenda schedule.

Roland F Griner

Roland F Griner

5 Enc:
1. Agenda
2. R-P&VE-DIR(J)-64-529 (Action Items)
3. Minutes
4. Appendices Listing
5. Appendices

[illegible]
[illegible], R-DIR
Mr. Dannenberg, R-SA
Dr. Kuettner, R-SA
Mr. King, R-SA
Mr. Cline, R-P&VE-DIR
Mr. Palaoro, R-P&VE-X

MSFC - Form 488 (August 1960)

N65 22847 (ACCESSION NUMBER) (THRU) 1
434 (PAGES) (CODE) 11 (CATEGORY)
TMX-56359 (NASA CR OR TMX OR AD NUMBER)
FACILITY FORM 602

GPO PRICE $
CFSTI PRICE(S) $
Hard copy (HC) 7.34
Microfiche (MF) 2.25

SUBJECT: Minutes of the Vehicle Mechanical Design Integration Working Group Meeting No. 6, S-IVB Stage (Saturn IB/V)

October 14, 1964

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Mr. Kuberg, R-P&VE-PJ
Mr. Thomson, R-P&VE-PA
Mr. Long, R-P&VE-PAS
Mr. Head/Bergeler, R-P&VE-PE
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Mr. Voss, R-P&VE-PM
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Mr. Platt, R-P&VE-PTF
Mr. Vaniman, R-P&VE-PTP
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Mr. Holmes, R-P&VE-M
Mr. Kingsbury, R-P&VE-ME
Mr. Mezo, R-P&VE/DAC

SUBJECT: Minutes of the Vehicle Mechanical Design Integration Working Group, Meeting No. 6, S-IVB Stage (Saturn IB/V)

October 14, 1964

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Mr. Drummond, I-E-J
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Mr. Young, I-DIR
Dr. Mrazek, I-SE-CH
Mr. Law, I-CO
Colonel James, I-I/IB-DIR
Mr. McCullough, I-I/IB-S-IVB
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SUBJECT: Minutes of the Vehicle Mechanical Design Integration Working Group Meeting No. 6, S-IVB Stage (Saturn IB/V) October 14, 1964

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Mr. Zeiler, R-LVO-AD
Mr. Pickett, R-LVO-M
Mr. Heimburg, R-TEST-DIR
Mr. Driscoll, R-TEST-S
Mr. Ward, R-TEST-SBS
Mr. Casey, NASA/Hdqtrs
Mr. Pease, NASA/MSFC, J-2 Res. Proj. Mgr.
Mr. Dell, MSC
Mr. Mull, DAC
Meeting Attendees

REVISION A
AUGUST 7, 1964

AGENDA FOR
SIXTH VEHICLE MECHANICAL DESIGN
INTEGRATION WORKING GROUP (VMDIWG) MEETING
(S-IVB STAGE)
AUGUST 26-27, 1964

FIRST DAY

1. INTRODUCTION 8:30-8:40

The Chairman/Secretary and senior Douglas Aircraft Company, Inc. (DAC) representative will recognize attendees by office grouping. The Chairman/ Secretary will describe the meeting ground rules.

2. DELINQUENT ACTION ITEMS 8:40-9:00

The Secretary and DAC will each provide a brief summary listing a new suspense date for the delinquent action items listed in memorandum R-P&VE-VAD-64-75, and applicable portions of SM-46542.

3. STAGE WEIGHT STATUS (Saturn IB/V) 9:00-9:30

a. DAC will present current interstage, dry stage, and stage-at-separation weights for Saturn IB and V by vehicle effectivity. The S-IVB Stage Manager, I-V-S-IVB, and [illegible] will present the contractual status and implementation efforts for the weight [illegible]ions described in memorandum R-P&VE-VJ-64-273.

b. DAC will present the status of plans to weigh the dry stage at SACTO and for monitoring the dry weight until launch.

c. DAC will present the status of the cryogenic weigh system to include (1) description of loading accuracy vs payload (2) alternate proposed means for establishing acceptable loading accuracy (3) current hardware procurement problems (4) resulting schedule improvement if cryogenic weighing is not required.

4. STRUCTURAL QUALIFICATION TESTING (SATURN IB/V) 9:30-10:00

DAC will present the program status for:

a. Additions to data acquisition system required in memorandum R-P&VE-SSS-64-62.

b. Problems anticipated by necessity of testing structural hardware designed for non-flight loads.

c. The internal loads analysis of the S-IVB Aft Interstage at the S-IVB/IB Interface for the structural test article.

d. The interface flange tensile test program to include a comparison of analytical and test results.

------------BREAK------------ 10:00-10:10

Enc. 1

5. STRUCTURAL DESIGN LOADS AND STRENGTH ANALYSIS 10:10-11:10

a. DAC will present a listing of Structures Division (R-P&VE-S) memoranda which are in use to describe design loads for each of the stages and its major components (Saturn IB/V).

b. The Structures Division will be prepared to approve the above listing or issue corrections if required.

c. DAC will discuss the status of implementation of R-P&VE-SL-212-63 loads to include impact on each major structural assembly for each S-IVB/IB Flight Stage.

6. BATTLESHIP 11:10-11:55

a. DAC will present the current schedule of events for the testing program.

b. DAC will present the current J-2 engine chill program and will outline the outstanding problems related to the J-2 engine start and their proposed resolution.

c. MSFC (R-P&VE-P) will summarize the activities of the J-2 Engine Start Committee.

d. DAC will provide a list of non-flight components as required in Action Item 4030 (due February 3, 1964).

7. CONTINUOUS VENTING (SATURN V) 11:55-12:15

DAC will present the status of the following items:

a. Vent design, thrust, and thrust tolerances.

b. Weight reductions in the aft skirt attributed to reduction in APS fairing size.

c. Tolerances on nozzle locations and angularity.

------------LUNCH------------ 12:15-1:00

8. AUXILIARY PROPULSION SYSTEM (APS) 1:00-1:55

a. DAC will describe the Saturn IB configuration design and fabrication status to include:

(1) Weight

(2) Test program including Gamma Complex status

(3) Service requirements and cleaning procedures (SACTO)

(4) Propellant measuring requirements (accuracy, signal transmission to ground/astronaut, continuous sensing)

(5) Environmental control provisions.

b. Formal direction is in progress for the use of the bladder, rather than the bellows concept (S-IVB/V). Anticipating that selected bellows tests, either planned or in progress, will continue if they provide technical support for the S-IVB/IB APS bellows program, DAC will describe the Saturn V configuration design status to include:

(1) Bladder layouts, expulsion systems, volumes and materials compatibility

(2) List of specific bellows tests with recommendations as to which are to be continued or stopped

(3) Propellant allocations

(4) Weights

(5) Schedules

(6) Propellant measuring requirements (accuracy, signal transmission to ground/astronaut, continuous sensing)

c. DAC will describe the static firing philosophy (Saturn IB/V) and plans to accomplish this philosophy.

9. PROPELLANT TANK DESIGN AND PRESSURIZATION 1:55-2:55

The LH_2 tank pressure has been reduced from 42 psia to 39 psia. DAC will present the Saturn IB and V design status of the LH_2 tank redesign for 39 psia to include, as a minimum:

a. Design

PROPELLANT TANK DESIGN AND PRESSURIZATION (cont'd)

(1) Waffle dimensions

(2) Valves, vents plumbing changes, and pressure switch settings

(3) Screens (including pressure drop tests to date)

(4) Reasons for only 175 pounds weight reduction (per TCB-272)

(5) Changes in heat transfer characteristics and consequent boil off rate changes.

(6) Test modifications and schedules.

b. Pressurization

(1) DAC will discuss means of not exceeding engine maximum allowable pump inlet pressures during static firings (Saturn IB/V).

(2) DAC will discuss the necessity of stepping the pressure level in the Saturn V LH_2 tank from first burn to second burn.

(3) DAC will discuss the prepressurization level of the S-IVB Stage LH_2 tank for the Saturn IB and Saturn V (first burn) vehicles.

(4) DAC will discuss the Saturn IB and V tank pressure schedules.

(5) DAC will discuss why the Saturn V LH_2 vent pressure can be only 37.4 psia without degrading structural integrity as stated in TCB-272. DAC will also present the ramifications due to this lower vent pressure.

------------BREAK------------ 2:55-3:05

10. PROPULSION SYSTEM PERFORMANCE 3:05-3:35

a. DAC will present the S-IVB performance impact due to the "in-run" mixture ratio shift during mainstage operation (reference section 1.2 of handout from J-2 engine/S-II and S-IVB Stage Interface Meeting June 23-24, 1964.

b. DAC should define maximum thrust capability of S-IVB Stage as presently designed and define limitations. This is necessary to fully evaluate the effect of any possible increase in nominal J-2 engine thrust for payload improvement studies.

c. DAC should present status of current studies on programmed mixture ratio for both Saturn IB and Saturn V application.

d. DAC will define the allowable variations in engine thrust chamber chill time for S-IVB/Saturn V restart.

CASE FILE COPY

11. PROPULSION MISCELLANEOUS (SATURN IB/V) 3:35-4:15

DAC will present:

a. The status of valve position sensors to include specifications, qualification test program, and inspection procedures.

b. The status of documentation to include component design cross sectional drawings, stating if and when they will be supplied (reference Action Item 2151).

c. Results of study and testing of S-IV helium heater application to S-IVB Stage (reference Change Order 228).

d. Status and problem areas of overfill and engine cutoff sensors.

e. A discussion on Rocketdyne requirements for moisture content of helium used in the J-2 engine and in the National Bureau of Standards grade A helium available at SACTO.

12. ENVIRONMENTAL CONTROL (SATURN IB/V) 4:15-5:00

a. DAC will present the status of:

(1) Forward skirt cold plates testing

(2) Forward skirt testing and problem areas

(3) Aft interstage testing and problem areas

b. MSFC (R-P&VE-VOR) will present the MSFC thermister status.

REVISION A
AUGUST 7, 1964

AGENDA FOR
SIXTH VEHICLE MECHANICAL DESIGN
INTEGRATION WORKING GROUP (VMDIWG) MEETING
(S-IVB STAGE)
AUGUST 25-26, 1964

SECOND DAY

13. THERMAL ENGINEERING 8:30-9:00

a. DAC will present the high performance insulation program status including the recommended configurations, weights, and payload improvements. Additionally, requirements/authorization needed for expediting the insulation development (to permit timely implementation into the Saturn V program) will be described by DAC.

b. DAC will present the S-IVB insulation test results on the eight-foot test tank, banjo testing, etc. This should include an outline of a continuing test plan for further insulation qualification and improvements.

c. DAC will present the results of the heat transfer dispersion study considering variations of absorptivity, emissivity, trajectory, etc. (reference Change Order 158).

14. LEAK DETECTION 9:00-9:45

a. MSFC (R-P&VE-P and R-ASTR) will review the MSFC leak detection policy and summarize the directions for Saturn IB and V (reference I-V-S-IVB-64-A-180, dated July 8, 1964).

b. DAC will present their plan and stage effectivity for mechanical separable connector leak detection in stage and J-2 engine areas and discuss how this plan differs from the requirements of memoranda M-P&VE-PI-350-63, and M-P&VE-PM-423-63.

15. HYDRAULIC SYSTEM (SATURN IB/V)

a. DAC will present proposed corrective action for precluding freezing of oil as reported in J-2/S-II/S-IVB Interface Meeting of June 23-24, 1964, and documented in memorandum R-P&VE-PTD-64-M-71.

b. DAC will report on relocation of oil temperature sensor to coldest point in the system per memorandum R-P&VE-PTD-64-M-71.

c. DAC will report on R-P&VE-PAE suggestion to add a redundant oil temperature sensor to control the on-off cycle of the auxiliary pump.

------------BREAK------------ 10:15-10:25

16. HYDROSTATIC STAGE 10:25-10:40

DAC will present a summary of the proof pressure failure, citing cause, corrective action, and their plans for continuing the functional purpose of the hydrostatic stage.

17. DYNAMICS STAGE (SATURN IB AND V) 10:40-11:00

a. MSFC (R-P&VE-VA) will describe differences between DAC Design Memo No. 101C, dated July 20, 1964, "Dynamics Stage Configuration" and MSFC preliminary document, dated April 10, 1964, "Saturn V Dynamic Test Vehicle Description" (reference memorandum I-V-S-IVB-64-497, dated August 5, 1964).

b. DAC will provide the status of the Dynamic Stage design, fabrication, test schedule, and configuration list release schedule.

18. FACILITIES CHECKOUT STAGE (S-IVB-F) 11:00-11:15

DAC will present the status with respect to the proposed supplemental agreement now being negotiated to include:

a. Implementation plan for configuration designated in the proposed supplemental agreement.

b. Problems related to simulating the design to SA-201 and SA-501 vehicle requirements with a single S-IVB-F configuration.

19. INTERSTAGE VENTING 11:15-12:15

a. DAC will provide a listing of all documentation (from all sources) being used to design the S-IVB interstage venting (vents, structural leakage, and drain holes) in the following regions:

(1) Forward skirt/IU (Saturn IB/V)

(2) Aft skirt and interstage/S-IB Stage

(3) Aft skirt and interstage/S-II Stage.

b. DAC will summarize the current design of the above items (for flight and ground conditions) to include:

(1) Vent size, area, location and flow rate

(2) Structural leakage areas, allocations, and sealing weights

(3) Drain hole size, area and location

(4) Sites, schedules, and schematics for basic test set-ups required to confirm the venting and leakage requirements

(5) Problem areas and proposed resolutions

INTERSTAGE VENTING (cont'd)

c. MSFC (R-AERO-P) will present the results of their studies for the (Saturn IB and V) S-IVB aft skirt and aft interstage allowable leakage area.

-------------LUNCH------------ 12:15-1:00

20. INTERFACE CONTROL 1:00-2:30

a. J-2/S-IVB Interface

(1) DAC will describe mechanical changes required between (a) J-2 engine and the S-IVB Stage and (b) the S-IVB Stage and GSE for implementation of the J-2 engine frequency measurements and turbopump overspeed safety cutoff requirements of memorandum M-SAT-WSF-#46-64. Changes will include stage effectivity for Saturn IB and V configurations.

(2) DAC will provide comments concerning the J-2/S-IVB Interface Drawing No. 13M50106 (Saturn V). Advance copies were distributed at the June 23-24, 1964, J-2/SIVB/S-II Interface Meeting and a later preliminary copy was sent to Carl Mezo August 7, 1964.

(3) DAC will provide comments concerning the preliminary J-2/S-IVB Interface (Saturn IB) Drawing No. 13M20102 to be sent under separate cover.

(4) DAC and MSFC (R-P&VE-P/VS) will discuss the status of the feed duct interface connections such as:

a. Problems of the leak monitoring port as discussed in TCB-242.

b. Recommended change to the propellant duct support bracket.

b. Interface Control Documentation

(1) MSFC (R-P&VE-VSI) will define the Mechanical Interface Control Documentation program, precedure and status for the S-IVB Stage (Saturn IB and V).

(2) MSFC (R-P&VE-VSI) will define the interface areas to be controlled by the Mechanical Interface Control program.

c. Stage-to-Stage (Saturn IB)

(1) Seal, S-IB/S-IVB

a. Method of attachment to S-IB Stage (memorandum M-P&VE-VA-199-63)

b. Number of attachments required for connecting seal to seal plate (Interface Revision Request #4-VSI-64)

INTERFACE CONTROL (cont'd)

c. Drawings of seal that are adequate for Chrysler Corporation Space Division to determine method of removing seal plate.

(2) Electrical Interface Connectors

a. Electrical connector designation at the separation plane of the S-IVB/S-IB, such as 11W45 etc. (memorandum I-V-S-IVB-TD-64-121).

b. Cable routing and/or cable length from interface plane to connector bracket.

(3) Location of interface bracket in S-IVB aft interstage for the separation and retrorocket measurement cable connector No. 9 (memoranda R-ASTR-EA-559-64, R-P&VE-VSA-64-454, I-V-S-IVB-C-64-391, and Change Order #267).

(4) Locations of exploding bridgewire firing units and pulse sensors for S-IB/S-IVB separation, retrorockets, and the routing of electrical cables from the S-IB Stage (memoranda R-P&VE-VSA-64-402 and I-V-S-IVB-TD-64-110).

(5) Location of interface bracket for the S-IVB/IU electrical connectors on cold plate #15 (memoranda R-P&VE-VSA-64-254, I-V-S-IVB-TD-64-48, and DAC Letter A3-850-K314-4.17.8-L-101, dated February 13, 1963).

(6) R-P&VE-VSI will discuss DAC comments to S-IB/S-IVB Stage physical requirements document 13M20106 (DAC Letter A3-850-K031-1.17.8-L-496).

d. Stage-to-Stage (Saturn V)

(1) Location of interface bracket in S-IVB aft interstage for the separation and retrorocket measurement cable (memoranda R-ASTR-EAI-152-64, I-V-S-IVB-64-378, and Change Order No. 273).

(2) Location of exploding bridgewire firing units and pulse sensors for S-II/S-IVB separation, retrorockets, and routing of electrical cables from the S-II Stage (memorandum R-P&VE-VSA-64-202).

(3) Location of interface bracket for the S-IVB/IU electrical connectors on cold plate #15 (memoranda R-P&VE-VSA-64-254, I-V-S-IVB-TD-64-48, and DAC Letter A3-850-K314-4.17.8-L-101, dated February 13, 1963).

e. S-IVB/IU

DAC and R-P&VE-VSA will review memorandum R-ASTR-G-236-64, dated July 8, 1964, "Interference with the ST-124-M Azimuth Laying by Lox Venting of the S-IVB Stage" (for Saturn V) and present recommendations for relocation of the Lox vents for Saturn IB and V.

21. CONFIGURATION LIST (SATURN IB/V) 2:30-2:35

DAC will present the release status and schedule for up-dating the configuration list.

22. SOLID ULLAGE ROCKETS 2:35-2:50

DAC will describe location, alignment, stage c.g. considerations, tolerances, etc. for Saturn IB and V.

------------BREAK------------ 2:50-3:00

23. GROUND SUPPORT EQUIPMENT 3:00-4:00

a. DAC will present a description of the SACTO propellant loading plans to include:

(1) Stage to GSE mechanical interface problems including the method of signal transmission, recording, and replenishing control system

(2) Modulating valve status

(3) Other problem areas and proposed resolution.

b. DAC will present a description of the method used to insure positive tank pressurization during shipping, handling, and storage to include:

(1) Type of pressurant

(2) Method of pressurizing and maintaining pressure

(3) Pressure required

(4) Compatibility of SACTO and KSC requirements.

c. DAC will list the prime technical problems for each GSE item not on schedule and describe corrective actions being implemented for GSE to be located at Huntington Beach, SACTO, and KSC. The problems should include those contract changes issued through July 1964 for reallocation of GSE.

24. DAC WILL IDENTIFY MAJOR PROBLEMS REQUIRING MSFC ACTION. 4:00-4:10

25. PREPARATION OF ACTION ITEMS. 4:10-5:00

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

Mr. Haggard/876-1862

TO See Distribution

DATE September 3, 1964

R-P&VE-DIR(J)-64-529

FROM S-IVB Stage Secretary, Vehicle Mechanical Design Integration Working Group, R-P&VE-DIR(J)

SUBJECT Action Items from the Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 6, August 26-27, 1964 (Saturn IB/V)

REFERENCE Memorandum R-P&VE-DIR(J)-64-458A, dated August 7, 1964, Subject: "Revised Agenda and Date for the Sixth Meeting of the Vehicle Mechanical Design Integration Working Group for the S-IVB Stage (Saturn IB/V)"

1. The Sixth Vehicle Mechanical Design Integration Working Group, S-IVB Stage, meeting convened at Plant A-3, Huntington Beach, California, as scheduled in the reference. The resulting action items and attendee list are enclosed. It is requested that the Saturn V Project Office, I-V-S-IVB, forward this memorandum to the Douglas Aircraft Company, Inc. (DAC) with the accompanying direction to comply with the action required in enclosure 1 for those items that list "DAC" as the action agency. It is further requested that others listed on the distribution list below complete those action items that fall within their respective areas of responsibility (as determined by the action agency columns in enclosure 1) on or before the due dates shown.

2. Advance copies of the action items were forwarded (September 1, 1964), to those offices listed under "Action Agency" with an accompanying request to review the (a) clarity of wording (b) stage effectivity (c) program effectivity and (d) due dates. Changes resulting from this review have been incorporated.

3. DAC is to be commended for their hospitality, cooperation, and efficiency in rotating DAC attendees so as to expedite presentations and minimize interference with their normal work activities.

Roland F. Griner

Roland F. Griner

CONCURRENCE

Chairman, VMDIWG H. A. Pelcan

2 Encs.
1. Action Items
2. Attendee List

Distribution
see next page

Enc. 2

MSFC - Form 489 (August 1962)

SUBJECT: Action Items for the Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 9, August 26-27, 1964 (Saturn IB/V)

September 3, 1964

Distribution
- Mr. Godfrey, I-V-S-IVB
- Mr. Drummond, I-E-J
- Mr. Long, R-P&VE-PAS
- Mr. Voss, R-P&VE-PM
- Mr. Glover, R-P&VE-VA
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- Mr. Schulze, R-P&VE-VS
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- Mr. Meyers, I-V-S-IVB
- Mr. Young, I-I/IB-S-IVB-L/DAC
- Mr. Vreuls, I-I/IB-E
- Mr. Duerr, I-V-IU
- Mr. Richard, R-ASTR-S
- Mr. Hoberg, R-ASTR-I
- Mr. Fichtner, R-ASTR-E
- Mr. Spears, R-ASTR-E
- Mr. Moore, R-ASTR-N
- Mr. Jones, R-ASTR-TJ
- Mr. Jean, R-AERO-DIR
- Dr. Speer, R-AERO-F
- Mr. Teague, R-AERO-P
- Mr. McNair, R-AERO-P
- Mr. Grau, R-QUAL-DIR
- Mr. Rowe, R-QUAL-J
- Mr. Hughes, R-QUAL-P
- Colonel Petrone, K-H
- Mr. Halcomb, K-PB
- Mr. Lealman, K-VG2
- Mr. Poppel, K-D
- Mr. Hunter, K-DT
- Mr. Kuers, R-ME-U
- Mr. Landreth, R-ME-U
- Mr. Nowak, R-ME-A
- Dr. Gruene, R-LVO-DIR
- Mr. Zeiler, R-LVO-AD
- Mr. Pickett, R-LVO-M
- Mr. Driscoll, R-TEST-S
- Mr. Ward, R-TEST-SBS
- Mr. Scheller, NASA/HDQTRS
- Mr. Pease, NASA/MSFC, J-2 Res. Proj. Mgr.
- Mr. Dell, MSC
- Mr. Mull, DAC
- Attendees

SATURN WORKING GROUP ACTION ITEM REPORT

TO:

Action Agency

FROM: (WORKING GROUP/SUB-GROUP)
Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 6

REPORT NUMBER: R-P&VE-DIR(J)-64-529

REPORT DATE: September 3, 1964

MEETING DATE: August 26-27, 1964

ITEM NO.	ACTION AGENCY	DESCRIPTION OF ACTION
Stage Weight Status		
4081	DAC	If cryogenic weighing cannot be accomplished for A/S and S-IVB/IB-1, DAC will provide flow measuring capability to determine the amount of cryogenics loaded. DAC will notify MSFC of the anticipated measuring accuracy. Due date: September 21, 1964
Structural Qualification		
4082	I-V-S-IVB	MSFC will direct that DAC prepare documentation to describe in detail the planned, step-by-step procedure to be used for each planned loading of each structural test specimen. This documentation is to be forwarded to the MSFC Structures Division not less than three weeks prior to implementation of the procedures described in the above documentation. Due date: September 15, 1964
4083	I-V-S-IVB	MSFC will direct that DAC include, as a part of all future Structural Test Plans, a description of all planned load applications to the test specimen. Sufficient detail shall be included such that the effect on the test specimen can be evaluated. Due date: September 15, 1964
Continuous Venting		
4084	DAC	For Saturn IB application the S-IVB axial ΔV limitation of 1 m/sec/vent, stated in memorandum WDC-S-IVB-64-8, dated April 8, 1964, can be relaxed not to exceed 2 m/sec/vent. This includes the total ΔV from both Gox and GH_2. (Verbal concurrence obtained from Dynamics & Control Working Group, August 26, 1964.)
Propulsion Miscellaneous		
4085	DAC	DAC will update (every 45 days) their (handout) listing of available vendor parts drawings and provide drawings from this list as they become available (Saturn IB/V). Effective Immediately
4086	R-P&VE-PAS	MSFC (R-P&VE-PAS) will implement action to eliminate incompatibility of helium dew point criteria between S-IVB

Enc. 1

H. R. Palaoro — Chairman

SATURN WORKING GROUP ACTION ITEM REPORT

TO:	REPORT NUMBER: R-P&VE-DIR(J)-64-528
Action Agency	REPORT DATE: September 8, 1964
FROM: (WORKING GROUP/SUB-GROUP) Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 6	MEETING DATE: August 26-27, 1964

ITEM NO.	ACTION AGENCY	DESCRIPTION OF ACTION
		Stage and J-2 engine contractors. Due date: September 15, 1964
Thermal Engineering		
4087	I-E-J (ROcketdyne)	Using the environmental criteria as established from Action Item 2132 (due October 17, 1964), Rocketdyne shall define the Saturn V- S-IVB Stage J-2 engine temperature-sensitive components and component temperature limits. (This item supersedes and closes Action Item No. 1402). Due date: January 7, 1965
Leak Detection		
4088	I-V-S-IVB	MSFC (I-V-S-IVB) will direct DAC to develop, qualify, and install a secondary seal for cryogenic and flight service for all flanged joints, 1.5" dia. and above. The target effectivity is S-IVB/IB-3 & subs., A/S (Saturn V), and S-IVB/V-1 & subs. Due date: September 15, 1964
4089	DAC	DAC shall investigate and report on the possibility of making manual quantitative measurements in place of a soap solution check on those flanges equipped with the secondary seal. Due date: November 1, 1964 for B/S and January 4, 1965 for S-IVB/IB & V flight stages.
4090	R-P&VE-PM/ I-V-S-IVB	MSFC will direct DAC to monitor 21 flanges for quantitative leak measurements during static firing. These are in addition to the 25 flanges previously selected for flight and static firing. Effectivity: A/S (Saturn V) and S-IVB/V-1 & subs and S-IVB/IB-3 & subs. Due date: September 15, 1964
4091	R-P&VE-VSI	R-P&VE-VSI will add the leak meters / J-2 engine mechanical interface to the Interface Control Document (Saturn IB/V). Due date: Immediately
4092	R-P&VE-PM	MSFC (R-P&VE-PM) will provide clarification concerning the leak monitoring port (a 1/8" female tubing port) for: a. Requirements for fitting and tubing between the flange and leak meter.

H. R. Palaoro — Chairman

SATURN WORKING GROUP ACTION ITEM REPORT

TO: Action Agency	REPORT NUMBER: R-P&VE-DIR(J)-64-529
	REPORT DATE: September 8, 1964
FROM: (WORKING GROUP/SUB-GROUP) Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 6	MEETING DATE: August 26-27, 1964

ITEM NO.	ACTION AGENCY	DESCRIPTION OF ACTION
		b. Pressure drop requirements and/or limitations of MSFC leak meters. Due date: September 15, 1964
4093	DAC	DAC shall submit (to MSFC, Attn: R-P&VE-PM) their laboratory separable connector test schedule (Due date: September 30,1964) and test results (as the tests are completed) (Saturn IB/V).
4094	R-P&VE-PM/ I-V-S-IVB	MSFC will provide contractual clarification for the use of the tubing material and wall thickness specified in MC 122 and MC 123. Due date: September 15, 1964
4095	R-P&VE-PM	MSFC (R-P&VE-PM) will provide recommendations for specification control of operational valve position switches (Saturn IB/V). Due date: October 1, 1964
Hydrostatic Stage		
4096	DAC	By analytical interpolation of test data, DAC will determine and include as a part of the Hydrostatic Structural Test Evaluation report, the magnitudes of principal stresses adjacent to, and between, the actual strain gage locations. This report shall include sufficient data to plot, as a minimum, the inside and outside fiber stresses for both principal stress directions at each instrumented area of the hydrostatic test tank. The above described data shall be presented in graphical form in the above report along with the actual strain level data obtained from the test. Additionally, the report will include graphs of stress levels derived from the test strain levels. Due date: With above report
Dynamics Stage		
4097	R-P&VE-VA R-AERO-D R-ASTR-F	MSFC (Control Dynamics and Structural Feedback Committee) will define requirements for providing flight hardware stiffness in the S-IVB dynamics stage forward skirt, aft skirt, and aft interstage. Due date: September 15, 1964
Interstage Venting		
4098	R-P&VE-SJ/ I-V-S-IVB	MSFC will provide contractual direction for the S-IVB/IB (reference R-AERO-AD-64-52) and S-IVB/V (reference R-AERO-AD-

H. R. Palaoro Chairman

SATURN WORKING GROUP ACTION ITEM REPORT

TO:	REPORT NUMBER:
Action Agency	R-P&VE-DIR(J)-64-329
FROM: (WORKING GROUP/SUB-GROUP)	REPORT DATE: September [illegible], 1964
Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 3	MEETING DATE: August 25-27, 1964

ITEM NO.	ACTION AGENCY	DESCRIPTION OF ACTION
		89-38) aft interstage and aft skirt internal pressure history. Due date: September 30, 1964
4099	R-P&VE-SJ	MSFC will furnish Saturn V structural design loads for the 64 sec. flight time after lift off. Due date: September 30, 1964
4100	DAC	Two weeks after receipt of Action Item 4099 design loads, DAC will report the effect of the increased pressure on the S-IVB/V aft skirt and aft interstage. Due date: as stated
4101	R-AERO-AD/P	MSFC will investigate the S-II/S-IVB interface sealing required to maintain the present minimum internal pressure history presented in memorandum R-AERO-AD-89-38. Due date: September 15, 1964
4102	R-AERO-AD/P	MSFC will determine the S-II/S-IVB compartment pressure history based upon the leakages listed in memorandum R-P&VE-[illegible] Due date: September 15, 1964
4103	R-AERO-AD/P	MSFC will provide an analysis of the S-IB/S-IVB aft interstage region to determine the acceptability of allowing 85 sq. in. of sidewall leakage with 25 sq. in. in the seal plate. Due date: September 15, 1964
Interface Control		
4104	DAC	DAC will submit to MSFC (Attn: R-P&VE-VSA) a layout showing (a) the bracket design and location for electrical connector No. 9 at the S-IB/S-IVB interface and (b) the length of cable required from the DAC bracket to the Chrysler splice plate. Due date: September 15, 1964 (Ref. I-V-S-IVB-TD-64-[illegible])
4105	DAC	DAC will submit to MSFC (Attn: R-P&VE-VSA) a layout showing (a) the bracket design and location for the separation retrorocket measurements cable connector at the S-II/S-IVB interface connect point and (b) the length of cable required from the DAC bracket to the North American (S&ID)/DAC [illegible] splice, located Sta. 2519, approximately 22° from position I toward position II. Due date: September 15, 1964

H. R. Palaoro
Chairman

SATURN WORKING GROUP ACTION ITEM REPORT

TO: Action Agency	REPORT NUMBER: R-P&VE-DIR(J)-64-529
FROM: (WORKING GROUP/SUB-GROUP) Vehicle Mechanical Design Integration Working Group, S-IVB Stage, Meeting No. 6	REPORT DATE: September 3, 1964
	MEETING DATE: August 26-27, 1964

ITEM NO.	ACTION AGENCY	DESCRIPTION OF ACTION
4106	DAC	DAC will provide recommendations for relocation of the S-IVB Stage Lox vents (Saturn IB/V) in reply to R-ASTR-G-236-64, dated July 8, 1964, "Interference with the ST-124-M azimuth laying by Lox venting of the S-IVB Stage" listing alternate means of resolving this problem. Due date: September 30, 1964

H. R. Palaoro, Chairman

ATTENDEE LIST

S-IVB VMDIWG MEETING NO. 6

NAME	OFFICE SYMBOL	PHONE
Mr. H. R. Palaoro	R-P&VE-DIR(X)	876-0714
Mr. R. F. Griner	R-P&VE-DIR(J)	876-7417
Mr. C. Haggard	R-P&VE-DIR(J)	876-1862
Mr. T. P. Isbell	R-P&VE-P	536-5586
Mr. W. Clark	R-P&VE-PAE	534-7971
Mr. J. A. Long	R-P&VE-PAS	534-3741
Mr. A. P. Laborte	R-P&VE-PE	876-5598
Mr. E. Rudder	R-P&VE-PE	876-0948
Mr. V. E. Voss	R-P&VE-PM	539-1931
Mr. R. C. Edwards, Jr.	R-P&VE-PM	534-3948
Mr. J. Levinson	R-P&VE-PM	[illegible]-4417
Mr. F. Britt	R-P&VE-PMC	530-1550
Mr. R. M. Hoodless	R-P&VE-PP	539-4224
Mr. T. W. Winstead	R-P&VE-PT	536-0381
Mr. R. Hill, Jr.	R-P&VE-SAF	534-2286
Mr. W. E. Cobb	R-P&VE-SAF	534-1400
Mr. W. R. Walters	R-P&VE-SJ	536-6656
Mr. P. W. Frederick	R-P&VE-SS	539-0793
Mr. N. C. Schlemmer	R-P&VE-SSS	539-0793
Mr. J. E. Morgan	R-P&VE-VAD	876-5505
Mr. O. E. Moon	R-P&VE-VAS	876-1277
Mr. J. H. Sims	R-P&VE-VAN	876-2[illegible]
Mr. R. G. Eudy	R-P&VE-VM	876-[illegible]
Mr. T. J. Weimer	R-P&VE-VMS	876-[illegible]
Mr. B. H. Adams	R-P&VE-VOR	876-0204
Mr. J. O. Phillips	R-P&VE-VSA	876-0039
Mr. G. W. Kraus	R-P&VE-VSI	876-3150
Mr. C. J. Mozo	R-P&VE/DAC	897-0311 Ext. 2021
Mr. R. C. McAnnally	R-AERO-AD	876-0484
Mr. R. J. Jackson	R-AERO-P	876-5470
Mr. R. D. Richardson	R-ASTR-ES	876-0353
Mr. J. A. Peoples	R-ASTR-NFM	876-3525
Mr. E. O. Berg	R-ASTR/DAC	897-0311 Ext. 2021
Mr. R. C. Littlefield	R-ME-U/DAC	897-0311 Ext. 2021
Mr. M. R. Chetron	R-ME-U/DAC	897-0311 Ext. 2021
Mr. F. Dolan	R-QUAL-ATA	876-3993
Mr. J. J. Lindsey	R-QUAL-ATT	876-8097
Mr. R. D. Cahall	R-QUAL-ATT/DAC	897-0311 Ext. 2021
Mr. C. M. Davis	R-TEST-SDS	876-3957
Mr. J. Eaton	I-E-J	876-3009
Mr. L. Coller	I-E-J/DAC	897-0311 Ext. 2021
Mr. L. D. McIlwain	I-I/IB-E	876-0043
Mr. R. S. Hamner	I-I/IB-S-IVB	876-3034
Mr. H. L. McDanie	I-I/IB-S-IVB	876-3597
Mr. J. Keeney	I-I/IB-S-[illegible]	876-3597
Mr. J. J. Delaney	I-I/IB-S-IVB-L	897-0311 Ext. 2021

Enc. 2.

ATTENDEE LIST (Cont'd)

NAME	OFFICE SYMBOL	PHONE
Mr. D. Brown	KSC-PA5	UL3-4848
Mr. J. Fulton	KSC-PA5	UL3-4848
Mr. L. S. Mull	DAC	897-0311 Ext. 2726
Mr. R. J. Thiele	DAC	897-0311 Ext. 2506
Mr. W. P. Wood	DAC	897-0311 Ext. 2935
Mr. W. S. O'Hare	DAC	897-0311 Ext. 2508
Mr. J. F. Henneberry	DAC	897-0311 Ext. 2536
Mr. R. M. Gunn	DAC	897-0311 Ext. 2555
Mr. M. D. Nadler	DAC	897-0311 Ext. 2810
Mr. D. L. Dearing	DAC-Aero/Thermo	897-0311 Ext. 2631
Mr. R. B. Scott	DAC-Aero/Thermo	897-0311 Ext. 2634
Mr. F. S. Mayer	DAC-Anal. Br.	897-0311 Ext. 2628
Mr. J. K. Ganoung	DAC-Anal. Br.	897-0311 Ext.2629
Mr. C. W. Gann	DAC-Aero.	897-0311 Ext. 2653
Mr. J. P. Sunak	DAC-Astr.	897-0311 Ext. 2659
Mr. B. D. Mallett	DAC-Astr.	897-0311 Ext. 2663
Mr. J. J. Kelley	DAC/FD&C	897-0311 Ext. 2757
Mr. R. S. Malloch	DAC/FD&C	897-0311 Ext. 2759
Mr. R. Norris	DAC/FD&C	897-0311 Ext. 2757
Mr. V. R. Perry	DAC-Life Sciences	897-0311 Ext. 2754
Mr. F. C. Tripp, III	DAC-Mech. Des.	897-0311 Ext. 2584
Mr. R. E. Overman	DAC-Prop.	897-0311 Ext. 2535
Mr. D. A. Smith	DAC-Prop.	897-0311 Ext. 2509
Mr. J. D. Schweikle	DAC-Prop.	897-0311 Ext. 2521
Mr. R. F. Muneske	DAC-Prop.	897-0311 Ext. 2535
Mr. C. O. Stephens	DAC-Strength	897-0311 Ext. 2641
Mr. H. E. Prichard	DAC-Strength	897-0311 Ext. 2761

ATTENDEE LIST (Cont'd)

NAME	OFFICE SYMBOL	PHONE
Mr. K. E. Berline	DAC-Struct.	897-0311 Ext. 2593
Mr. J. Sagata	DAC-Struct	897-0311 Ext. 2598
Mr. R. V. Rogers	DAC-Sys. Div.	897-0311 Ext. 2029
Mr. D. Comer	DAC-Sys. Eng.	897-0311 Ext. 2340
Mr. R. B. French	DAC-Sys. Eng.	897-0311 Ext. 2339
Mr. M. R. Collins	DAC-Sys. Test	897-0311 Ext. 2725
Mr. W. L. Beck	DAC-Sys. Test	897-0311 Ext. 2725
Mr. H. R. Linderfelt	DAC/VDB	897-0311 Ext. 2591
Mr. J. H. Tobias	DAC/MSFC	[illegible]-3850
Mr. R. M. Baugh	DAC/R-P&VE-VAD	[illegible]-7245
Mr. N. Y. Smith	NAA-S&ID	[illegible]-5111 Ext. 4013
Mr. J. R. Costello	Rocketdyne/DAC	347-5831 Ext. 3008
Mr. J. N. Siksnius	Rocketdyne/DAC	897-0311 Ext. 2341
Mr. H. A. Fredrickson	Rocketdyne-J-2 Eng.	347-5831 Ext. 3008

MINUTES OF SIXTH VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP FOR THE S-IVB STAGE (SATURN IB/V)

1. INTRODUCTION

The Sixth Meeting of the Vehicle Mechanical Design Integration Working Group (VMDIWG) for the S-IVB Stage (Saturn IB/V) convened August 26-27, 1964 at the Douglas Aircraft Company's (DAC) Huntington Beach, California Plant. The VMDIWG S-IVB Stage Secretary introduced the chairman, the DAC senior representative, and identified the various Marshall Space Flight Center (MSFC) organizations and other contractors represented.

2. DELINQUENT ACTION ITEMS

Mr. Morgan, R-P&VE-VAD, presented a list (appendix B) of Action Items (A.I.) closed since the issuance of memorandum R-P&VE-VAD-64-83. The delinquent action items were reported to the meeting by number only. Mr. Hoodless, R-P&VE-PPF, stated that a memorandum was in process to close delinquent A.I. 2132. This information is in turn needed by Rocketdyne (RKD) to close delinquent A.I. 1402 (assigned to R-P&VE-P). Subsequent to the meeting, A.I. 4087 was generated to name the Engine Project Office (and Rocketdyne) as the action agency and superseded A.I. 1402. The Rocketdyne representative stated that delinquent A.I. 1363 can be closed by defining the J-2 engine envelope as a 81 inch diameter cylinder except for the customer connect panel. Mr. Thiele, DAC Propulsion, accepted this definition; therefore, this A.I. is closed.

Mr. Comer, DAC, stated that the DAC A.I. status report is described in the DAC handout of appendix B; pages 2-19. Mr. Haggard, R-P&VE-XJ, pointed out that A.I.'s have been incorrectly closed in the DAC monthly status report by stating that a reply (Scope Change or TCB, etc.) will be sent to MSFC. An A.I. is closed only when the working group secretary or chairman has accepted the closing documentation (as denoted by the monthly A.I. status report published by R-P&VE-VA, or by other documentation transmitted through the Stage Manager's office, I-V-S-IVB).

3. STAGE WEIGHT STATUS (SATURN IB/V)

Mr. Simko, DAC Weights, presented the material shown in appendix A, pages 20-30. Mr. Sims, R-P&VE-VAW, questioned the Saturn V effectivities shown in the presentation and stated that the Astrionics Laboratory is currently preparing a list of R&D measurements and associated equipment that will not be required on operational vehicles. Mr. Mull, DAC, stated a reply for the weight reduction measures described in I-V-S-IVB-TD-64-133 would be provided by September 15, 1964.

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Mr. Simko stated that some S-IV weigh system components will be utilized at Sacramento and Huntington Beach for dry stage weighing of the S-IVB Stage. No weighing will be performed at Kennedy Space Center (KSC). Weight status of the stage will be provided at KSC by a weight log maintained by a DAC weight engineer. The dry stage weight at launch will be measured within an accuracy of 0.1%

Mr. Simko stated that the first S-IV cryogenic loading (SA-9) weight was accurate to within 0.5% (0.25% error was the largest noted). One day (plus) could be gained if cryogenic weighing is deleted but DAC recommends that the cryogenic weighing be continued as described in appendix C (received during the meeting). The cryogenic weigh system will not be available for S-IVB/IB-1 (SA-201) because of diversion of funds and late procurement of the environmental cover (due to late funding). Mr. Miller, DAC, stated that flow measurement is intended for S-IVB/IV-1. Mr. Davis, R-TEST-SBS, stated that a requirement had been established in the Static Firing Working Group to perform a full propellant loading sequence test prior to the first static firing (reference Action Item No. 9 of R-TEST-SBS-#119-64). Action item 4082 resulted from this discussion.

4. STRUCTURAL QUALIFICATION TESTING (SATURN IB/V)

Mr. Stewart, DAC, presented the program status of additions to the Data Acquisition System required in memorandum R-P&VE-SSS-64-62, as described in appendix A, pages 31-35.

Mr. Stephens, DAC, outlined the problems anticipated by the necessity of testing structural hardware designed for non-flight loads as described in appendix A, pages 36-38.

Mr. Stephens, DAC, stated that the internal loads analysis of the S-IVB/IB Aft Interstage (A.I. 4048) had not been completed and committed a September 15, 1964, completion date for this item.

Mr. Stephens discussed the analytical and test results of the interface flange tensile test program described in appendix A, pages 38-43. Mr. Schlemmer, R-P&VE-SSS, stated that the MSFC analysis based upon R-P&VE-SLL-64-26 loads, indicates a negative margin of safety at the interfaces (in tension). DAC had not received this memo. It was pointed out that R-P&VE-SLL-64-26 loads were not based upon the latest payload and LES (8200 lbs) weights. According to Mr. Sims, R-P&VE-VAW, and Mr. Schlemmer, R-P&VE-SSS, MSFC has not investigated the effect of the new increased payload.

5. STRUCTURAL DESIGN LOADS AND STRENGTH ANALYSIS

Mr. Pritchard, DAC, presented a listing of the MSFC structural design memoranda (appendix A, pages 44-48) that are being used by DAC in the design of each of the S-IVB stages and the major structural components (Saturn IB and V).

Mr. Pritchard described an agreement made with the Aero-Astrodynamics Laboratory (R-AERO) to complete the APS module loads analysis based on M-AERO-A-71-63. It was stated that R-AERO loads are accepted by DAC as information only; R-P&VE-S memos are used by DAC as the official design loads; DAC then reruns MSFC loads and fairs in certain areas (i.e., fair steps in the shear curve). The acceptability of this practice was deferred for review within the MSFC Structures Division. Mr. Comer provided Mr. Haggard with one copy each of two DAC confidential design memos for this purpose (these were transmitted to the Structures Division as enclosures to R-P&VE/DAC-27-64, appendix D).

Mr. Walters, R-P&VE-SJ, handed out copies of charts (appendix E) depicting a "family tree" of all design loads documents issued by MSFC for S-IVB/IB and V. Mr. Walters stated that the MSFC list included two memoranda not included on the comparable DAC list. These are:

(1) R-P&VE-SLL-64-13 supplementing R-P&VE-SL-212-63 (it was subsequently determined that this memo was enclosed in I-V-S-IVB-TD-64-53).

(2) R-P&VE-SLR-64-43 (this was thought to have been received by DAC but was not located prior to conclusion of the meeting).

Mr. Comer, DAC, stated that DAC is using R-P&VE-SD-396-62 loads to design non-flight S-IVB/IB Stages; R-P&VE-SL-212-63 loads are being used to design S-IVB/IB-1 and -2 (except for the aft skirt which is designed for R-P&VE-SD-396-62 loads); and R-P&VE-SL-212-63 loads will be used to design S-IVB/IB-3 and subs. It was brought out that R-P&VE-SL-9-62 and appending memoranda shown in appendix E describes the design loads for SA-501-503; R-P&VE-SLL-64-26 loads are to be used in the design of SA-504 and subs. Mr. Schlemmer, R-P&VE-S, requested a detail stress analysis from DAC of the stages affected by R-P&VE-SL-212 loads and DAC indicated that these data would be provided by September 18, 1964.

6. BATTLESHIP (B/S)

Mr. Comer, DAC, presented the current schedule of events for the B/S testing program as shown in appendix A, page 50, and subsequently provided a B/S hot firing work schedule, appendix F for the minutes.

Mr. Schweikle, DAC Propulsion, presented the current J-2 engine chill program and outlined the outstanding problems related to the J-2 start and their proposed resolution (see appendix A, pages 51-56). He stated that a modulating valve will not be used in the B/S during propellant loading. In response to a question from the floor, he stated that the new gas generator configuration (gas generator plus gas generator bleed valve) will be installed on the battleship engine.

Mr. Long, R-P&VE-PAS, summarized the activities of the J-2 Engine Start Committee, Appendix G, and memo R-P&VE-PPF-64-M-187 was discussed briefly at this time.

A list of non-flight components is provided in appendix A, pages 57-62 as required to complete A.I. 4030.

7. CONTINUOUS VENTING (SATURN V)

Mr. Schweikle, DAC Propulsion, presented the vent design, thrust and thrust tolerances shown in appendix A, pages 63-64. There have been no changes since the June meeting at MSFC and no decision regarding the separator. The S-IVB/IB fuel tank vent nozzle design cannot meet the MSC requirement to not exceed one m/sec. delta V during venting. The S-IVB/V can meet this requirement. Mr. Schweikle stated that the S-IVB/IB nozzle could meet a 1.5 m/sec. thrust limit if MSC will accept this. Mr. Jackson, R-AERO-P, stated that the Dynamics and Control Working Group will permit a relaxation of the requirements from 1 to 2 m/sec. for the Saturn IB only (A.I. 4084 was prepared to document this decision).

The reduction in the APS fairing size results in a weight reduction of approximately 25 pounds in the aft skirt (appendix A, page 63).

Tolerances for nozzle locations and angularity are presented in appendix A, pages 65-67. Fuel tank vent system drawings are shown in appendix H.

8. AUXILIARY PROPULSION SYSTEM (APS)

Mr. Abe, DAC Propulsion, described the S-IVB/IB APS configuration design and fabrication status and Mr. Rodgers, DAC, discussed Gamma testing using appendices A, pages 68-88, I and J. Mr. McDaris, I-V-S-IVB, asked and Mr. Abe replied, that the 3% accuracy for propellant measurement in flight is expected to include vibration, slosh, and telemetry errors. In the current design, the astronaut receives a propellant measurement signal from the ground. It was indicated that DAC plans to lead to 1/2% accuracy by volume. A "yo-yo" type measuring device is planned for S-IVB/IB and a microswitch cutoff on the end bellows plate has been planned for S-IVB/V. Mr. Jackson, R-AERO-P, stated that MSC requirements for APS propellant measurements have been requested from Mr. Palaoro, thru the MSC/MSFC Apollo Mechanical Integration Panel. Mr. Voss stated that the Crew Safety Panel had established a requirement for redundancy in the Emergency Detection System (EDS); i.e., two sensors in the system. DAC stated that schedule slippage will result if this was to be implemented. DAC asked if EDS for the APS propellant measurement system is required. This question was deferred for separate action. Mr. Abe stated that each measuring device will be qualified as a component and as a part of the tank assembly. Mr. Abe discussed the orbital temperature charts of appendix K. In reply to a question from Mr. Phillips, R-P&VE-VSA, concerning materials compatibility of propellant line bracketry, Mr. Abe stated that in his opinion there was no explosive hazard.

Mr. Abe, DAC, stated that the bladder concept design has been initiated for the S-IVB/V APS and presented the S-IVB/V APS bladder design concept shown in appendix A, pages 89-94. He indicated that the S-IVB/V bellows test would not serve to support the APS/IB program and would therefore be discontinued. He indicated that these changes will be firm in about two months and Mr. Eudy, R-P&VE-VM, asked for documented confirmation so that the APS GSE requirements could be established. It was brought out that the bladder concept does not employ sensors; however, DAC has investigated sensors from Acoustica and a radioactive isotope device from another source. Mr. Voss recommended that DAC also contact Acoustica relative to the latter item. Mr. Abe agreed to do so.

Mr. Abe, DAC, described the DAC APS static firing program as shown in appendix A, pages 95-98, and indicated that their engine performance tests will eliminate the necessity of APS hot firing. He stated that DAC has instigated a Gamma hot firing (Beta has this capability) although they do not recommend acceptance firing of the APS. He stated that acceptance firing leak and functional checks would be accomplished manually, Mr. Thiele, DAC Propulsion, said the APS will be shipped with the stage from SACTO to KSC. Mr. Weimer, R-P&VE-VMH, and Mr. Thiele, DAC, were to discuss the KSC requirements separately but were unable to meet.

9. PROPELLANT TANK DESIGN AND PRESSURIZATION

Mr. Berline, DAC Structures, presented the status of the LH_2 tank structural changes, appendix A, pages 99, 100 and 102. Mr. Frederick, R-P&VE-SS, stated that the Structures Division is conducting a study to determine the weight reductions possible for the Saturn Vehicles if the tanks are pressurized on the pad during ground wind conditions. Mr. Schlemmer expressed an opinion that the ground wind restrictions will likely be relaxed as a result of the requirement to pressurize the stage during ground handling, storage, and transport; if so, a reduction of approximately 100 lbs in weight may result. Mr. Sims, R-P&VE-VAW, asked why one (1) ambient helium bottle can't be removed now that the NPSH is back where we started. Mr. Schweikle stated that an extra bottle would have been added anyway under the old pressure schedule. No Lox anti-vortex screen tests have been conducted to date. It was brought out that the Contracting Officer's letter, (I-CO-VB-4-218, dated August 14, 1964) requires a reply from DAC by September 10, 1964 as to what screen tests are planned.

Mr. Schweikle, DAC Propulsion, discussed the pressurization information of appendix A, pages 104-110. Mr. Schweikle asked that MSFC request, from Rocketdyne, a raise in the pressure for maximum allowable Lox pump inlet pressure for static testing. The current pressure limit is 48 psia but the DAC analysis for the S-IVB/V indicates that the pressure during start transient will be 49 psia. Mr. Arnett, R-P&VE-P, stated that MSFC is now looking into this. Mr. Arnett requested that DAC expedite pressure switch procurement to provide a 39 psia design for S-IVB/IB-1 in lieu of the 42 psia planned (see appendix A, page 109). Mr. Mull stated that every pressure is already being exerted upon their subcontractor for the 42 psia switch delivery. A discussion of the pressure switch requirements as related to the 3 psi control band was deferred for separate discussion in a smaller group on the following day. The smaller group subsequently reported that (1) if an additional 1.2 psi is required, the Southwestern pressure switch could be modified to mate with the DAC pressure switch module and (2) that because of the time required for module compatibility development, the Southwestern switch can be removed from the module and fitted to the tank.

Mr. Schweikle stated that anti-vortex screen design Δp was 1 psi.

10. PROPULSION SYSTEM PERFORMANCE

Mr. Schweikle, DAC Propulsion, stated that this subject was adequately covered in appendix A , pages 111-114, and noted errors contained therein (which are tabulated in the errata sheets, appendix CC). A Rocketdyne representative stated that a Propellant Mixture Ratio shift (upward) causes a slight thrust increase.

11. PROPULSION MISCELLANEOUS (SATURN IB/V)

Mr. Manoske, DAC Propulsion, presented the status of the valve position sensors of appendix A, page 115. Mr. Voss, R-P&VE-PM, stated that from S-IV stage experience, all position indicator switches must be qualification tested per the requirements of the Automation Board and presented a document, "Saturn V Valve Position Sensor Requirements Summary" for inclusion in the minutes (appendix L). Mr. Voss and Mr. Hamner, I-V-S-IVB, were to meet later to discuss contractual implementation of these requirements.

Mr. Manoske, DAC Propulsion, presented the charts of appendix M, depicting Specification Control Drawings, vendors, etc, for propulsion system purchased parts. A question as to whether the specification control drawings, listed as available in the charts, had been forwarded to MSFC was unanswered. Mr. Mull stated that they would be forwarded and A.I. 4085 ensued.

Mr. Manoske presented the results of the study and testing of the S-IV helium heater using appendix A, pages 116-118, and 121-130, charts which reflect payload gains based upon pre-continuous venting weights (see R-P&VE-XJ-64-573, dated September 18, 1964, for corrected payload gains). He stated planning is for single start capability, only. If the helium heater is used on the S-IVB Stage, it would be installed on late stages, maybe S-IVB/V-1. Two heaters will provide repressurization of the LH_2 tank in 5 minutes. The continuous vent would be closed during the repressurization operation. DAC pointed out that the S-IVB/V-1 tank is scheduled for September 1964 manufacture, and requested immediate direction from MSFC to add pads to the S-IVB/V-1 tank for use in the event MSFC desires to use this system.

Mr. Pellicciotti, DAC, discussed capacitance point level sensors and provided appendix N for inclusion in the minutes to supersede page 119 of appendix A.

Mr. Manoske discussed the R&D requirements concerning moisture content of helium. R-P&VE-P will continue discussion with Rocketdyne to eliminate the incompatability of dew point criteria between DAC and Rocketdyne per A.I. 4086. Mr. Adams, R-P&VE-VOR, stated that he thought that the latest MSFC specification for grade AA helium listed a -78°F dew point.

12. ENVIRONMENTAL CONTROL (SATURN IB/V)

Mr. Gray, DAC, discussed cold plate testing plans as described in appendix A, pages 131-139. He stated that RFI is prevented by .040" x 1" side, beryllium copper bonding strips between the cold plates and structural skin and that DAC testing had demonstrated that this is adequate. In reply to a question from Mr. Edwards, R-P&VE-P, Mr. Gray stated that the 20 cold plates ordered by MSFC are on schedule, as far as he knows. Mr. Edwards asked that the test control drawings be forwarded to him. Mr. Gray said that the S-IVB batteries will not be mounted on cold plates because heating, not cooling, is required. Battery tests are planned to determine the characteristics of the battery designed for the aft interstage which may also be used in the forward interstage environment. Aft interstage environmental testing will be conducted on the Battleship because of All Systems slippage. It was brought out that the interstage was to be purged to 4% or less oxygen content.

Mr. Adams, R-P&VE-VOR, stated that the MSFC Saturn IB thermistor specification is in MSFC Industrial Operations now and DAC should receive this during the week of August 31, 1964. The Saturn IB and V thermistors are different because of KSC control characteristics and vibration test requirements. Also, the Saturn V thermistor is being qualified at MSFC; the resulting specification will be forwarded to DAC. (Subsequent to the meeting, notification was received in I-V-S-IVB-64-A-190 that KSC has agreed to modify the Saturn IB ground environmental control facility to accept the S-IVB/V thermistor.)

13. THERMAL ENGINEERING

Mr. Miller, DAC, presented the status of the high performance insulation program of appendix A, pages 140-152. The weights shown do not reflect the continuous venting philosophy and the payload gain is too high by approximately 15-20%. Mr. Palaoro asked that the weight numbers be updated prior to the presentation to Dr. Mrazek on September 3, 1964. (These updated values are shown in R-P&VE-XJ-64-573, dated September 18, 1964). DAC indicated that they had datafaxed corrections to Mr. Peters, I-V-S-IVB, but had not been able to prepare the corrections in time for inclusion in the working group presentation.

Mr. Dearing, DAC, presented the results of the S-IVB insulation tests and the heat transfer dispersion study of appendix A, pages 153-175. Mr. Griner asked and Mr. Dearing confirmed that the Phase I insulation, with reduced resin content, is being used on the MSFC battleship, but not the DAC Battleship. The difference in thermal conductivity is negligible according to Mr. Dearing.

14. LEAK DETECTION

No leak detection handout was presented by DAC because of the plan to cover this agenda item in a pre-meeting. Mr. Edwards, R-P&VE-P, discussed the leak detection charts of appendix O. He stated that there were more than 7200 fluid connectors in the Saturn V vehicle. Mr. Edwards stated that the blank spaces in his charts are an indication of the difficulty he is having in obtaining data from the stage contractors; however, DAC has provided information during and after the pre-meeting held on August 25, 1964. Mr. Edwards read the conclusions from the pre-meeting and action items 4089-4093 ensued. Appendix P was given to the secretary for inclusion in the minutes to describe 21 flanges, in addition to the 12 flanges considered critical, that require leakage monitoring during static firing.

Mr. Comer, DAC, stated that the DAC plans and effectivity for the mechanical separable connector leak detection system in the stage and J-2 engine were discussed in detail at the August 25, 1964 pre-meeting. DAC needs contractual clarification for the use of the tubing material and wall thickness specified in MC 122 and MC 123 (A.I. 4094). DAC plans to use 1/8" tubing on the stage and the MC documents do not authorize the use of tubing smaller than 1/4". Due to weight consideration, DAC plans to use tubing with various wall thicknesses; however, the MC documents only permit one wall thickness with each diameter tubing. Other problems with the MC document include bend radii, welding and low temperatures, etc. Mr. Comer agreed to send a letter to Mr. Voss, R-P&VE-P, describing in detail the problems related to the above usage in approximately two weeks.

15. HYDRAULIC SYSTEM (SATURN IB/V)

Mr. Hamilton, DAC, presented appendix Q in addition to page 177 of appendix A. Appendix R was likewise received at this time. Mr. Hamilton concurred with the corrective action described in memorandum R-P&VE-PTD-64-M-71, required to preclude hydraulic oil freezing, and stated that the temperature sensor will be relocated to the critical point on the first flight stage (S-IVB/IB-1). DAC does not plan to provide a redundant sensor electrical system since no other part of the hydraulic system has redundancy. The sensor will be qualified separately and as a part of the hydraulic system. Mr. Voss asked why this test philosophy cannot be extended to the propellant valves and switches (i.e., test the switch and propellant valve separately) as discussed earlier during agenda item 11a coverage. A.I. 4095 resulted from the latter discussion.

16. HYDROSTATIC STAGE

Mr. Mull summarized the pre-meeting discussion and stated that complete information regarding the hydrostatic stage failure was available in SM-46755, 'Failure Analysis Report Hydrostatic Vehicle", which was distributed to the attendees in the August 25, 1964 pre-meeting. Mr. Mull, DAC, stated that the DAC position concerning a new hydrostatic stage was to test to the burst condition to determine the actual margin of safety. DAC would not recommend that another stage be provided for limit load testing only. (see appendix S). A.I. 4096 was subsequently prepared and the wording agreed upon between MSFC and DAC structures representatives.

17. DYNAMIC STAGE (SATURN IB AND V)

Mr. Moon, R-P&VE-VAS presented the charts of appendix T to describe the differences between DAC Design Memo #101C and MSFC documents as to the Dynamics Stage design requirements. A splinter meeting was arranged to discuss the detail differences in DAC and MSFC requirements and attempt to define mandatory (as opposed to "nice-to-have") changes required. Primary differences concerned (1) whether the interstage structure was to be reinforced to simulate the flight article stiffness, (2) what GSE was required and what contractual action was in process, (3) S-IVB/IB aerodynamic fairing requirements, (4) simulated mass requirements and how these are to be mounted, and (5) whether flight type insulation, propellant feed lines, dummy prevalves, and dummy ordnance items are to be provided. The report from this splinter group indicated that their meeting was fruitless and that separate action would be required from the Dynamics Control and Structural Feedback Committee.

Mr. Whiteman, DAC, discussed the Dynamics Stage status (appendix A pages 179-181), and stated that currently the stage is on schedule and it is expected to remain on schedule. He stated that it is highly desirable to move the Dynamics stage out of A3 before it is delayed by All Systems, S-IVB/IB-1, etc., (it has lowest priority) and suggested that we implement any MSFC required modifications at MSFC, if possible. It was indicated that such items as the flight feed lines can be added at MSFC but DAC engineering at A3 will be required which would be the pacing item. Follow-up with Mr. Shaver, DAC/MSFC representative, will be required to see if any time is available for DAC modifications at MSFC and what DAC modification capability exists at MSFC.

18. FACILITIES CHECKOUT STAGE (SATURN IB AND V)

Mr. Whiteman, DAC, presented a status report for the Facilities Checkout Stage as outlined in appendix A, pages 182-184. It, too, should leave A3 as soon as possible to prevent schedule slippage caused by its low priority.

19. INTERSTAGE VENTING

Mr. Unger, DAC Aero, presented a list (appendix A, page 185 and 186) of the documents that are in use for the S-IVB interstage venting design. A comparable list prepared by the Design Integration and Criteria Branch, R-P&VE-VA, is shown in appendix U. The DAC list does not contain R-AERO-A-89-63. It was agreed that this memo would be forwarded as official design loads by R-P&VE-SJ and I-V-S-IVB (A.I. 4098). (Subsequent to the meeting, R-P&VE-SJ-64-431 was received by the secretary indicating that the R-AERO-A-89-63 information is contained in memoranda R-P&VE-SVA-64-90, and R-P&VE-SLL-64-11).

Mr. Berline, DAC Structures, summarized the interstage venting design (vents, structural leakage, and drain holes) of appendix A, page 187-191. He stated that the vents in the Forward Skirt are not located 122 inches from the forward face of the IU as directed by MSFC. They are located approximately 115 inches from the forward face of the IU because of the requirement that the throat area of the internal rain shields be three times the vent size. The rain shield would not meet this requirement if mounted lower because of interference with the LH_2 tank bulkhead. The Forward Skirt contains 54, 3/8 inch, drain holes (one hole at every other stringer). The structural leakage areas listed in appendix A incorporate an estimate of the sealing lost due to flight dynamic effects. Mr. Comer, DAC, stated that (1) testing to verify venting and leakage requirements cannot be accomplished at plant A3, (2) DAC plans to recommend that this testing be done at KSC (Scope Change 1256), (3) DAC is not planning to conduct any R&D testing of the Aft Skirt, Forward Skirt or Interstage (Saturn IB and V) to determine structural leakage and (4) expressed reluctance to guarantee <u>any</u> leakage area limits without test data.

Mr. Jackson, R-AERO-P, discussed the S-IB/S-IVB interstage allowable leakages of appendix V and indicated that 55 sq. in. of side wall leakage in the S-IVB/IB aft skirt and interstage with 25 sq. in. leakage in the seal plate was acceptable. Mr. Gray, DAC, stated that the 55 sq. in was predicated upon the ground purge allowable oxygen content condition and should not be considered as the structural leakage area that would preclude production leak testing. He indicated that the 84.2 sq. in. of appendix A, page 190 is more realistic. R-AERO agreed to re-run the Saturn IB analysis using 85 sq. in., 25 sq. in., and 160 sq. in. values (A.I. 4103).

Mr. McAnnally, R-AERO-AD, presented a status report (appendix W) of the allowable structural leakage studies being prepared for the S-IVB/V aft skirt and aft interstage. He stated that more work should be done on the mass inflow problem and it should be determined if the aft skirt can tolerate the addition of 0.4 psi (crushing) caused by the difference in R-AERO-A-89-63 and DAC Design memo no. 57A internal pressure coupled with an increased leakage area. A splinter meeting convened to discuss details of this problem and reported that no action would be taken pending official receipt of R-AERO-A-89-63.

Mr. McAnnally, R-AERO, stated that R-AERO would conduct an aerodynamic analysis on the S-IVB Forward Skirt, IU, and LEM adapter as soon as MSC provides MSFC with the LEM adapter and Service Module structural leakage values.

20. INTERFACE CONTROL

Mr. Morata, DAC, presented appendix X for inclusion in the minutes and stated that DAC had not received direction to comply with M-SAT-WSF-#46-64 concerning J-2 engine frequency measurements and turbopump overspeed safety cut off requirements of Change Order No. 168.

Mr. Phillips, R-P&VE-VSA, presented charts (appendix Y) to describe a hazardous condition at the suction duct flange and recommended solutions. Mr. Mull, DAC, questioned the source of the manufacturing tolerances shown in the charts. Mr. Phillips replied that the plate dimensions were obtained from DAC drawings and the seal tolerances were nominal values obtained from a Navan catalog (that he had been unable to obtain these values from DAC).

Mr. Oster, DAC, presented the DAC recommended solution to the problem as shown in appendix A, pages 192-194 and stated that their tests to date demonstrate that their method of sealing is acceptable for all manufacturing tolerance buildup conditions, and that DAC does not consider this to be a problem. He noted that the right hand view on page 193 of appendix A was inverted.

Mr. Palaoro, R-P&VE-X, stated that the MSFC Research and Development Operations (R&D) recommendations have been made to MSFC Industrial Operations and DAC warned of a hazardous condition, and that no further action is required by R&D.

Mr. Kraus, R-P&VE-VSI, presented the Mechanical Interface Control charts of appendix Z for inclusion in the minutes. Mr. Kraus stated that the interface control program had been discussed with DAC at a pre-meeting, August 25, 1964 and for the most part all problems were resolved. Appendix AA was handed to the secretary to summarize the pre-meeting results.

Mr. Berline, DAC Structures, referred to the material in appendix A, page 195, concerning the S-IVB/S-IB Interstage seal discussed in the pre-meeting. It was agreed that this applied to the remaining interface control items so that it was unnecessary to discuss them at the main meeting.

DAC was not prepared to present recommendations for relocation of the Lox vents to prevent ST-124-M interference and A.I. 4106 ensued.

21. CONFIGURATION LIST (SATURN IB/V)

Mr. Comer, DAC, said that he felt the material listed in appendix A, pages 197-198 was complete and neither a presentation nor a discussion was necessary. Meeting attendees agreed.

22. SOLID ULLAGE ROCKETS

Mr. Walton, DAC Propulsion, likewise skipped his presentation in the interest of time and only presented corrections to the material in appendix A, pages 199-204, as shown in the errata sheets (appendix CC).

23. GROUND SUPPORT EQUIPMENT

Mr. McMillen, DAC GSE, discussed the SACTO propellant loading plans described in appendix A, page 205. He stated that DAC is complying with Change Orders 165 and 298 for the modulating (replenishing) valve requirements.

Mr. Killibrew, DAC GSE, described the ground support equipment for the propellant tank positive pressurization system required during transportation, handling, and storage in appendix A, pages 206-209. This latest design concept was presented to MSFC approximately one month ago. Mr. Killibrew stated, in reply to a question from Mr. Voss, that DAC does not have a requirement for recording pressure history. Mr. Voss stated that S&ID does have such a requirement for the S-II Stage. DAC plans to use GN_2 for the pressurant. It was stated that a relief valve is a requirement for all pressure levels and that the GSE will have this provision even though it is not shown in the appendix A schematic drawing. The GSE will contain 10 cu. ft. of GN_2 at 3000 psig. Each propellant tank will contain a static and pressurizing line although this is not reflected in appendix A. The stage disconnects will add approximately 10 lbs. to the stage.

Mr. Lapham, DAC, discussed GSE technical problems that were affecting the delivery schedule as outlined in appendix A and supplemented by appendix BB.

24. DAC WILL IDENTIFY MAJOR PROBLEMS REQUIRING MSFC ACTION

Mr. Comer, DAC, stated that DAC had discussed their major problem areas during the course of the meeting.

Mr. Holmen, DAC, presented a status report for the DAC Orbital Debris Study. The Orbit Debris Committee will meet at MSFC in approximately two weeks*. He stated that (1) the Lockheed Aircraft Company (LAC) proposal for spherical retromotors is not acceptable to DAC, (2) neither of the LAC proposals were felt to be practical and DAC will submit alternate proposals at the next committee meeting, (3) an additional problem of the interference between the retros and the LEM adapter panels must be resolved.

*LATER SCHEDULED FOR SEPT. 25, 1964 AT MSFC, BUILDING 4200, ROOM 513

APPENDICES

A. DAC document (219 pages) entitled 'Sixth Vehicle Mechanical Design Integration Working Group Meeting, 8-26-64 and 8-27-64"

B. MSFC Action Item Status Report dated August 21, 1964 (13 pages)

C. A3-850-K010-4.1.6-T-55, dated August 14, 1964, 'Requirement for the S-IVB Weight System" (2 pages)

D. R-P&VE/DAC-27-64, dated September 1, 1964 (1 page)

E. MSFC official loads listing (5 pages)

F. B/S Hot Firing DAC Work Schedule (1 page)

G. J-2 'Start Committee" Status Report (1 page)

H. Fuel Tank Vent System (2 pages)

I. APS Fabrication Status, # 1 Module (1 page)

J. Gamma Complex Testing Milestone Chart (1 page)

K. Orbital Temperature History for APS Fairing (5 pages)

L. Saturn V Valve Positioner Sensor Requirements Summary (8 pages)

M. S-IVB Propulsion Spec. Control Drawings (purchased parts) (7 pages)

N. Capacitance Point Level Sensors (8 pages)

O. Saturn V Separable Fluid Connectors - Zero Leakage Effort (17 pages)

P. S-IVB Static Firing Leak Measuring Program (1 page)

Q. Summary of Thermal Analysis and Tests on the S-IVB Hydraulic System (48 pages)

R. 1A74765-1 Auxiliary Pump Thermal Switch (1 page)

S. DAC Recommendation for Hydrostatic Stage Replacement (1 page)

T. Primary Differences between MSFC & DAC S-IVB-D Description (7 pgs)

U. Interstage Venting Criteria (5 pages)

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V. R-AERO-AD-64-81 dated August 17, 1964, "Design Criteria: Allowable Leakages in the S-IB/S-IVB Interstage Region of the Saturn IB Vehicle" (3 pages)

W. Allowable Structural Leakage area for S-IVB/V Aft Skirt and Aft Interstage (3 pages)

X. Operation of the Flow Rate and Turbopump Speed Signal Conditioning System (5 pages)

Y. S-IVB Stage Suction Duct Support, SK10-1749 (6 pages)

Z. Mechanical Interface Control Program Objectives (10 pages)

AA. Interface Control (notes from Pre-Meeting) (2 pages)

BB. Prime Technical Problems for each GSE Item not on schedule (2 pages)

CC. Errata sheets for Appendix A (4 sheets)

SIXTH VEHICLE
MECHANICAL DESIGN
INTEGRATION WORKING
GROUP MEETING

8-26-64

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APPENDIX A

Enc. 5

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LIST OF TABLES

1.0 INTRODUCTION

This report contains the information prepared and compiled in preparation for the Sixth Vehicle Mechanical Design Integration Working Group meeting for the S-IVB Stage (Saturn IB/V) held at Douglas Aircraft Co., Inc., Huntington Beach, August 26-27, 1964. Data was not available in time for inclusion in this document for those agenda items not mentioned herein. Informal data on these items will be distributed during the meeting.

2.0 DELINQUENT ACTION ITEMS

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE

Item No.	Action Agency	Description of Action	Due	Status
		SEVENTH ELECTRICAL SYSTEM DESIGN INTEGRATION WORKING GROUP MEETING (SATURN IB/V), 7/10/63		
1393	DAC	Propellant Draining - DAC will establish gas requirements for propellant draining at AMR and forward to M-P&VE-EF by September 3, 1963. (M-P&VE-EF-689 No. 2)	9/3/63	Closed by TCB 146. Gas requirements same at SACTO and KSC
		VH-403 INTERFACE SUB-WORKING GROUP MEETING, 9/6/63		
1404	DAC	DAC and S&ID will study facility capability to provide water to J-2 extension with capability to gimbal complete by September 20. (R-P&VE-VH-403 No. 2)	9/20/63	Closed by scope change 1171
1427	DAC	Effects of Fill Propellant Quality - Analyze effects of fill-propellant quality on the pre-pressurization cycle and propellant utilization (P. U.) probes for pressurized and unpressurized ullage and forward analysis to MSFC by December 15, 1963. (R-P&VE-VOR-63-9 No. 8)		Will be ans'd by CR to TD 232 approx 9/15/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		VJ-384-63 PROPULSION SYSTEM DESIGN STATUS REVIEW SPLINTER MEETING, 11/12/63		
		AUXILIARY PROPULSION SYSTEM (APS)		
2104	DAC	Incorporate a requirement into the positive expulsion bellows specification control drawings for functional testing of the bellows after exposure to the propellants and subsequent storage for applicable periods of time. The revised specification control drawings and test plan shall be submitted to MSFC for approval (Saturn IB/V). (R-P&VE-VJ-384-63 No. 4)	12/16/63	Closing action per 1A67911 spec. control dwg and 1T00238 test requirements dwg now rec to DAC system
2108	DAC R-P&VE-PT	Prepare a feasibility study to investigate rotating APS modules 90° above the stage centerline to satisfy equal, or nearly equal, sun-time during orbit (Saturn V). (R-P&VE-VJ-384-63 No. 8)	1/2/64	MSFC DATAFAX 7/11/64 indicated closing action
		PROPELLANT MANAGEMENT SYSTEM		
2110	DAC	Submit the following information on capacitance discrete level sensors to MSFC (R-P&VE-PMS) for evaluation and consideration for approval (Saturn IB/V):	1/2/64	Open. DAC will submit by 8/28/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		a. Technical reasons and requirements for selection of capacitance point level sensor over others (Minneapolis-Honeywell, Bendix Optical, Acoustica, etc. - to include a summary of the DAC evaluation rating by points).		
		b. Comparison of S-IVB sensor and control unit with S-IV sensor and control unit (feedback control shielding, automatic checkout, connectors, and reason for same setting point for LOX and LH_2 automatic checkout).		
		c. Detailed design evaluation test program and job work orders (JWO's).		
		d. Reason for difference configuration of LOX and LH_2 emergency overfill sensors and drawings of each.		
		e. Exact capacitance values for wet and dry conditions, tolerance bands and explanation of dead band zone.		
		f. The effect of capacitance changes on the discrete level sensor system caused by connectors, feed-throughs, splices, etc., for bench adjustment prior to installation in the stage.		

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		g. Reasons why the sensors cannot be adjusted on bench without readjustment on vehicle. h. Detailed procedures for adjusting, locking and handling of sensor and control unit (include sketches). NOTE: If in-tank adjustment is required it shall shall be accomplished without the use of propellants. i. Applicable drawings of sensors, cables, feed throughs, connectors, control units, checkout, etc. (R-P&VE-VJ-384-63 No. 10)		
2111	DAC	Submit fast-fill emergency cutoff sensors layout to MSFC (R-P&VE-PMS) for evaluation and consideration for approval to include the type and location of sensors and other pertinent information. The LH_2 fast-fill emergency cutoff shall be located on the continuous probe. The LOX fast-fill emergency cutoff may be located on the instrumentation probe if installation on the continuous probe is not possible (reference TD-168, Dated 9/5/63) (Saturn IB/V) (R-P&VE-VJ-384-63 No. 11)	1/2/64	Open. DAC will submit by 8/28/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		RECIRCULATION CHILLDOWN SYSTEM (SC-1027A)		
2120	DAC	Provide hardware and S-IVB stage capability to retrofit the battleship vehicle with uprated LOX and LH_2 recirculation pumps to simulate the design flight recirculation flowrates utilizing ground power for the pumps (Saturn IB/V). (R-P&VE-VJ-384-63 No. 20)		Closed - Incorporated into Scope Change 1027B.
2125	DAC	Evaluate impact on S-IVB stage design of using S-IVB insulation design thermal conductivity as obtained from the S-IV stage, and described by the curve as a straight line between: Insulation "Nodal" Temperature — "k" 95° R — 0.03 365° R — 0.06	1/2/64	Closed by submittal of information required as enclosure to CR TD-243 Rev 2, 7/7/64
2127	DAC	Provide effectivity of application of insulation improvement efforts to S-IVB non-flight and flight stages (Saturn IB/V). (R-P&VE-VJ-381-63 No. 27)	12/16/63	Closed by 2nd revision to CR TD-243 indicating effectivity for A/S and flight stages, 7/7/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		PROPELLANT TANK PRESSURIZATION AND VENT RELIEF		
2134	DAC	Investigate and report on whether screens should be wrapped around the hydrogen pressurant diffuser to keep LH_2 out of the line during orbital coast (Saturn V). (R-P&VE-VJ-384-63 No. 34)	1/2/64	Closed by CRTD-243, Rev 2
2135	DAC	Conduct a study to provide possible solutions to the potential problem of LH_2 entering the zero "g" separator during coast and possibly filling the vent line to the vent valve (Saturn V). (R-P&VE-VJ-384-63 No. 35)	1/2/64	Closed by CRTD-243, Rev 2
2136	DAC	Determine methods to prevent LOX from entering the tank vent line (Saturn V) to include: a. Screening the He diffuser. b. Other methods (R-P&VE-VJ-384-63 No. 36)	1/2/64	Closed by CRTD-243, Rev 2

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
2137	DAC	Calculate loads on the diffuser from forcing LOX out vent line during repressurization if a positive means of preventing this (see item 36) is not found or the means provided is assumed unsuccessful (Saturn V). (R-P&VE-VJ-384-63 No. 37)	1/2/64	Closed by CRTD-243 Rev 2
2140	DAC	For the LH_2 and LOX antivortex screens (Saturn IB/V):		Closed by CRTD-243 Rev 2
		a. Investigate means of eliminating possible bubble entrapment during orbital low "g" operation.	1/15/64	
		b. Submit a detailed test program to prove the adequance of the present design. (R-P&VE-VJ-384-63 No. 40)	2/15/64	
2141	DAC	Submit an analysis to MSFC concerning analyses and test of bubble hold up, entrainment of liquid in vented vapor during venting (Saturn V). (R-P&VE-VJ-384-63 No. 41)	2/3/64	Closed by CRTD-243 Rev 2
2144	DAC	Forward to R-P&VE-PT the analysis, made by DAC, justifying the conclusion that a heat exchanger vent is excessive in weight (Saturn IB/V). (R-P&VE-VJ-384-63 No. 44)	12/2/63	Open. Will furnish data requested by 9/15/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		MISCELLANEOUS		
2149	DAC	Prepare a test and flare development program to use MC fittings as specified in M-P&VE-PI-350-63. Incorporation of MC fittings into S-IVB stage will be on a no schedule impact basis (Saturn IB/V) (R-P&VE-VJ-384-63 No. 49)	1/15/64	Closing action per Scope Changes 1151 and 1176 to MSFC 8/3/64 and 7/17/64
2150	DAC	Review contract requirements for MSFC approval of first and lower tier documents referred to in component specifications and drawings but not listed in DAC Report SM-41411; DAC to submit these documents in accordance with contract requirements (Saturn IB/V). (R-P&VE-VJ-384-63 No. 50)		Closing action per Scope Change 1053A approx 9/15/64
		VJ-64-25 VMDIWG MEETING, 1/14/64		
		<u>Systems Integration Splinter Meeting</u>		
4018	DAC	DAC will comply with the MSFC Design Data Saturn V Launch Vehicle Book in designing the S-IVB helium bottles to a burst pressurization factor of safety of 2.0.	Immed.	Closed. DAC Specification DS-2163 (safety factor 2.5) in effect. MSFC concurrence rec'd (Per DAC SM-46542)

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		<u>Working Group Meeting, 1/15-16/64</u> <u>Battleship Tank Pressure</u>		
4030	DAC	DAC will provide a revision to the Battleship components list (attachment to DAC letter, A2-K310-4.18.9-L-630) to identify those components which are <u>not</u> flight type items. Due date February 3, 1964	2/3/64	Closing action per agenda item G.D. Sixth meeting of VMDIWG 8/26-27/64
		<u>Impact of H-1 Uprated Thrust</u>		
4033	DAC	DAC shall evaluate the impact of incorporating revised Saturn IB loads as described by MSFC Memorandum R-P& VE-SL-212-63-1, "Preliminary Structural Loads for Saturn IB Vehicle with Uprated H-1 Engines," dated November 20, 1963 (reference Change Order 146). The specific items to be evaluated are: a. Structural Weight Variations b. Structural Design Documentation c. Schedule Changes Due date February 26, 1964	2/26/64	Open. DAC will submit in letter by 9/15/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP, S-IB/S-IVB STRUCTURAL INTERFACE SPLINTER MEETING, 4/20/64		
4048	DAC	Supply magnitude of the kick loads, tensile, and compressive load on each shear pin at 64.6 sec. (max. fin loads), q max, and cut-off.	4/24/64	Open. Will furnish information requested by 9/15/64
		VJ-64-278 AUXILIARY PROPULSION SYSTEM 150 POUNDS THRUST ENGINE REVIEW SPLINTER MEETING, 5/6/64		
4054	DAC	DAC shall submit the following data to MSFC: a. Engine and components acceptance test procedures. b. Design evaluation and preliminary flight rating test procedures. c. TRW 150 pounds thrust engine model specifications. d. Detail drawings of Model 5 engine sub-assemblies to include valves, thrust chamber, etc.	ASAP	Open. A3 850-K031-12.8.8-L-556 dated 7/14/64 provides status and closure date expected for items 4054, 4055, and 4056

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
		e. Detailed test results of tests conducted on both engine and engine components by TRW and vendors to include typical curves of relaxed electrical impulse versus time, valve current versus time, engine thrust level versus time, etc.		
4055	DAC	DAC will conduct a TRW engine review for MSFC during August, 1964.	8/64	Open.
4056	DAC	DAC will officially notify MSFC at least two weeks in advance of any DAC or TRW formal engine design review.		Open.
		VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP, S-IVB STAGE AUXILIARY PROPULSION SYSTEM CONCEPT REVIEW (SATURN V), 6/16/64		
4065	DAC	Define the APS propellant loading procedures, tank volume, and mission requirements used in the Saturn V design. Due date: July 20, 1964	7/20/64	Closing action for items 4065 through 4070 will be furnished in DAC A3-850-K031-12.8.8-L-556 by 9/15/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
4066	DAC	Provide a summary of the payload improvements with APS/continuous venting redesign. Due date: August 20, 1964.	8/20/64	Closing action for items 4065 through 4070 will be furnished in DAC A3-850-K031-12.8.8-L-556 by 9/15/64
4067	DAC/MSFC (I-O)	Expedite transmittal of bellows/bladder concept to NASA headquarters. Due date: July 1, 1964.	7/1/64	Closing action for items 4065 through 4070 will be furnished in DAC A3-850-K031-12.8.8-L-556 by 9/15/64
4068	DAC	Supply to MSFC (R-P&VE-PAS) firm Gemini 70 lbs. thrust engine delivery requirements, designating the configuration and use. Due date: July 1, 1964	7/1/64	Closing action for items 4065 through 4070 will be furnished in DAC A3-850-K031-12.8.8-L-556 by 9/15/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
4069	DAC	Define the LH_2 liquid/gas separator operating characteristics as required by stage modifications relating to the LH_2 continuous vent system. Due date: July 20, 1964.	7/20/64	From droplet trajectory calculations and turbine load-speed characteristics, analytical estimates of separator performance can be made. Separation efficiencies of approximately 90% are expected for inlet liquid qualities up to approximately 75%, at inlet liquid droplet sizes of 0.1 inch. At higher inlet liquid qualities, the efficiency is expected to be reduced. Above inlet liquid qualities of 90% the turbine-separator speed becomes so low

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
				that little separation may be expected. Low separation efficiencies at high inlet qualities are the result of the power limit imposed by the 2 psi pressure drop requirement. High separator speeds cannot be maintained with good separation efficiency at high inlet qualities.
4070	DAC	Review the pressure switch and vent band requirements to determine the minimum acceptable band in an effort to reduce the current 3 psi spread. Due date: July 2, 1964.	7/2/64	Closing action for items 4065 through 4070 will be furnished in DAC A3-850-K031-12.8.8-L-556 by 9/15/64

DAC ACTION ITEM STATUS REPORT - S-IVB STAGE (Continued)

Item No.	Action Agency	Description of Action	Due	Status
4072	DAC/MSFC (R-P&VE-PAS)	Review the DAC proposed method of mounting the continuous vent system lines. DAC will provide drawings to the S-IVB Project Office (R-R&VE-DIR(J)) not later than July 17, 1964. MSFC review is to be completed in three weeks after receipt of the drawings.		Closed. Drawings transmitted to MSFC by DAC letter A3-850-K031-1.17.8-L-681 dated 8/19/64

H_2 EQUIVALENT SEPARATOR PERFORMANCE FROM NON-CRYOGENIC DATA

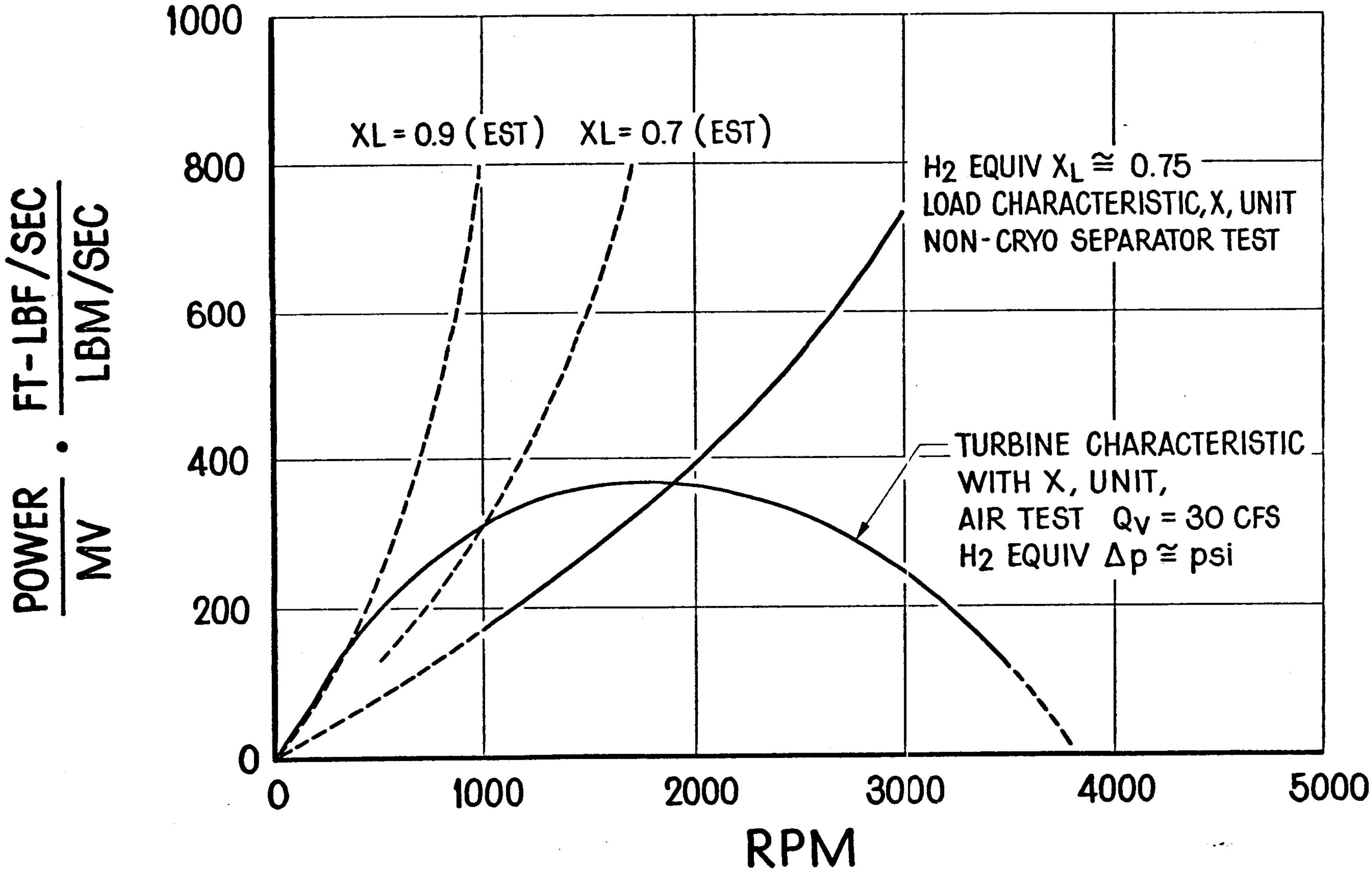


FIGURE 1

SEPARATOR SPEED VS LIQUID DROPLET DIAMETER

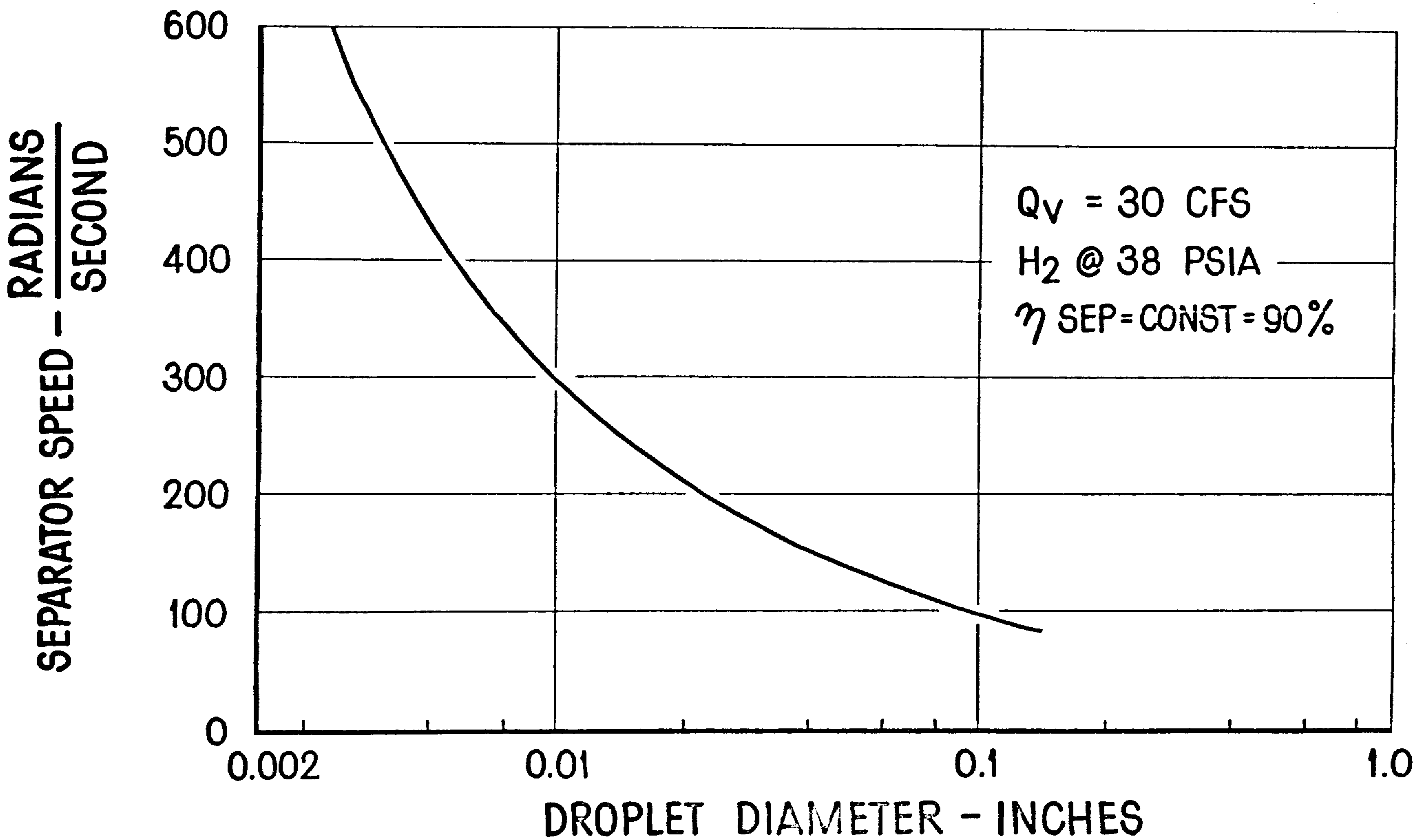


FIGURE 2

SEPARATOR PERFORMANCE PREDICTION

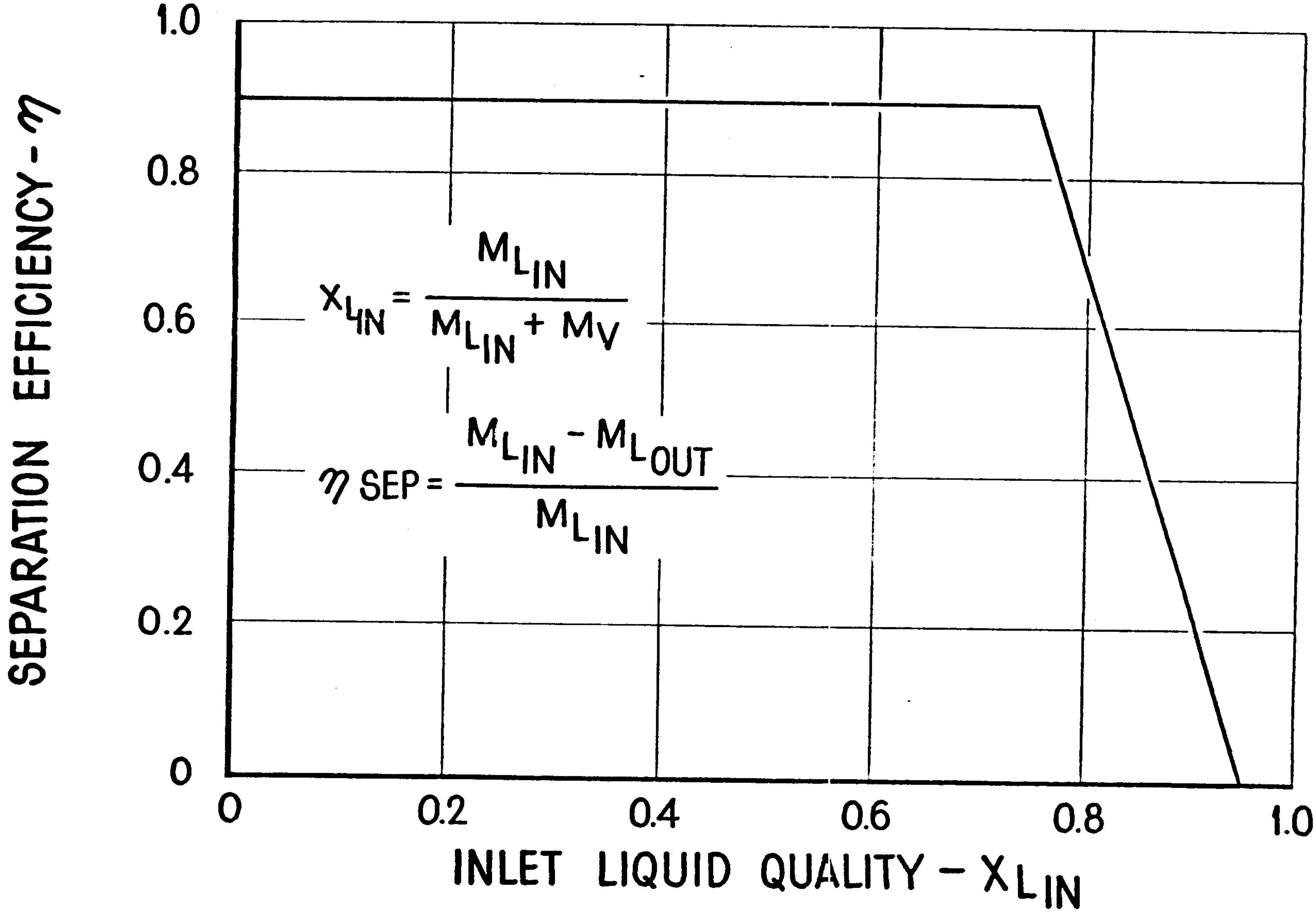


FIGURE 3

MSFC ACTION ITEM STATUS REPORT

Item No.	Action Agency	Description of Action	Due	Status
		VJ-54-63 VMDIWG MEETING NO. 3, 2/26/63		
1363	I-E-J	J-2 Engine Side Loads and Engine Loads - MSFC is to direct Rocketdyne to provide MSFC/DAC with a dimensional J-2 engine envelope to include the vertical Customer Connect Panel with electrical and fluid lines. (M-P&VE-VJ-54-63 No. 3-26).	~~4/4/63~~ 9/15/64	Open. Awaiting reply from RKDN. (per R-P&VE-VJ-64-18, 1/13/64)
		VJ-68 (1962) VMDWIG MEETING NO. 2, 12/4/62		
1371	R-P&VE-P	Propellant Definitions - M-P&VE-P will review the propellant definitions stated in Item 2-15 and submit final definition to M-SAT-WM. (M-P&VE-VJ-68 No. 2-17)	~~3/3/63~~ NEW DATE 9/15/64	Open. Awaiting R-AERO input prior to publication.
1372	R-P&VE-VK	LEM Environmental Conditions - MSFC to request from MSC information concerning the environmental conditions existing in the Lunar Excursion Module (LEM) aft interstage and the forward skirt section of the S-IVB stage. These conditions should include thermal conditions, vibrations, etc. (M-P&VE-VJ-68 No. 2-28)	~~11/30/63~~ NEW DATE 9/7/64	Open. Awaiting reply from MSC. (Per VJ 64-18, 1/13/64)
		VJ-129-63 VMDIWG MEETING NO. 4, 5/15/63		
1385	R-P&VE-VS R-P&VE-VA R-P&VE-VH R-P&VE-VJ	Bulkhead Protection Criteria for Saturn V - MSFC will specify S-IVB and S-II forward bulkhead protection criteria for use during service and inspection of the interstage areas after vertical assembly. (M-P&VE-VJ-129-63 No. 4-21)		Closed. Superseded by A/I 1474 from November 6, 1963, Human Engineering Splinter Meeting. Proposed Boeing specs. being reviewed by MSFC.
		EF-689 S-IVB STAGE FLUIDS REQUIREMENTS SPLINTER MEETING (SATURN IB/V, 8/21/63)		
1393	DAC	Propellant Draining - DAC will establish gas requirements for propellant draining at AMR and forward to M-P&VE-EF by September 3, 1963. (M-P&VE-EF-689 No. 2)	9/3/63	Open. Awaiting DAC's final studies. Need AMR requirement

ACTION ITEM STATUS REPORT

Item No.	Action Agency	Description of Action	Due	Status
		EF 701 VMDIWG MEETING, 8/28/63		
1402	R-P&VE-PP	J-2 Engine Components - Define the Saturn V, S-IVB stage J-2 engine temperature-sensitive components and component temperature limits by October 15, 1963. (M-P&VE-EF-701 No. 3)	10/15/63	Open. Studies continuing to determine need for -200° F component qualification. THIS ACTION ITEM WILL BE COMBINED WITH ACTION ITEM NO. 2132
		VH-403 INTERFACE SUB-WORKING GROUP MEETING, 9/6/63		
1404	DAC	DAC and S&ID will study facility capability to provide water to J-2 extension with capability to gimbal complete by September 20. (R-P&VE-VH-403 No. 2)	9/20/63	Open. Duplicates A/I-1193, S-II Stage.
1405	DAC	DAC and S&ID will provide GSE capable of pressurizing J-2 start bottle to 1500 psig nominal operating pressure. (R-P&VE-VH-403 No. 5)		Open. S-IVB closed by compliance with Contractual Direction provided in Change Order No. 127.
		VOR-63-9 S-IVB STAGE PROPELLANT LOADING SPLINTER MEETING (SATURN IB/V), 10/31/63		
1427	DAC	Effects of Fill Propellant Quality - Analyze effects of fill-propellant quality on the pre-pressurization cycle and propellant utilization (P. U.) probes for pressurized and un-pressurized ullage and forward analysis to MSFC (R-P&VE-PT) by December 15, 1963. (R-P&VE-VOR-63-9 No. 8)		Open. DAC compliance directed by I-V-S-IVB-TD-232, dated 11/12/63. DAC to answer by ~~5/15/64. (Per DAC-SM-46542, April)~~. 15 JULY 1964. (PER DAC SM-46542 JUNE)
		WDC-S-IVB-2-63 VJ-443-63) THIRD S-IVB STAGE VEHICLE DYNAMICS & CONTROL WORKING GROUP MEETING, 11/20/63		
1435	R-P&VE-VJ R-P&VE-P DAC	Determination of Maximum Non-venting Time - DAC will determine and R-P&VE-VJ/P will confirm the maximum time after translunar injection that venting of the Saturn V S-IVB stage tanks can be prevented. (Memo No. WDC-S-IVB-2-63, No. 8)	Prelm. Ans. 12/2/63	Open. DAC WILL ESTABLISH NEW DATE AT THE SIXTH VMDIWG FOR THE S-IVB STAGE ON 8/26/64

ACTION ITEM STATUS REPORT

Item No.	Action Agency	Description of Action	Due	Status
		FJ-129-63 VMDIWG MEETING NO. 4, 5/15/63		
1436	R-P&VE-PT R-P&VE-M R-P&VE-VM	MSFC will provide DAC with the exact proportion and specifications of all constituents of the cold plate system coolant. (M-P&VE-VJ-120-63 No. 4-10)		Open. DUE DATE TO BE ESTABLISHED.
		AUXILIARY PROPULSION SYSTEM (APS)		
2104	DAC	Incorporate a requirement into the positive expulsion bellows specification control drawings for functional testing of the bellows after exposure to the propellants and subsequent storage for applicable periods of time. The revised specification control drawings and test plan shall be submitted to MSFC for approval (Saturn IB/V). (R-P&VE-VJ-384-63 No. 4)	12/16/63	Open. Pending receipt of Spec Control drawings and test plan. (Per C. Haggard 7/6/64)
2108	DAC R-P&VE-PT	Prepare a feasibility study to investigate rotating APS modules 90° above the stage centerline to satisfy equal, or nearly equal, sun-time during orbit (Saturn V). (R-P&VE-VJ-384-63 No. 8)	1/2/64	Closed by memorandum R-P&VE-PTP-64-127.
2109	R-SAT-WDC	Establish the justification for orientation of the S-IVB and payload perpendicular to an earth radius during orbital coast. The payload penalty caused by LH_2 boil-off for the current orientation may be as high as several hundred pounds (Saturn V).	12/16/63	Closed by memorandum R-ASTR-TJ-63-64/V, dated 4/1/64. Indicates selection of continuous venting mode closes action item.
		PROPELLANT MANAGEMENT SYSTEM		
2110	DAC	Submit the following information on capacitance discrete level sensors to MSFC (R-P&VE-PMS) for evaluation and consideration for approval (Saturn IB/V): a. Technical reasons and requirements for selection of capacitance point level sensor over others (Minneapolis-Honeywell, Bendix Optical, Acoustica, etc. - to include a summary of the DAC evaluation rating by points).	1/2/64	Open. ~~DAC expected to respond May 1, 1964. (Per DAC SM-46542, April)~~ DAC EXPECTED TO RESPOND BY JULY 24, 1964. (PER DAC SM-46542 JUNE)

ACTION ITEM STATUS REPORT

S-IVB Stage Sheet 4

Item No.	Action Agency	Description of Action	Due	Status
		b. Comparison of S-IVB sensor and control unit with S-IV sensor and control unit (feedback control shielding, automatic checkout, connectors, and reason for same setting point for LOX and LH_2 automatic checkout). c. Detailed design evaluation test program and job work orders (JWO's) d. Reason for difference configuration of LOX and LH_2 emergency overfill sensors and drawings of each. e. Exact capacitance values for wet and dry conditions, tolerance bands and explanation of dead band zone. f. The effect of capacitance changes on the discrete level sensor system caused by connectors, feed-throughs, splices, etc., for bench adjustment prior to installation in the stage. g. Reasons why the sensors cannot be adjusted on bench without readjustment on vehicle. h. Detailed procedures for adjusting, locking and handling of sensor and control unit (include sketches). NOTE: If in-tank adjustment is required it shall be accomplished without the use of propellants. i. Applicable drawings of sensors, cables, feed throughs, connectors, control units, checkout, etc. (R-P&VE-VJ-384-63 No. 10)		

Item No.	Action Agency	Description of Action	Due	Status
2111	DAC	Submit fast-fill emergency cutoff sensors layout to MSFC (R-P&VE-PMS) for evaluation and consideration for approval to include the type and location of sensors and other pertinent information. The LH_2 fast-fill emergency cutoff shall be located on the continuous probe. The LOX fast-fill emergency cutoff may be located on the instrumentation probe if installation on the continuous probe is not possible (reference TD-168, Dated 9/5/63) (Saturn IB/V) (R-P&VE-VJ-384-63 No. 11)	1/2/64	Open. ~~DAC will submit by 5/1/64 (Per DAC SM-46542, April)~~ DAC WILL SUBMIT BY 7/24/64 (PER DAC SM-46542 JUNE)
		RECIRCULATION CHILLDOWN SYSTEM (SC-1027A)		
2120	DAC	Provide hardware and S-IVB stage capability to retrofit the battleship vehicle with uprated LOX and LH_2 recirculation pumps to simulate the design flight recirculation flowrates utilizing ground power for the pumps (Saturn IB/V). (R-P&VE-VJ-384-63 No. 20)		Open. To be incorporated into Scope Change 1027B. (Refer to Memo R-P&VE-PP-223-63.)
2123	R-SAT-WDC	Conduct a Saturn V trajectory dispersion analysis to provide a maximum and minimum heating trajectory. (R-P&VE-VJ-384-63 No. 23)	~~12/1/63~~ NEW DATE 9/1/64	Open.
2125	DAC	Evaluate impact on S-IVB stage design of using S-IVB insulation design thermal conductivity as obtained from the S-IV stage, and described by the curve as a stright line between: Insulation "Nodal" Temperature — "k" $95^\circ R$ — 0.03 $365^\circ R$ — 0.06	1/2/64	Closed by submittal of information required as enclosure to CRTD-243 (second revision).
2126	R-P&VE-PT	Provide DAC with the detailed evaluation of insulation thermal conductivity and test data obtained from MSFC S-IV stratification test program (Saturn IB/V). (R-P&VE-VJ-384-63 No. 26)	12/16/63	Open. INFORMATION FROM R-P&VE-PT IS AVAILABLE TO CLOSE THIS ITEM.
2127	DAC	Provide effectivity of application of insulation improvement efforts to S-IVB non-flight and flight stages (Saturn IB/V). (R-P&VE-VJ-381-63 No. 27)	12/16/63	Closed, by receipt of second revision to CRTD-243, indicating effectivities for all systems and flight stages.

Item No.	Action Agency	Description of Action	Due	Status
		FORWARD AND AFT INTERSTAGE ENVIRONMENTAL CONDITIONING SYSTEM		
2132	R-P&VE-PT	Determine if the aft interstage prelaunch environment is compatible with the J-2 engine electronic components (Saturn IB/V). (R-P&VE-VJ-384-63 No. 32).	1/15/64	Open. Study in progress. MSFC WILL TRANSMIT INFORMATION TO ROCKETDYNE BY 10/17/64 FOR COMBINING INTO A/I 1402.
		PROPELLANT TANK PRESSURIZATION AND VENT AND RELIEF		
2134	DAC	Investigate and report on whether screens should be wrapped around the hydrogen pressurant diffuser to keep LH_2 out of line during orbital coast (Saturn V). (R-P&VE-VJ-384-63 No. 34)	1/2/64	Closed by CRTD-243 revision II, indicating need for the screens is cancelled by use of continuous venting.
2135	DAC	Conduct a study to provide possible solutions to the potential problem of LH_2 entering the zero "g" separator during coast and possibly filling the vent line to the vent valve (Saturn V). (R-P&VE-VJ-384-63 No. 35).	1/2/64	Closed by CRTD-243 revision II indicating need for study is cancelled by use of continuous venting.
2136	DAC	Determine methods to prevent LOX from entering the LOX tank vent line (Saturn V) to include: a. Screening the He difusser. b. Other methods. (R-P&VE-VJ-384-63 No. 36)	1/2/64	Closed by study results described in CRTD-243, revision II.
2137	DAC	Calculate loads on the diffuser from forcing LOX out vent line during repressurization if a positive means of preventing this (see item 36) is not found or the means provided is assumed unsuccessful (Saturn V). (R-P&VE-VJ-384-63 No. 37)	1/2/64	Open. ~~Reply to be combined with reply to A/I-2136.--Further analysis, if required, will be under Scope Change 1027B. (Per DAC SM-46542)~~ REFER TO DAC SM-46542, JUNE PAGE 8.

ACTION ITEM STATUS REPORT

Item No.	Action Agency	Description of Action	Due	Status
2140	DAC	For the LH_2 and LOX antivortex acreens (Saturn IB/V): a. Investigate means of eliminating possible bubble entrapment during orbital low "g" operation.	1/15/64	Open. ~~Completion of study expected by 5/1/64.~~ ~~(Per DAC SM-46542, April)~~ REFER TO DAC SM-46542, JUNE PAGE 9.
		b. Submit a detailed test program to prove the adequance of the present design. (R-P&VE-VJ-384-63 No. 40)	2/15/64	
2141	DAC	Submit an analysis to MSFC concerning analyses and test of bubble hold up, entrainment of liquid in vented vapor during venting (Saturn V). (R-P&VE-VJ-384-63 No. 41)	2/3/64	Open. Preliminary results to be available by 5/1/64. SEE ALSO DAC SM-46542, JUNE PAGE 10.
2144	DAC	Forward to R-P&VE-PT the analysis, made by DAC justifying the conclusion that a heat exchanger vent is excessive in weight (Saturn IB/V). (R-P&VE-VJ-384-63 No. 44)	12/2/63	Open. RESULTS OF ANALYSIS WERE TO BE FORWARDED TO MSFC BY 15 JULY 1964.
		MISCELLANEOUS		
2149	DAC	Prepare a test and flare development program to use MC fittings as specified in M-P&VE-PI-350-63. Incorporation of MC fittings into S-IVB stage will be on a no schedule impact basis (Saturn IB/V). (R-P&VE-VJ-384-63 No. 49)	1/15/64	Open. Scope Change 1151 and 1176.
2150	DAC	Review contract requirements for MSFC approval of first and lower tier documents referred to in component specifications and drawings but not listed in DAC Report SM-41411; DAC to submit these documents in accordance with contract requirements (Saturn IB/V). (R-P&VE-VJ-384-63 No. 50)		Open. ~~CO-102, superseded by CO-145. Final report expected 5/15/64.~~ ~~(Per DAC SM-46542, April)~~ REFER TO DAC SM-46542, JUNE. TO BE MADE PART OF SCOPE CHANGE 1053A.

ACTION ITEM STATUS REPORT

Item No.	Action Agency	Description of Action	Due	Status
		VJ-64-25 VMDIWG MEETING, 1/14/64		
		Systems Integration Splinter Meeting		
4014	R-P&VE-VSI	MSFC will provide the following interface control drawings for the interface control areas pertaining to the S-IVB stage, Saturn IB and Saturn V vehicles, shall be released in an "as is" status: Dwg. No. / Release Date: 13M20102 Aug.15, 1964; 13M20104 October, 1964; 13M20107 Released; 13M50098 Released Dwg. No. / Release Date: 13M50102 Released; 13M50106 Aug. 15, 1964; 13M50109 August, 1964		Open. Drawings released are: 13M20107 (R-P&VE-VJ-64-144) 13M50102 (R-P&VE-VJ-64-144) 13M50098 (R-P&VE-VJ-64-235) (Per Baker, R-P&VE-VSI)
4018	DAC	DAC will comply with the MSFC Design Data Saturn V Launch Vehicle Book in designing the S-IVB helium bottles to a burst pressurization factor of safety of 2.0. Effective Immediately	Immed.	Open. DAC Specification DS-2163 (safety factor 2.5) in effect. (per DAC SM-46542)
		GSE Splinter Meeting		
4025	R-P&VE-VJ I-V-S-IVB	R-P&VE-VJ and I-V-S-IVB are to coordinate with line organizations and clarify S-IVB Contract Change Orders 40, 107, 113, 114 and 127; also establish uniformity of approval requirements of documentation generated under these change orders. Due date January 31, 1964.	1/31/64	Closed. Review of these Change Orders indicates no clarification required. (MSFC approval requirements are being rescinded through contractual channels per S. Hamner, 7/2/63).
4026	R-P&VE-V	R-P&VE-V will take action to establish contractual design review requirements by sub-system, rather than establishing one set of requirements applicable to the entire vehicle support system (Saturn IB/V).	1/31/64	Open. MAY BE CANCELLED AFTER NEXT REVISION TO GROUND RULES

ACTION ITEM STATUS REPORT

S-IVB Stage Sheet 9

Item No.	Action Agency	Description of Action	Due	Status
		<u>Working Group Meeting, 1/15-16/64</u>		
		<u>Battleship Tank Pressure</u>		
4030	DAC	DAC will provide a revision to the Battleship components list (attachment ot DAC letter, A2-K310-4. 18.9-L-630) to identify those components which are not flight type items.	2/3/64	Open. DAC will list in letter A3-850-K314-6. 21.8-L-167 by about 15 JULY 1964 (per DAC Sm-46542. JUNE)
		<u>Impact of H-1 Uprated Thrust</u>		
4033	DAC	DAC shall evaluate the impact of incorporating revised Saturn IB loads as described by MSFC Memorandum R-P&VE-SL-212-63-1, "Preliminary Structural Loads for Saturn IB Vehicle with Uprated H-1 Engines." dated November 20, 1963 (reference Change Order 146). The specific items to be evaluated are: a. Structural Weight Variations b. Structural Design Documentation c. Schedule Changes	2/3/64	Open. DAC will list in letter A3-860-K411-4. 209-L-112. (Per DAC SM-46542)
		VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP, S-IB/S-IVB STRUCTURAL INTERFACE SPLINTER MEETING, 4/20/64		
4048	DAC	Supply magnitude of the kick loads, tensile, and compressive load on each shear pin at 64.6 sec. (max. fin loads), q $\propto$ max, and cut-off.	4/24/64	Open. (See Memorandum R-P&VE-SJ-64-222)
4053	R-P&VE-S	Revise R-P&VE-SSM-64-19, "Structural Loads Distribution for the S-IB Stage of the Saturn IB Vehicle with 200 KIP Engines" to incorporate the effect of the S-IVB "kick" loads.	5/22/64	Open. THE ACTIVITY OF THIS ACTION ITEM WILL BE INCLUDED IN THE INTERFACE ITEM ON THE AGENDA. A NEW DATE IS NOT PRACTICAL

ACTION ITEM STATUS REPORT

S-IVB Stage Sheet 10

Item No.	Action Agency	Description of Action	Due	Status
		VJ-64-278 AUXILIARY PROPULSION SYSTEM 150 POUNDS THRUST ENGINE REVIEW SPLINTER MEETING, 5/6/64		
4054	DAC	DAC shall submit the following data to MSFC: a. Engine and components acceptance test procedures. b. Design evaluation and preliminary flight rating test procedures. c. TRW 150 pounds thrust engine model specifications. d. Detail drawings of Model 5 engine sub-assemblies to include valves, thrust chamber, etc. e. Detailed test results of tests conducted on both engine and engine components by TRW and vendors to include typical curves of relaxed electrical impulse versus time, valve current versus time, engine thrust level versus time, etc.	ASAP	Open.
4055	DAC	DAC will conduct a TRW engine review for MSFC during August, 1964.	8/64	Open.
4056	DAC	DAC will officially notify MSFC at least two weeks in advance of any DAC or TRW formal engine design review.		Open.
4059	R-P&VE-P R-P&VE-VJ I-I/IB-S-IVB I-V-S-IVB	MSFC will review the DAC/TRW proposed 150# thrust engine delivery schedule. The schedule must be reviewed relative to Saturn impact on DAC by Contract Change Order No. 210. (DAC estimates that impact data is to be available at MSFC by June 30, 1964). Due date: July 10, 1964.	7/10/64	Open.
		VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP, S-IVB STAGE AUXILIARY PROPULSION SYSTEM CONCEPT REVIEW (SATURN V), 6/16/64		
4061	DAC	Submit Lox tank stratification analyses to R-P&VE-DIR(J). Due date: June 16, 1964.	6/16/64	Open.

ACTION ITEM STATUS REPORT

S-IVB Stage Sheet 11

Item No.	Action Agency	Description of Action	Due	Status
4062	DAC	Proceed with the S-IVB Stage common tank design (for Saturn IB/V) using design pressures of: a. 44 and 42 psia for Lox and LH_2 tanks, respectively, for all non-flight stages and flight stages through SA-202. b. 44 and 39 psia for Lox and LH_2 tanks, respectively, for SA-203 with the exception of LH_2 tank structure which is to be designed for 42 psia. c. 44 and 39 psia for Lox and LH_2 tanks, respectively, for SA-204 and subsequent and SA-501 and subsequent.	Immed. Immed.	Open.
4063	I-V-S-IVB	Provide contractual direction for Item No. 4062 (Closed by TWX I-V-S-IVB-64-60, dated July 1, 1964)		Closed by TWX I-V-S-IVB-64-60 dated July 1, 1964
4064	I-V-S-IVB	Provide contractual authorization to test Lox anti-vortex screen to reduce pressure drops. Due date: Immediately.	Immed.	CLOSED BY I-V-S-IVB-TD-64-83, DATED 23 JUNE 1964.
4065	DAC	Define the APS propellant loading procedures, tank volume, and mission requirements used in the Saturn V design. Due date: July 20, 1964.	7/20/64	Open.
4066	DAC	Provide a summary of the payload improvements with APS/continuous venting redesign. Due date: August 20, 1964.	8/20/64	Open.
4067	DAC I-V-S-IVB	Expedite transmittal of bellows/bladder concept to NASA headquarters. Due date: July 1, 1964.	7/1/64	CLOSED, WILL USE BLADDER CONCEPT. MEMO TO MR. T. SMITH
4068	DAC	Supply to MSFC (R-P&VE-PAS) firm Gemini 70 lbs. thrust engine delivery requirements, designating the configuration and use. Due date: July 1, 1964.	7/1/64	Open.
4069	DAC	Define the LH_2 liquid/gas separator operating charcteristics as required by stage modifications relating to the LH_2 continuous vent system. Due date: July 20, 1964.	7/20/64	Open.

ACTION ITEM STATUS REPORT

S-IVB Stage Sheet 12

Item No.	Action Agency	Description of Action	Due	Status
4070	DAC	Review the pressure switch and vent band requirements to determine the minimum acceptable band in an effort to reduce the current 3 psia spread. Due date: July 2, 1964.	7/2/64	Open.
4071	R-P&VE-PPF R-P&VE-VO	Review the DAC propulsion sequence of operations with continuous venting. Due date: July 8, 1964.	7/8/[illegible]	~~Open~~ CLOSED 8/21/64 MSFC REVIEW COMPLETED.
4072	DAC R-P&VE-PAS	Review the DAC proposed method of mounting the continuous vent system lines. DAC will provide drawings to the S-IVB Project Office (R-P&VE-DIR(J)) not later than July 17, 1964. MSFC review is to be completed in three weeks after receipt of the drawings.	9/2/64	Open.
4073	R-P&VE-PAS	Forward Gemini 70 lbs. thrust engine installation drawings (thru official channels) to DAC.	7/1/64	Open.
4074	DAC	Douglas Aircraft Company, Inc. (DAC) will state impact of recalibration of J-2003 and 2006 on their respective battleship test facilities and submit to Marshall Space Flight Center (MSFC). It takes one hour to reorifice the engine, and five hours to replace the fuel pump turbine stator seal. (Due date: July 20, 1964)	7/20/64	Open. This action item is identical to action item 1861 which was imposed on the S-II stage.
4075	DAC	DAC will define post test purge procedure. (Due date: August, 1964)	8/64	Open.
4076	R-P&VE-P	MSFC will determine the environment that the J-2 engine will be subjected to in the S-IVB Stage for Saturn IB and V flights, including restarts. (Continuous effort required for more than a year)		Open.
4077	R-P&VE-P	MSFC will furnish official engine redline values to DAC. (Due date: July 15, 1964)	7/15/64	Open.
4078	I-V-S-IVB	MSFC will recommend to DAC that Hydrogen Blowdown Tests be conducted on the battleship test stand to determine if DAC's propellant conditioning system is adequate to allow safe engine start. (Due date: August 3, 1964)	8/3/64	~~Open~~ CLOSED BY MEMORANDUM R-P&VE-PPF-64-M-187, DATED 20 JULY 1964.

ACTION ITEM STATUS REPORT

Item No.	Action Agency	Description of Action	Due	Status
4079	DAC	DAC will investigate the feasibility of incorporating the 1 1/2 inch diameter hydrogen bleed line simulator into their battleship recirculation test program. (due date: August 10, 1964)	8/10/64	Open.
4080	DAC	DAC will submit currently available thermal analyses of S-IVB feed systems respectively (Lox and LH_2) for the battleship, all systems, and flight vehicles. Also, define ground rules, handling procedures, and other information controlling the thermal performance of the feed systems. This information will be supplemented as added data becomes available from normal development progresses. (Due date: August 10, 1964)	8/10/64	Open.

3.0 STAGE WEIGHT STATUS

3.A NOMINAL AND CONFIGURATED STAGE AND INTERSTAGE WEIGHTS

3.A.1 NOMINAL STAGE AND INTERSTAGE

The nominal stage and interstage is the configuration chosen for weight reporting purposes. This configuration is used and defined in the S-IVB Monthly Weight and Balance Status Report. The weight status of the nominal stage is shown in Figure 4 and is derived from the body and appendices of the August 15, 1964 weight status report.

3.A.2 CONFIGURATED STAGE AND INTERSTAGE

A configurated S-IVB stage and interstage represents a singular stage assigned to a specific vehicle mission. Configurated weights for the Saturn IB/S-IVB and Saturn V/S-IVB are shown in Figure 5. As vehicle effectivities and missions become more firm, one or more configurated stage will be added to the monthly weight and balance status report.

3.A.3 WEIGHT REDUCTION REDESIGNS INCORPORATED IN CONFIGURATED WEIGHTS

Redesigns for the purpose of improving payload capability which have been incorporated into the configurated weights are shown in Figure 6.

3.B DRY STAGE WEIGHT AND BALANCE AT SACRAMENTO

3.B.1 INTEGRATION OF WEIGHT AND BALANCE OPERATIONS

Final S-IVB weight and balance will be performed using Model 345, Weight and Balance Kit, at Sacramento Test Center in the Vertical Checkout Laboratory (VCL). The sequence of operations including weight and balance is shown in Figure 7. Since this sequence leads to a vehicle configuration at the time of weighing that is basically the same as the previously planned KSC weighing, no degradation in final dry weight accuracy is expected. The weighing positions in the VCL are shown in Figure 8.

3.B.2 WEIGHT AND BALANCE MONITORING UNTIL LAUNCH

During and after the final stage weighing at Sacramento a running log will be maintained reflecting weight changes after final weighing. The weight log book will be prepared at Sacramento and shipped to KSC where it will be maintained by a Weight Control representative. The weight log will be in accordance with MSFC Form 998.

3.C CRYOGENIC WEIGH SYSTEM

3.C.1 CURRENT HARDWARE PROCUREMENT STATUS

The cryogenic calibration weigh system consists of seven major end items (Models 500, 569, 570, 571, 572, 573, and 574). Detailed drawings of the overall system are approximately 80 to 85 percent complete (Figure 9). Under present schedules, all drawings are expected to be completed within two months. One Work Release Order (WRO) has been approved under Model 500 for the procurement of the working dead weights. WRO's are pending for the following items:

a. Environmental Enclosure

b. Environmental Enclosure Support Structure

c. Environmental Control and Vertical Sensor Transducers and Cables

d. Lift Sling and Truss Assembly

Negotiations are in progress with Orbitan Company, Inc., Lakeside, California, for the design engineering of Model 574, Measuring and Recording Unit.

3.C.2 SCHEDULE IMPACT

The first cryogenic weigh system usage will require three complete calibrations of each propellant tank for system evaluation and repeatability determination. The first usage will require approximately one to two weeks for complete calibration. Subsequent calibrations will require one separate calibration of each tank. Since the stage and GSE preparations are similar for either the cryogenic calibration cold flows or for the Static Acceptance Firing and as the weigh system preparations may be made in parallel, the schedule impact due to the cryogenic calibration cold flows is minimal. Experience from the S-IV stage (SA-9) indicates that the complete calibration cold flows may be accomplished within a twenty-four hour period. The fill and drain cycle for the S-IV-9 LO_2 tank calibration was accomplished in approximately three hours. Due to the increased capabilities of the Beta Complex over the Alpha Complex, the LO_2 and LH_2 tank calibration may be accomplished on the same day rather than on different days as for the S-IV stage. Figure 10 represents the cryogenic calibration effort for a typical stage at Sacramento on a two shift, 40 hour week.

3.C.3 PAYLOAD PENALTY DUE TO PROPELLANT LOADED ERROR

The effect of S-IVB stage propellant loaded error on payload is shown in Figure 11. The curves are based on the worst case combination of LO_2 and LH_2 loading errors (i.e., opposite signs on LO_2 and LH_2 loading errors). Based on these curves, the loading accuracy tolerance of ±0.5 percent of nominal propellant load (Change Order 263) results in a payload penalty of 10 pounds for Saturn V and 25 pounds for Saturn IB at an engine mixture ratio of 5:1. For Saturn IB with stepped engine mixture ratio, the payload penalty is 70 pounds.

3.C.4 ALTERNATE METHODS OF PU SYSTEM CALIBRATION

A review of the immersed probe PU calibration method and the engine flow mass method as possible alternates or backup for the cryogenic PU calibration has been made. Neither the immersed probe method using water calibration techniques nor the engine flow mass method provide the required accuracy of ±0.5 percent. However, for missions which are not payload critical, these methods provide a possible alternate. Of the two, the engine flow mass calibration appears the most attractive since it has no schedule impact and no additional hardware requirements. The data obtained from the cryogenic weigh system will be used to develop the J-2 engine flow mass analysis to its greatest accuracy potential.

NOMINAL SATURN S-IVB WEIGHT STATUS

BASED ON SM 46720, MONTHLY WEIGHT & BALANCE STATUS REPORT, DTD AUG 15, 1964

	S-IVB/V	S-IVB/IB
DRY STAGE		
• REVISED SPECIFICATION WEIGHT	26,164	23,958
• CURRENT WEIGHT	27,300	24,037
• OVER/UNDER WEIGHT	+1,136	+79
STAGE AT SEPARATION (EQUIVALENT TO BURNOUT WEIGHT)		
• REVISED SPECIFICATION WEIGHT	30,233	26,398
• CURRENT WEIGHT	30,774	26,392
• OVER/UNDER WEIGHT	+541	-6
INTERSTAGE AT GROUND IGNITION		
• REVISED SPECIFICATION WEIGHT	8,055	6,826
• CURRENT WEIGHT	7,419	6,647
• OVER/UNDER WEIGHT	-586	-179

FIGURE 4

CONFIGURATED WEIGHTS

DESCRIPTION	S-IVB/V 501 THRU 503	S-IVB/V 504 & SUBS	S-IVB/IB 201	S-IVB/IB 202	S-IVB/IB 203	S-IVB/IB 204	S-IVB/IB 205 206
DRY WEIGHT AS REPORTED (NOMINAL)	27,300	27,300	24,037	24,037	24,037	24,037	24,037
EFFECTIVITY DIFFERENCES	- 897	- 897	- 205	- 20	- 195	-370	-370
PROPOSED AND PENDING CHANGES	- 89	-1,089					-1,089
CONFIGURATED DRY WEIGHT	26,314	25,314	23,832	24,017	23,842	23,667	22,588
DRY TO SEPARATION WEIGHT AS REPORTED	3,474	3,474	2,355	2,355	2,355	2,355	2,355
EFFECTIVITY DIFFERENCES	- 271	- 271	+154	+154	+154	+131	+131
PROPOSED AND PENDING CHANGES	- 200	- 200	-200	-200	- 200	- 200	-200
CONFIGURATED DRY TO SEPARATION WEIGHT	3,003	3,003	2,309	2,309	2,309	2,286	2,286
CONFIGURATED SEPARATION WEIGHT TOTAL	29,317	28,317	26,141	26,326	26,151	25,953	24,874

FIGURE 5

ESTIMATED WEIGHT REDUCT & PERF IMPROV INCLUDED IN CONFIGURATED WEIGHT STATUS

(EFFECTIVITIES NOT FIRM)

	EST. PAYLOAD GAIN		NOMINAL	201	202	203	204	205	501	504
	S-IVB/V	S-IVB/IB								
REDUCE MANUFACTURING TOLERANCES	89	89						X	X	X
REDUCE INTERNAL INSULATION	517	517	X	X	X	X	X	X	X	X
REMOVE LEAK DETECTION COMPONENTS PRIOR TO FLIGHT	190	165				X	X	X	X	X
OPERATIONAL TELEMETRY	1,000	1,000						X		X
LOWER DEPLETION SENSORS	200	200		X	X	X	X	X	X	X
REDUCE LH_2 TANK PRESSURE	TBD	198					X	X	X	X
CONTINUOUS VENTING	1,688+	N/A							X	X

FIGURE 6

SACTO OPS INCLUDING DRY STAGE WEIGHT & BALANCE

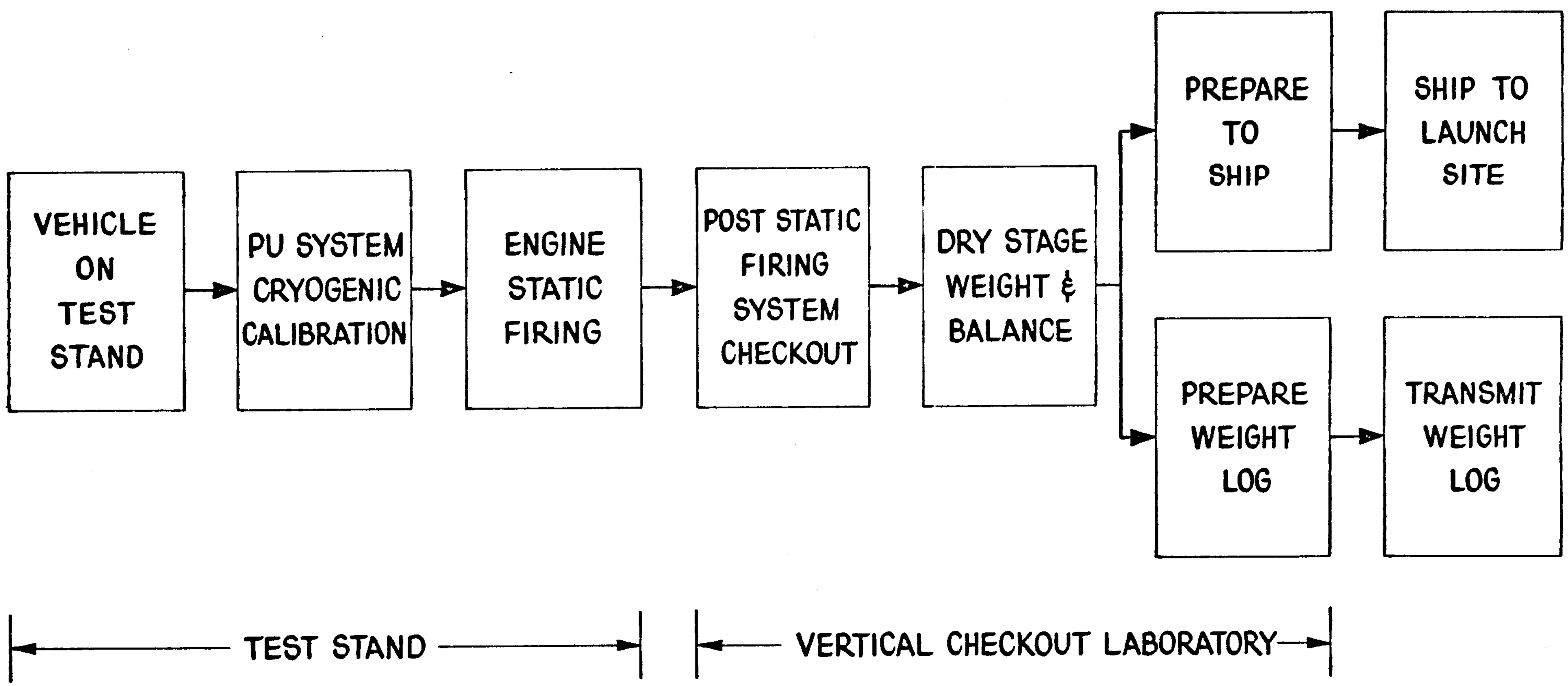


FIGURE 7

S-IVB WEIGHT & BALANCE

SACTO VERTICAL CHECKOUT LAB GROUND FLOOR PLAN

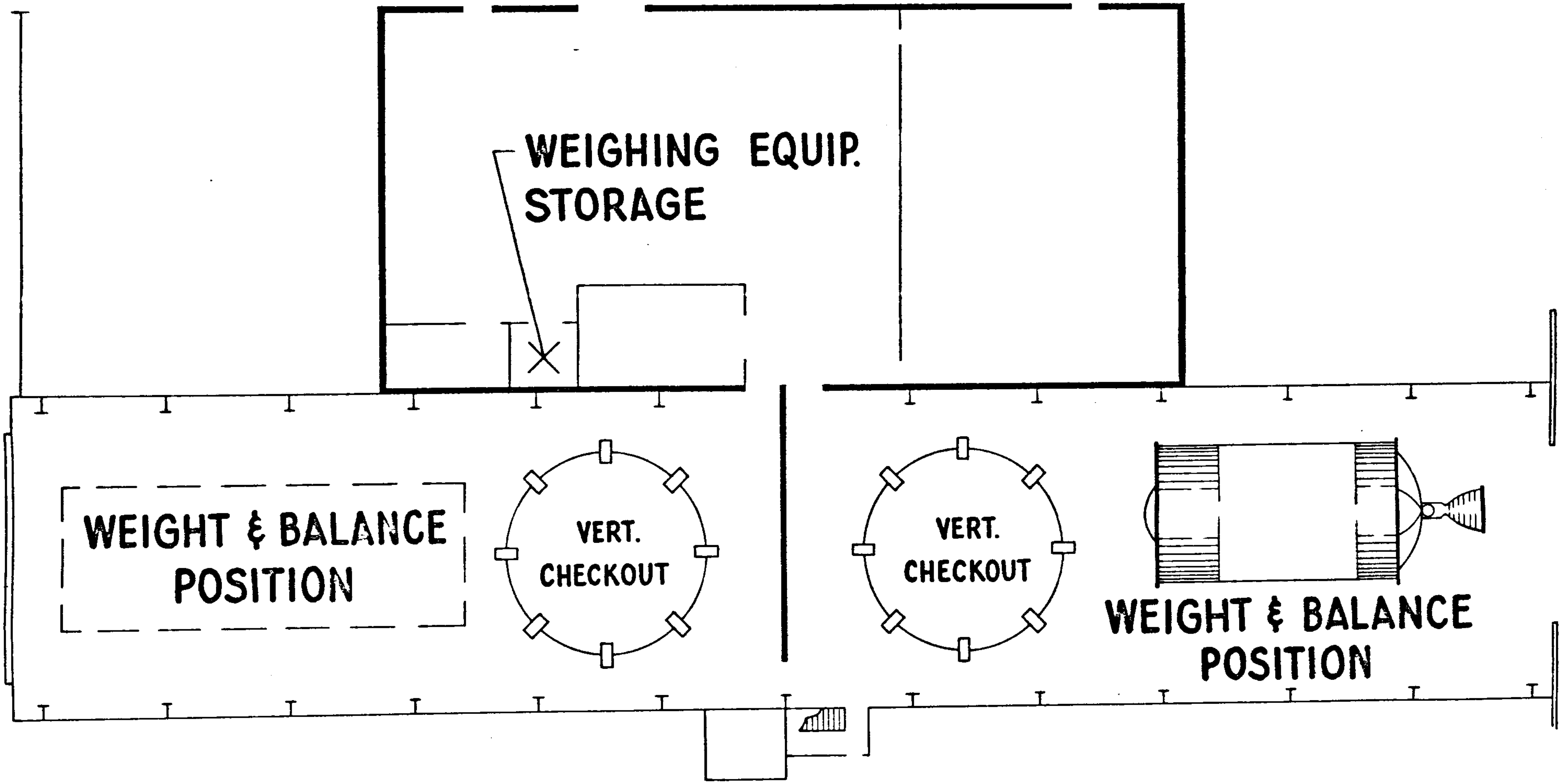


FIGURE 8

SUMMARY OF S-IVB CRYOGENIC WEIGH SYSTEM STATUS

DESIGN

- DETAIL DRAWINGS 80 TO 85% COMPLETE
- EXPECTED DRAWING COMPLETION BY OCTOBER 1964

PROCUREMENT

- 10,000 lb. WORKING DEAD WEIGHTS ARE BEING FABRICATED
- WORK RELEASE ORDERS ARE PENDING FOR PROCUREMENT OF
    1) ENVIRONMENTAL ENCLOSURE
    2) ENVIRONMENTAL ENCLOSURE SUPPORT STRUCTURE
    3) ENVIRONMENTAL CONTROL AND VERTICAL SENSOR TRANSDUCERS AND CABLES
    4) LIFT SLING AND TRUSS ASSEMBLY

- NEGOTIATIONS BEING HELD WITH ORBITRAN CO., INC. FOR ENGINEERING DESIGN OF MODEL 574, MEASURING AND RECORDING UNIT

FIRST EXPECTED EFFECTIVITY

- VEHICLE 202

FIGURE 9

CRYOGENIC CALIBRATION SCHEDULE FOR TYPICAL STAGE

CRYOGENIC WEIGH SYSTEM PREPARATION

STAGE PREPARATION FOR COLD FLOWS

TEST STAND AND GSE PREPARATION

CRYOGENIC CALIBRATION

RESUME PREPARATION FOR STATIC ACCEPTANCE FIRING

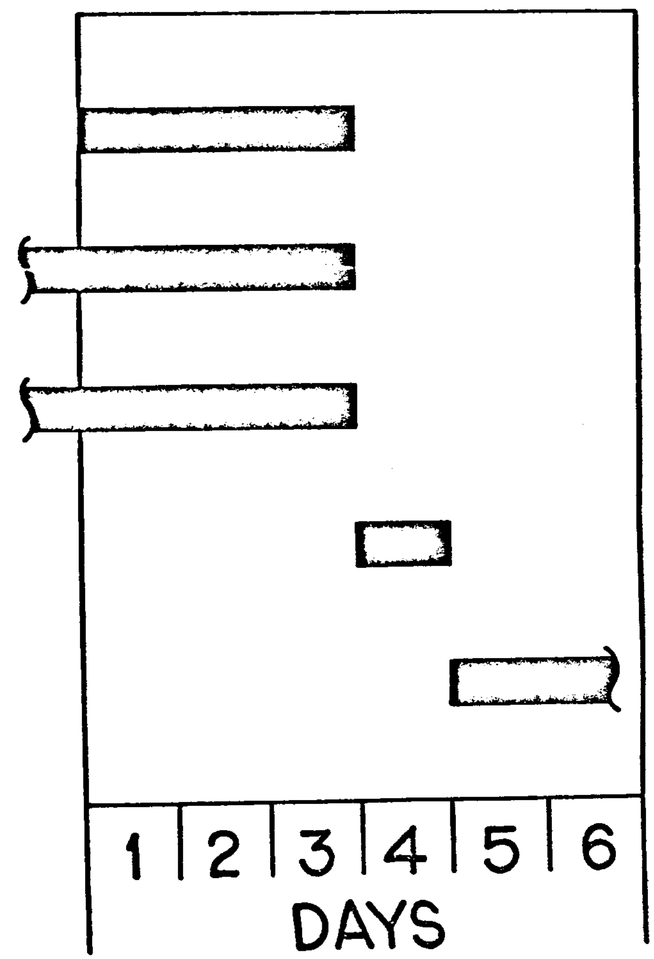


FIGURE 10

PAYLOAD PENALTY DUE TO S-IVB PROP. LOADING ERROR

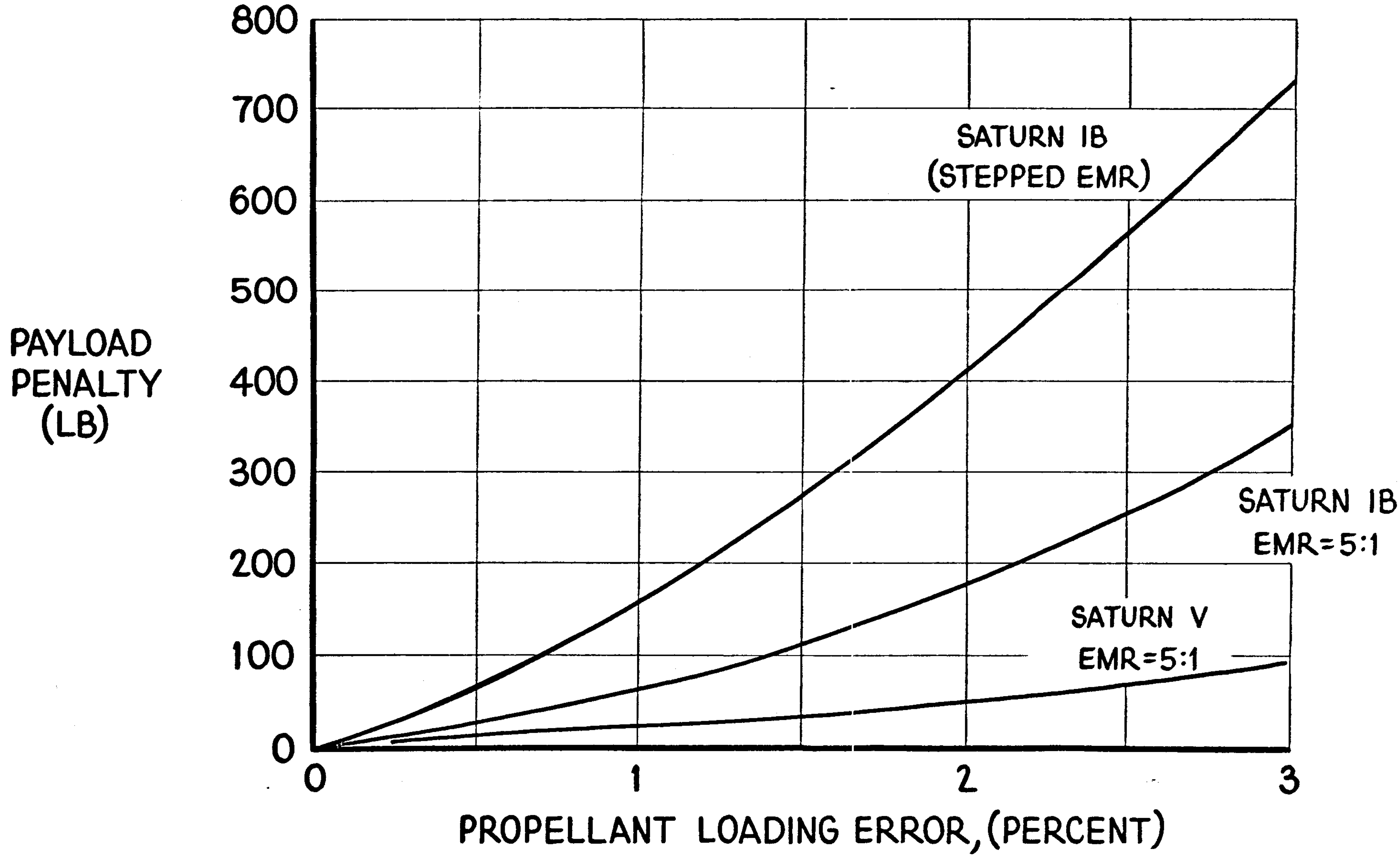


FIGURE 11

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MR. R. E. GODFREY, I-V-S-IVB
GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

AUG [illegible]

DOUGLAS AIRCRAFT COMPANY, INC., T. J. GORDON
NASA/MSFC, J. C. MC CULLOCH, I-I/S-IVB, HUNTSVILLE, ALABAMA
NASA/MSFC, W. F. SHAVER, DAC REP., BLDG 4481, RM 58, HUNTSVILLE, ALABAMA
DAC, F. L. DICKEY, A61-111
H. T. GIBBS, I-IB/DAC (WE SEND)
R. H. YOUNG, I-I/IB-S-IVB-L (WE SEND - 2)

IN REPLY REFER TO A3-850-K010-4.1.6-T-55/T. J. GORDON

SUBJECT: REQUIREMENT FOR THE S-IVB WEIGH SYSTEM

AS YOU ARE AWARE, WE HAVE RECENTLY REANALYZED THE REQUIREMENT FOR A CRYOGENIC WEIGH SYSTEM IN THE S-IVB PROGRAM. RECENT INFORMATION FROM YOUR OFFICE ESTABLISHES THE S-IVB VEHICLE CONTRIBUTION TO WEIGHT UNCERTAINTY AT LIFTOFF AS .35% OF THE GROSS S-IVB PROPELLANT WEIGHT. IT IS NOT POSSIBLE TO OBTAIN THIS ACCURACY BY ANY TECHNIQUE OTHER THAN A CRYOGENIC WEIGH SYSTEM.

WE BELIEVE THAT THIS ACCURACY IS PERHAPS MORE PRECISE THAN THAT ACTUALLY REQUIRED FOR PERFORMANCE REASONS. FOR EXAMPLE, OUR COMPUTATIONS SHOW THAT FOR A MIXTURE RATIO OF 5 TO 1, A 1% LOAD ERROR WOULD RESULT IN A 60 POUND PAYLOAD LOSS ON THE SATURN IB AND A 15 POUND PAYLOAD LOSS ON SATURN V.

THE PAYLOAD LOSSES BECOME MORE SIGNIFICANT IF THE VEHICLE PERFORMANCE IS COMPUTED WITH PROGRAM MIXTURE RATIO GAINS IN MIND. CONSIDERING A SATURN IB MISSION, OFF-LOADED TO OBTAIN HIGH THRUST DURING THE EARLY PORTIONS OF FLIGHT, A PAYLOAD GAIN OF APPROXIMATELY 1700 POUNDS OVER NOMINAL COULD BE PREDICTED WITH PRECISE LOADING AT LIFTOFF. IF THE LOADING WERE INACCURATE BY 1%, HOWEVER, PAYLOAD LOSS WOULD BE 175 POUNDS. AT 2% ERROR, THIS LOSS GROWS TO 425 POUNDS OUT OF THE 1700 POUNDS EXPECTED GAIN.

THE WEIGH SYSTEM INSTALLATION AT SACRAMENTO IS BEHIND SCHEDULE AND WILL NOT BE AVAILABLE FOR EITHER THE ALL SYSTEMS VEHICLE OR -201. THIS CONDITION RESULTS FROM AN EARLY JOINT DAC/NASA DECISION TO DIVERT APPROXIMATELY $288,300 FROM THE CRYOGENIC WEIGH SYSTEM TO COMPLEX GAMMA EQUIPMENT. IT IS OUR UNDERSTANDING THAT APPROXIMATELY $70,000 OF FACILITY MONEY IS AVAILABLE TO COMPLETE THE CRYOGENIC WEIGH SYSTEM. ACCORDING TO OUR PRESENT ESTIMATES, AN ADDITIONAL 1.5 MILLION DOLLARS WILL BE REQUIRED TO COMPLETE THE SYSTEM PLANNED.

APPENDIX C

AUG 17 1964

8-17-64

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WE HAVE REVIEWED IN SOME DETAIL THE ACCURACY OF LOADING WHICH COULD BE EXPECTED IF WE WERE AT THIS TIME TO CHANGE TO A WATER CALIBRATION SYSTEM. BECAUSE OF UNCERTAINTY IN THERMAL CONTRACTION, TANK DEFLECTION AT PRESSURIZATION, AND OTHER SOURCES, WE ESTIMATE THAT A 2 SIGMA RSS LOADING ACCURACY IS APPROXIMATELY 1.5%. THIS WOULD RESULT IN A PAYLOAD LOSS OF 300 POUNDS IN A SATURN IB MISSION EMPLOYING PROGRAMMED ENGINE MIXTURE RATIO. BASED ON PREVIOUS DISCUSSIONS OF THE COST EFFECTIVENESS OF WEIGHT SAVING DEVICES, WE FEEL THAT THE EXPENDITURE TO COMPLETE THE WEIGH SYSTEM TO OBTAIN THE PAYLOAD GAINS ACHIEVABLE IS WARRANTED. IT IS OUR RECOMMENDATION, THEREFORE, THAT THE SYSTEM BE INSTALLED AS PLANNED.

TJG:lah

cc: T. J. Gordon, A3-850 (2)
S. Greene, A3-852
C. B. Humphrey, A3-130
W. Miller, A-860
A. P. O'Neal, A3-860
L. S. Mull, A3-860
F. S. Mayer, A3-860

W. M. Shempp, A3-850
Saturn Correspondence Control, A3-130

4.0 STRUCTURAL QUALIFICATION TESTING (SATURN IB/V)

4.A Additions to Data Acquisition System Required in Memorandum R-P&VE-SSS-64-62.

4.A.1 INTRODUCTION

The Saturn S-IVB (IB/V) Structural Test program utilizes 5 test pads with several major qualification tests being set up and conducted simultaneously (see figure 12). A new requirement was generated by NASA which increased the test instrumentation as much as 232 per cent per test specimen. This increase has imposed a requirement greater than the existing DAC capability, thus necessitating the additional equipment noted in NASA memorandum R-P&VE-SSS-64-62. This equipment being: (a) 60 Balance, Normalize, and Calibrate Units; (b) 5 Balance, Normalize, and Calibrate Readout Units; and, (c) 5 Cathode Ray Tube Units.

The basic Digital Data System at the A3 Structures Laboratory consists of 3 major components: (a) Transducer; (b) Balance, Normalizing, and Calibration Unit (Signal Conditioning); and, (c) Data Acquisition Unit. See figure 13. Additional equipment is required which gives the system flexibility to set up several tests simultaneously, and for instantaneous visual monitoring of various test parameters. These units are the Balance, Normalizing & Calibrating Readout Units and Cathode Ray Tube Units, respectively. See figure 13.

4.A.2 PURPOSE

a. Balance, Normalize, and Calibrate Units (Signal Condition)

The use of strain gages, bridge type transducers, etc., for test data acquisition necessitates the requirement for circuitry to supply excitation power to the transducer and for the output signal of the transducer to be balanced, normalized, and calibrated to a usable level for accurate data recovery and processing. The subject (BNC) panel is a mandatory piece of signal conditioning equipment, necessary to complete the data signal circuit from the data pressure transducer, strain gage, thermocouple, etc., of the Saturn S-IVB test specimen to the Digital Data System.

Each BNC provides 25 channels with the necessary bridge completion networks, data signal balancing and normalizing adjustments, automatic calibration functions, and strain gage power routing circuitry. Each channel input of the BNC panel accepts two, three, four or six wire type transducers; that is, thermocouples, pressure transducers, single active leg strain gages, 4 leg strain gages, load rings, bending beams, etc. The BNC panel output supplies conditioned signal data to the Digital Data System for recording, monitoring and processing.

b) Balance, Normalize, and Calibrate Readout Units

Five (5) Balance, Normalize and Calibrate Readout Units should be provided. These units will allow independent checkout of the test setup at each of the facility test positions without the use of the digital data system. This is an important requirement in regard to meeting the test schedule of Figure 12 in that it allows parallel testing as shown in schedule instead of series testing.

c) Cathode Ray Tube Unit (Bar Chart)

Five (5) Cathode Ray Tube Units should be provided. This will allow the display of 100 measurements during testing. These are needed for monitoring critical areas for determining critical stresses. The data system provides the ability for switching to any channels.

4.A.3 STATUS

All AFE's have been written, submitted to NASA, approved by NASA, and are currently being processed by DAC Plant Engineering. All necessary paper work has been initiated to validate the preliminary vendor bids on the subject items. It is anticipated that the Cathode Ray Tube Units, Balance, Normalize, and Calibrate Readout Units, and 40 of the 60 Balance, Normalize, and Calibrate Units will be available by mid-November 1964. The remaining 20 units will be available 30 days later or mid-December 1964. This will bring the permanent DAC data capability at the Structures Laboratory to 1950 channels, sufficient to meet all normal data requirements. However, there still remains one period, April and May of 1965, at which time the data requirement exceeds the capability. To over-come this deficiency, the data system at the Santa Monica Plant will be scheduled to supplement the Huntington Beach data system, thus eliminating the problem.

STRUCTURES TEST INSTRUMENTATION REQ & STATUS

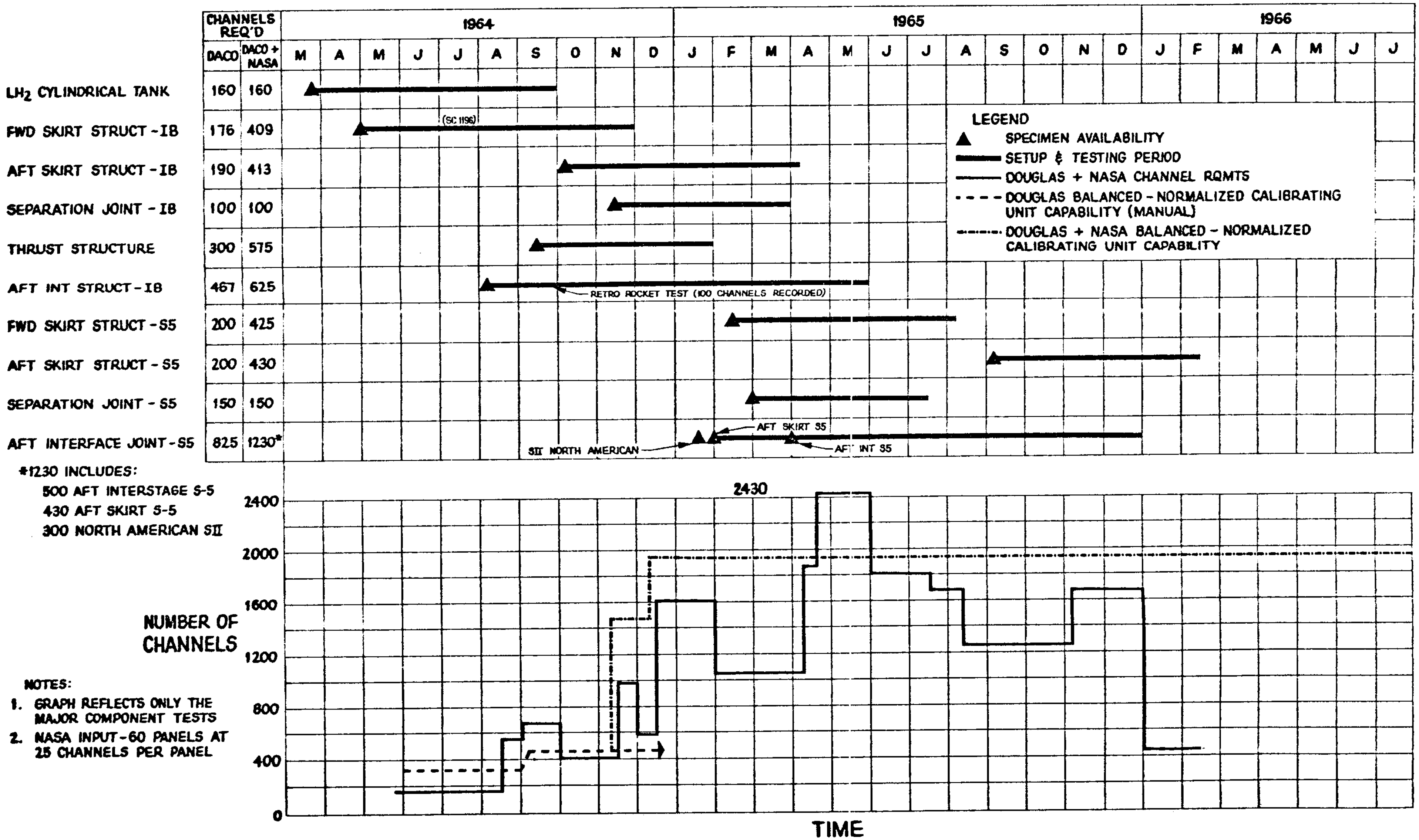


FIGURE 12

BASIC DATA ACQUISITION SYST

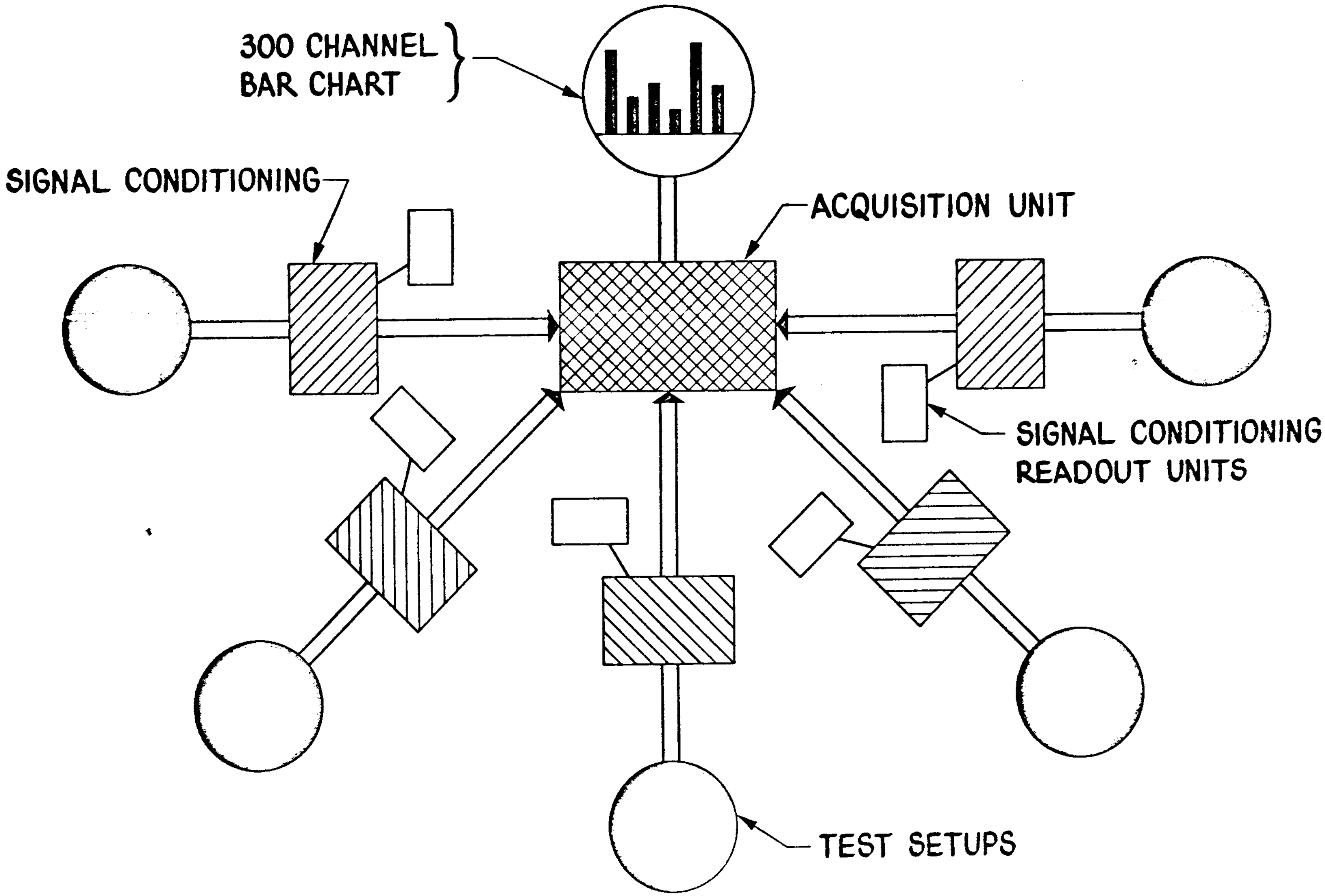


FIGURE 13

4.B. Problems Anticipated by Necessity of Testing Structural Hardware Designed for Non-Flight Loads

One of the requirements that is considered mandatory within any valid qualification test program is that the specimens tested be production parts duplicating actual flight hardware. The airframe is primary structure and part of the Vehicle Critical Items List. Thus, it is even more important that the airframe hardware tested duplicate the flight hardware. To be more specific, primary structure qualification tests require a unique procedure for test plan coordination, review and approval prior to initiating the specific structural test. Therefore, it is difficult to conceive that sound engineering judgments that have prevailed to date have suddenly been waived in favor of a more reasonable expense or to expedite a continuously changing test program. A test program based on sound engineering judgments should always be our goal regardless of political impact.

One of the prime reasons for testing an assembled structure is to determine the effect of certain built-in physical characteristics that influence the structural behavior of the design and are not readily accounted for in the analysis. If these characteristics are unknown for the part to be tested, it is logical to assume that the information derived from this test cannot be used to predict the behavior of another structure designed to an altogether different criteria.

As an example, some of the problem areas that require resolution prior to the analytical qualification of flight structure include:

1. Testing structure designed for a present non-flight load condition.
2. Testing it between two test dummy structures.
3. Testing with an environment foreign to any proposed flight environment and recording results.

4. Substantiating a stress analysis with test results or establishing an analysis technique based on the test results.

5. Correlating substantiated method of analysis with method of analysis for flight hardware.

Each of these conditions creates an analytical problem of its own.

In condition number one above, the test specimens were designed for a present non-flight load condition using a beam column analysis of the maximum compressed stringer, similar to (a) in Figure 14. The basic assumption in this analysis is that of immovable supports, and is quite reasonable considering the loading condition. There were no transverse loads on the stringer for the original design condition, so deflections of the support frames would be small. Regrettably, this assumption is not valid for the test setup or the flight structure.

The problem associated with condition number two is one of fixity. The two test dummy structures will undoubtedly give the specimen more (less flexible) restraint than adjacent flight structure, since they are designed to assure failure of the specimen. In our case, the effect of dummy structure fixity will be a difficult parameter to determine. Dummy structure fixity is always a test problem, but its effect is usually easy to evaluate. Normally, the proper structure is tested with the correct environment, and dummy structure fixity is the only variable.

The test environment will consist of original design limit loads, plus whatever internal pressure the specimen can withstand, but not exceeding expected flight pressures. Using this environment will not qualify any structure. However, its use will add a parameter, pressure distribution, to the analysis.

The analysis that will attempt to account for the variables posed in conditions one through three (frame displacements, end support fixities, and pressure distribution) is shown in (d) of Figure 14. This figure also illustrates other analyses that would attempt to account for the variables. (b) is a rather simple analysis that can account for end support fixity only. (c) is more complex but can include only two of the three variables, frame displacements and end support fixity.

To sketch the model (d) in Figure 14 is very easy, but to extract numbers with an analysis using this model is quite difficult. Whenever axial compression is an applied load, the effects of other parameters are not easily determined. Axial compression will tend to increase the apparent effect of any one parameter. In fact, the larger the axial compression, the more effect it has on the other parameters. So, determining (even by test) the frame spring constant, fixity of the test dummy structure, and the pressure distribution, each required for an accurate analysis, will be extremely difficult.

Assuming that these difficulties can be overcome and that an accurate analysis is accomplished, the final condition, correlation of methods of analysis, must then be accomplished. The flight structure will be analyzed for a load environment different from the test environment. The variables posed in testing (frame displacements, end support fixity, and pressure distribution) must now be considered for flight structure. The effects of the variables and different load environment will have to be evaluated with a best guess based on the test results. The best guess will be subject to inaccuracies because axial compression has a nonlinear effect, and the flight compression load per stringer is much larger than the test compression.

In conclusion, if all five steps are to be accomplished, each associated analytical problem must be evaluated accurately. Otherwise, the Saturn-IB Flight Structure will not be qualified.

4.C. The Internal Loads Analysis of the S-IVB Aft Interstage at the S-IVB/IB Interface for the Structural Test Article

A Redundant Force Analysis (RFA) has been prepared to evaluate the load distribution at the S-IVB/S-I Interface. This analysis was performed on the flight configuration. The idealized analytical model was assumed to be supported by a semi-rigid foundation at the eight reaction beams. The maximum $q\alpha$ load condition was investigated for the combined effects of the external axial, bending moment, and shear loads (reference R-P&VE-SL-212-63) and the internal pressure distribution (reference S-IVB Technical Coordination Bulletin No. 233).

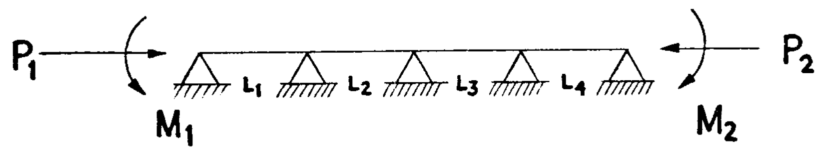
The non-flight test specimen will be analyzed, utilizing the Redundant Force Analysis, to determine the expected load distribution at the simulated test interface. The RFA idealized model will be modified to reflect the section properties of the test specimen. This analysis will be completed prior to the initiation of the structural test.

4.D. The Interface Flange Tensile Test Program to Include a Comparison of Analytical and Test Results

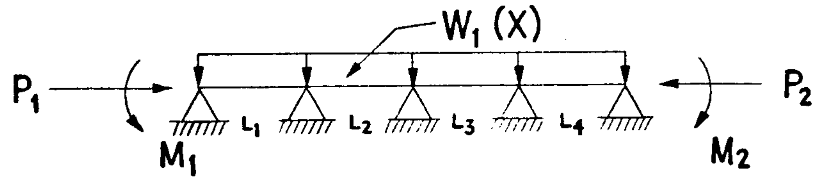
Development tests of joints simulating the separation joint of the aft skirt and interstage and the LH_2 tank to the skirt structures have been performed. The test results are applicable to both the Saturn-V and -IB. These tests were designed to establish the load capability in the local joint region. The test data shows that the joint designs can resist the required design ultimate loads. Figures 15 and 16 show the test results and compare the required design loads graphically.

STRUCTURAL SUPPORT IDEALIZATIONS

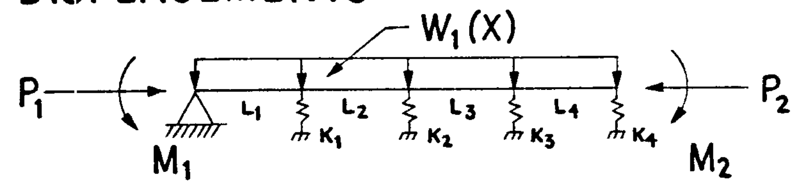
(a) THE STRUCTURAL SUPPORT ASSUMED TO BE VALID FOR THE ORIGINAL FLIGHT DESIGN CONDITIONS



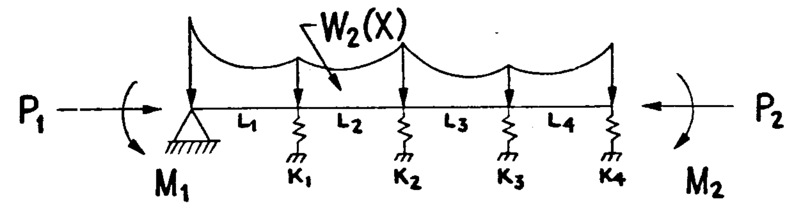
(b) THIS IDEALIZATION ACCOUNTS FOR THE END SUPPORT FIXITIES ONLY



(c) THIS IDEALIZATION ACCOUNTS FOR END SUPPORT FIXITIES AND FRAME DISPLACEMENTS



(d) THIS IDEALIZATION ACCOUNTS FOR END SUPPORT FIXITIES, FRAME DISPLACEMENTS, AND PRESSURE DISTRIBUTION. THIS IS THE IDEALIZATION USED FOR THE PRESENT FLIGHT CONFIGURATION OF THE FORWARD SKIRT.



$W_1(X)$ - STRINGER TAKES ALL TRANSVERSE LOAD
$W_2(X)$ - SKIN RELIEVES STRINGER OF A PORTION OF THE TRANSVERSE LOAD

FIGURE 14

SEPARATION JOINT PANEL TESTS

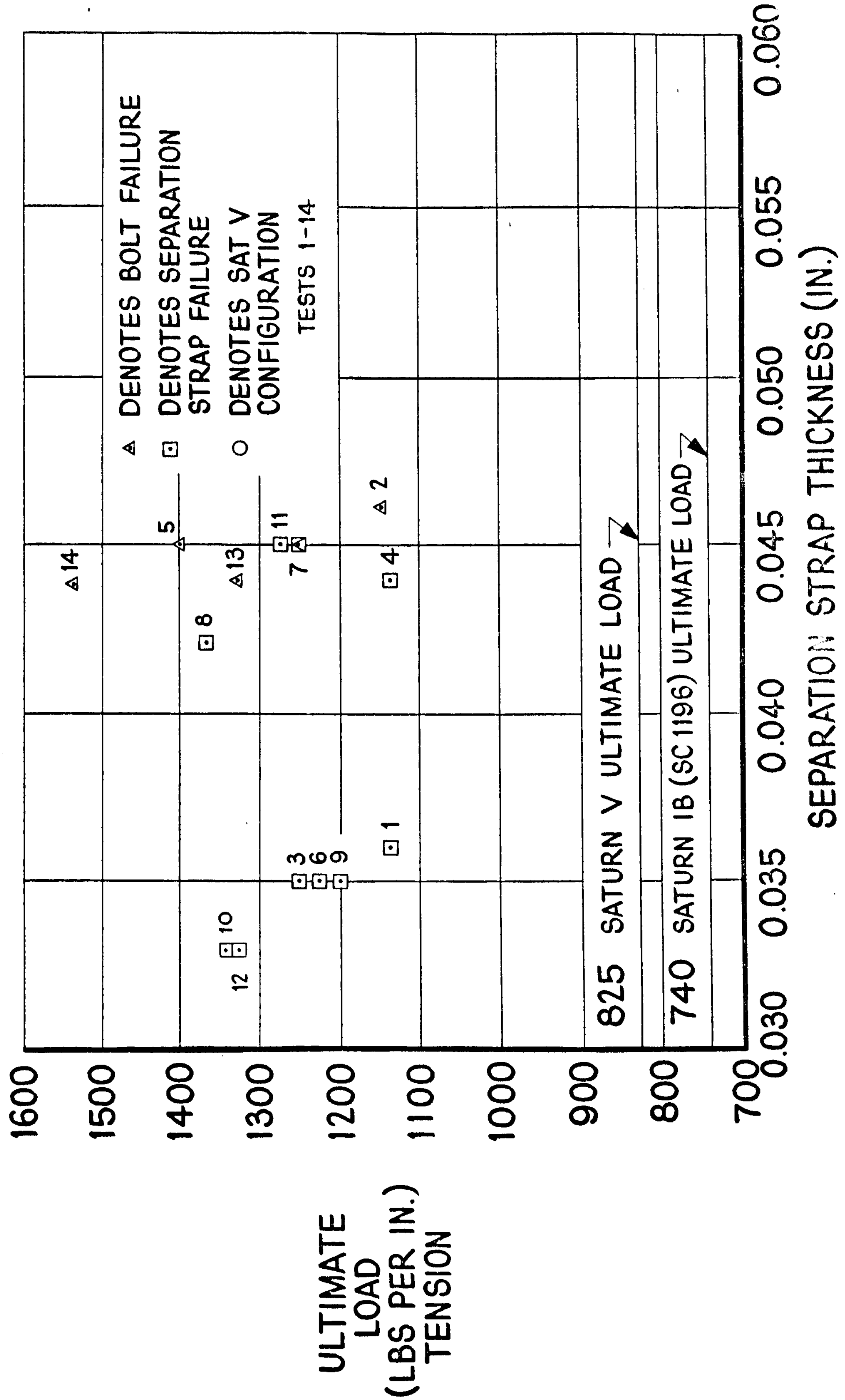


FIGURE 15

LH_2 TANK – SKIRT JOINT TESTS

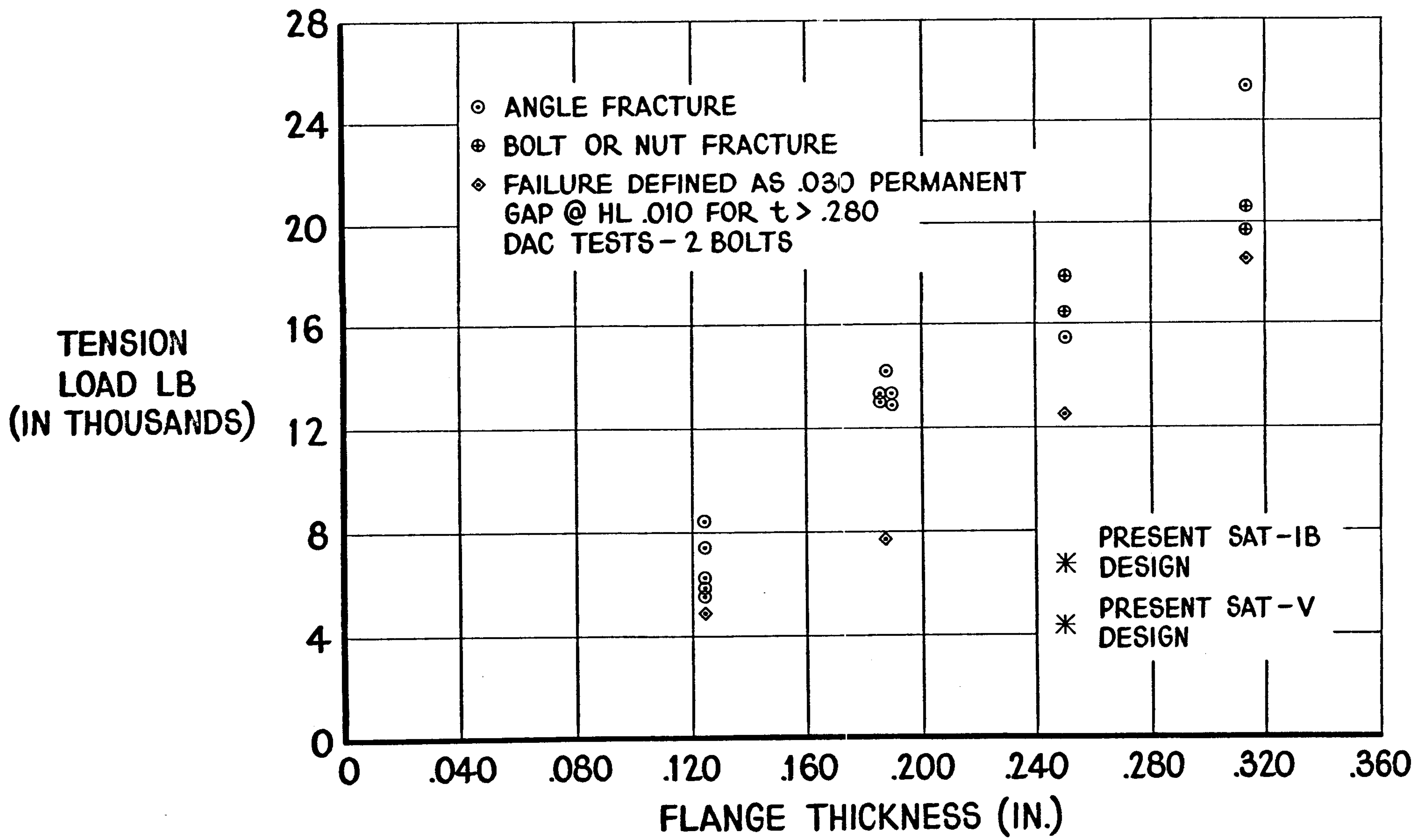


FIGURE 16

CONDITIONS AFFECTING THE ANALYTIC QUALIFICATION OF FLIGHT HARDWARE

1. TESTING OF STRUCTURE DESIGNED TO NON-FLIGHT LOAD CONDITIONS
2. TESTING SPECIMEN BETWEEN RIGID DUMMY STRUCTURES
3. TESTING WITH AN ENVIRONMENT FOREIGN TO ANY PROPOSED FLIGHT ENVIRONMENT
4. SUBSTANTIATING A STRESS ANALYSIS WITH TEST RESULTS OR ESTABLISHING AN ANALYSIS TECHNIQUE BASED ON THE TEST RESULTS
5. CORRELATING SUBSTANTIATED METHOD OF ANALYSIS WITH METHOD OF ANALYSIS FOR FLIGHT HARDWARE

FIGURE 17

5.0 STRUCTURAL DESIGN LOADS AND STRENGTH ANALYSIS

5.A.1. Summary of MSFC Load Documents Applicable to S-IVB Stage (August 1964)

5.A.1.1. Saturn IB

a. Primary Design Data

1) R-P&VE-SL-212-63 (CO 146)

"Preliminary Structural Loads for Saturn IB Vehicle with Uprated H-1 Engines"

2) Addendum to R-P&VE-SL-212-63 (CO 146)

3) R-P&VE-SL-217-63 (CO 146)

"Corrections to R-P&VE-SL-212-63 . . ."

4) R-P&VE-SL-219-63 (CO 184)

"Preliminary Investigation of Longitudinal Dynamic Loads on the Saturn IB Operational Vehicle with 200 KIP Engines"

5) TD-270 (Reference M-AERO-A-71-63)

"Preliminary Aerodynamic Loads on the Auxiliary Propulsion System for the Saturn IB Vehicles"

6) M-P&VE-VA-318-63 (TD-255, CO 107)

"Revised S-IB/S-IVB Interstage Design Criteria" (Fairing Design only)

b. Structural Test Data (Early Design Data)

1) R-P&VE-SD-396-62 (TD-16)

"Preliminary Flight Loads of Saturn IB Configuration Number 1"

2) R-P&VE-SD-413-62 (TD-16)

"Wind Loads for the Saturn C-IB Configuration Number 1"

c. Secondary Design Data

1) I-V-S-IVB-TD-64-108

"Reduction of Erection Load Factor"

2) I-V-S-IVB-64-396 (CO 288)

"Hydrogen Fuel Tank Pressure Reduction and Redesign"

d. Pending Design Data

1) R-P&VE-VA-318-63 (TD-211)

"Revised S-IB/S-IVB Interstage Design Criteria"

2) R-AERO-AD-64-55 (Letter I-V-S-IVB-64-A-181)

"Design Criteria: Saturn V and Saturn IB Vehicles In-Flight Venting Analysis of the Forward S-IVB Stage Skirt, Instrument Unit, LEM Adapter and Service Module Compartment" (Venting CO 284)

5.A.1.2 Saturn V

a. Primary Design Data

1) M-P&VE-SL-9-62 (TD 15)

"Structural Loads for the Saturn C-5 LOR Vehicle (Sub-Orbital Start)"

2) M-P&VE-SL-2-62 (TD 15)

"Shear, Moment, Deflection and Lateral Acceleration of the Saturn C-5 LOR (Sub-Orbital Start) Vehicle on the Pad"

3) M-P&VE-SL-89-63 (TD 112)

"Preliminary Investigation of Longitudinal Dynamic Tension Loads for C-5 LOR at Flight Cut-off"

4) R-P&VE-SL-203-63 (CO 185)

"Preliminary Investigation of Longitudinal Vibration Loads for the Saturn V LOR during Buildup"

b. Secondary Design Data

1) M-P&VE-SL-11-62 (TD 15)

"In-Flight Slopes and Deflections of the Saturn C-5 LOR Vehicle (Sub-Orbital Start)"

2) M-P&VE-SL-29-63 (TD 45)

"Wind-Induced Oscillations of the Saturn V LOR Vehicle on the Launcher/Umbilical Tower"

3) M-P&VE-SL-75-63 (TD 129)

"Saturn V Lateral Accelerations on the Launcher/Umbilical Tower"

c. Pending Design Data

1) M-P&VE-SL-53-63 (TD 87)

"Longitudinal Force for αq Maximum, q Maximum and Cut-off Applicable to Saturn V LOR (Sub-Orbital Start) Vehicle"

2) R-P&VE-SLR-64-22 (CO 223)

"Preliminary Investigation of Longitudinal Vibration Loads in the Saturn V LOR During Buildup and Emergency Rebound" (Less critical than CO 185)

3) R-P&VE-SL-202-63 (TD-284)

"Design In-Flight Pressure Loads for the Saturn V, S-II/S-IVB Interstage"

4) R-P&VE-SJ-64-1 (TD-284)

"Design Load Criteria for the S-II/S-IVB Interstage"

5) R-P&VE-SLL-64-11 (TD 64-57)

"Addendum to 'R-P&VE-SL-202-63'"

6) R-AERO-AD-64-55 (Letter I-V-S-IVB-64-A-181)

"Design Criteria: Saturn V and Saturn IB Vehicles In-Flight Venting Analysis of the Forward S-IVB Stage Skirt, Instrument Unit, LEM Adapter and Service Module Compartment" (Venting CO 284)

7) I-V-S-IVB-64-396 (CO 288)

"Hydrogen Fuel Tank Pressure Reduction and Redesign"

8) R-P&VE-SLR-64-32 (TD 64-118)

"Preliminary Investigation of Longitudinal Dynamic Tension Loads for the Saturn V LOR During Flight Cut-off and First Stage Separation"

9) R-P&VE-SVA-64-76 (TD 64-126)

"Vibration Response of the S-IVB Interstage and Aft Skirt Skin Panels"

10) R-P&VE-SVA-64-90 (TD 64-126)

"Addendum to Memorandum R-P&VE-SVA-64-76, ..."

5.A.2. MSFC Load Memoranda Presently Being Used to Design the SA 201 and Subs (Except SA 201 Aft Skirt)

1. R-P&VE-SL-212-63 (CO 146)

   "Preliminary Structural Loads for Saturn IB Vehicle with Uprated H-1 Engines"

2. Addendum to R-P&VE-SL-212-63 (CO 146)

3. R-P&VE-SL-217-63 (CO 146)

   "Corrections to R-P&VE-SL-212-63 . . ."

4. R-P&VE-SL-219-63 (CO 184)

   "Preliminary Investigation of Longitudinal Dynamic Loads on the Saturn IB Operational Vehicle with 200 KIP Engines"

5. M-P&VE-VA-318-63 (TD-255, CO 107)

   "Revised S-IB/S-IVB Interstage Design Criteria" (Fairing Design only)

5.A.3. MSFC Load Memoranda Presently Being Used to Design the SA 201 Aft Skirt

1. R-P&VE-SD-396-62

   "Preliminary Flight Loads of Saturn IB Configuration Number 1"

2. R-P&VE-SD-413-62

   "Wind Loads for the Saturn C-IB Configuration Number 1"

5.C <u>Implementation of R-P&VE-SL-212-63 Loads on S-IVB/IB Flight Stages.</u>

Forward skirt – Redesign stringers, forward and aft end frame caps.

Effective SA 201 and subs.
Dwg. release status – 90% complete

Aft skirt – Redesign stringers, forward intermediate frame and separation joint. Two frames will be redesigned as required to support the APS modules and ullage rockets.

Effective SA 202 and subs.
Dwg. release status – 90% complete

Aft Interstage – Completely redesigned, all frames, stringers and reaction beams affected.

Effective SA 201 and subs
Dwg release status – 85% complete

No schedule impact is expected except for SA 202 aft skirt as outlined in TWX A3-850-K031-4.23.8-T-679, dated 8-14-64.

GEORGE C. MARSHALL SPACE FLIGHT CENTER
SATURN RESIDENT MANAGEMENT OFFICE
HUNTINGTON BEACH, CALIFORNIA

Memorandum

TO Mr. J. H. Furman, R-P&VE-SJ

DATE September 1, 1964
R-P&VE/DAC-27-64

FROM Resident Representative, R-P&VE/DAC

SUBJECT Douglas Aircraft S-IVB Space Systems Design Memorandums

1. Forwarded herewith, for information, is one (1) copy each of the following classified (confidential) S-IVB Design Memorandums:

No. 2 - Preliminary Design Program
No. 5 - Ground Rules for Realigned S-IVB Program
No. 13 - Preliminary Loads for Design of the S-IVB Stage of the C5 Vehicle
No. 13A - Preliminary Loads for Design of the S-IVB Stage of Saturn V Vehicle
No. 19 - Preliminary Loads for Design of the S-IVB Stage of the C-5 Vehicle, LOR Suborbital Start - 185.2 KM Circular Orbit
No. 19A - MSFC - Supplied Design Loads for the S-IVB Stage of the C-5 Vehicle
No. 19B - MSFC - Supplied Design Loads for the S-IVB Stage of the C-5 Vehicle
No. 21A - Design Loads for the S-IVB Stage of the C-1B Vehicle
No. 21B - Design Loads for the S-IVB Stage of the Saturn 1B Vehicle
No. 50 - S-IVB/Saturn 1B Design Mission Definition
No. 84 - S-IVB/Saturn V Design Mission Definition

2. With this first transmittal of design memorandums, it is requested that Mr. M. O. Enger of R-P&VE-SA initiate a central file copy to be made available to interested personnel of the Structures Division.

3. All other design memorandums to date will be forwarded within two (2) weeks.

CJMezo

C. J. Mezo

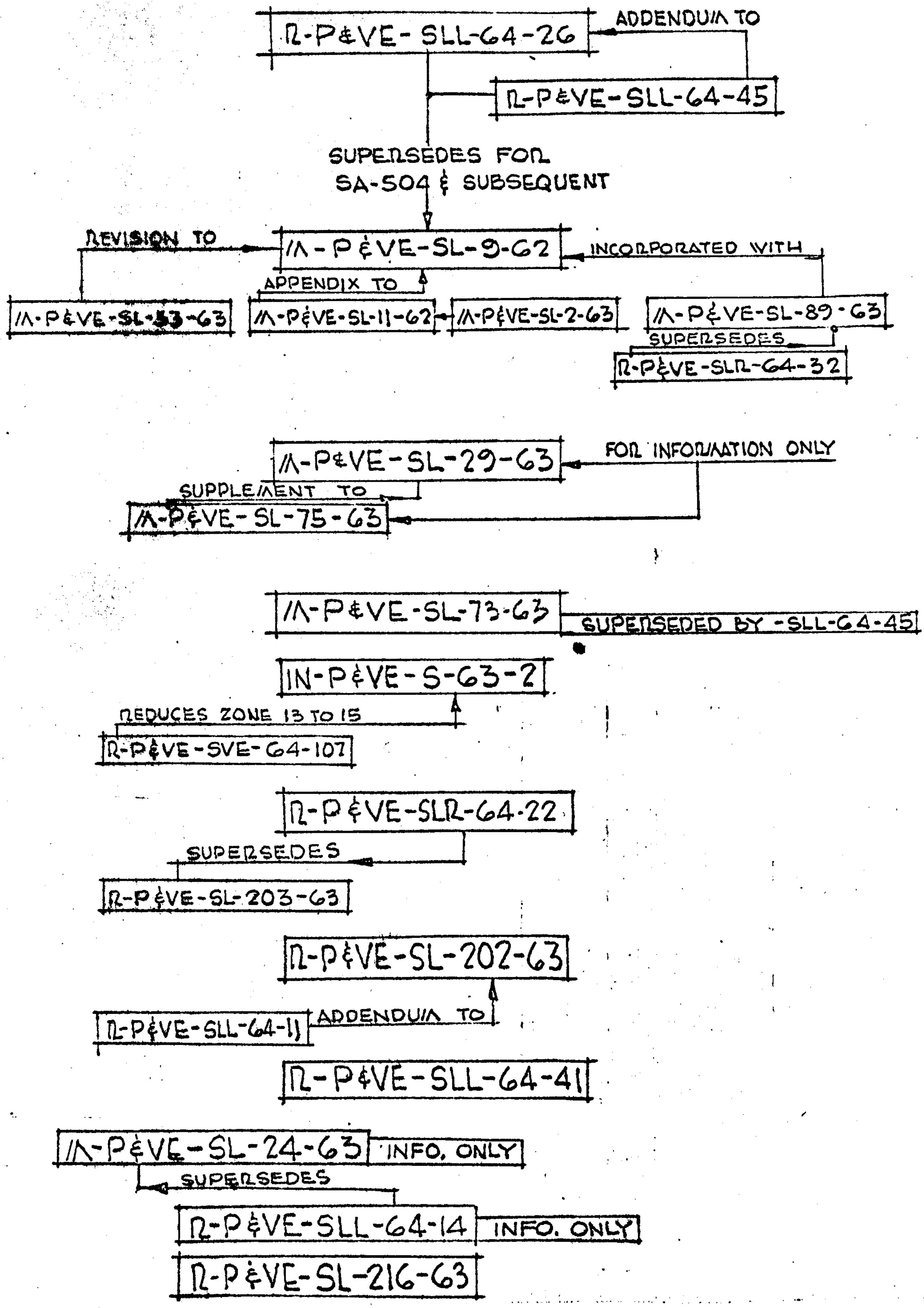
CJM:evh

Encls. a/s

cc: Mr. R. F. Griner, R-P&VE-DIR(J) (w/o enc) ✓
Mr. W. R. Walters, R-P&VE-SJ (w/o enc)
Mr. J. Blumrich/Mr. M. Enger, R-P&VE-SA (w/o enc)
Mr. P. Frederick/Mr. N. Schlemmer, R-P&VE-SS (w/o enc)
Mr. N. Showers, R-P&VE-SL (w/o enc)
Mr. H. Gibbs, I-I/IB-DAC

MSFC - Form 488 (August 1960)

APPENDIX D

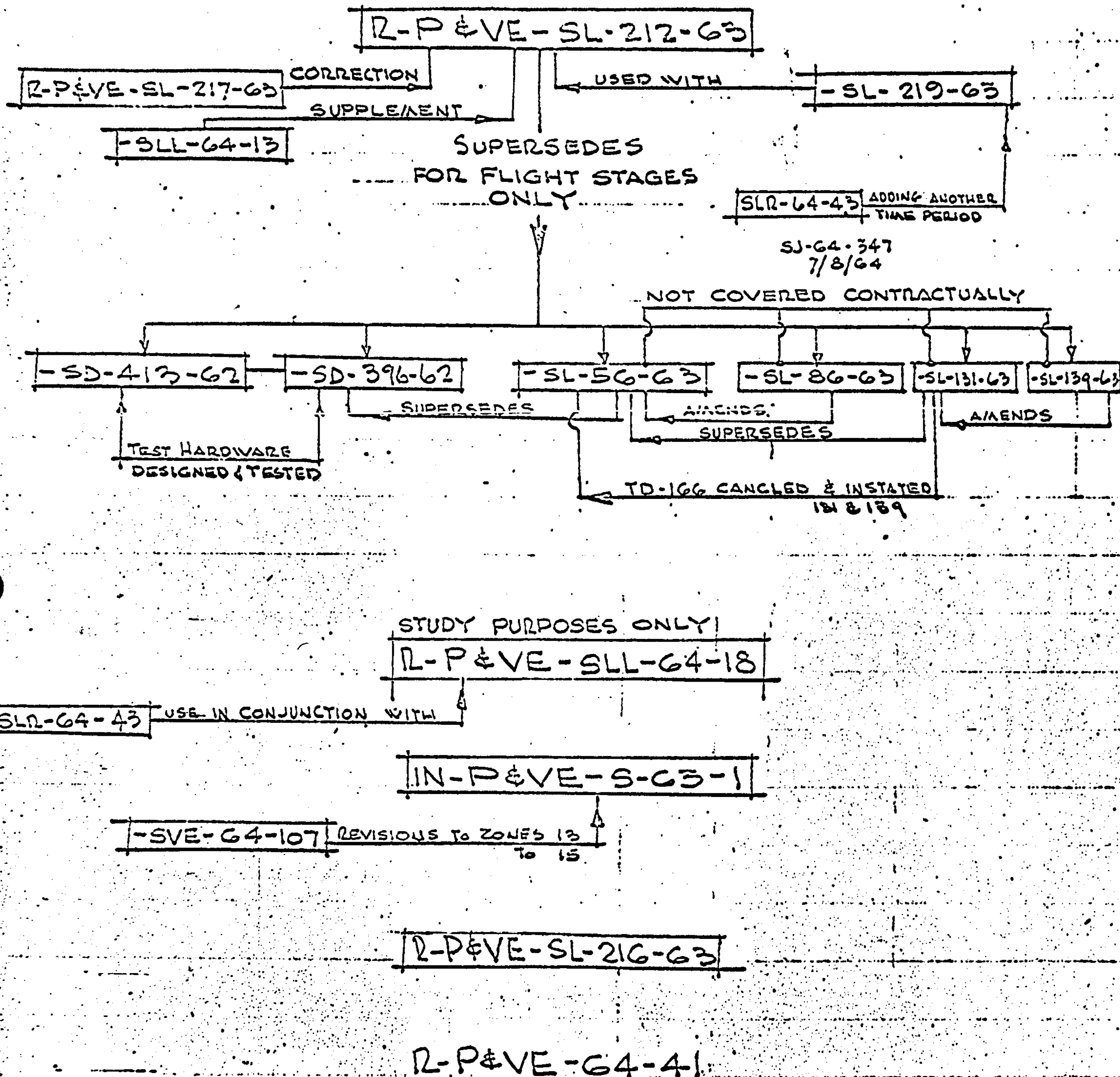


R-P&VE-SLL-64-26
ADDENDUM TO
R-P&VE-SLL-64-45
SUPERSEDES FOR SA-504 & SUBSEQUENT
REVISION TO
M-P&VE-SL-9-62
INCORPORATED WITH
APPENDIX TO
M-P&VE-SL-53-63
M-P&VE-SL-11-62
M-P&VE-SL-2-63
M-P&VE-SL-89-63
SUPERSEDES
R-P&VE-SLR-64-32
M-P&VE-SL-29-63
FOR INFORMATION ONLY
SUPPLEMENT TO
M-P&VE-SL-75-63
M-P&VE-SL-73-63
SUPERSEDED BY -SLL-64-45
IN-P&VE-S-63-2
REDUCES ZONE 13 TO 15
R-P&VE-SVE-64-107
R-P&VE-SLR-64-22
SUPERSEDES
R-P&VE-SL-203-63
R-P&VE-SL-202-63
R-P&VE-SLL-64-11
ADDENDUM TO
R-P&VE-SLL-64-41
M-P&VE-SL-24-63
INFO. ONLY
SUPERSEDES
R-P&VE-SLL-64-14
INFO. ONLY
R-P&VE-SL-216-63

APPENDIX E

S-IVB/SATURN IB

8-21-64



8-21-64

S-IVB/SATURN V LOADS

SA-501, 502 & 503

M-P&VE-SL-9-62	
M-P&VE-SL-11-62	APPENDIX TO-SL-9
M-P&VE-SL-2-63	
M-P&VE-SL-53-63	REVISION TO -SL-9
R-P&VE-SLR-64-32	INCORPORATED WITH -SL-9
M-P&VE-SL-29-63	FOR INFORMATION ONLY
M-P&VE-SL-75-63	FOR INFORMATION ONLY
M-P&VE-SL-73-63	SUPPLEMENT TO -SL-9 APPLICABLE TO DWG. 0299
IN-P&VE-S-63-2	
R-P&VE-SVE-64-107	REDUCES ZONES 13 THROUGH 15
R-P&VE-SLR-64-22	
R-P&VE-SL-203-63	SUPERSEDED BY -SLR-64-22
R-P&VE-SL-202-63	
R-P&VE-SLL-64-11	ADDENDUM TO -SL-202-63
R-P&VE-SLL-64-41	
R-P&VE-SL-216-63	

8-21-64

S-IVB/SATURN V LOADS
SA-504 & SUBSEQUENT

R-P&VE-SLL-64-26	
R-P&VE-SLL-64-45	ADDENDUM TO -SLL-64-26
M-P&VE-SL-29-63	FOR INFORMATION ONLY
M-P&VE-SL-75-63	
M-P&VE-SL-73-63	
IN-P&VE-S-63-2	
R-P&VE-SVE-64-107	REDUCES ZONES 13 THROUGH 15
R-P&VE-SLR-64-22	SUPERSEDES -SL-203-63
R-P&VE-SL-203-63	
R-P&VE-SL-202-63	
R-P&VE-SLL-64-11	ADDENDUM TO -SL-202-63
R-P&VE-SLL-64-41	
R-P&VE-SL-216-63	

8-21-64

S-IVB/SATURN IB - LOADS

TEST LOADS -
AFT SKIRT LOADS SA-201

M-P&VE-SD-396-62
FLIGHT LOADS

M-P&VE-SD-413-62
WIND LOADS -

IN-P&VE-S-63-1

R-P&VE-SVE-64-107
REVISION TO ZONES 13 TO 15
OF -S-63-1

R-P&VE-SL-216-63

R-P&VE-SLL-64-41

S-IVB/SATURN IB - LOADS

SA-201 EXCEPT AFT SKIRT -
SA-202 & SUBSEQUENT

R-P&VE-SL-212-63

R-P&VE-SL-219-63 USE WITH -SL-212

R-P&VE-SLR-64-43 ADDING ANOTHER TIME PERIOD TO - SL-219

R-P&VE-SL-217-63 CORRECTION TO -SL-212

R-P&VE-SLL-64-13 SUPPLEMENT TO -SL-212

IN-P&VE-S-63-1

R-P&VE-SVE-64-107

REVISIONS TO ZONES 13 TO 15

R-P&VE-SL-216-63

R-P&VE-SLL-64-41

6.0 BATTLESHIP

6.A. Program Testing Schedules

The Battleship Schedules are presently being updated. Current information was not available at the printing deadline of this document.

6.B. J-2 Engine Chill Program

The outstanding problems related to the J-2 Engine start are:

- LH_2 and LO_2 turbopump chilldown.
- Bubble removal from the LH_2 and LO_2 antivortex screens.
- Conditioning and maintaining the bell chill.
- Chilling to and maintaining the engine start bottle conditions.

The solutions to these problems will be part of the objectives of Battleship testing as outlined in the following test program.

LOADING TEST LN_2 AND LO_2

OVERBOARD CHILLDOWN THRU GG ONLY LO_2 AND LH_2

FORWARD FLOW RECIRCULATION

VERIFICATION RUN AND IGNITION TEST

20 SEC HOT FIRING

TEST PROGRAM TO ESTABLISH S-IVB/S-IB BATTLESHIP J-2 ENGINE AND PROPELLANT FEED SYSTEM CONDITIONING REQUIREMENTS

OVERBOARD BLEED - GG ONLY

Test Conditions

1. LH_2 engine pump discharge bleed system.
2. Propellants loaded with prevalves open.
3. LH_2 and LO_2 loaded to 100% level for each run.
4. Forward flow LO_2 recirculation chilldown system.
5. Stainless steel LH_2 duct installed.
6. No LH_2 chilldown pump operation - LH_2 prevalve open.
7. Oversize engine bell chill orifice installed.
8. Engine bell diffuser installed and purged with GN_2 followed by cooling with water.
9. LO_2 tank pressurized to 37 - 40 psia.

Hardware Modifications

1. LH_2 engine pump discharge bleed system installed.
2. LH_2 chilldown shutoff valve closed (disable electrical circuit).

Run No. 1 (LH_2 Tank Pressurized to 37 psia)

1. Flow propellants to thermal equilibrium.
2. Chill engine bell to -200°F and cycle flow to maintain bell at -150 ± 50°F.
3. Chill and load the engine high-pressure (pneumatic control and turbine start) bottles.
4. Ignite single hydrogen burner.

Run No. 2 (LH_2 Tank Pressurized to 30 psia)

1. Allow engine pump housing to return to initial equilibrium conditions (Monitor surface temperature patches on turbopumps).
2. Allow engine bell to return to initial conditions and determine warm-up characteristics.
3. Same as Run No. 1, except for LH_2 tank pressure and ignite two hydrogen burners.

Run No. 3 (LH_2 Tank Pressurized to 22 psia)

1. Same as Run No. 1, except for LH_2 tank pressure and no hydrogen burner ignition.

Run No. 4 (LH_2 Tank Pressurized to 22 psia)

1. Same as Run No. 1, except for LH_2 tank pressure.

FORWARD FLOW RECIRCULATION

Test Conditions

1. LH_2 and LO_2 loaded to 100% level for each run.
2. Plastic LH_2 feed duct installed.
3. Propellants loaded with prevalves open.
4. Flight chilldown pumps installed.
5. Forward flow chilldown.
6. Nominal engine bell chill orifice installed - size based on previous test.
7. Engine bell diffuser installed and purged with GN_2 followed by cooling with water.

Hardware Modifications

1. Normal flight chilldown system installed.

Run No. 1 (Tanks Unpressurized)

1. Run both chilldown pumps simultaneously until thermal equilibrium is reached at the engine pump inlets and gas generator bleed valve outlets.
2. Prepressurize the propellant tanks (LO_2 tank 37 - 40 psia and LH_2 tank 28 - 31 psia), open prevalves with chilldown pumps running, and observe bubble expulsion at liquid surface inside fuel tank. Motion picture and TV coverage required. Duration 30 seconds.
3. Chill engine bell to -200°F and cycle flow to maintain bell at -150 ± 50°F.
4. Chill and load the engine high-pressure (pneumatic control and turbine start) bottles.
5. Ignite single hydrogen burner.

Run No. 2 (Pressurize LH_2 Tank to 29.5 ± 1.5 psia and LO_2 Tank to 38.5 ± 1.5 psia)

1. Allow engine pump housing to return to initial equilibrium conditions.
2. Allow engine bell to return to initial conditions and determine warm-up characteristics.
3. Run both chilldown pumps simultaneously until thermal equilibrium is reached at the engine pump inlets and gas generator bleed valve outlets.
4. Open prevalve with chilldown pumps running and observe bubble expulsion at liquid surface inside fuel tank. Duct and overall motion picture and TV coverage required. Duration 30 seconds.
5. Chill engine bell to equilibrium.
6. Chill and load engine high-pressure (pneumatic control and turbine start) bottles.
7. Ignite both hydrogen bleed burners.

Run No. 3 (Tanks Unpressurized)

1. Same as Run No. 1, except no hydrogen burner ignited.

Run No. 4 (Tanks Pressurized to Nominal Value)

1. Same as Run No. 2, except for tank pressure.

VERIFICATION RUN AND IGNITION TEST

This test will be conducted provided forward flow chilldown proves adequate. This test will allow a blowdown of the engine turbine start bottle and permit the engine to proceed through the initial start phase before cutoff. Engine cutoff will be initiated by automatic firing control logic at engine start - no ignition (Run No. 1), and by expiration of the engine's ignition phase timer (Run No. 2). This will permit an evaluation of the engine's ability to start without proceeding to main-stage operations.

Test Conditions

1. LH_2 and LO_2 loaded to 100% level for each run.
2. Stainless steel LH_2 duct installed.
3. Propellants loaded with prevalves open.
4. Flight chilldown pumps installed.
5. Forward flow chilldown.
6. Nominal engine bell chill orifice installed.
7. Engine bell diffuser installed, and purge with GN_2 followed by cooling with water.
8. Douglas automatic firing control logic.

Hardware Modifications

1. Normal flight chilldown recirculation system installed.

2. Rocketdyne recommends the following procedure be used for ignition tests on J-2 engine S/N 2003:

   a. Disconnect the electrical connector P16 from the start tank pressure switch.

   b. Cap J16 (i.e., the pressure switch end of the connector) to protect from dirt and water.

   c. Fabricate a jumper across pins B&G of a 14S shell size, 5 pin connector.

   d. Connect the jumper, mentioned in Step 3, to the start tank pressure switch harness. (P16 connector of electrical harness 502126).

   e. Disconnect the electrical connector P15 from the mainstage solenoid.

   f. Cap J15 (i.e., the solenoid portion of the connector) to protect from dirt and water.

   g. Fabricate a jumper across pins C&D of a 14S shell size, 4 pin connector.

   h. Connect the jumper, mentioned in Step 7, to the mainstage solenoid harness (P15 connector of electrical harness 502126).

3. Upon completion of (2) above, a sequence test must be performed per RA0220-300D, J-2 Rocket Engine Assembly Acceptance Firing Procedure, Section 4.4.7 through 4.4.8. The installation of the aforementioned jumpers will cause the test to terminate upon the expiration of the ignition phase timer, due to the absence of a turbine start bottle depressurized signal.

Run No. 1 (Propellant Tanks Unpressurized)

1. Prepressurize the LH_2 and LO_2 tanks to 37 - 40 psia.
2. Engine cutoff initiated by the automatic firing control logic - NO IGNITION.

Run No. 2

1. Same as Run No. 1, except engine cutoff will be initiated by the expiration of the engine's ignition phase timer.

6.D. BATTLESHIP NON-FLIGHT COMPONENTS

The following list closes Action Item No. 4030

Part Number	Component
1A69680	Purging System Installation
1A69671	Duct, Flexible
1A69672	Support, Duct
1A69674	Duct, Distribution
1A69675	Duct, Inlet
1A69677	Duct, Short
1A69678	Bracket, Purging System
1A69679	Strap, Duct Support
1A82512	Bracket, Duct, Helium Bottle
1A82515	Duct, Lower, Attitude Control Simulation
1A82516	Brace, Horizontal, Duct, Attitude, Control Simulation
1A82517	Brace, Vertical, Duct, Attitude Control Simulation
1A82827	Support Bracket, Helium Bottle
1A86812	Plate, Dud, Electronic Panel
1A86813	Plate, Center, Electronic Panel
1A86814	Clip, Plate, Upper, Electronic Panel
1A86815	Clip, Plate, Lower, Electronic Panel
1A86974	Baffle, Manifold, Purging System
1A87015	Plate, Electronic Panel
1A87487	Frame, Aft Skirt, Station 201.250
1A87549	Frame, Aft Skirt, Station 220.688
1A87930	Frame, Aft Skirt, Station 235.375
1A87931	Frame, Aft Skirt, Station 235.375
1A87932	Frame, Aft Skirt, Station 235.375
1A87933	Frame, Aft Skirt, Station 220.688
1A88186	Plate, End, Electronic Panel
1A89994	Duct, Umbilical Connector
1A93041	Gasket, Duct, Umbilical Connector
1A93797	Panel, Aft Interstage
1A94701	Duct Assy, Flow Control
1A69665	Valve, Butterfly, Environmental Control

Part Number	Component
1A69666	Shaft, Environmental Control
1A69668	Fitting, Environmental Control
1A69669-1	Plate, Orifice, Environmental Control
1A69670	Gasket, Environmental Control
1A69673	Plate, Indicator, Environmental Control
1A69676	Duct, Long, Purging System
1A69681	Duct, Flanged, Purging System
1A95029	Test Requirements, Flow Control, Duct Assy.
1A94858	Duct Assy., Attitude Control Simulation
1A69667	Indicator, Environmental Control
1A82513	Duct, Upper Extension
1A82514	Duct, Attitude Control Simulation
1A82518	Valve, Butterfly Control Simulation
1A82519	Shaft, Attitude Control Simulation
1A82520	Plate, Orifice, Attitude Control Simulation
1A82521	Gasket, Attitude Control Simulation
1A95175	Stiffener, Environmental Control
1A95243	Duct Assy., Helium Bottle
1A82510	Duct Flanged, Helium Bottle, Air Conditioning
1A82511	Duct, Extension
1A98744	Test Requirements, Duct Assy., Helium Bottle, Flow Control
1A97095	Baffle, Umbilical Connector
1A98050	Plate, End, Electronic Panel
1A98051	Plate, End, Electronic Panel
1A98052	Plate, End, Electronic Panel
1A98053	Plate, End, Electronic Panel
1A98054	Plate, End, Electronic Panel
1A98055	Plate, End, Electronic Panel
1A96233	Bolt, Skirt Aft Interstage
1A95631	Plate, Center, Electronic Panel
1A96641	Support, Tank
1B26717	Plate, Support
1A67848	Sequence Mounting Assy

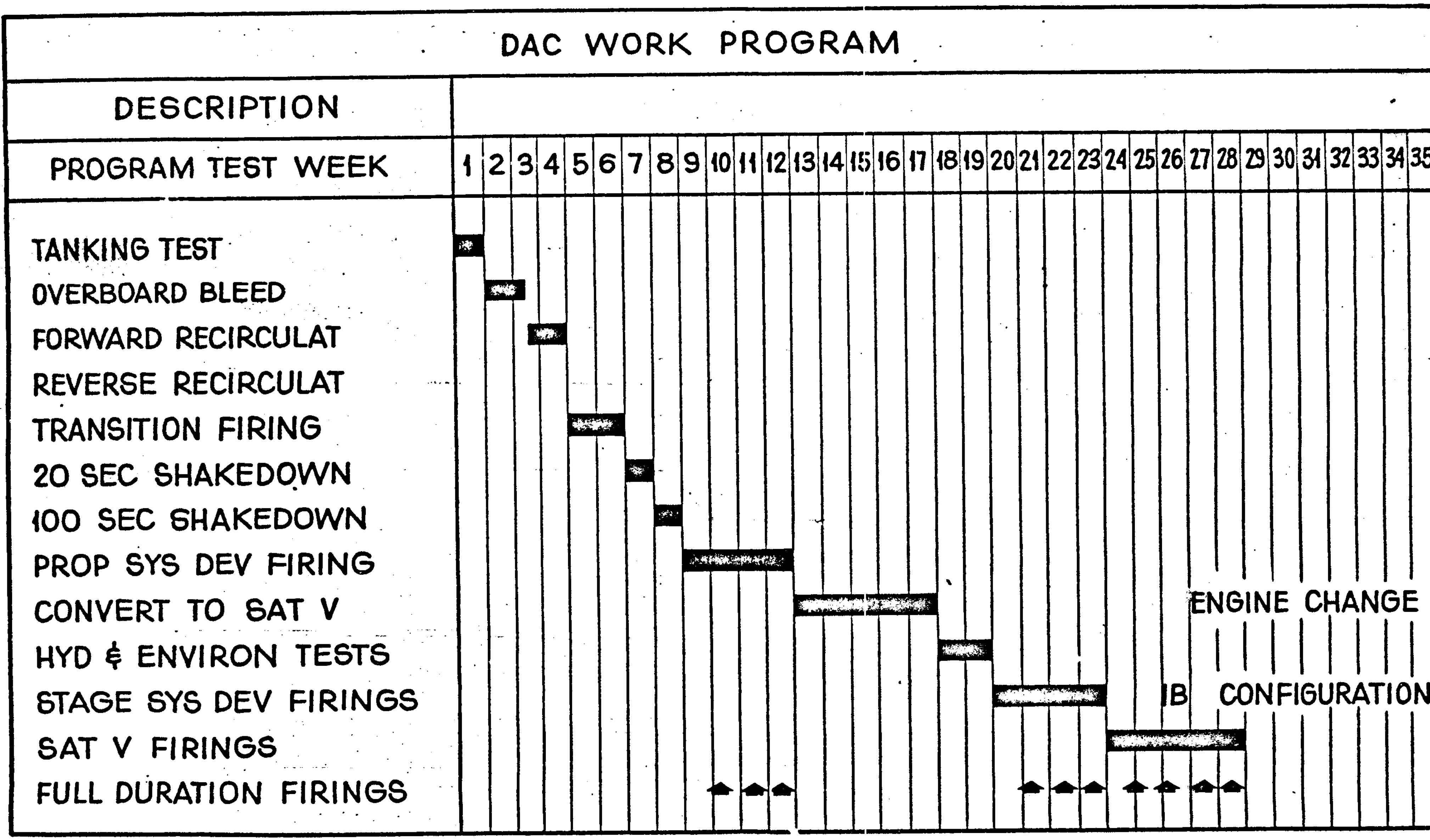
Part Number	Component
1B27293	Plate, End, Electronic Panel
1B27294	Plate, End, Electronic
1A96999	Support, Accumulator, Reservoir Assy
1B26903	Support, Accumulator, Reservoir Assy.
1B26904	Plate, Adapter, Flex Hose Support
1B27506	Plate, Adapter, Hydraulic Pump
1B28722	Support, Hydraulic Lines
1A96641	Support, Tank, Aft Interstage
1B29716	Frame, Aft Skirt-Station 235, 375, Battleship
1B31156	Frame, Aft Skirt - Station 235, 375, Battleship
1B27981	Tube Assembly, Low, Pressure, Aux. Pump
1B27982	Tube Assembly, High Pressure, Aux. Pump
1B27983	Tube Assembly, Therm. Cond. Aux. Pump
1B27984	Tube Assembly, Low Pressure Acc. Reservoir
1B27986	Tube Assembly, Low Pressure, Actuators
1B27989	Tube Assembly, Low Pressure, Pitch Actuator
1B27990	Tube Assembly, High Pressure, Pitch Actuator
1B27985	Tube Assembly, High Pressure, Acc. Reservoir
1A67967-1	Support Installation Tank
1A72765-1	Elect. Equip. Instl. Stage
1A69481-1	Elect. Equip. Instl. LH_2 Tank
1A68596-1	Support Instl., Point Level Transducer LH_2 Tank
1A68092-1	Adapter Supt., Universal
1A68130-1	Structure Assy, P.U. Probe
1A68129-1	Fitting
1A68225-1	Mount, Probe, Lower
1A68222-1	Saddle Assy, Supt., Probe
1A68997-1	Adapter, Instrument and P.U. Probe
1A68998-1	Adapter, Rough Mach., Instr. and P.U. Probe
1A68468-1	Probe Instl., Instru. LH_2 Tank
1A69376-1	Supt., Temp. Sensor
1A68129-1	Fitting
1A69289-1	Support, Sensor
1A68226-1	Clamp, Probe Supt.
1A68223-1	Supt. Assy, Mtg Probe, Lower

Part Number	Component
1A68224-1	Supt., Probe, Upper
1A68382-1	Elect. Equip. Instl. LOX Tank
1A69282-1	Supt. Instl. Probe LOX Tank
1A74134-1	Supt. Assy, Probe Mass, Lower
1A74745-1	Beam Assy, Probe Supt, LOX Tank
1A74673-1	Retainer Pad, Supt., Lower Probe, LOX
1A74814-1	Supt. Assy., LOX Probe #2
1A74815-1	Supt. Assy., LOX Probe #3
1A74813-1	Supt. Assy., LOX Probe #1
1A74672-1	Pad, Supt. Lower, LOX Probe
1A77079-1	Supt. Adjustment, LOX Tank
1A77815-1	Retainer, Pad Supt., Upper LOX Probe
1A77814-1	Pad, Supt., Upper LOX
1A77813-1	Pad. Supt., Upper LOX
1A77816-1	Retainer Supt., Upper LOX Probe
1A78065-1	Tube, Beam Supt.
1A78066-1	Tube, Beam, Adj. Supt.
1A67943-1	Supt. Instl. Point Level Trans. LOX Tank
1A68826-1	Adapter, Point Level Feed Thru LOX Tank
1A68827-1	Adapter, Rough Mach. Point Level Feed Thru LOX Tank
1A69160-1	Probe Instl., P. U. LOX Tank
1A67904-1	Adapter, P. U. Probe, LOX
1A68700-1	Adapter, Rough Mach., P. U. Probe LOX, Tank
1A83764-1	Transducer, Instl. Temp., Common Dome Tank
1A68942-1	Probe Instl., Instr., LOX Tank
1A67903-1	Adapter, Instr. Probe, LOX Tank
1A68699-1	Adapter, Rough Mach. Instr. Probe, LOX Tank
1A98543-1	Wiring Harness
1A98593-1	Wiring Harness
1A95836-1	Wiring Harness
1A98594-1	Wiring Harness
1A95844-1	Wiring Harness
1A95846-1	Wiring Harness
1A95847-1	Wiring Harness

Part Number	Component
1A68936-1	Adapter Assembly (LOX)
1A74160-1	Bellows Assembly (LOX)
1A69064-1	Adapter Assembly (Fuel)
1A74534-1	Bellows Assembly (Fuel)
Vendor P/N 31120	Diffuser Assembly
1A74675-1	Flange Assembly
1A77118-1	Elbow Assembly
1A74835-1	Adapter Assembly
1A69035-1	Elbow Assembly
1A86539-1	Arm
1A86540-1	Support
1A86540-2	Support
1A77843-1	Bellows Assembly
1A89490-1	Mount Internal Fuel
Vendor P/N SCS1000	Annin Valve (Vernier Control)
1A88081-1	Hose Assembly (For Vernier Control)
1A96230	Fitting, Fuel Feed Strut Right
1A96229	Fitting, Fuel Feed Strut Left
1A96228	Fitting, Fuel Feed Strut Right
1A96227	Fitting, Fuel Feed Strut Left
1A68760-1	LOX Sump
1A82829-1	Flange - LH_2 Pump Adapter
1A97073-1	Duct Assy. - LH_2 Recirculation
1A87199-1	Elbow Assembly
1A87741-501	Duct Assy. LH_2 Tank Return
1A87739-1	Duct Assy. LH_2 Panel Tank Return
1A49423-1	Pump LO_2 Recirculation
1A82830-1	Flange - LOX Pump Adapter
1A86886-1	Elbow LO_2 Return
1A87737-1	Duct Assy LO_2 Tank Return
1A93181-1	Pipe Assy, LOX Dump, Port End
Vendor P/N 526542	Butterfly Valve 6" NC
1A93882-1	Beam, Bellows Support
1A93882-2	Beam Bellows Support
1A93881	Bracket Bellows Support

Part Number	Component
Vendor P/N LF-060-150	TempFlex Bellows (With SS Flanges Welded for LOX Service)
1A88768-1	Harness, Helium Bottle
1A78064-1	Adapter, Cold Helium Bottle
1A68863-501	Manifold - Cold Helium Bottle
1A68863-1	Manifold - Cold Helium Bottle
1A87645-1	Connector, Manifold, Cold Helium Bottle
1A87989-1	Tube Assy. Cold Helium Bottle
1A82778-1	Arm Support
1A82777-1	Plate Assy
1A82663-1	Leak Detector - Riser, Cold Helium
1A83292-1	Flange Adapter, Hydrogen
1A83902-1	Diffuser Assy. Hydrogen
1A87184-1	Adapter, Oxygen Pressure Sensing
1A96470-1	Mount, Component, Helium Control
1A96471-1	Mount, Component, LO_2 Tank Pressurization
10156-1 Vendor P/N	Hose Assy, Metal Flexible, Prepress. Fuel Tank

BATTLESHIP HOT FIRING



STATUS REPORT OF J-2 "START COMMITTEE"

As a result of the June 1964 Interface Meeting at MSFC, a committee was formed to evaluate and coordinate problems associated with starting the J-2 engine. Membership to the committee includes representatives of Douglas Aircraft Company (DAC), Space and Information Systems Division (S&ID), Rocketdyne, and Marshall Space Flight Center.

In conjunction with DAC, Rocketdyne and MSFC, this committee has formulated minimum test programs to be conducted at Rocketdyne and Sacrameto which will provide basic information necessary to evaluate the adequacy of systems presently being considered to chill the J-2 engine. In addition to the above, the chill system instrumentation is being reviewed to insure compatibility between the engine and stage contractors.

AUG 20 REC'D

APPENDIX G

7.0 CONTINUOUS VENTING (SATURN V)

7.A. Vent Design

The present design for the Saturn 5 vent system includes propulsive continuous vent ports and non-porpulsive blowdown vent ports. For a tank pressure of 21 psia, and only the continuous vents system operating, the axial thrust is 6.7 pounds. Using the same tank pressure, but adding the effect of the non-propulsive vent flow, the thrust is 4.9 pounds.

The low axial thrust toward the end of fuel tank blowdown indicates the desirability of obtaining some axial thrust from the present non-propulsive vents by canting the exits aft. The factors limiting the angle at which the vents can be directed aft are the velocity increase restrictions applying to Saturn IB orbital coast and Saturn 5 translunar coast. For Saturn 5 translunar coast, the vent angle can be as large as 13.1° without exceeding 1 meter/sec. velocity increase due to fuel and oxidizer venting. However, the velocity increase on Saturn IB due to LOX tank blowdown alone is almost 1 meter per second. Thus, if the velocity change limitation on Saturn IB is maintained, the blowdown vent system cannot directed aft. Figure 18 shows the additional thrust that can be obtained during fuel tank blowdown as a function of vent angle. Figure 19 indicates the increase in velocity during the first Saturn IB fuel and oxidizer tank ventings as a function of the fuel blowdown vent angle.

7.B. Aft Skirt Weight Reduction

The resizing of the Saturn 5 APS modules has resulted in a weight reduction on the aft skirt of approximately 25 pounds.

The primary sources for this reduction were the back-up intercoastals and fittings. Modifications to the frames had a minor effect on the weight reduction. The frame loads decreased due to the lighter APS module; however, the attachment at the tank joint was eliminated resulting in a small net change.

7.C. Fuel Tank Vent Tolerances

Figure shows the location and angularity tolerances of the non-propulsive and continuous fuel tank vents. These tolerances, combined with orifice and vent duct manufacturing tolerances, were used to estimate the variation in thrust at each exit. The thrust tolerance at each non-propulsive vent exit was estimated to be less than ±1.5% of the nominal balanced exit thrust. The tolerance on the continuous vents will also be within this range. For the purpose of sizing the APS a thrust tolerance of ±10% for each vent exit was used.

SATURN IB FUEL BLOWDOWN AXIAL VELOCITY INCREASE vs VENTING ANGLE

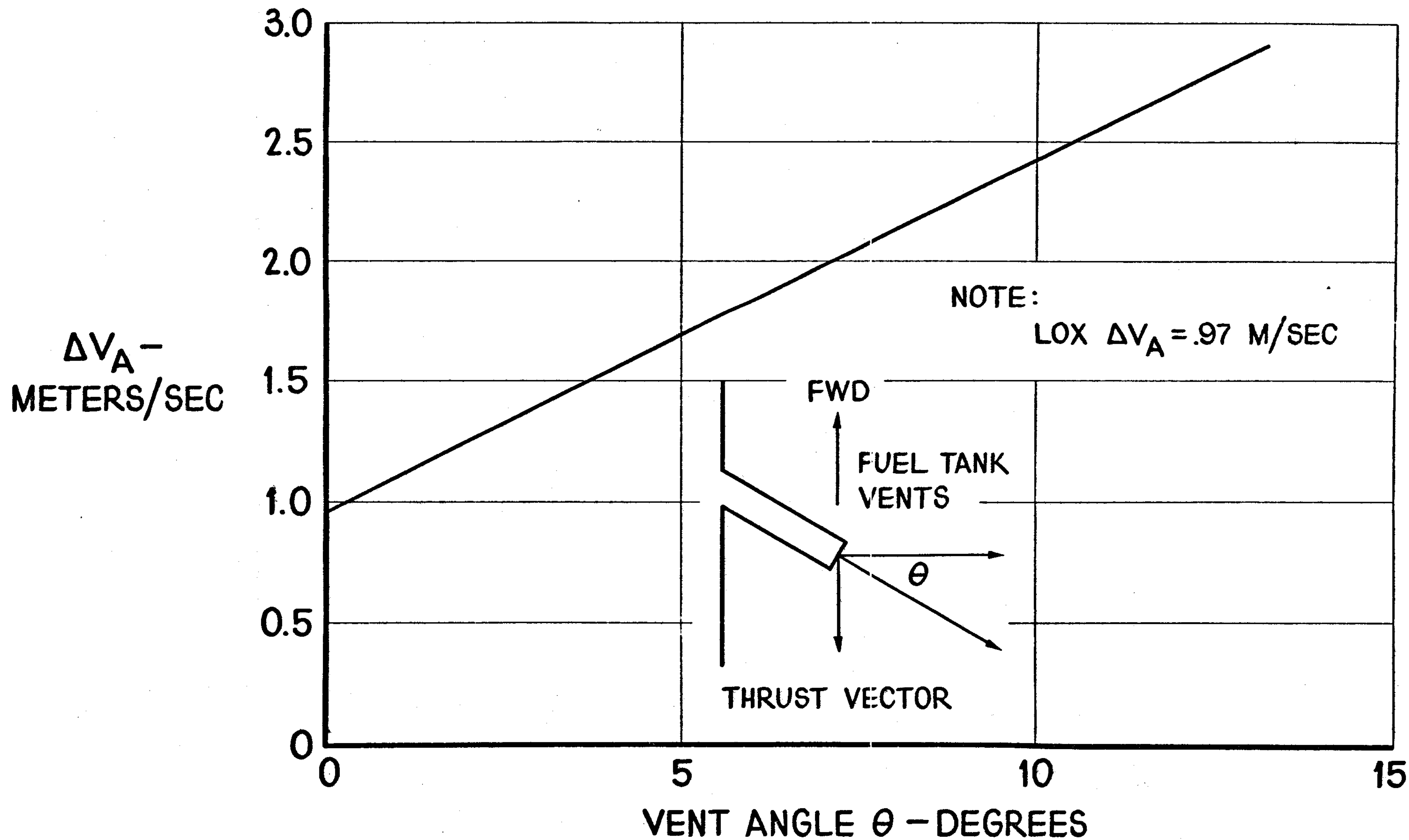


FIGURE 18

SATURN V HYDROGEN BLOWDOWN AXIAL VENTING THRUST VS VENTING ANGLE

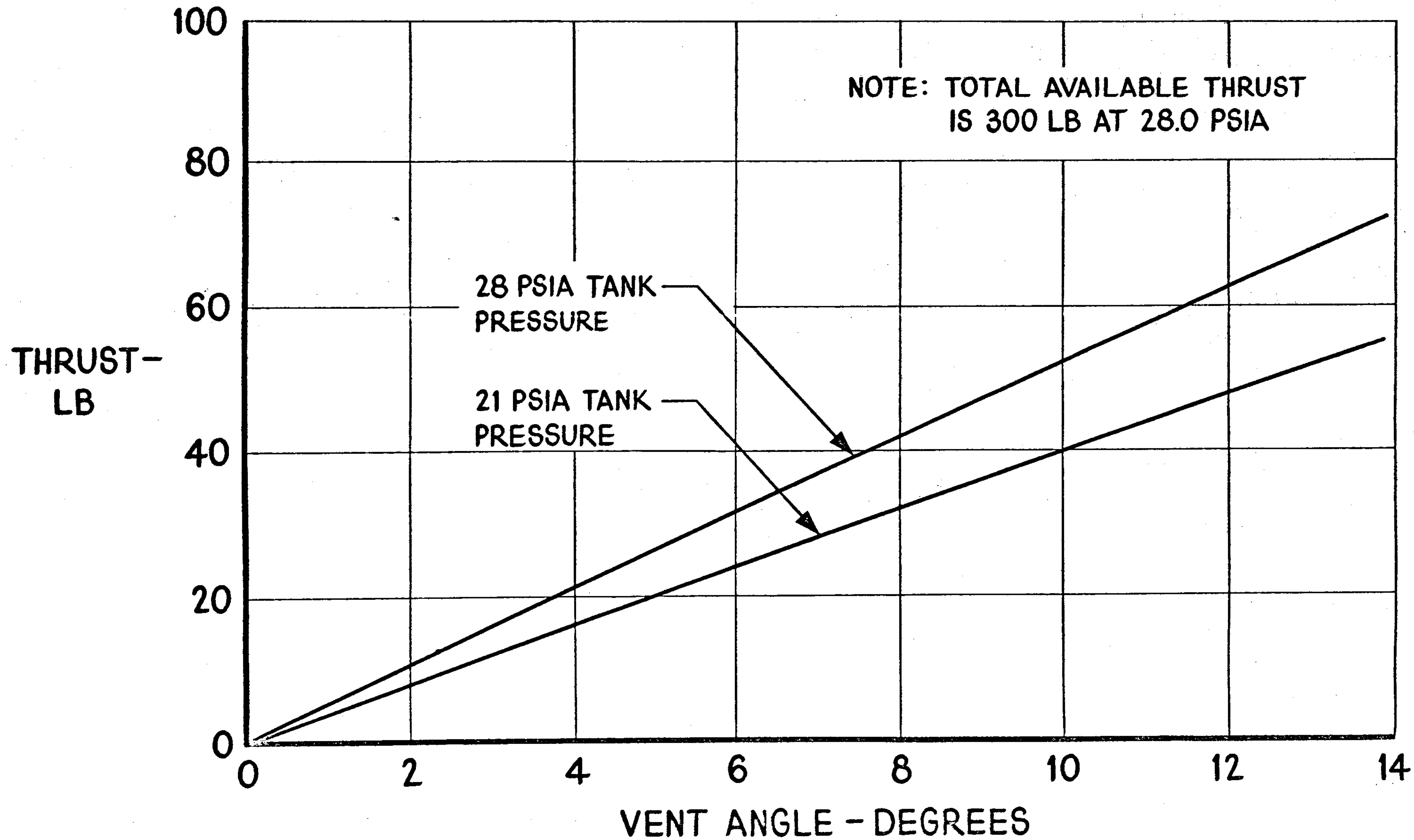


FIGURE 19

EXIT TOLERANCES OF HYDROGEN VENT SYST.-PRELIMINARY

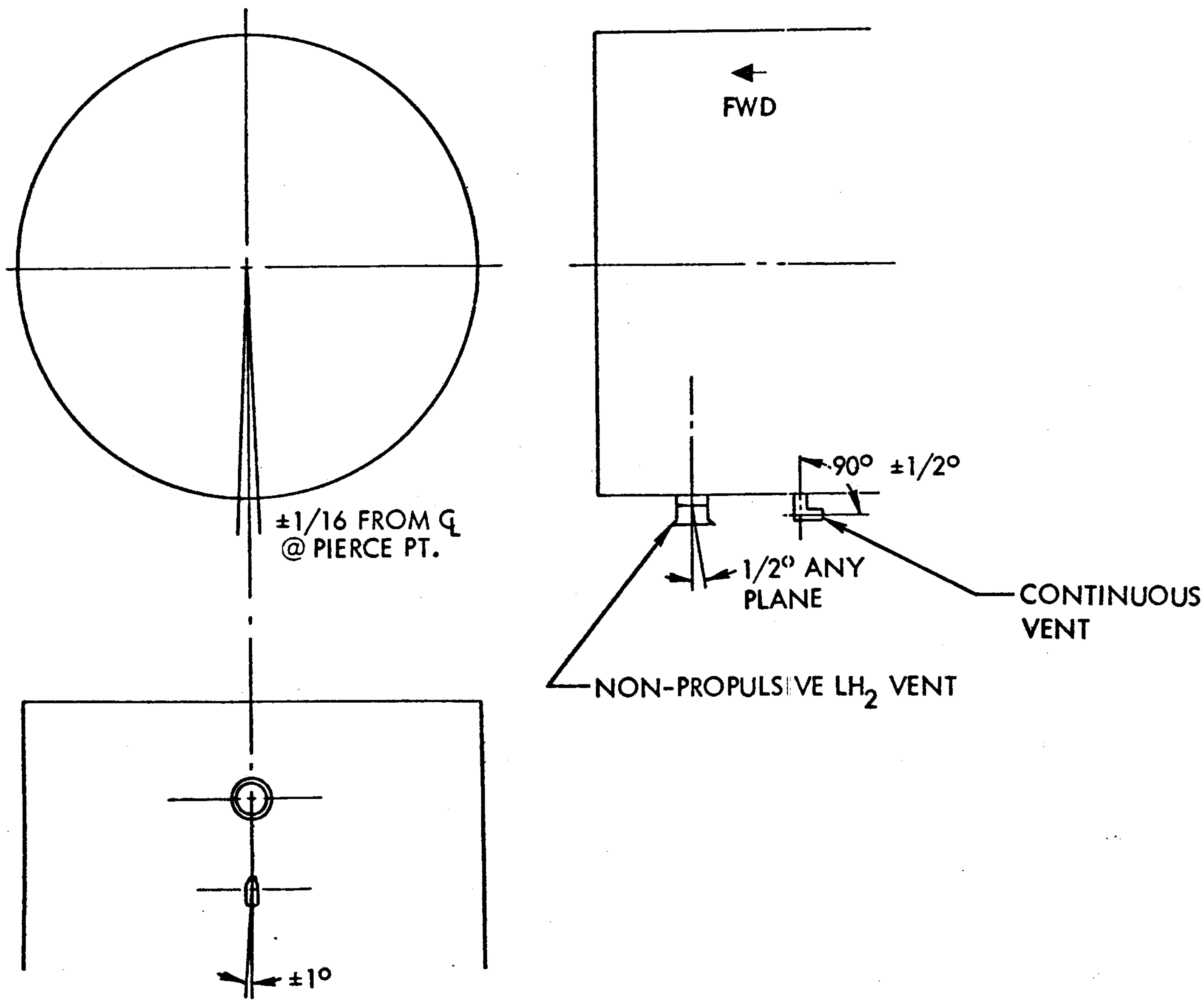
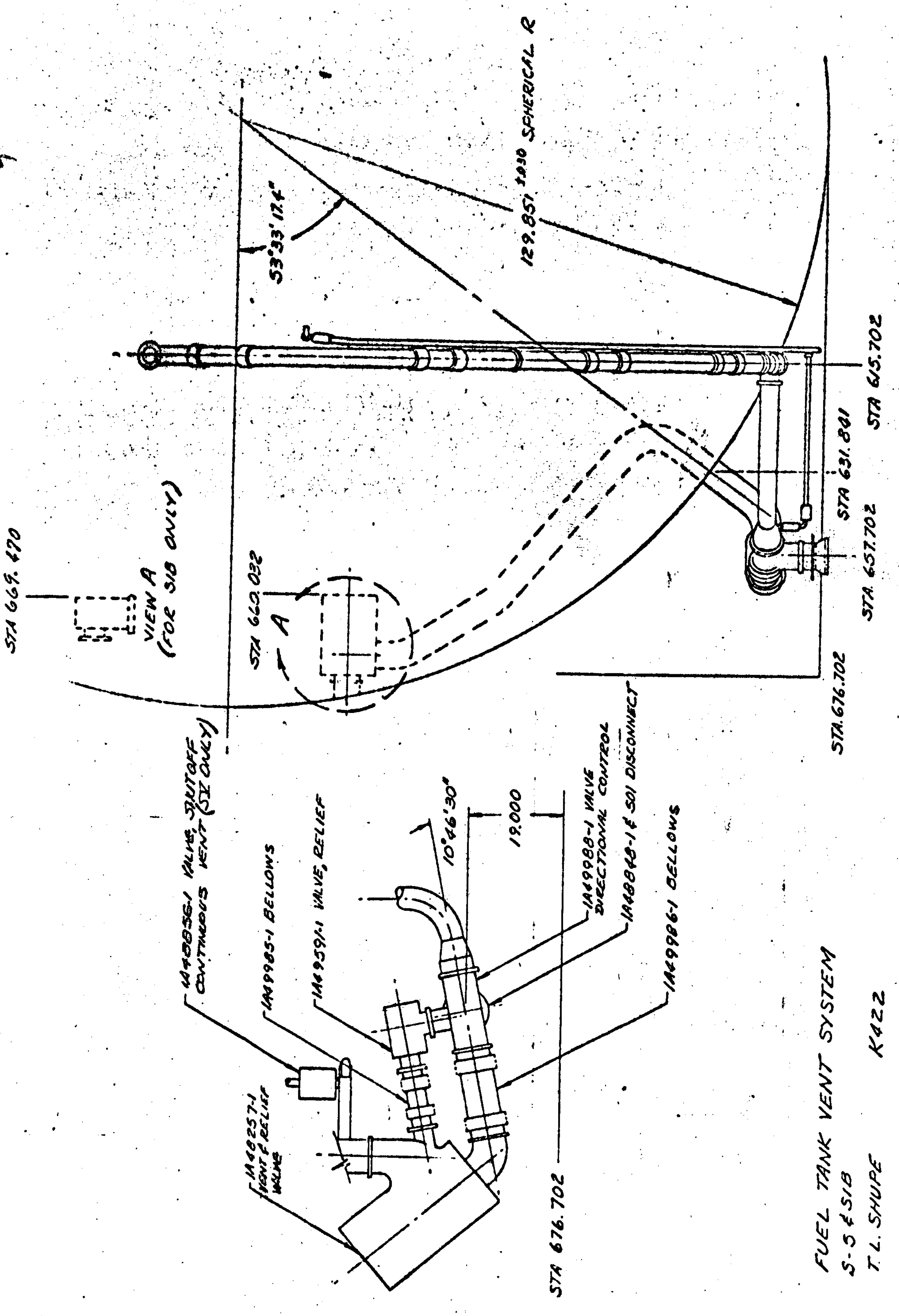
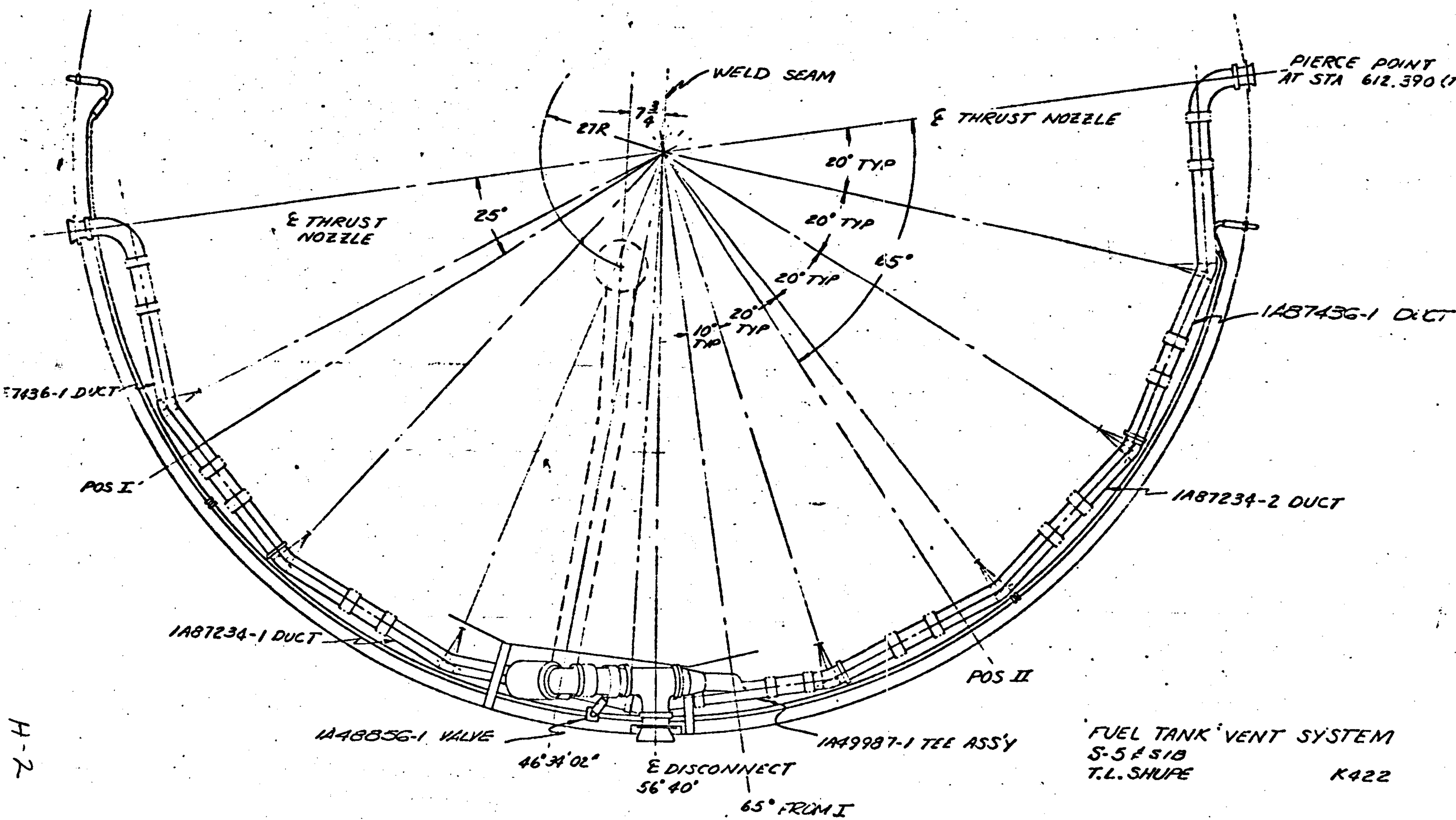


FIGURE 20


STA 669.470
VIEW A
(FOR S1B ONLY)
STA 660.032
A
129.851 ±.030 SPHERICAL R
53°33'17.4"
STA 615.702
STA 631.801
STA 657.702
STA 676.702
1A48836-1 VALVE, SHUTOFF
CONTINUOUS VENT (S-I ONLY)
1A49985-1 BELLOWS
1A49591-1 VALVE, RELIEF
1A48257-1
VENT & RELIEF
VALVE
10°46'30"
19.000
1A49988-1 VALVE
DIRECTIONAL CONTROL
1A48848-1 & S01 DISCONNECT
1A49986-1 BELLOWS
STA 676.702
FUEL TANK VENT SYSTEM
S-I & S1B
T.L. SHUPE
K422


PIERCE POINT
AT STA 612.390
WELD SEAM
$7\frac{3}{4}$
27R
℄ THRUST NOZZLE
℄ THRUST NOZZLE
25°
20° TYP
20° TYP
20° TYP
20° TYP
10° TYP
65°
1A87436-1 DUCT
7436-1 DUCT
POS I
POS II
1A87234-2 DUCT
1A87234-1 DUCT
1A48856-1 VALVE
46°34'02"
℄ DISCONNECT
56°40'
65° FROM I
1A49987-1 TEE ASS'Y
FUEL TANK VENT SYSTEM
S-5 & S1B
T.L. SHUPE
K422

8.0 AUXILIARY PROPULSION SYSTEM (APS)

8.A.1 Weight

The Saturn IB configuration design and weight status is presented in Figure 21.

8.A.2 Test Program

The status of the test program will be presented. Current information was not available at the printing deadline of this document.

8.A.3 Service Requirements and Cleaning Procedures (SACTO)

The servicing and cleaning requirements are presented in Figures 22 and 23.

The following presents the procedures for securing and cleaning the APS:

8.A.3.1 Over-all Plan (See Figure 24)

a. Definitions

1. To "secure" is defined as "to make safe for stand-by" (Propellant systems empty, but not necessarily dry).

2. To "clean" is defined as complete removal of all liquids and their vapors to a predetermined measurable level.

b. When "securing" (Safe) is required.

1. Whenever there is a launching abort producing a delay long enough to result in personnel approaching the APS, but the time to re-use of the APS is less than 30 days.

c. When "cleaning" is required

1. After a "hot" acceptance test firing.

2. Whenever time to re-use of the APS exceeds 30 days but does not exceed 90 days.

3. When the APS must be prepared for indefinite storage or shipment.

SATURN IB APS DESIGN & WEIGHT STATUS

REMAINING DESIGN

- COMPLETE ENV'RT PROVISIONS
- PLUMBING DEV MODIFICATIONS
- ELECTRICAL HARNESS DEV
- REVISION & UP-DATING PRODUCTION TEST REQ'MTS
- SPECIAL TEST EQUIPMENT
- MISC, REVISION & CORRECTIONS (SUSTAINING)

WEIGHT STATUS

- APS WEIGHT EXCLUDING AFT SKIRT MOUNTING PROVISIONS — 789 LB/STAGE

FIGURE 21

APS REQUIREMENTS FOR GSE

1. CHECKOUT (H_e OR GN_2 GAS SUPPLY REQUIRED
   - CHECK CALIBRATION, 6 PRESSURE SWITCHES
   - CHECK INSTRUMENTATION CALIBRATION
   - LEAK-CHECK, MANUAL
   - FUNCTIONAL CHECK (AUTOMATIC)

2. PROPELLANT FILL
   - NITROGEN PURGE (MINIMIZE MOISTURE & AIR)
   - RECIRCULATE PROPELLANT TO MINIMIZE GAS TRAPS
   - PROPELLANT TEMPERATURE CONTROL (PREVENT PROPELLANT FREEZING DURING COAST), 85 ± 5°F AT AMR ONLY
   - CONTROLLED FILL RATES, GROUND SHUT-OFF FOR SAFETY
   - BELLOWS PROTECTION
     - A) CONTROLLED ΔP ACROSS BELLOWS
     - B) POSITION INDICATION (PROPELLANT MEASUREMENT DEVICE) CONTROLS CUT-OFF
   - H_e PRESSURIZATION FOR PROPELLANT STORAGE DURING STANDBY OR HOLD, 75 PSIA NOMINAL
   - MINIMUM SPILLAGE OR LEAKAGE, SAFETY

FIGURE 22

APS REQUIREMENTS FOR GSE (CONT)

3. PROPELLANT DRAIN & SECURE

- BELLOWS, COLLAPSE, DRAIN
- AMB GN_2 PURGE, MINIMIZE PROPELLANTS RESIDUALS (SHORT HOLD)
- LONG TERM STORAGE

    A) HOT GN_2 PURGE, VAPORIZE PROPELLANTS RESIDUALS (30 TO 90 DAYS)

    B) FREON MF SOL'N FLUSH, HOT GN_2 PURGE (IF REQ'D FOR OVER 90 DAYS)

    C) COMPLETE DISASSEMBLY & WASH (IF REQ'D FOR OVER 90 DAYS)

- SECURE, PROVIDE DRY AMB INTERNAL PRESSURE & CAP PORTS (DESSICANT FOR LONG TERM STORAGE)

4. HELIUM FILL, 3000 PSIA SUPPLY

FIGURE 23

S-IVB/SATURN IB APS MODULE CLEANING

FLOW DIAGRAM

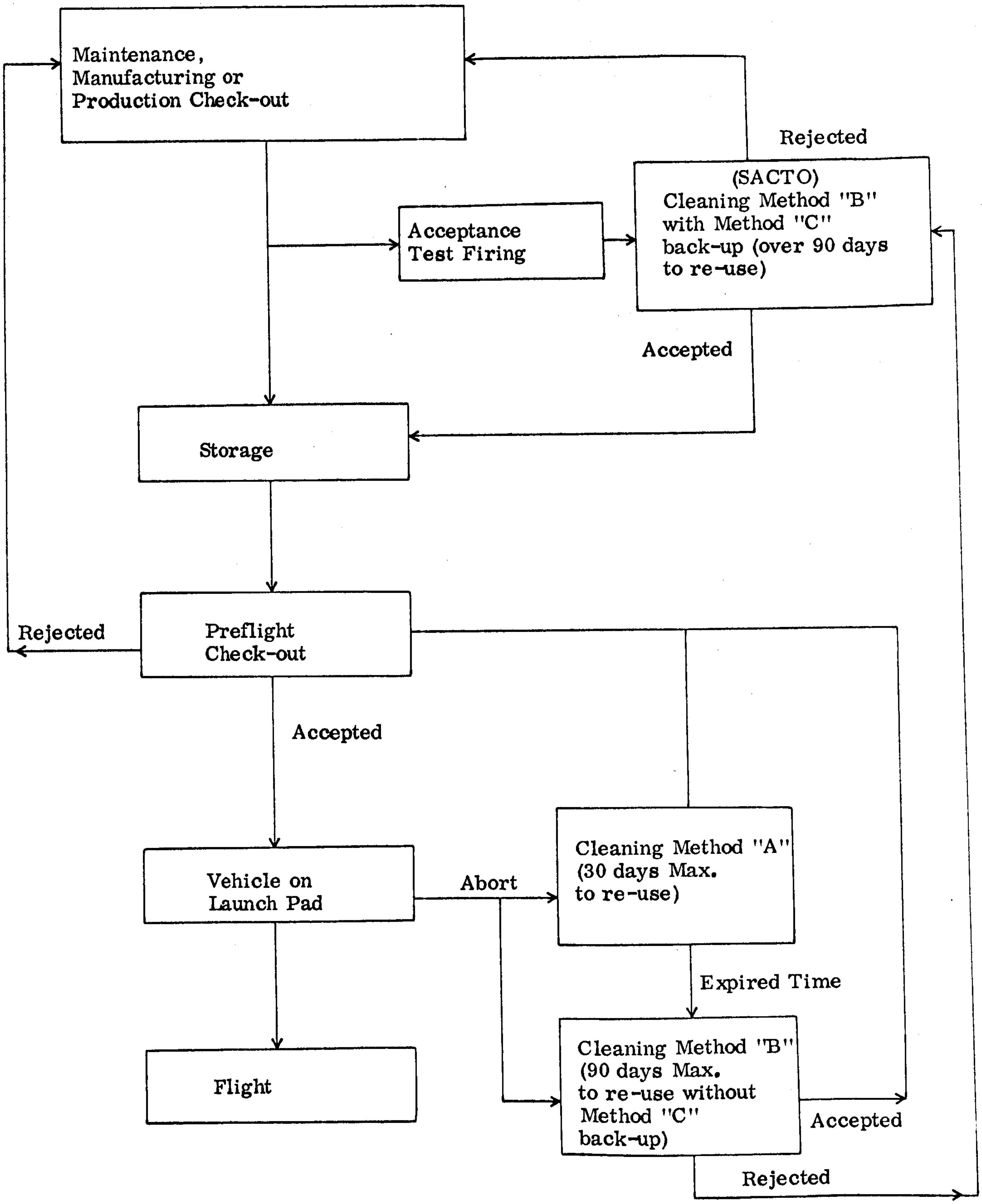


FIGURE 24

d. Purpose of each of the Methods (Procedures)

1. Method "A" ("Secure" for stand-by, AMB GN_2 Purge)

   a. To make the APS sufficiently inert and safe for stand-by, not to exceed 30 days.

   b. To make it safe to remove the APS from the vehicle if removal is necessary.

2. Method "B" (Maximum cleanliness through hot nitrogen purging only).

   a. To make the APS sufficiently inert and safe for stand-by and re-use for indefinite periods.

   b. To make the APS sufficiently safe for disassembly without use of elaborate protective equipment for personnel.

   c. To make the APS safe for shipment.

   d. To form a portion of cleaning Method "C", if Method "C" is required.

3. Cleaning Method "C" (Freon MF flush, hot nitrogen purge).

   a. To provide a back-up cleaning method to be used if Method "B" is not adequate for periods in excess of 90 days.

8.A.3.2 Brief Description of Cleaning Methods

a. "Secure" for stand-by (Method "A")

1. Off-load high pressure helium.

2. Off-load oxidizer.

3. Off-load fuel.

4. Purge each propellant system with ambient nitrogen for 15 minutes.

5. Pressurize the propellant systems and the ullage volumes to provide a safe blanket storage pressure.

b. Maximum Cleanliness (Method "B")

1. Off-load high pressure helium.

2. Off-load oxidizer.

3. Off-load fuel.

4. Purge each propellant system with hot nitrogen (160°F) until the outflowing gas sample shows less than 50 ppm.

5. Pressurize the propellant systems and the ullage volumes to provide a safe blanket storage pressure.

6. After 30 days and at 60 days, repeat gas sampling to determine propellant concentration and repurge if necessary. At 90 days, if repurging is required, perform back-up Method "C".

c. Maximum Cleanliness back-up using Freon MF flush and hot GN_2 purge (Method "C")

1. Load and off-load each propellant system with Freon MF.

2. Purge each propellant system with hot nitrogen as in Method "B", above, until gas samples indicate propellant and Freon MF concentrations are less than 50 ppm.

3. Return the systems to the "storage" condition noted above.

8.A.4 APS Propellant Measurement Requirements

8.A.4.1 Loading Accuracy Based on Full Load

a. Micro switch actuation TOL, approx. ±0.1% (requirement 9.760 ±.010)

b. Electrical transmission (hardwired), neglect

c. Hardware TOL, approx. ±0.2%

d. Flow rate variations (1/2 GPM) and valve closing response variations (20 millisecs), approx. ±0.025%

e. Total TOL ≈ ±0.33% of full load

f. Requirement = ±0.5% of full load

8.A.4.2 Propellant Measurement

The MRD which requests the measurement called for a ±3% accuracy. The sensor is an extensiometer, DAC P/N 1A74488, which calls for a linearity of ±0.5%. A signal is transmitted via the S-IVB telemetry system to the ground and is not made available to the astronaut. No signal conditioning is required. The signal is sampled at 12 samples per second on PAM and 4 samples per second on PCM. With these sampling rates the ±3% accuracy can be met.

8.A.5 Environmental Control Provisions

8.A.5.1 Design

The design environmental control provisions are presented in Figure 25.

8.A.5.2 Analysis

The analytical environmental control provisions are presented in Figure 26.

a. General Discussion

The thermal analysis of the Auxiliary Propulsion System depends on the thermal characteristics of the design and on engine firing sequence assumptions. These factors have been studied in considerable detail for a number of configurations with the objective of determining the least complex system which will provide non-freezing of the propellants for the duration of the mission. This objective, however, will probably not be attained until information is available on minimum required engine firing sequences. Theoretically, the possibility that one of the two modules will never pulse can be shown to exist (assuming no maneuvering or venting). However, it is very unlikely that this will occur and studies are in progress in an effort to define realistic minimum pulsing rates. Further information is required, particularly in the area of mission definition, to assist in these studies. Commanded pulsing of the APS engines offers a seemingly simple solution to the problem of obtaining desired minimum oxidizer flow should studies in progress indicate that the possibility of insufficient oxidizer flow (for any given thermal design) exists for realistic mission conditions, provided sufficient propellants are available.

Due to the lack of information concerning realistic minimum engine firing sequences, the system initially must be designed on the conservative assumption that no firing occurs. The study actually includes assumed engine pulse rates for comparative purposes, but the potential advantage

SATURN IB/S-IVB APS FLT. DESIGN ENV'RT CONTROL PROVISIONS

DESIGN PHILOSOPHY — PASSIVE SYSTEM

DESIGN CONSIDERATIONS

- EXTERIOR FINISH
  - THERMOLAG (NOSE) $\epsilon \approx .84$, $\alpha \approx .94$, $\frac{\alpha}{\epsilon} \approx 1.12$
  - BLACK PAINT $\epsilon \approx .84$, $\alpha \approx .94$, $\frac{\alpha}{\epsilon} \approx 1.12$
  - AL Si PAINT $\epsilon \approx .22$, $\alpha \approx .24$, $\frac{\alpha}{\epsilon} \approx 1.09$
- INTERIOR FINISH — AL Si PAINT, $\epsilon \approx .22$
- PROPELLANT LINES — LOW EMISSIVITY
  - POLISHED STAINLESS LINES
  - AL Si PAINT
  - LINE SUPPORTS
- COMPONENTS — LOW EMISSIVITY
  - POLISHED
  - AL Si PAINT
- HIGH PERFORMANCE INSULATION ONLY IF REQ'D

FIGURE 25

SATURN IB/SIVB APS FLT. ANALYSIS ENV'RT CONTROL

PHASE I ANALYSIS – NO PROP FLOW

PHASE II ANALYSIS – PROP FLOW

BASIC ASSUMPTIONS

- BLACK OR AL Si PAINT ON EXTERIOR
- SUMMER MID-NIGHT LAUNCH (WORST CASE)
- LINE EMISSIVITY $\approx$ 0.22
- NO HIGH PERFORMANCE INSULATION

FIGURE 26

is not used for design. It is, therefore, requested that DAC be furnished as soon as possible with the information required to determine APS engine minimum pulsing rates. The design will of necessity proceed, however, as discussed above. The analysis is made to determine how long the APS propellants will remain unfrozen in orbit for the initial system design and to determine the modifications required to assume satisfactory thermal performance for the full 4-1/2 hour coast mission. The modifications include the use of fiberglas spacers to reduce contact conductions, teflon clips, and fiberglas intercoastals for clip attachment points. Internal and external surface emissivity control with paint and high performance insulation are also considered.

The freezing temperature of the oxidizer (N_2O_4) is 12°F and that of the fuel (MMH) is -65°F and this analysis, therefore, centers around the thermal protection of the oxidizer system. Any thermal protection system found satisfactory for the oxidizer will be adequate for the fuel. The environment that a given area of propellant tank or a given section of propellant line is subjected to is strongly dependent on the launch time and date. This presentation considers only that launch time and date which is the most severe, thermally, for the oxidizer system (i.e., summer midnight). The study considers the propellant in the lines and tanks separately because of the difference in geometry and heat transfer characteristics.

The propellant tanks are mounted on fiberglas supporting brackets on each end which in turn are attached to the aluminum bulkheads located in the same vicinity. Heat conduction takes place between the propellant tanks and the pod fairing structure through this bracket-bulkhead connection and radiation heat transfer takes place between the fairing structure and the pod interior.

The lines, which run from the propellant tanks to the propellant control modules and from there to the engines, are supported by metal clips with teflon sleeves to reduce the metal-to-metal contact. The clip attachment locations establish the thermal environment to which the line in the vicinity of the clip attach point will be subjected. For example, the pod fairing structure in a given area can have an average orbital temperature of -50°F or lower depending on the paint configuration used. Hence, a clip attached to the fairing in this area may cause freezing of the oxidizer.

An internal fairing surface emissivity of 0.22 was assumed for all configurations. This is possible through paint control or surface treatment. In those configurations where high performance insulation is utilized (attached either directly on the tanks and lines or inside the fairing structure), it is assumed that the high performance insulation properties are degraded sufficiently in the region of the supporting structures as to be ineffective (i.e., the insulation is assumed to be installed between the support and the associated component or fairing which compresses it sufficiently so that the high performance qualities are lost).

The forward line support requires special consideration with regard to external paint or surface conditions. This support is in the region of externally applied ablating material whose surface properties approximate those of the black paint. ($\alpha = 0.94$, $\epsilon = 0.84$). A fiberglas intercostal for mounting the teflon line clip will probably be required for this area to provide satisfactory insulation.

b. Results

(1) Propellant Tanks

It was conservatively assumed in the tank analysis that the propellant does not provide bulk heat storage capacity. The tanks were considered both with and without high performance insulation wrapped around them. The results show that there is negligible propellant temperature change when high performance insulation is used. The temperature remains above freezing in both cases, however.

(2) Propellant Lines

Figure shows that the metal clip with teflon sleeves design is unsatisfactory for a range of engine pulse rates. Neither the use of high performance insulation on the lines nor aluminum silicone paint on the pod exterior provides a satisfactory modification.

Figure 28 presents the results by adding to the above design a thin (0.1 inch) insulating spacer at the clip mounting. The performance is slightly improved, but remains unsatisfactory unless firing rates are considered.

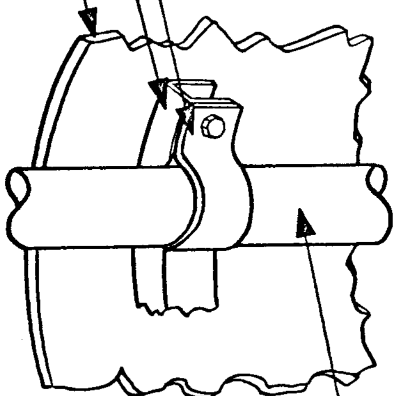
Figure 29 presents the results for a thick (1.0 inch) insulating spacer at the clip mounting. The performance is improved, but remains unsatisfactory for the non-firing condition.

Figure 30 indicates that use of a teflon clip (100% contact area) and aluminum silicone paint on the pod exterior provides satisfactory performance independent of flow conditions.

Figure 31 indicates that a 25% contact area teflon clip is somewhat improved in performance over the 100% contact clip for black paint on the fairing exterior.

Figure 32 shows the results for the most complex of the configurations analyzed (and is associated with the forward support). The system is satisfactory with very low line emissivity control ($\epsilon = 0.05$). It is anticipated that 1) teflon clips, with partial contact area will be utilized in the support design; 2) aluminum silicone paint will be used on the fairing exterior.

"B" INITIAL DESIGN



PHASE	TIME BETWEEN PULSES-MINUTES	TIME PRIOR TO FREEZING	
		BLACK PAINT ON FAIRING EXTERIOR	ALUMINUM SILICONE PAINT ON FAIRING EXTERIOR
I	∞	22 MIN	1 HR 20 MIN
*I	∞	22 MIN	—
II	15	30 MIN	—
II	7.5	33 MIN	2 HRS 38 MIN
II	4	40 MIN	—
II	1.9	44 MIN	—

* HIGH PERFORMANCE INSULATION ON LINES

FIGURE 27

"B" INITIAL DESIGN MODIFIED BY 0.1 IN. FIBERGLAS SPACER FOR CLIP

PHASE	TIME BETWEEN PULSES-MINUTES	TIME PRIOR TO FREEZING	
		BLACK PAINT ON FAIRING EXTERIOR	ALUMINUM SILICONE PAINT ON FAIRING EXTERIOR
I	∞	31 MIN	2 HRS
II	15	2 HRS 15 MIN	FULL MISSION
II	7.5	2 HRS 30 MIN	FULL MISSION
II	3	FULL MISSION	FULL MISSION

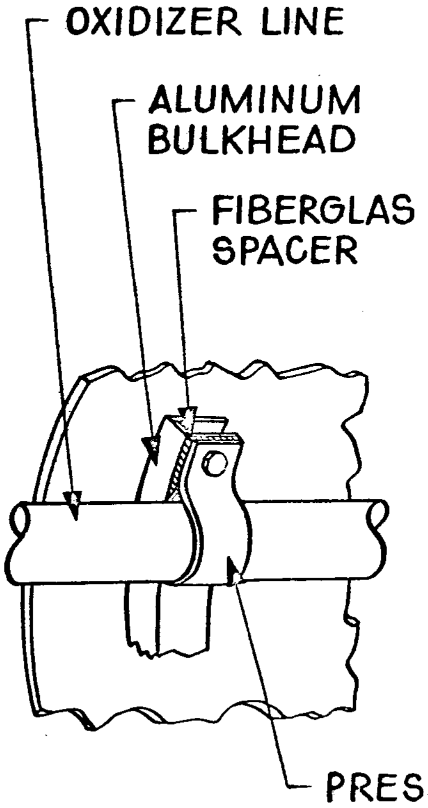


FIGURE 28

INITIAL DESIGN MODIFIED BY 1.0 IN. FIBERGLAS SPACER FOR CLIP

PHASE	TIME BETWEEN PULSES-MINUTES	TIME PRIOR TO FREEZING	
		BLACK PAINT ON FAIRING EXTERIOR	ALUMINUM SILICONE PAINT ON FAIRING EXTERIOR
I	∞	1 HR 45 MIN	4 HRS 15 MIN
II	15	—	FULL MISSION
II	3	FULL MISSION	FULL MISSION

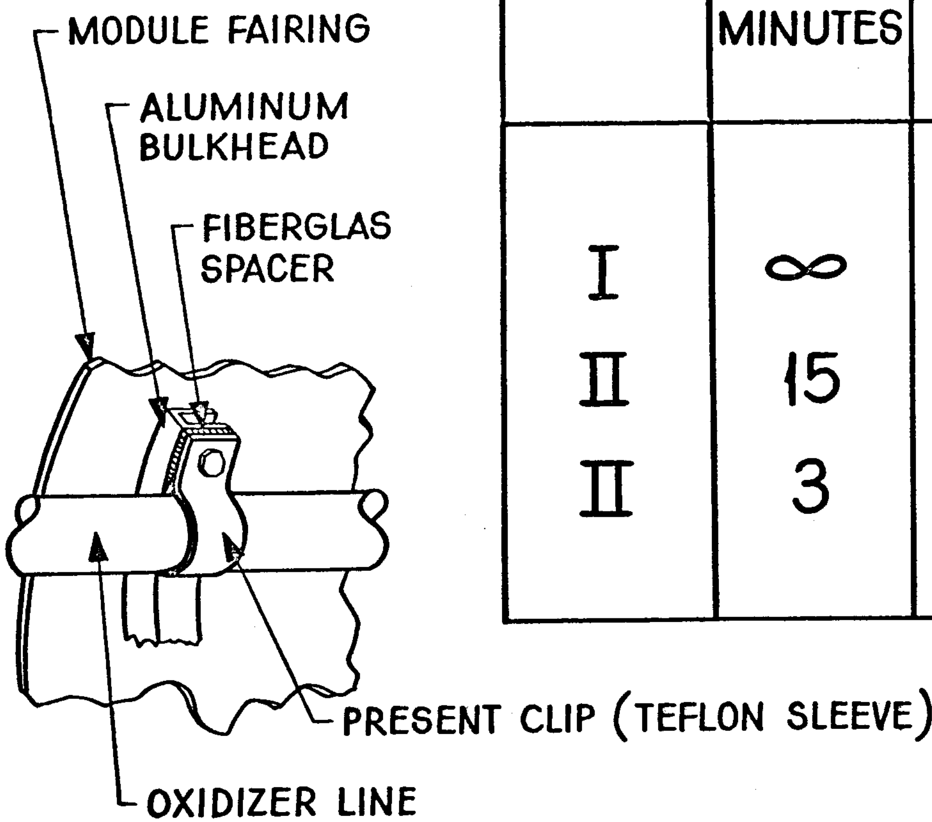


FIGURE 29

TEFLON CLIP 100% CONTACT AREA

PHASE	TIME BETWEEN PULSES-MINUTES	TIME PRIOR TO FREEZING	
		BLACK PAINT ON FAIRING EXTERIOR	ALUMINUM SILICONE PAINT ON FAIRING EXTERIOR
I	∞	2 HRS 45 MIN	FULL MISSION
II	15	3 HRS 15 MIN	FULL MISSION
II	7.5	FULL MISSION	FULL MISSION

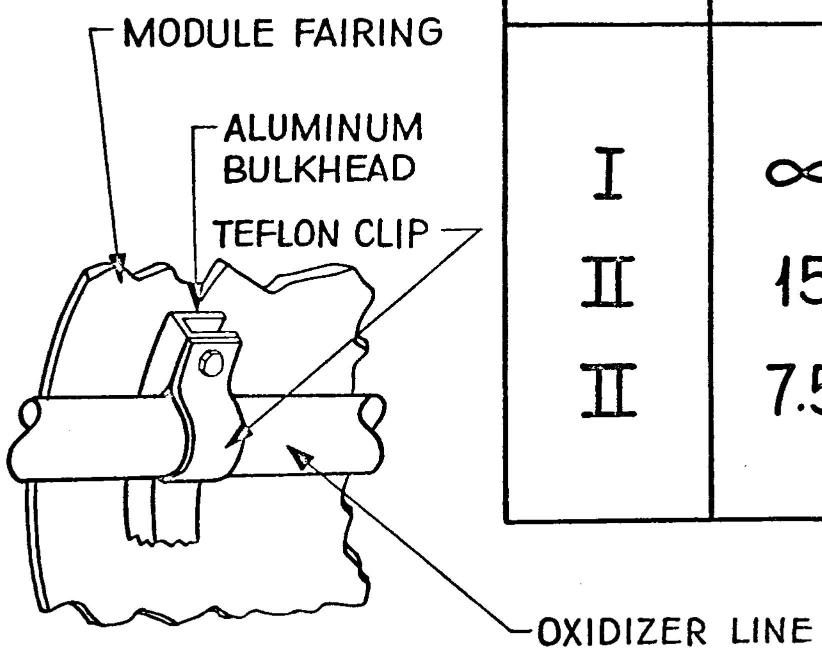


FIGURE 30

TEFLON CLIP APPROX 25% CONTACT AREA

PHASE	TIME BETWEEN PULSES-MINUTES	TIME PRIOR TO FREEZING: BLACK PAINT ON FAIRING	TIME PRIOR TO FREEZING: ALUMINUM SILICONE PAINT ON FAIRING
I	∞	—	FULL MISSION
II	15	4 HRS	FULL MISSION
II	7.5	FULL MISSION	FULL MISSION

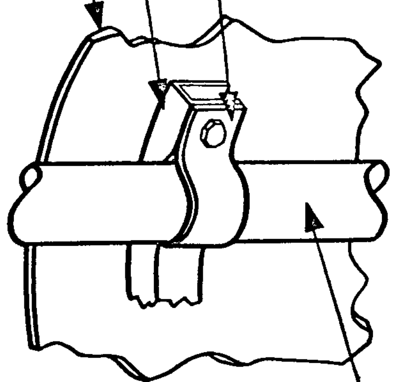


FIGURE 31

TEFLON CLIP APPROX 25% CONTACT AREA MOUNTED ON A FIBERGLAS INTERCOSTAL

PHASE	TIME BETWEEN PULSES-MINUTES	TIME PRIOR TO FREEZING: BLACK PAINT ON FAIRING	TIME PRIOR TO FREEZING: ALUMINUM SILICONE PAINT ON FAIRING
I	∞	3 HRS 15 MIN	NOT APPLICABLE FOR FORWARD CLIP
* I	∞	FULL MISSION	

* LINE EMISSIVITY = 0.05

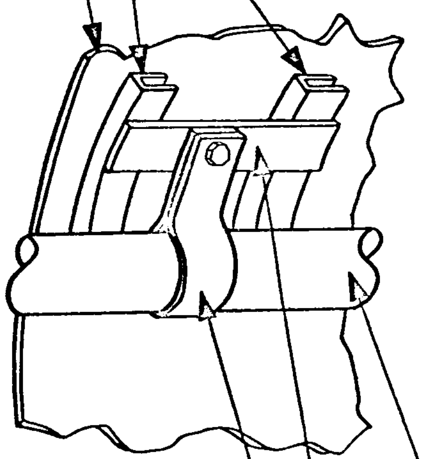


FIGURE 32

ANALYSIS RECOMMENDATIONS & CONCLUSIONS

- TEMPERATURE CHANGE OF THE PROPELLANTS INSIDE THE TANKS IS NOT A PROBLEM
- ENGINE FIRING RATE ASSUMPTIONS, ALTHOUGH POTENTIALLY VERY SIGNIFICANT, SHOULD NOT BE RELIED ON AT THE PRESENT TIME TO RELIEVE PROPELLANT FREEZING IN THE LINES
- TEFLON LINE CLIPS SHOULD BE USED
- THE POD EXTERIOR SHOULD BE PAINTED WITH A LOW EMISSIVITY PAINT SUCH AS ALUMINUM SILICONE PAINT ($\epsilon = 0.22$)
- THE FORWARD OXIDIZER LINE SUPPORT SHOULD UTILIZE A LOW CONTACT AREA TEFLON CLIP ATTACHED TO A FIBERGLAS INTERCOSTAL MOUNTED TO A BULKHEAD AND AT LEAST ONE LAYER OF ALUMINIZED MYLAR ATTACHED TO THE LINE EXTERIOR APPROXIMATELY 10 INCHES ON EITHER SIDE OF THE CLIP

FIGURE 33

 8-24-64

AUXILIARY PROPULSION SYSTEM

SUBJECT: FABRICATION STATUS #1 TEST MODULE (GAMMA PHASE II) SATURN IB AUXILIARY PROPULSION SYSTEM.

I. STRUCTURE

Completed, except minor rework still required for additional access provisions.

II. TANK ASSEMBLY

Ready to weld metal bellows into tank assembly September 7, 1964.

III. CONTROL MODULES

Propellant Controlled Quad Valve
Lo Pressure Helium
Helium Fill
Helium Control

All expected in the week ending August 30, 1964.

IV. WIRE HARNESSES

Developed, except for Instrumentation.

V. WELDED LINES - (PROPELLANT AND PRESSURIZATION)

Weld Fixtures Completed
Lines to be completed September 7, 1964.

VI. ENGINES

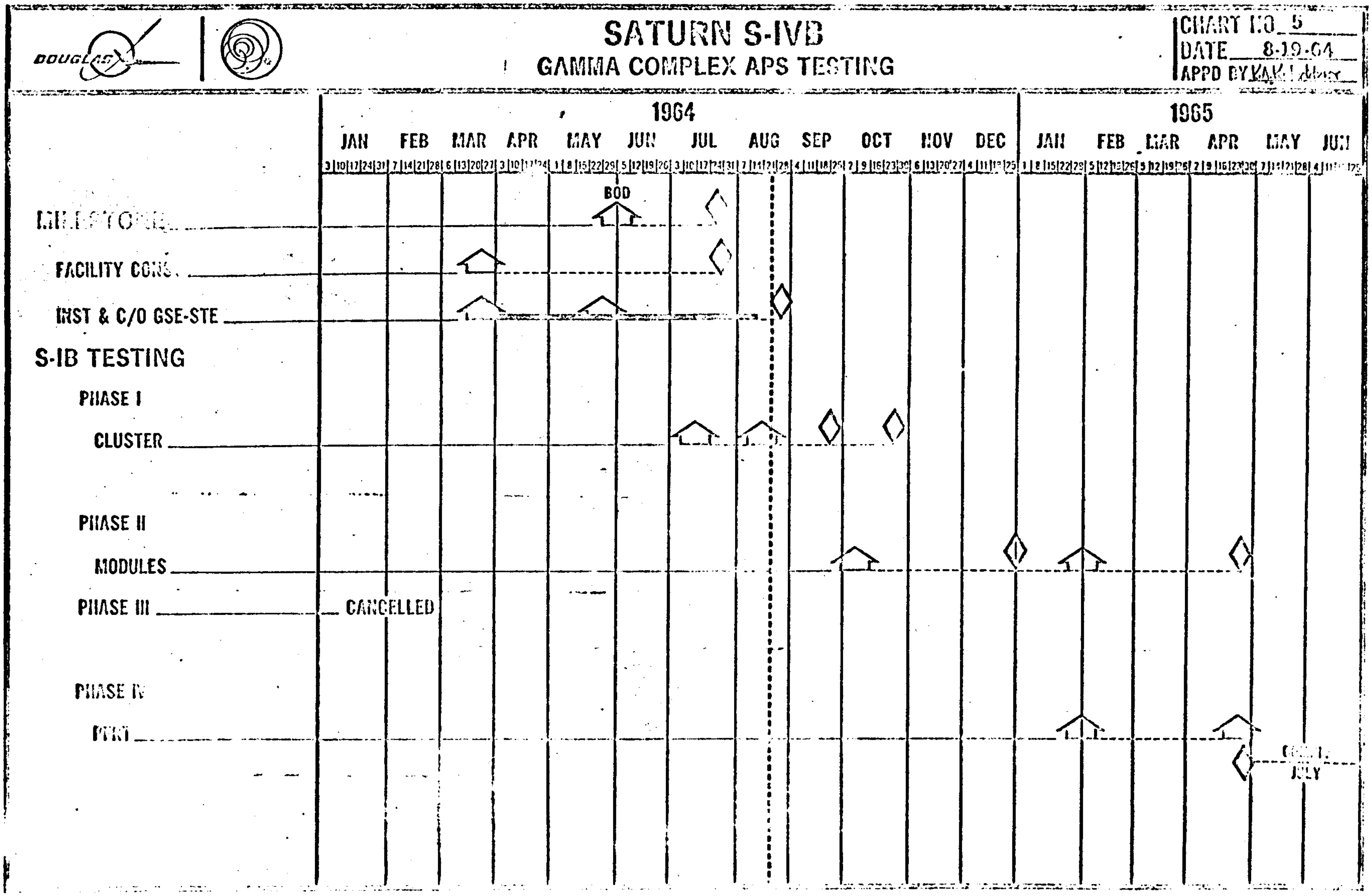
Sent back to TRW - (Cleveland) for recleaning. Expected August 28, 1964.

VII. PRODUCTION TEST EQUIPMENT

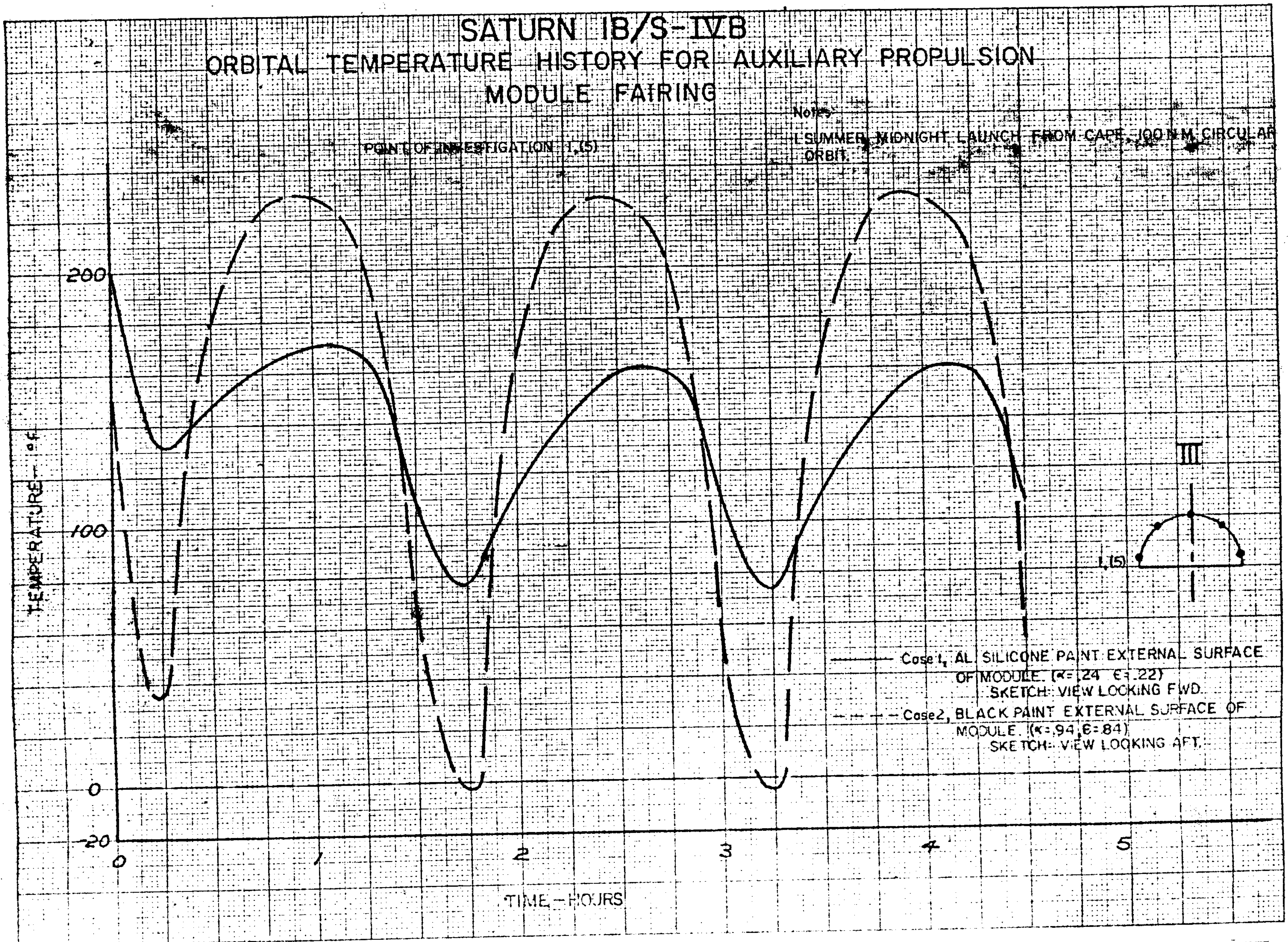
In Progress.

APPENDIX I

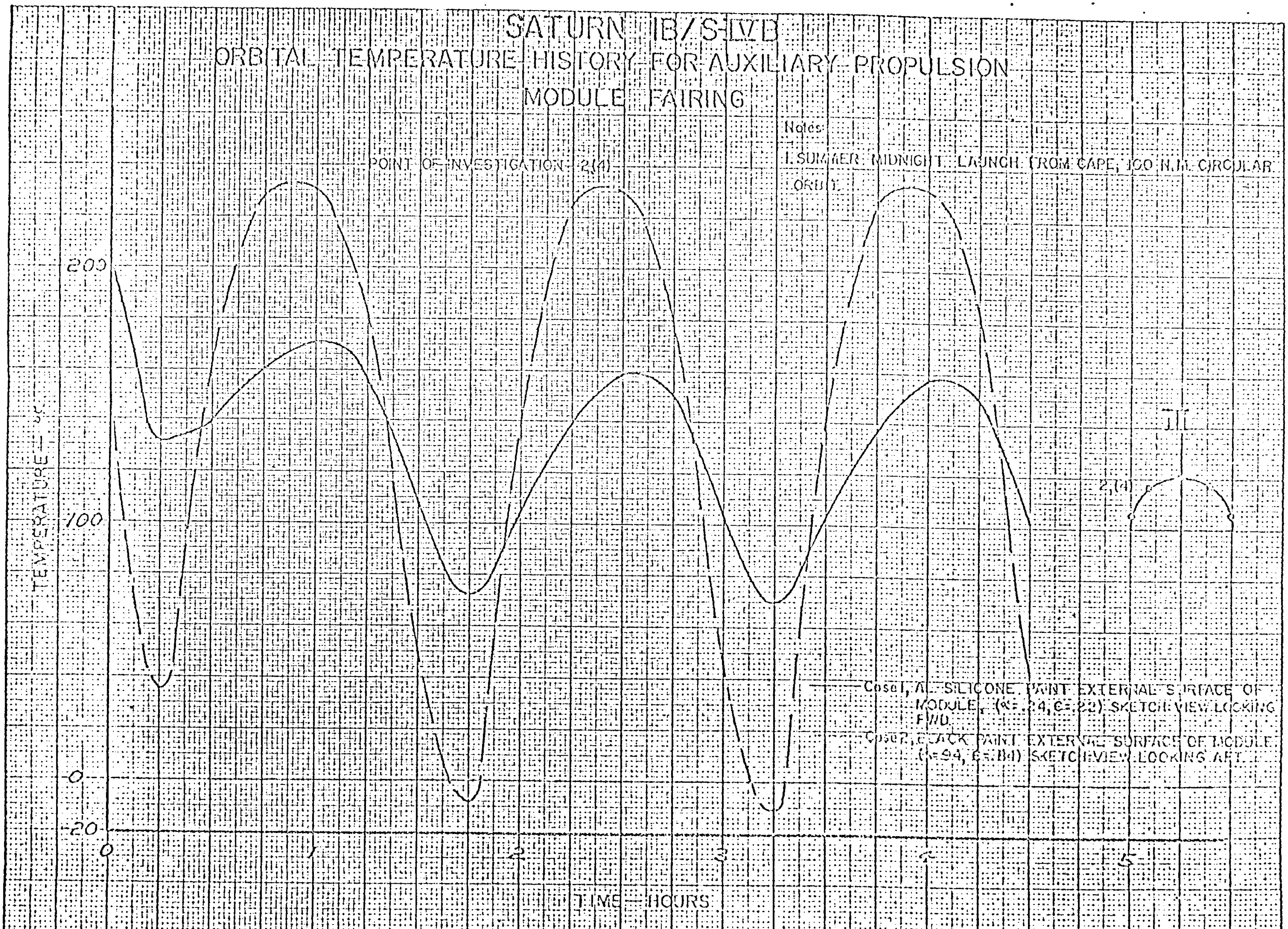
SATURN IB



APPENDIX J

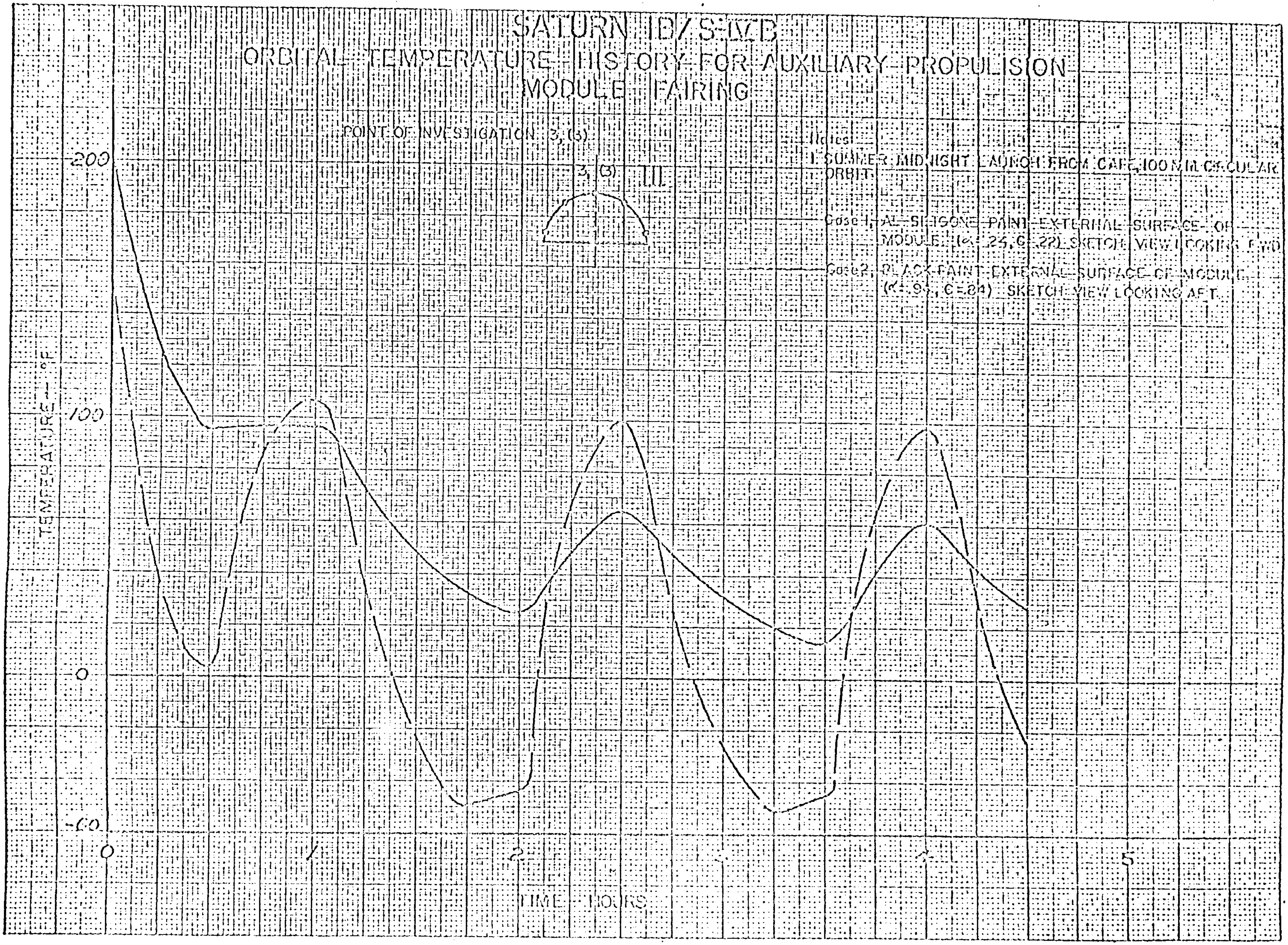

SATURN IB/S-IVB
ORBITAL TEMPERATURE HISTORY FOR AUXILIARY PROPULSION MODULE FAIRING
Notes:
1. SUMMER MIDNIGHT LAUNCH FROM CAPE, 100 N.M. CIRCULAR ORBIT.
POINT OF INVESTIGATION 1,(5)
200
100
0
-20
TEMPERATURE — °F
0
1
2
3
4
5
TIME — HOURS
III
1,(5)
Case 1, AL SILICONE PAINT EXTERNAL SURFACE OF MODULE. (α=.24 ε=.22)
SKETCH: VIEW LOOKING FWD.
Case 2, BLACK PAINT EXTERNAL SURFACE OF MODULE. (α=.94 ε=.84)
SKETCH: VIEW LOOKING AFT.

APPENDIX K

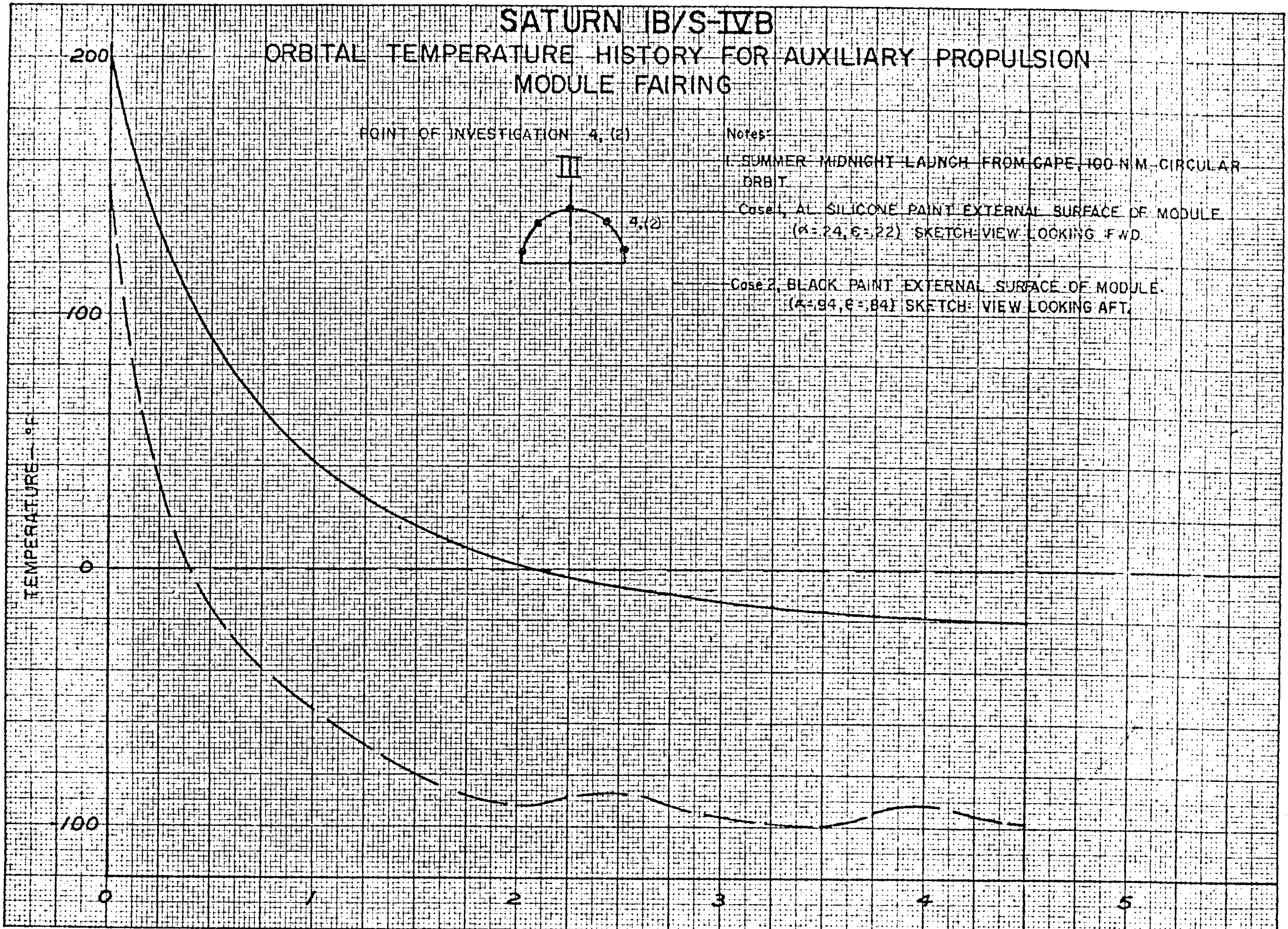


SATURN IB/S-IVB
ORBITAL TEMPERATURE HISTORY FOR AUXILIARY PROPULSION MODULE FAIRING
Notes:
1. SUMMER MIDNIGHT LAUNCH FROM CAPE, 100 N.M. CIRCULAR ORBIT
POINT OF INVESTIGATION 2(4)
Case 1, AL SILICONE PAINT EXTERNAL SURFACE OF MODULE. SKETCH VIEW LOOKING FWD.
Case 2, BLACK PAINT EXTERNAL SURFACE OF MODULE SKETCH VIEW LOOKING AFT.
2(4)
TEMPERATURE — °F
200
100
0
-20
0
1
2
3
4
5
TIME — HOURS

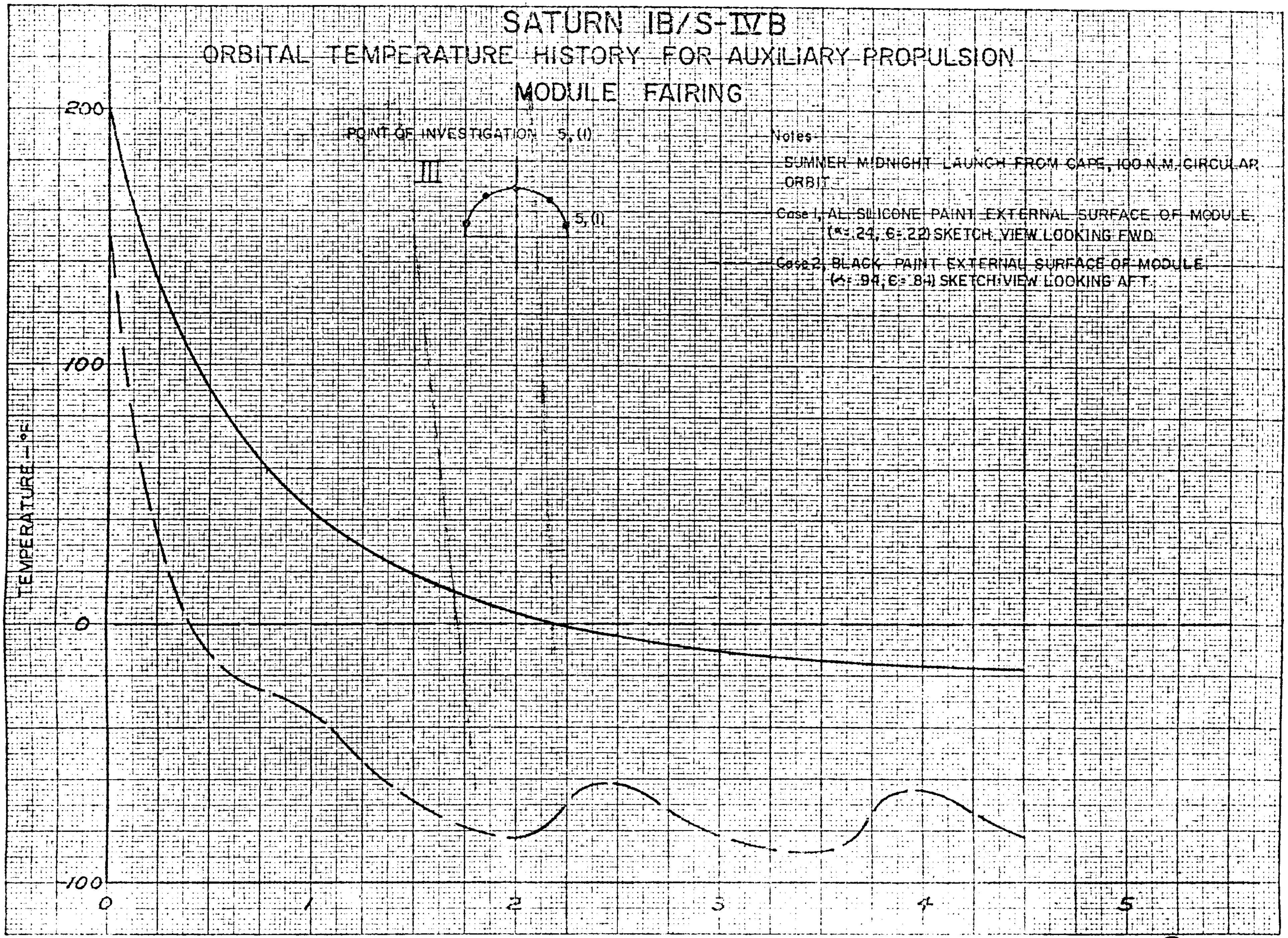
K-2



SATURN IB/S-IVB
ORBITAL TEMPERATURE HISTORY FOR AUXILIARY PROPULSION MODULE FAIRING
POINT OF INVESTIGATION 3, (3)
3, (3)
III
Notes:
1. SUMMER MIDNIGHT LAUNCH FROM CAPE, 100 N.M. CIRCULAR ORBIT
Case 1, AL SILICONE PAINT EXTERNAL SURFACE OF MODULE (α=.25, ε=.22) SKETCH VIEW LOOKING FWD
Case 2, BLACK PAINT EXTERNAL SURFACE OF MODULE (α=.95, ε=.84) SKETCH VIEW LOOKING AFT
TEMPERATURE — °F
200
100
0
-100
0
1
2
3
4
5
TIME — HOURS



10 X 10 TO THE CM. 359T-14
KEUFFEL & ESSER CO. MADE IN U.S.A.
ALBANENE


SATURN IB/S-IVB
ORBITAL TEMPERATURE HISTORY FOR AUXILIARY PROPULSION
MODULE FAIRING
POINT OF INVESTIGATION 5, (I)
III
5, (I)
Notes
SUMMER MIDNIGHT LAUNCH FROM CAPE, 100 N.M. CIRCULAR ORBIT
Case I, AL. SILICONE PAINT EXTERNAL SURFACE OF MODULE (α=.24, ε=.22) SKETCH, VIEW LOOKING FWD.
Case 2, BLACK PAINT EXTERNAL SURFACE OF MODULE (α=.94, ε=.84) SKETCH VIEW LOOKING AFT.
200
100
0
-100
TEMPERATURE — °F
0
1
2
3
4
5
TIME — HOU

K-5

SATURN V

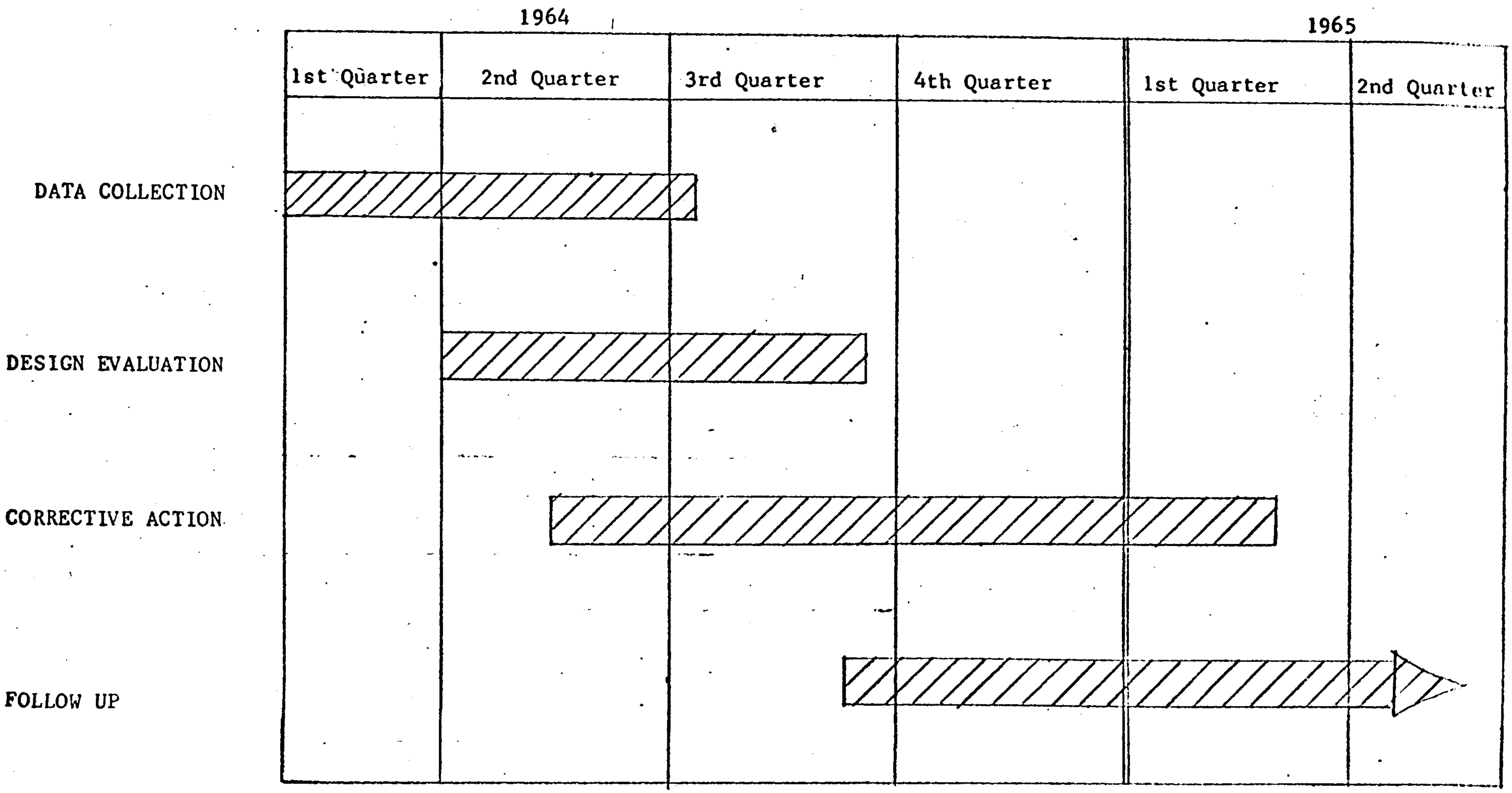
VALVE POSITION SENSOR
REQUIREMENTS SUMMARY

R-P&VE-PMP

MAY 27 1964

APPENDIX L

DESIGN SURVEY SCHEDULE



SATURN V

VALVE POSITION SENSOR SWITCH SUMMARY

3

	NUMBER OF VALVES WITH POSITION SENSORS	NUMBER OF SWITCHES		
		* OPERATIONAL	COMPONENT ANALYSIS	TOTAL
I U	2	2	1	3
S-IVB	9	32	0	32
J-2 (1)	9	8	1	9
S-II	35	37	4	41
J-2 (5)	45	40	5	45
S-IC	38	67	8	75
F-1 (5)	35	40	0	40
GRAND TOTALS	173	226	19	245

* OPERATIONAL: Used for sequence, remote checkout, or safety.

S-IC STAGE

VALVE NONEMCLATURE	NUMBER OF VALVES	SWITCHES PER VALVE	INDICATION PROVIDED		SIGNAL USE	
			OPEN	CLOSED	OPERATION-AL	COMPONENT ANALYSIS
Fuel Emergency Drain (Removed for Flight)	1	2	X	X		X
LOX Emergency Drain (Removed for Flight)	1	2	X	X		X
Fuel Pre-Valve	10	2	X	X	X	
LOX Pre-Valve	5	2	X	X	X	
Fuel Fill and Drain	1	1	X	X	X	
LOX Fill and Drain	3	2	X	X	X	
LOX Interconnect	4	2	X	X	X	
Fuel Vent and Relief	1	2	X	X	X	
Fuel Vent (Removed for Flight)	2	2	X	X		X
LOX Vent and Relief	1	2	X	X	X	
LOX Vent	1	2	X	X	X	
Fuel Tank Pressurization	5	2	X	X	X	
Helium Emergency Dump	1	2	X	X	X	
GOX Flow Control	1	2	X	X	X	
Helium Fill Shut-Off	1	2	X	X	X	
F-1 ENGINE						
Hypergol Manifold *	1	1	X		X	
G. G. Ball	1	1	X	X	X	
Main LOX	2	1	X	X	X	
Main Fuel	2	1	X	X	X	
Checkout Valve **	1	2	X	X	X	

* Loaded

** Engine Position and Ground Position

S-II STAGE

VALVE NOMENCLATURE	NUMBER OF VALVES	SWITCHES PER VALVE	INDICATION PROVIDED		SIGNAL USE	
			OPEN	CLOSED	OPERATION-AL	COMPONENT ANALYSIS
LOX Tank Vent	2	2	X	X	X	
LH_2 Tank Vent	2	2	X	X	X	
LOX Tank Pressurization Regulator	1	1	X			X
LH_2 Tank Pressurization Regulator	1	1	X			X
LOX Tank Fill	1	2	X	X	X	X
LH_2 Tank Fill	1	2	X	X	X	X
LOX Pre-Valve	5	1	X	X	X	
LH_2 Pre-Valve	5	1	X	X	X	
LOX Recirculation Shut-off (Return & Bleed)	10	1	X	X	X	
LH_2 Recirculation Shut-off (By Pass, Return & Purge)	7	1	X	X	X	
<u>J-2 ENGINE</u>						
Main Fuel	1	1	X	X	X	
Main LOX	1	1	X	X	X	
GG Control	1	1	X	X	X	
Fuel Bleed	1	1		X	X	
LOX Bleed	1	1		X	X	
LOX Turbine By-Pass	1	1	X	X	X	
ASI LOX	1	1	X		X	
LOX Valve Sequence Control	1	1		X		X
Start Tank Discharge	1	1	X	X	X	

S-IVB STAGE

VALVE NOMENCLATURE	NUMBER OF VALVES	SWITCHES PER VALVE	INDICATION PROVIDED		SIGNAL USE	
			OPEN	CLOSED	OPERATIONAL	COM. ANALYSIS
FUEL FILL AND DRAIN	1	4	X	X	X	
LOX FILL AND DRAIN	1	4	X	X	X	
Fuel Pre-Valve	1	4	X	X	X	
LOX Pre-Valve	1	4	X	X	X	
Fuel Tank Vent & Relief	1	4	X	X	X	
Oxidizer Tank Vent and Relief	1	4	X	X	X	
Directional Control (SAT V only) *	1	4	X	X	X	
Fuel Chilldown System Shut-off	1	2	X		X	
Oxidizer Chilldown System Shut-off	1	2	X	X	X	
Continuous Vent Valve	1	4	X	X	X	
<u>J-2 ENGINE</u>						
Main Fuel	1	1	X	X	X	
Main LOX	1	1	X	X	X	
G G Control	1	1	X	X	X	
Fuel Bleed	1	1		X	X	
LOX Bleed	1	1		X	X	
LOX Turbine By-Pass	1	1	X	X	X	
ASI LOX	1	1	X		X	
LOX Valve Sequence Control	1	1		X		X
Start Tank Discharge	1	1	X	X	X	

* Ground Discharge and Flight Discharge

L-6

Valve Nomenclature	Number of Valves	Switches per Valve	Indication Provided		Signal Use	
			Open	Closed	Operational	Component Analysis
3-way by-pass *	1	1	X	X		X
Water Shut-off	1	2	X	X	X	

* No by-pass, any intermediate position, or full by-pass position

VALVE POSITION SENSOR SWITCH MANUFACTURER'S

a. SNAP ACTION	NUMBER
TEXAS INSTRUMENTS (KLIXON)	60
MINNEAPOLIS-HONEYWELL (MICRO)	55
b. KNIFE BLADE	
TELEDYNE PRECISION INSTRUMENTS	14
BOURNS LABORATORIES INC.	20
HAYDON SWITCH COMPANY	2
BECKMAN INCORPORATED	70
c. OTHER	
ROCKETDYNE	24
TOTAL	245

ACTUATING MECHANISMS

CAM
DISPLACEMENT ROD (ROTARY & LINEAR)
RIGID COUPLING (ROTARY & LINEAR)

8.A.5.3 SAT-IB/S-IVB A.P.S. Environmental Control

The SAT-IB/S-IVB A.P.S. uses nitrogen tetroxide (N_2O_4) for an oxidizer and monomethyl hydrazine (MMH) for fuel. For environmental control DAC is using the temperature limits of 20°F to 120°F for the complete system to prevent freezing or boiling of these propellants.

A passive conditioning system has been selected for the orbital coast period; however, to make this system work, the A.P.S. must be stabilized at 80°F at launch. Because of this high minimum temperature, the A.P.S. has become the most temperature-critical item of the aft skirt and interstage thermoconditioning system. Therefore, the thermistors controlling the temperature of the air or GN_2 at the umbilical inlet are located in the gas exhaust stream of the A.P.S. Presently, the thermistor consists of four individual probes wired in series. Each A.P.S. exhaust has two of these probes which results in an averaged temperature between the A.P.S. modules. DAC has requested this temperature control point be set at 87°F ± 5°F.

A maximum of 2000 lb/hr of gas flows to each A.P.S. This large amount of gas was selected so that the temperature drop from the A.P.S. inlet to the A.P.S. exhaust would be approximately 10°F for extreme ambient conditions. This low ΔT is required because it is related directly to the gas temperature at the umbilical inlet. A reasonably low inlet temperature is desirable because of those components in the aft skirt area which expend heat.

The flow distribution through the A.P.S. is controlled by a series of constant area orifices. The gas is forced through an orifice in the main manifold into a duct formed by two stringers on the outside of the aft skirt, the A.P.S. skin and the aft skirt skin, and thence into the A.P.S. A series of orifices around the fuel and oxidizer tanks serves as a distribution manifold to cause an even flow through the A.P.S. and also serves as the principal pressure drop control. The gas flows from the nose of the A.P.S. aft and back into the aft skirt area below the main manifold.

Passive control of the propellants during orbital coast will be discussed at the September meeting of the Dynamics and Control Working Group at Huntsville.

8.B Saturn V Auxiliary Propulsion System

The S-V APS system is presented in Figures 34, 35, 36, 37 and 38.

8.C APS Static Firing Philosophy

The APS static firing philosophy is presented in Figures 39 and 40.

SATURN V APS DESIGN & WEIGHT STATUS

DESIGN

- BLADDER / TANK APS DESIGN START MID-AUG (FORMAL DIRECTION REQ'D)
- ENVELOPE ESTABLISHED — GEN'L ARRANGEMENT
- STRUCTURAL L/O STARTED MID-AUG, AERODYNAMIC & STRESS ANALYSIS REQ'D TO DETERMINE MTG PROVISIONS
- L/O STARTED ON PRESSURIZATION & PROPELLANT SYSTEMS

ESTIMATED WEIGHT STATUS

- METAL BELLOWS DESIGN 1073 LB / STAGE, EXCLUDING AFT SKIRT MTG PROVISIONS
- BLADDER DESIGN (LEM OXIDIZER TANK), 124 LB / STAGE LIGHTER

FIGURE 34

SATURN V APS MODIFICATION REQ'MTS

MODIFICATIONS TO APS FLIGHT SYSTEM, GSE AND TEST REQUIREMENTS WITH BLADDER TANKS ARE AS FOLLOWS :

- INSULATION DESIGN
  INCREASE LOWER TEMPERATURE LIMIT FROM 20°F TO 40°F
- REDESIGN PROPELLANT CONTROL MODULE
  PROVIDE CAPABILITY OF ENGINE RECIRCULATION AND BLADDER TANK VENT. (PRESENT PROVISIONS MAY NOT BE COMPATIBLE WITH BLADDER DESIGN)
- REDESIGN PROPELLANT TANK RELIEF VALVE
  RELIEF VALVE SETTING TOO HIGH FOR LOWER PRESSURE RATED TANKS
- PROPELLANT SENSORS
  PRESENT SATURN IB DESIGN IS NOT COMPATIBLE WITH BLADDER DESIGN. (SENSORS WILL NOT BE PROVIDED)
- ADD OR MODIFY GSE
  PROVIDES PROPER ULLAGE CONTROL FOR LOADING
- REVISE OR REPLACE PRESSURE SWITCHES AND RELIEF VALVES
  NECESSARY FOR BLADDER SERVICE REQUIREMENTS
- MODIFY OR ADD CONTROL PANELS AND ASSOCIATED ELECTRONICS
- RESTRICT FULL EXPULSION CYCLE AND CHECKOUTS
  ALSO MAINTAIN WARM TEMPERATURES (ABOVE 50° F) FOR CHECKOUT

FIGURE 35

S-IVB/V APS PROPELLANT REQ'MTS

(CONTINUOUS VENT)

MIN IMPULSE PULSING I_{SP}	BURN TIME AV I_{SP}	VENT SPLIT	BURN TIME AV O/F	USABLE PROP LBS REQ'D			DELIVERABLE OXIDIZER VOL REQ'D (IN^3)			DELIVERABLE FUEL VOL REQ'D (IN^3)		
				FUEL	OXIDIZER	TOTAL	O/F = 1.35	O/F = 1.5	O/F AV = 1.472	O/F = 1.35	O/F = 1.5	O/F AV = 1.472
208 SEC	233 SEC	45/55	1.472	113.7 @1.472	152.5 @1.472	266.2	3011	3085	3073	3800	3680	3700
235 SEC	250 SEC	45/55	1.472	109.7 @1.472	146.6 @1.472	256.3	2896	2966	2954	3663	3549	3568

NOTES :

1. EXPULSION EFF OR HARDWARE TOL. HAS NOT BEEN INCLUDED
2. MIN IMPULSE (.065 SEC DURATION), AVERAGE I_{SP}, & O/F ARE FOR TRW ENGINES ONLY, & DO NOT REFLECT GEMINI ENGINE PERFORMANCE
3. PROPELLANT WEIGHT INCLUDES GEMINI ENGINE REQ'MT @ 1.2 MIXTURE RATIO

FIGURE 36

PROPOSED SATURN IVB/V APS SCHEDULE

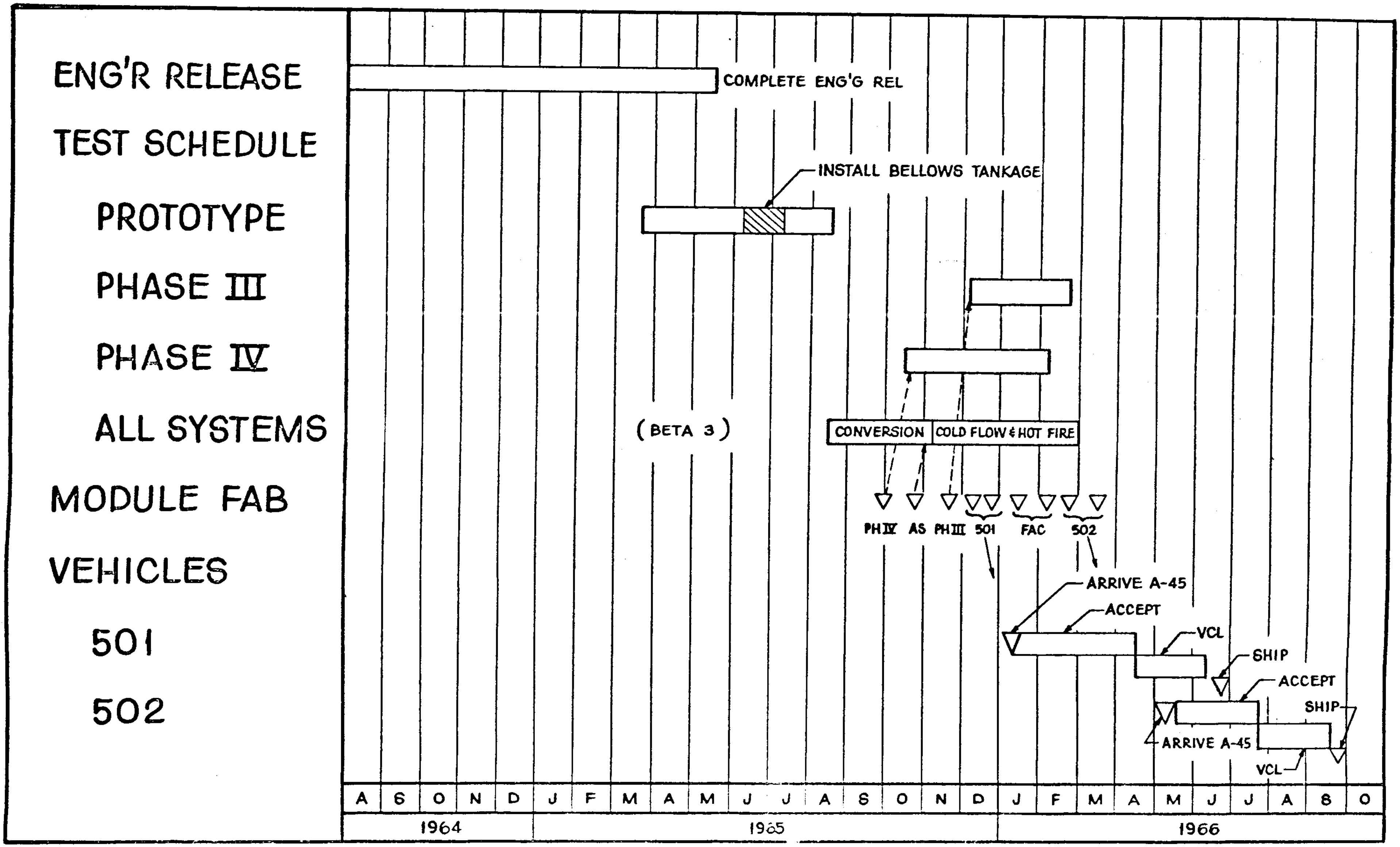


FIGURE 37

APS PROPELLANT CAPACITY SIZING

Operation	Total Impulse	Isp Av.	Prop. Wt. Total	O/F Av.	Wt. Oxidizer	Wt. Fuel	Vol. Oxidizer	Vol. Fuel	Fuel % Total Vol.
POWERED ROLL	5,170	208	24.86	1.35	14.28	10.58	288	344	9.47
EARTH ORBIT									
1. Attitude Stabilization (includes null of initial conditions @ orbit insertion)	7,490	244	30.70	1.53	18.57	12.13	374	395	10.88
2. Ullage Control (prior to initiation of continuous venting)	7,200	270	26.67	1.20	14.54	12.13	293	395	10.88
3. Maneuvering, (21 maneuvers)	10,710	272	39.38	1.569	24.05	15.33	485	499	13.74
4. Venting Disturbances									
a. Continuous LH_2 vent balance (45/55 split of I_T = 115,000 lb sec)	5,475	208	26.32	1.35	15.12	11.20	305	364	10.02
b. Override LH_2 vent balance (vent prior to prepressurization, 45/55 split of I_T = 8000 lb sec)	315	208	1.51	1.35	0.87	0.64	18	21	0.58
c. LOX vent balance (4 ft. axial misalignment - C.G. directed vent)	730	208	3.51	1.35	2.02	1.49	41	49	1.35
5. Prepressurization, Chilldown, and Restart	23,760	270	88.	1.20	48.00	40.00	967	1301	35.83
6. Ullage Engine Distrubance Balance (±3 LB_f/engine)	615	208	2.96	1.35	1.70	1.26	34	41	1.13
TRANS-LUNAR COAST									
1. Attitude Stabilization	1,540	208	7.40	1.35	4.25	3.15	86	103	2.84
2. LOX Tank Blowdown Balance (C.G. directed vent)	Negligible								
3. LH_2 Tank Blowdown Balance (45/55 split of I_T = 42,000 lb sec)	1,790	208	8.61	1.35	4.95	3.67	100	119	3.28
TOTALS	64,795		259.92		148.35	111.58	2991 in^3	3631 in^3	100

NOTE: The full propellant allotment for the GEMINI ullage engine specified by MSFC in change order 210 is not included in the above tabulation.

Expulsion efficiency and manufacturing tolerances are not included in the above tabulation.

FIGURE 38

S-IVB APS TOTAL PRODUCTION ACCEPTANCE TEST PLAN

- ✓ COMPONENTS & SYSTEM HARDWARE - PRODUCTION ACCEPTANCE TESTS
- ✓ ENGINE PERFORMANCE TESTS - CORRELATION, WATER CALIBRATION, HOT FIRING
  - CALIBRATE INJECTOR
  - CALIBRATE VALVE ASSEMBLY
  - HOT FIRE INJECTOR W/WORKHORSE VALVES FOR PERFORMANCE
  - DETERMINE & EVALUATE CORRELATION DURING DET & PFRT ENGINE TESTS
- ✓ ENGINE PERFORMANCE TESTS (ALTERNATE IF REQ'D.)
  - ENGINE FIRING - 10 SEC.
  - PURGE & CLEAN PROCEDURE REQUIRED - VACUUM BAKE
- ✓ APS MODULE PRODUCTION ACCEPTANCE TEST (SM)
  - LEAK & FUNCTIONAL (MANUAL)
  - SYSTEM REGULATION
  - ELECTRICAL
  - CHECK CALIBRATION
- ✓ APS CHECKOUT W/S-IVB STAGE (A3)
  - LEAK (MANUAL) & FUNCTIONAL (AUTOMATIC)
  - ELECTRICAL
  - CHECK CALIBRATION

FIGURE 39

S-IVB APS TOTAL PRODUCTION ACCEPTANCE TEST PLAN (CONT.)

✓ APS ACCEPTANCE TEST AT BETA W/S-IVB STAGE SACTO (INERT GAS)

- LEAK (MANUAL) & FUNCTIONAL (AUTOMATIC)
- ELECTRICAL
- CHECK CALIBRATION
- SYSTEM REGULATION PERFORMANCE
- VIBRATION
- DETERMINE & EVALUATE "INERT GAS-HOT FIRING" SYSTEM OPERATION DURING DEV./QUAL. (GAMMA) & ALL SYSTEMS

✓ APS HOT FIRING ACCEPTANCE TEST GAMMA, SACTO (NOT RECOMMENDED)

- LEAK & FUNCTIONAL
- ELECTRICAL
- CHECK CALIBRATION
- SYSTEM OPERATION "HOT FIRING" (10 SEC.)
  PROVIDE ADDITIONAL CLEANING DEVELOPMENT. SATISFY TWO YEAR STORAGE CAPABILITIES AFTER PROPELLANT EXPOSURE (NO DISASSEMBLY)
- INSPECTION TECHNIQUE REQUIRED
- SYSTEM REGULATION PERFORMANCE - EXPELL REMAINING PROPELLANTS THRU TRANSFER VALVES
- VIBRATION - S-IVB ACCEPTANCES (BETA)

✓ AMR CHECKOUT

- LEAK (MANUAL) & FUNCTIONAL (AUTOMATIC)
- ELECTRICAL
- CHECK CALIBRATION

FIGURE 40

APS COMPONENT STATUS

COMPONENT	DEVELOPMENT TESTS	DELIVERY SCHED	QUAL STATUS
1A49997, HELIUM CONTROL MODULE	COMPLETED 1. BELLOWS (SEALED)- SPRING RATE, CYCLING PROOF AND BURST 2. REGULATOR-DYNAMIC STABILITY, REGULATION CHARACTERISTICS AND LEAKAGE AT LOCK-UP 3. SOLENOID VALVE ACTUATION AND DEACTUATION, RESPONSE AND LEAKAGE TO BE DONE ON PROTOTYPE MODULE 1. OPERATIONAL TEST - HIGH, LOW TEMP AND VIBRATION	8/24/4 E.D.S.I.L. 9/4/4 PHASE II 9/11/4 PNEUMATIC 9/18/4 PHASE III	10/16/64 QUAL UNIT WILL BE AVAILABLE
1A49422 PROPELLANT CONTROL MODULE	COMPLETED 1. SOLENOID VALVES - LEAKAGE, ACTUATION, DEACTUATION, AND RESPONSE 2. FILTER - FLOW AND PRESSURE DROP	5/19/4 PHASE I 6/30/4 PHASE II 9/11/4 E.D.S.I.L.	9/18/4 QUAL UNIT WILL BE AVAILABLE
1A49998, LOW PRESSURE HELIUM MODULE	COMPLETED 1. RELIEF VALVE - STABILITY, FLOW AND PRESSURE DROP 2. SOLENOID DUMP VALVE - ACTUATION, DEACTUATION AND RESPONSE 3. LEAKAGE	8/25/4 PHASE II 9/11/4 E.D.S.I.L. 9/25/4 PNEUMATIC	10/9/4 QUAL UNIT WILL BE AVAILABLE
1A49996, HELIUM FILL MODULE	COMPLETED - MODULE TEST 1. LEAKAGE 2. STABILITY OF RELIEF VALVE 3. FLOW AND PRESSURE DROP (RELIEF AND SOLENOID DUMP VALVES)	8/11/4 E.D.S.I.L. 8/24/4 PHASE III 9/9/4 PNEUMATIC	9/23/4 QUAL UNIT WILL BE AVAILABLE
1A67912, QUADRUPLE CHECK VALVE	COMPLETED 1. FLOW AND PRESSURE DROP 2. LEAKAGE	PARTS AVAILABLE	QUAL TEST IN PROGRESS
1A67600 BELLOWS HI PRESS (LINE)	COMPLETED 1. BURST TEST	PARTS AVAILABLE	QUAL TEST IN PROGRESS

FIGURE 41

APS COMPONENT STATUS (CONT)

COMPONENT	DEVELOPMENT TESTS	DELIVERY SCHED	QUAL STATUS
1A67601 BELLOWS LOW PRESSURE LINE	NONE	PART AVAILABLE	QUAL TEST IN PROGRESS
DISCONNECTS	COMPLETED 1. FUNCTIONAL 2. CYCLES 3. LEAKAGE	PARTS AVAILABLE	(1) QUAL TEST COMPLETED ON 2 SETS AFTER RE-PLACEMENT OF SEALS (2.) 1 SET FAILED (EXCES-SIVE LEAKAGE) DURING QUAL TEST (3) OTHER SETS (2) AVAIL.
1A67911 BELLOWS POSITIVE EXPULSION S1B	COMPLETED 1. PRESSURE TEST 2. LIFT CYCLES 3. MATERIALS	PARTS AVAILABLE	BELLOWS AVAILABLE FOR QUAL. TEST FIX-TURE REQ'D.
1A78094 SPHERE HIGH PRESSURE S1B	DEV. TEST SUCCESSFUL, ONE PART SECOND PART SCHEDULED 8/21/4	ADDITIONAL PARTS IN FAB	——
1B29974 TANK (WITHOUT BELLOWS FOR QUAL) S1B	ASSEMBLY BEING WELDED	AUG 28, 1964	——

FIGURE 42

9.0 PROPELLANT TANK DESIGN AND PRESSURIZATION

9.A.1 Waffle Dimensions

Waffle dimensions and LH_2 tank forward dome and cylinder skin thicknesses for the Saturn S-IVB common tank are shown on Figure 43. All skin thicknesses shown are based on 39 psia max. LH_2 pressure and 44 psia max. LO_2 pressure for the IB stage only. The LH_2 tank cylinder waffle rib thickness is established by Saturn V buckling requirements for the ground wind condition.

9.A.2 Valves, Vents, Plumbing Changes, and Pressure Switch Settings

There are no plumbing changes.

The vent and relief valves, and the backup relief valves are being changed as indicated in Table I.

The pressure switch settings are shown in Table II.

TABLE I

LH_2 VENT VALVE & VENT & RELIEF VALVE SETTINGS

	LH_2 Vent & Relief	LH_2 Backup Relief
S-IB, 201-203	39-42	40-43
S-IB, 204 & Subs	36-39	37-40
SV	34-37	35-38

9.A.3 Screens (Including Pressure Drop Tests to Date)

Pressure drops in the LOX anti-vortex screen and feed duct entrance have been reanalyzed with the result that the estimated total pressure drop at maximum LOX flow has been reduced from 2.0 psi to 0.9 psi.

S-IVB COMMON TANK

IB LH_2 TANK MAX VENT PRESSURE = 39 PSIA
V LH_2 TANK MAX VENT PRESSURE = 37.4 PSIA
(WAS 42 PSIA)

NO CHANGE TO COMMON BULKHEAD OR TO LO_2 AFT DOME

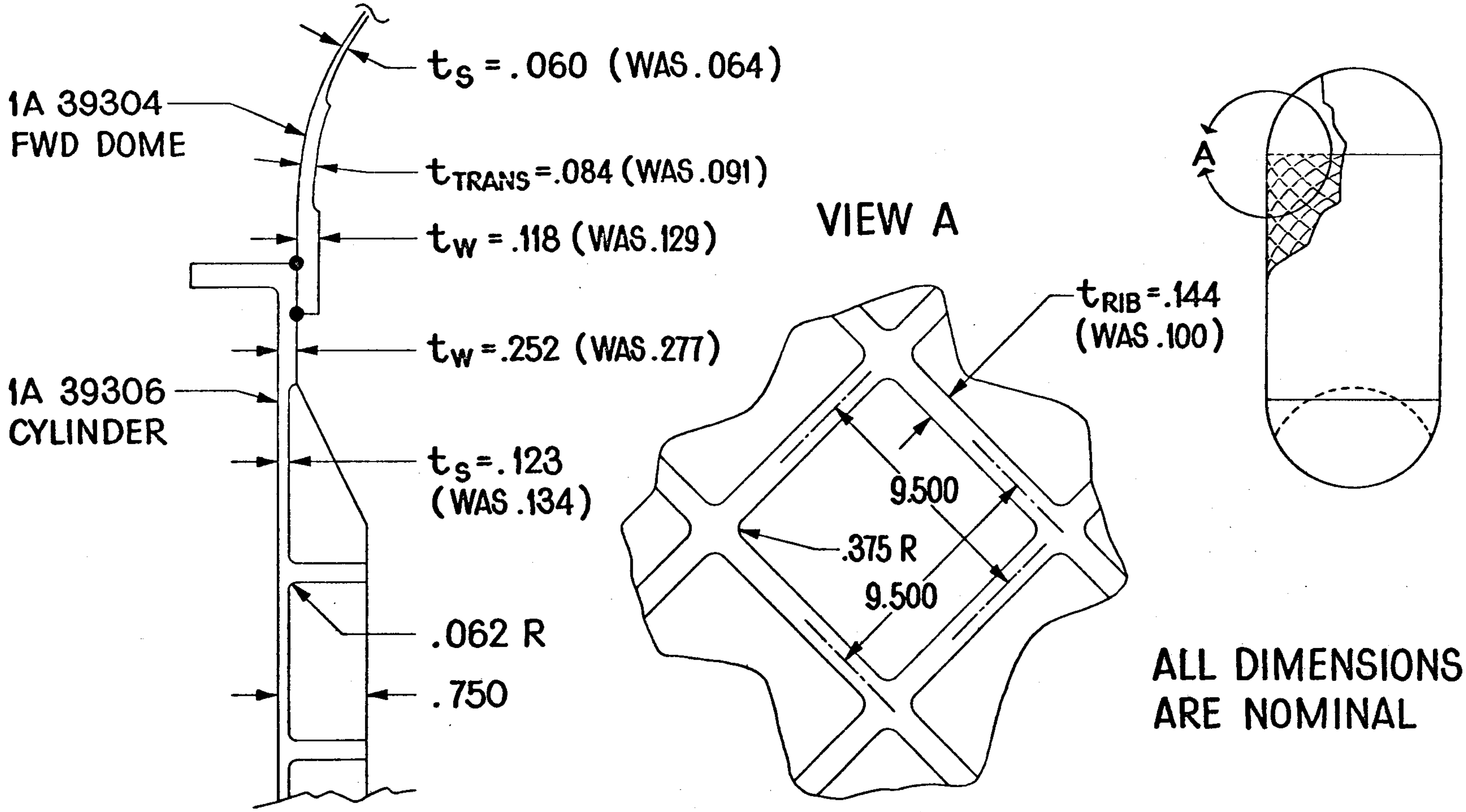


TABLE II

PRESSURE SWITCH REQUIREMENTS

P/N	Name	Function	Was	Is	Note
1A66996	Helium Minimum Liftoff	Act	2940 ± 25	3000 Max	Min. deadband of 50 psia
		Deact	2840 ± 25	2815 Min	
1A66997	LO_2 Pressurization Regulator Back-up	Act	465 ± 10	450 to 475	
		Deact	350 ± 10	340 to 365	
		Sys. Op. Press	1600	2000 psia	
1A66998	Helium Pad Safety	Act	1650 ± 100	No Change	
		Deact	1450 ± 100		
1A66999	Control He Regulator	Act	535 ± 10	525 to 550	
		Deact	450 ± 10	440 to 465	
1A67000	APS He Regulator Back-Up Hi	Act	225 ± 2	224 ± 3	Min. deadband of 10 psia
		Deact	210 ± 2	208 Min.	
		Sys. Op. Press	3200	1500 psia	
1A67001	APS He Regulator Back-Up Low	Act	190 ± 2	190 Max	Min. deadband of 10 psia
		Deact	175 ± 2	176 ± 3	
		Sys. Op. Press	3200	1500	
1A67002	LO_2 Pump Purge Control Chilldown	Act	120 ± 10	130 Max	Min. deadband of 5 psia
		Deact	110 ± 5	105 Min	
1A67003	LH_2 Tank Gnd Fill Valve Control				
	(a) SIB	Act	39 ± 1	37 Max	Min. deadband of 1 psia
		Deact	36 ± 1	32 Min	
	(b) SV	Act	39 ± 1	35 Max	Min. deadband of 1 psia
		Deact	36 ± 1	30 Min	
1A67004	LH_2 Tank Pre-Press, Flt. Control				
	(a) SIB (201-203) SV First Burn	Act	30.5 ± .5	31 Max	Min. deadband of .5 psia
		Deact	28.5 ± .5	28 Min	

TABLE II (Continued)

P/N	Name	Function	Was	Is	Note
	(b) SIB (204 & Subs)	Act	$30.5 \pm .5$	29.5 Max	Min. deadband of .5 psia
		Deact	$28.5 \pm .5$	26.5 Min	Prepress. & Min. L/O TBD
1A67005	LH_2 Tank Re-Press & Vent Control	Act	$36.5^{+0}_{-.5}$	34 Max	Min. deadband of .5 psia
		Deact	$35.0^{+.5}_{-0}$	31 Min	
1A67008	LH_2 Tank Coast Vent Control	Act	$26 \pm .5$	24 Max	Min. deadband of .5 psia
		Deact	$24.5^{+.5}_{-0}$	$20.5^{+.5}_{-0}$	
1A67009	LH_2 Tank Step Press & Vent Control	Act	$37.5 \pm .5$	34 Max	Min. deadband of .5 psia
		Deact	$35.5 \pm .5$	31 Min	
	NOTE: (use 1A67005)				
1A67010	LO_2 Tank Pad Safety	Act	30 ± 1	No Change	
		Deact	25 ± 1		
1A67011	LO_2 Tank Gnd Fill Valve Control	Act	40 ± 1	40 ± 1	Min. deadband of 1 psia
		Deact	38 ± 1	37 min	
1A67013	LO_2 Tank Pre-Press & Flt. Control				
	(a) SIB	Act	$39.5 \pm .5$	40 Max	Min. deadband of .5 psia
		Deact	$37.5 \pm .5$	37 Min	
	(b) SV	Act	$39.5 \pm .5$	41 Max	Min. deadband of .5 psia
		Deact	$37.5 \pm .5$	38 Min	

A search is currently in progress for information related to pressure drop tests run on the Thor anti-vortex screen. (The Thor and S-IV-B screens are practically identical and the flow rates are about the same.)

9.A.4 Weight Reduction Justification

During the VMDIWG Splinter meeting at DAC in June 1964 to establish S-IVB pressure schedules, proposed estimated weight reductions were presented by DAC for S-IVB for non-common tanks. After reviewing the weight data, MSFC directed that structural changes be limited to the LH_2 tank cylinder and forward dome.

The common tank design was predicated on the Saturn IB 39 psia pressure requirement establishing the skin thicknesses and the Saturn V ground wind requirements, which greatly exceed the Saturn IB ground wind requirements, establishing the waffle rib thicknesses. Therefore, the 175 pound weight reduction for the cylinder and forward dome is less for the common tank than for separate tanks.

9.A.5 Saturn V Fuel Tank Redesign

Lowering of the Saturn V fuel tank redesign pressure from 39 to 37.4 psia necessitated dropping the restart blowdown pressure 2 psi. This resulted in a boiloff increase of approximately 200 pounds. However, due to a lower second burn control band the gas residuals at cutoff would be reduced by 42 pounds.

Continuous Venting - Lox Boiloff. The amount of lox loaded for orbital boiloff will not change significantly for continuous venting. The total loaded will be about 475 lb. (including 100 lb. for boiloff during chilldown). Of this, about 155 lb. will be vented during coast.

9.B.1 Maximum Pump Inlet Pressures for Static Testing

There is no danger of exceeding the fuel pump maximum allowable pump inlet pressure during static firing. The highest fuel pump inlet pressure that could be seen during the start transient under present operating conditions is 38 psia, while the maximum allowable pressure is 42 psia.

The LOX pump inlet pressure during the start transient could exceed the maximum allowable in the Saturn 5 configuration and is marginal in the Saturn IB configuration:

	Saturn IB	Saturn 5
Maximum prepressurization ullage pressure	40.0	41.0
Head of LOX above engine interface (psi)	7.8	8.0
Maximum LOX pump inlet pressure at start	47.8	49.0
Maximum allowable pressure	48	48

Since the LOX ullage pressures required at start are about three psi below the maximum prepressurization pressures for both configurations, it may be possible to avoid excessive pump inlet pressures by means of observer-controlled cycling of the LOX vent valve. This procedure, however, would require exclusion of the LOX ullage minimum-liftoff pressure signal from the countdown logic.

Since meeting the maximum pump inlet requirements will involve both procedural and hardware changes, it is recommended that the requirements be reviewed to determine if a two psi increase in maximum allowable pressure is possible.

9.B.2 Saturn 5 Fuel Tank Pressure

The Saturn 5 fuel tank pressure is currently controlled at a lower pressure during first burn that second burn due to pressurant weight considerations. Assuming the tank is prepressurized to 33 psia, it would require approximately 20 pounds of additional GH_2 pressurant to operate at 31-34 rather than 28-31 psia.

9.B.3 Fuel Tank Prepressurization Levels

The fuel tank prepressurization levels are dictated by the engine start transient rather than steady state requirements. As the curves in figures 44 and 45 indicate, a minimum prepressurization level of 33 psia will be sufficient to meet NPSH minimum and pump inlet pressure requirements during the start transients of Saturn IB and first burn of Saturn V. The curve in figure 46 shows the ullage pressure required for the Saturn V second burn start transient. Repressurization to the upper half of the second burn control band will meet this requirement.

9.B.4 Saturn IB and V Tank Pressure Schedules

The tank pressure schedules are shown in Figures 47 and 48.

9.B.5 Saturn V LH_2 Limit Pressure

The common tank structure when flown in the Saturn V configuration will be subjected to greater trajectory heating and higher first stage burning accelerations than when flown as a Saturn IB. The effects of heating and acceleration permit only 37.4 psia maximum pressure within the LH_2 tank as shown by the equation below:

$$\underset{\underline{\text{IB}}}{\frac{P_{max} + \text{load factor } (P_{head})}{F_{TU} \text{ (at temp)}}} = \underset{\underline{\text{V}}}{\frac{P_{max} + \text{load factor } (P_{head})}{F_{TU} \text{ (at temp)}}}$$

$$\frac{39 + 4.17\ (.9)}{66,000 \text{ (at 115°F)}} = \frac{37.4 + 4.72\ (.9)}{64,500 \text{ (at 160°F)}}$$

$$.65 = .65$$

The redesign of the Saturn V fuel tank from 42 to approximately 37 psia has resulted in lower mission heat input. With the continuous vent system configuration the maximum heat input is 735,500 Btu. This is 28,500 Btu lower than the value used for the initial continuous venting studies. However, only 5000 Btu's of the reduction are due to the thinner tank wall with the balance attributed to refined heat input estimates. The maximum boiloff, based on 735,500 Btu, is 3030 pounds.

REQ'D. & ACTUAL ULLAGE PRES. DURING ENGINE START TRANSIENT FOR SATURN IB

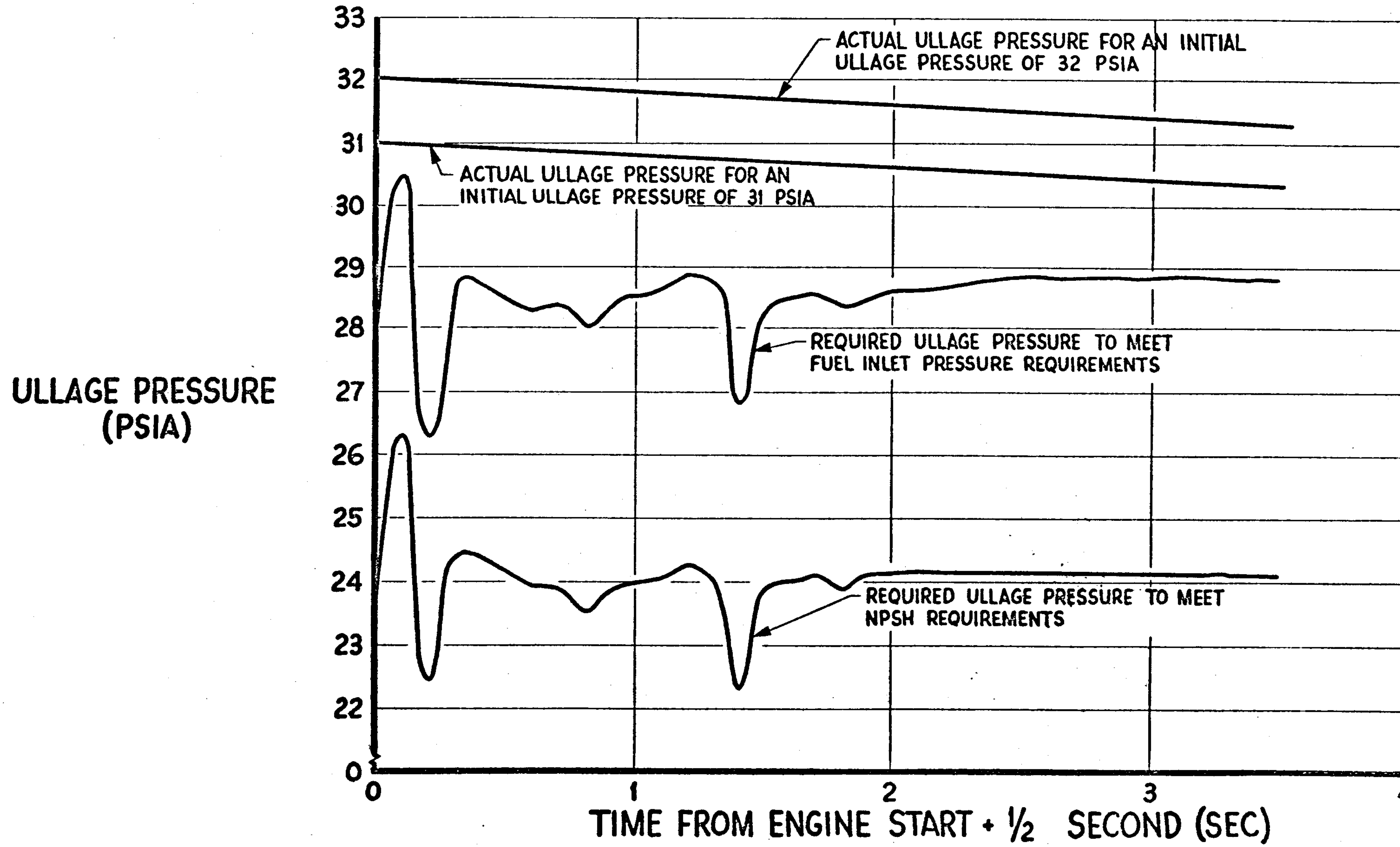


FIGURE 44

REQ'D. & ACTUAL ULLAGE PRES. DURING ENGINE START TRANSIENT FOR SAT. 5 - 1ST BURN

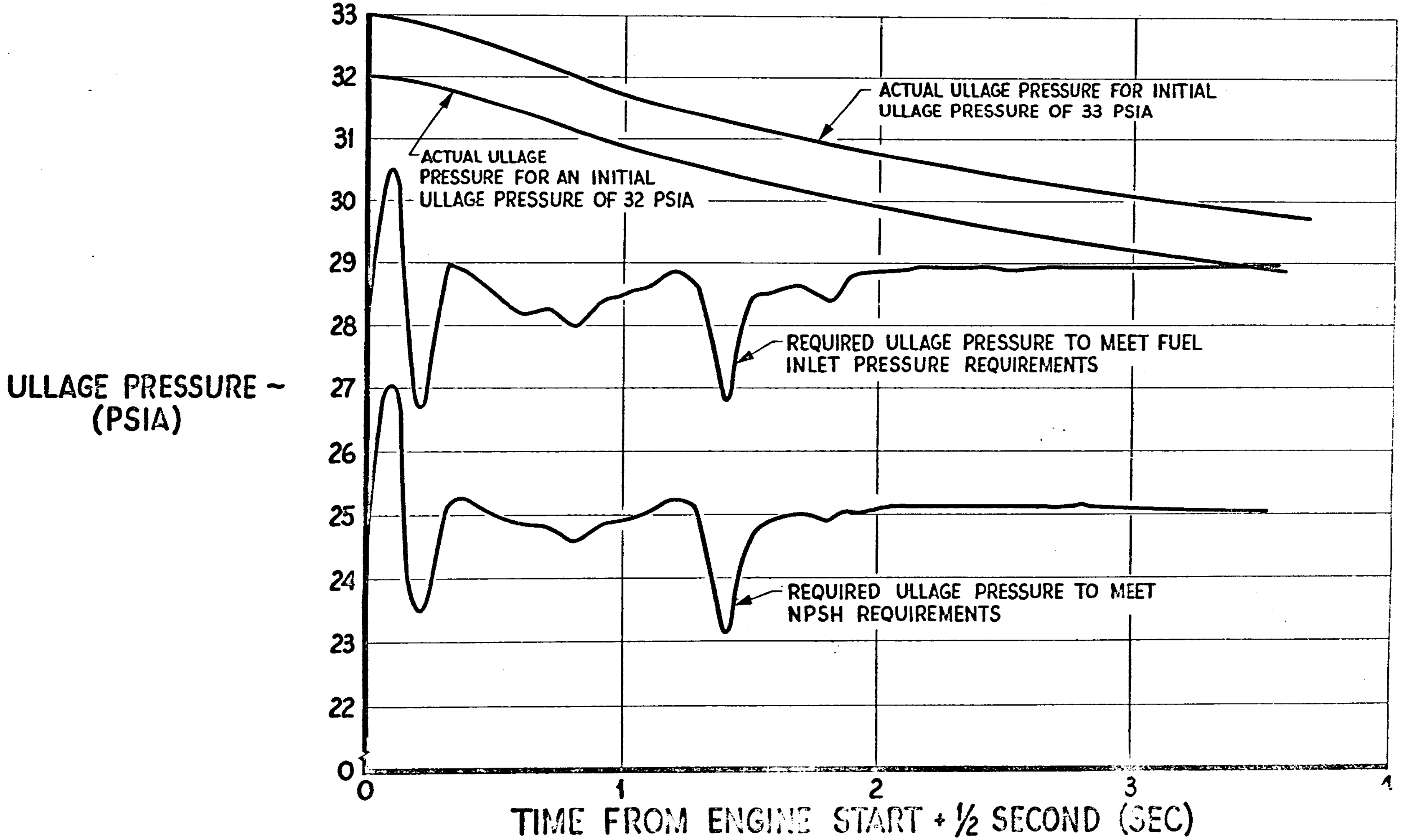


FIGURE 45

REQ'D. ULLAGE PRES. DURING ENGINE START TRANSIENT FOR SATURN 5 - 2ND BURN

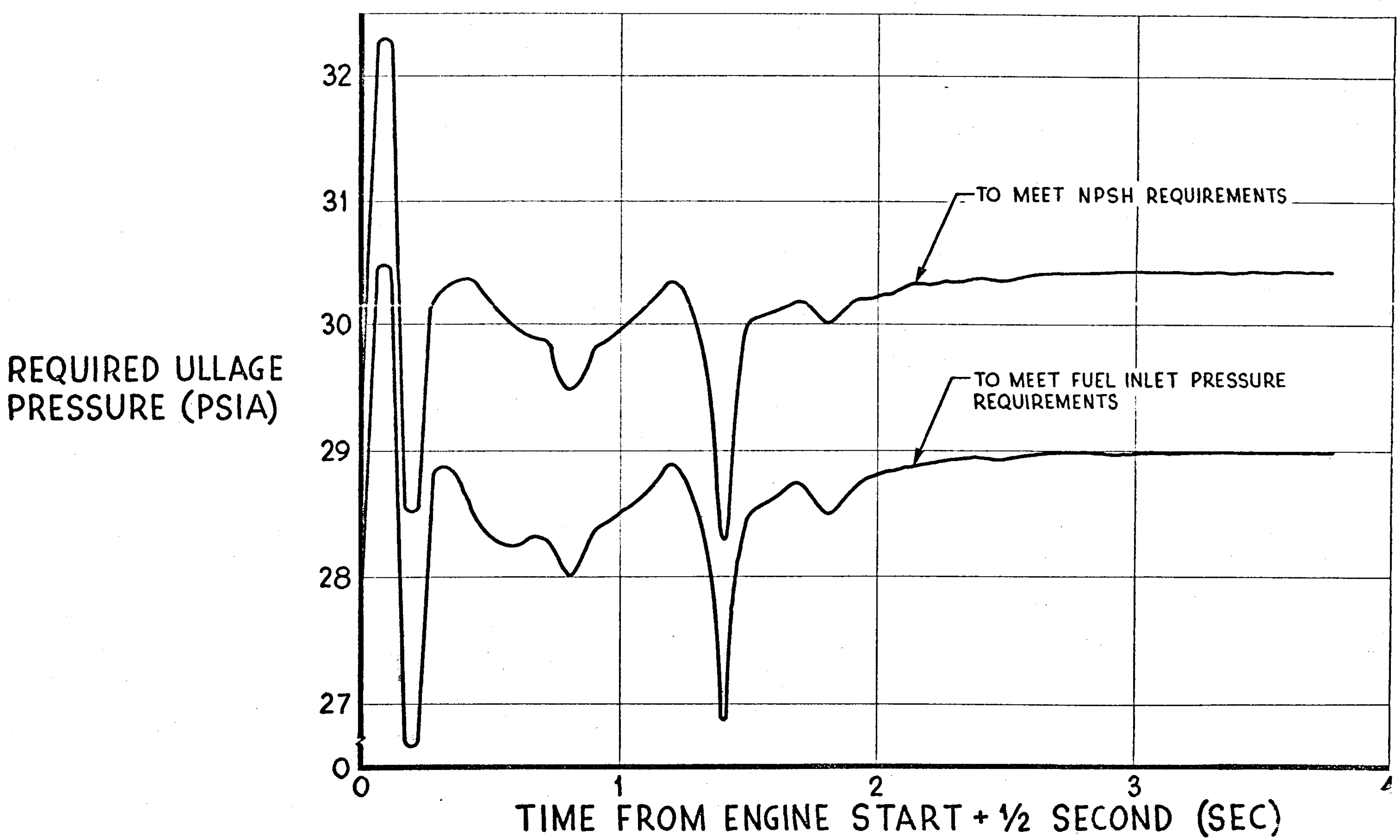


FIGURE 46

S-IVB FUEL TANK PRES. SCHEDULES

	SATURN IB		SATURN 5
	201 - 203	204 & SUBS	
DESIGN PRESSURE	42	39	37.4
PRE-PRESSURIZATION	33 (MIN)	33 (MIN)	33 (MIN)
CONTROL BAND	28 - 31	26.5 - 29.5	28 - 31 (1ST)
	STEP TO 39	STEP TO 36	31 - 34 (2ND)
VENTING RANGE	39 - 42	36 - 39	34 - 37
BLOWDOWN AT RESTART			20.5 - 21

FIGURE 47

S-IVB LOX TANK PRES. SCHEDULES

	SATURN IB	SATURN 5
DESIGN PRESSURE	44	44
PREPRESSURIZATION	40	41
CONTROL BAND	37–40	38–41
VENTING RANGE	41–44	41–44
TANK DESIGN PRESSURE	44	44

FIGURE 48

10.0 PROPULSION SYSTEM PERFORMANCE

10.A Propulsion System Performance "IN-RUN" Mixture Ratio

The curve on page 1.2.2 (figures 49 and 50) of the handout from the J-2 engine/S-II and S-IVB stage interface meeting June 23-24, 1964 indicates the J-2 engine operating at a mixture ratio slightly lower than the nominal 5.0/1.0. This is attributed to fuel turbine wear-in and implies that the fuel flow rate is slightly greater than nominal. This indicates both a slightly higher thrust and specific impulse, and consequently a slight increase in open loop engine performance. However, there would be a slight increase in open loop residuals.

In a closed loop engine operation the P. U. valve will compensate for this slight change in mixture ratio.

Preliminary indications are that the "in-run" mixture ratio shift will not have any impact on the stage performance. However, if a complete analysis is desired, more detailed information is needed from Rocketdyne pertaining to thrust specific impulse and propellant flow rate as a function of the "in-run" mixture ratio shift phenomenon.

10.B Maximum J-2 Thrust Calculations

The total maximum thrust is based on the 200,000 LB nominal value. The effects of off-nominal pump inlet conditions, pressurization, calibration, and P. U. excursion effects are also taken into consideration. For a total thrust of 246,640 LB. the ultimate strength of the thrust structure and casting is 247,000 LB. The casting has been tested to 150% over the ultimate value. The thrust structure has not been statically tested yet.

10. C Propellant Mixture Ratio Study

Phase I of the PMR study is nearly complete. Phase I considers loading the Saturn IB/S-IVB stage propellant tanks to a LOX-rich condition (a mass ratio greater than 5 to 1) and utilizing the propellant utilization (PU) system's design capability to correct this unbalance during the initial portion of powered flight. When the mass ratio has reached 5 to 1 the P. U. valve returns to a nominal 5 to 1 operating condition for the remainder of the S-IVB flight.

From Phase I analysis cutback times, propellant loads, gross payload gains, etc., were determined for several different initial mixture ratios greater than 5 to 1. Although operating at an initial high EMR will produce considerable gross payload gains, the optimum initial EMR can not be established until the propellant residuals are determined. The propellant residuals and the performance of the J-2 engine for a simulated flight of the S-IVB under Phase I conditions is in process.

An analysis of Phase II is in the early stages and no conclusions have yet been obtained. Phase II states that the Saturn IB/S-IVB will operate at an initial high EMR (greater than 5 to 1) and then cut back to a low EMR (less than 5 to 1) in order to obtain maximum payload gains.

The Saturn V/S-IVB PMR study is also in the early stages and no definite conclusions as to the optimum EMR history for operation have been resolved. From preliminary calculations it has been determined that the entire Saturn V/S-IVB powered flight will have to operate at an EMR less than 5 to 1 in order to obtain a maximum payload gain.

10. D Thrust Chamber Chilldown at Restart

The current J-2 engine restart sequence allows 1/2 second for GH_2 thrust chamber chill plus an additional 1/2 second of chill if required. At the end of the one second period, an over-ride signal is given by the I. U. to allow the engine start sequence to continue even though a temperature signal indicating chill completion is lacking. This method of chilldown should allow the thrust chamber to reach the required -100°F to -200°F band from starting temperatures in the range of +42°F to -160°F. The possibility of a 1/2 second variation in ignition time does not create launch window problems since sufficient propellant reserves are available for the required trajectory corrections.

PROGRAMMED MIXTURE RATIO STUDY

SATURN 1B/S-IVB

PHASE I

- LOADING IN A LOX RICH CONDITION
- CONTROLLED BY PRESENT P.U. SYSTEM
- INITIAL PART OF FLIGHT AT HIGH EMR (>5.0/1.0) RETURN TO 5.0/1.0 AT CUTBACK TIME
- PHASE I ANALYSIS IS 90% COMPLETE

INITIAL EMR	INCREASE IN GROSS WEIGHT INJECTED INTO ORBIT (LBM)	USABLE LIQUID HYDROGEN LOAD (LBM)	USABLE LIQUID OXYGEN LOAD (LBM)	LOADING RATIO	CUTBACK TIME (SEC)
5.2	1040	37,000	190,500	5.15	325
5.4	1900	36,000	190,500	5.28	309
5.5	2260	35,600	190,500	5.35	302

- SOME ENGINES MAY NOT BE CAPABLE OF ATTAINING AN EMR OF 5.5/1.0; THUS 5.4/1.0 IS BEING CONSIDERED FOR WORST CASE
- OPERATIONAL EFFECTS ON RESIDUALS ARE PRESENTLY BEING DETERMINED

FIGURE 49

PROGRAMMED MIXTURE RATIO STUDY (CONT)

SATURN 1B / S-IVB

PHASE II

- LOADING IN A LOX RICH CONDITION
- MODIFY P.U. SYSTEM REFERENCE MIXTURE RATIO (<5.0/1.0)
- INITIAL PART OF FLIGHT AT HIGH EMR (>5.0/1.0)
- RETURN TO REFERENCE MIXTURE RATIO
- PHASE II IS IN EARLY STAGES; NO DEFINITE CONCLUSIONS

PHASE III

- LOADING IN A LOX RICH CONDITION
- CONTINUALLY CHANGING EMR
- MAJOR CHANGE TO P. U. SYSTEM
- PHASE III INVESTIGATION NOT YET INITIATED

SATURN 5 / S-IVB

- PRELIMINARY RESULTS-OPERATE EMR <5.0/1.0 FOR ENTIRE FLIGHT

FIGURE 50

11.0 PROPULSION MISCELLANEOUS (SATURN IB/V)

11.A Status of Valve Position Sensors

This effort is in response to Memorandum R-P&VE-PM-64-M-386 from NASA Propulsion Division requesting copies of certain documents to substantiate purchase, qualification test, and acceptance test specifications on valves with position sensor switches.

The purpose of this request is to enable NASA to review these specifications and qualifications to circumvent recurrence of valve position sensor malfunctions.

At this time about half of the specified documents or the equivalent have been obtained. It is estimated that the remaining documents will be obtained and a letter of transmittal written by September 1st.

11.B Status of Documentation on Cross Sectional Drawings

A list of those components with cross sectional drawings is now available to MSFC through DAC vendor files.

11.C Results of Study and Testing of S-IV Helium Heater

The following represents the results of the study to determine the adaptability of the S-IV helium heater to the S-IVB stage.

11.C.1 S-IVB Cryogenic APS Design Study (See Figures 51, 52, and 53)

Cold helium heated in the helium heater coils is used to repressurize the hydrogen tank and the oxygen tanks. Also, cold helium can be diverted to the skirt nozzles for override attitude control during orbit. Hydrogen gas is bled from the engine to the skirt nozzles to provide roll control during power flight. Residual cold helium from the helium spheres is bled through the skirt nozzles to provide attitude control during translunar coast.

Attitude control during orbit is provided by diverting helium heater combustion products through valves and nozzles as required. Propellants for use in the cryogenic APS are provided from the hydrogen tank and the LOX tank through vacuum jacketed lines.

External views of the cryogenic APS are shown on Figure 54. Essentially, this is an S-IV helium heater with a modified aft section to install three attitude control nozzles and three ullage nozzles.

An internal diagram of the cryogenic APS heater is shown on Figure 55. Propellants from the tanks are vaporized in the regenerative coils and injected as gases. The cold helium is heated in a separate set of coils to pressurize the hydrogen tank and to provide override attitude control during orbit.

There are three attitude control nozzles with valves, and three ullage control nozzles (2 with valves) directed aft. When attitude control is required, an ullage control nozzle is cycled to maintain a constant combustion exit area, and therefore, a constant chamber pressure. This minimizes perturbations to the combustion process. For example; when a pitch command is required the pitch valve opens and one ullage valve (valve #7) closes. When a yaw or roll command is required, the appropriate valve opens and the other ullage valve (valve #5) closes. Simultaneous pitch and yaw or pitch and roll is also possible.

A possible layout for the attitude control system is shown in Figures 56, 57, and 58. The cold gas nozzles are mounted on the skirt and are protected by a fairing. The cryogenic APS units are mounted on the thrust structure near the attached point of the thrust structure and the aft LOX dome. Vacuum jacketed lines from the hydrogen tank and from the LOX tank provide propellants. S-IV type propellant valves are installed.

In Figure 59 heated hydrogen could be used to repressurize the fuel tank resulting in additional weight saving. Initial repressurization would be performed with helium to give the small ullage pressure rise needed for operation of the fuel chilldown pump. Liquid hydrogen is bled from the LH_2 chilldown pumps during recirculation and plumbed to the helium heater where the hydrogen would be vaporized and heated. This heated hydrogen would be routed to the fuel tank ullage to complete the repressurization function. Preliminary analysis indicates that a payload gain of approximately 160 lbs. over heated helium repressurization could be realized.

Figure 60 shows an alternative method of diverting the warm gas flow. The warm gas valves are omitted. Three nozzles face aft; two of these nozzles are connected to the helium heater by flex hoses. When an attitude control command is required a pneumatic or electrical actuator positions the nozzles 90° from aft. This scheme eliminates hot gas valves and requires only development of flex hoses and sample actuators.

11.C.2 Cryogenic Auxiliary Propulsion System Feasibility Testing Program

The "Cryogenic APS Feasibility Program" successfully demonstrated the operation of a prototype unit. The modified S-IV helium heater operated with excellent combustion stability and pulsing capability. Two tests involving various sequences of the attitude control valves were conducted at propellant feed pressures controlling the combustion temperature to approximately 1400°F, which is the theoretical temperature at the predicted S-IVB cryogenic APS operating conditions.

Although the test plan, which defined the heater operational sequence, was not completed, the primary objective of establishing the dynamic response and adaptability of this heater to accept pulsing operation was fully accomplished. Pulse lengths varied from 2 sec. to 60 sec. and the two valves were cycled both independently and simultaneously.

The "ball" valves employed were of an unproven design obtained on the basis of the earliest possible delivery in this size range, (i.e., 3/4" diameter valve). Although the valve action was erratic during certain portions of the test, there is no question that hot-gas valves operating in this temperature range (1200°F nominal) can be developed. In addition, other methods are available such as mechanically controlled hot-gas ducts which achieve the same results and may provide the additional operational flexibility of differential thrust vector control.

11.D Status and Problem Areas of Overfill and Engine Cutoff Sensors

On S-IV we have experienced problems with the overfill and instrumentation Point Level Sensors. The problems have been traced to: 1) faulty electrical installation, (cables and connectors cause cross talk, mutual cap, grd loops); 2) inadequate adjustment procedures, which resulted in either oversensitive or inadequate sensitivity for proper operation.

Electrical installations have been corrected on S-IV-7 and subs for the overfill sensors. The rework eliminated a ground loop problem and a source of stray capacitance caused by the absence of shielding on either signal lead passing through a conventional connector.

The checkout and adjustment procedures were revised from adjusting the trim pot to a certain number of turns to adjusting the trim pot as necessary to establish the proper ΔC required for proper operation.

Proper operation of the LH_2 overfill sensor was achieved on S-IV-9 during Cryogenic Weight tests using present hardware, revised procedures, and reworked installations.

A special test was instrumented for the LH_2 overfill sensor for S-IV-9 Acceptance Firing test. An automatic capacitance measuring bridge was substituted for the control unit. The bridge output was monitored on a strip chart recorder.

The purpose of the test was to verify that LH_2 did reach the point level sensor prior to venting liquid overboard.

During loading, and over the 100% point on the mass probe, the bridge output indicated a 100% ΔC change on the point level sensor. At that time the vent valves were closed and the bridge indication reverted back to a dry sensor indication. Loading was continued and the bridge indication again changed to a wet sensor. The vent valves were opened but the sensor wet indication persisted.

Hot firing was initiated and a dry sensor indication was obtained after the liquid level dropped below the sensor position.

On S-IVB the wiring installation is correct for all sensors and the control unit design has been improved.

11.E RKD Requirements for Moisture Content of Helium

Questions are raised about contaminants in the helium used at Sacramento and about the need to remove those impurities at the Beta Complex. A brief study indicates that the problem centers around the water vapor content in the helium. Sacramento uses Bureau of Mines' Grade-A helium which can have a moisture content of up to about 26 ppm by volume. Rocketdyne, however, has specified in their J-2 Engine Manual that the moisture content must not exceed about 7 ppm.

Rocketdyne's requirement thus concerns the helium supplied to the engine control sphere and to the seal cavities. As it stands now, the helium flow to the control sphere may meet this requirement. The flow is routed through the precooler, which should reduce the moisture concentration to less than 1 ppm. Moisture pick-up in the plumbing downstream of the precooler up to the interface could raise the concentration again above Rocketdyne's limit. The Bureau of Mines, using extreme means of helium purification and container cleaning, is apparently not able to keep the moisture content consistently below 10 ppm. Therefore, tests can only determine whether the flow to the control sphere can meet with Rocketdyne's requirements.

The ambient helium flow to the seal cavities is not purified according to the present plan. The intention behind Rocketdyne's specification in this case is not clear. The flow to the cavities is supposed to purge the moisture that has collected there. The higher moisture content of the grade A helium does not materially reduce the purging capability of the flow. The only difference would be, that after purging, the moisture concentration in the cavities can be up to 26 instead of 7 ppm. It is not clear why this concentration should have a detrimental effect on the engine operation. But, even if it is assumed that purification is required, it remains questionable that system clean-up at the Beta Complex is sufficient to maintain 7 ppm helium, because of the downstream contamination effects mentioned above.

PROPULSION SUBSYSTEMS FUNCTIONS

- S-II/S-IVB SEPARATION : ULLAGE CONTROL BY SOLID MOTORS
- POWERED ROLL CONTROL : J-2 BLEED HYDROGEN TO NOZZLES MOUNTED ON AFT SKIRT
- ATTITUDE AND ULLAGE CONTROL DURING EARTH ORBITAL COAST :
  - ULLAGE CONTROL BY CAP UNIT THRUST
  - ATTITUDE CONTROL BY CAP UNIT THRUST
- ATTITUDE OVERIDE CONTROL : BY COLD HELIUM HEATED BY CAP UNIT TO NOZZLES ON AFT SKIRT
- ATTITUDE CONTROL DURING TRANSLUNAR COAST : COLD RESIDUAL HELIUM TO NOZZLES ON AFT SKIRT
- REPRESSURIZATION : COLD HELIUM HEATED BY CAP UNIT TO TANK
- PNEUMATIC CONTROL : AMBIENT HELIUM
- OXIDIZER TANK ORBITAL VENTING : OXIDIZER SETTLED, VENT AS REQUIRED

FIGURE 51

CRYOGENIC APS WEIGHT SAVINGS

	STAGE WEIGHT	PAYLOAD
HYPERGOLIC APS (DELETED)	1839 LBS	1839
CRYOGENIC APS (ADDED)	638 LBS	638
AMBIENT REPRESSURIZATION BOTTLES & SUPPORTS (DELETED)	1254 LBS	1254
PNEUMATIC SUPPLY & OVERRIDE CONTROL (ADDED)	85 LBS	85
JETTISONABLE ULLAGE ROCKETS (ADDED)	287 LBS	95
HELIUM GAS (ADDED)	78 LBS	78 (MAX)
HYPERGOLIC APS PROPELLANTS & GASES (DELETED)	1587 LBS	794
CRYOGENIC APS PROPELLANTS (ADDED)	1620 LBS	810
NET WEIGHT (DELETED)	1972 LBS*	
PAYLOAD GAIN		2181 LBS

* NOT PAYLOAD WEIGHT GAIN
WEIGHTS STUDY BASED ON PULSE VENTING

(SEE ENCLOSURE TO R-P&VE-XJ-64-573 FOR REVISED AND ADDITIONAL VALUES)

FIGURE 52

S-IVB CRYOGENIC APS DESIGN STUDY

BLOCK DIAGRAM

1. AMBIENT He FILL MODULE
2. FUEL PRESSURIZATION CONTROL MODULE
3. LOX MAKEUP & FUEL REPRESS MODULE
4. He HEATER & LOX PRESSURIZATION MODULE
5. AMBIENT He CONTROL MODULE
6. He CONTROL GAS FROM 5 WITH CONTROL SOLENOID

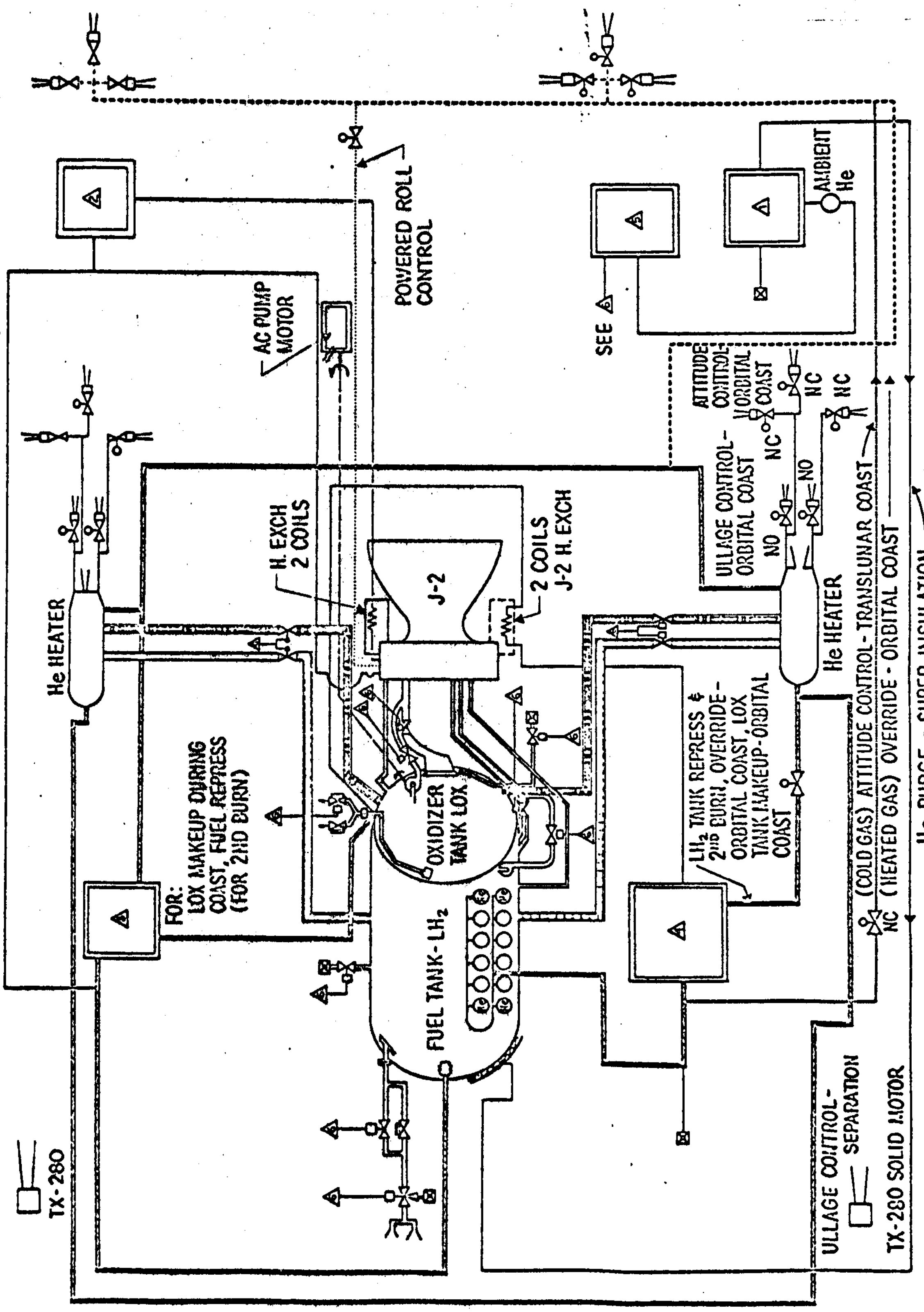


FIGURE 53

S-IVB/S-V CRYOGENIC AUXILIARY PROPULSION UNIT

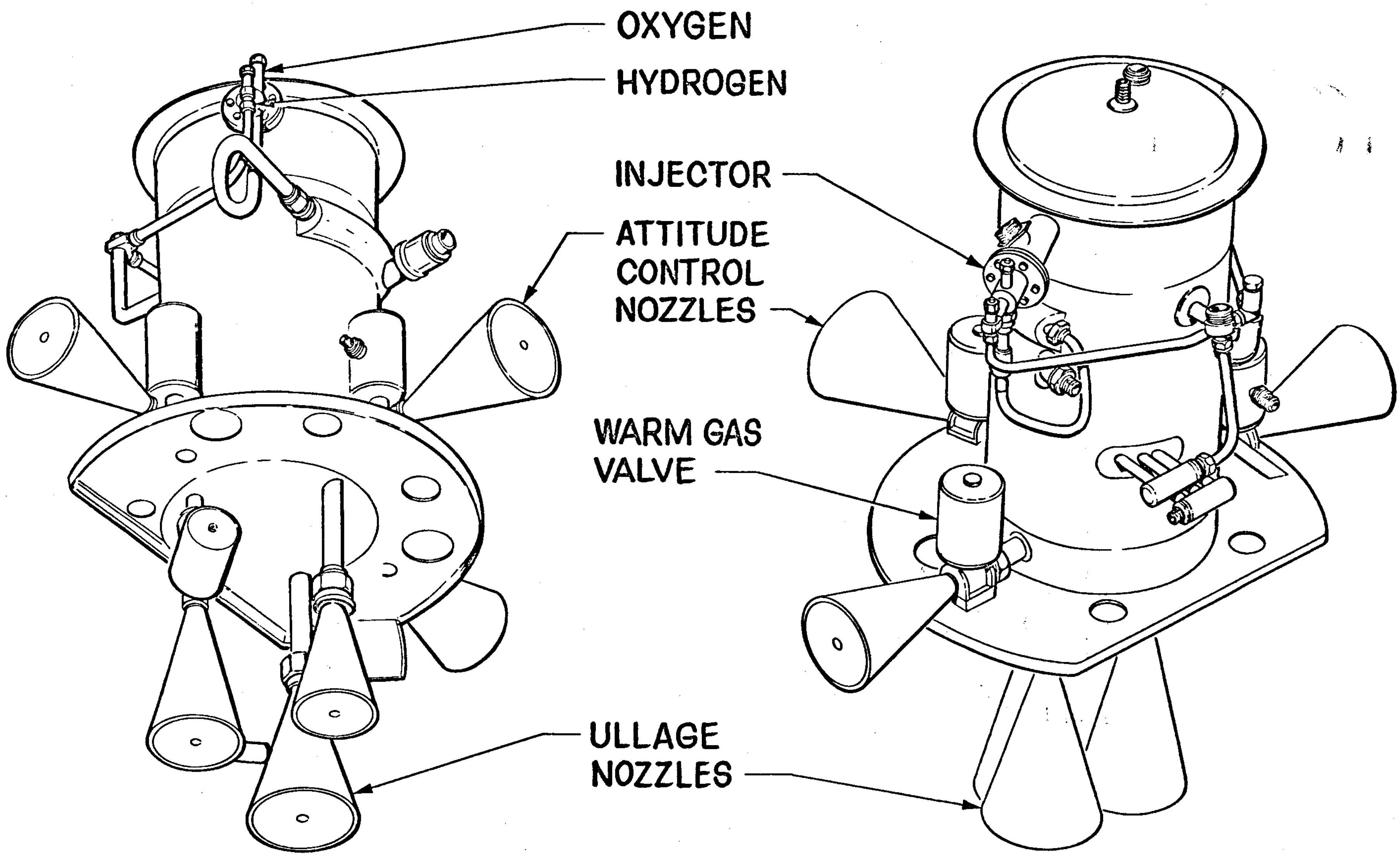


FIGURE 54

CRYOGENIC APS INTERNAL SCHEMATIC

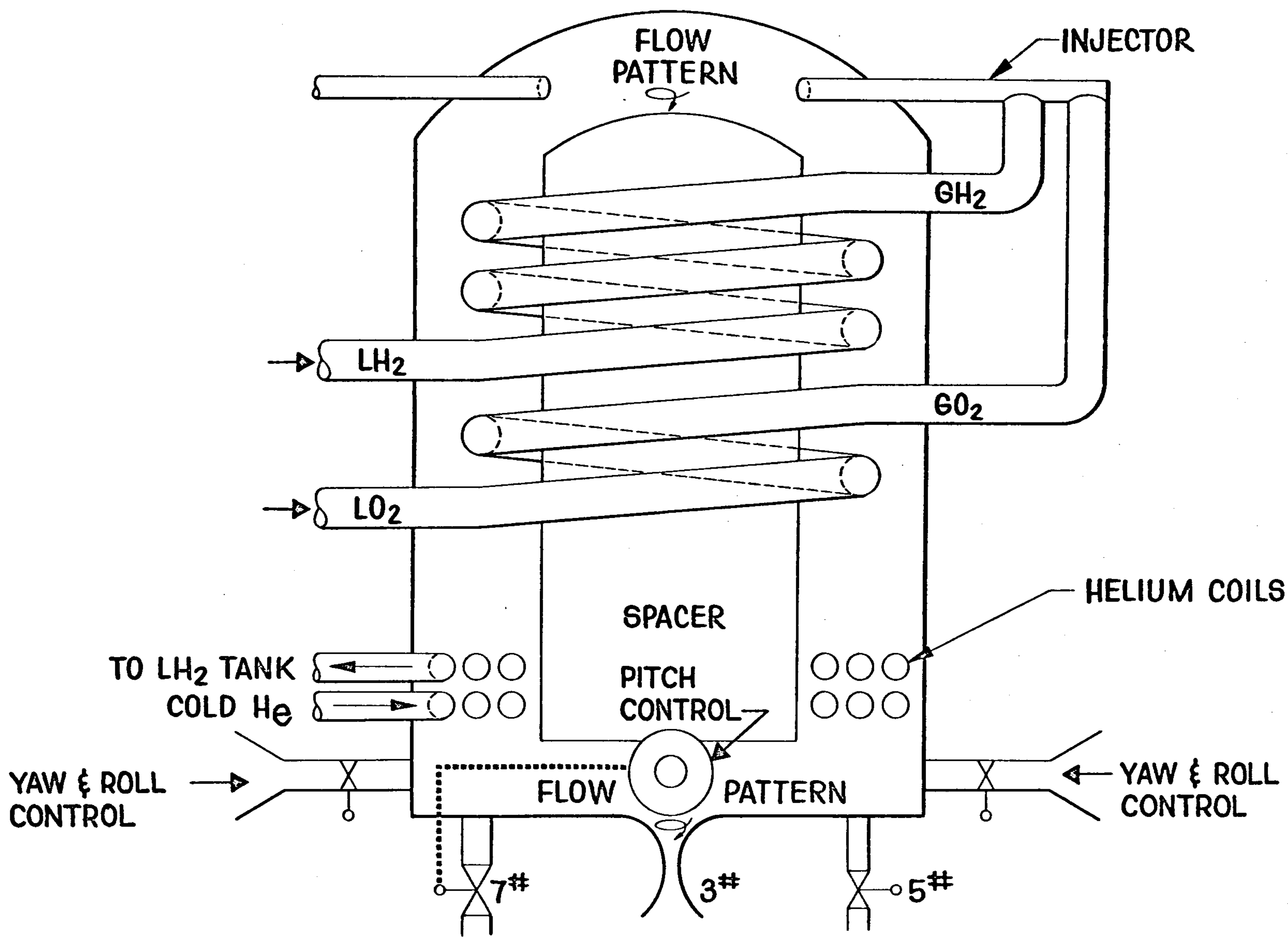


FIGURE 55

S-IVB/S-V CRYOGENIC AUXILIARY PROPULSION SYSTEM

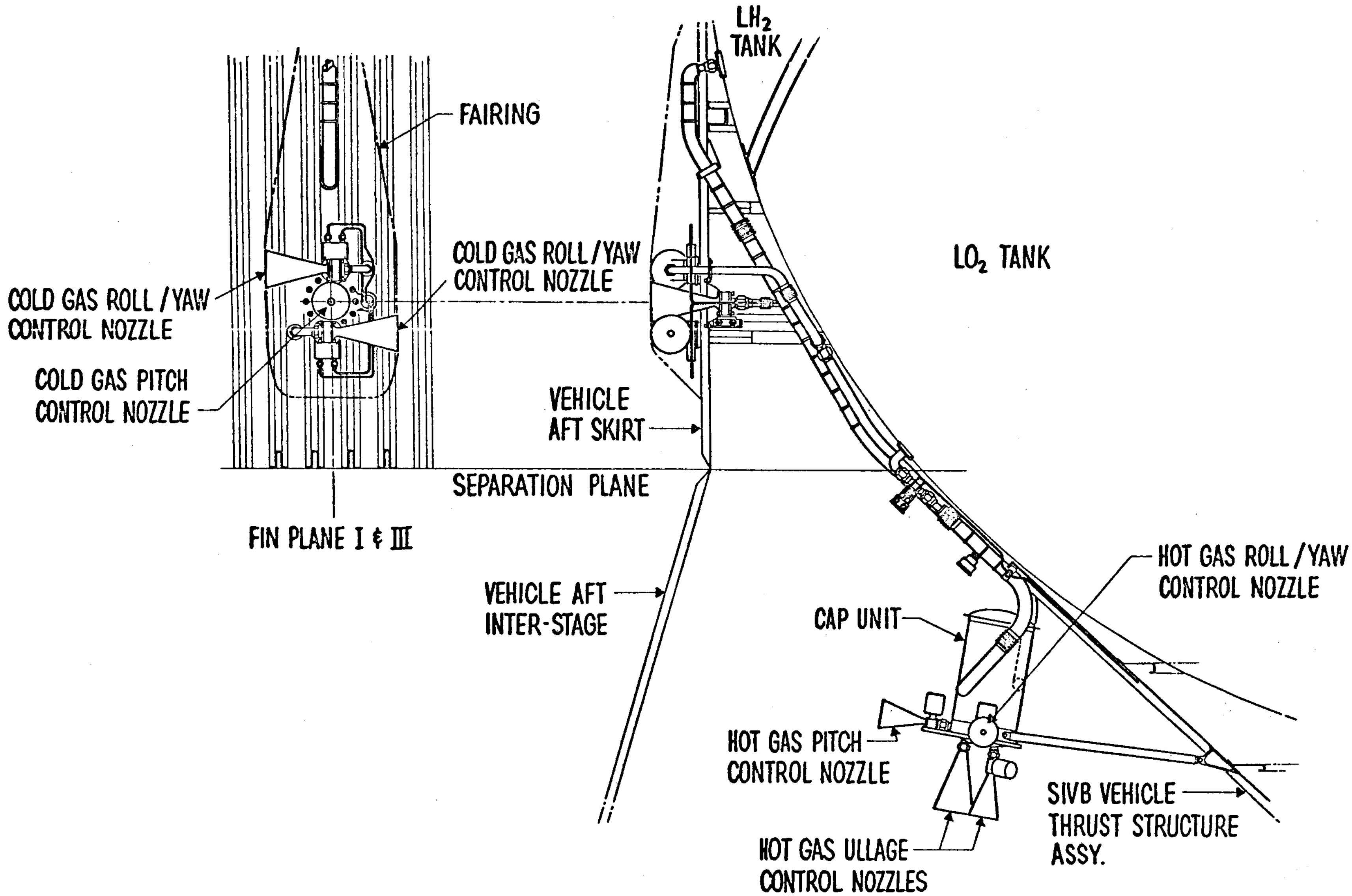


FIGURE 56

CAP UNIT DESIGN CRITERIA

• HYDROGEN INJECTION PRESSURE (MIN.)	18 PSIA.
• OXYGEN INJECTION PRESSURE (NOM.)	38 PSIA.
• TOTAL PROPELLANT FLOW RATE (HIGH)	0.044 LBS/SEC
• MIXTURE RATIO (HIGH)	1.1 TO 1
• COMBUSTION TEMPERATURE (RANGE)	800 TO 1800° F
• CHAMBER PRESSURE	6 PSIA.

FIGURE 57

HYDROGEN GAS FOR REPRESSURIZATION

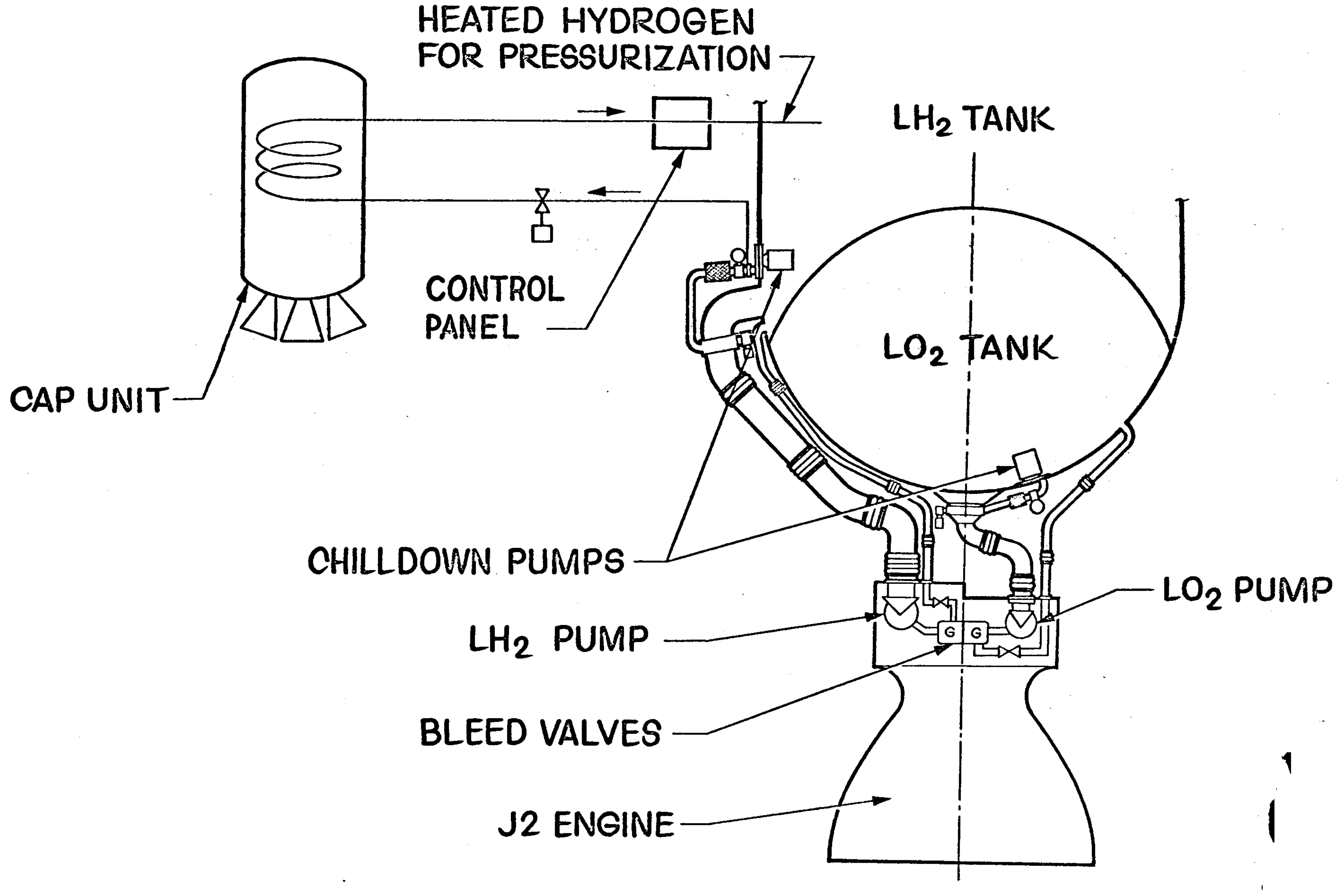


FIGURE 59

CRYOGENIC AUXILIARY COMBUSTORS TES

- DEVELOPMENT

  VERIFY WARM GAS VALVE OPERATION
  VERIFY NOZZLE THRUST LEVELS
  VERIFY IGNITER - INJECTOR PERFORMANCE
  UPDATE AND VERIFY HEAT TRANSFER CHARACTERISTICS (LH_2 TURB ΔP)

- PERFORMANCE VERIFICATION AND QUALIFICATION

  VERIFY PERFORMANCE (SEE TEST OUTLINE)
  QUALIFY (VIBRATE, PROOF TEST, X-RAY, FIRE AND BURST TEST)
  ALL SYSTEMS VEHICLE TESTING

- PRODUCTION CALIBRATION AND ACCEPTANCE

  CALIBRATE INJECTORS, ORIFICES AND NOZZLES AND VERIFY BY FIRING EACH UNIT
  ACCEPTANCE FIRE WITH STAGE

FIGURE 58

CRYOGENIC APS FLEX-LINE CONFIGURATION

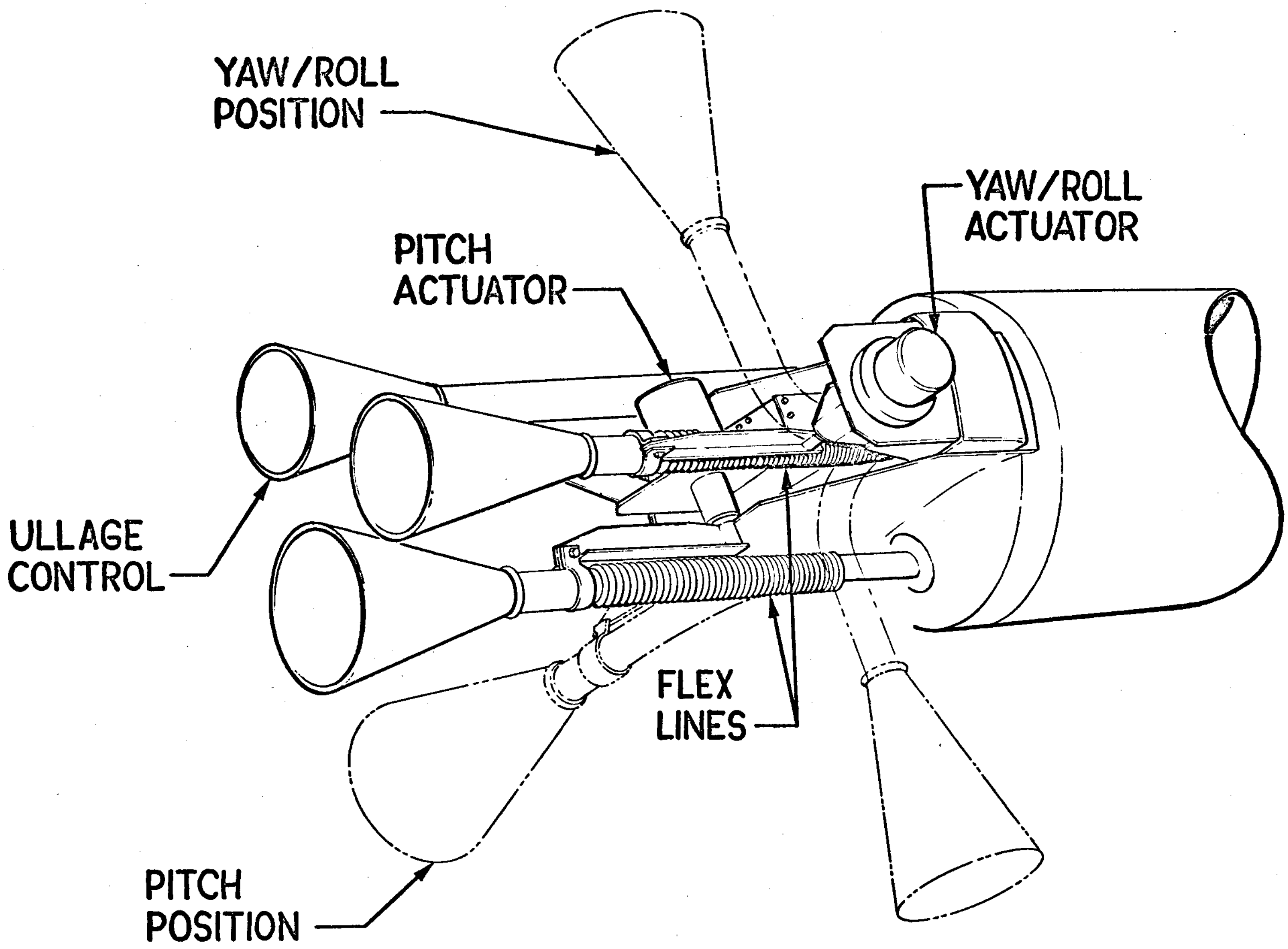


FIGURE 60

WORKSHEET
Form 30-1038-1 (7-63)

S IV B PROPULSION SPEC CONTROL DWGS. (PURCHASED PARTS)

(TO BE UPDATED EVERY 45 DAYS)
8-20-64 G. SED

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDER NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A39621-1	BELLOWS ASSY, LOW PRESSURE	FLEX. METAL HOSE	10195-1	NO PRINT	
1A39621-501	BELLOWS ASSY, LOW PRESSURE	FLEX. METAL HOSE	10195-501	NO. PRINT	
1A39621-503	BELLOWS ASSY, LOW PRESSURE	FLEX. METAL HOSE	10195-503	NO PRINT	
1A39622-1	BELLOWS ASSY, HIGH PRESSURE	FLEX. METAL HOSE	10196-1	NO PRINT	
1A39622-501	BELLOWS ASSY, HIGH PRESSURE	FLEX. METAL HOSE	10196-501	NO PRINT	
1A39622-503	BELLOWS ASSY, HIGH PRESSURE	FLEX. METAL HOSE	10196-503	NO PRINT	
1A39622-505	BELLOWS ASSY, HIGH PRESSURE	FLEX. METAL HOSE	10196-505	NO PRINT	
1A39622-507	BELLOWS ASSY, HIGH PRESSURE	FLEX. METAL HOSE	10196-507	NO PRINT	
1A48240-1	VALVE, FILL AND DRAIN, OXIDIZER TANK	FAIRCHILD STRATOS	63-570	YES	
1A48257-1	VALVE, VENT AND RELIEF, FUEL TANK	CALMEC	519-501	YES	
1A48312-1	VALVE, VENT AND RELIEF, OXIDIZER TANK	CALMEC	528-501	YES	
1A45712-1	BELLOWS ASSY, HIGH PRESSURE	FLEX. METAL HOSE	10197-1	NO PRINT	
1A48848-503	DISCONNECT ASSY., FUEL TANK VENT (FLIGHT HALF)	FAIRCHILD STRATOS	63-529	YES	
1A48848-505	DISCONNECT ASSY., FUEL TANK VENT (GND HALF)	FAIRCHILD STRATOS	63-530	YES	
1A48550-1	HOSE ASSY, METAL, FLEXIBLE, HELIUM CONTROL	FLEX METAL HOSE	10050-1	NO PRINT	
1A48550-505	HOSE ASSY, METAL, FLEXIBLE, HELIUM CONTROL	FLEX METAL HOSE	10050-505	NO PRINT	
1A48851-1	GIMBAL JOINT 2 INCH DUCT	FAIRCHILD STRATOS	41288-501	YES	
1A48852-1	HOSE ASSY, METAL, FLEXIBLE, COLD HELIUM	FLEX METAL HOSE	10040-1	NO PRINT	
1A48852-503	HOSE ASSY, METAL, FLEXIBLE, COLD HELIUM	FLEX METAL HOSE	10040-503	NO PRINT	

~~SHEET 1 OF 7~~

APPENDIX [redacted]

WORKSHEET
Form 30-1058-1 (7-69)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES
1A48852-505	HOSE ASSY, METAL, FLEXIBLE, COLD HELIUM	FLEX METAL HOSE	10040-505	NO PRINT
1A48853-501	HOSE ASSY, METAL, FLEXIBLE, PRE-PRESS, F/T	FLEX METAL HOSE	10039-501	NO PRINT
1A48857-1	TANK, COMPRESSED GAS, COLD HELIUM	AIRTEK DYNAMICS	4425002-901	NO PRINT
1A48858-1	SPHERE, STORAGE, HELIUM, LO2 TANK PRESS.	MENASCO	750000-503	NO PRINT
1A49157-1	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON	K2261-2	YES
1A49157-501	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON	K2320-2	YES
1A49320-1	DUCT ASSY., FUEL, LOW PRESSURE	STAINLESS STEEL PROD	1303427	YES
1A49398-1	MODULE, COLD HELIUM FILL	FAIRCHILD STRATOS	63-034	YES
1A49421-1	PUMP, LH2, AUXILIARY MOTOR DRIVEN, CHILLDOWN	PESCO	144668-100	NO PRINT
1A49423-1	PUMP, LO2, AUXILIARY MOTOR DRIVEN, CHILLDOWN	PESCO	144666-100	NO PRINT
1A49590-1	VALVE, RELIEF, OXIDIZER TANK	H. W. LOUD	1538L000	YES
1A49591-1	VALVE, RELIEF, FUEL TANK	H.W. LOUD	1538L000-1	YES
1A49958-1	DISCONNECT ASSY, ENGINE	ON MARK	1264004-02	YES
1A49958-501	" " "	" "	1265004-02	YES
1A49958-503	" " "	" "	1264006-02	YES

WORKSHEET
Form 30-1035-1 (7-43)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A49958-505	DISCONNECT ASSY, ENGINE	ON MARK	1265008-02	YES	
" -507	" " "	" "	1264008-02	YES	
" -509	" " "	" "	1264008-01	YES	
" -511	" " "	" "	1264006-01	YES	
" -513	" " "	" "	1264008-01	YES	
" -515	" " "	" "	1264004-06	YES	
" -517	" " "	" "	1265004-06	YES	
" -519	" " "	" "	1264006-06	YES	
" -521	" " "	" "	1265008-06	YES	
1A49958-523	DISCONNECT ASSY, ENGINE	ON MARK	1264008-06	YES	
	BELLOWS ASSY, LOW PRESSURE				
1A49961-1	~~[illegible]~~	~~[illegible]~~	FOR RE-BID		
1A49962-1	RESILIENT MOUNT, 2 INCH DUCT	ROBINSON VIBRASHOCK	K2319-2	YES	
-501	" "	" "	K2319-4	YES	
-503	" "	" "	K2319-6	YES	
-505	" "	" "	K2319-8	YES	
-507	" "	" "	K2319-10	YES	
1A49962-509	RESILIENT MOUNT, 2 INCH DUCT	ROBINSON VIBRASHOCK	K2319-12	YES	
1A49963-1	SPHERE, STORAGE-HELIUM	AIRTEK DYNAMICS	9490122	NO PRINT	
1A49964-1	VALVE, SWING CHECK, CHILL SYSTEM	PARKER AIRCRAFT	2630213	YES	
1A49965-1	VALVE, SOLENOID SHUT-OFF, CHILL SYSTEM	FAIRCHILD STRATOS	63-1039	YES	
1A49965-501	VALVE, SOLENOID SHUT-OFF, CHILL SYSTEM	FAIRCHILD STRATOS	63-1038	YES	

SHEET 3 OF 7

WORKSHEET
Form 30-1038-1 (7-65)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A48852-505	HOSE ASSY, METAL, FLEXIBLE, COLD HELIUM	FLEX METAL HOSE	10040-505	NO PRINT	
1A48853-501	HOSE ASSY, METAL, FLEXIBLE, PRE-PRESS, F/T	FLEX METAL HOSE	10039-501	NO PRINT	
1A48857-1	TANK, COMPRESSED GAS, COLD HELIUM	AIRTEK DYNAMICS	4425002-901	NO PRINT	
1A48858-1	SPHERE, STORAGE, HELIUM, LO2 TANK PRESS.	MENASCO	750000-503	NO PRINT	
1A49157-1	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON	K2261-2	YES	
1A49157-501	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON	K2320-2	YES	
1A49320-1	DUCT ASSY., FUEL, LOW PRESSURE	STAINLESS STEEL PROD	1303427	YES	
1A49398-1	MODULE, COLD HELIUM FILL	FAIRCHILD STRATOS	63-034	YES	
1A49421-1	PUMP, LH2, AUXILIARY MOTOR DRIVEN, CHILLDOWN	PESCO	144668-100	NO PRINT	
1A49423-1	PUMP, LO2, AUXILIARY MOTOR DRIVEN, CHILLDOWN	PESCO	144666-100	NO PRINT	
1A49590-1	VALVE, RELIEF, OXIDIZER TANK	H. W. LOUD	1538L000	YES	
1A49591-1	VALVE, RELIEF, FUEL TANK	H.W. LOUD	1538L000-1	YES	
1A49958-1	DISCONNECT ASSY, ENGINE	ON MARK	1264004-02	YES	
1A49958-501	" " "	" "	1265004-02	YES	
1A49955-503	" " "	" "	1264006-02	YES	

WORKSHEET
Form 30-1035-1 (7-43)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A49958-505	DISCONNECT ASSY, ENGINE	ON MARK	1265008-02	YES	
" -507	" " "	" "	1264008-02	YES	
" -509	" " "	" "	1264008-01	YES	
" -511	" " "	" "	1264006-01	YES	
" -513	" " "	" "	1264008-01	YES	
" -515	" " "	" "	1264004-06	YES	
" -517	" " "	" "	1265004-06	YES	
" -519	" " "	" "	1264006-06	YES	
" -521	" " "	" "	1265008-06	YES	
1A49958-523	DISCONNECT ASSY, ENGINE	ON MARK	1264008-06	YES	
1A49961-1	BELLOWS ASSY, LOW PRESSURE ~~[illegible]~~	~~[illegible]~~	FOR RE-BID		
1A49962-1	RESILIENT MOUNT, 2 INCH DUCT	ROBINSON VIBRASHOCK	K2319-2	YES	
-501	" "	" "	K2319-4	YES	
-503	" "	" "	K2319-6	YES	
-505	" "	" "	K2319-8	YES	
-507	" "	" "	K2319-10	YES	
1A49962-509	RESILIENT MOUNT, 2 INCH DUCT	ROBINSON VIBRASHOCK	K2319-12	YES	
1A49963-1	SPHERE, STORAGE-HELIUM	AIRTEK DYNAMICS	9490122	NO PRINT	
1A49964-1	VALVE, SWING CHECK, CHILL SYSTEM	PARKER AIRCRAFT	2630213	YES	
1A49965-1	VALVE, SOLENOID SHUT-OFF, CHILL SYSTEM	FAIRCHILD STRATOS	63-1039	YES	
1A49965-501	VALVE, SOLENOID SHUT-OFF, CHILL SYSTEM	FAIRCHILD STRATOS	63-1038	YES	

WORKSHEET
Form 30-1033-1 (7-63)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR. FILES	
1A49966-501	DUCT ASSEMBLY, LH2 RECIRCULATION	FAIRCHILD STRATOS	41105-501	YES	
1A49967-1	FLEXIBLE SECTION, 2 INCH DUCT	ANACONDA	88208-901	YES	
1A49967-501	FLEXIBLE SECTION, 2 INCH DUCT	ANACONDA	88208-902	YES	
1A49967-503	FLEXIBLE SECTION, 2 INCH DUCT	ANACONDA	88208-903	YES	
1A49968-1	VALVE, PROP. TANK SHUT-OFF	CLARY CORP	526540	YES	
1A49968-501	VALVE, PROP. TANK SHUT-OFF	CLARY CORP	526541	YES	
1A49969-1	DUCT ASSEMBLY, LOW PRESSURE, LO2	STAINLESS STEEL PROD	1303349-1	YES	
1A49969-501	DUCT ASSEMBLY, LOW PRESSURE, LO2	STAINLESS STEEL PROD	1303349-101	YES	
1A49970-501	DISCONNECT, FILL & DRAIN, OXIDIZER TANK	FAIRCHILD STRATOS	63-365	YES	
1A49970-503	DISCONNECT, FILL & DRAIN OXIDIZER TANK	FAIRCHILD STRATOS	63-364	YES	
1A49977-1	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON VIBRASHOCK	K2295-2	YES	
1A49977-501	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON VIBRASHOCK	K2295-4	YES	
1A49978-501	DISCONNECT, FILL & DRAIN FUEL TANK	FAIRCHILD STRATOS	63-363	YES	
1A49978-503	DISCONNECT, FILL & DRAIN FUEL TANK	FAIRCHILD STRATOS	63-362	YES	
1A49979-1	BELLOWS ASSY, LH2 FILL & DRAIN (UPPER	MARMAN DIVISION	M0359862	NO. PRINT	
1A49971-501	BELLOWS ASSY, EXTERNAL, LO2 FILL	MARMAN DIVISION	59220	YES	
1A49972-501	BELLOWS ASSY, INTERNAL, LO2 FILL	STAINLESS STEEL PROD	1303449-1	YES	

WORKSHEET
Form 30-1035-1 (7-63)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A49980-A	BELLOWS ASSY, LH2 FILL, (LOWER)	MARMAN DIVISION	MOB59968	YES	
1A49981-1	BELLOWS, ASSY, VENT, EXT	AVICA	14273	NO PRINT	
1A49982-1	MODULE, ACTUATION VENT CONTROL	CLARY DYNAMICS	520773	YES	
1A49982-501	MODULE, ACTUATION VENT CONTROL	CLARY DYNAMICS	520809	YES	
1A49983-1	SEPARATOR, VENT, ZERO GRAVITY	PESCO	04479-100	NO PRINT	
1A49984-1	DUCT, INTERNAL, FUEL VENT	MARMAN DIVISION	MOA69719	NO PRINT	
1A49985-501	BELLOWS ASSY, LH2 RELIEF	AVICA	14226	NO PRINT	
1A49986-1	BELLOWS ASSY, LH2 FLANGE	AVICA	14180	NO PRINT	
1A49988-1	VALVE, DIRECTIONAL CONTROL, FUEL VENT	CALMEC	511	YES	
1A49989-1	MODULE, REPRESS CONTROL, LO2 TANK	VINSON	A-62391-1	NO PRINT	
1A49989-501	MODULE, REPRESS CONTROL, LO2 TANK	VINSON	A-62391-501	NO PRINT	
1A49990-1	SPHERE, STORAGE, HELIUM, PROP. TANK PRESS	AIRTEK DYNAMICS	4425003	NO PRINT	
1A49991-1	TANK, COMPRESSED GAS, COLD HELIUM	MENASCO	925000-503	NO PRINT	
1A49992-1	MODULE, CONTROL, LO2 TANK PRESS	FREBANK CO.	3158-1	NO PRINT	

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WORKSHEET
Form 30-1033-1 (7-49)

SPEC CONTROL DWG. NO.	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A49993-1	MODULE, CONTROL, FUEL TANK PRESS.	VINSON	A-62386	NO PRINT	
1A57350-1	MODULE, HELIUM FILL	FAIRCHILD STRATOS	S-2269	NO PRINT	
1A58345-1	MODULE, PNEUMATIC POWER CONTROL	VINSON	A-62390	NO PRINT	
1A58346-1	VALVE, SOLENOID, LEAK CHECK.	VINSON	A-63019	NO PRINT	
1A58347-1	MODULE, ENGINE PUMP, PURGE CONTROL	B.H. HADLEY	11439-1	NO PRINT	
1A67313-1	VALVE, LO2 CHILLPUMP MOTOR CONTAINER	CALMEC	586	NO PRINT	
1A69044-1	DUCT, OXIDIZER VENT, INTERNAL	FAIRCHILD STRATOS	41247	NO PRINT	
1A69044-501	DUCT, OXIDIZER VENT, INTERNAL	FAIRCHILD STRATOS	41248	NO PRINT	
1A69739-1	HOSE ASSEMBLY, METAL, FLEXIBLE, FUEL TANK	FLEXIBLE METAL HOSE	10015-1	NO PRINT	
1A74710-1	MOUNT, RESILIENT, LH2 PROPELLANT DUCT	ROBINSON VIBRASHOCK	K2229-4	YES	
1A77111-501	HOSE ASSY, METAL, FLEXIBLE, REPRESS.	FLEXIBLE METAL HOSE	10038-501	NO PRINT	
1A86703-1	BELLOWS, TEE LH2 TANK VENT	MARMAN DIVISION	N0859798	NO PRINT	
1A87647-1	BELLOWS, PRESS COMPENSATED	STAINLESS STEEL PROD	1303658	NO PRINT	

WORKSHEET
Form 30-1033-1 (7-49)

SPEC CONTROL DWG. NO	NAME OF COMPONENT	VENDOR NAME	VENDOR PART NO.	CROSS SECTION VIEW AVAILABLE IN VENDOR FILES	
1A48239-1	VALVE, DEBRIS, FILL & DRAIN	ON RE-BID		NO PRINT	
1A48856-1	VALVE, SHUT-OFF-CONTINUOUS VENT	ON RE-BID		NO PRINT	
1A49957-1	ENGINE, DISCONNECT, WARM-HELIUM PURGE	ON RE-BID		NO PRINT	
1B37129-1	PUMP, AUXILIARY MOTOR DRIVEN-LH2 CHILLDOWN	~~ON BID~~ PESCO	144668-110	NO PRINT	
7851823-503	DISCONNECT ASSY, He FILL	ON MARK	1198004-02	YES	
7851844-1	DISCONNECT ASSY, COLD He FILL	CALMEC	262-16	YES	
7851861-1	DISCONNECT ASSY, FUEL TANK PRE-PRESS	CALMEC	273-21	YES	

~~SHEET 7 OF 7~~ M-

ABSTRACT

CAPACITANCE POINT LEVEL SENSORS

On the S-IV vehicle we have experienced problems with the overfill and instrumentation point level sensors. The problems are primarily due to: 1) faulty electrical installation, Figure 1 (cause crosstalk, mutual cap, ground loops) 2) inadequate adjustment procedures resulted in either over sensitive or inadequate sensitivity for proper operation, Figure 2.

In order to rectify these problems electrical installations have been corrected on S-IV-7 and subs for the overfill sensors, Figure 3. The rework eliminated a ground loop problem and a source of stray capacitance caused by the absence of shielding on either signal lead passing through a conventional connector.

The checkout and adjustment procedures were revised from adjusting the trim pot to a certain number of turns to adjusting the trim pot as necessary to establish the proper ΔC required for proper operation.

The LH_2 or overfill cutoff sensor was activated for the first time during the cryogenic calibration tests on the S-IV-9 vehicle. The overfill cutoff signal was obtained using S-IV hardware adjusted per the revised procedure, and installed per the reworked installation.

During the calibration tests, the LH_2 tank was vented on several occasions with the liquid hydrogen above the 100 percent level. Each time the tank was vented, the overfill sensor was activated and the overfill signal persisted until the vents were closed.

The activation of the overfill sensor appeared to be erratic and was thought due to inaction with the vent valve command or due to pressurization or both. A special test was conducted during the loading for the S-IV-9 Acceptance Firing Test to verify that liquid hydrogen did reach the overfill sensor prior to venting liquid overboard, and to monitor sensor capacitance during the loading operation in order to explain the operation observed during the cryogenic calibration tests.

APPENDIX N

An automatic capacitance measuring bridge was substituted for the control unit and the bridge output was monitored on a strip chart recorder.

During LH_2 loading, and over the 100% point on the mass probe, the bridge output indicated a 100% Δ C change on the point level sensor. At that time the vent valves were closed and the bridge indication reverted back to a dry sensor indication. Loading was continued and the bridge indication again changed to a wet sensor indication. The vent valves were opened but the sensor wet indication persisted.

A dry sensor indication was obtained after the liquid level dropped below the sensor position, indicating that the sensor was working properly and that information obtained from the overfill sensor during the cryogenic calibration tests was valid. On S-IVB the wiring installation is correct for all sensors and the control unit design has been improved.

The S-IVB B/S point level sensors are presently being checked out. During the checkout, all the sensors simultaneously began to cycle ON and OFF at approximately a 12 CPS rate.

This problem is caused by the Mathers AFB radar and an ungrounded GSE power supply, which provides power to the control units. This problem is being investigated further by the RF Group.

STATUS - S-IVB DE/Q TESTING

1. Instrumentation/Depletion

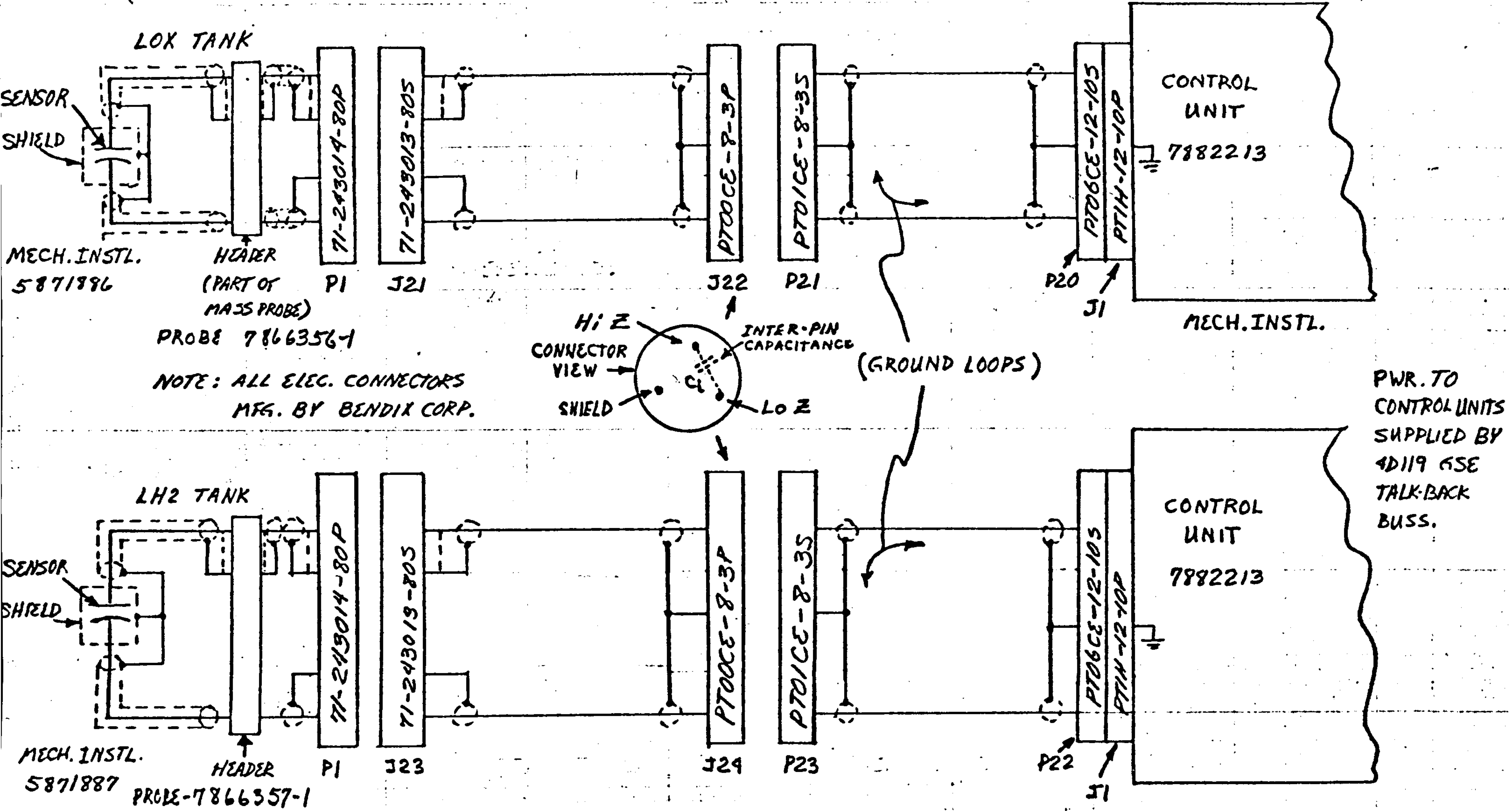
A copy of the Minneopolis Honeywell Test Plan has been received and is presently being reviewed by Engineering for approval.

Honeywell estimates 12 to 14 weeks to complete DE/Q testing after go-ahead. They are planning to farm out some of the testing to Wyle Labs.

2. Overfill Cutoff Sensors

   a. LH_2 Sensors - The proposed test plan for the LH_2 PU probe and a revision to same have been submitted for DAC approval. The test hardware is available and it is estimated that the testing will require approximately 1 month for completion. A portion of the test requiring the use of LH_2 are being subcontracted to Wyle Labs.

b. LOX Sensors - The test plan is presently being written by M-H. Test hardware is available contingent on availability of a feed-through connector and a mating plug (est. 10-20-64). Here again a portion of the test is to be performed by Wyle.

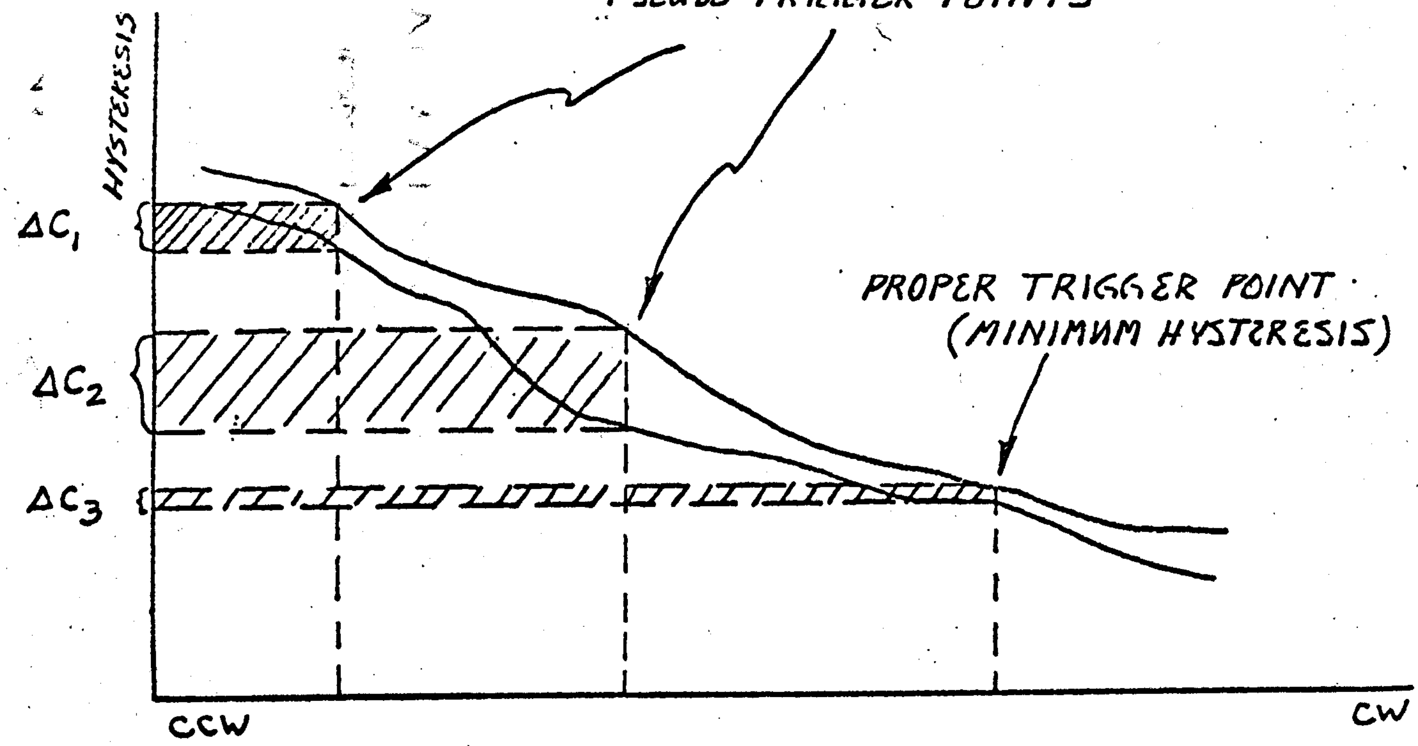


FUNCTIONAL SCHEMATIC

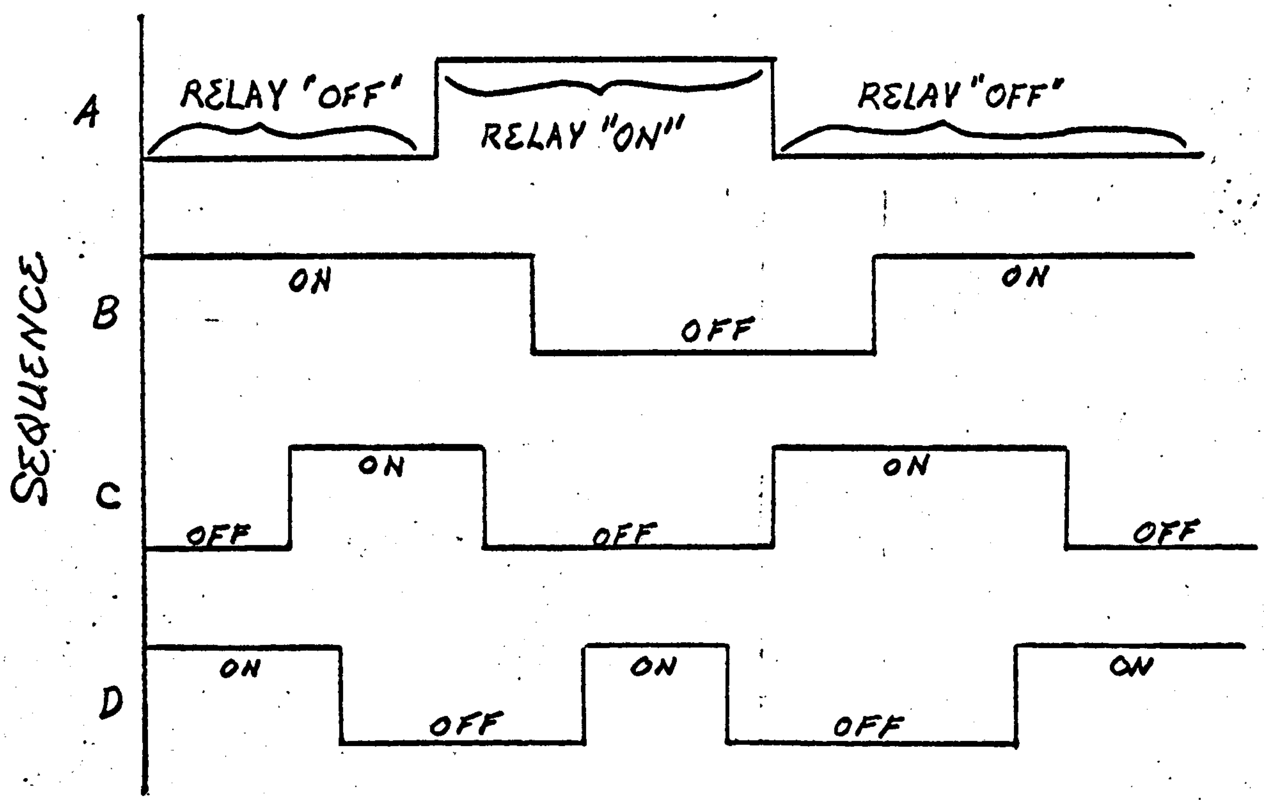
OVERFILL SENSOR INSTALLATION

S IV -5,6

FIGURE 1.2



1.14 - A

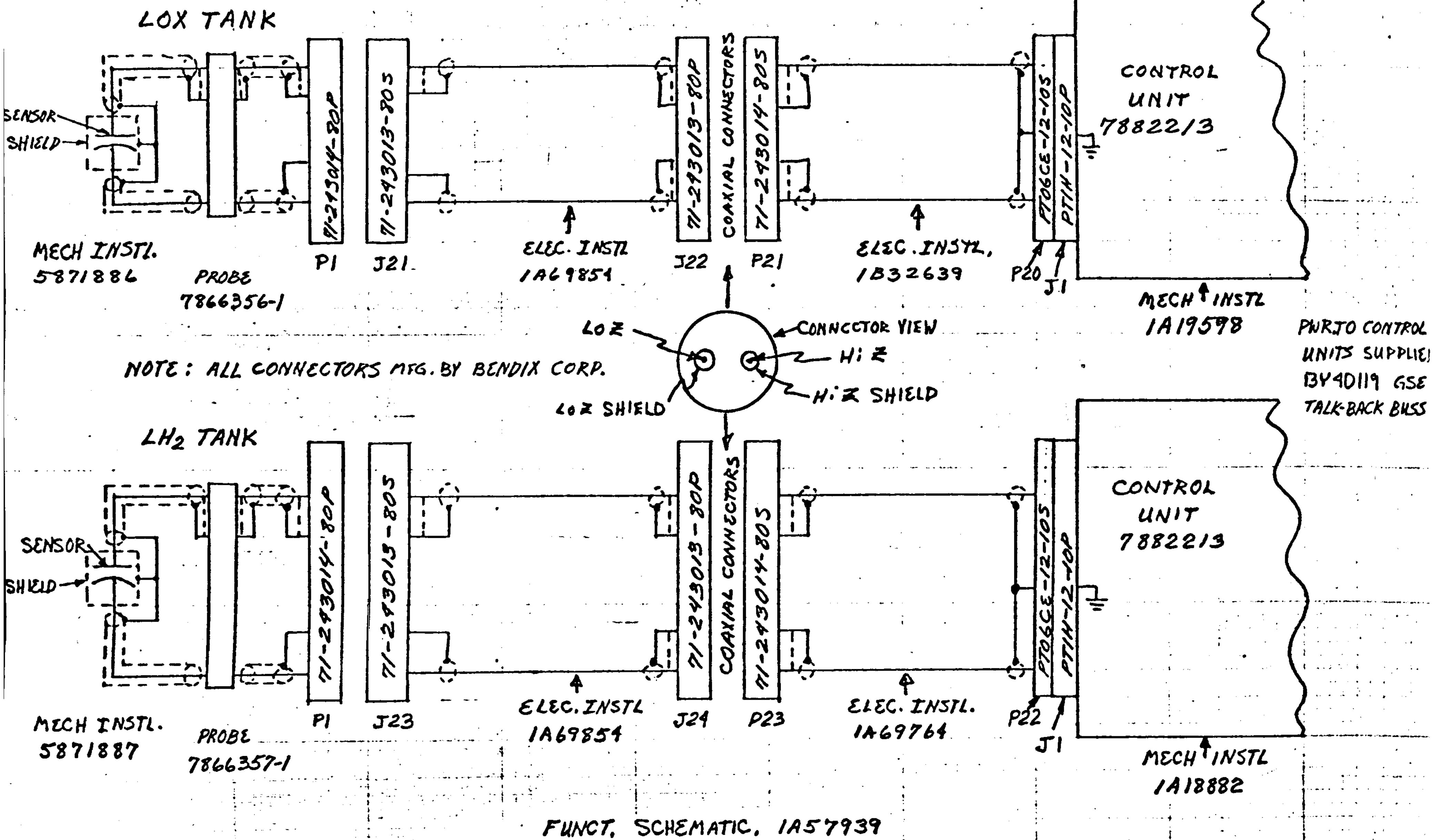


AS TRIMPOT IS ROTATED (CCW TO CW) THE OUTPUT RELAY WILL PASS THROUGH ONE OF THE SEQUENCES SHOWN ABOVE.

1.14 B

PSEUDO TRIGGER POINT ANALYSIS

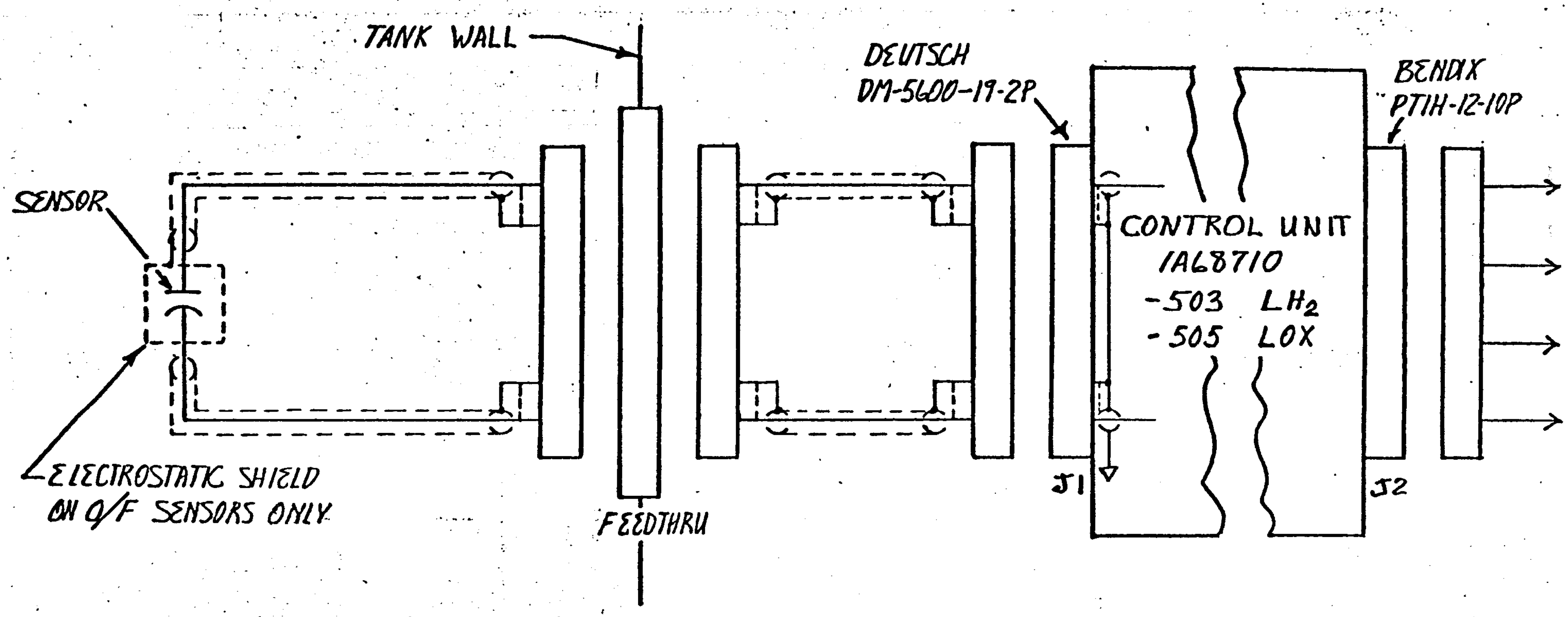
FIGURE ~~1.13~~ 2



OVERFILL SENSOR INSTALLATION

S IV-7,8,9,10

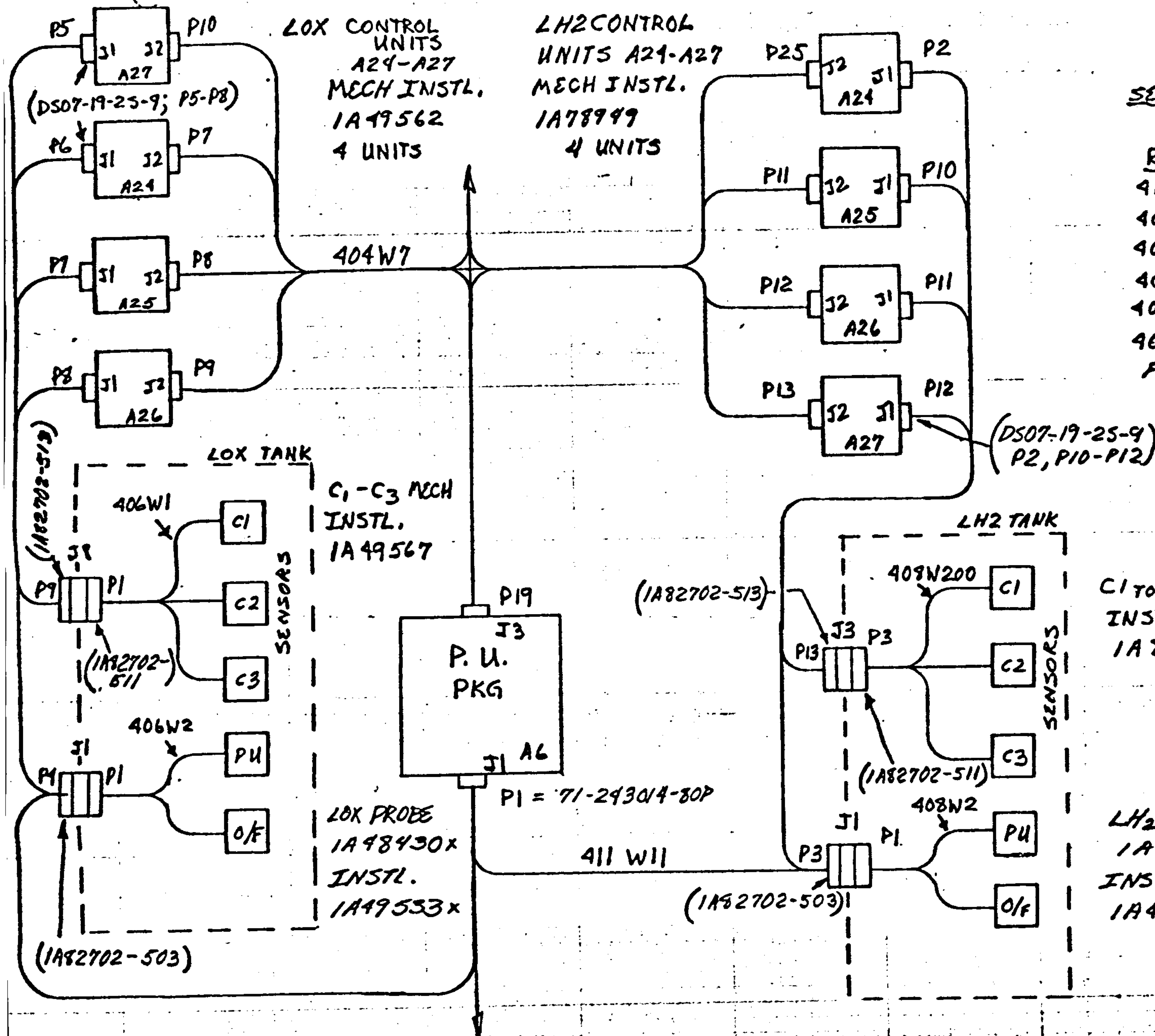
FIGURE 1.22 3



S IV B

REPRESENTATIVE LIQUID LEVEL SENSOR INSTALLATION
OVERFILL, DEPLETION AND INSTRUMENTATION

FIGURE 4



SEQ IA CABLE NTWK. DIA. 1A67753

WIRE HARNESS DWGS

REF NO	DWG. NO.	
411 W11	1A69584	x
406W1	1A79544	x
406 W2		
408W200	1A94046	x
408W2		
404W7	1A67486	
FEEDTHRUS (SAME AS INSTR)	1A72229	

SIV B LH2 & LOX CONTROL POINT LEVEL SENSORS

SIB & 55 A/S

FIGU ~~2-19~~ 5

12. ENVIRONMENTAL CONTROL (SATURN IB/V)

12.A.-B. Test Status

(1) COLD PLATES

(a) Dynamic testing of five cold plates, each with different arrangements of attached components and categorized as to total weight, is now being conducted. These development tests are directed primarily at obtaining dynamic environments for use in qualification testing of hard-mounted astrionic components. Each test specimen includes, in addition to the cold plate, a section of the forward skirt structure, vibration isolators, and segments of the supply and return coolant manifolds. The fluid portion of the system is pressurized with water at 40 psig. Tests of three of the five plates have been completed; there have been no mechanical or structural problems.

(b) Authorization has recently been received to proceed with the following development tests (except for thermal/vacuum testing which was authorized by the original General Test Plan). Testing will begin as soon as Test Control Drawings (TCD) can be written and test parts fabricated.

BURST TEST:

This test will determine the ultimate pressure that the cold plate can withstand. Design burst pressure is 130 psig. In addition, the test will provide leakage and heat transfer contact surface deflection and flatness data.

LIFE TEST:

This test will simulate the cyclic, pressurized operation of the cold plate system during checkout at Huntington Beach, Sacramento and KSC. It will terminate with a period of random vibration to simulate launch followed by 6-1/2 hours at limit pressure to simulate orbital coast and translunar travel.

VIBRATION TEST:

This test will determine the degradation of the heat transfer surface, structural integrity (fluid tightness and bond strength) and transient pressure fluctuation within the pressurized and fluid-filled coolant channels. The cold plate will be subjected to vibration and shock while supported by vibration isolators on a section of the forward skirt structure. Simulated astrionic components chosen with consideration as to what is "worst for the plate" will be mounted to the plate. The effects of vibration on the component attaching bolt torque and on fluid fitting torque will be determined.

THERMO/VACUUM:

This test will determine the heat transfer capability of the cold plate in vacuum while loaded with varying arrangements and amounts of heat inputs. In addition, it will determine the effects of surface imperfections and flaws on heat transfer, and the degree of improvement that can be expected with the use of flaw rework techniques.

SYSTEM FLOW TEST:

This test will (1) size the orifices in the system so that proper flow distribution can be obtained, (2) obtain information for the design of orifice selection charts to be included with production test procedures, (3) obtain a correlation between water and water-methanol for the system and for individual plates and (4) establish techniques for draining and filling the system.

Two of these five development tests, Vibration and System Flow, are defined by released Test Control Drawings and parts are being fabricated. TCD's for the remaining three are being prepared.

COMPLETED TESTS

1. Determination of Lightening Hole Discharge Coefficients

   Technical Memorandum No. A2-860-K411-63-TM-68. Tests conducted during February and March, 1963.

   Purpose:

   To determine the discharge coefficients of three standard lightening hole configurations which were being considered for use as orifices in the purge distribution system.

Results:

It was found that production forming tolerances affected the discharge coefficients to an equal or greater extent than the lightening hole configuration differences.

2. Thrust Structure Manifold Airflow Distribution Tests

Technical Memorandum No. A2-860-K411-63-TM-78. Tests conducted during March, 1963.

Purpose:

To verify satisfactory thrust structure manifold airflow, distribution, determine thrust structure manifold leakage, size the manifold supply duct orifice, and calibrate the particular structure (mock-up) being tested for future tests of the complete aft skirt and interstage thermo-conditioning and purge system.

Results:

All objectives were accomplished satisfactorily.

3. Aft Skirt and Interstage Thermo-Conditioning and Purge System Airflow Distribution Tests

Technical Memorandum No. A3-860-K411-64-TM-117. Tests conducted during October, 1963.

Purpose:

To verify satisfactory purge gas distribution throughout the system and determine system operating pressures.

Results:

System operating pressures were determined and system distribution was proven satisfactory.

4. APS Module Thermo-Conditioning System Development and Pressure Drop Tests - SAT IB Configuration

Technical Memorandum A3-860-K411-64-TM-118. Tests conducted between August and December, 1964.

Purpose:

To develop an external skirt passage design to duct the required thermo-conditioning gases from the aft skirt thermo-conditioning and purge system manifold to the APS module thermo-conditioning system inlet and to size the APS module inlet orifices.

Results:

The external skirt passage configuration was developed with some amount of difficulty due to the restrictions on passage area. The passage is bounded by two vertical stringers on the sides, the aft skirt on the bottom and the APS module skin on top. Because of this, development of the passage to a configuration that would pass the required amount of flow was involved with inlet designs and proper sizing of the APS module inlet orifices. A satisfactory configuration was obtained without complicated passage inlet and outlet devices. However, the passage pressure drop is marginal and final verification tests on production hardware is necessary.

5. Aft Interstage Air Discharge Vent Sizing - SAT V Configuration

Technical Memorandum No. TU24891 (Tulsa). Tests conducted during February, 1964.

Purpose:

To determine the actual discharge coefficient of the SAT V aft interstage discharge vents for comparison with the computed value. If the actual C_D was found to be considerably different from the computed value the vent area would have had to be adjusted accordingly to compensate.

Results:

The actual C_D determined by the test was 0.64 against 0.61 as used for calculations. The 5 per cent difference was acceptable for ground purging and flight venting requirements.

TESTS TO BE CONDUCTED

1. Aft Interstage Air Discharge Vent Sizing - SAT IB Configuration

Purpose:

The purpose of this test is identical to the purpose of the same test conducted on the SAT V configuration aft interstage.

Status:

It is possible that this test will not be necessary. From a ground purge aspect, the vent area is flexible enough to override any error in the C_D used for vent area calculations. However, the inflight vent aspects must be determined by the Aeroballistics section before a decision as to whether or not the test is necessary. Test Control Drawing Number 1TO2676 has been obtained for this test. If conducted, the test is expected to be completed by December, 1964.

2. APS Module Thermo-Conditioning System Development - SAT V Configuration

Purpose:

To develop an external skirt passage configuration as was done in the SAT-IB configuration APS module tests; and to size the module inlet and internal orifices for optimum thermo-conditioning distribution within the module.

Status:

On the SAT V configuration the aft skirt stringers are spaced closer together than on the SAT IB configuration, requiring the space between three stringers rather than two to provide the necessary passage area. The final cross-sectional area of the SAT V passage is not appreciably larger than that of the SAT IB configuration and the passage will also be longer. These facts indicate that development of a satisfactory passage will be more difficult for the SAT V configuration. However, tests conducted on the SAT IB configuration have indicated several inlet designs that can be employed to increase the efficiency of the passage if necessary. Test Control Drawing Number 1TO2677 has been obtained for these tests. Because of recent design changes in the SAT V APS module, the final configuration is not yet known and consequently the final test configuration has not yet been established. Because of this only a tentative test completion date of February, 1965 has been established.

3. S-IB to S-IVB Interface Seal Development Tests

Purpose:

To develop a seal of minimum leakage between the S-IVB aft interstage closing frame and the S-IB seal plates. The tests will also determine relative deflections between the S-IVB structure and the S-IB seal plates, and develop seal plate installation and removal procedures.

Status:

The tests will be conducted per Test Control Drawing Number 1TO0261 and are scheduled to be completed by December, 1964.

4. Final APS Module Orifice Sizing and Thermo-Conditioning System Verification - SAT IB/V

Purpose:

To verify APS module thermo-conditioning system design flow rate and internal distribution on production hardware.

Status:

These tests are necessary to verify test results obtained from simulated and mock-up parts. The tests will be conducted as soon as production assemblies become available.

5. MSFC Model 270 Multiplexer Assembly Tests

Purpose:

This component has been qualified by MSFC to less severe conditions than those to be encountered on the S-IVB, yet its use and operation on the S-IVB must be within the thermal conditions for which it has been qualified, i.e., no change in component design is permitted.

One multiplexer is located on the aft skirt. A development test will be conducted in a thermal vacuum chamber to determine if the multiplexer box temperature can be controlled between the MSFC qualified temperature of -4°F and 185°F by means of a passive system.

Status:

The test fixture and facilities used for this test are being improved so that the temperature of the aft skirt can be regulated at the calculated coldest condition. Panel assembly 1A94955-1 is being fabricated. The wiring has been completed and the test has been scheduled for the thermal vacuum chamber upon completion of the test fixture and panel.

6. Aft Skirt and Interstage Thermo-Conditioning and Purge System Qualification Test - SAT IB

Purpose:

Because of the inter-relationship between the aft skirt and interstage thermo-conditioning and purge systems, these systems must be tested as a unit to verify each system's ability to perform its function. These tests require the short-time use of a stage with cryogenics aboard and large ground support equipment.

Test Specimen:

The aft skirt interstage thermo-conditioning and purge system will be tested at SACTO on the SAT IB configuration of the Battleship. At the initiation of the S-IB programs the Battleship was chosen for the test specimen because of schedule requirements. To use the Battleship as a test specimen considerable simulation was necessary. The following points of simulation were required:

(a) Main Manifold Cross-Sectional Area - The basic shape of the manifold is different because of the smaller diameter aft skirt and thick steel structure. The area was made effectively equal to that of the stage by lowering the bottom frame five inches at DAC Station 241.

(b) LOX Dome and LH_2 Dome Surface Area - The LOX and LH_2 dome surface at the common bulkhead form one surface of the manifold. Since the shape, area of each, and materials are different from the stage, the Battleship surface was insulated differently in this area to form a heat transfer surface equivalent to that of the stage.

(c) Equipment - The equipment is simulated both by aluminum boxes and by actual equipment. They are not located precisely as they will be in the stage. This deviation was necessary because exact installation information was not available at the time Battleship drawings had to be released.

(d) Flow Simulation of the APS - Flow restriction valves were installed on ducts simulating the APS. The ducts have been calibrated and final adjustments to make the flows equivalent to the stage flows will be accomplished on the Battleship.

(e) Interstage Simulation - To prevent high ambient winds from affecting the thermo-conditioning test results and to provide for the Saturn IB interstage purge tests, the S-IVB stage to S-IB stage interstage has been simulated with a flexible bag. The interstage vent holes will be located as they are on the stage. However, they will be sized to regulate the internal interstage pressure at approximately one-half inch of H_2O.

Test Procedure

Thermo-Conditioning System

The aft skirt thermo-conditioning system will be tested with cryogenics aboard, using GN_2 as the thermo-conditioning gas. The temperature of the gas will be manually regulated to 87°F at the set point while the flow is regulated to the minimum amount of 16,000 lb/hr. A large number of pressure and temperature measurements will be made from which will be determined system performance.

Purge System:

The purge system is integral with thermo-conditioning system. The system will be operated at ambient temperatures, with no cryogenics aboard and with a minimum flow of 16,000 lbs/hr of GN_2. The test will continue for approximately 30 minutes. Gas will be sampled for O_2 content at 20 locations.

Status:

Battleship test EB-501 Saturn IB/V, S-IVB Aft Skirt and interstage thermo-conditioning test and EB-502 Saturn IB, S-IVB Aft Interstage Purge Verification tests have been moved to the "hot" firing program period after the No. 2 engine change. The tests should be performed during January or February, 1965.

A temporary supply of gaseous nitrogen is being provided for these tests, but the installation will not be complete until December, 1964.

7. SAT V Forward and Aft Battery Tests

Purpose:

This development test program will determine the battery case thermal characteristics required to maintain the operating temperature of the battery with minimum heating.

Status:

The Test Control Drawings are 90% complete. Test fixtures are available. Brackets for mounting the batteries to the test fixture and wire harnesses to the chamber penetration are being fabricated.

8. Environmental testing of the Hydraulic (Gimbal) System is included in Agenda Item 15.

13.0 THERMAL ENGINEERING

13.A High Performance Insulation

What is it?

High performance insulation is designed as a system of multiple radiation barriers that have an equivalent thermal performance of 10^{-4} BTU/hr-ft^2-°F or less. There are three trade products currently known to be available. The National Research Corporation distributes a very thin aluminized mylar under the trade name of NRC-2. The Linde Company's product is known as Superinsulation. The Owens-Corning Company also uses thin films of mylar that they either electro-deposited with gold or silver. DAC recommends NRC-2.

How does it work?

All of the materials function by the same principle; namely, heat that is transferred to a vehicle by either solar or reflected radiation is absorbed at the tank wall and reduced to a very small percentage of the initial quantity by a series of multiple radiation barriers. This implies that conductive and radiative heat transfer are eliminated or are negligible. How that is possible is a critical part of the practical design application of such materials. The elimination of conductive heat transfer requires that the materials be loosely separated with very small contact areas between adjacent sheets and virtually no structural supports or attachments along or around the periphery of the vehicle. The elimination of convective heat transfer is somewhat simplified by the availability of an infinite vacuum in space. However, to eliminate the possibility of freezing air on the tank wall during ground hold a helium purge of the insulation must be provided. This then necessitates that the helium be exhausted during flight so that convective heat transfer is eliminated.

How is it applicable to the S-IVB?

The use of the internal insulation developed for the Saturn S-IV stage results in approximately 4,000 pounds of boiloff to the S-IVB. This comes from, in a large part, heat transfer through the cylindrical part of the hydrogen tank. The elimination or drastic reduction of heat transfer through the cylinder is possible through the use of

HPI. It is also possible to substantially reduce the heat transfer through the forward dome. With HPI, the majority of the internal insulation is not required so that most of the 2,000 pounds of insulation weight can be eliminated. The main factor to bear in mind is that the S-IVB is designed only for a LOR mission. This means that relatively high heat transfer rates can be withstood through joints and external projections into the tank. As mission times increase, however, the importance of each of the heat leaks becomes more important.

What are the future uses ?

HPI is required to store liquid hydrogen in orbit. While other insulations can be shown to work for the few hours in length missions, HPI is definitely required for missions in excess of a half a day. The future national space programs will undoubtedly require the use of liquid hydrogen after storage in space for many days. The development of HPI now will not only allow for a more efficient performance of the LOR mission, but will allow for the development of an insulation that can be applied to a tank designed for long term storage in space.

Refer to Plate 1: (Figure 61)

Shown on this chart is an outboard profile of the S-IVB with the HPI and shroud installed. Shown are a series of straps to retain each of the 8 honeycomb shroud panels that are used to protect the HPI as well as provide insulation during hold and ascent. It can be seen that the installation includes the entire cylindrical area extending fore and aft from the external flanged rings as shown in chart 3.

Refer to Plate 2: (Figure 62)

This is a detailed longitudinal cross section of the HPI and shroud. Shown on the right is the helium purge gas manifold which is used to purge throughout the layers of HPI. Each layer is spaced away from adjacent layers by a separating film of mylar with gaps between each spacer to allow for the flow of the purge gas. The shroud is a fiberglas honeycomb material. A non-metallic honeycomb core was selected to maintain within acceptable limits heat transfer to the hydrogen during the pressurized hold and ascent portions of flight. Shown in the left hand side of the chart is a typical purge gas vent hole to allow for escape of the helium gas during flight. The size of the vents are critical in that the bursting pressure differential across the shroud must be minimized. Fiberglas heat barriers 1/16 of an inch thick will be placed between the bolted joints of the forward and aft skirts to reduce conducted heat transfer through the warm skirt. Also retained are rings of the internal foam insulation approximately 1 foot wide at each of the forward and aft tank joints as well as at the common bulkhead joint. The shroud is rigidly attached at the forward part of the vehicle, but allowed to slide free on a bearing surface at the aft tank joint due to thermal contraction of the tank. Each of the 8 shroud panels will be designed to absorb circumferential contraction of the tank. This will be achieved through the use of pre-tensioned straps with the degree of pre-tensioning based on the tank contraction. These straps will then be severed during flight to allow for the jettisoning of the shroud. Shroud jettisoning is one of the main requirements for achieving high payload capability in that the nearly 3,000 pound shroud can impose a significant weight penalty increase jettisoned, as shown in chart 4.

Refer to Plate 3: (Figure 63)

This figure is a presentation of the Saturn V trade-off factors from liftoff through translunar injection. The left hand scale has been converted to shroud weight to show the influence of jettisoning time on the effective shroud weight (actual weight of shroud effecting payload). It can be seen at S-IC/S-II separation the shroud effectively weighs 250 pounds, whereas if it is carried to S-II/S-IVB separation it weighs about 900 pounds. Likewise, the longer the shroud is carried the closer it weighs to its installed weight of 3,000 pounds. It is the DAC recommendation that the shroud be jettisoned as near to S-IC/S-II separation as feasible considering such things as dynamic pressure.

Refer to Plate 4: (Figure 64)

Comparison of the heat transfer to the current vehicle with the internal insulation to that with the HPI is shown. It can be seen that the greatest reduction in heat transfer comes at the cylindrical section where the HPI's efficiency shows up. This efficiency, however, is not extremely critical in that, (1) the numbers include degradation in heat transfer by a factor of 5 and (2) a further degradation would not have a large effect on the total. This is because the total is made up principally of heat leaks and heat transfer through the common bulkhead, aft dome and aft joint areas that cannot be changed. The resultant reduction in heat transfer of approximately 692,000 BTU's is equivalent to about 3,500 pounds of boiloff. The 3,500 pound boiloff reduction cannot be used entirely, however, since in the overall HPI/CAPS

(5) That the basic incompatibility of continuous venting and HPI be rectified by using the intermittent vent scheme or cryogenic auxiliary propulsion.

Status

All work on development of HPI has been terminated pending receipt of ATP and funding. A day by day slippage of the hypothesized schedule has been in effect since 1 August 1964.

VEHICLE PROFILE-HIGH PERFORMANCE INSULATION

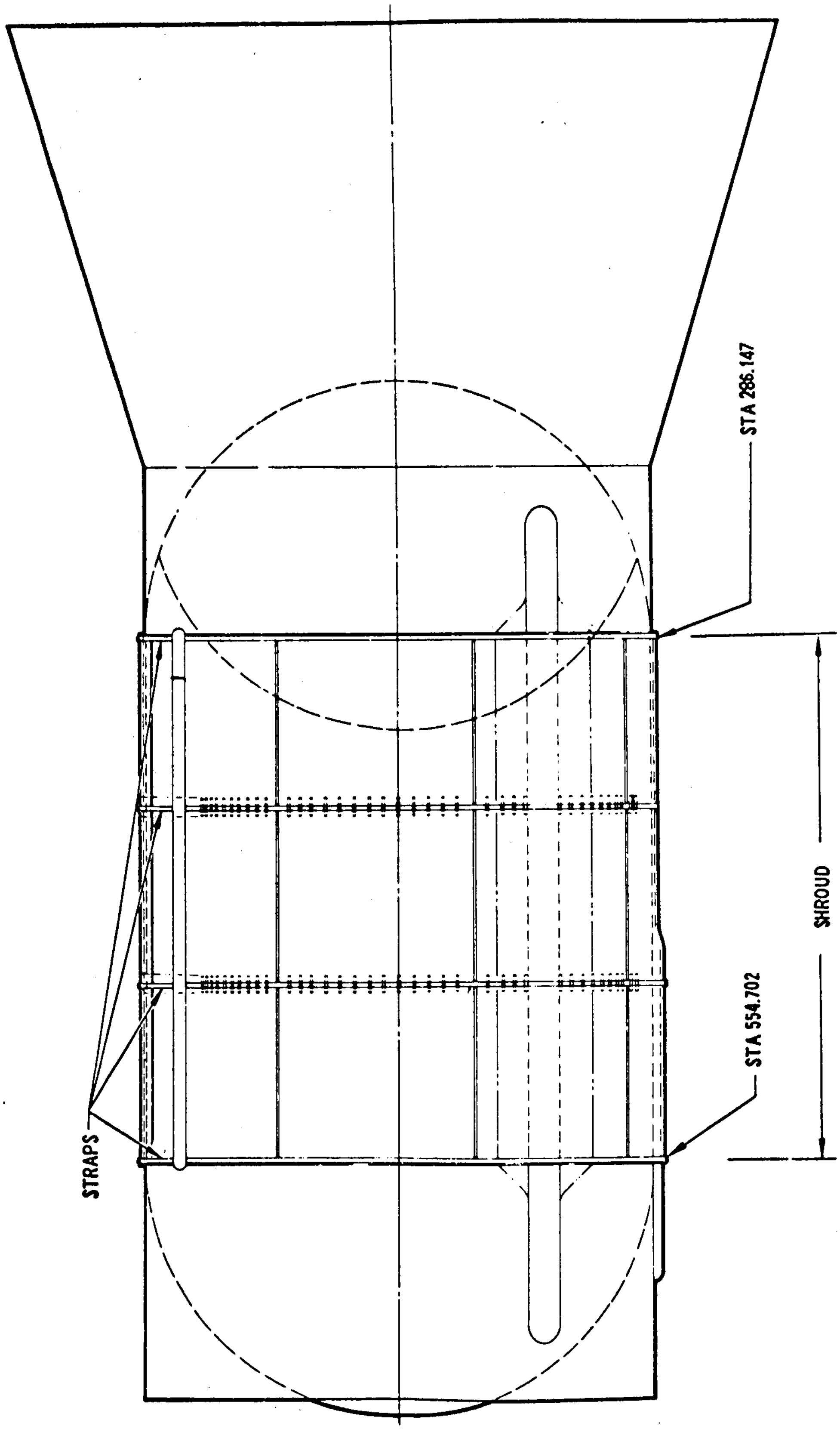


FIGURE 61

LONGITUDINAL SECTION OF HIGH PERFORMANCE INSULATION SYS

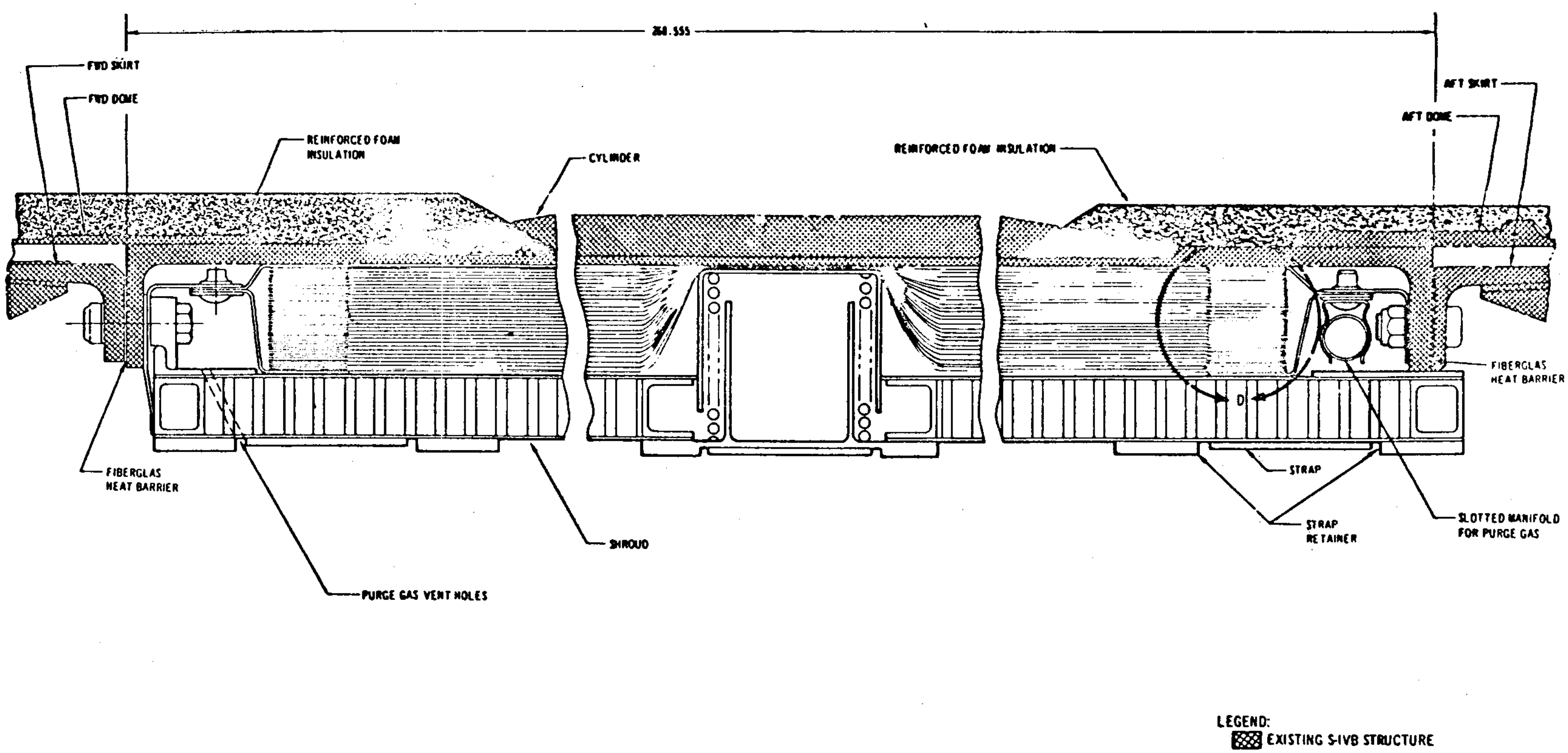


FIGURE 62

EFFECTIVE SHROUD WEIGHT

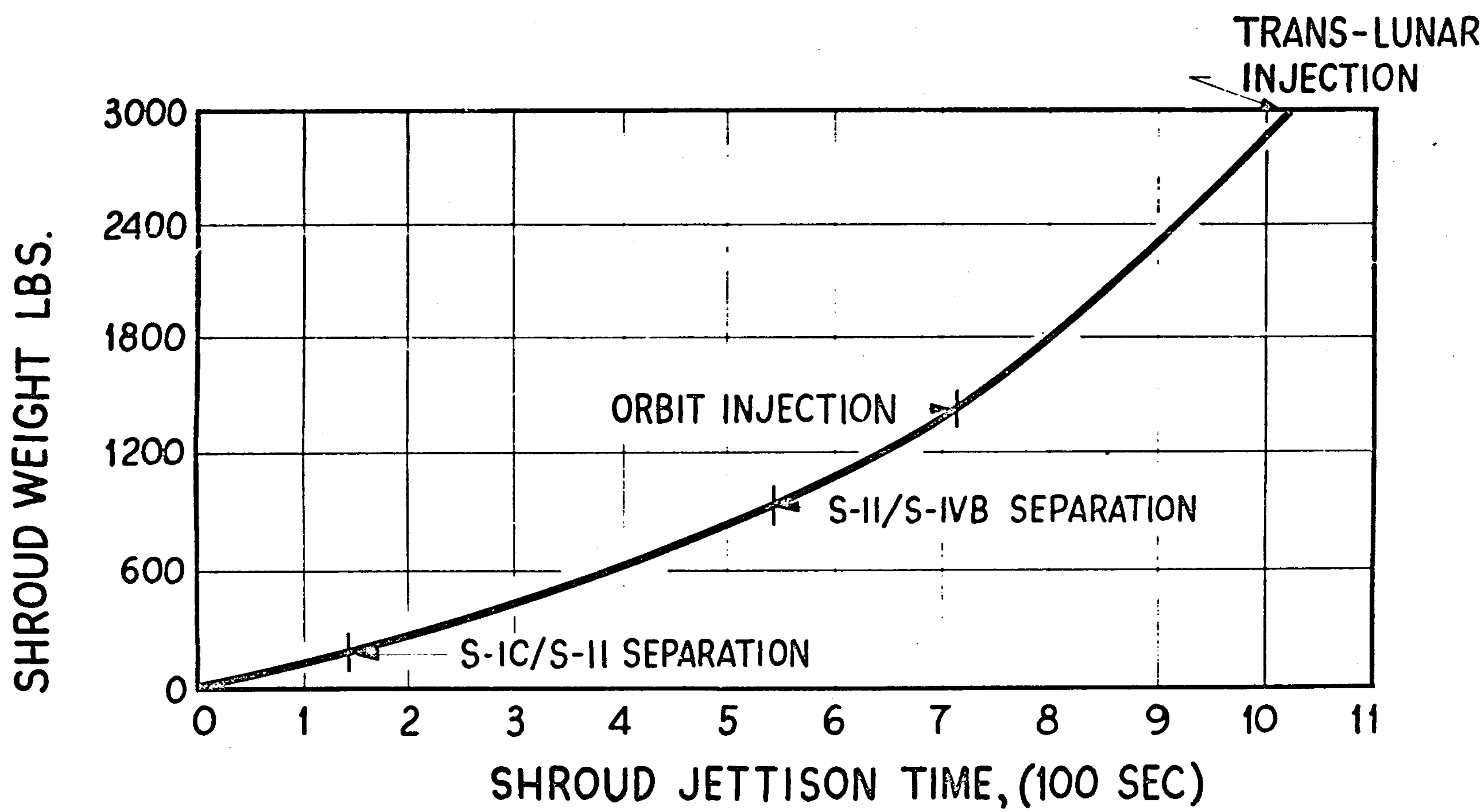


FIGURE 63

COMPARISON OF HPI CAPS & PRESENT SATURN V S-IVB

LH_2 HEATING TRANSFER - LOR MISSION

		HEAT INPUTS, BTU	
		PRESENT SYSTEM	HPI / CAPS
FORWARD DOME	79,870	~~70,000~~	15,000
FORWARD JOINT	25,160	~~24,100~~	6,600
CYLINDRICAL SECTION	580,000	~~615,300~~	9,400
AFT DOME, COMMON BULKHEAD & JOINT AND AFT JOINT	81,600	~~81,500~~	97,500
FEED AND CHILL LINES	9,800	~~9,800~~	9,500
HELIUM BOTTLES	12,120	~~30,300~~	NEGLIGIBLE
TOTALS	*788,550	~~831,000~~	138,000

DECREASE IN PROPELLANT HEATING = ~~693,500~~ *650,550 BTU (~~3500~~ *2400 lb BOILOFF)

* THESE VALUES WERE PRESENTED IN 9/3/64 CRYOGENIC APS MEETING (R-P&VE-XJ-64-573)

FIGURE 64

COMPARISION OF HPI CAPS & PRESENT SATURN V S-IVB

INSULATION WEIGHTS

	PRESENT SYST.	HPI/CAPS
INTERNAL FOAM INSULATION	1920	100
FORWARD DOME HPI & HELIUM PURGE DUCTS	50	205
CYLYNDRICAL SECTION HPI & HELIUM PURGE DUCTS		360
NON-JETTISONABLE SHROUD ATTACHMENTS & HEAT BARRIERS		70
NON-JETTISONABLE TOTAL	1970	735
JETTISONABLE SHROUD & EJECTION SYST.		(3038)
SHROUD WEIGHT OUT S-IC BURN-OUT		230

EQUIVALENT STRUCTURAL WEIGHT CHANGE DUE TO HPI = -1005 LBS

(ABOVE VALUES ARE QUESTIONABLE IN VIEW OF CORRECTIONS LISTED ON PAGE 149)

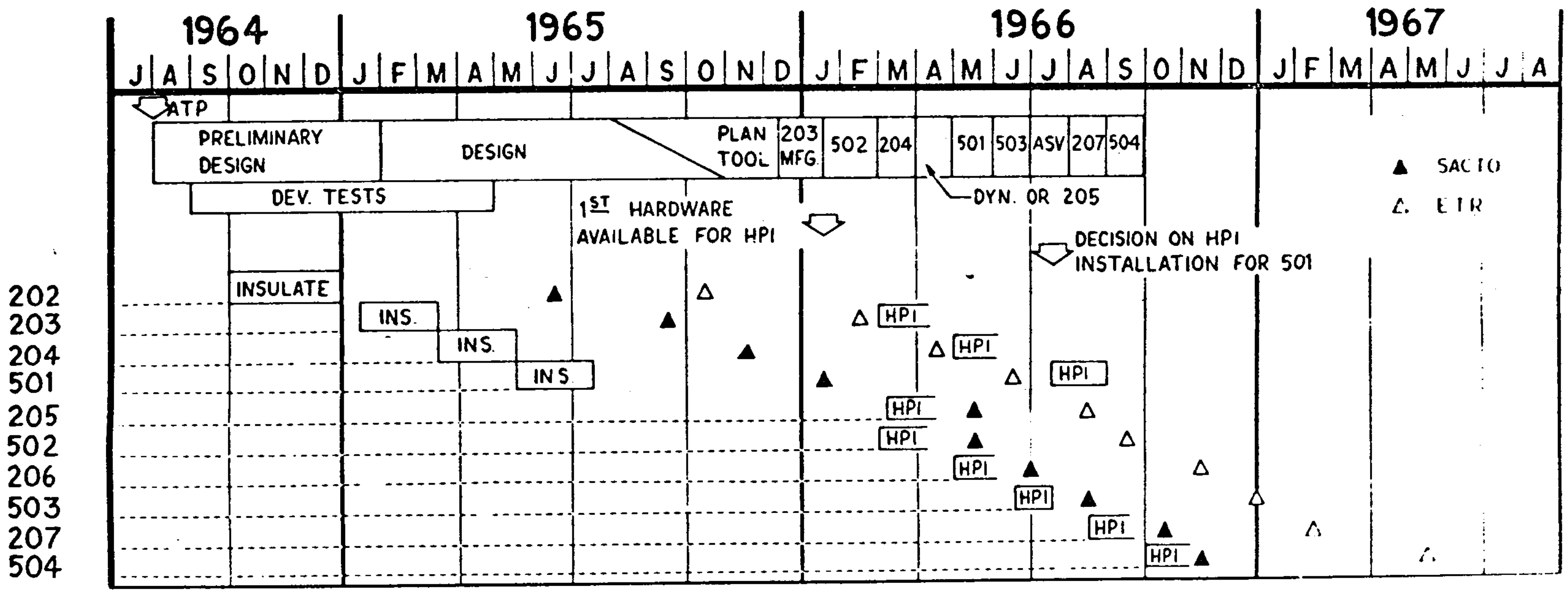
FIGURE 65

HPI DEVELOPMENT TEST PROGRAM

○ INSULATION TESTS	DETERMINE HPI MATERIAL PROPERTIES
○ SHROUD PANEL TESTS	DETERMINE SHROUD MATERIAL PROPERTIES SCALE SHROUD STRUCTURAL TEST SHROUD JETTISON TESTS
○ SHROUD STRAP TESTS	DETERMINE STRAP MATERIAL PROPERTIES STRAP CUTTING TESTS
○ SYSTEMS TESTS	8' TANK GROUND TESTS 8' TANK ORBITAL SIMULATION TESTS S-IV DYNAMICS/FACILITIES VEHICLE TESTS
○ MISCELLANEOUS TESTS	PURGE GAS EXHAUST DESTRUCT SYSTEM WIND TUNNEL MODEL GENERAL ATTACH FITTING AND JOINTS SMALL SCALE CYLINDER BUCKLING

FIGURE 66

PROP. HIGH PERFORMANCE INSUL DEVELOPMENT SCHEDULE



1. SEND 1ST SET OF HARDWARE TO ETR FOR 203
2. USE 2ND SET OF HARDWARE AT A3 FOR 502
3. SEND 3RD SET OF HARDWARE TO ETR FOR 204
4. SEND 4TH SET OF HARDWARE TO MSFC DYN. VEHICLE MOD. OR USE AT A3 ON 205 (1ST I-B WITH HPI ONLY)
5. SEND 5TH SET OF HARDWARE TO ETR 501 (INTERNALLY INSULATED)
6. USE 6TH SET OF HARDWARE AT A3 503
7. USE 7TH SET OF HARDWARE AT SACTO ASV MOD. TO SATURN V CONFIGURATION
8. USE 8TH SET OF HARDWARE AT A3 207
9. USE 9TH SET OF HARDWARE AT A3 504
10. USE 10TH SET OF HARDWARE AT ETR FACILITIES VEHICLE MODIFICATION

FIGURE 67

13.B S-IVB Insulation Test Results.

13.B.1 INTRODUCTION

The improvement program for the S-IVB LH_2 tank internal insulation was performed in two phases. The first phase was designed primarily to save weight on the Saturn IB-S-IVB vehicle by reducing the amount of resin in the liner and potentially eliminating the sealer. No changes were proposed for the 3-D foam or the adhesive which bonds the foam to the tank wall. The second phase was aimed primarily at the Saturn V/S-IVB vehicle where thermal performance is critical. The test objective was to improve thermal performance by improving the hydrogen diffusion barrier. Again no changes were proposed for the 3-D foam or the adhesive system.

Both phases of the development program have been completed. Each phase required a number of "Banjo" thermal conductivity tests to determine the optimum insulation configuration on the basis of thermal performance. These tests were accomplished by utilizing S-IV equipment which in turn limited the test specimen insulation thickness to 0.5 inch. In addition to the "Banjo" tests, each phase required an 8-foot scale tank test to verify structural integrity and thermal performance of the improved insulation prior to full scale testing.

This report summarizes the results of the "Banjo" thermal conductivity tests and the 8-foot scale tank tests. The effectivity of the improved insulation is also presented along with a disucssion of future qualification and improvement tests.

13.B.2 TEST RESULTS

13.B.2.1 PHASE I

A weight reduction of 280 lb per vehicle can be realized by using the liner/sealer configuration developed during this phase of the test program. The liner consists of a 181 style glass fabric impregnated with 50 percent ERL 2795/2807 epoxy resin. In comparison with the S-IV liner this represents a 25% reduction in resin content. The liner is vacuum bag pressured to maintain intimate contact of the liner to the 3-D foam until the resin has cured. The vacuum bag is then removed and the liner is given three hand rubbed coats of ERL 2795/2807 epoxy resin. Each application of resin is carefully rubbed into the pores of the liner and the excess resin removed with clean lint free cloths. The rub-on coats of resin act as a barrier film in a manner similar to the spray coats of DV-1180 used on Saturn S-IV. The other components of the composite insulation are identical to the Saturn S-IV internal insulation configuration insofar as the materials are concerned. The 3-D foam tiles used in the cylindrical portion of the S-IVB tank are larger and thicker than those used in S-IV tank.

"Banjo" Tests

The results of several "Banjo" thermal conductivity tests with the S-IV and Phase I liner/sealer configuration are presented in Table 3. A comparison of the thermal conductivity values indicates that eliminating the DV-1180 sealer and reducing the liner resin content has no significant effect on thermal performance of the insulation.

8-Foot Scale Tank Tests

A series of 7 LH_2 fill, boiloff and drain cycles was performed with the improved insulation. Some liner delamination was observed after the first few test cycles, however, the delaminated areas remained small and therefore were not considered a serious problem. Several areas of liner delamination were repaired after test cycle No. 5. The repaired liner performed satisfactorily during test cycles No. 6 and 7. As a result of the 25 percent reduction in resin content, no cracking or crazing of the liner (a serious problem with the S-IV liner) was observed indication of the 3-D foam debonding from the tank wall.

Temperature and boiloff data obtained from the test were used to calculate the effective thermal conducitivity of the improved insulation. The results of these computations are presented in Table 4. Thermal conductivity values calculated from the 8-foot scale tank test show very close agreement with values measured in the laboratory with the "Banjo" apparatus.

13.B.2.2 PHASE II

An impervious hydrogen diffusion barrier was not found; however, a lighter weight liner/sealer configuration was developed offering the greatest hydrogen diffusion retardation characteristics within structural integrity limitations. A weight saving of 517 lb. will be realized for both the Saturn IB and V with no sacrifice in thermal performance. The liner consists of a 116 style glass fabric impregnated with Narmco 7343/7139 polyurethane resin (60 percent resin content). The liner is vacuum bag pressured to maintain intimate contact of the liner to the 3-D foam until the resin has cured. The vacuum bag is then removed and the liner is given three hand rubbed coats of Narmco 7343/7139 polyurethane resin. Each application of resin is carefully rubbed into the pores of the liner and the excess resin removed with clean lint free cloths. The rub-on coats of resin act as a barrier film in a manner similar to the spray coats of DV-1180 used on Saturn S-IV. The other components of the composite insulation are identical to the Phase I configuration.

"Banjo" Tests

The results of several "Banjo" thermal conductivity tests with the Phase II liner/sealer configuration are presented in Table 5. Comparing thermal conductivity values with the S-IV and Phase I liner/sealer configurations indicates a slight improvement in thermal performance of the insulation. In other words, the polyurethane resin is a more effective hydrogen diffusion barrier than the epoxy resin.

8-Foot Scale Tank Tests

The improved insulation was subjected to eight LH_2 fill, boiloff, and drain cycles. A malfunction prevented completion of test cycle No. 5. Several holes were drilled in the liner prior to test cycles No. 7 and 8 to determine the effect of hydrogen diffusion on the liner-to-goam bond. A visual inspection of the liner after each test cycle revealed no delamination, cracking or crazing on the cylinder and dome portions of the tank. Liner delamination was observed on the circumferential stop-off areas between the cylinder and domes. This phenomenon was attributed to the vacuum bag technique used to apply the liner. The use of a bleeder cloth which would not conform to the curvature of the tank wall resulted in a poor bond between the liner and 3-D foam. This problem is unique with the 8-foot scale tank and will not occur with the S-IVB LH_2 tank.

Ultrasonic inspection performed throughout the test revealed no indication of the 3-D foam debonding from the tank wall.

Temperature and boiloff data obtained from the test were used to calculate the effective thermal conducitivity of the improved insulation. The results of these computations are presented in Table 6. Thermal conducitivity values for the 8-foot scale tank test agree very close with the "Banjo" test data. The increase in thermal condicitivity in test cycles No. 7 and 8 is the result of the holes drilled in the liner.

13.B.3 EFFECTIVITY

Table presents the effectivity of the various liner/sealer configurations with respect to the S-IVB ground and flight test vehicles. The Phase II insulation improvement will be effective on all flight vehicles.

13.B.4 FUTURE TESTING

13.B.4.1 QUALIFICATION TEST

Additional thermal conducitivity tests are required for the improved insulation to determine:

a. The effect of increasing the insulation thickness on thermal performance.

b. The effect of reducing the sealer application from 3 to 1 rub-on coats (maintaining the same sealer density per square foot of liner) on thermal performance.

c. The validity of the "Banjo" test as a method of measuring thermal performance by comparing thermal conducitivity values calculated from the 8-foot scale tank test with data obtained in the laboratory.

d. The influence of the Saturn V/S-IVB ground hold and orbit thermodynamic environment on thermal performance.

The thermal conducitivity test apparatus is currently being modified to permit testing of 1.0 inch thick insulation specimens consistent with S-IVB design.

13.B.4.2 IMPROVEMENT TESTS

Liner improvement through state-of-the-art advances has been accomplished to the maximum extent practical. The development of an impervious hydrogen diffusion barrier for the S-IVB LH_2 tank is not practical from the standpoint of material technology and inherent application problems. However, a weight optimization program for the 3-D foam and the adhesive (lefkoweld) system could result in an additional weight saving of 500 to 600 lb. The areas of possible weight reduction are:

3-D Foam

	Configuration	
	Present	Proposed
Type of foam	Polyurethane	T.B.D.
Foam Density (lb/ft^3)	4.7	2.35
Thread Density (lb/ft^3)	0.8	0.8
Total Weight (lb)	884	442
Weight Reduction (lb)	0	442

Adhesive

	Configuration		
	Present	Proposed	Proposed
Type of Adhesive	Lefkoweld	Lefkoweld	Narmco
Weight/ft^2 of Foam	0.108	0.08	0.05
Total Weight (lb)	389	288	180
Weight Reduction (lb)	0	101	209

A number of component tests at cyrogenic temperatures would be required to obtain data for various parameters such as permeability, tensile and compressive strength, tensile bond strength, thermal contraction and expansion, and thermal conducitivity. An 8-foot scale tank test would also be required to verify structural integrity and thermal performance prior to full scale testing.

TABLE III

"BANJO" THERMAL CONDUCTIVITY TESTS

Test Specimen	Liner/Sealer Configuration	Insulation Mean Temp. (°F)	LH_2 Exposure Time (Hr.)	LH_2 Tank Pressure (PSIA)	Thermal Conductivity (BTU/HR-FT-°F)
2	S-IV (Control)	-170	0 - 14	22	0.026 to 0.030
		-170	14 - 28	42	0.030 to 0.036
3	S-IV (No Sealer)	-170	0 - 18	22	0.027 to 0.031
			18 - 24	42	0.031 to 0.037
11	Phase I	-170	0 - 16	22	0.028 to 0.030
			16 - 32	42	0.034 to 0.038
12	Phase I	-170	0 - 16	22	0.027 to 0.029
		-170	16 - 32	42	0.030 to 0.033
13	Phase I	-170	0 - 17	22	0.020 to 0.022
21	Phase II	-170	0 - 16	22	0.022 to 0.024
		-170	16 - 32	42	0.024 to 0.027
22	Phase II	-170	0 - 16	22	0.020 to 0.022
		-170	16 - 32	42	0.022 to 0.025

NOTE: These "Banjo" tests were performed with 0.5 inch thick insulation.

TABLE IV

8-FOOT TANK TESTS - PHASE I

Test Cycle	Test Date	LH_2 Exposure Time (Hr.)	LH_2 Tank Pressure (PSIA)	Insulation Mean Temperature (°F)	Thermal Conductivity (BTU/HR-FT-°F)
1	4-2-64	10.0	16 - 17*	-197	0.024
2	4-3-64	16.0	16 - 17*	-275	0.025
3	4-6-64	8.25	16 - 17*	-216	0.031
4	4-7-64	10.0	16 - 17*	-250	0.030
5	4-8-64	9.5	16 - 17*	-245	0.030
6	4-10-64	8.25	16 - 17*	-200	0.029**
7	4-13-64	8.75	16 - 17*	-230	0.030**
		70.75 Total			

* The LH_2 tank was pressurized to 42 psia for 15 minutes prior to boiloff.

**Liner delaminations were repaired.

NOTE: Thermal conductivity values are for 1.0 inch thick insulation.

TABLE V

8-FOOT TANK TESTS - PHASE II

Test Cycle	Test Date	LH_2 Exposure Time (Hr.)	LH_2 Tank Pressure (PSIA)	Insulation Mean Temperature (°F)	Thermal Conductivity (BTU/HR-FT-°F)
1	5-20-64	14.5	16 - 17*	-230	0.025
2	5-21-64	7.75	16 - 17*	-215	0.032
3	5-22-64	8.0	16 - 17*	-230	0.032
4	5-23-64	8.0	16 - 17*	-235	0.030
5	5-25-64	.75	16 - 17*	---	---
6	5-26-64	7.75	16 - 17*	-250	0.031
7	5-27-64	7.5	16 - 17*	-250	0.037
8	5-28-64	7.75	16 - 17*	-265	0.036
		62.0 Total			

*The LH_2 tank was pressurized to 42 psia for 15 minutes prior to boiloff.

**16 holes drilled in liner varying in size from 1/64 inch to 1/16 inch diameter.

NOTE: Thermal conductivity values are for 1.0 inch thick insulation.

TABLE VI

LINER/SEALER CONFIGURATION EFFECTIVITY

DAC Serial No.	S-IVB Vehicle Name	Test Location	Liner/Sealer Configuration
1000	Battleship	Sacto	S-IV
1001	Hydrostatic	H. B.	None
1002	All-Systems	Sacto	Phase II
1003	Dynamics	MSFC	Phase II/Cylinder Only
1004	Facilities	AMR	Phase II
1005 to 1010	Flight (V)	Sacto/AMR	Phase II
2000	Battleship	MSFC	Phase I
2001 to 2004	Flight (IB)	Sacto/AMR	Phase II

13.C RESULTS OF LH_2 HEAT TRANSFER DISPERSION STUDY

The effect of variations in the various parameters affecting propellant heating has been studied under Scope Change 1199A for the Saturn V/S-IVB lunar orbital rendezvous mission. Comparisons are made with the current estimate of propellant heating. Relative importance of the various parameters affecting propellant heating has been determined. It is assumed that minimum propellant heating is generally desirable, but not to the extent of introducing undue insulation weight penalties and flight restrictions such as launch date and vehicle orientation. It has been determined which parameters should receive most attention in attaining minimum propellant heating.

Propellant heating effects of the following parameters have been determined:

a. solar absorptivity

b. tank skin emissivity

c. launch date and time

d. orientation

e. insulation physical and thermal properties

f. (exit) trajectory dispersion

The assumptions relating to LH_2 heating which are currently used for design purposes are generally conservative, although no "factors of safety" have been included. This approach is believed to be the only correct one for design to avoid flight limitations.

The following information and assumptions were used in determining the "design" value of propellant heating through the cylindrical portion of the tank:

100 nautical mile circular orbit

vehicle longitudinal axis parallel to velocity vector

α(solar absorptivity) = 0.3, (emissivity) = 0.9, A (albedo) = 0.4

c (insulation specific heat Btu/lb-°R) = variable as a function of temperature

k (insulation conductivity) = 0.03 Btu/hr-ft-°R insulation thickness = 1.0 inch

insulation core density = 5.5 lb/ft^3

effective tank wall thickness $(\bar{t})$ = 0.148 inch

wall material: 2014-T6 aluminum, anodized

launch date and time: winter noon

trajectory: (MSFC) Ref.: M-AERO-D-1-63, (4-29-63)

This study indicates that there are a considerable number of parameters which affect propellant heating. Many of these are only moderately important, in that they affect propellant heating of the order of 5 percent. Reductions of this magnitude are thermally desirable, but in most cases would impose flight restrictions such as launch date and time of day and weather conditions. From an overall standpoint such restrictions may not be desirable. There are other factors which affect propellant heating to the extent of about 2 or 3 percent.

Large scale effects are those associated with LH_2 tank surface finish (solar absorptivity and emissivity) and insulation conductivity. These represent areas of greatest potential control and, consequently, most of the effort to minimize propellant heating has been in these areas.

Figure 68 shows the effect of varying emissivity while all other factors are held constant. It can be seen that the extreme variation from 0.1 to 0.9 (current value) results in a spread of approximately 60,000 Btu. This indicates that it would take a highly reflective surface before any substantial reduction in propellant heating can be achieved.

Figure 69 shows a similar effect by varying solar absorptivity over the range 0.1 to 0.9. This range covers a variation in heat transfer of approximately 400,000 Btu and it can be seen that changes in absorptivity are much more significant than comparable changes in emissivity. This is further indicated by Figure 70 which is a cross plot of both emissivity and absorptivity effects on propellant heating for the total mission duration.

Figure 71 shows the effects of launch time and date considering only the two extremes resulting in maximum and minimum solar input, since there is only a 30,000 Btu spread between the extremes.

Figure 72 shows the effect of the insulation thermal conductivity. This is one of the most significant parameters and one where it was hoped to achieve reductions from the current value of 0.03 Btu/hr-ft-°F in the recently completed insulation improvement program. The potential maximum condition is shown at a k = 0.04 which corresponds to the insulation being completely saturated by hydrogen vapor. This value of 0.04 is the equivalent constant conductivity considering changes in the insulation temperature throughout the orbit duration.

Figure 73 shows the effect of insulation thickness and conductivity on the equivalent weight of the insulation itself and the boiloff based on a particular value of conductivity. This shows that no reduction in heat transfer is achieved by thickening the insulation and it is more costly in terms of the insulation weight increase rather than a reduction in boiloff.

Figure 74 shows the effect of various orientations of S-IVB with respect to the earth and the sun. The top curve represents the currently assumed orientation, namely, the longitudinal axis parallel to the velocity vector. There would be a possibility of reducing heat transfer by upwards of 75,000 Btu by an inertially oriented vehicle whose longitudinal axis is parallel to the suns rays.

Figure 75 shows the effect of varying the product of density and specific heat of the aluminum tank. This parameter affects the heating storage capacity of the tank and, therefore, the amount of heat that is eventually conducted into the propellant. A variation of 20 percent in this parameter results in a variation of 40,000 Btu.

Exit trajectory dispersions were also considered. These dispersions affect structural temperatures more significantly than propellant heating. The maximum increase in heat transferred to the LH_2 was less than 0.25 percent of the total through the cylindrical section.

Figure 76 shows the overall effect of all major parameter variations related to the current design value for propellant heating. It is believed that the upper curve represents an extremely unlikely condition in that the insulation foam would have to be completely saturated with the hydrogen gas, the density-specific heat parameter would have to increase by 10 percent and the vehicle would have to be launched on the worst possible launch date. The bottom two curves represent more likely conditions for propellant heating resulting from more favorable values for some of the parameters as well as a more favorable launch time. It is recommended that an attempt be made to reduce the emissivity and absorpotivity of the hydraogen tank and that other parameters be left to the values currently in use.

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING VARIATION WITH TANK SURFACE EMISSIVITY

LONGITUDINAL AXIS PARALLEL TO VELOCITY VECTOR ($\gamma = 90°$, $\phi = 0°$)
100 NAUTICAL MILE ORBIT
$\alpha = 0.8$ $\epsilon = 0.3$ A = 0.4
LAUNCH DATE & TIME: WINTER NOON
C (INSULATION BTU/LB - °R) = EMPIRICAL VALUES
ρ (INSULATION LB/ft^3) = 5.5 LB/FT^3 INSULATION THK. = 1 IN
$\bar{t}$, TANK WALL EFFECTIVE THICKNESS = 0.148 IN K (INSUL. CONDUCTIVITY) = 0.03 BTU/HR-FT - °F
ALUMINUM WALL MATERIAL, 2014-T6, ANODIZED
TRAJECTORY: (MSFC) REF: M-AERO D-1-63
DATED 4-29-63

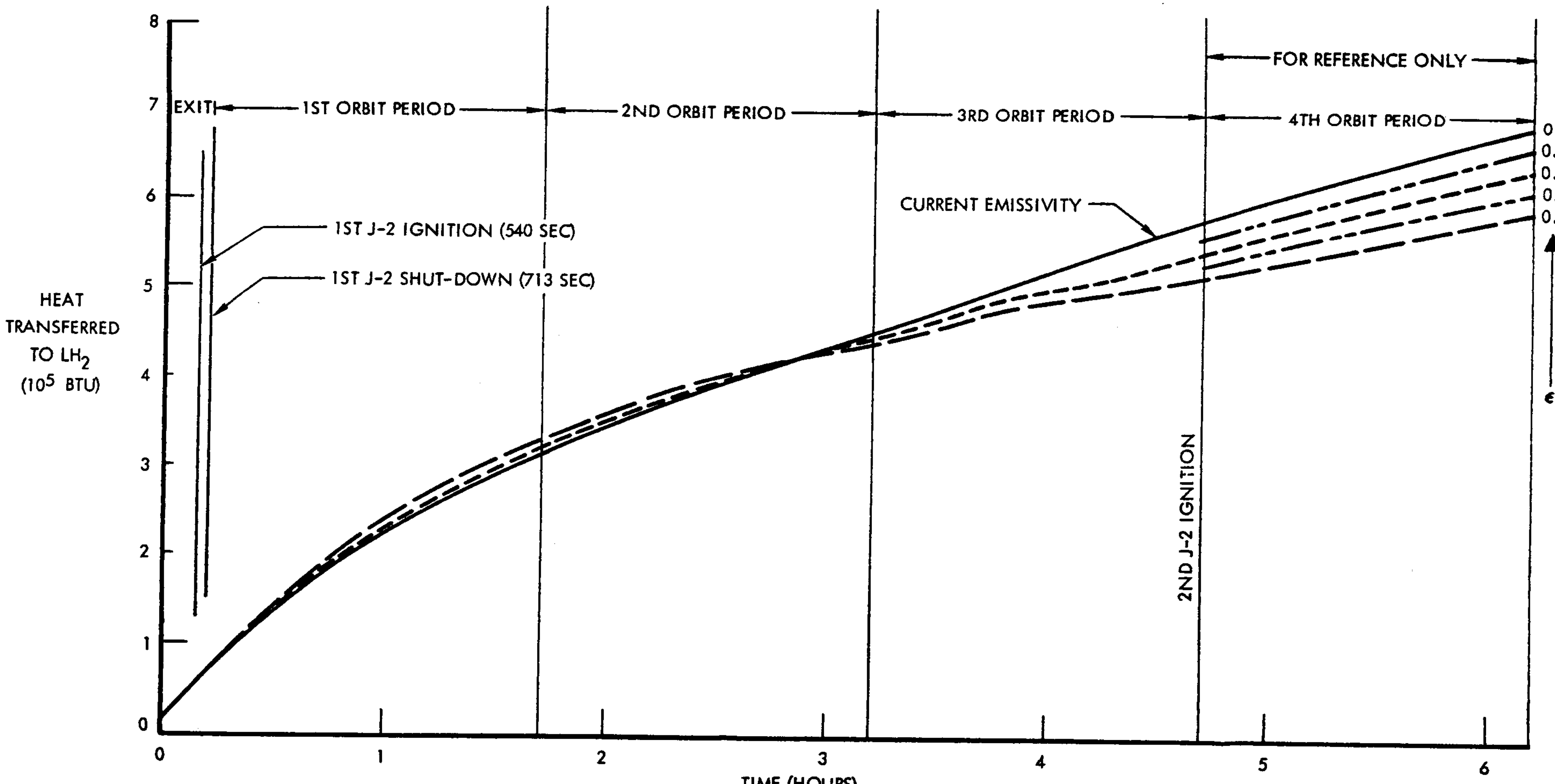


FIGURE 68

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING VARIATION WITH SOLAR ABSORPTIVITY

LONGITUDINAL AXIS PARALLEL TO VELOCITY VECTOR
100 NAUTICAL MILE ORBIT
$\epsilon = 0.9$ $A = 0.4$
LAUNCH DATE & TIME: WINTER NOON
C (INSULATION BTU/LB - °R) = EMPIRICAL VALUES
ρ (INSULATION LB/FT^3) = 5.5 LB/FT^3 INSULATION THK. = 1 IN
$\bar{t}$, TANK WALL EFFECTIVE THICKNESS = 0.148 IN K (INSUL. CONDUCTIVITY) = 0.03 BTU/HR-FT - °F
ALUMINUM WALL MATERIAL, 2014-T6, ANODIZED
TRAJECTORY: (MSFC) REF: M-AERO D-1-63 DATED 4-29-63

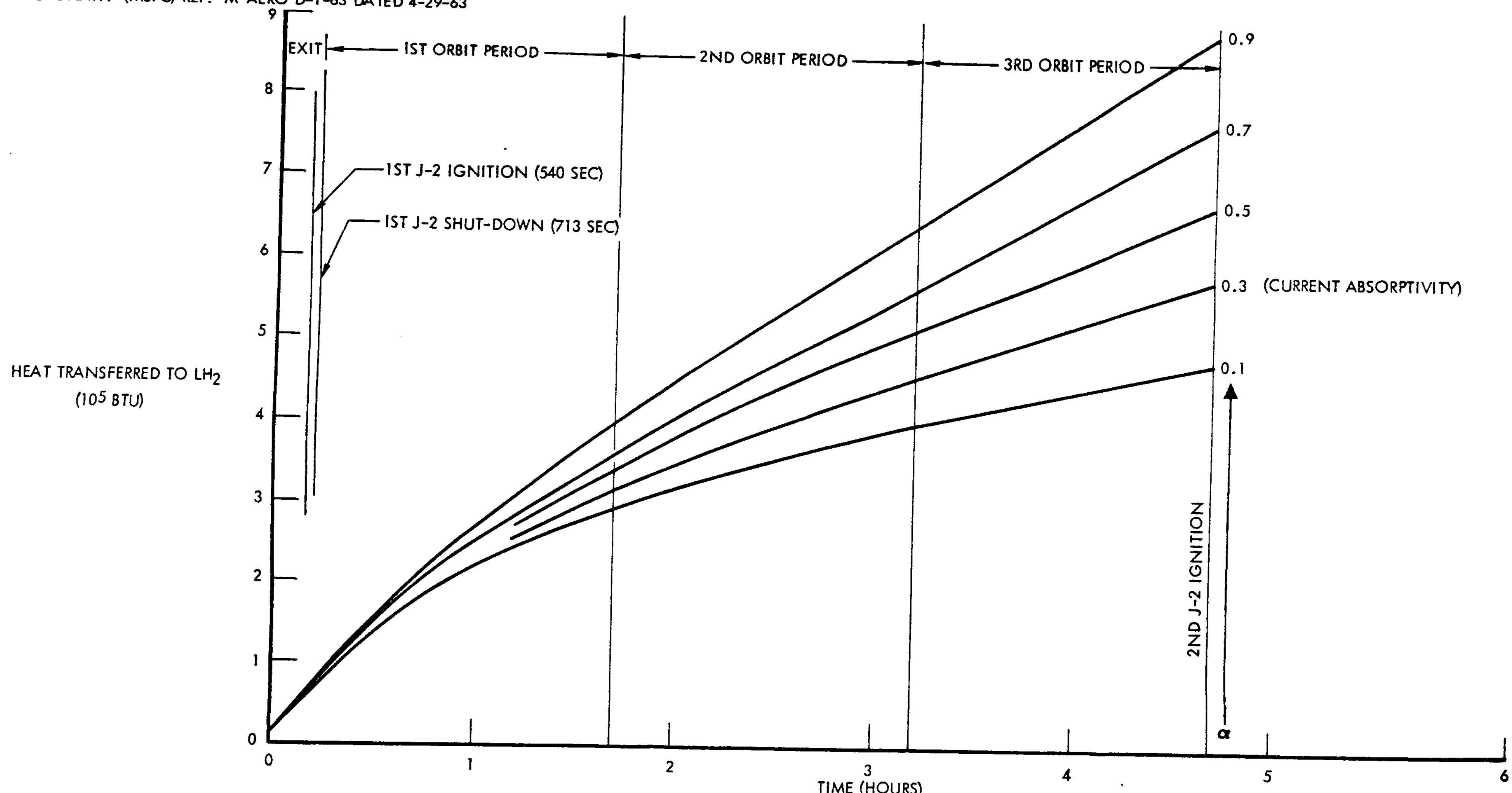


FIGURE 69

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING DURING 4.7 HOUR MISSION SHOWING ABSORBTIVITY-EMISSIVITY DEPENDENCE

NOTE: DESIGN CONDITIONS APPLY.

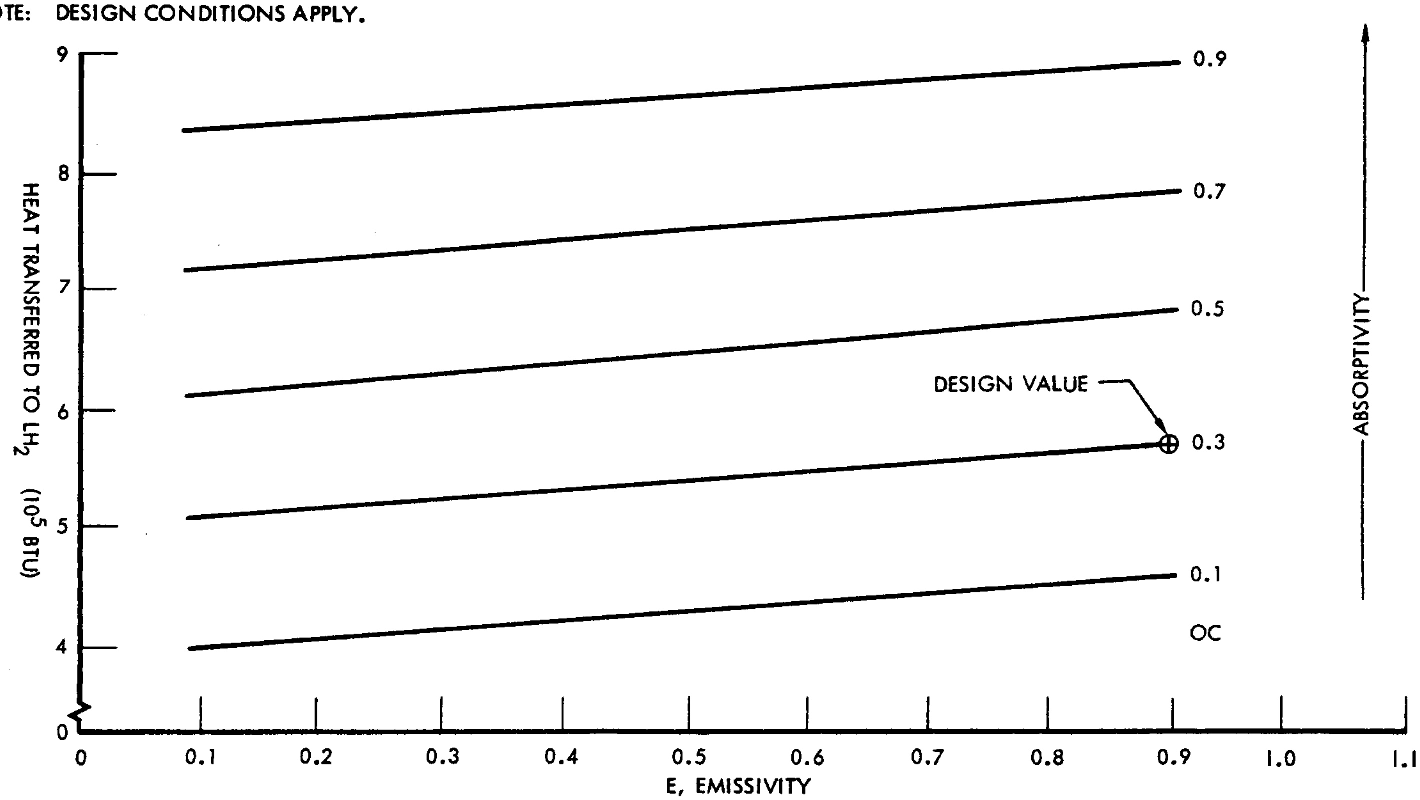


FIGURE 70

A-169

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING VARIATION WITH LAUNCH DATE & TIME

LONGITUDINAL AXIS PARALLEL TO VELOCITY VECTOR
100 NAUTICAL MILE ORBIT
$\alpha = 0.9 \quad \epsilon = 0.3 \quad A = 0.4$
C (INSULATION BTU/LB - °R) = EMPIRICAL VALUES
ρ (INSULATION LB/ft^3) = 5.5 LB/ft^3 INSULATION THK. = 1 IN
$\bar{t}$, TANK WALL EFFECTIVE THICKNESS = 0.148 IN K (INSUL. CONDUCTIVITY) = 0.03 BTU/HR-FT-°F
ALUMINUM WALL MATERIAL, 2014-T6, ANODIZED
TRAJECTORY: (MSFC) REF: M-AERO D-1-63
DATED 4-29-63

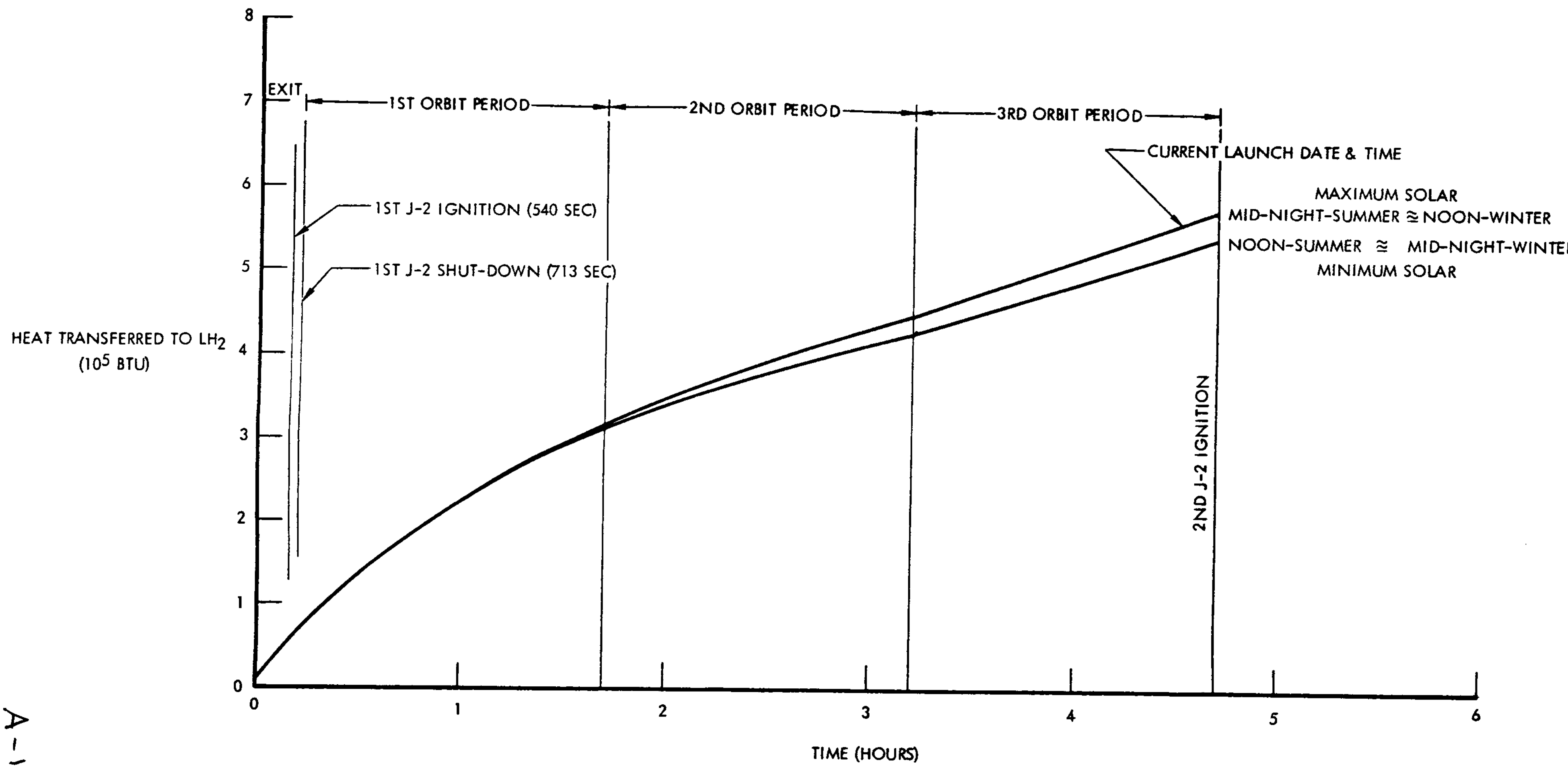
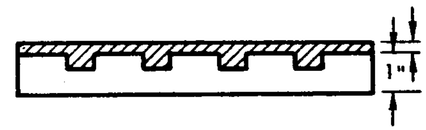


FIGURE 71

A-170

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING VARIATION WITH INSULATION CONDUCTIVITY

LONGITUDINAL AXIS PARALLEL TO VELOCITY VECTOR
100 NAUTICAL MILE ORBIT
$\alpha = 0.3$ $\epsilon = 0.9$ A = 0.4
LAUNCH DATE & TIME: WINTER NOON
C (INSULATION BTU/LB -. R) = EMPIRICAL VALUES
ρ (INSULATION LB/ft^3) = 5.5 LB/ft^3
$\bar{t}$, TANK WALL EFFECTIVE THICKNESS = 0.148 IN
ALUMINUM WALL MATERIAL, 2014-T6, ANODIZED
TRAJECTORY: (MSFC) REF: M-AERO D-1-63
DATED 4-29-63



*POTENTIAL MAXIMUM: BASED ON PERMEATION OF INSULATION BY H_2 VAPOR.

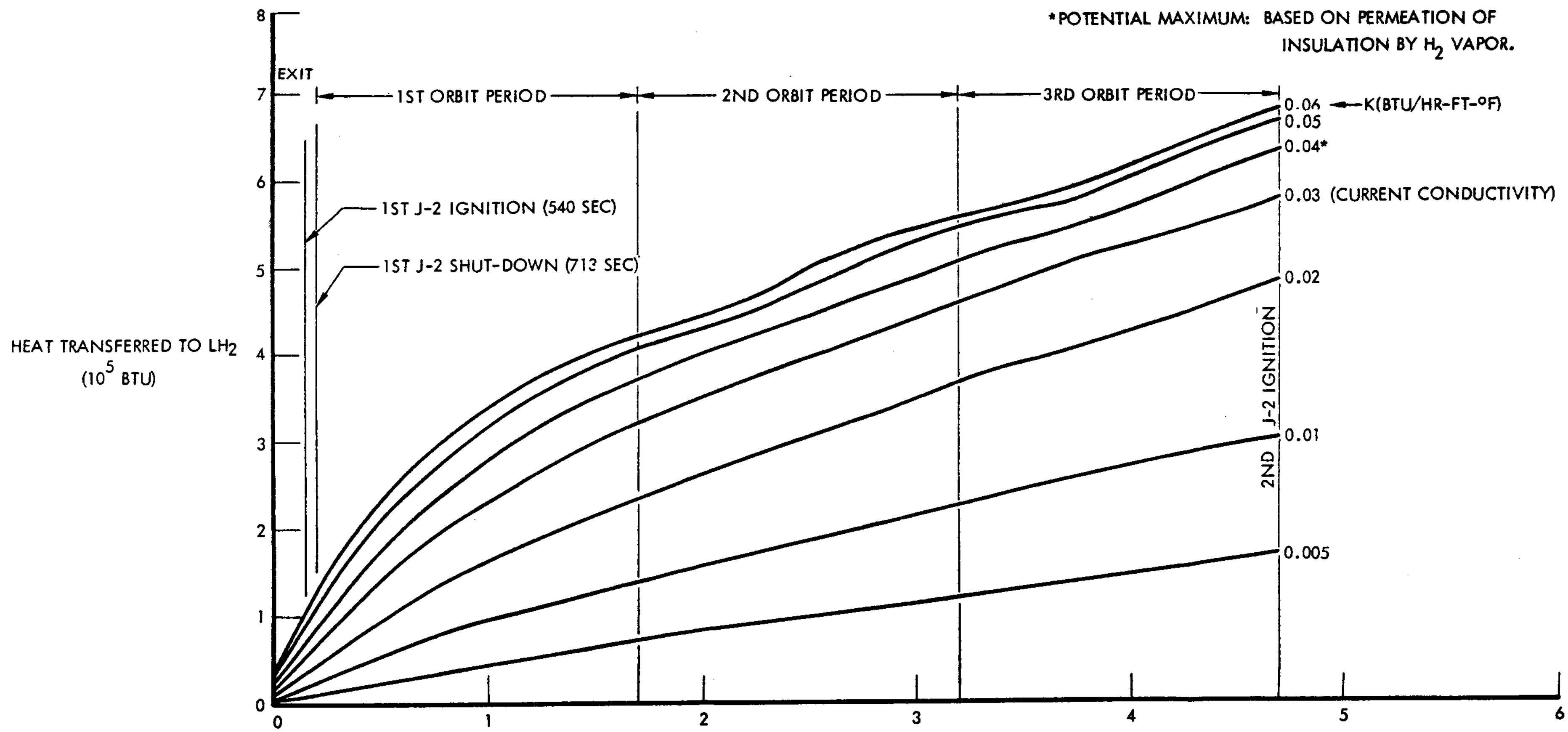


FIGURE 72

A-171

SATURN V/S-IVB EFFECT ON INSULATION CONDUCTIVITY ON SYSTEM WEIGHT CYLINDRICAL TANK WALL

NOTE: PRE-PRESSURIZATION, EXIT & ORBIT PERIODS INCLUDED
EQUIVALENT WEIGHT = $0.43\ W_{bo} + d \quad 0.43\ W_{BO} + W_{INS}$

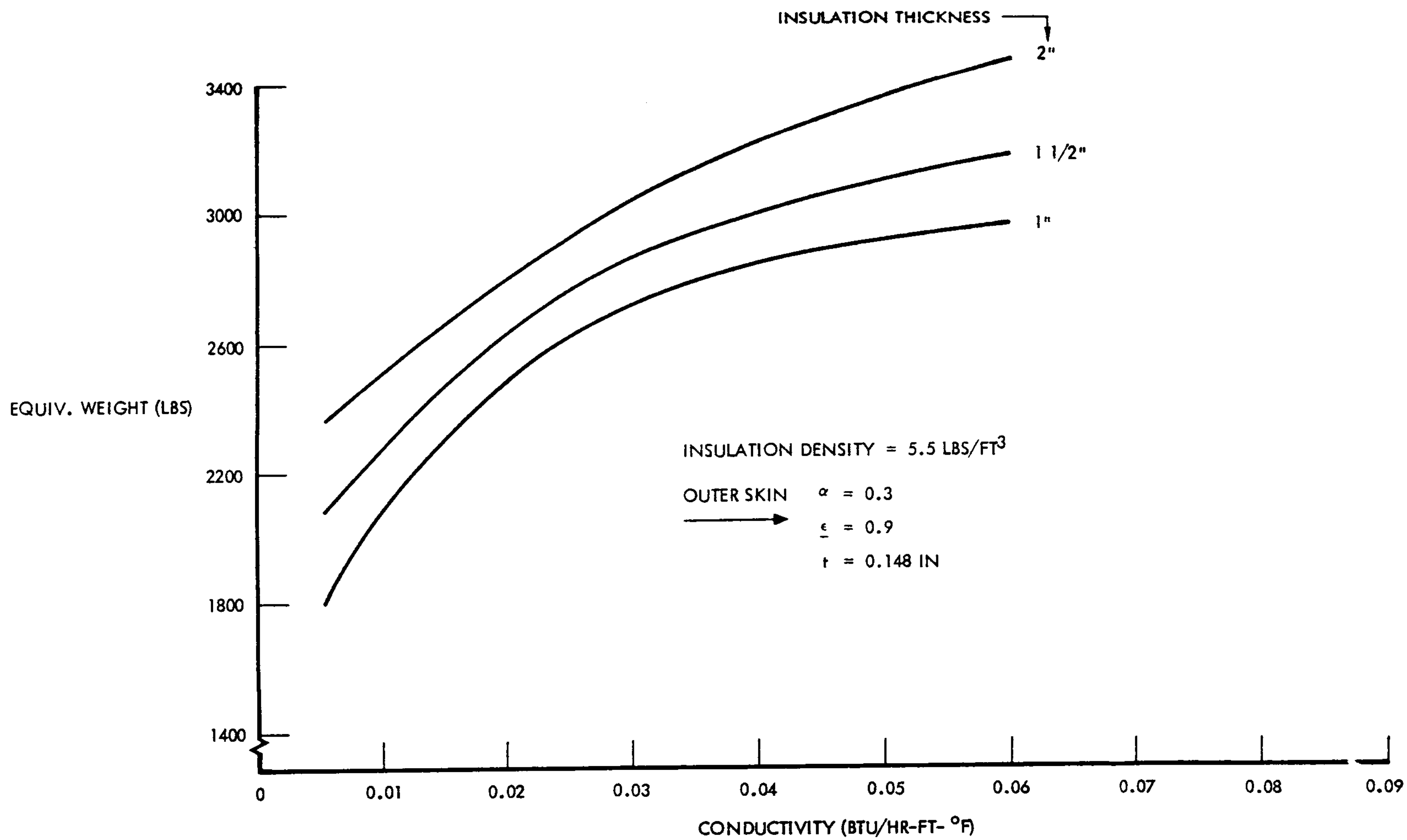


FIGURE 73

A-172

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING VARIATION WITH ORBITAL VEHICLE ORIENTATIONS

100 NAUTICAL MILE ORBIT

α = 0.3 ϵ = 0.9 A = 0.4
LAUNCH DATE & TIME: WINTER NOON
C (INSULATION BTU/LB-°R) = EMPIRICAL VALUES
ρ (INSULATION LB/ft^3) = 5.5 LB/ft^3 INSULATION THK. = 1 IN
$\bar{t}$, TANK WALL EFFECTIVE THICKNESS = 0.148 IN K (INSUL. CONDUCTIVITY) = 0.03 BTU/HR-ft-°F
ALUMINUM WALL MATERIAL, 2014-T6, ANODIZED
TRAJECTORY: (MSFC) REF: M-AERO D-1-63
DATED 4-29-63

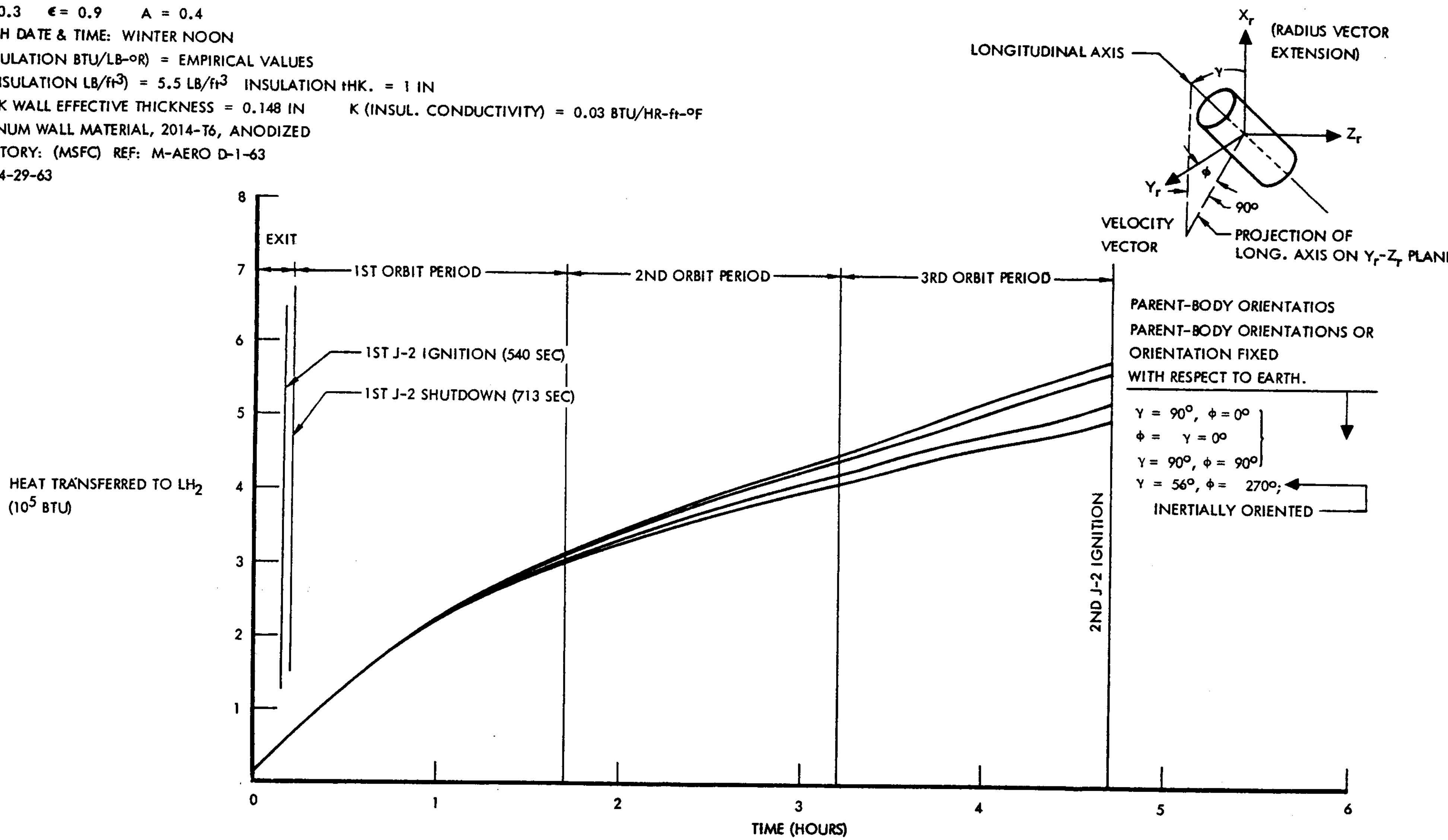


FIGURE 74

A-173

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING VARIATION WITH ρC_p OF ALUMINUM TANK WALL

LONGITUDINAL AXIS PARALLEL TO VELOCITY VECTOR
100 NAUTICAL MILE ORBIT
$\alpha = 0.3$ $\epsilon = 0.9$ $A = 0.4$
LAUNCH DATE & TIME: WINTER NOON
C (INSULATION BTU/LB- °R) = EMPIRICAL VALUES
ρ (INSULATION LB/ft^3 = 5.5 LB/ft^3
$\bar{t}$, TANK WALL EFFECTIVE THICKNESS = 0.148 IN INSULATION THK = 1"
ALUMINUM WALL MATERIAL, 2014-T6, ANODIZED K, INSULATION CONDUCTIVITY = 0.03 BTU/HR-FT-°F
ALUMINUM WALL MATERIA
TRAJECTORY: (MSFC) REF: M-AERO D-1-63
DATED 4-29-63

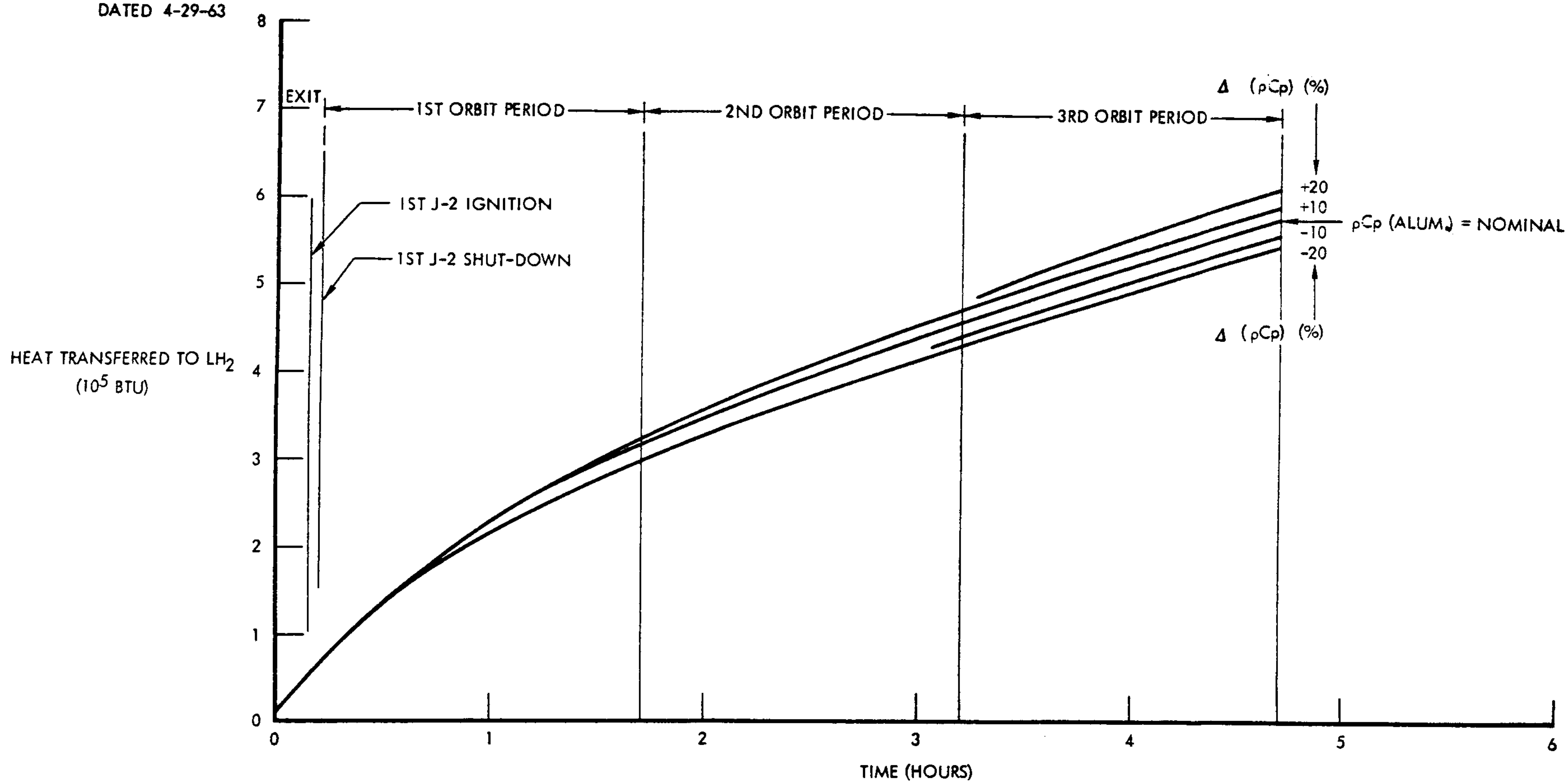


FIGURE 75

SATURN V/S-IVB CYLINDRICAL TANK CONTRIBUTION TO PROPELLANT HEATING SHOWING RELATIONSHIP OF DESIGN VALUE WITHIN POSSIBLE EXTREMES

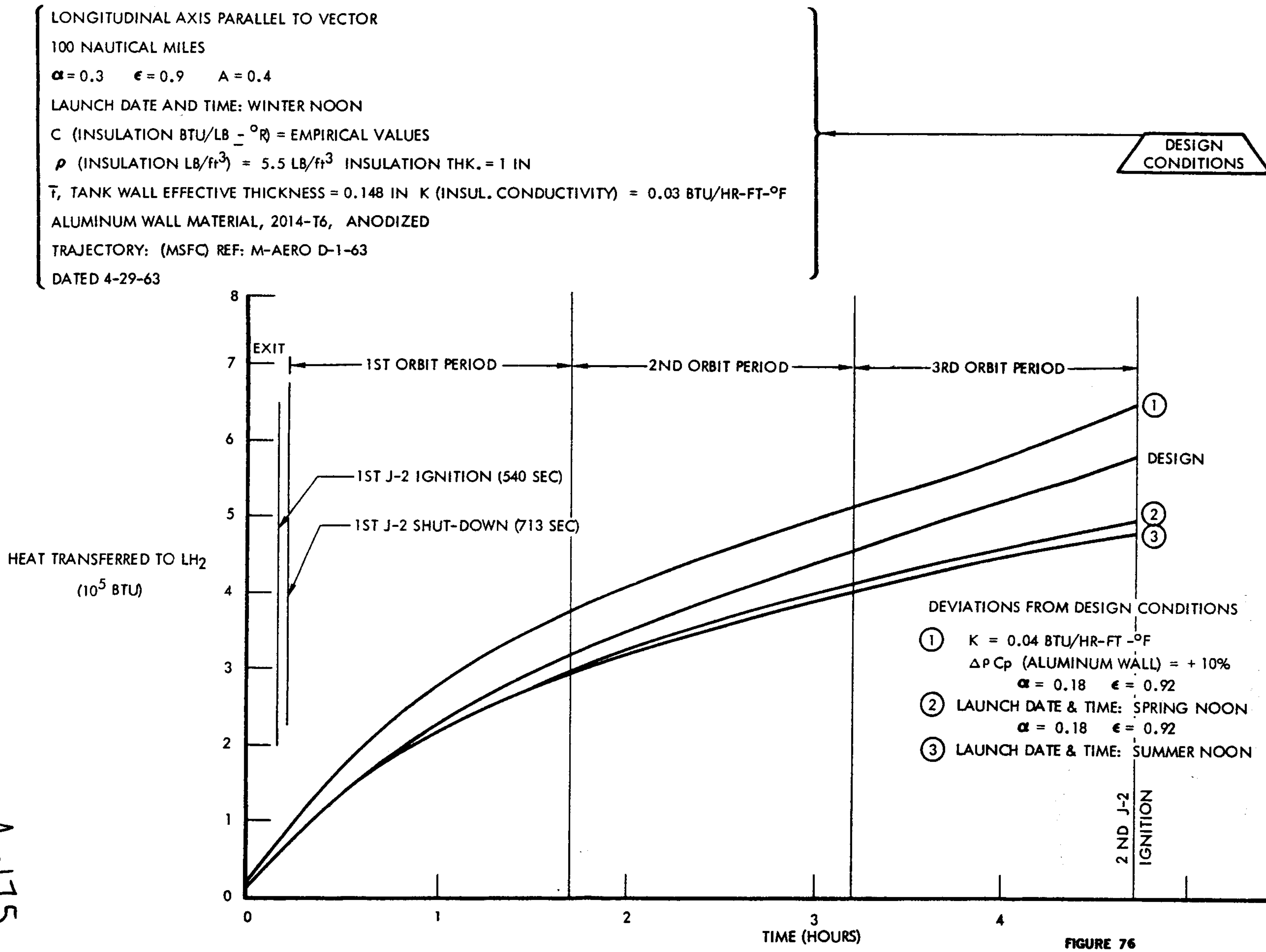


FIGURE 76

14.0 LEAK DETECTION

14.B Mechanical Separable Connector Leak Detection

DAC will present the plan and stage effectivity of this item at the "Leak Detection Splinter Meeting" on August 25, 1964.

A summary of the results of the splinter meeting will be presented by the meeting chairman.

SATURN V SEPARABLE FLUID CONNECTORS - ZERO LEAKAGE EFFORT

For the purposes of this discussion, separable fluid connectors are defined as those which can be connected, disconnected and reconnected in the field. Permanent connectors are defined as those welded joints which have replaced threaded and/or flanged connectors. This welded joint is serviceable in the field by use of a special tool. "Quick disconnect" type couplings are specifically excluded.

PROBLEM STATEMENT

During system design, the requirement was imposed to keep the number of separable fluid connections to a minimum. Due to the size and complexity of the SATURN V propulsion systems, the minimum number of connectors required is 7200, each of which is a potential leakage source. These connectors vary in size from 1/4" to 20" in diameter, are located in systems utilizing six different media, and are typed as threaded, permanent and flanged connectors.

DAMAGE BY CONNECTOR LEAKAGE

Separable fluid connector applications are varied; no common denominator can be readily established which permits an estimate of damage by leakage. General conclusions concerning resultant damage from connector leakage are presented. The extent of damage cannot be predicted and may range from "negligible" to "catastrophic failure" of the vehicle, e.g., the combination of hydrogen and oxygen leakage into a closed compartment will probably result in a catastrophic explosion; inert gas leakage in small quantities occurring late in the operational phase should not be critical, but substantial leakage occurring early could result in catastrophic failure of control functions.

In order to realistically predict damage attributable to leakage the following variables must be assessed:

1. Leakage rate as function of size, pressure and medium
2. Total leakage, including other fluids
3. Proximity to reactive gases and/or components
4. Leakage into closed compartment or open area
5. Leakage with ignition source present or absent

STANDARD R & D PLAN

APPENDIX O

The accepted R & D plan for components, sub-systems and systems includes preliminary evaluation during ground testing and a final evaluation during flight. This philosophy applied to the development of all components likewise applies to the separable fluid connector.

This entails extensive testing in ground programs, in addition to limited inflight data acquisition for final performance evaluation. It should be noted that the ground test program is a continuing effort, and the flight program is limited to only a few seconds per flight and will be completed prior to the operational phase. The program proposed for evaluation of the separable fluid connector is the same type (although more limited) as has been considered standard for other components.

SIC/S-II AND S-II/S-IVB INTERSTAGE PROPELLANT CONCENTRATION VERSUS TIME

An analysis was performed to determine the concentration of oxygen and hydrogen, in the interstage, as a function of time.

The concentration of oxygen is a function of ground winds and stage leakage. The concentration of hydrogen is primarily a function of stage leakage.

If the stage leakage rates used for this anaylsis, i.e. maximum allowable component external leakage per component specifications and maximum probable seal leakage for separable connectors per test data, is not exceeded the environmental control system will maintain oxygen concentration at a maximum of 1% and hydrogen concentration below 1%.

The ignition limits for a gaseous oxygen and gaseous hydrogen mixture are as follows:

a. Both oxygen and hydrogen must be at least 4%, by volume, of the total gas mixture.

b. The environmental pressure must be at least .19 psia.

In view of these limits it was determined that the environmental pressure will be considerably lower than .19 psia when oxygen and hydrogen concentrations reach the 4% level.

31 July 1964

Handout for Presentation of "Analysis of Ignition Hazards in S-IC/S-II and S-II/S-IVB Interstage Areas". Prepared by: R-P&VE-PMP, MSFC

1. Analysis Ground Rules:

   a. No ignition possible if either oxygen or hydrogen concentration is below 4 % by volume.

   b. No ignition possible when interstage pressure is below 0.19 psia.

   c. Assume complete mixing of oxygen and hydrogen leakage with remaining gas in interstage area. Utilize a safety factor of three to allow for mixing imperfections.

   d. Assume 99.9% steady state winds.

   e. Assume maximum allowable component external leakage per component specifications. Assume maximum probable seal leakage for separable connectors per test data.

2. Analysis Procedure:

   a. Equations were written for all variables and computer techniques were utilized. The computer program accounted for the following:

      1. Residual air which cannot be removed by the environmental control system in the allotted time period and also for air leakage into the interstage areas on the upwind side of the vehicle.

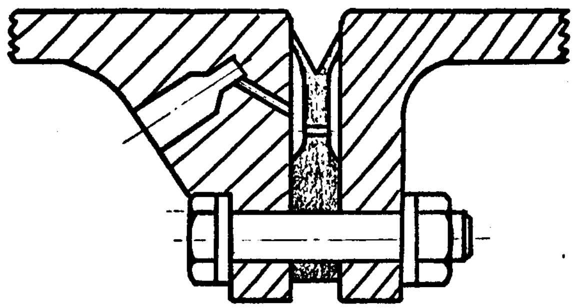
      2. Propellant leakage into the interstage areas from initiation of tanking until lift off +135 seconds (0.19 psia interstage) pressure.

      3. Oxygen and hydrogen vented overboard on the ground and in flight.

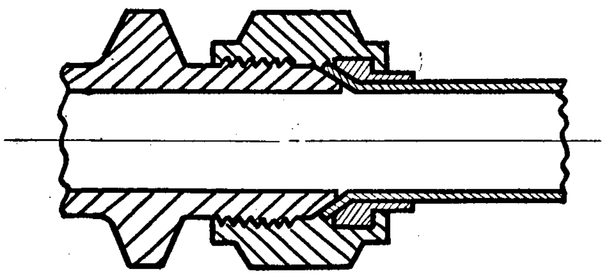
3. Should either interstage environmental purge be lost subsequent to propellant loading and prior to launch, the contamination of the interstage area becomes very difficult to predict, however it appears that 4% oxygen would be realized in a matter of minutes (due to air leakage) and 4% hydrogen in a matter of hours (due to hydrogen system leakage). The most unpredictable portion of such an analysis is that the assumption of complete mixing is no longer valid and combustible pockets may form.

The probability of a failure causing prolonged interruption of the conditioning flow to the interstage areas will be investigated.

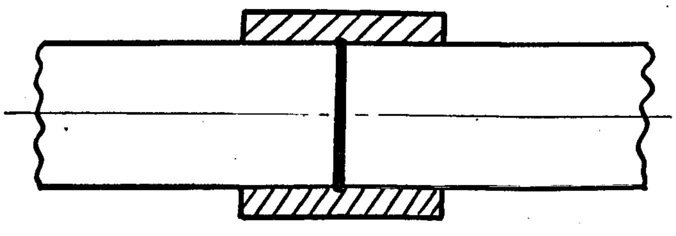
TYPICAL CONNECTIONS



FLANGE



THREADED



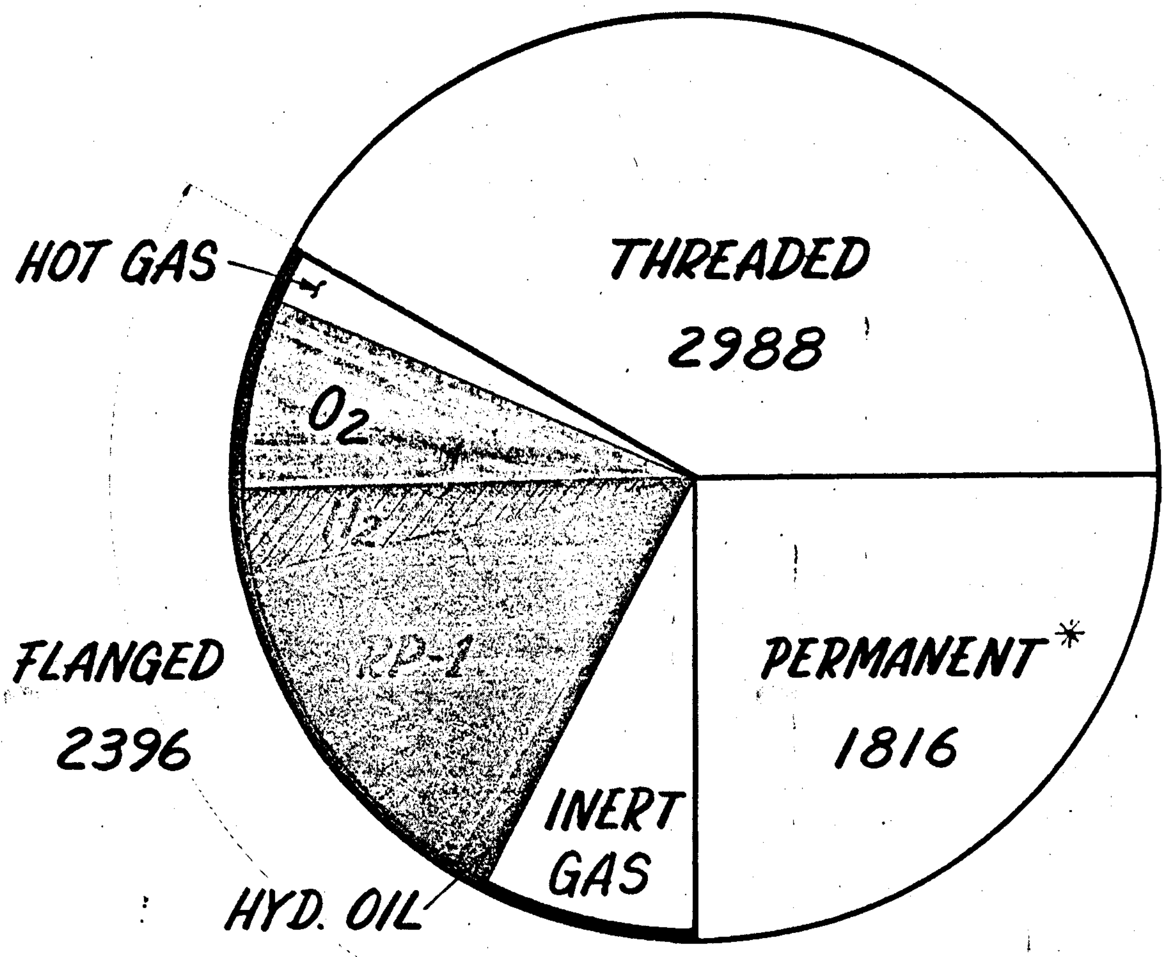
PERMANENT

SATURN V

SUMMARY

TYPE	NUMBER
FLANGED	2396
THREADED	2988*
PERMANENT	1816*
TOTAL	7200

* ESTIMATE ±10%



TOTAL - 7200

* FIELD SERVICEABLE
SPECIAL TOOL

SATURN V

SUMMARY OF STAGES

STAGE	FL	THD	P	TOTAL
S-IC	1460	1973*		
S-II	609	622*		
S-IVB	327	130*		
I.U.	0	263		
TOTAL	2396	2988*	1816*	7200

FL = FLANGED , THD = THREADED , P = PERMANENT
* ESTIMATE ±10%

S-IVB STAGE *

FLANGE CONNECTIONS

MEDIA	NO.	TYPE Δ	SIZE (INCHES O.D.) 1/4-1 1/4	1 1/2-5 3/4	6-10	OVER 10
OXIDIZER	44	C.S.	22	19	1	2
	2	N.A.		1	1	
TOTAL	46					
FUEL	56	C.S.	23	23	8	2
	2	N.A.		1	1	
TOTAL	58					
INERT GAS	140	C.S.	111	29		
GRAND TOTAL	244					

C.S. = CONOSEAL, N.A. = NAFLEX

* EXCLUDING ENGINE & HYD. SYSTEM

Δ GASKET

S-IVB STAGE *

THREADED CONNECTIONS

MEDIA	NO.	TYPE	SIZE (INCHES O.D.)				
TOTAL	38						

* EXCLUDING ENGINE & HYD. SYSTEM

S-IVB HYDRAULIC SYSTEM

	FLANGE		SIZE (INCHES O.D.)				
MEDIA	NO.	TYPE △					
MIL-H-5606	6						

△ GASKET

	THREADED		SIZE (INCHES O.D.)				
MEDIA	NO.	TYPE	1/4	3/8	1/2	5/8	3/4-1 1/4
MIL-H-5606	70		8	6	16	21	19
GN_2	2		1		1		

J-2 ENGINE

FLANGE CONNECTIONS

MEDIA	NO.	TYPE Δ	SIZE (INCHES O.D.)			
						MEAS. CAP.
OXIDIZER	17					17
	4*					1*
TOTAL	21					18
FUEL	14					14
	6*					1*
TOTAL	20					15
HOT GAS	10					10
TOTAL	10					
INERT GAS	22+					22
	4*					0*
TOTAL	26+					22
GRAND TOTAL	77+					65

* INTERFACE + APPROX. Δ GASKET

J-2 ENGINE

THREADED CONNECTIONS

MEDIA	NO.	TYPE	SIZE (INCHES O.D.)				
TOTAL	20*						

* ESTIMATE

J-2 ENGINE

PERMANENT CONNECTIONS

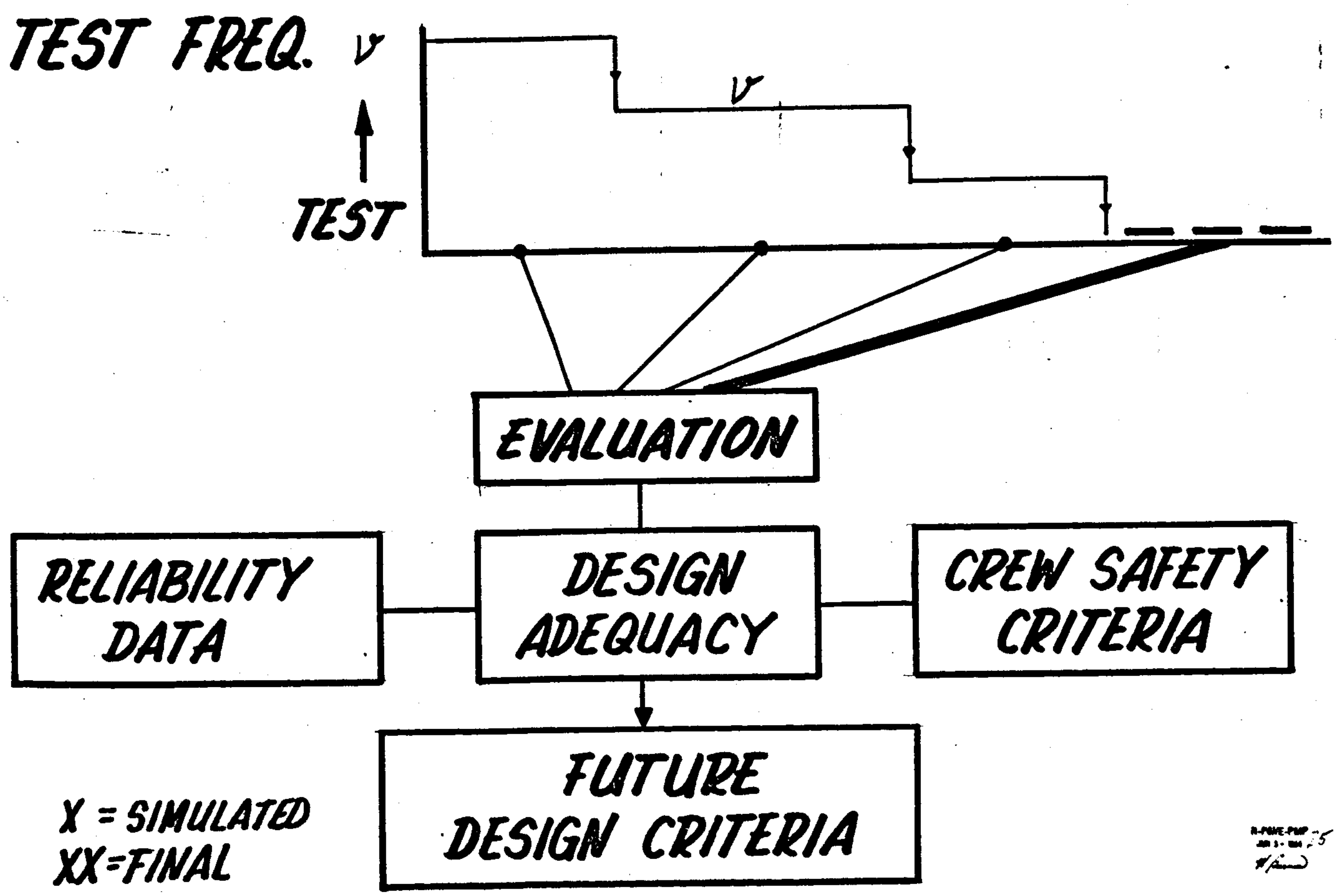
MEDIA	NO.	TYPE	SIZE (INCHES O.D.)			

DAMAGE BY CONNECTOR LEAKAGE

HAZARD SCALE	WORKING FLUID	EFFECT OF LEAKAGE
A	HOT GAS	PROGRESSIVE BLOW-TORCH DESTRUCTION IGNITION SOURCE
B	OXYGEN HYDROGEN	FIRE EXPLOSION
C	HYDROCARBON & OTHER FUEL	FIRE
D	HYDRAULIC OIL	LOSS OF FUNCTION & FIRE
E	INERT GAS	LOSS OF FUNCTION

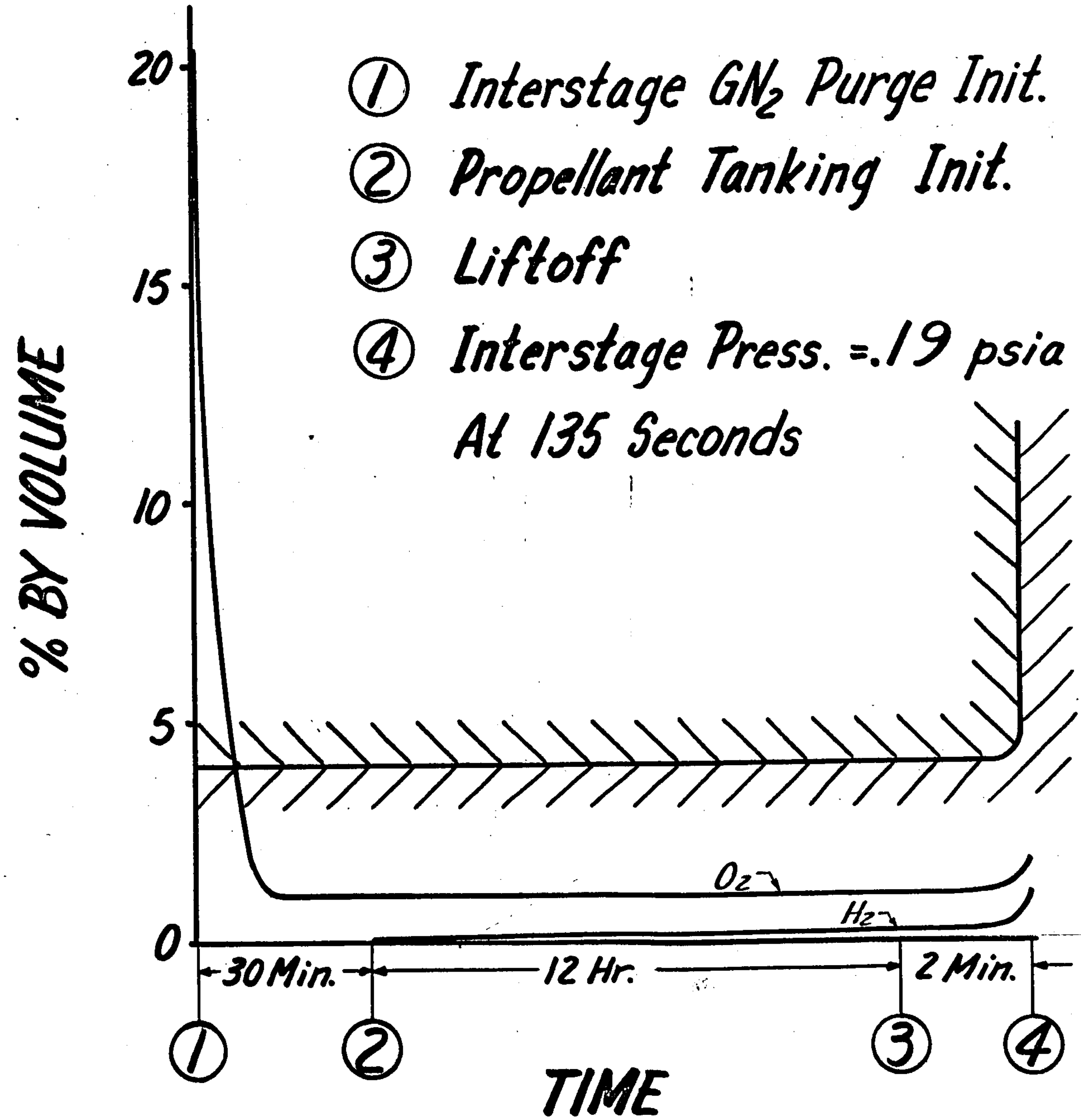
STANDARD R&D PLAN

	GROUND			FLIGHT
	COMP.	SUB-SYS.	SYS.	VEHICLE
DESIGN	X			
MATERIAL	X			
ENVIRONMENT	X	X	X	XX
PERFORMANCE	X	X	X	XX



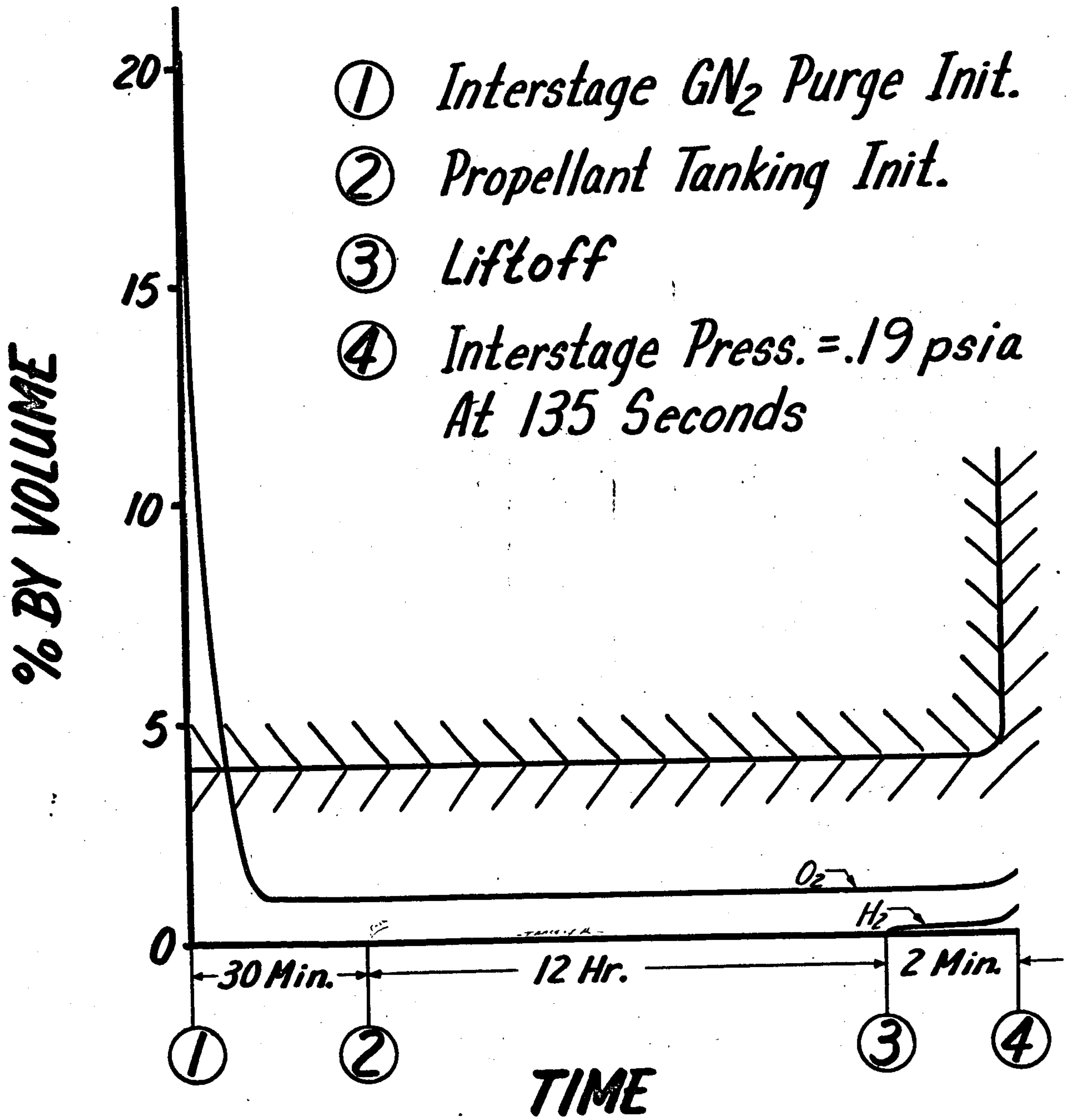
X = SIMULATED
XX = FINAL

S-IC/S-II INTERSTAGE
PROPELLANT CONCENTRATION VS TIME



27

S-II/S-IVB INTERSTAGE
PROPELLANT CONCENTRATION vs TIME



26 August 64

S-IVB STATIC FIRING LEAK MEASURING PROGRAM

The 12 critical flanges previously selected for leakage monitoring have been reviewed and it is agreed that they should be continued. However, it is recommended that the following flanges be monitored during static firing in addition to the 12 noted above.

	P/N	DESCRIPTION
1.	75	LOX Fill & Drain Duct to Tank
2.	94	LOX Pump Chill System: Shut-off Valve to Recirculation Pump,
3.	97	Duct to Prevalve
4.	98	Engine Return
5.	101	Check Valve to Tank
6.	150	LH_2 Pressurization Duct
7.	151	LH_2 Pressurization Duct
8.	157	LH_2 Pressurization Duct
9.	159	LH_2 Pressurization Duct
10.	189	LH_2 Fill & Drain Duct to Tank
11.	199	LH_2 Pump Chill System: Shut-off Valve to Recirc Pump
12.	202	Duct to Prevalve
13.	203	Engine Return
14.	208	Check Valve to Tank
15.	210	LH_2 Vent Duct to Tank
16.	210	LH_2 Vent Duct to Vent & Relief Valve
17.	230	LH_2 Tank PU Probe
18.	231	LH_2 Tank Wire Bundle
19.	236	LO_2 Tank PU Probe
20.	237	LO_2 Tank Wire Bundle
21.	239	LO_2 Tank Instrumentation

APPENDIX P

15.0 HYDRAULIC SYSTEM (SATURN IB/V)

15.A Tests conducted in the most adverse ground hold environment (-80°F) show that a flow through the main pump discharge line of 0.04 gal/min. of 50°F oil will maintain this line at a minimum temperature of 0°F. DAC is proceeding with tests simulating the orbital coast condition. DAC will proceed with changes to provide for a small flow through this line pending the results of the simulated orbital coast tests.

15.B DAC Engineering is working on installation of the temperature sensor at the LOX pump bracket location.. This location has been calculated to be the critical point during orbital coast. The coldest point during ground hold is located between brackets by both calculation and test, however, the temperature difference is less than 10°F.

15.C Data not presently available.

A summary document encompassing both thermal analysis and tests to date is available from M. J. Hamilton, Ext. 2573, if more detailed information is desired.

SUPPLEMENTARY HANDOUT FOR SIXTH VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP MEETING, S-IVB:

SUMMARY OF THERMAL ANALYSIS AND TESTS ON S-IVB HYDRAULIC SYSTEM

APPENDIX Q

SATURN IB/V S-IVB

GIMBALS SYSTEM THERMAL ANALYSIS

INTRODUCTION

This report covers DAC's gimbals system thermal analysis to date. The thermal analysis of the hydraulic system has been in progress for the past nine months. During this time, many studies were made of the various hydraulic components. These studies are being updated and refined so as to reflect the latest developments or thinking; and hence, present a clear, complete, and representative thermal picture of the system.

Generally, the hydraulic system has two sets of thermal problems. One problem area concerning the hydraulic system is present during the ground hold period after liquid oxygen loading has begun, and the other problem area begins after S-IVB engine cutoff where the vehicle sees deep space during the 4 1/2 hour earth orbit (V mission only).

The Saturn S-IV is unlike the S-IVB in that electronic equipment is mounted on the thrust structure of the S-IV. S-IV's gaseous nitrogen purge system must condition the electronic equipment of the thrust structure which in turn produces a temperature range of 35 to 70°F in the vicinity of the hydraulic systems. S-IVB's ground hold temperatures were calculated. The conservative minimum temperatures used in this analysis are considered to be -100°F for the thrust structure and -80°F for the area in the vicinity of the hydraulic system. These temperature conditions, linked with thermally undesirable hydraulic line attach points, create the ground hold problems. The undesirable attach points are hydraulic line brackets mounted on the liquid oxygen line (-297°F) and mounted to the turbine exhaust dome (-297°F to +600°F to -297°F). The attach points are also responsible for the problems during the orbital coast period.

SATURN IB/V S-IV-B GIMBALS SYSTEM THERMAL ANALYSIS

MECHANICAL DESIGN SECTION

VEHICLE DESIGN BRANCH

Q-3

ORBITAL COAST - V MISSION

Prior to launch, the auxiliary pump is programmed to start at T-210 seconds and to run continuously through to S-IVB engine cutoff (about 15 minutes). The main hydraulic pump runs during engine firing only (about 3 minutes). Therefore, heat is being generated in the hydraulic system from T-210 seconds prelaunch to engine cut-off. At this time, estimated oil temperature is 150°F. Thrust structure temperature is assumed to be -100°F and space temperature is -459°F.

Time - temperature charts 1 through 10 illustrate the hydraulic system component analyses for the orbital coast period. Below, each curve will be discussed in turn.

CHART 1

Chart 1 shows that the hydraulic oil temperature in the main pump, accumulator-reservoir, and the pitch and yaw actuators is above 0°F after the entire 4 1/2 hour orbital coast period. The above mentioned components are all large-mass items ranging in weight from 17 to 63 pounds and have heat storage capability. The oil in the 1/2 inch hydraulic line at a point between support brackets loses heat by radiating to space. After 2 hours in space, the oil temperature is approximately 50°F. Extrapolation of this curve shows that the oil in this line would reach 0°F after 3 1/2 or 4 hours. However, the oil in the 1/2 inch line at the point of contact to the bracket that anchors to the liquid oxygen line drops to 0°F in about 2 1/2 hours. At this point additional heat is lost by conduction through the bracket to the -297°F liquid oxygen line.

Further discussion of the oil temperature in the lines appears below under the headings of Charts 6, 7, and 8.

CHART 2

This chart compares how various values of emissivities would effect the oil temperature in a hydraulic line radiating to space. Significant temperature improvement can be made with the installation of a radiation shielding material such as aluminized mylar ($e = 0.1$). The lower curve value of 0.44 was used to represent the stainless steel hydraulic lines.

In the thermal analysis, $e = 0.1$ was assumed as the surface finish for all the various components radiating to space.

CHART 3

This chart represents the temperature history of the hydraulic oil within the main pump. During boost, the hot gas turbine drives both the liquid oxygen pump and the main hydraulic pump. After engine cutoff, heat from the turbine exhaust drive is transferred to the pump and causes the rise in temperature of the hydraulic fluid. After the exhaust dome temperature drops below the hydraulic pump temperature, heat is lost from the pump. There are two conductive heat paths from the pump to the cold sink (-297°F liquid oxygen pump). One path is from the hydraulic pump through the pump isolator, through the thin shell of the turbine exhaust dome to the cold sink. The other heat path is via the internal drive shaft. Heat must pass from the hydraulic pump through one spline to the drive shaft and through another spline to the turbine and to the cold sink. Both splines are considered as point contacts. A Rocketdyne test of an engine firing using a Vicker's main hydraulic pump with an isolator furnished the temperature data for this analysis.

This study will be updated. Rocketdyne drawings are now available for the turbine, dome, and liquid oxygen pump. A comparison will be made between these drawings and our heat transfer model. Also, the turbine gas temperature will be increased from the 600°F test data temperature to 750°F, a more realistic high-side gas turbine temperature, and to 900°F, a maximum gas turbine temperature.

CHART 4

This chart shows the cylinder oil temperature history of the pitch and yaw actuators. The estimated weight of this component was 29 pounds. An actual part, however, was weighed at 37 pounds. This additional weight was incorporated in the analysis. From a conservative initial oil temperature of 100°F, the oil temperature drops to 50°F in two hours. Estimated oil temperature after 4 1/2 hours, based on extrapolating the curve beyond two hours, is about 30°F.

CHART 5

The accumulator reservoir study curve presents two time - temperature plots. This component contains hydraulic fluid in an upper chamber and nitrogen gas in lower chamber. The high pressure nitrogen gas temperature and the oil temperature are both critical. From an initial temperature of 150°F the accumulator oil temperature falls to approximately 55°F in 4 1/2 hours. From an initial temperature of 50°F, the high pressure gas temperature falls to approximately 35°F during the same 4 1/2 hour period. The weight of the part is 63 pounds.

CHARTS 6, 7, and 8

Charts 6, 7, and 8 show the results of the analysis for the 1/2, 5/8, and 3/4 inch hydraulic line assembly at, and including, the bracket mounted to the liquid oxygen line. Each chart has a family of curves that give the hydraulic oil temperature history at the bracket center line, at a point about 3 inches from the bracket center line, and at a point about 7 inches from the center line. Previous study results that did not include the three hydraulic lines in conjunction with the bracket, show the oil temperature dropping from an initial temperature of 100°F to 0°F in 20 minutes. Efforts to achieve thermal isolation of oil from the liquid oxygen line attach point lead to the redesign of this bracket. Three improvements can be cited.

CHARTS 6, 7, and 8 (Continued)

When the auxiliary pump cycles, oil flows through the 1/2 inch and 3/4 inch lines only, as the 5/8 inch high pressure main pump discharge line is not included in the circuit. Repositioning of the three lines placed the 1/2 and 3/4 inch lines between the 5/8 inch high pressure main pump discharge and the cold sink. There is metal contact between the three lines. This improvement would result in some heating of the 5/8 inch line at the bracket by warm oil in the 1/2 and 3/4 inch lines. Metal to metal contact between the hydraulic lines and the bracket, and between the bracket and the liquid oxygen lines, is thermally undesirable. The combination of insulating washers and bolt inserts was incorporated into the bracket design to eliminate this metal contact. Additional improvement was gained through changing the bracket configuration from a flat plate to a tubular design which lengthened the heat path from the base to the hoses and will provide uniform temperatures across the face of the bracket.

CHARTS 9 and 10

These time - temperature curves assume oil temperatures in all the hydraulic lines have reached $0^{o}F$, as in an extended mission. At such a time, the auxiliary pump would cycle and bring the system oil temperature to $50^{o}F$. Therefore, the oil temperature in the 1/2 and 3/4 inch hydraulic lines would then be at $50^{o}F$ but the 5/8 inch line remains at $0^{o}F$ because it is not in the auxiliary pump circuit.

Results of this analysis show that at the bracket, oil in the 5/8 inch line (Chart 9) receives heat from the 1/2 and 3/4 inch lines. The oil temperature in the 5/8 inch line between brackets drops from $0^{o}F$ initially to $-16^{o}F$ in one hour, as shown in Chart 10. Rough calculations indicate that if the three lines were in a common shroud, the two heated lines would provide heat for the 5/8 inch line.

SUMMATION OF ORBITAL COAST

Thermal analyses thus far have shown that all the components in the hydraulic system with the exception of hydraulic lines in contact with certain brackets would remain above 0°F for the entire 4 1/2 hour orbital coast period. The entire length of the three hose portion of the hydraulic system can be singled out as the area in which problems may occur. Oil temperatures in all the lines at the brackets, and in the entire length of the 5/8 inch high pressure main pump discharge are the specific problems.

Hydraulic line attach points were provided by the engine manufacturer based on mechanical convenience. From a thermal standpoint, the liquid oxygen line and the turbine exhaust dome are undesirable locations and create the bulk of the thermal problems.

Improvements have been made by redesign of bracketry, mainly to eliminate the metal to metal contact from the hydraulic lines to the cold attach points. In spite of these bracket design improvements, oil temperatures at the brackets fall below 0°F.

It is evident that some form of further design improvement may be required. The following variations are being considered:

1. Changing the temperature cycle limits upward.
2. Relocating the temperature cycle switch.
3. Heating the oil at the brackets electrically.

A vacuum chamber test of the three hose portion of the hydraulic system has been scheduled for July, 1964. Temperature sensors will be placed in the oil lines and at the brackets. The temperature conditions that this portion of the system will experience in space will be simulated in this test. Provisions will be made for supplying heated oil to the system at the same flow rate the auxiliary pump would supply oil. When the oil in any point in the system reaches 0°F, SUMMATION OF ORBITAL COAST (Continued)

the system will cycle and the process repeated not to exceed 4 1/2 hours. Should this test prove unsatisfactory, heaters will be installed at the brackets and the test will be rerun. Also in the test program is a hydraulic system thermal test in MSSD's 39 foot diameter vacuum chamber. This test is scheduled for February, 1965.

The limited ground hold test data available indicates quite satisfactory agreement between calculations and tests. The calculations are conservative in that they show a more rapid temperature decay.

GROUND HOLD - IB/V MISSION

The following work was done on the engine gimbals control system for the ground hold period. The vehicle was considered to be in an environment such that the internal components had assumed a steady state temperature of 50°F. Upon loading the liquid oxygen at the beginning of ground hold, temperatures interior to the vehicle will descend. Warm nitrogen purge gas will be circulated through the vehicle to maintain an inert atmosphere and to hold many locations at a desirable temperature level. The nitrogen gas comes in contact with the liquid oxygen propellant tank, resulting in a thrust structure temperature of -100°F and a -80°F nitrogen gas temperature by the time it has circulated into the vicinity of the engine gimbals control system. These cold temperature conditions cause oil temperatures to fall below 0°F in certain hydraulic components. Since 0°F is the lowest acceptable temperature for the components in this particular system, counter-measures will have to be taken during a 12 hour ground hold.

One procedure that has been suggested, based on calculations, is to cycle the auxiliary hydraulic pump every 30 minutes. The electric motor of the pump produces heat as a by-product along with the heat derived from the friction in the flowing hydraulic oil. Thus, a heat energy source and a distribution mechanism is made available.

CHART 11

Chart 11 shows the temperature cycles that different components will experience from an initial component steady state condition of 50°F, when exposed to a -80°F environment. It is evident that the components react differently. The succeeding graphs are of individual cases and will be taken up successively.

CHART 12

Chart 12 presents the temperature history of the hydraulic oil in the main pump during ground hold. The main pump is separated from the turbine exhaust dome by an isolator. Initial temperatures of 50°F for the unit, -80°F for the environmental nitrogen gas, and -297°F for the liquid oxygen pump, were assumed. The oil in the pump was allowed to descend to 0°F. Then the oil was raised to 50°F and certain parts of the component raised an appropriate amount to account for the circulation of the oil for 5 minutes. The oil was stopped after the warming period and the temperature allowed to descend for 30 minutes. This was repeated. As can be seen on Chart 12, the temperature of the oil does not go below 0°F during a 30 minute wait. The information thus gained was modified slightly to a 25 minute pump cooling, a 5 minute oil pump warming period, and plotted on Chart 11. A temperature sensing switch is located in the return line at the pump and will form the basis of cycling. The other components on Chart 11 are phased in with this common denominator.

CHART 13

There is little chance that the auxiliary pump will experience temperatures below 0°F during a 30 minute cycling in that it is a source of heat energy and has a relatively large mass. A temperature history was calculated for the contained oil. It is shown on Chart 13. In 30 minutes the greatest temperature drop in the hydraulic oil was 25°F from an initial temperature of 50°F. Under normal 30 minute cycling, the oil in the auxiliary pump will start the temperature decline from higher than 50°F so that these results are conservative. The curve on Chart 11 represents the auxiliary pump oil cycling from 50°F.

CHARTS 14 and 15

The accumulator-reservoir is the most massive piece of equipment (63 pounds) in the hydraulic system. The warm circulating oil from the auxiliary pump passes through one end of this long cylindrical shaped component. Chart 14 shows that the oil will remain well above 0°F. However, the other end which contains high pressure nitrogen gas continuously cools. The nitrogen must be kept above 0°F if the accumulator-reservoir is to function properly. To surmise how much of a problem existed, a second program was run with the ambient nitrogen gas held to a -25°F. Chart 15 contains the results. With the moderate conditions stated, the nitrogen gas temperature descends to -10°F after a period of 10 hours. In an environment of -80°F counter-measures will have to be taken.

CHARTS 16 and 17

The two actuators are quite massive (37 pounds each) and, therefore, hold good quantities of heat when warm. Also, the heat paths throughout the component are good. However, the servo valves are the only portions that receive circulation when the auxiliary pump is run during the ground hold period. Chart 16 shows the temperature decline through the first two hours. After this period of time, a 30 minute cycle is shown for the servo valves in Chart 17. The table to the side is data on the oil in the cylinders of the actuators. The servo valves are shown cycled at 30 minute intervals on Graph 11. The solid line on the graph is the oil in the cylinders. Though the temperatures become marginal, they fall within the limits of desirability.

CHARTS 18, 19, and 20

The hydraulic components are connected by 1/2, 5/8, and 3/4 inch stainless steel tubing and flexible tubing. The tubing that will be effected the most adversely by low temperature environment is the 1/2 inch tubing and that which will be effected the least will be the 3/4 inch tubing. -Because there is some uncertainty about the ground hold temperature environment, tests of the three hose portion of the gimbals system were

CHARTS 18, 19 and 20 (Continued)

conducted at three different ambient temperatures. The following is a comparison of calculations and test data of the two sized tubings in environments of -25°F, -45°F, and -80°F.

Charts 18, 19, and 20 are for -25°F, -45°F, and -80°F environments respectively. The computed data is shown to be consistently conservative compared to the data from laboratory testing. Free convection occurs throughout until the -80°F environment is imposed upon the lines. The hydraulic lines do experience turbulent flow of the nitrogen gas around the exterior surfaces at the lower ambient temperature. If their respective diameters had been 2 1/2 inches, rather than 3/4 inch or less, free convection would have predominated. Care must be exercised when considering small articles at the temperature differences imposed here. Since all of the earlier considered components connected by the hydraulic lines have diameters greater than 2 1/2 inches, they were considered to experience free convection in the computations.

The hydraulic lines cool too quickly for a 30 minute cycling period to realize the desired results. Supplementary measure will be required.

HYDRAULIC LINE BRACKETS

An added problem closely associated with the hydraulic lines is the support brackets between the several components. These brackets anchor on to the cold thrust structure and main oxygen propellant line. Heat will be conducted through the brackets from the hydraulic lines constituting problem points distributed throughout the engine gimbals system. Brackets with the lowest heat conductance possible are being developed, but since the oil in the lines is cooled below 0°F in 3 to 7 1/2 minutes exclusive of the bracket effect, there is every reason to believe that a supplemental heat energy supply will be needed in addition to circulating the hydraulic oil once every 30 minutes.

CRITICAL AREAS

In the preceding work, it was shown that there are several areas in the system that will attain temperatures below marginal when warming the system with a 30 minute auxiliary pump cycle in a cold nitrogen gas environment. These are:

Reservoir-accumulator (high pressure nitrogen gas end).
Hydraulic lines.
Bracket-hydraulic line attach points (cold regardless of the environment).

POSSIBLE REDRESS

Three schemes have been considered for eliminating temperature problems. They include:

1. Shrouding the accumulator-reservoir and the dead line with a mylar sock and purging with warm nitrogen gas.
2. Routing the nitrogen purge gas that contacts the liquid oxygen tank differently so as to keep the cold gas off the gimbals system.
3. Heaters.

The accumulator-reservoir and the no-flow hydraulic line could be shrouded in a thin film of nitrogen. Three lines could be placed in a common sock - the 1/2, 5/8, and 3/4 inch lines. Aluminized mylar would act as a radiation shield during orbital coast. Warm nitrogen gas, ducted from the purge system located over the accumulator-reservoir, would be passed through the shroud enveloping the vulnerable components. The supply of nitrogen gas needed was calculated to be approximately 100 pounds per hour for the entire system.

Routing the cold nitrogen purge gas so that it would not spill out over the hydraulic system would in theory be ideal from the thermal standpoint. The holes in the thrust structure would perhaps have to be sealed and the cold gas routed past the gimbals system and overboard. The warm nitrogen gas descending along the vehicle skin would then migrate over

POSSIBLE REDRESS (Continued)

into the engine gimbals system and create a warm environment. How the top of the S-II liquid fuel tank would effect the environment is not known. No coordination regarding this suggestion has been made.

Electrical heat could be supplied to the effected components. If external power only were used, the problems of installation and efficiency would be lessened. Immersion type heater in a bracket assembly would be reliable and solve the problem of localized freezing. Electrical power supplied through heaters would have to be compared with power required to run the auxiliary pump for the V Mission only.

SUMMARY

During ground hold the engine gimbals system will not remain above the minimum desired temperature of $0^{\circ}F$ in the expected minimum environment of $-80^{\circ}F$ nitrogen gas without corrective measures. Many of the components to the system can be held at satisfactory temperature, if the auxiliary pump is run intermittently. Several of the components will need special attention with this scheme and they include the reservoir-accumulator, hydraulic lines and the bracket hydraulic line attach points.

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CHECKED BY: MECH DESIGN SECT V D B (K-411)
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MODEL: SIV B
REPORT NO.:

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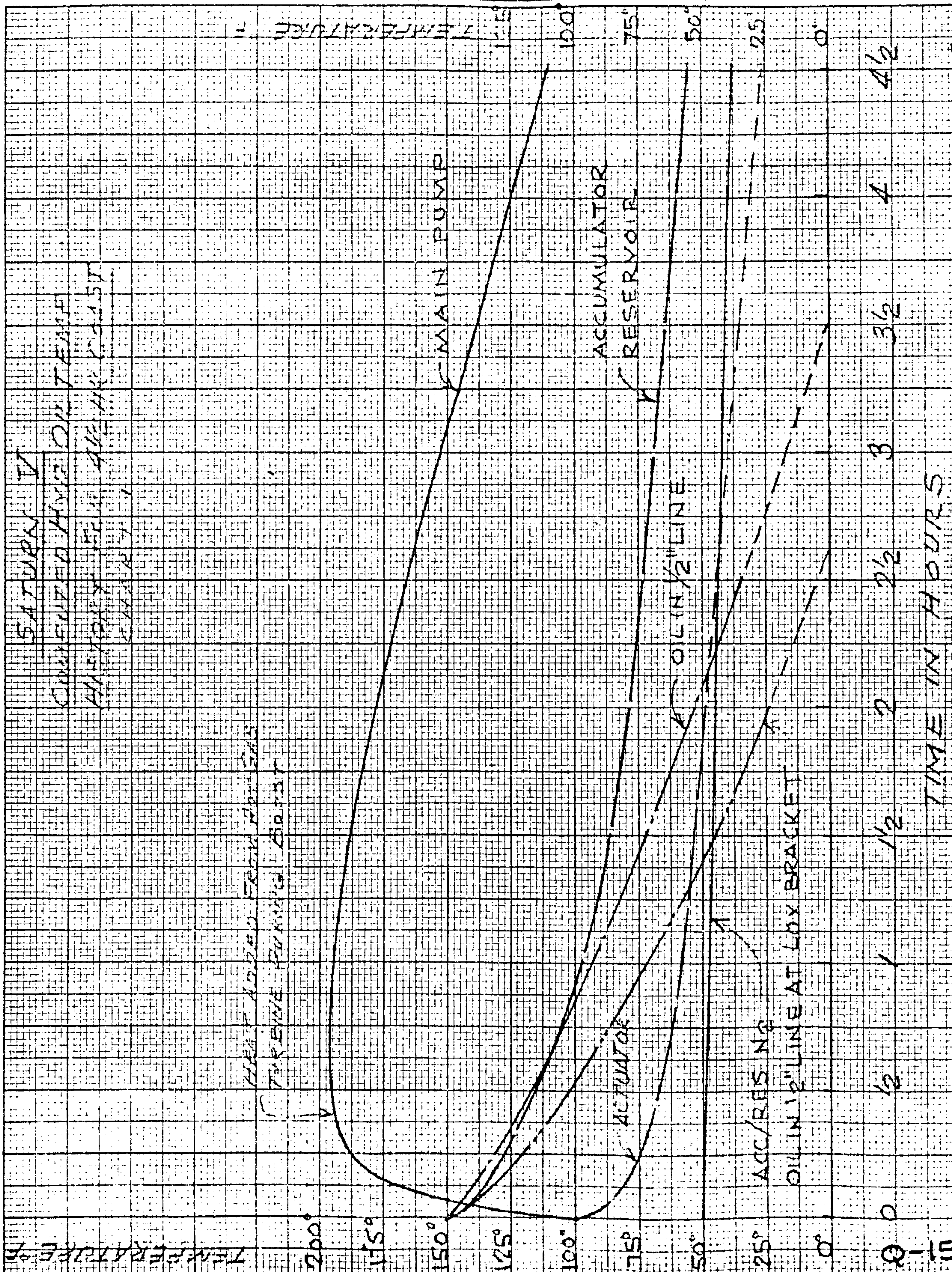

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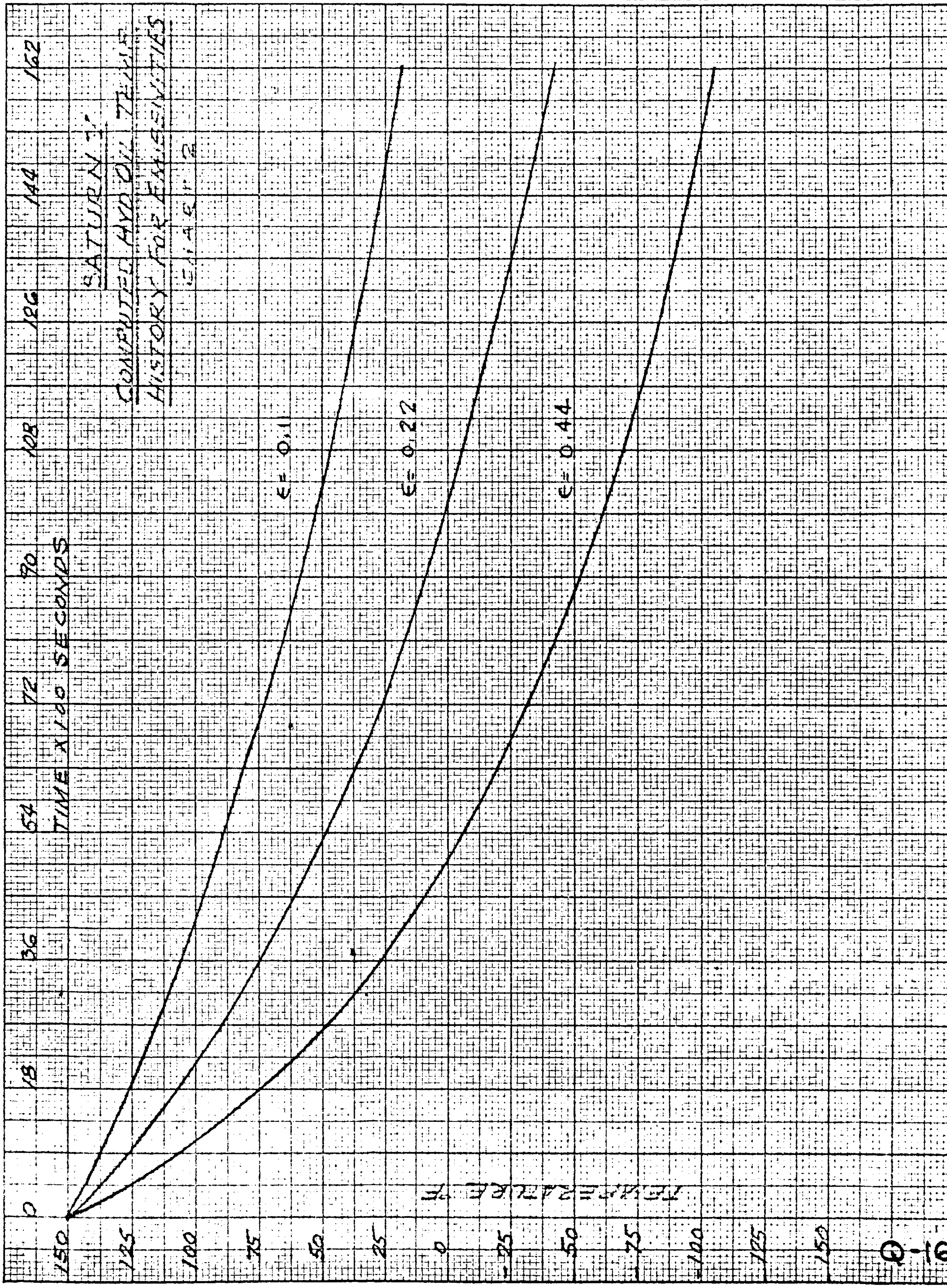

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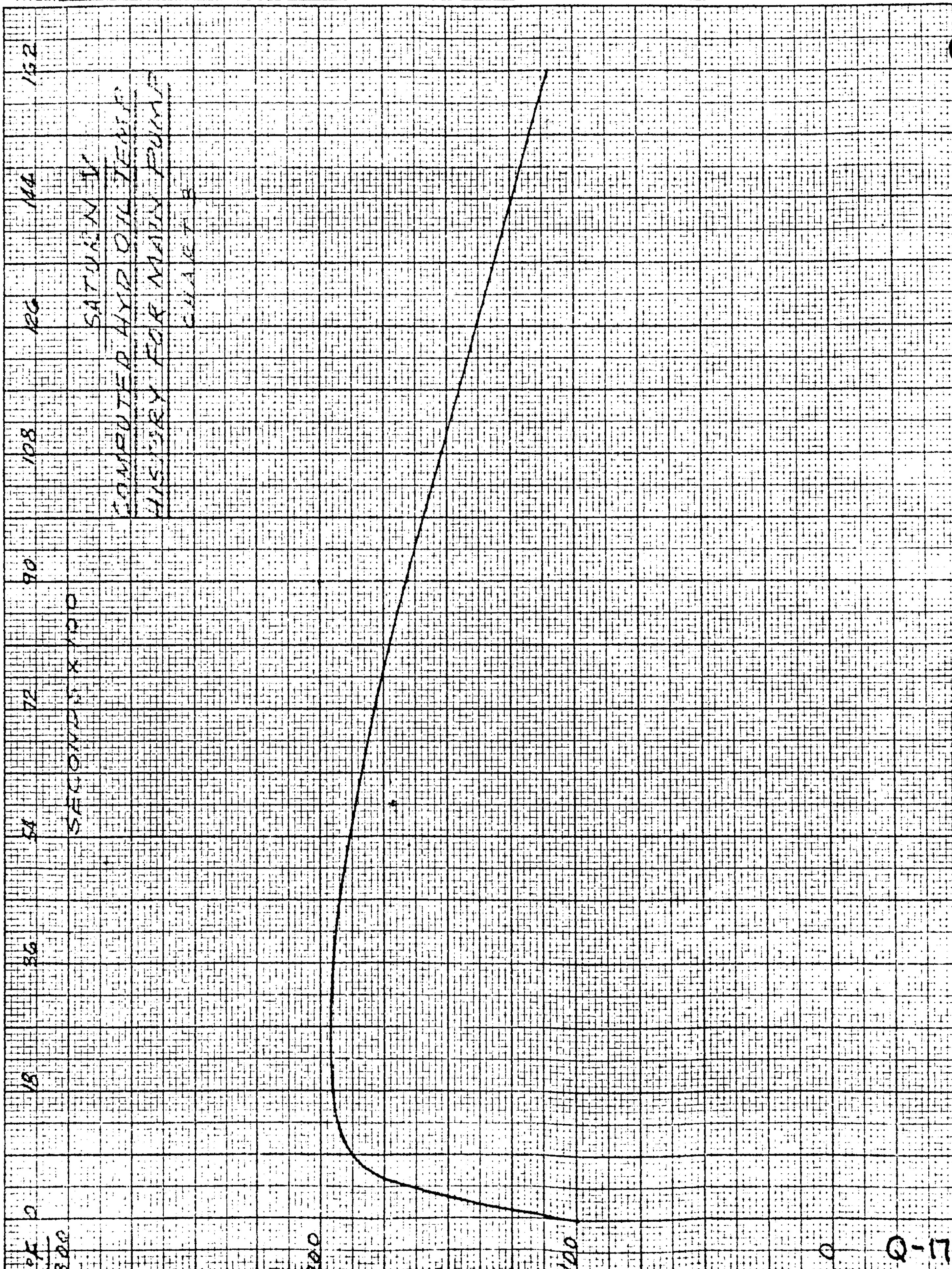
TITLE: HYD SYSTEM TEMPERATURE STUDY | REPORT NO.:



Q-17

FORM 25 DS
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PAGE: 16

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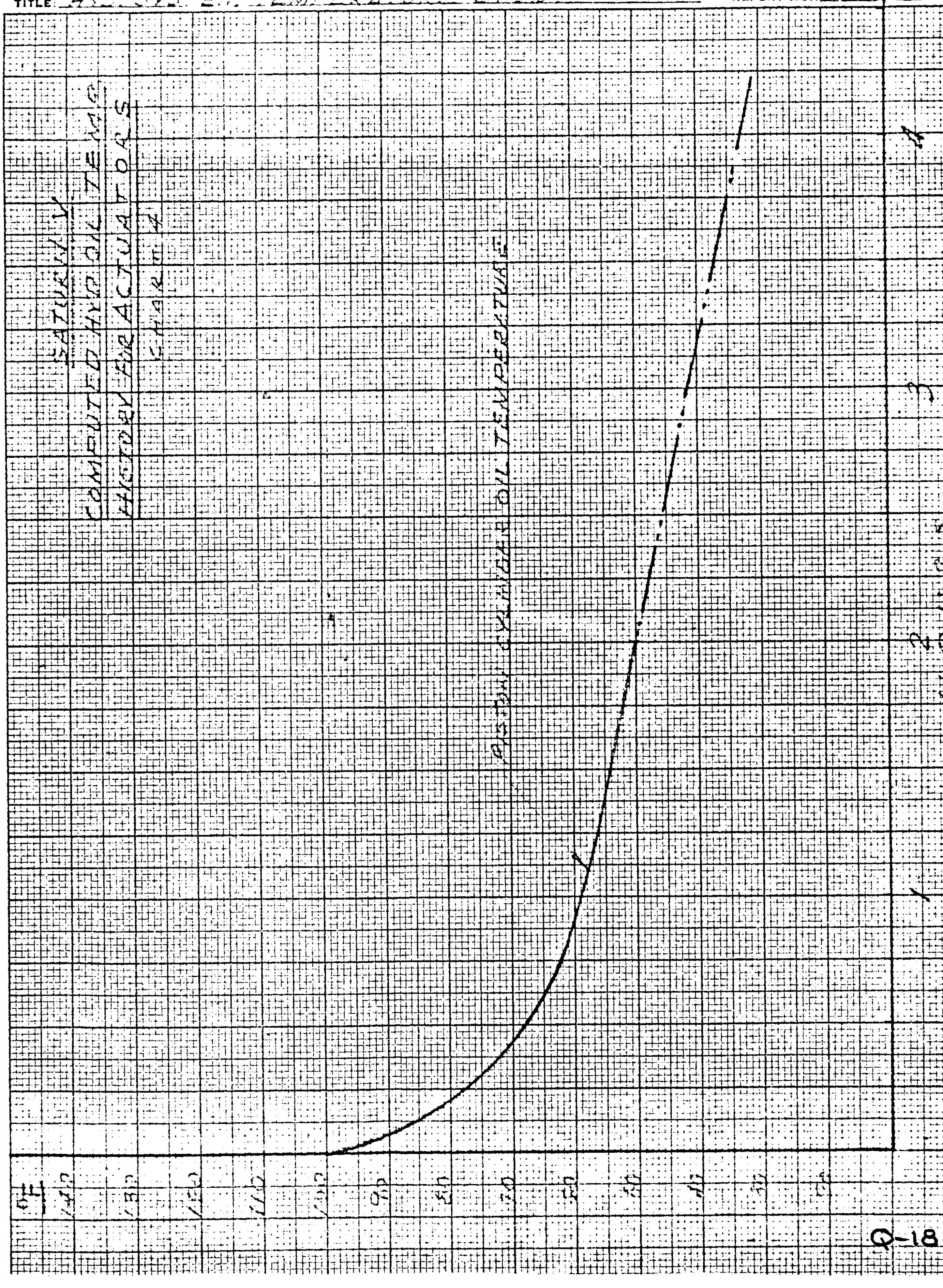

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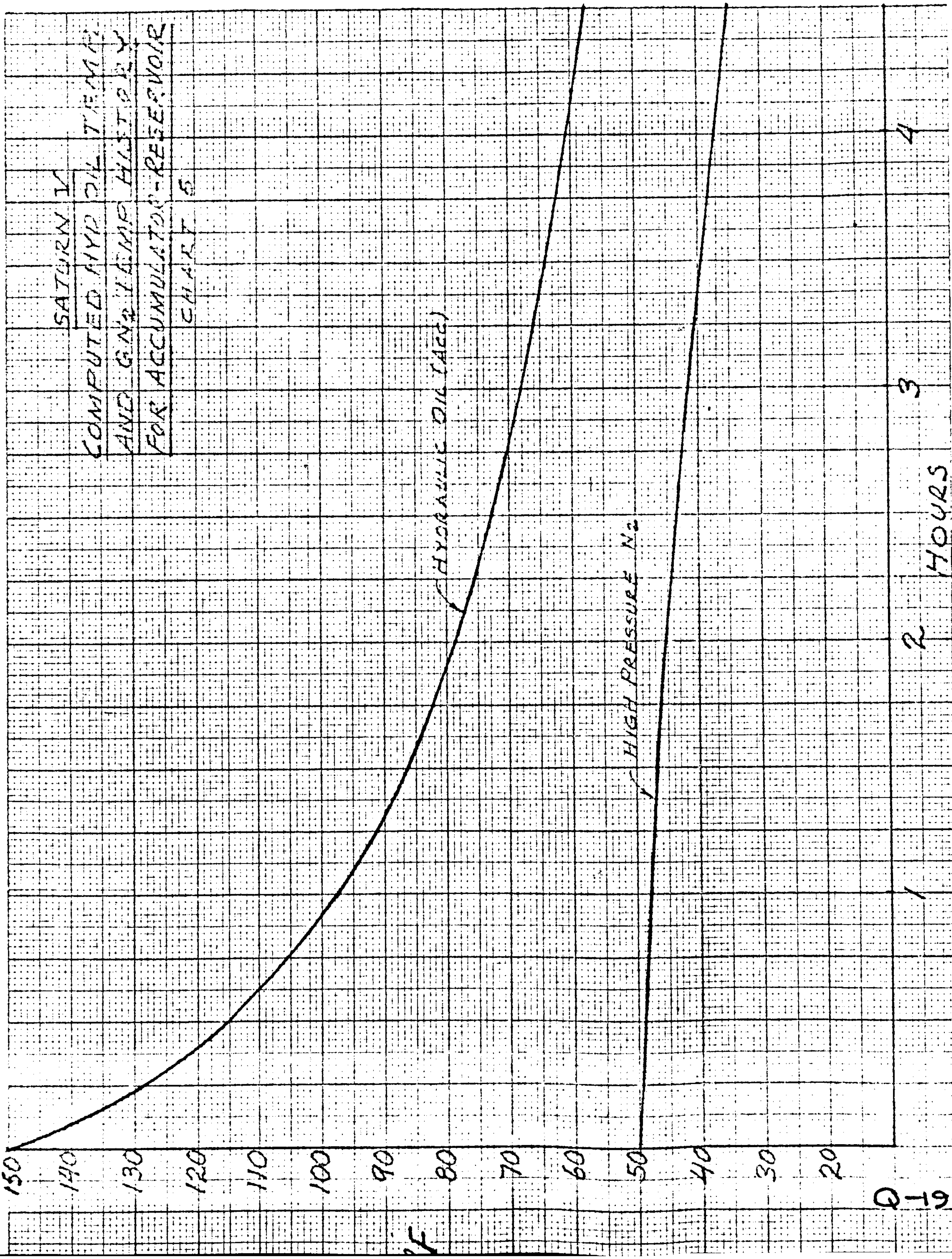
HYD. SYSTEM TEMP. STUDY MODEL: SIVB



Q-19

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(REV. 3-54)

PREPARED BY: MARTYNDLL

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VDB (K-411)

TITLE: HYD SYSTEM TEMPERATURE STUDY

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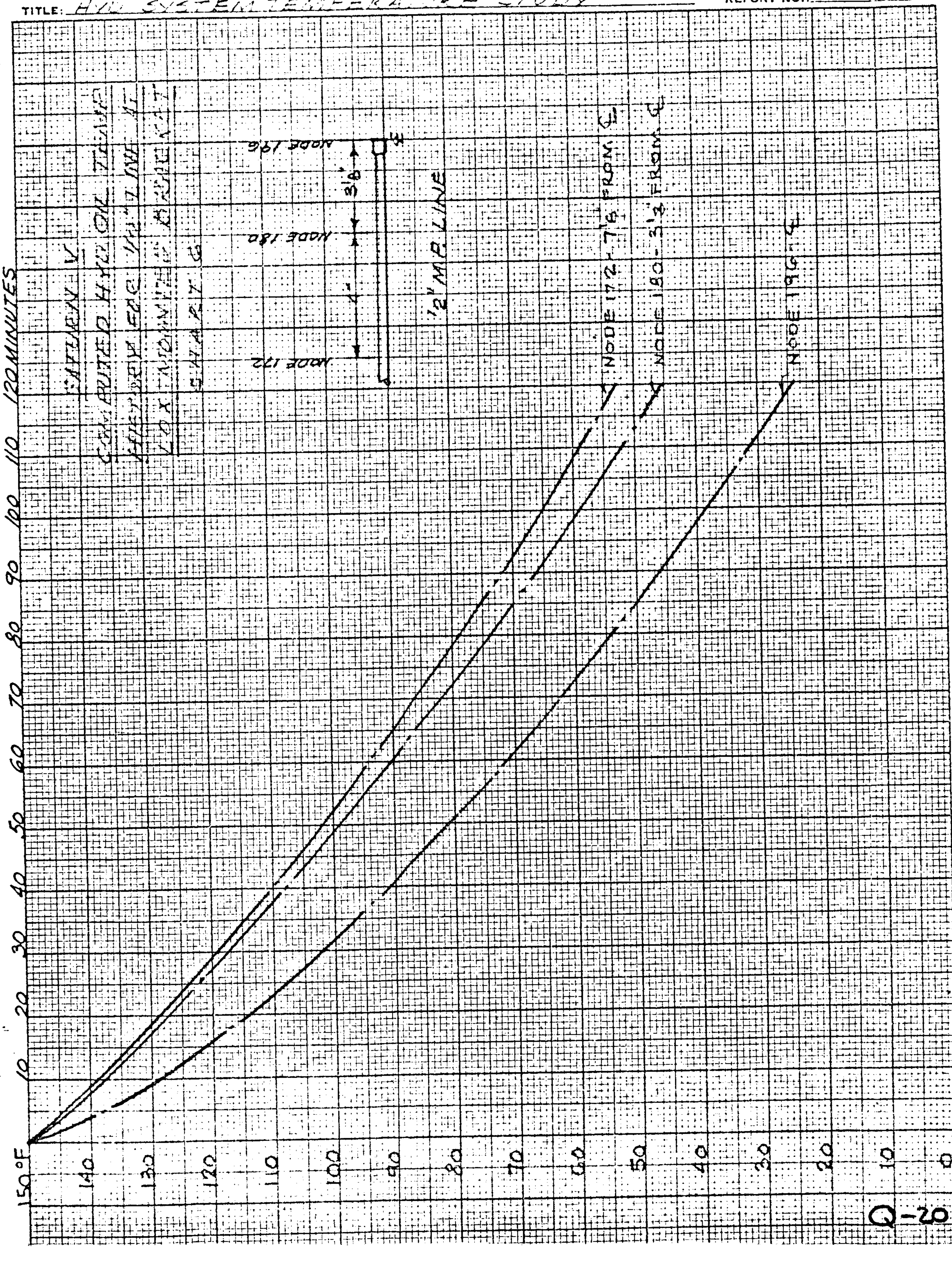
MSSD DIVISION

PAGE: 15

MODEL: SIV B

REPORT NO.:



Q-20

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VDB (K411)

DIVISION

MODEL:

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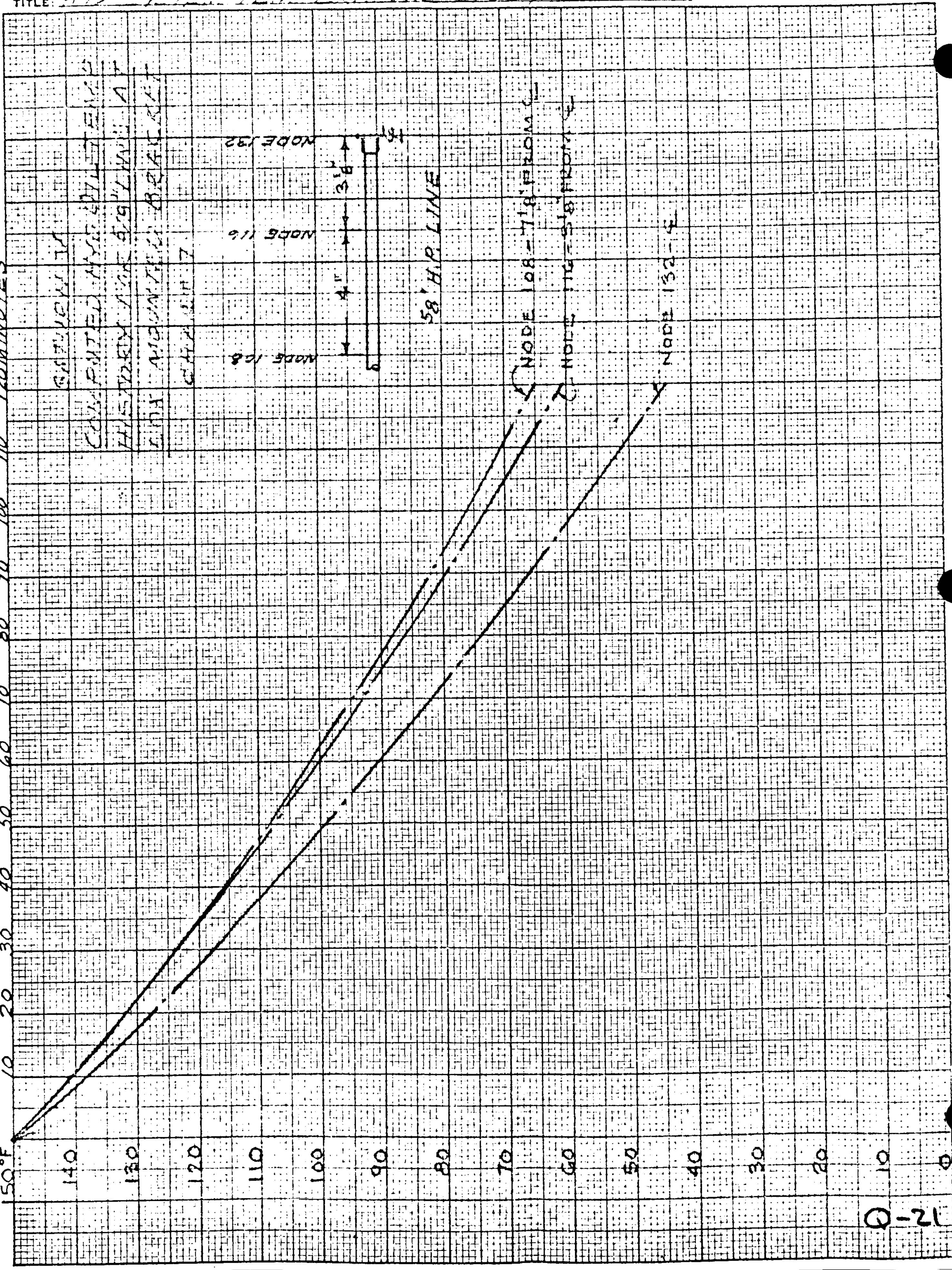
REPORT NO.:



FORM 25 BS (REV. 3-54)

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TITLE: HYD SYSTEM TEMPERATURE STUDY

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MSSD DIVISION

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MODEL: SIV B

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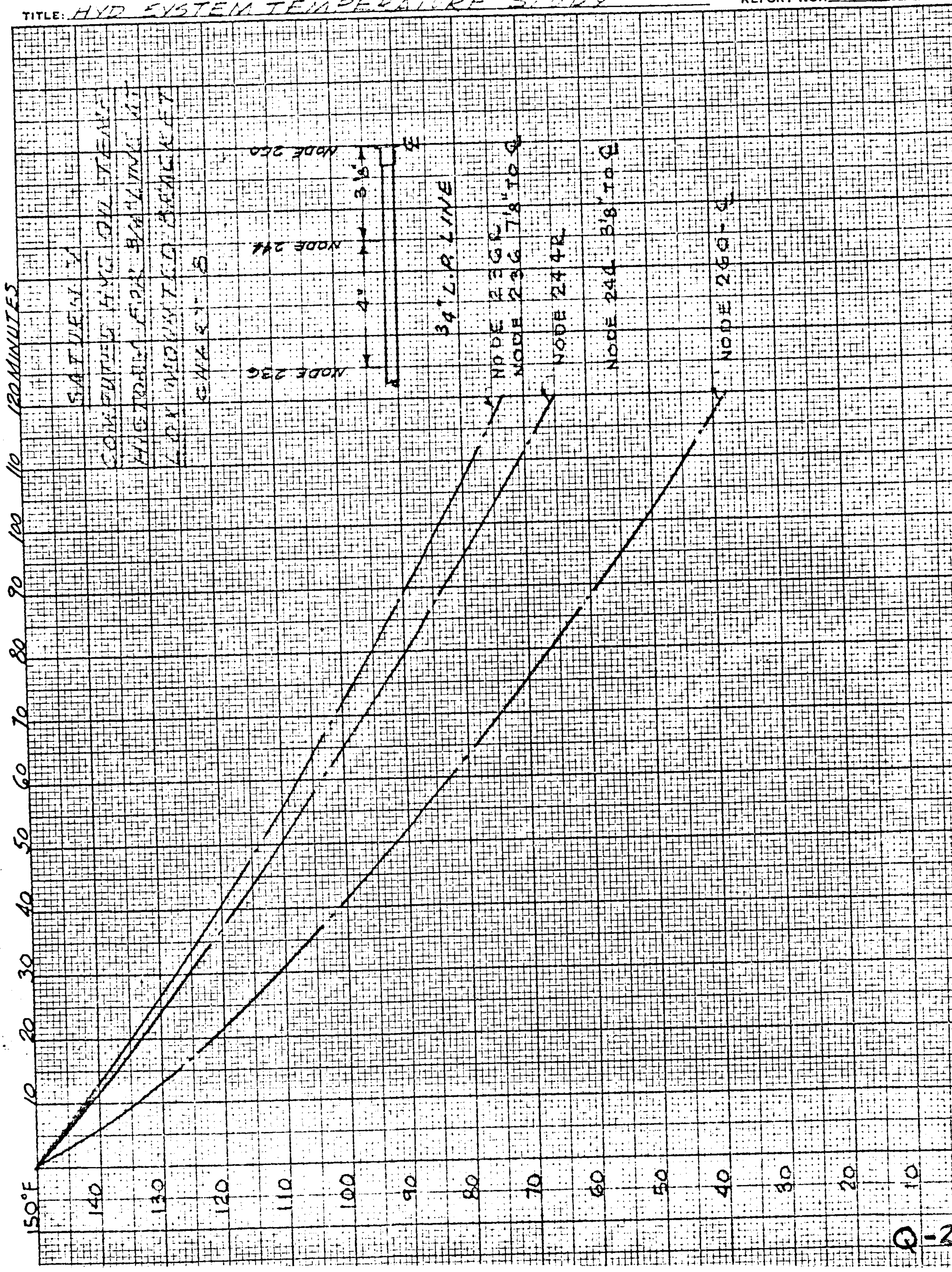

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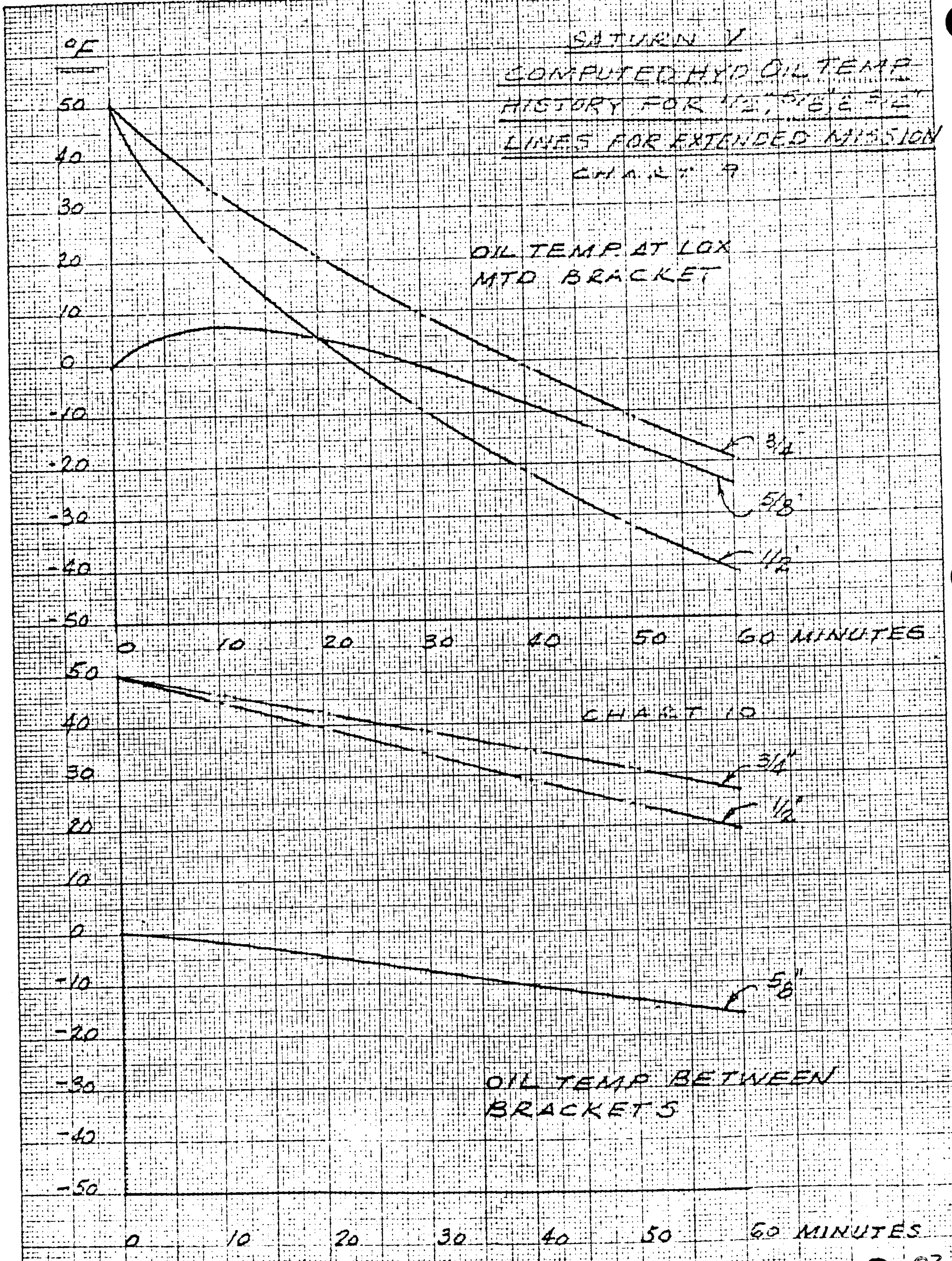
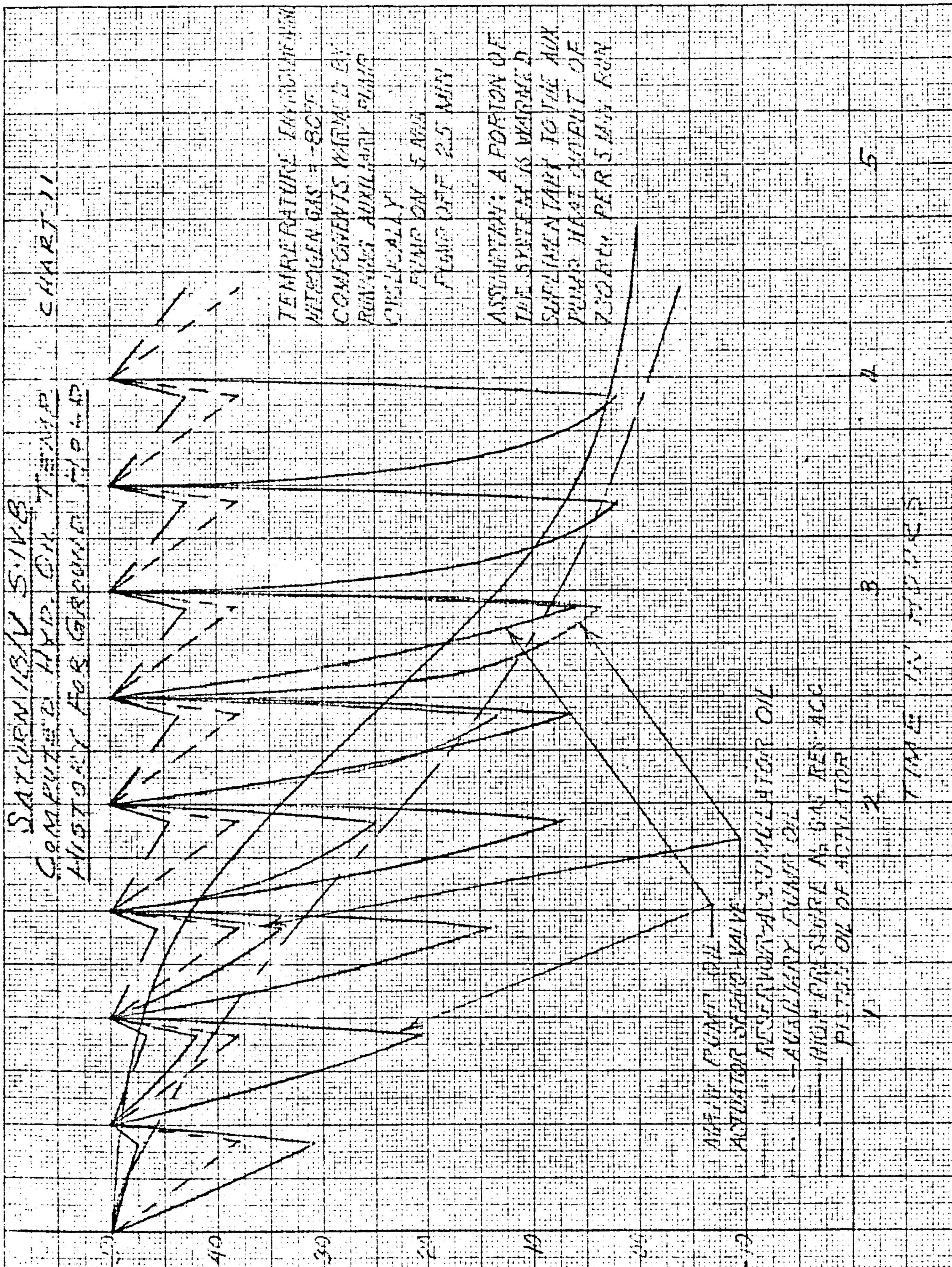
Q-22

DOUGLAS AIRCRAFT COMPANY, INC.

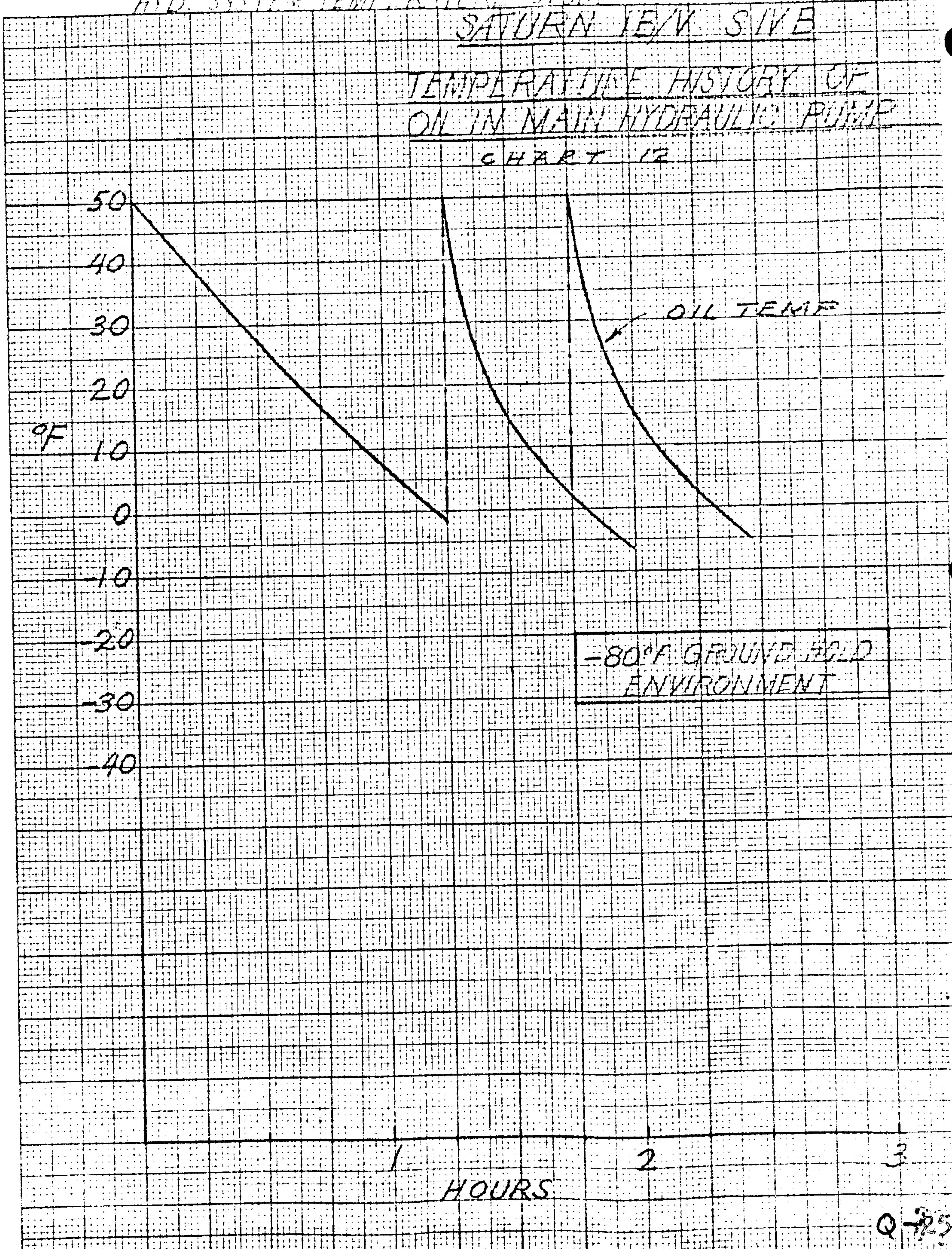
PREPARED BY: [illegible]
MECH. DESIGN SECT — MSSD DIVISION
VDB (A411)
TITLE: HYD SYSTEM TEMPERATURE STUDY

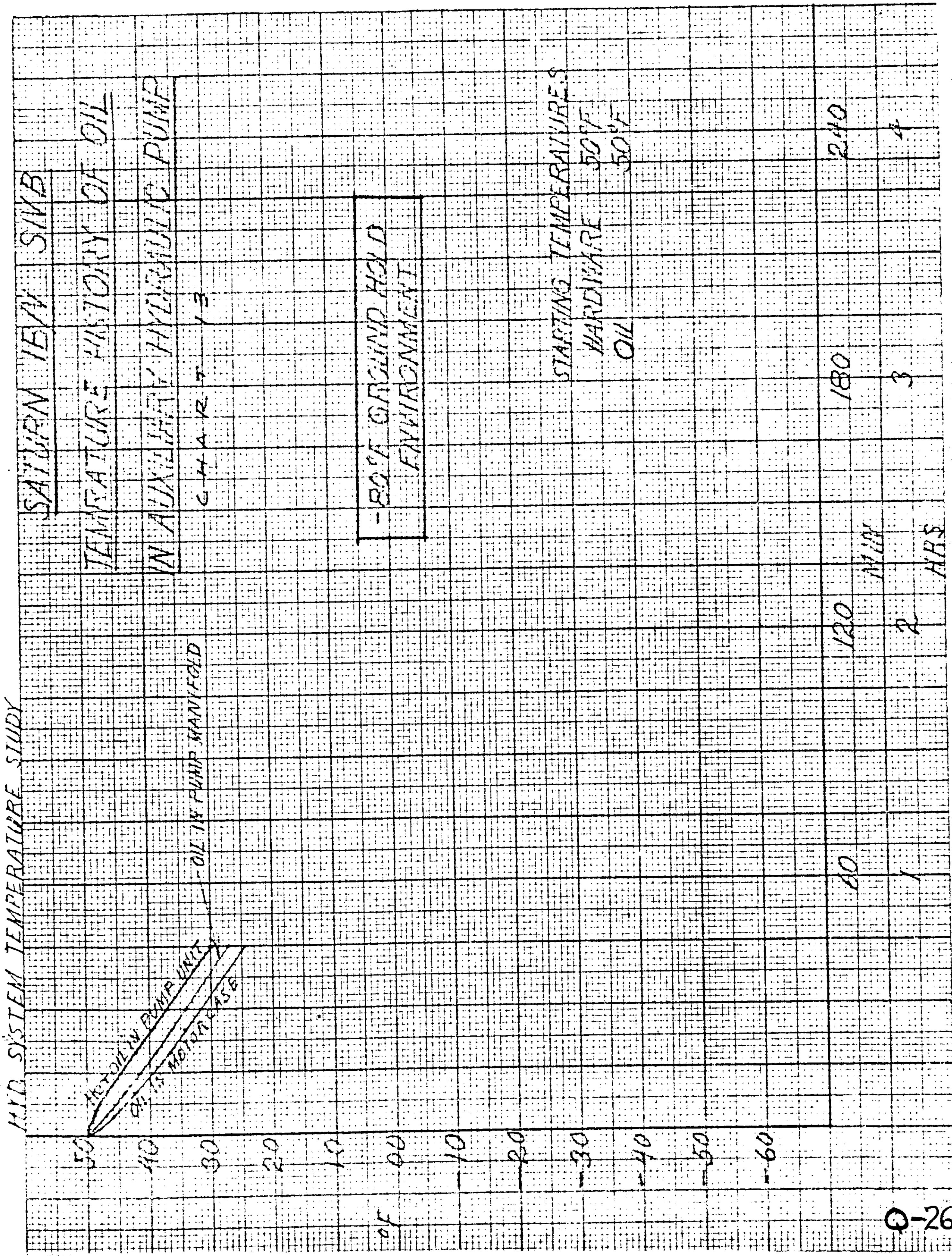
PAGE: 21
MODEL: S-IVB
REPORT NO.:

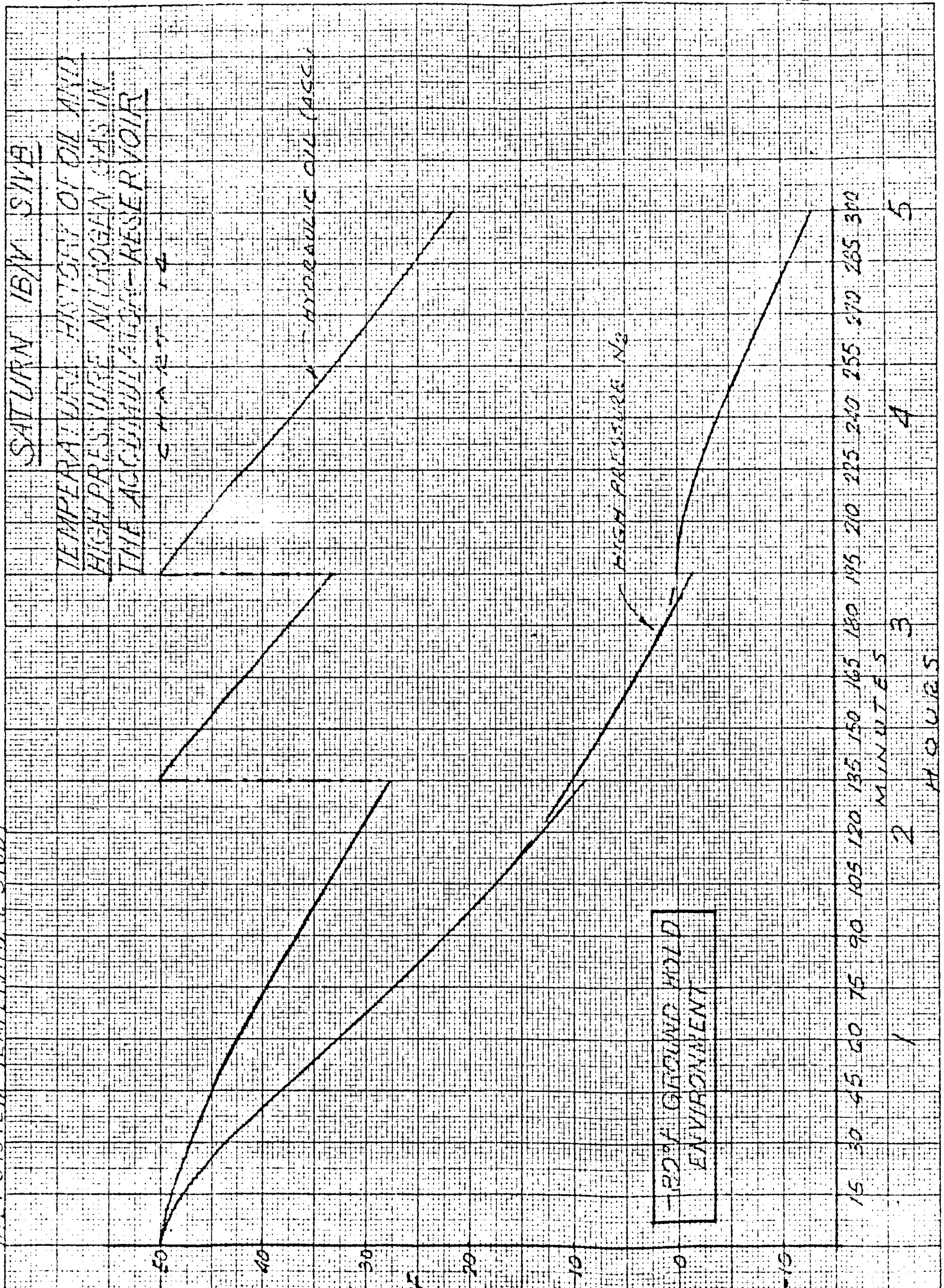


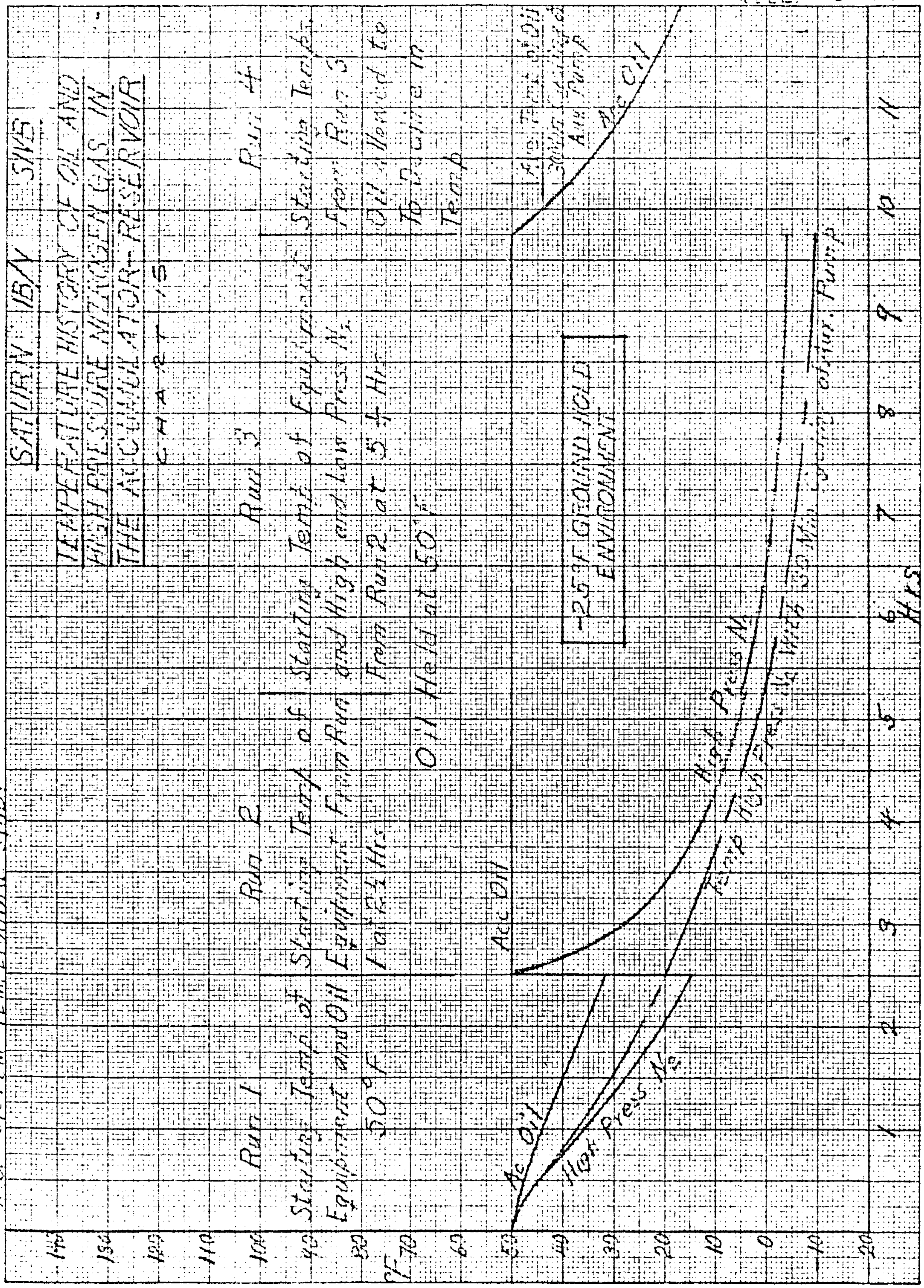

SATURN IB/V S-IVB
COMPUTED HYD. OIL TEMP
HISTORY FOR GROUND HOLD
CHART 11
TEMPERATURE ENVIRONMENT
NITROGEN GAS = -80°F
COMPONENTS WARMED BY
RUNNING AUXILIARY PUMP
CYCLICALLY
PUMP ON 5 MIN
PUMP OFF 25 MIN
ASSUMPTION: A PORTION OF
THE SYSTEM IS WARMED
SUPPLEMENTARY TO THE AUX
PUMP HEAT OUTPUT OF
730 BTU PER 5 MIN RUN
°F
40
30
20
10
-10
AUX. PUMP OIL
ACTUATOR SERVO-VALVE
RESERVOIR-ACCUMULATOR OIL
AUXILIARY PUMP OIL
HIGH PRESSURE N_2 GAS RES-ACC
PISTON OIL OF ACTUATOR
1
2
3
4
5
TIME IN

HYD. SYSTEM TEMPERATURE STUDY




SATURN IB/V SIVB
TEMPERATURE HISTORY OF OIL
IN AUXILIARY HYDRAULIC PUMP
CHART 13
-80°F GROUND HOLD
ENVIRONMENT
STARTING TEMPERATURES
HARDWARE 50°F
OIL 50°F
HOT OIL IN PUMP UNIT
OIL IN MOTOR CASE
OIL IN PUMP MANIFOLD
60
120
180
240
MIN
1
2
3
4
HRS
50
40
30
20
10
00
-10
-20
-30
-40
-50
-60
°F
HYD SYSTEM TEMPERATURE STUDY


SATURN IB/V SIVB
TEMPERATURE HISTORY OF OIL AND
HIGH PRESSURE NITROGEN GAS IN
THE ACCUMULATOR—RESERVOIR
HYDRAULIC OIL (ACC.)
HIGH PRESSURE N2
-20°F GROUND HOLD
ENVIRONMENT
HYD. SYSTEM TEMPERATURE STUDY
50
40
30
°F
20
10
0
-10
15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300
MINUTES
1 2 3 4 5
HOURS



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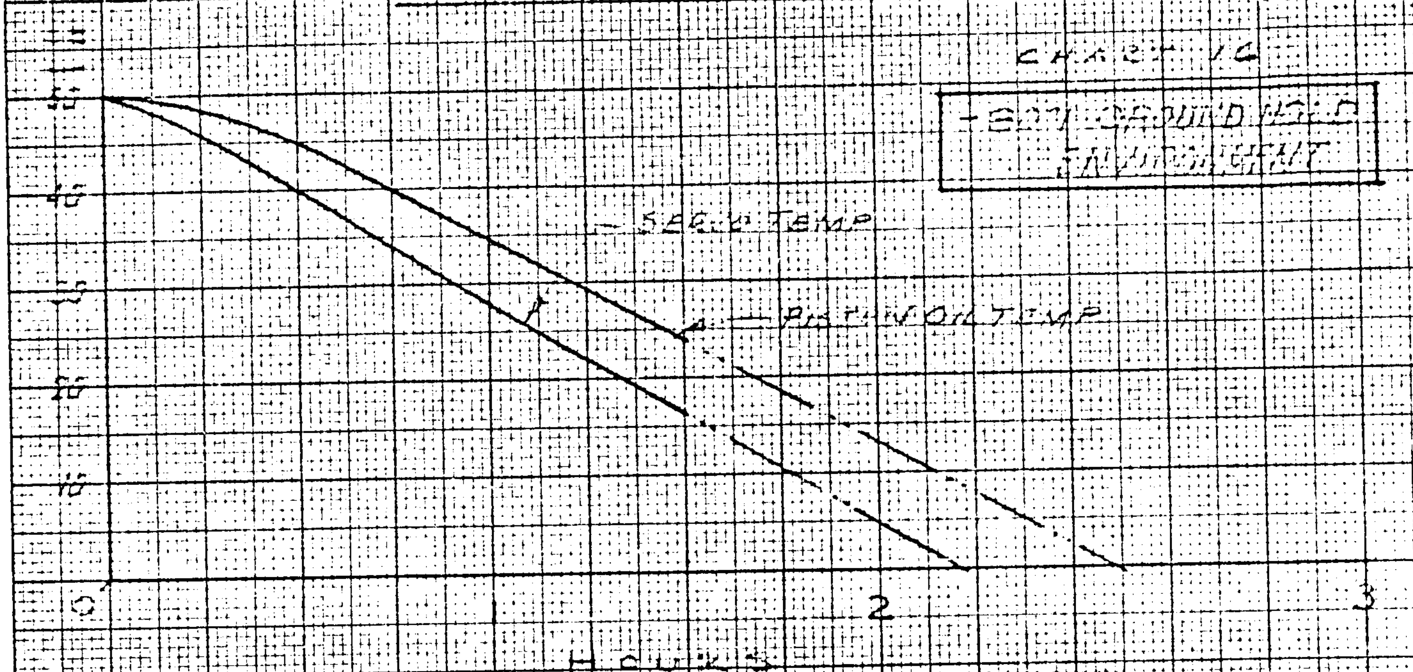
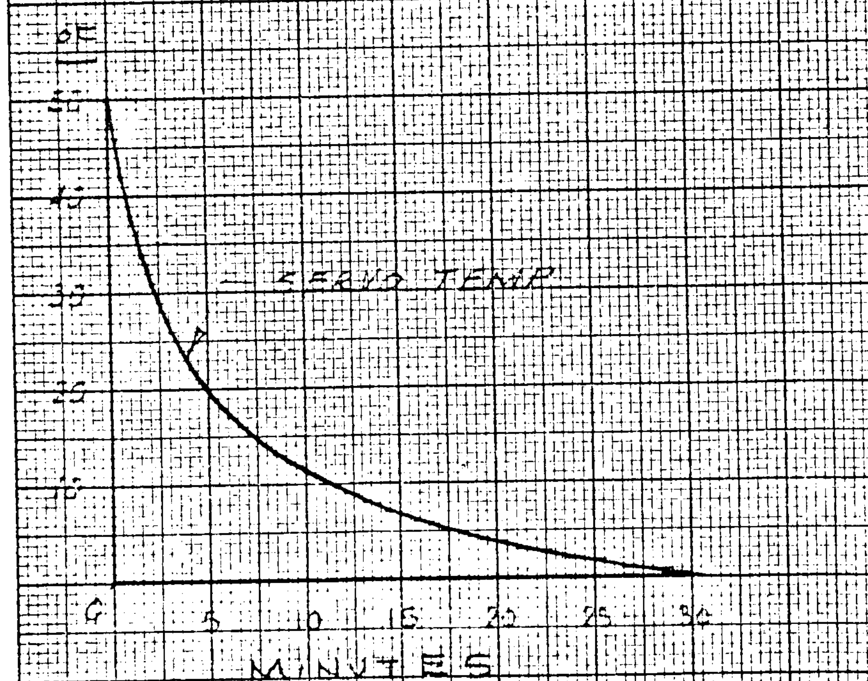
SATURN IB/V SIVB

TEMPERATURE HISTORY OF OIL IN HYDRAULIC ACTUATOR



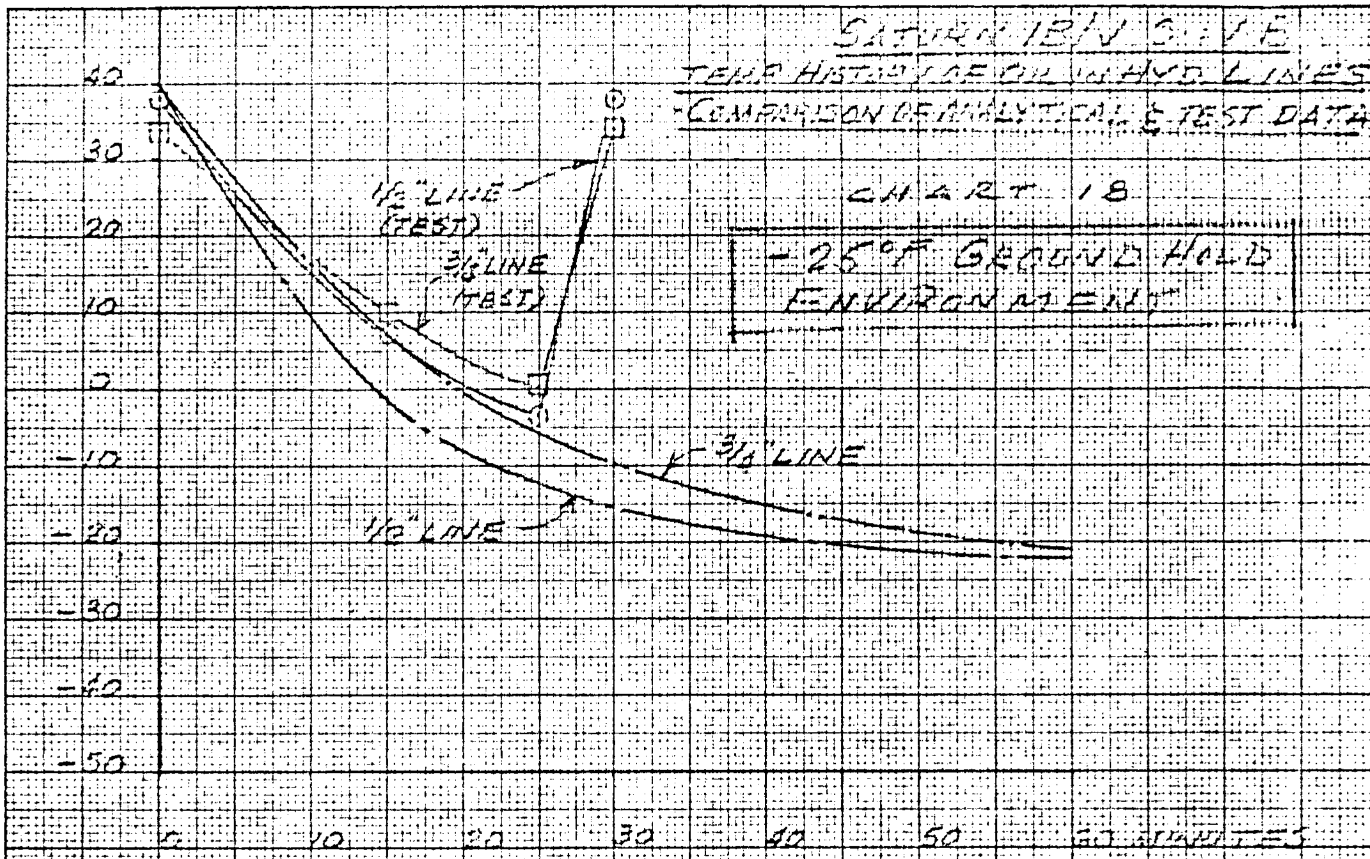


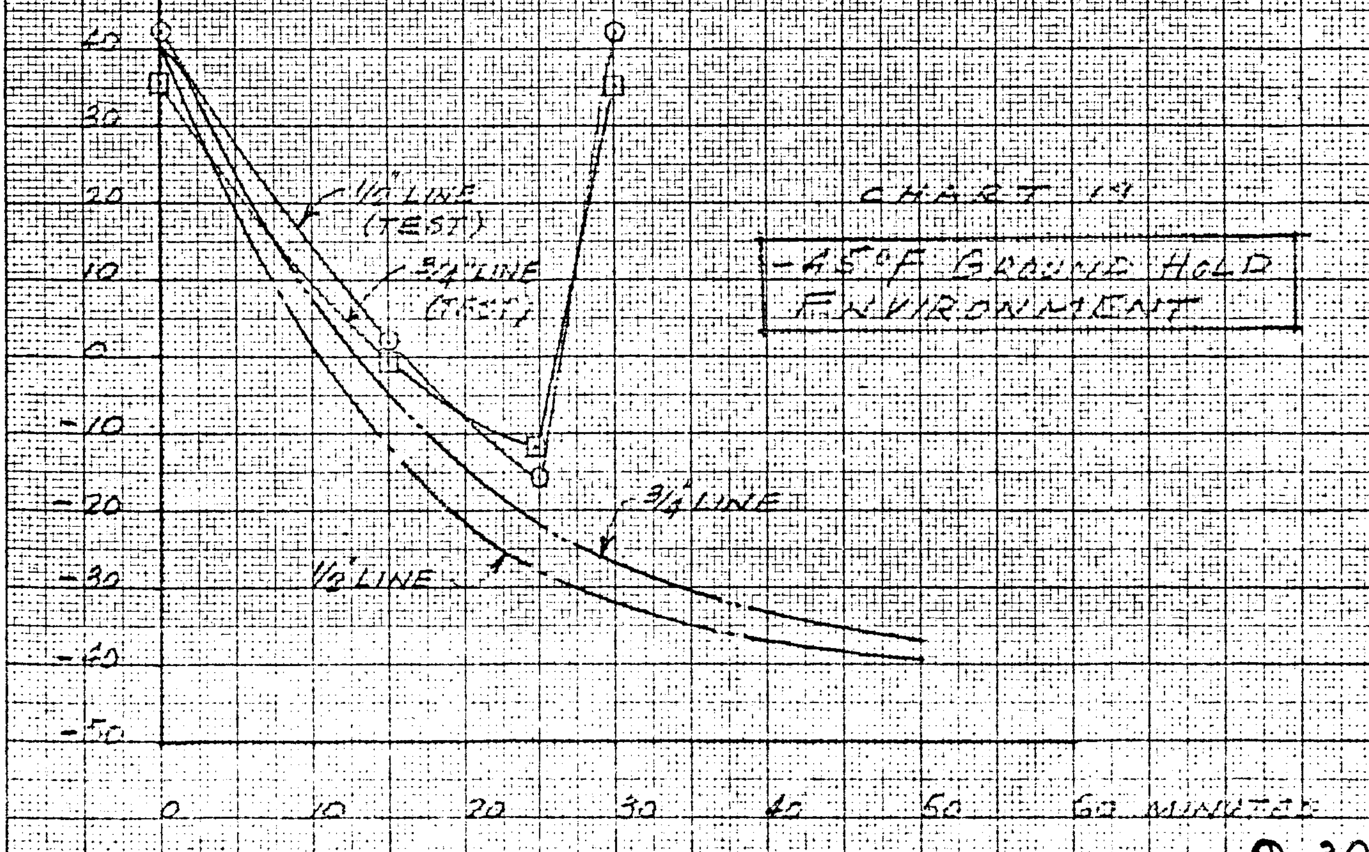
PISTON OIL TEMP

t (MIN)	TEMP
0	1.0
10	0.0[illegible]
20	0.2812
30	-0.1011

-80°F GROUND HOLD ENVIRONMENT

CHART 17





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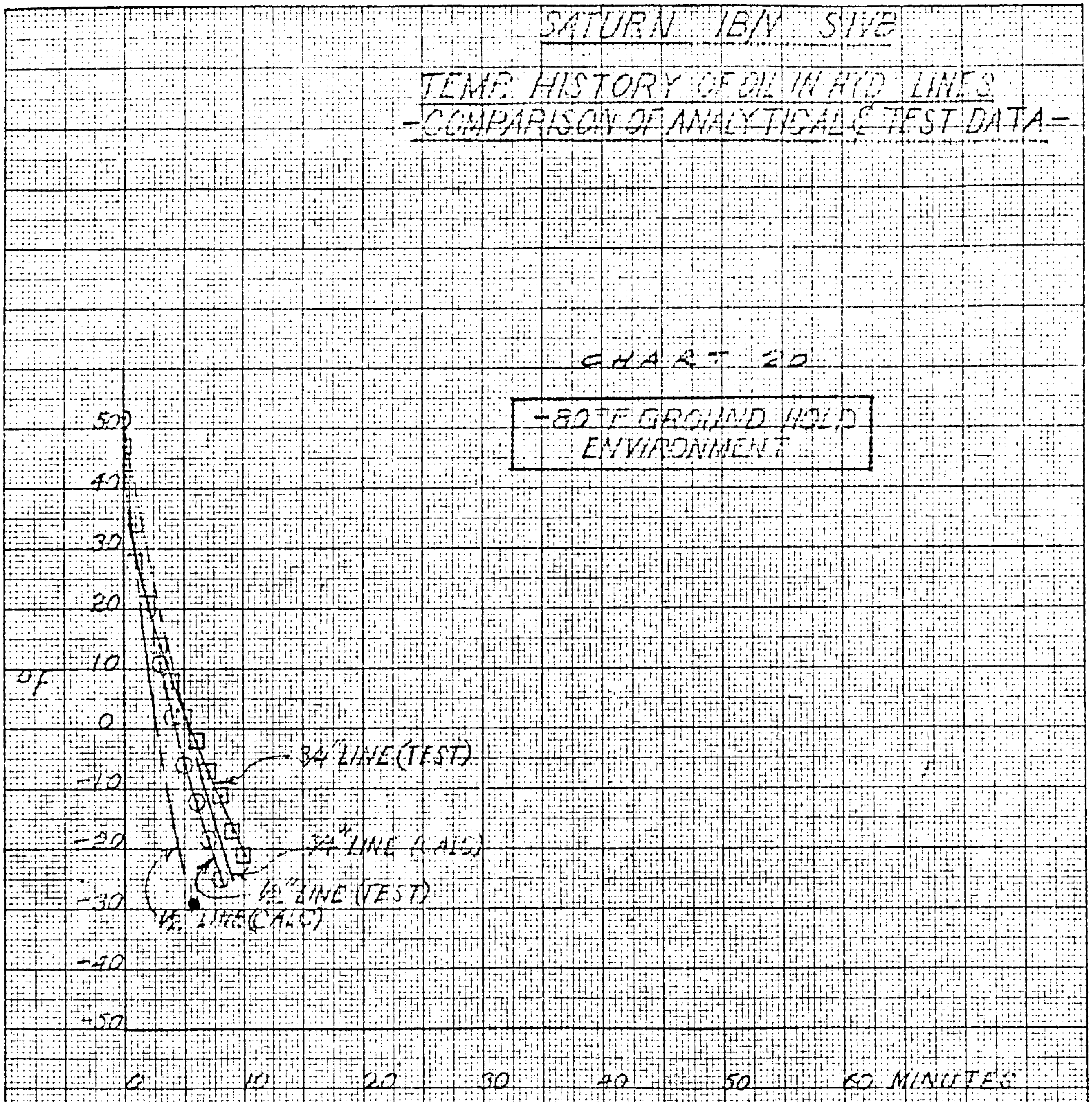

SATURN IB/V SIVB
TEMP. HISTORY OF OIL IN HYD. LINES
-COMPARISON OF ANALYTICAL & TEST DATA-
CHART 20
+80°F GROUND HOLD ENVIRONMENT
°F
50
40
30
20
10
0
-10
-20
-30
-40
-50
3/4" LINE (TEST)
3/4" LINE (CALC)
1/2" LINE (TEST)
1/2" LINE (CALC)
0
10
20
30
40
50
60 MINUTES

SHROUDED HYDRAULIC LINES TEST - GROUND HOLD

TEST SET-UP

This test set-up simulates the three hose portion of the hydraulic systems. Flexible hydraulic hoses and steel tubing were connected together in a circuit as shown in Figure 1. A 30 cubic inch manifold was included to represent the main hydraulic pump. Brackets of three designs were used to support the lines. Each bracket was attached to a controllable heat sink. Thermocouples were placed to sense temperatures in the flow stream of the hydraulic circuit, at points where dormant oil exists in the shroud and in the environmental chamber.

Poly vinyl chloride sheeting, 0.007 inch thick, was used to fashion a shroud, or duct, encircling the hydraulic lines, portions of the brackets and the manifold. Figure 1 indicates the average diameter of the shroud over several intervals of the test items.

TEST REQUIREMENTS

These tests were run in a -80°F environment to determine the effectiveness of shrouding hydraulic lines in a thin walled plastic duct. Warm air was circulated through the duct during the test. It was desired to know what would happen to 50°F oil supplied through the 1/2 inch line at 0.6 GPM, passing to the manifold and returning in the 3/4 inch line; and what would happen if the oil flow were shut off for a period of time. Further, what temperatures could be expected at the line brackets connected to cold sinks and in dormant oil contained in a 5/8 inch hydraulic line.

TEST PROCEDURE

The test started by lowering the temperature of the environmental chamber holding the test fixture to -80°F. Hydraulic oil was circulated at 0.6 GPM through the 1/2 inch line, the manifold and the 3/4 inch line at a nominal starting temperature of 50°F. The cold sinks to the brackets were lowered to a -100°F or -300°F as indicated on Figure 1. The oil in the 5/8 inch line was held dormant. Warm air was circulated through the shroud. After temperature stabilization was acquired, recordings of all the thermocouples were taken and the oil flow was stopped. Temperature histories were recorded during the temperatures decline. When the temperature decline rates became minimal, the oil supply was turned back on.

TEST RESULTS

Three thermocouples, (see Figure 1) numbers 16 in the 1/2 inch line, 36 in the 5/8 inch line, and 20 in the 3/4 inch line, were chosen to compare test results at a given point along the shroud axis. An additional thermocouple, number 35 in the 5/8 inch line, was used to show results in a nearby bracket attached to a -300°F heat sink. The temperature histories of these thermocouples under different parameters are shown on Charts 21, 22, and 23.

Chart 24 shows the temperatures of the oil along the 1/2, 5/8, and 3/4 inch lines immediately before halting the oil flow and along the 1/2 and 3/4 inch lines six minutes after the flow was halted. The 5/8 inch line at six minutes is not shown, but all the temperatures in this line approach -80°F with time.

Charts 25 and 26 show the temperatures of the oil in the 5/8 inch line immediately before stopping oil flow and before resuming oil flow after the respective temperature declines of Charts 22 and 23.

CHART 21

The first data was taken before the shroud was installed so that the overall effect of shrouding could be ascertained. Chart 21 curves prove that the temperature declines of the oil in the 1/2 and the 3/4 inch lines are rapid. In 5 and 6 minutes respectively the temperature is at the minimum allowable 0°F. As stated on the chart, the thermocouple in the 5/8 inch line is constant at a -78°F. The thermocouple in the bracket declines from -48°F to -58°F.

CHART 22

After shrouding the lines, the environment was lowered to -74°F and air with an initial temperature of 40°F was supplied through the shroud. The oil in the 1/2 and 3/4 inch lines was circulated at a nominal 50°F. When the oil flow was stopped, the temperatures declined as shown in Chart 22. Temperatures are marginal after 40 minutes.

CHART 23

The initial air flow temperature through the shroud was raised to 87°F for this test. The other parameters were held close to those of the preceeding chart. The final stabilizing temperatures an hour after the oil flow was shut off were well above 0°F as shown on Chart 23.

CHART 24

Chart 24 is plotted data from the same test used for information on Chart 21. However, all the temperatures of the thermocouples in the lines are plotted at two precise moments so that the temperatures along the lines are known. The top group of points for the 1/2 and 3/4 inch lines is a plot of the temperatures at stabilization just before oil flow was stopped. The second group of points was taken six minutes after stopping oil flow. The bottom group of points was taken at the same time as the first group but along the 5/8 inch line containing the dormant oil.

As can be seen, the oil does not change much from one end of the circuit to the other during oil flow. After six minutes of no oil flow, the temperatures along the lines do not vary greatly from one thermocouple to the next but the general temperature has dropped 50°F. The oil in the 5/8 inch line remains below -70°F at most points except at the brackets where heat is acquired from the 1/2 and 3/4 inch lines during oil flow. When the oil stops flowing through the 1/2 and 3/4 inch lines, all temperatures decline to below -70°F.

CHART 25

Chart 25 is data from the same test used for the information on Chart 22. The temperatures along the 5/8 inch line are plotted against positions along the line. The data for the upper curve was taken just before oil shut off and the data for the lower curve was taken

40 minutes later, just before the resumption of oil circulation. Several air temperatures in the shroud are also plotted.

The temperature declines along the line in a uniform curve as progress is made from the air entrance to the air exit. When the oil is flowing, the 1/2 and 3/4 inch lines warm the shroud air helping the overall picture.

CHART 26

Chart 26 is data from the same test used for the information on Chart 23. The temperatures along the 5/8 inch line are plotted against positions along the line. The data for the upper curve was taken just before oil shut off and the data for the lower curve was taken 60 minutes later just before the resumption of oil circulation. Several air temperatures in the shroud are also plotted. The duct entrance air is 87°F compared to 40°F for Chart 25. Since the oil during flow is held to a nominal 50°F or half-way between 87°F and 12°F, the results are not surprising. Charts 25 and 26 indicate that an essentially passive mass in the duct will remain at the temperature of the duct air. The oil which assumes a temperature between 87°F and 12°F in the 5/8 inch line does not change in temperature when the oil flow through the 1/2 and 3/4 lines is shut off.

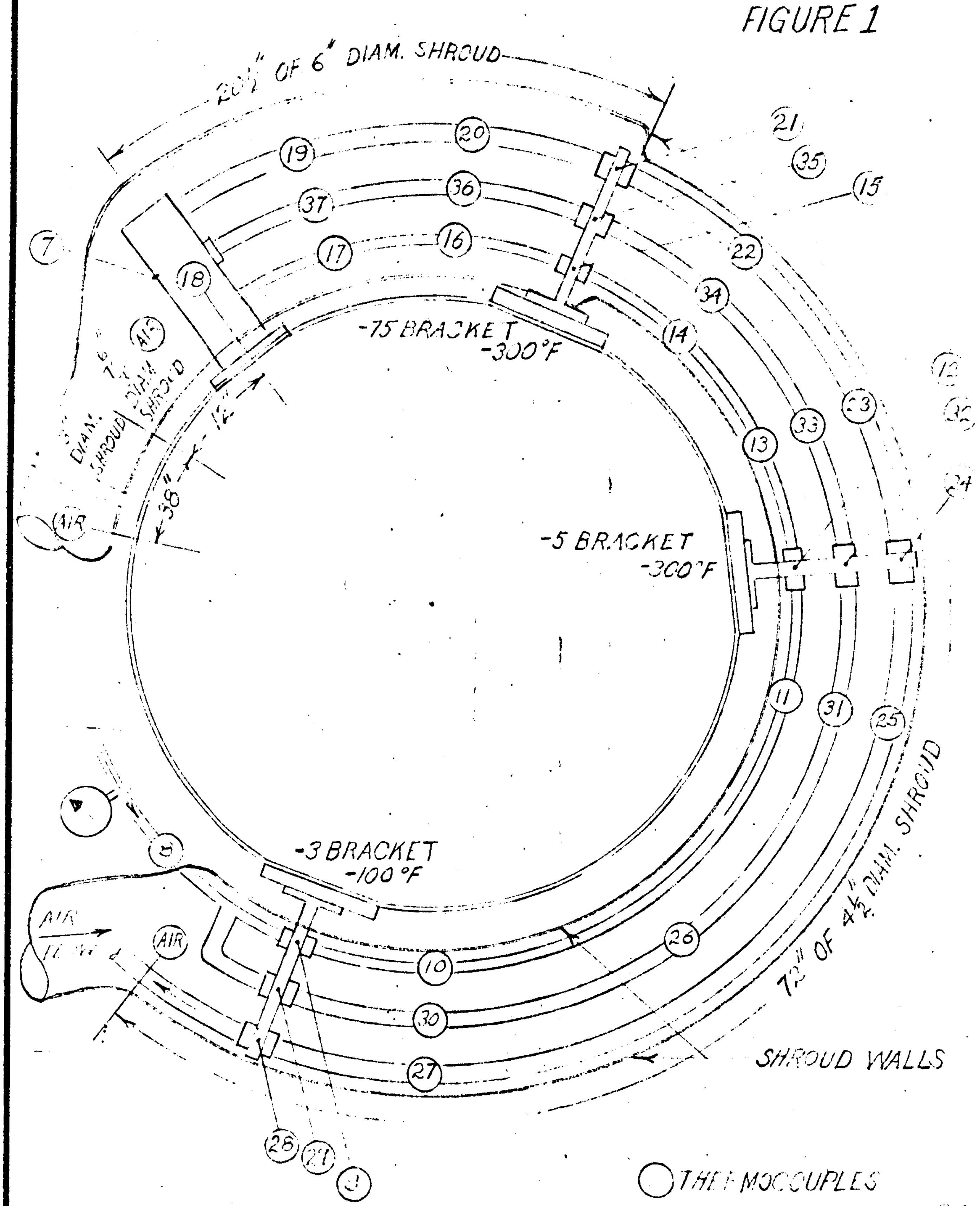


FIGURE 1
20½" OF 6" DIAM. SHROUD
-75 BRACKET
-300°F
-5 BRACKET
-300°F
-3 BRACKET
-100°F
AIR FLOW
AIR
DIAM. SHROUD
38"
12"
72" OF 4½" DIAM. SHROUD
SHROUD WALLS
THERMOCOUPLES

FORM 25-85 (REV. 3-64)

PREPARED BY: D.N. ELLIOTT

CHECKED BY:

DATE:

DOUGLAS AIRCRAFT COMPANY, INC.

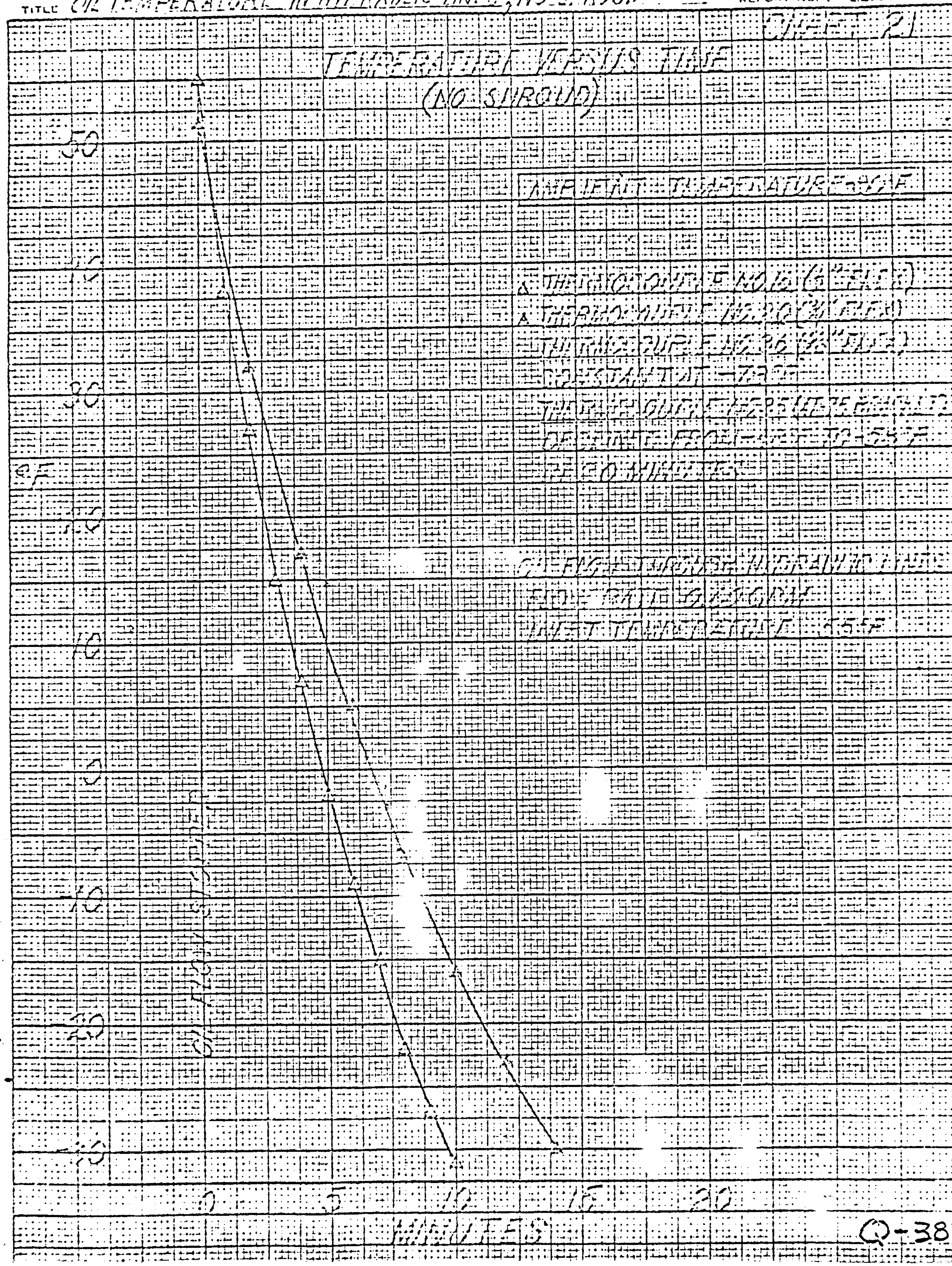
MSSD DIVISION

PAGE: 36

MODEL SATURN IB/V SIVB

REPORT NO.

TITLE OIL TEMPERATURE IN HYDRAULIC LINES; NO SHROUD



Q-38

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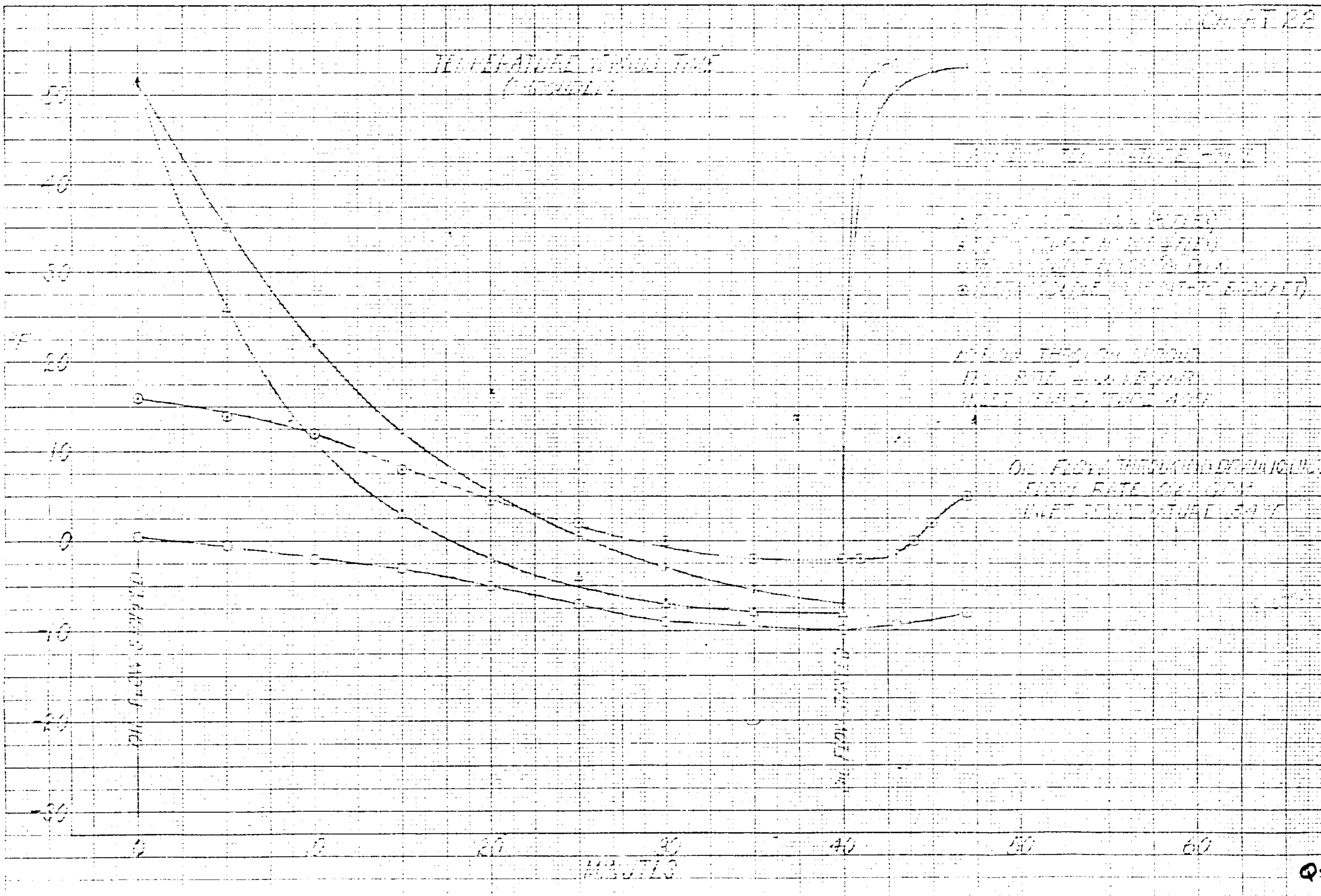

Q-39

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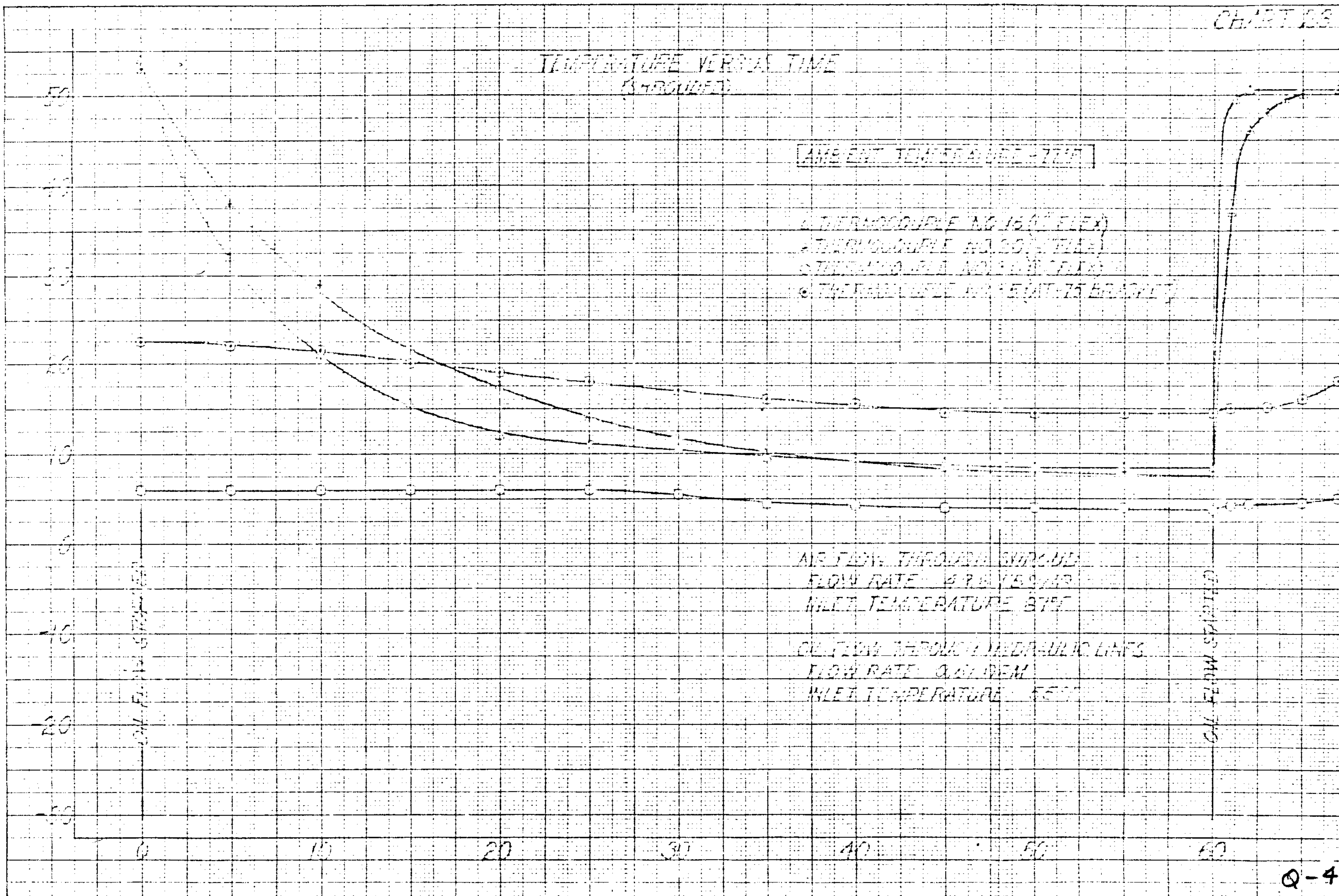

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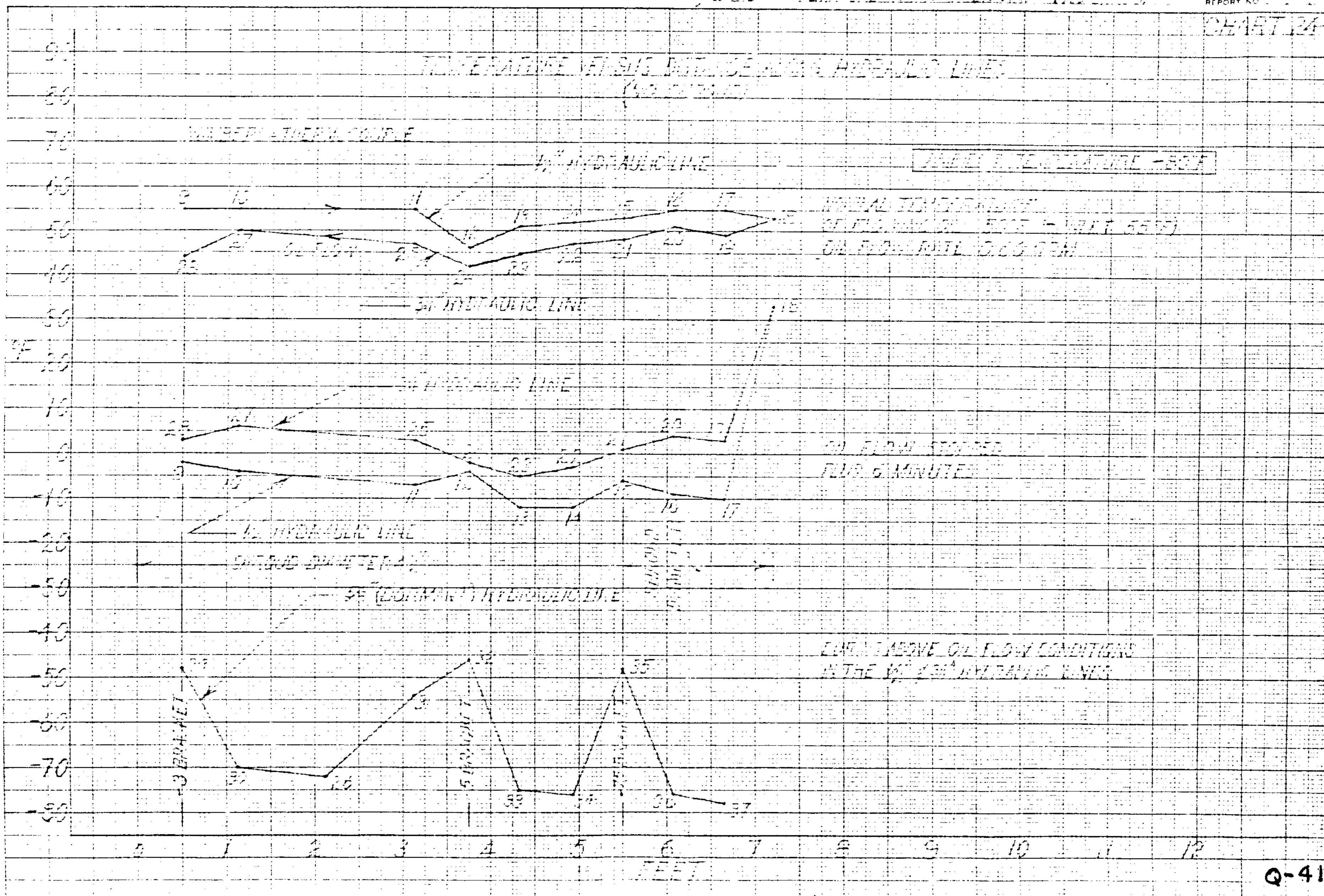

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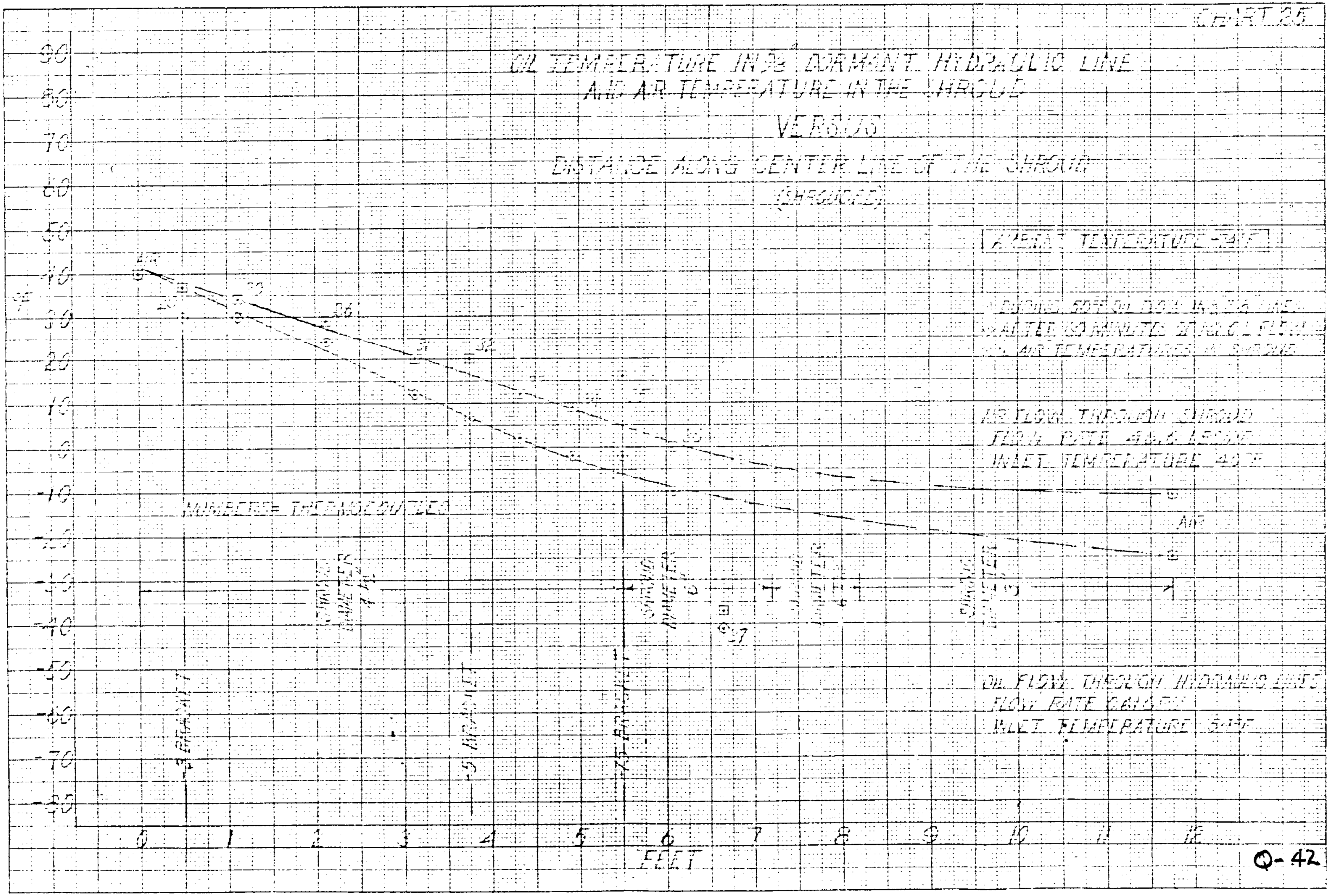
DOUGLAS AIRCRAFT COMPANY, INC.

TITLE OIL TEMPERATURE IN DORMANT HYDRAULIC LINE ...



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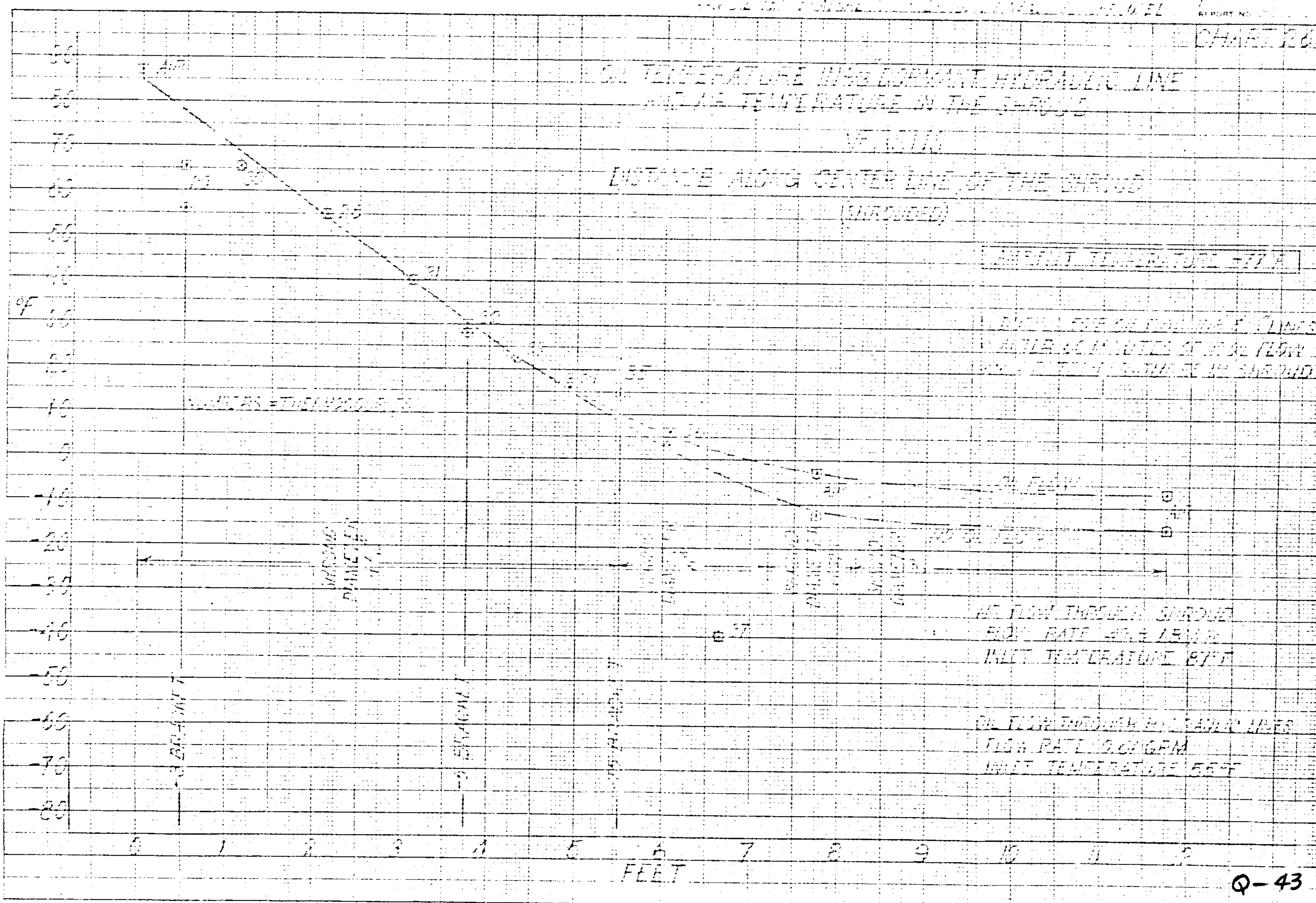
CHART 26
OIL TEMPERATURE IN A DORMANT HYDRAULIC LINE
AND AIR TEMPERATURE IN THE SHROUD
VERSUS
DISTANCE ALONG CENTER LINE OF THE SHROUD
(SHROUDED)
AIR
AIR FLOW THROUGH SHROUD
INLET TEMPERATURE 87°F
OIL FLOW THROUGH HYDRAULIC LINES
INLET TEMPERATURE 55°F
°F
FEET
Q-43

MEMORANDUM

DATE: 8-6-64
A-860-K410-537

TO: J. A. Riccobono, A3-860

FROM: W. E. Pipes, III, A-863

SUBJECT: RESULTS OF HYDRAULIC SYSTEM LINES THERMAL ISOLATION TESTS AT SANTA MONICA

COPIES TO: E. C. Tripp, III, A3-860; M. J. Hamilton, A3-863; H. R. Liebman, A-863
L. Gray, A3-863; L. Martynow, A3-863; A-860 Files

REFERENCE:

The following memo is a short summary of the simulated ground hold tests which have been conducted on the hydraulic system lines attached to the cold engine structure. These tests have been conducted at Santa Monica under JWO 0038. The technical memorandum on the simulated ground hold tests is presently being written. The simulated orbital tests on the hydraulic system lines will be run in the Space Simulations Laboratory at Huntington Beach.

1. RESULTS AND DISCUSSION

Table 1 of this memo presents the test results obtained for the three methods used to condition the 5/8 stagnant line, and also the results with no thermal conditioning.

1.1 No Thermal Conditioning

With no thermal conditioning, the temperature of the stagnant hydraulic oil is approximately the same as the surrounding ambient temperature of ≈80°F. Figure 1 is a schematic showing the test system and the thermocouple locations. Figure 2 is the test system.

1.2 Warm Air Flow in Shroud

The shroud arrangement consisted of directing controlled laboratory air over the hydraulic lines and brackets by use of a plastic shroud. As shown in table 1, where the inlet air was 87°F and the flow was 49.8 lbs./hr., the oil temperature in the system remained above 0°F after the oil flow in the system has been stopped for 60 minutes. It should be noted, that in cases where the shroud touched the stagnant line the oil temperature at that location dropped to -40°F. Figure 3 shows the test system with the shroud.

1.3 Flow in the Stagnant Line

With 50°F oil flow in the system, the minimum continuous flow rate in the stagnant line which maintained the oil temperature above 0°F was 0.04 gpm. With a flow rate of 0.06 gpm and 50°F system oil temperature, the minimum temperature in the stagnant line declined to 0°F after the oil flow had been stopped 2 minutes. With the same flow rate and 100°F system oil, the minimum temperature in the stagnant line reached 0°F after 7 minutes of no oil flow. A complete summary of the various flow rates and temperatures in the stagnant line is given in Table 1. Figure 4 shows the test system used for flow in the stagnant line.

1.4 Heater Blankets on Stagnant Line

With a continuous 50°F system oil flow of 0.6 gpm, the stagnant line averaged approximately 13°F for a total input to the heater blankets of 85 watts. It should be noted, however, that the oil temperature in the stagnant line at the bracket locations under these conditions was -33° F. Figure 6 shows the test system with heater blankets.

1.5 General

With no thermal conditioning, the temperature decline rate of the hard lines was greater than the flex lines. The hard lines having a lower thermal resistance conducted heat much more readily to the -80°F environment. The 1/2 inch inlet line had a greater decline rate than the 3/4 inch return line, due to the greater mass of fluid in the 3/4 inch line. Due to the bracket design, the -80°F environment had a more significant effect on the stagnant line temperature than the -300°F sink to which the bracket was attached. At the bracket locations heat is conducted from the inlet and return lines to the stagnant line. Under continuous 50°F system flow with no thermal conditioning of the stagnant line, the stagnant oil temperature at the bracket locations was 30 to 40°F higher than the stagnant oil temperatures at non-bracket locations. This is shown in Table 1 under "No Thermal Conditioning."

2. CONCLUSIONS

2.1 The significance of the shroud was its ability to maintain the temperature in the stagnant line, as well as the inlet and return lines, above 0°F regardless of the flow condition in the system. However, there are certain installation problems which must be overcome.

2.2 Flow in the stagnant line worked well and could be accomplished by installing a small orifice bleeder line from the main pump outlet and into the main pump thermal conditioning line. Using this method, temperatures in the stagnant line could also be maintained during the orbital period. The steep temperature decline rate, however, should be considered in regard to duration of auxiliary pump operation.

2.3 The heater blankets worked well on the hydraulic lines; however, they were unsatisfactory at the bracket locations.

W. E. Pipes III

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Saturn Vehicle Design Branch
Santa Monica

WEP/jwh

TABLE I

RESULTS OF HYDRAULIC SYSTEM LINES THERMAL ISOLATION TESTS AT SANTA MONICA

HYDRAULIC LINE LOCATION / THERMAL CONDITIONING OF STAGNANT LINE		(1) DECLINE OF STAGNANT LINE TO MIN. TEMP. 50°F OIL FLOW FLEX LINE	50°F OIL FLOW HARD LINE	100°F OIL FLOW FLEX LINE	100°F OIL FLOW HARD LINE	150°F OIL FLOW FLEX LINE	150°F OIL FLOW HARD LINE	(2) OIL TEMP. DECLINE AT -5 BRACKET (-300 °F) STAGNANT	INLET	RETURN	(2) TEMP. DECLINE OF INLET LINE (3) ½ FLEX	(3) ½ HARD	(2) TEMP. DECLINE OF RETURN LINE (3) ¾ FLEX	(3) ¾ HARD
NO THERMAL CONDITIONING		-80 °F (OIL FLOW HAD NO EFFECT)		—	—	—	—	-4? °F TO -50 °F	46 °F TO 0 °F	43 °F TO 1 °F	55 °F TO -2 °F	48 °F TO -6 °F	51 °F TO 10 °F	48 °F TO 2 °F
								FLOW OFF 5 MINUTES			FLOW OFF 5 MINUTES		FLOW OFF 5 MINUTES	
WARM AIR FLOW IN SHROUD	41°F INLET 46.6 LBS/HR	1°F TO -10 °F	9°F TO -2 °F	—	—	—	—	20 °F TO 6 °F	48 °F TO 3 °F	45 °F TO 2 °F	52 °F TO -8 °F	51 °F TO -1 °F	52 °F TO -7 °F	50 °F TO -4 °F
		40 MINUTES OFF						FLOW OFF 40 MINUTES			FLOW OFF 40 MINUTES		FLOW OFF 40 MINUTES	
	87°F INLET 49.8 LBS/HR	5 °F	17 °F	—	--	—	—	30 °F TO 25 °F	48 °F TO 23 °F	47 °F TO 25 °F	54 °F TO 9 °F	53 °F TO 19 °F	53 °F TO 8 °F	52 °F TO 14 °F
		NO CHANGE 60 MINUTES OFF						FLOW OFF 60 MINUTES			FLOW OFF 60 MINUTES		FLOW OFF 60 MINUTES	
FLOW IN STAGNANT LINE	0.04 GPM	0°F TO -1[illegible] °F	14 °F TO -1[illegible] °F	3[illegible] °F TO -12 °F	48 °F TO -13 °F	61 °F TO -7 °F	34 °F TO -1[illegible] °F	12 °F TO -9 °F	SAME AS NO THERMAL COND.		FLOW IN STAGNANT LINE AND HEATER BLANKETS GAVE THE SAME RESULTS AS NO THERMAL CONDITIONING			
		5 MINUTES OFF		8 MINUTES OFF		10 MINUTES OFF		FLOW OFF 5 MINUTES						
	0.06 GPM	3 °F TO -12 °F	22 °F TO -12 °F	42 °F TO -4 °F	6[illegible] °F TO -7 °F	30 °F TO 4 °F	102 °F TO -3 °F	23 °F TO -6 °F	SAME AS NO THERMAL COND.					
		5 MINUTES OFF		5 MINUTES OFF		10 MINUTES OFF		FLOW OFF 5 MINUTES						
	0.09 GPM	18 °F TO -2 °F	31 °F TO -3 °F	52 °F TO 0 °F	70 °F TO -5 °F	92 °F TO 10 °F	114 °F TO 3 °F	30 °F TO -5 °F	SAME AS NO THERMAL COND.					
		5 MINUTES OFF		5 MINUTES OFF		10 MINUTES OFF		FLOW OFF 5 MINUTES						
HEATER BLANKETS ON STAGNANT LINE	TOTAL INPUT TO HEATERS 85 WATTS	AVERAGE OF 13 °F (CONSTANT 50°F OIL FLOW)		—	—	—	—	-33 °F (CONSTANT OIL FLOW)	SAME AS NO THERMAL CONDITIONING					
	TOTAL INPUT TO HEATERS 185 WATTS	AVERAGE OF 75 °F (CONSTANT 50°F OIL FLOW)		—	—	—	—	-17 °F (CONSTANT OIL FLOW)						

TEST CONDITIONS

The ambient temperature for all test results given was -60 ± 3°F. The brackets were made of stainless steel. The insulators used were from phenolic fiber.

(1) Upon reaching thermal equilibrium with the system oil flow at 0.6 gpm and the indicated temperature, all oil flow was stopped. The temperatures given in the table are the equilibrium oil temperature and the oil temperature reached after the flow had been stopped for the indicated time.

(2) Same as (1) except the system oil temperature was 50°F. (See Figure 5 for -5 bracket. See Figure 1 for thermocouple locations on bracket.)

(3) The thermocouple locations used for the inlet flex and hard lines were No. 15 and No. 14 and No. 20 and No. 22 for the return flex and hard lines respectively. (See Figure 1.)

NOTE: When the flow was resumed both the inlet and return lines returned to their original stable temperature in 2 to 5 minutes.

FORM 25 BS (REV. 3-54)

PREPARED BY:

CHECKED BY:

DATE:

TITLE:

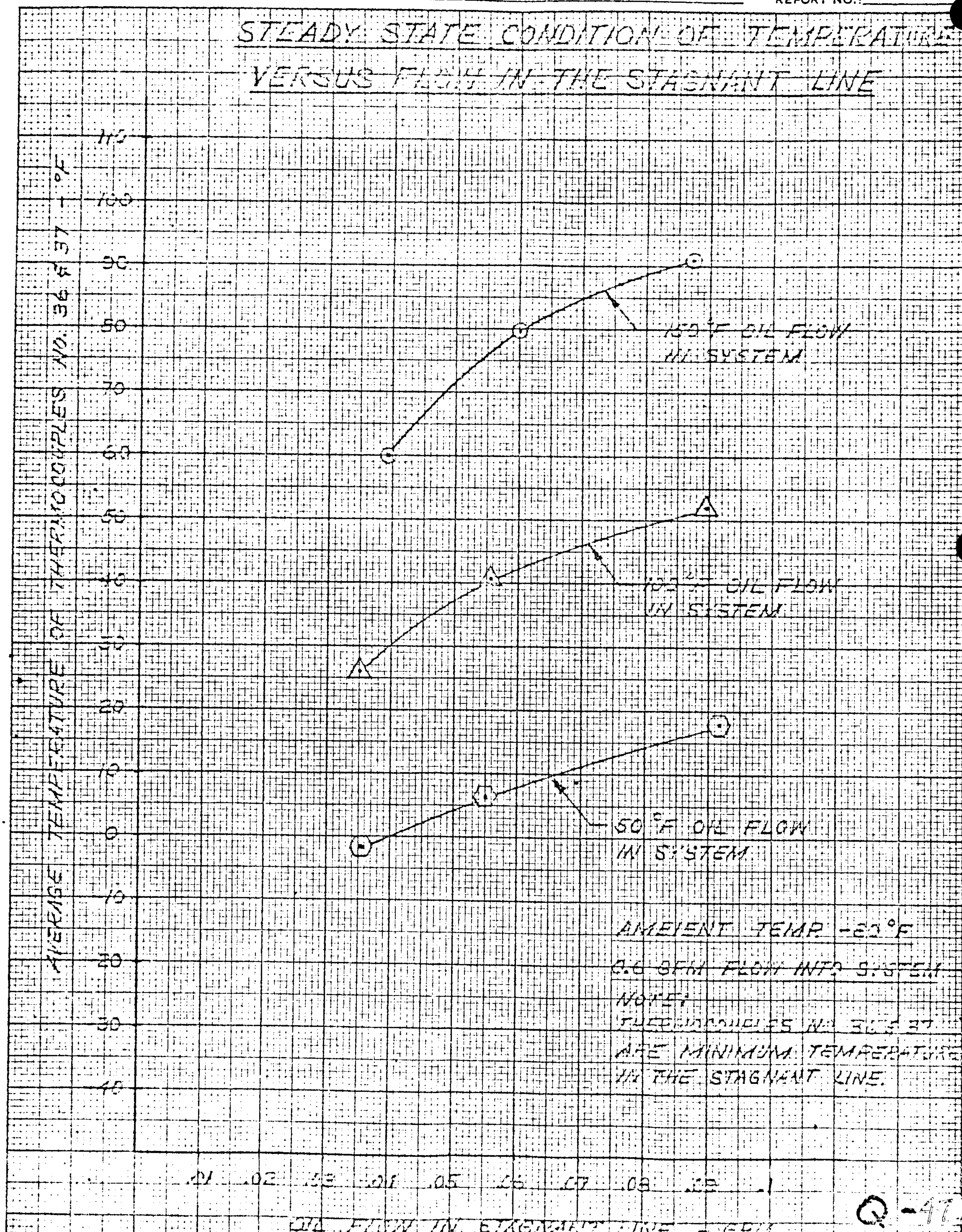
DOUGLAS AIRCRAFT COMPANY, INC.

DIVISION

PAGE:

MODEL:

REPORT NO.:



Q-47

K+E ALBANENE® TRACING PAPER LA 0348

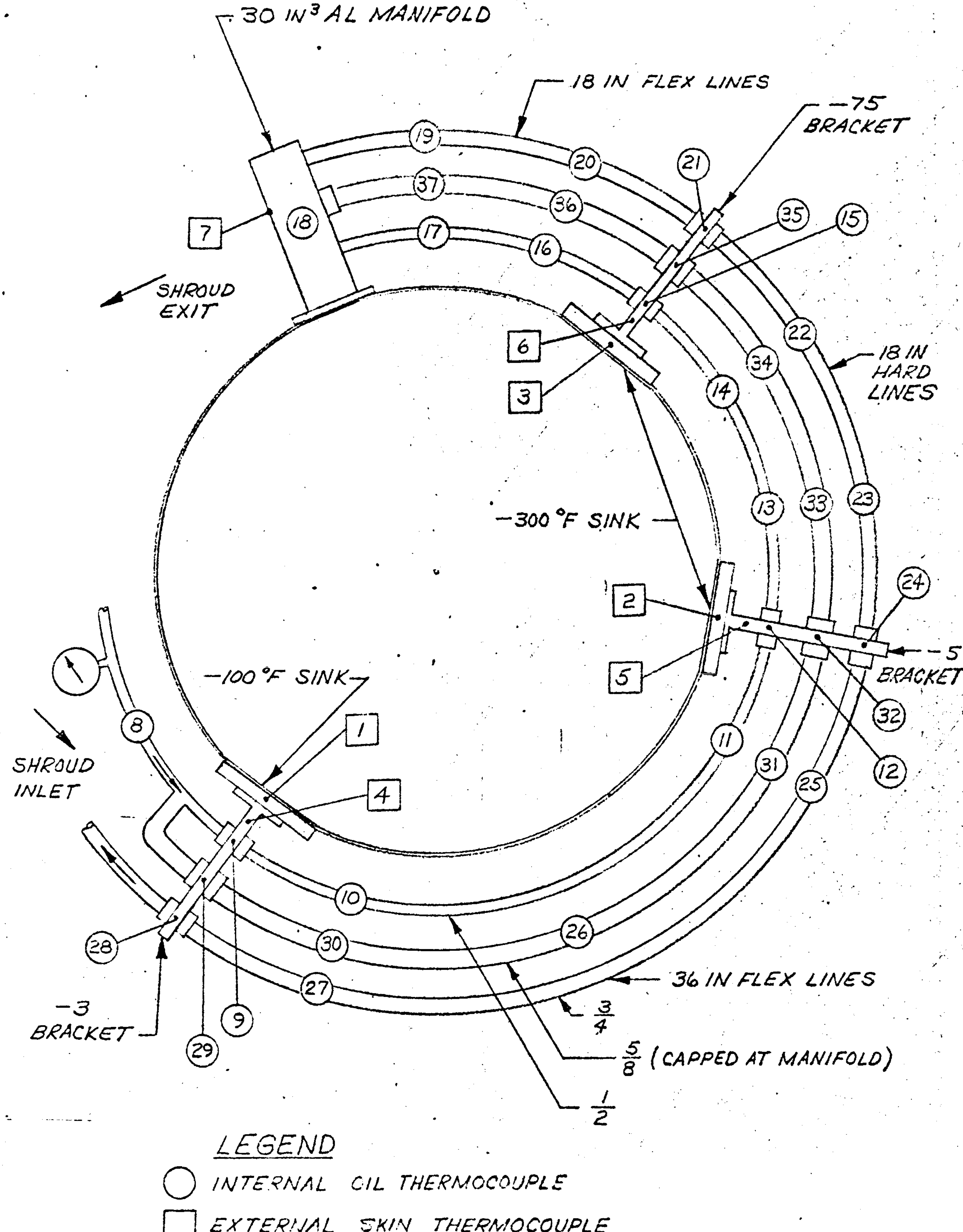


FIGURE 1
Schematic of Test System Showing
Thermocouple Locations

AGENDA ITEM 15 (C), SIXTH VEHICLE MECHANICAL
DESIGN INTEGRATION WORKING GROUP MEETING - S-IVB

1A74765-1 Auxiliary Pump Thermal Switch (off at 50°F - on at 5°F)

The failure rate for this switch is approximately 4 failures/10^6 cycles. The failure modes are failure to open or failure to close. If the switch fails open, the pump continues to operate and the battery will be depleted before mission is completed. If the switch fails to close, the pump will not operate and the hydraulic lines will freeze. Our recommendation is to investigate the testing, Quality Control, manufacturing and assembly of this switch as a means to assure its reliability in service. We feel that very little is to be gained in installing another switch in redundancy for the following reasons:

1. There have been no failures of a similar switch on the S-IV vehicle.

2. We do not have any data as to which failure mode is most troublesome.

3. The remaining electrical system is not redundant.

APPENDIX R

16.0 HYDROSTATIC STAGE

Complete information on the S-IVB hydrostatic stage failure is contained in Report No. SM-46755, titled Failure Analysis Report, Hydrostatic Vehicle.

August 25, 1964

AGENDA ITEM 16

DAC RECOMMENDATION FOR HYDROSTATIC VEHICLE REPLACEMENT

Preliminary evaluation of the data from the hydrostatic vehicle test indicates that very little could be gained by testing another vehicle to limit loads. The loadings achieved were 90 percent, or more, of the intended proof load values and were adequate for comparison with calculated stresses.

However, since we have not performed an ultimate load test on a similar structure, much could be learned as to the actual margin of safety which the tank structure provides by performing an ultimate load test. We, therefore, do recommend that another vehicle be provided for these tests. It appears that a tank could be available from the production line in time to perform these tests by the middle of 1965 if a decision is reached immediately.

APPENDIX 5

17.0 DYNAMICS STAGE (SATURN IB AND V)

17.B Status of Dynamic Stage (Figure 77)

(a) All Engineering — including redesigns due to NASA change orders — is expected to be completed by first week in September.

(b) Procurement — some problems due to late delivery by vendors of purchased parts. These problems are expected to be solved shortly.

(c) Manufacturing — complete to latest engineering.

(d) Assembly — about three weeks late due to parts shortages. Changes in in-house sequence of assembly and checkout will recover this three weeks. Manufacturing Department is expediting fabrication and assembly with full schedule recovery expected.

(e) Cleaning, clip bonding, installation of miscellaneous parts now in process.

PERT MILESTONES COMPLETED

#978 Fabrication and assembly structure (propellant tank assembly) — Completed 27 March 1964.

#979 Installation of insulation (LH_2 tank) — Completed 24 July 1964.

PROBLEMS

(a) No technical problems which prevent design completion.

WORK REMAINING

(a) Joining of thrust structure, forward skirt, aft skirt, and dummy engine to be completed by end of September.

(b) Stage checkout to start by 9 October and be completed by 31 October 1964.

(c) Stage to be ready for shipment to MSFC on 3 December 1964. (DAC milestone.)

PERT MILESTONES TO MEET

		Schedule Date	Expected Date
(a)	Installation of thrust structure, skirts, fit tunnels	8/25/4	9/18/4
(b)	Complete system checkout	11/1/4	11/1/4
(c)	Ship stage to MSFC	12/3/4	12/3/4
	Stage available at MSFC	12/31/4	12/31/4

DYNAMIC TEST STAGE DEV'MT
TEST PLAN

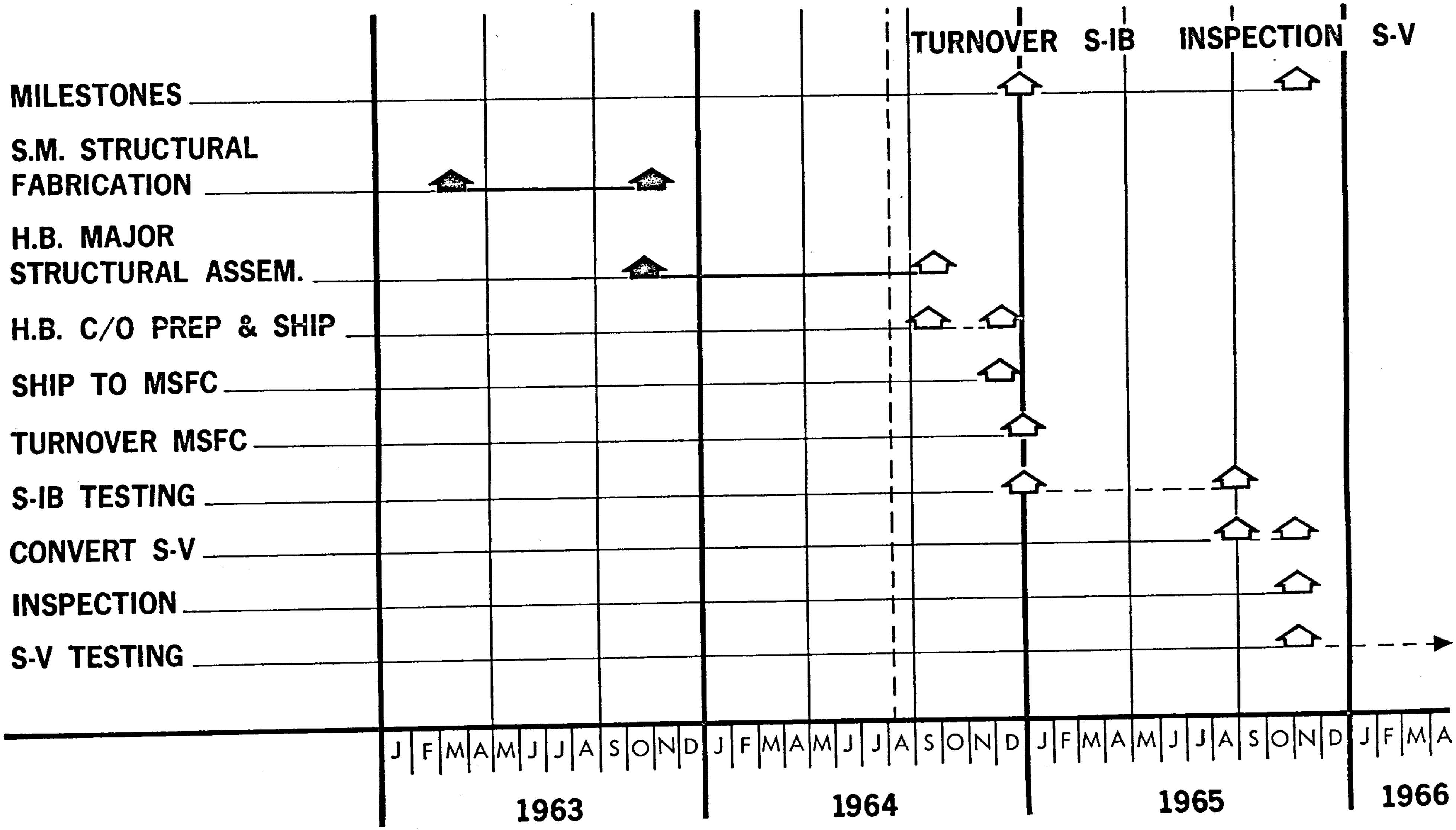


FIGURE 77

PRIMARY DIFFERENCES BETWEEN MSFC SATURN IB AND SATURN V DYNAMIC TEST DESCRIPTIONS AND DAC DESIGN MEMO NO. 101C DATED 20 JULY 1964.

ITEM	MSFC	DAC
1. CONCEPT	MSFC PREFERS TO USE THE "FLIGHT SPECIFICATION HARDWARE EXCEPT AS NOTED ------- TYPE OF PHRASEOLOGY."	DAC USES "ONLY THOSE ITEMS SPECIFICALLY CALLED OUT WILL BE INSTALLED."
2. FORWARD SKIRT	MSFC CONSIDERS THE OLD (PRE CHANGE ORDER 146) SKIRT ACCEPTABLE PROVIDED IT IS MODIFIED TO THE STIFFNESS OF THE NEW SKIRT.	DAC PLANS TO SUPPLY OLD SKIRT WITHOUT MODIFICATIONS.

APPENDIX T

ITEM	MSFC	DAC
3. INSULATION H_2 TANK	MSFC DESIRES S-IVB FLIGHT SPECIFICATION INSULATION.	DAC PLANS TO USE S-IV HYDROSTATIC/DYN. STAGE INSULATION.
4. AFT SKIRT	MSFC WANTS THE AFT SKIRT TO BE MODIFIED TO THE STIFFNESS OF THE NEW SKIRT.	DAC PLANS TO SUPPLY OLD SKIRT WITHOUT MODIFICATIONS.
5. AFT INTERSTAGE	MSFC WANTS THE INTERSTAGE TO BE MODIFIED TO THE STIFFNESS OF THE NEW ~~SKIRT~~. INTERSTAGE	DAC PLANS TO SUPPLY OLD INTERSTAGE WITHOUT MODIFICATION.

ITEM	MSFC	DAC
6. J-2 ENGINE SIMULATOR	MSFC WANTS MASS PROPERTIES OF J-2 SIMULATED WITHIN 5% OF THE WET CONDITION AND INCLUDE GIMBAL, ACTUATOR, PROPELLANT FEED LINES, AND MOUNTING INTERFACES TO FLIGHT SPECIFICATION.	DAC TO SIMULATE MASS PROPERTIES WITHIN 5% AND PROVIDE GIMBAL AND ACTUATOR ATTACH POINTS.
7. PROPELLANT FEED LINES (STAGE SIDE)	MSFC WANTS FLIGHT SPECIFICATION PROPELLANT FEED LINES INSTALLED.	DAC DOES NOT PLAN TO INSTALL FEED LINES.

ITEM	MSFC	DAC
8. SIMULATED MASS PROPERTIES	MSFC WANTS A TOLERANCE OF 10% ON SIMULATED MASS PROPERTIES OF COMPONENTS IN GENERAL, AND A TOLERANCE OF 3% ON THE MASS DISTRIBUTION OF THE COMPLETE STAGE.	DAC USES 5% ON MANY COMPONENTS AND SOME HAVE NO TOLERANCES.
9. BRACKETS	MSFC DESIRES FLIGHT SPECIFICATION BRACKETS INSTALLED FOR ALL COMPONENTS INSTALLED OR SIMULATED, AND FLIGHT SPECIFICATION BRACKETS FOR ALL COMPONENTS AND INSTRUMENTATION INSTALLED AT MSFC.	DAC DOES NOT SPECIFY FLIGHT SPECIFICATION BRACKETS.

ITEM	MSFC	DAC
10. PREVALVES	MSFC NEEDS DUMMY PREVALVES WITH FLIGHT SPECIFICATION FLANGE INTERFACES AND PROVISIONS FOR DRAINING THE TANKS AND PRESSURIZING THE FEED LINES SEPARATELY.	DAC DOES NOT PLAN TO SUPPLY PREVALVES.
11. AUXILIARY PROPULSION SYSTEM	MSFC NEEDS ONLY THE FUELED CONDITION SIMULATED ON THE S-IVB/IB; HOWEVER BOTH FUELED AND UNFUELED CONDITIONS ARE REQUIRED FOR S-IVB/V.	DAC PLANS TO SUPPLY FUELED AND UNFUELED CONDITIONS FOR IB ALSO.

ITEM	MSFC	DAC
12. ORDNANCE INTERFACES	MSFC NEEDS DUMMY ORDNANCE ITEMS FOR THE PROPELLANT DISPERSION SYSTEM BELOW STATION 100.00	NEW MSFC REQUIREMENT
13. COMPONENTS MOUNTED CLOSE TO CONTROL SENSORS	COMPONENTS, MOUNTED IN VICINITY OF CONTROL SENSORS, MUST BE MASS SIMULATED AND MOUNTED ON FLIGHT BRACKETS IF THEIR WEIGHT EXCEEDS 10 POUNDS.	MSFC GROUND RULES

ITEM	MSFC	DAC
14. POSITIVE TANK PRESSURE REQUIREMENT	MSFC REQUIRES PROVISIONS FOR INTERFACING WITH THE GSE POSITIVE PRESSURE CONTROL MODULE.	NEW MSFC REQUIREMENT
15. ACCESS KITS	ACCESS KITS ARE REQUIRED IN THE FORWARD SKIRT AREA.	IB GROUND RULES

18.0 FACILITY CHECKOUT STAGE (S-IVB-F)

ACCOMPLISHMENT

Present within two weeks of on-schedule

(1) Tank Section completed

(2) Hydrostatic Proof Test completed

(3) Stage now undergoing cleaning and leak check in Tower 4 - VAB.

(4) Stage will move to Environmental Chamber for insulation installation on/or about 4 September 1964.

(5) Aft interstage being assembled in the assembly jig - Building 45.

MILESTONE

(1) Facility Checkout Stage - Completed fabrication and assemble structure on 31 July 1964. (NASA milestone)

(2) Insulation installation completion - 6 November 1964. (NASA milestone)

(3) Installation - Thrust structure, skirts, ducting, tunnels, and fairing - 11 December 1964. (NASA milestone)

(4) System installation and checkout - Completion 5 March 1965. (NASA milestone) (Figure 78)

(5) Vehicle ship to KSC - 9 April 1965.

(6) Aft interstage - S-IB - Ship 12 April 1965.

(7) Deliver S-IVB-F/IB to NASA - 15 May 1965.

(8) Aft interstage - SV - Ship 8 October 1965.

(9) Conversion - Facility Checkout Stage S-IB to S-V - 1 November 1965, through 15 January 1966.

(10) Deliver S-IVB-F/V to NASA 15 January 1966.

SCOPE CHANGE/CHANGE ORDERS

Scope Change 1100C	Supplemental Agreement 149 adds 1B Facility Checkout Schedule; Supplemental Agreement 304 - Definition of S-IVB-F systems
Scope Change 1165	Requirement for Second Checkout Position at A3. Change Order 303 - reallocates GSE.
Scope Change 1189	Additional coast period requirement
	Change Order 111 - MSFC Contracting Officer's letter, 4/1/64, I-CO-VB
	Change Order 126 - 12/18/63
Scope Change 1196	Revised flight stage structural loads
	Change Orders 146 and 206 Contract letter I V-S-IVB-64-TD-53
Scope Change 1207	Modify propellant utilization system
	Change Order 197 - 4/6/64
	Change Order 213 - 5/22/64

OUTSTANDING TECHNICAL PROBLEMS

(1) LOX Mass Probe - Redesign of Deutsch Connector required. E/R 8/28/64. Part supplied to Honeywell which is subcontractor for LOX Mass Probe.

(2) APS Module

(3) Checkout Tower at A3

SATURN S-IVB
FACILITY CHECKOUT STAGE FLOW PLAN

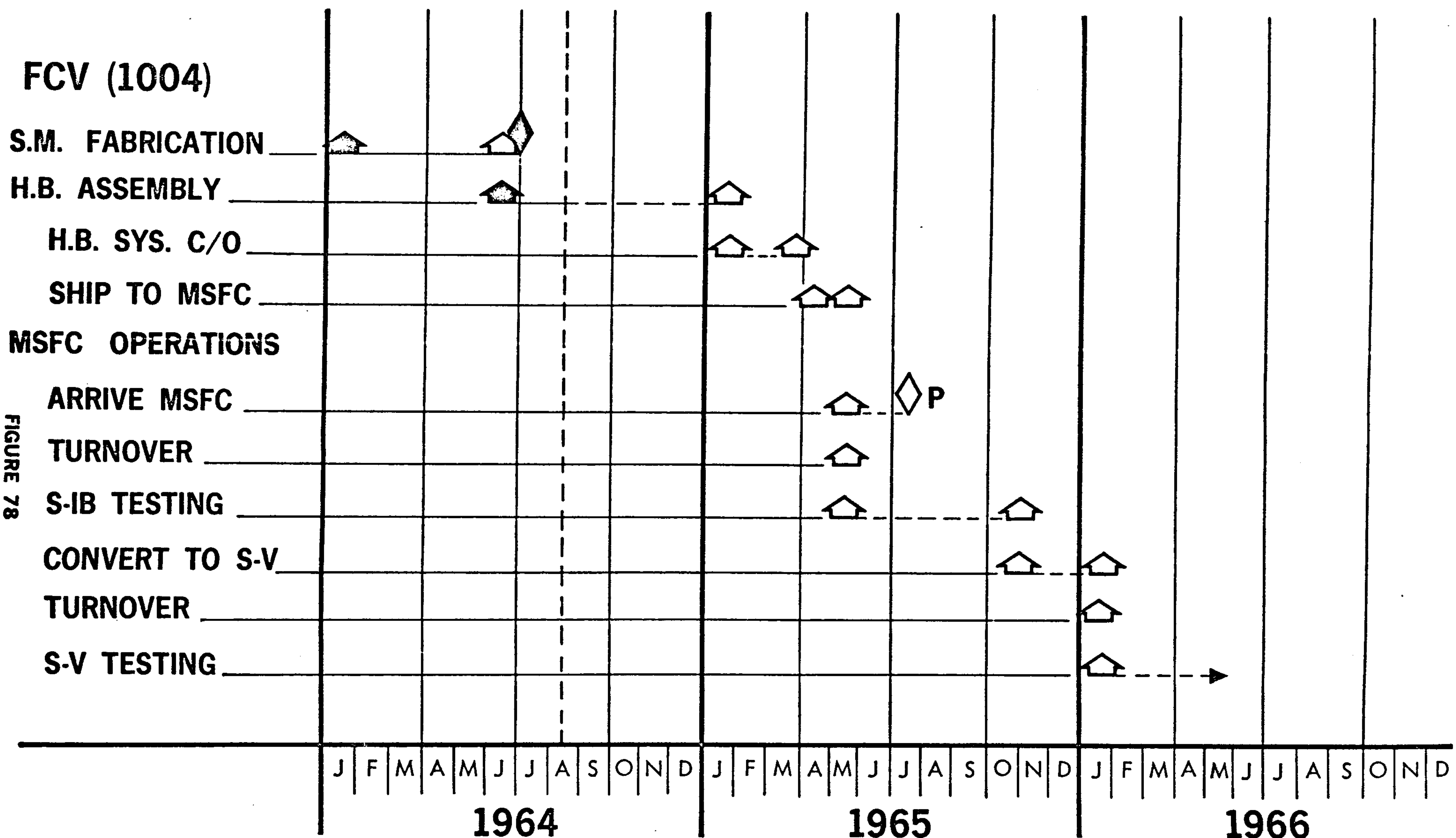


FIGURE 78

19.0 INTERSTAGE VENTING

19.A Documents Presently Being Used for S-IVB/V Interstage Venting Design

Pressure Design	Current Design	Pending Design
Aft Interstage	Saturn S-IVB Monthly Progress Report April, 1963	1. R-P&VE-SL-202-63 R-P&VE-SLL-64-11 These data were transmitted by Contract Letter I-V-S-IVB-TD-64-57 May 4, 1964 2. Acoustic Pressures R-P&VE-SVA-67 R-P&VE-SVA-90 These data were transmitted by Contract Letter I-V-S-IVB-TD-64-126
Aft Skirt	Saturn S-IVB Monthly Progress Report October, 1963	R-P&VE-SL-202-63 R-P&VE-SLL-64-11 These data were transmitted by Contract Letter I-V-S-IVB-TD-64-57 May 4, 1964

R-P&VE-VOR-64-100 June 29, 1964 is being used for information in establishing allowable leakage in the Aft Skirt and Interstage.

Pressure Design	Current Design	Pending Design
Forward Skirt	1. Change Order 284 is being used for Vent Area and Location in the S-IVB Forward Skirt 2. R-AERO-AD-64-55 Information Letter I-V-S-IVB-64-A-181, July 14, 1964. 3. Information Letter, I-V-S-IVB-64-A-148 June 9, 1964 is being used for information in establishing drain hole requirements.	
Aft Skirt, Aft Interstage & Aft Interstage Fairing	TCB-S-IVB-233 May 25, 1964	1. Technical Directive 255 December 17, 1963 2. R-AERO-AD-64-52 Contract Letter I-V-S-IVB-TD-64-82 June 24, 1964
Forward Skirt	TCB S-IVB-233 May 25, 1964	

NOTE:
1. Change Order 284 is being used for Vent Area and location in the S-IVB Forward Skirt.
2. Information Letter I-V-S-IVB-64-A-181, July 14, 1964 is being used for information in establishing design pressure requirements.
3. Information Letter I-V-S-IVB-64-A-148 June 9, 1964 is being used for information in establishing drain hole requirements

19. B. 1-2-3 Forward Skirt – Saturn IB and Saturn V

200 square inches of vent area will be provided as shown on Figure 79. Eight vents will be in groups of two and located four places around the periphery. Each vent will be 2-9/16 x 10-9/32 inches in size and have an area of 25 square inches. The aft ends of the vents will be located 117-1/8 inches aft of the I. U. forward interface. Rain shields will be provided internally to prevent water from entering the skirt.

DAC has not been informed by MSFC as to the pre-launch or flight flow rates.

3/8 dia. drain holes will be provided around the periphery at the skirt aft flange and will produce a maximum of 6 square inches of area.

Structural leakage areas tabulated below are estimated to be maximum and should be applicable if no leak tests are to be conducted. However, all joints will be sealed, and leak tests probably would show a maximum of 15 square inches of leakage area, which is the DAC design target.

Tentative Leak Area Allocations

1.	Fwd. interface joint includes attachment to IU	8.16 sq. in.
2.	Umbilical	.15
3.	Antennae (6)	13.79
4.	Longitudinal Skin Splices (18)	10.98
5.	Tunnels (2)	.60
6.	Circumferential skin splice	8.16
7.	Aft interface joint includes attachment to tank	8.16
	Total	50.00 sq. inches

Weight of sealant is estimated to be 3 pounds.

S-IVB FWD SKIRT VENT LOCATIONS

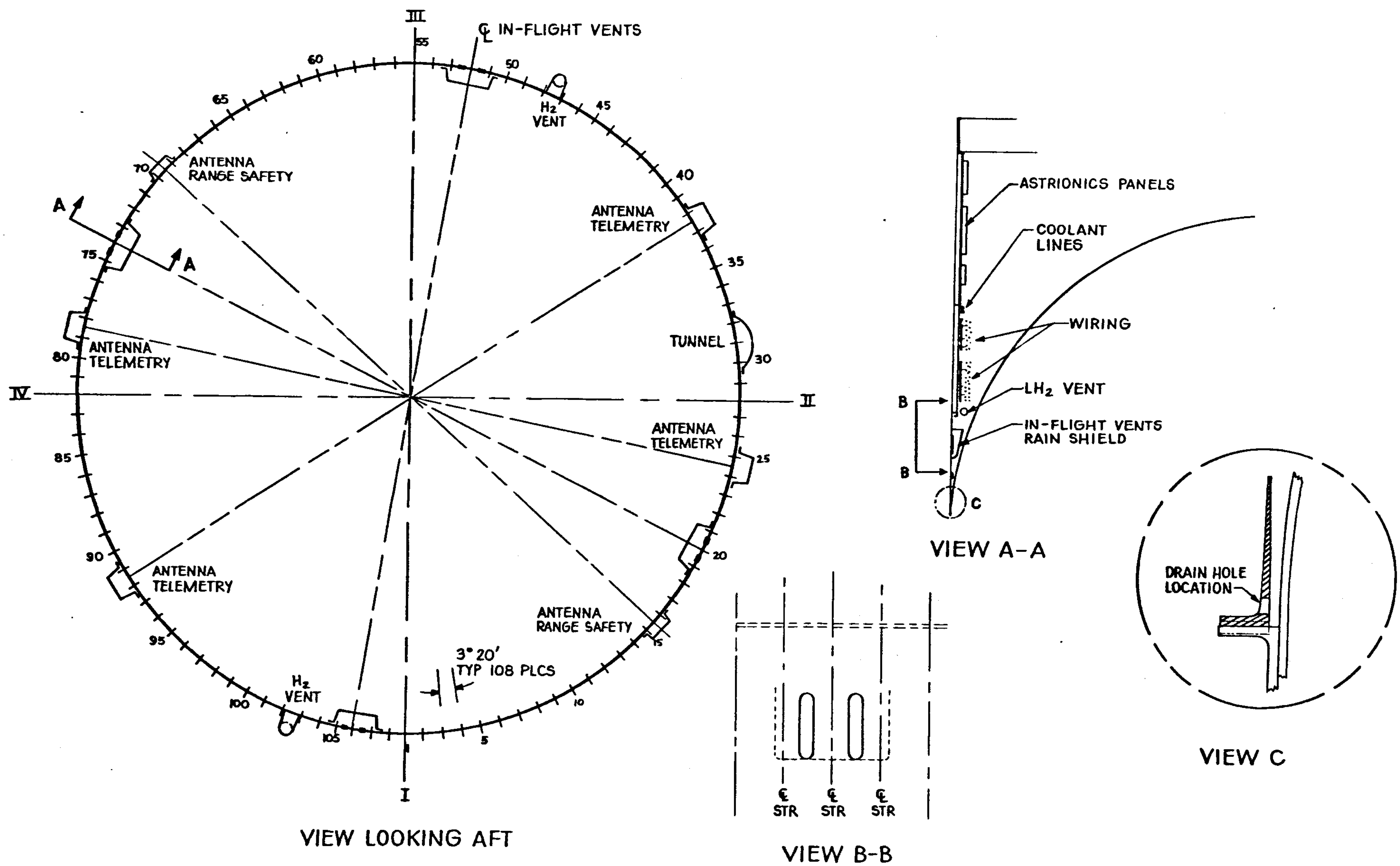


FIGURE 79

Aft Skirt and Aft Interstage – Saturn IB

160 square inches of vent area will be provided in the aft interstage. The vents will be in groups of two and will be 180 degrees apart. They will be symmetrical about a centerline 22-1/2 degrees from position plane II towards I. Each group will consist of 8 vents, 2 rows of 4 each. Each vent will be 1-5/8 x 6-1/2 inches in size and will have an area of 10 square inches. The aft ends of the aft vents will be approximately 3-1/2 inches forward of the aft interface. The forward ends of the forward vents will be approximately 22-1/4 inches forward of the aft interface. Internal rain shields will be provided.

Pre-launch flow rate will be approximately 300 pounds/minute of air or GN_2.

Drain holes will not be provided.

Structural leakage areas tabulated below are estimated to be maximum and should be applicable if no leak tests are to be conducted. However, all joints will be sealed and leak tests probably would show a maximum of 15 square inches of leakage area, which is the DAC design target.

Tentative Leak Area Allocations

Aft Skirt

1.	Forward interface joint (includes attach to tank)	8.16 sq. in.
2.	Circumferential skin splice	8.16
3.	Umbilical	.70
4.	Chill Down Return Line	.88
5.	LH_2 Fill	1.96
6.	Chill down pump	1.52
7.	LH_2 feed line	2.84
8.	LO_2 Vent	.08
9.	Air Cond. Door	.72
10.	Longitudinal skin splices (19)	7.88
11.	Aft interface joint (includes attach. to aft interstage)	8.16
		41.06 sq. in.

Aft Interstage

1.	Forward Interface Joint	8.16
2.	Door	3.20
3.	Retro rocket cutouts	.06
4.	Longitudinal skin splices (16)	17.92
5.	Aft Interface joint	13.80
		43.14 sq. in.
	TOTAL =	84.20 sq. in.

Weight of sealant is estimated to be 8 pounds.

Aft Skirt and Aft Interstage – Saturn V

160 square inches of vent area will be provided in the aft interstage. The vents will be in groups of two and will be 180 degrees apart. They will be symmetrical about a centerline 10° 45' from position plane II towards I. Each group will consist of 2 rows with 4 vents in each row. Each vent will be 1-5/8 x 6-1/2 inches in size and will have an area of 10 square inches. The aft ends of the aft vents will be approximately 2-1/8 inches forward of station 2601.166. The two rows of vents will be 6-1/2 inches apart. Internal rain shields will be provided.

Pre-launch flow rate will be 325 to 425 pounds/minute depending on the Saturn S-II stage thermo-conditioning design.

Drain holes will not be provided.

Structural leakage areas and allocations are assumed to be the same as those shown for the aft skirt-aft interstage combination for the Saturn IB. A total leakage area of 85 sq. in. should be applicable if no leak tests are to be conducted.

Weight of sealant is estimated to be 9 pounds including sealing at the S-IVB/S-II interface.

19.B.4 Structural Leakage Testing

MSFC TWX I-V-S-IVB-64-76 stated that structural testing of the Saturn IB aft skirt and interstage is not required and that the evaluation of the Saturn V leakage requirements had not been completed. In view of this, DAC has suspended Scope Change 1256 until further information is received from MSFC.

Since Saturn V leakage is more critical, it is not clear that the testing program proposed in Scope Change 1256 would be optimum for Saturn V. Therefore, DAC will re-write or cancel Scope Change 1256, as required, upon receipt of MSFC's testing criteria.

19.B.5 Problem Areas and Proposed Resolutions

MSFC direction to provide 200 sq. in. of inflight vent area in the S-IVB forward skirt is valid only if the drain hole area is less than 15 sq. in. and if structural leakage is virtually eliminated. (Reference: Change Order 284 and MSFC Memo R-AERO-AD-64-55). DAC can design for a maximum drain hole area of 6 sq. in. but cannot design for zero structural leakage. DAC presumes that a major MSFC objective is to achieve a vent design which will not require production leak testing of structure. In view of this presumption, DAC finds that the potential leakage will be no larger than 50 sq. in. This additional vent area does not affect the S-IVB structural strength, and if it can be shown that the Instrument Unit and Spacecraft are unaffected, leak testing of the S-IVB can be avoided.

Similarly, an allowance of 85 sq. in., instead of the current 15 sq. in. for SAT V/IB S-IVB aft skirt and interstage structural leakage will be sufficient to preclude leak testing of these structures. Again, however, the effect of this additional vent area on structural strength would have to be determined.

The increases in allowable leakage as proposed above do, however, restrict the purge capability of the DAC designed system in the aft skirt and interstage and of the MSFC system in the S-IVB forward skirt LEM Spacecraft. It is the opinion of DAC that recently proposed increases in the amount of purging gas discharged into the S-II/S-IVB interstage area by NAA/S&ID will be sufficient to meet the MSFC purge requirement of 4% O_2. It is doubtful, however, that the amount of gas currently proposed by MSFC for the forward skirt area will provide a purge capability that can tolerate an increase in forward skirt leakage.

INTERSTAGE VENTING CRITERIA

MEMO NO.	TITLE	TD NO.	REMARKS
R-P&VE-VA-205-63	S-IVB Stage Compartment Preflight Purge Criteria	154	Superseded by 64-1
R-P&VE-VA-64-1	Revised S-IVB Stage Compartment Preflight Purge Criteria	648	
M-AERO-A-40-63	Aerodynamic Load Across the Seal Plate Between the S-I and S-IVB Stages of the Saturn IB Vehicle		Superseded by R-AERO-A-65-63
R-AERO-A-43-63	Removal of Seal Plate Between S-IB and S-IVB Stages		Still in effect
M-AERO-A-65-63	Aerodynamic Loads in the S-IB/S-IVB Interstage Region of the Saturn IB Vehicle	140	Superseded by R-AERO-AD-A-102-63
R-AERO-A-102-63	An Inflight Venting Analysis of the Operational Saturn IB, SIB/S-IVB Interstage		Superseded by R-AERO-AD-64-52
R-AERO-AD-64-52	Design Criteria: Differential Pressure in the S-IB/S-IVB Interstage Region of the Operational Saturn IB Vehicle		
R-AERO-AD-64-55	Design Criteria: Saturn V & IB Vehicles Inflight Venting Analysis of the S-IVB Stage, Skirt, IU, LEM Adapter and Service Module Compartment		
R-AERO-AD (No No.)	Addendum to R-AERO-AD-64-55		
M-P&VE-PT-349-63	Prevention of Hydrogen Hazards in Interstage Areas		

APPENDIX U

INTERSTAGE VENTING CRITERIA (Cont'd)

MEMO	TITLE	TD NO.	REMARKS
M-P&VE-EF-653	Saturn Vehicle Preflight Purge Criteria		
M-P&VE-EF-676	Saturn Vehicle Preflight Purge Requirements		
M-AERO-A-50-63	S-IVB/S-II Interstage Design Criteria		Superseded by R-AERO-89-63
M-AERO-A-89-63	Saturn V S-II/S-IVB Inflight Venting Schedule		

S-IB/S-IVB INTERSTAGE DESIGN CRITERIA

MEMO NO.	TITLE	TD NO.	REMARKS
R-P&VE-VA-150-63	S-IB/S-IVB Interstage Design Criteria		
R-P&VE-VA-199-63	S-IB/S-IVB Interstage Design Criteria	156	Superseded by 263-63
R-P&VE-VA-263-63	Revised S-IB/S-IVB Interstage Design Criteria	211	Superseded by 318-63
R-P&VE-VA 318-63	Revised S-IB/S-IVB Interstage Design Criteria	255	
M-P&VE-EL-818	Action Item 4-5 from Vehicle Mechanical, Design Integration Working Group Meeting No. 4 May 15, 16, 1963 for the S-IVB Stage	169	
SL10-3979	Layout S-IVB Stage Shroud Clearance With S-IB Stage Saturn IB	169	

COLLAPSING PRESSURE DESIGN CRITERIA

MEMO NO.	TITLE	TD NO.	REMARKS
R-P&VE-VAD-64-6	Collapsing Pressure Design Criteria for Propellant Tanks of all Stages on the Saturn IB and Saturn V Launch Vehicles		Superseded by 69-42
R-P&VE-VAD-64-42	Collapsing Pressure Design Criteria for Propellant Tanks of all Stages on the Saturn IB and Saturn V Launch Vehicles, Rev. 1		Superseded by 64-86
R-P&VE-VAD-64-86	Collapsing Pressure Design Criteria for Propellant Tanks of all Stages on the Saturn IB and Saturn V Launch Vehicles, Rev. 2		
R-P&VE-SS-63-19	Clarification of Structural Philosophy on Collapsing Pressure for Flight Vehicle Propellant Tankage		
R-P&VE-SVM-91-63	Differential Pressure Criteria for Propellant Tanks of all Stages on the Saturn IB and Saturn V Vehicles		

DRAIN HOLE DESIGN CRITERIA

MEMO NO.	TITLE	ID NO.	REMARKS
R-P&VE-VAD-64-28	Requirement for Drain Holes in the Unpressurized Compartments of the Saturn IB and Saturn V Launch Vehicles	Letter I-V-S-IVB -64-A-148 6/9/64	

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

Mr. Bacchus/876-4909

TO See Distribution

DATE August 17, 1964
MEMO NR: R-AERO-AD-64-81

FROM : Aerodynamic Design Branch, R-AERO-AD

SUBJECT Design Criteria: Allowable Leakages in the S-IB/S-IVB Interstage Region of the Saturn IB Vehicle

REFERENCES

(a) Palaoro, H. R., Revised S-IB/S-IVB Interstage Design Criteria, R-P&VE-VA-318-63, December 2, 1963, Unclassified.

(b) Bacchus, David L., Design Criteria: Differential Pressures in the S-IB/S-IVB Interstage Region of the Operational Saturn IB Vehicle, R-AERO-AD-64-52, May 7, 1964, Unclassified.

(c) Schulze, W. A., S-IB/S-IVB Interface (13M20106) Interface Revision Request (IRR) No. 4-VSI-64, R-P&VE-VSI-64-83, June 1, 1964, Unclassified.

1. The Douglas Aircraft Company has expressed concern over the present design criteria for leakage in the S-IB/S-IVB interstage region of the Saturn IB vehicle. The maximum allowable leakages from Reference a are 15 square inches through the interstage side wall and 15 square inches through the S-IB seal plate based on estimates and Saturn I seal plate leakage tests, respectively. The interstage pressure histories, based on these leakage areas, are presented in Reference b. Douglas has stated that the maximum side wall leakage cannot be guaranteed to be less than the prescribed 15 square inches without a test program which would involve testing each interstage. This would cost on the order of one million dollars and result in a schedule slip for SA-201 of from two to four weeks. In addition, since the 15 square inches of leakage through the seal plate is based on leakage through gaps in the eight panels only, DAC feels that this places a zero leakage requirement on the curtain seal between the S-IB and S-IVB seal plates. A sketch of this seal is presented in Reference b.

2. A meeting was held on July 29, 1964, between AERO Laboratory, P&VE Laboratory, and S-IVB Stage Manager Office to discuss the possibility of relaxing the present leakage limitation. It was learned that, with no production testing, Douglas could guarantee the side wall leakage to be no more than 55 square inches. However, some testing of the first article may still be necessary. In addition, Douglas has quoted a leakage area of 10 square inches as a reasonable upper limit for the curtain seal. Coupled with the 15 square inches allotted for the seal plate, this gives a total of 25 square inches of leakage for the seal plate area.

APPENDIX V

MSFC - Form 488 (August 1960)

SUBJECT: Design Criteria: Allowable Leakages in the S-IB/S-IVB Interstage Region of the Saturn IB Vehicle

August 17, 1964

3. In order to determine the impact of the additional leakages in the interstage environmental conditions, compartment pressure histories were computed as a function of flight time to determine:

a. If the lower compartment pressures create a crushing load on the interstage side wall in excess of the current 0.3 psi maximum crushing load allowed.

b. If the lower pressures cause undesirable inflow of hot boundary layer air, thus hindering chilldown of the J-2 engine.

The results of the study indicate that, with a side wall leakage area of 55 square inches and a seal plate leakage of 25 square inches (including the curtain seal), the maximum crushing load on the interstage is somewhat marginal, but not excessive. Since some conservatism has been used in the analysis to obtain the highest possible ΔP loads, it is felt with a reasonable degree of confidence that the 0.3 psi maximum crushing load will not be exceeded with the additional leakages. This confidence level is based on comparisons of Saturn I, Block II flight pressure measurements located in the S-IV stage with predicted values. The results also indicate that inflow will not be a problem to chilldown. If inflow does occur, it will be limited to the first 10 or 15 seconds of flight and during this time period the temperature in the boundary layer is near ambient.

4. Based on the results of the study, the Aerodynamic Design Branch believes that the testing of each interstage is unnecessary and therefore recommends that the maximum leakage criteria be changed to the following:

Structure	Maximum Leakage (square inches)
S-IVB Aft Skirt and Aft Interstage Side Walls	55
S-IB Seal Plate	15
Curtain Seal	10

These values are based on a vent area of 160 square inches.

David L. Bacchus

David L. Bacchus

SUBJECT: Design Criteria: Allowable Leakages in the S-IB/S-IVB Interstage Region of the Saturn IB Vehicle

August 17, 1964

APPROVAL:

O. C. del Sueror
for W. K. Dahm
Chief, Aerodynamics Division

CONCURRENCE:

Lewis L. McNair
L. L. McNair
Chief, Projects Office

Geissler
E. D. Geissler
Director, Aero-Astrodynamics Laboratory

DISTRIBUTION:

Col. James, I-I/IB-DIR
Mr. Thompson, I-I/IB-SI-IB
Mr. Stevenson, I-MICH-OA
Mr. Cline, R-P&VE-DIR
Mr. Palaoro, R-P&VE-V
Mr. Rothe, R-P&VE-VF (6)
Mr. Griner, R-P&VE-VJ (5)
Mr. Kistler, R-P&VE-VO
Mr. Schulze, R-P&VE-VS
Mr. Prasthofer, R-P&VE-VSA
Mr. Kraus, R-P&VE-VSI
Mr. Paul, R-P&VE-P
Mr. Heusinger, R-P&VE-PP
Mr. Askew, R-P&VE-PPF
Mr. Wood, R-P&VE-PT
Mr. Vaniman, R-P&VE-PTP
Mr. Verble, R-P&VE-S
Mr. Blumrich, R-P&VE-SA
Mr. Showers, R-P&VE-SL (3)
Mr. Furman, R-P&VE-SJ
Mr. Scheffler, R-P&VE-SSS
Dr. Geissler, R-AERO-DIR
Mr. Jean, R-AERO-DIR
Mr. Windham, R-AERO-T (LRC)
Mr. McNair, R-AERO-P (6)
Mr. Teague, R-AERO-P (16)
Mr. Jackson, R-AERO-P
Dr. Speer, R-AERO-F
Mr. Lindberg, R-AERO-F
Mr. Dahm, R-AERO-A
Mr. Linsley, R-AERO-AA
Mr. May, R-AERO-AD
Mr. Weaver, R-AERO-AD (2)
Mr. Wilson, R-AERO-AT
Mr. Reed, R-AERO-AU
Mr. Dunn, R-AERO-ADD
Mr. Nunley, R-AERO-ADD
Mr. Bacchus, R-AERO-ADD
Mr. Jump, R-AERO-ADS
Branch Reserve File, R-AERO-AD (5)
Mr. Unger, DAC
Mr. Rawls, CCSD

20.0 INTERFACE CONTROL

20.A.2-3 J-2/S-IVB Interface

Comments and Corrections made to drawings 13M20102 and 13M50106

1) Changed view - Cross section DAC Thrust Casting
2) Table IV Item 12 — SPT I.D. 3.00 was 3.18
3) Table IV Item 3 and 4 — SEAL I.D. 8.304 was 8.070 / 8.060

Drawings containing the above marked corrections will be returned to MSFC.

20.A.4 Status of Feed Duct Interface

a. DAC will review and describe the leak monitoring problem occurring at the main feed duct interface. (Figure 80)

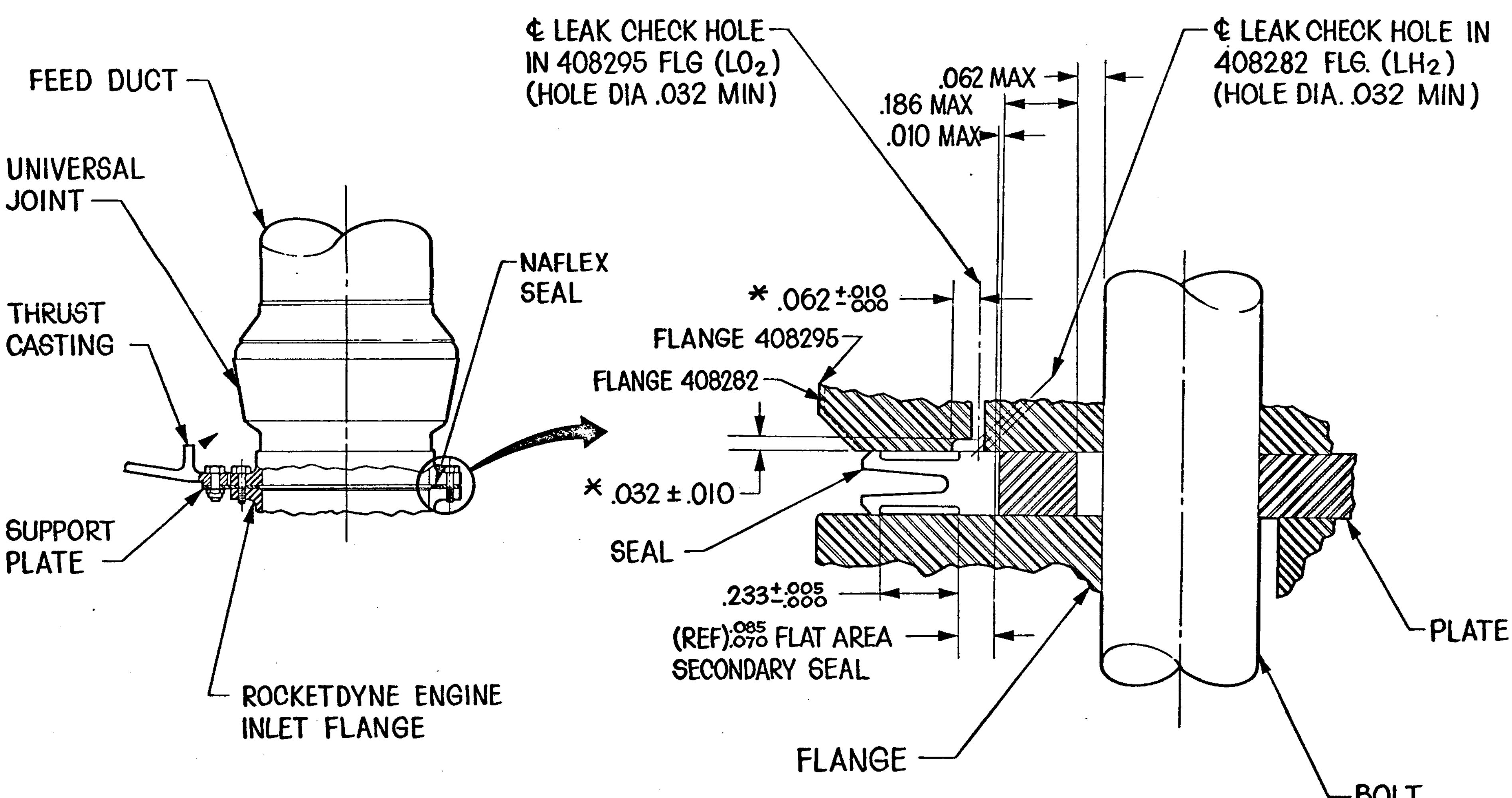
b. DAC will describe the present feed duct interface connection. The support plate used in this connection is a 6AL4V titanium plate.

Concern has been expressed by MSFC as to the use of titanium in this application, due to its impact sensitivity in the presence of oxygen. The Propulsion Branch feels this installation is satisfactory, because of the following reasons:

1. The plate is not in direct contact with the oxygen.

2. The seal separating the plate from the oxygen is a double seal and therefore would take a double failure for the oxygen to contact the plate.

DAC/RKD PROPELLANT FEED DUCT INTERFACE CONNECTION



* NEW SEAL (VD-261-0040-0008) & PROPOSED CUTOUT IN FLANGES

FIGURE 80

3. In the event the plate was exposed to concentrated oxygen, it would then take an ignition source (such as impact or fresh rupture) to cause a reaction.

The original engineering release of the back-up plate called for the material to be 301 stainless steel, 1/2 hard minimum. Due to material availability and schedules, inconel 718 was substituted. Subsequently, another material substitution was made because our manufacturing had difficulty machining the inconel 718. The drawing was changed to call out 6A14V titanium sheet which is presently being used in Battleship and vehicle installations.

20.C.1 (a), (b), and (c) S-IVB/S-IB Interstage Seal

Slide fastener type seals will be incorporated between the Saturn IB aft interstage aft frame and the seal plates forward of the S-IB stage spider beams. See Figure 81. This type of seal was chosen to accommodate both large deflections and reasonably large tolerances for installation. Chrysler has calculated approximately a .58 inch seal plate deflection at mid span between spider beams for a 3.0 psi pressure differential. The seal will accommodate approximately a 1.0 inch deflection at mid span. Seal material is nitrile rubber over nylon. Douglas will supply the seals and retainers. Removal of a seal plate does not require removal of any additional fasteners other than already provided by Chrysler. Actuation of the slide fastener separates the seal plate from the interstage.

Each of the eight seal segments will require 32 attachments to the adjoining seal plate and will utilize 4 existing attachments. Each segment will also require adding approximately 14 attachments to the fixed plates over the spider beams.

Drawings showing the seal installation will be sent to MSFC for transmittal to Chrysler as soon as they are available.

S-IB/S-IVB INTERFACE SEAL

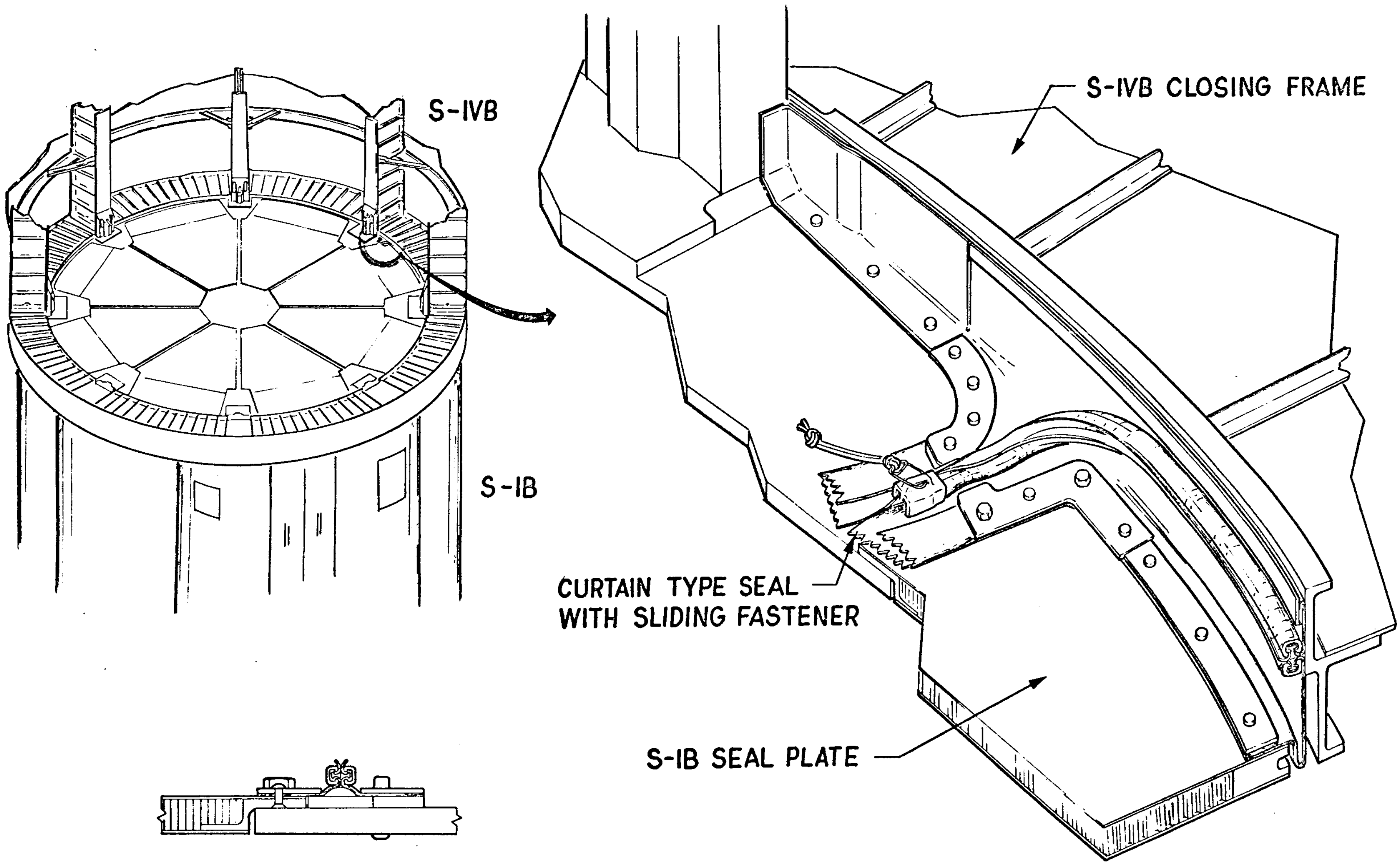


FIGURE 81

HANDOUT FOR 6th VMDIWG

Status report on allowable leakage studies for the S-IVB aft skirt and aft interstage for Saturn V.

1. Presently, the S-II/S-IVB interstage compartment pressure history is based on the following criteria as presented in M-AERO-A-89-63.

a. S-IVB Aft Skirt

(1) No drain holes
(2) 15 sq. in. leakage area @ Sta. 2772

b. S-IVB Aft Interstage

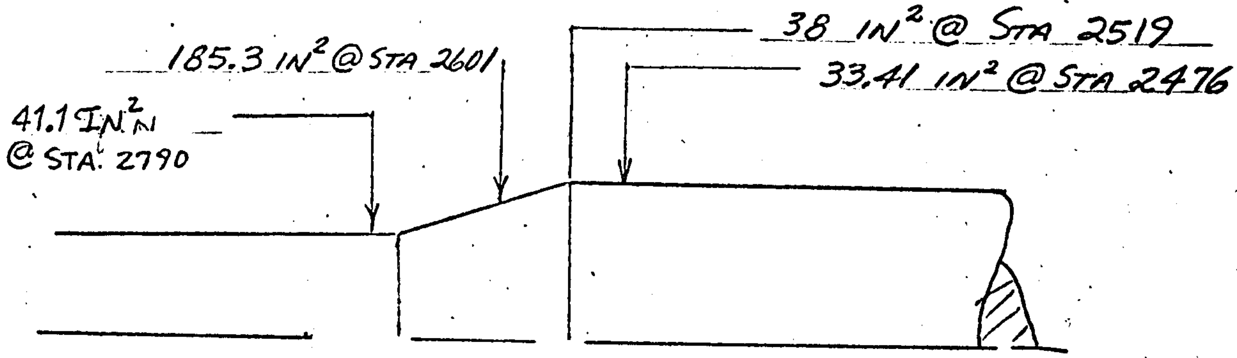
(1) No drain holes
(2) No leakage
(3) 160 sq. in. of prescribed vent area @ Sta. 2601

c. S-II Forward Skirt

(1) 15 sq. in. drain holes @ Sta. 2389
(2) 15 sq. in. of leakage area @ Sta. 2476

2. Results for the above assumptions are presented in M-AERO-A-89-63 yielding a maximum compartment pressure histroy along with a minimum compartment pressure history and will be used as a basis for comparison.

3. The general effect of leakage in the interstage region will be to reduce the internal pressure, thus, increasing the crushing load on the S-IVB aft skirt and aft interstage. The following sketch depicts the model employed at MSFC for this study.



The leakage areas indicated in the above sketch represent the various leakage areas for each section as presented by R-P&VE-VOR-64-100, and are concentrated at the four (4) indicated locations for calculation purposes. By assuming the maximum leakage throughout the interstage in an attempt to survey the overall effects, the following information was obtained:

a. Internal pressure dropped approximately .25 p.s.i. at some time points.

b. In-flow occurred through the S-IVB aft skirt and for a short time through the 160 sq. in. venting ports.

The effect of in flow into the compartment is being studied by Mr. Helms, R-P&VE-PTP.

Since in flow did occur for the maximum leakage condition, it was necessary to investigate the internal pressure history assuming zero leakage through the S-IVB aft skirt as an attempt to create even lower values of internal pressure. Results of this study indicated that the internal pressures were essentially unchanged by changing leakage through the S-IVB aft skirt.

4. Pending the acceptability of mass in flow through the S-IVB aft skirt and the capability of the S-IVB aft skirt and aft interstage to withstand an additional .25 p.s.i. crushing pressure, it appears that there may be no requirement for sealing the components to values

below those indicated. If mass flow cannot be accepted, sealing will be required. If the increased crushing load cannot be accepted the areas to be sealed will have to be in the S-II forward skirt area or a combination of S-II forward skirt sealing plus reducing the specified venting area. Work is continuing at MSFC to study the effect on internal pressure and mass in flow for sealing the S-II/S-IVB interface since this location is in a very low pressure region.

20 a (1)

OPERATION OF THE FLOW RATE

AND

TURBOPUMP SPEED

SIGNAL CONDITIONING SYSTEM

L. P. Morata, Chief
Electronic Design Section
Astrionics Branch

APPENDIX X

The signal conditioning for the J2 Engine LH_2 and LOX pump speed and flow measurements consist of frequency division shaping and summing into a signal compatible with FM system frequency response requirements. The speed frequency output is divided by 16 and the flow frequency output is divided by 8. The frequency divided outputs are summed in a pulse forming network providing a 2.75 volts positive going pulse riding on top of 2 volts DC bias for the speed output and 1.5 volt negative going pulse riding on top of the 2 volt bias for the flows. Exact coincidence of a flow and speed pulse results in a positive going pulse about .75 volts high. The calibration oscillators provide pulse outputs with waveform similar to the transducer output at frequencies of 5 $\pm$ 1 khz for the speeds and 250 $\pm$ 100 hz for the flows.

The calibration oscillators are an integral part of the signal conditioning modules. The calibration oscillators will, upon command from the RACS, provide checkout signals to verify the integrity of the transducer and signal conditioning network. The original method consisted of coupling the checkout signal to the telemetry coil by means of transformer action between the two windings on the transducer for all engine flow and speed measurements. By direction of change order 168, the method of inserting a checkout signal into the speed transducer was modified by inserting the signal in series with the telemetry coil, thereby freeing the checkout coil for use with the GSE engine overspeed equipment. The method of checkout for the flow measurements was not changed.

Vehicle wiring was modified by connecting the checkout coil to a disconnect plug so that a drag-in cable could be connected to the transducer from the GSE overspeed equipment. During flight operation and at other times when the GSE overspeed equipment is not used, the checkout coils are terminated in 2 K load resistors to insure proper operation of the checkout circuit. These resistors are contained in the back shell of a connector which is disconnected when GSE overspeed equipment is used.

To provide a calibration signal to the transducer a command must be received from the RACS. The checkout oscillators for the speed measurements have dual switching transistors to initiate operation of the oscillator. If no RACS command is present, simultaneous failure of both transistors must occur before the oscillator will operate.

In summary, the flow rate and turbopump speed signal conditioning system meets with the requirements of change order 168 (Douglas Scope Change 1203) and provides a reliable method for insuring that a calibration signal cannot be generated in the absence of an RACS command.

FORM 25-S-1
(REV. 8-53)

PREPARED BY: R.D. Heuerman

CHECKED BY: ____

DATE: 8-26-64

DOUGLAS AIRCRAFT COMPANY, INC.

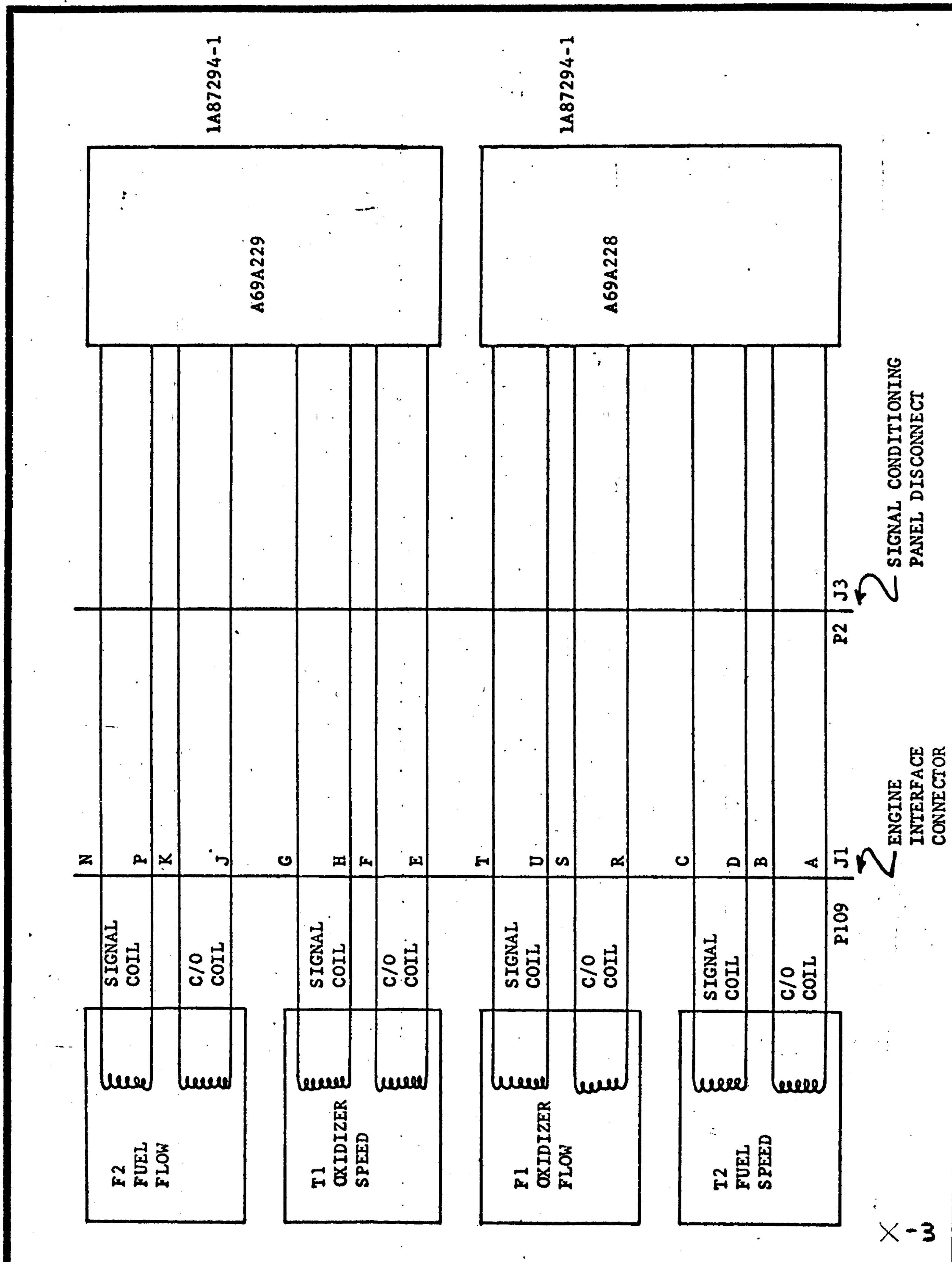
M S S DIVISION

PAGE: ____

MODEL: DSV-4B

REPORT NO.: ____

TITLE: SIMPLIFIED DIAGRAM - ORIGINAL FRATS WIRING



X-3

M 25-5-1
V. 8-53)

PREPARED BY: R.D. HEUERMAN

DOUGLAS AIRCRAFT COMPANY, INC.

PAGE:

CHECKED BY:

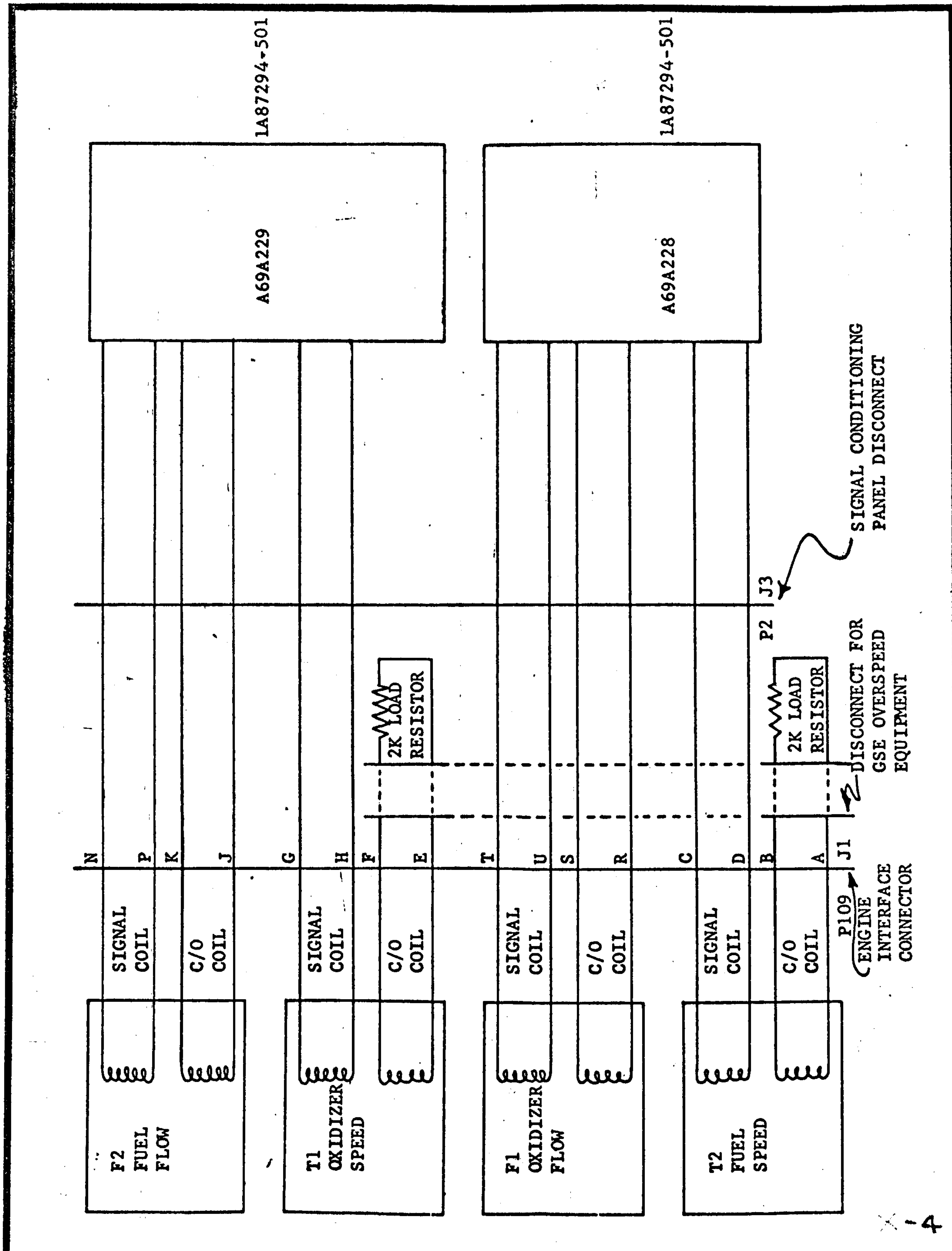
DIVISION

MODEL: DSV-4B

DATE: 8-26-64

TITLE: SIMPLIFIED DIAGRAM- FRATS WIRING AFTER C.O. 168

REPORT NO.:



X-4

FORM 25-S-1 (REV. 8-53)

PREPARED BY: R. D. Heuerman

DOUGLAS AIRCRAFT COMPANY, INC.

PAGE: —

CHECKED BY:

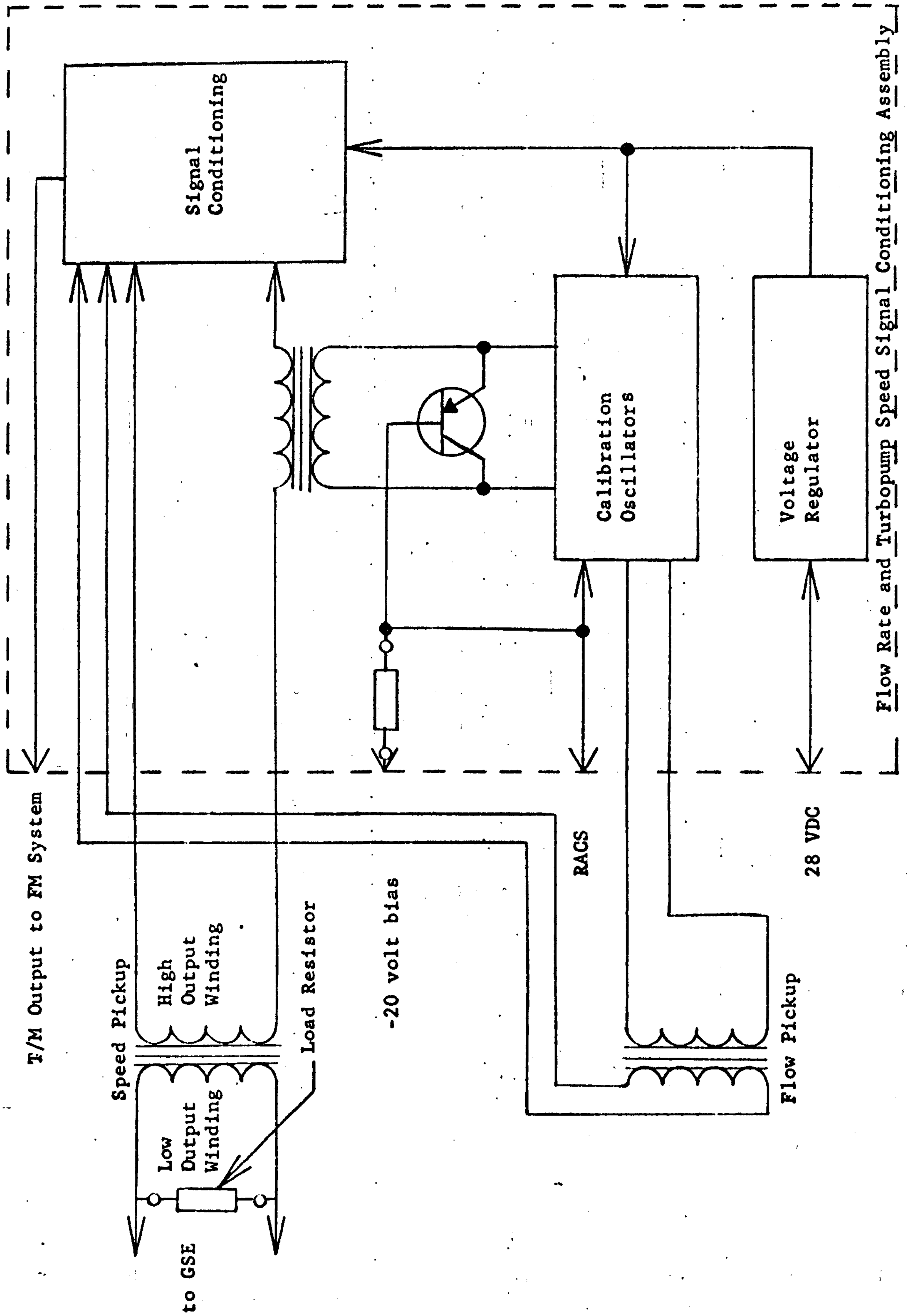
M S S DIVISION

MODEL: DSV-4B

DATE: 8/20/64

REPORT NO.: —

TITLE: SIMPLIFIED DIAGRAM OF FLOW & SPEED SIGNAL CONDITIONING



SIMPLIFIED DIAGRAM OF FLOW AND SPEED SIGNAL CONDITIONING AFTER CHANGE ORDER 168

X-5

K+E ALBANENE® LA 0947 TRACING PAPER

S-IVB STAGE

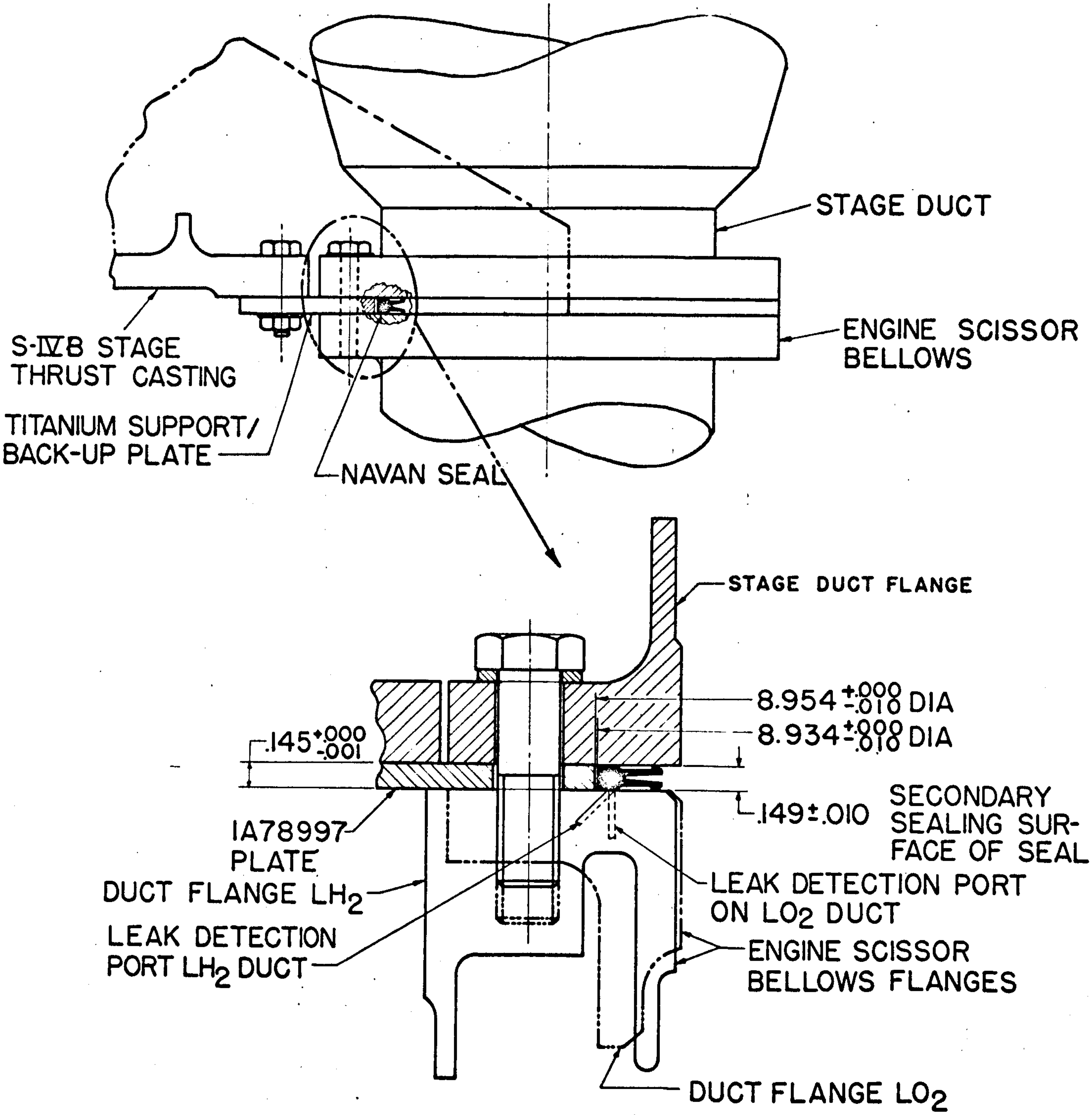
SUCTION DUCT

SUPPORT

R-P&VE-VSA
SK10-1749

APPENDIX Y

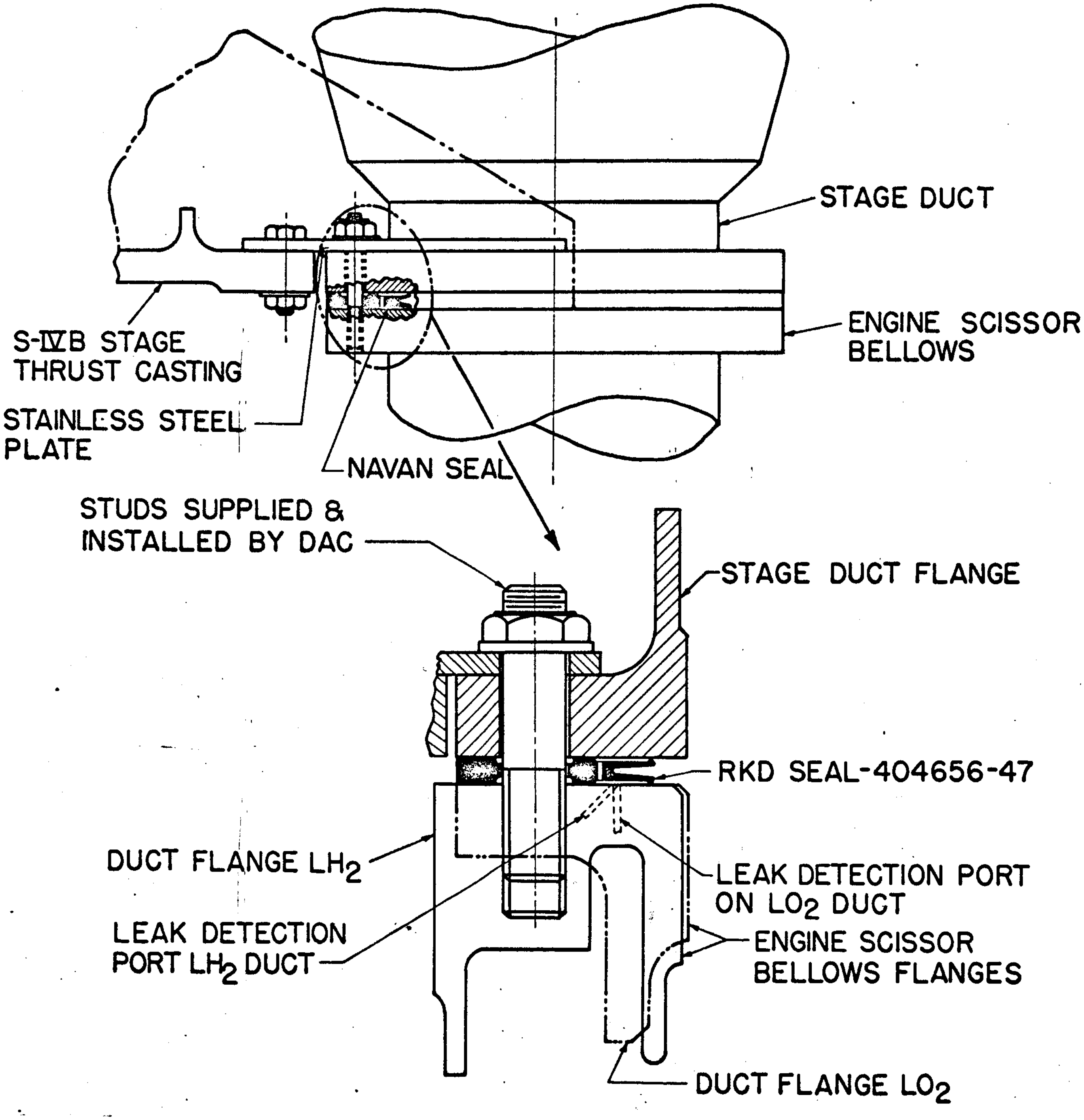
DAC EXISTING SUPPORT CONFIGURATION



R-P&VE-VSA
SK10-1749

Y-2

MSFC PROPOSED SUPPORT CONFIGURATION



R-P&VE-VSA
SK10-1749

Y-3

TOLERANCE CONDITIONS
DAC SUPPORT PLATE/SEAL

BASIC THICKNESS:	SEAL	$.149 \pm .010$
	SUPPORT PLATE	$.145^{+.000}_{-.001}$

CONDITION I:

SEAL: NOMINAL	.149
SUPPORT PLATE NOM.	.145
	$\Delta T = .004$

RESULT: LOOSE FIT BETWEEN SUPPORT PLATE AND DUCT FLANGES.

CONDITION II:

SEAL: PLUS TOL.	.159
SUPPORT PLATE: MINUS TOLERANCE	.144
	$\Delta T = .015$

RESULT: LOOSE FIT BETWEEN SUPPORT PLATE AND DUCT FLANGES.

CONDITION III:

SEAL: TOLERANCE	.139
SUPPORT PLATE NOM.	.145
	$\Delta T = .006$

RESULT: LOSS OF SECONDARY SEAL AND EXPLOSIVE HAZARD.

R-P&VE-VSA
SK10-1749

TOLERANCE CONDITIONS
DAC SUPPORT PLATE/SEAL

CONDITION IV:

SEAL: TOLERANCE .139
SUPPORT PLATE: NOM.
PLUS ALLOWABLE WAVI-
NESS TOLERANCE (.004) .149
$\Delta T = .010$

RESULT: LOSS OF SECONDARY SEAL
AND EXPLOSIVE HAZARD.

R-P&PE-VSA
SK10-1749

CHANGES REQUIRED BY MSFC CONFIGURATION

I. MACHINE SURFACE ON THRUST CASTING SUPPORT ARMS.

II. REDESIGN EXISITING SEAL.

III. CHANGE SUPPORT PLATE MATERIAL AND CONFIGURATION.

IV. REPLACE BOLTS WITH STUDS.

REFERENCES:

MEMO R-P&VE-PMD-64-M-34, APR. 2, 1964
MEMO R-P&VE-VJ-64-236, APR. 21, 1964
MEMO R-P&VE-VSA-64-388, JUN. 5, 1964
MEMO R-P&VE-PA-64-M-1058, JUL. 22, 1964
MEMO R-P&VE-VSA-64-485, AUG. 3, 1964

P-P&VE-VSA
SK10-1749

Y-6

APPENDIX Z

MECHANICAL INTERFACE CONTROL (IC) PROGRAM OBJECTIVES

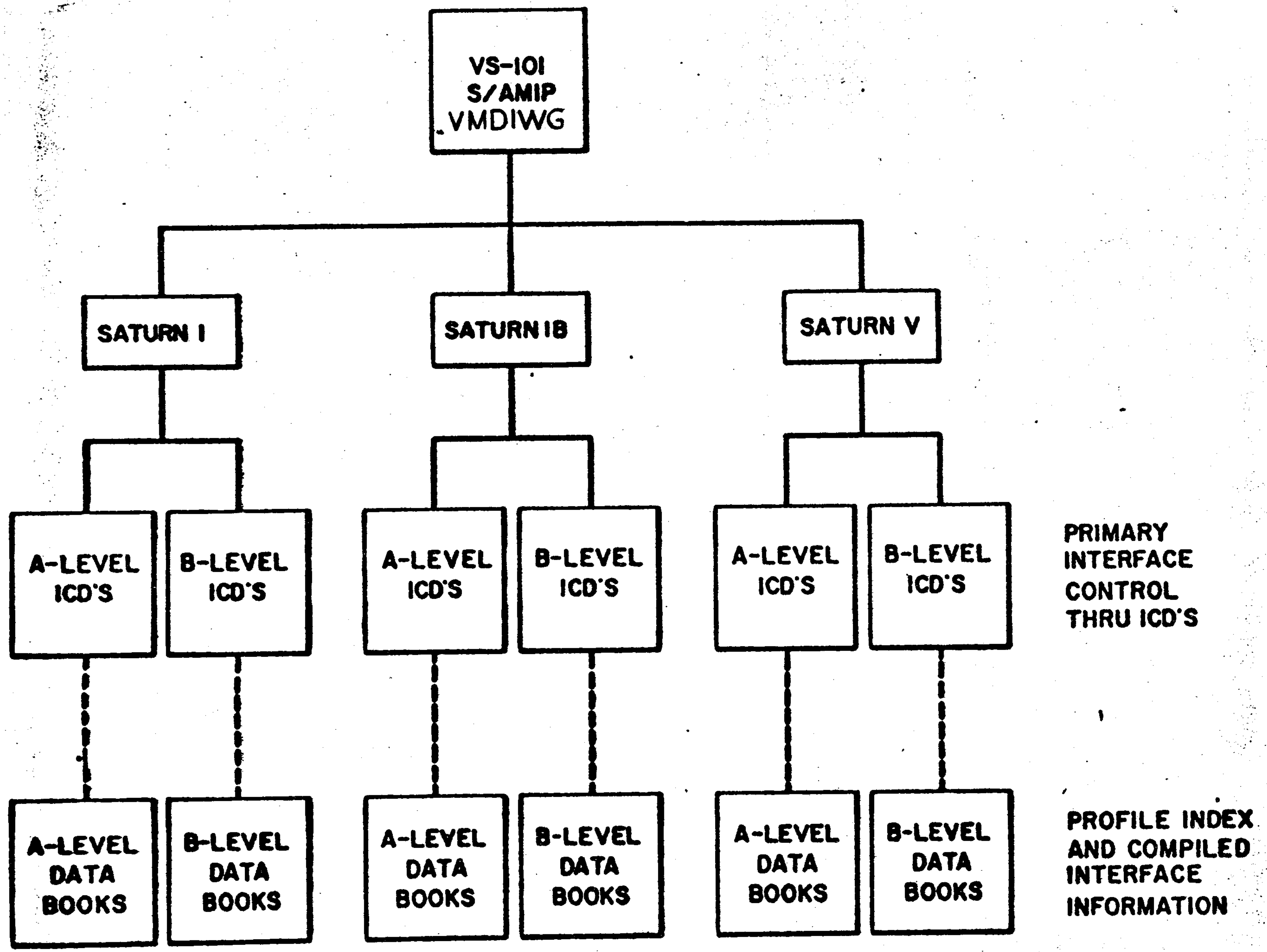
1) AID & ASSIST DESIGN

2) PROVIDE MANAGEMENT TOOL

3) CONTROL

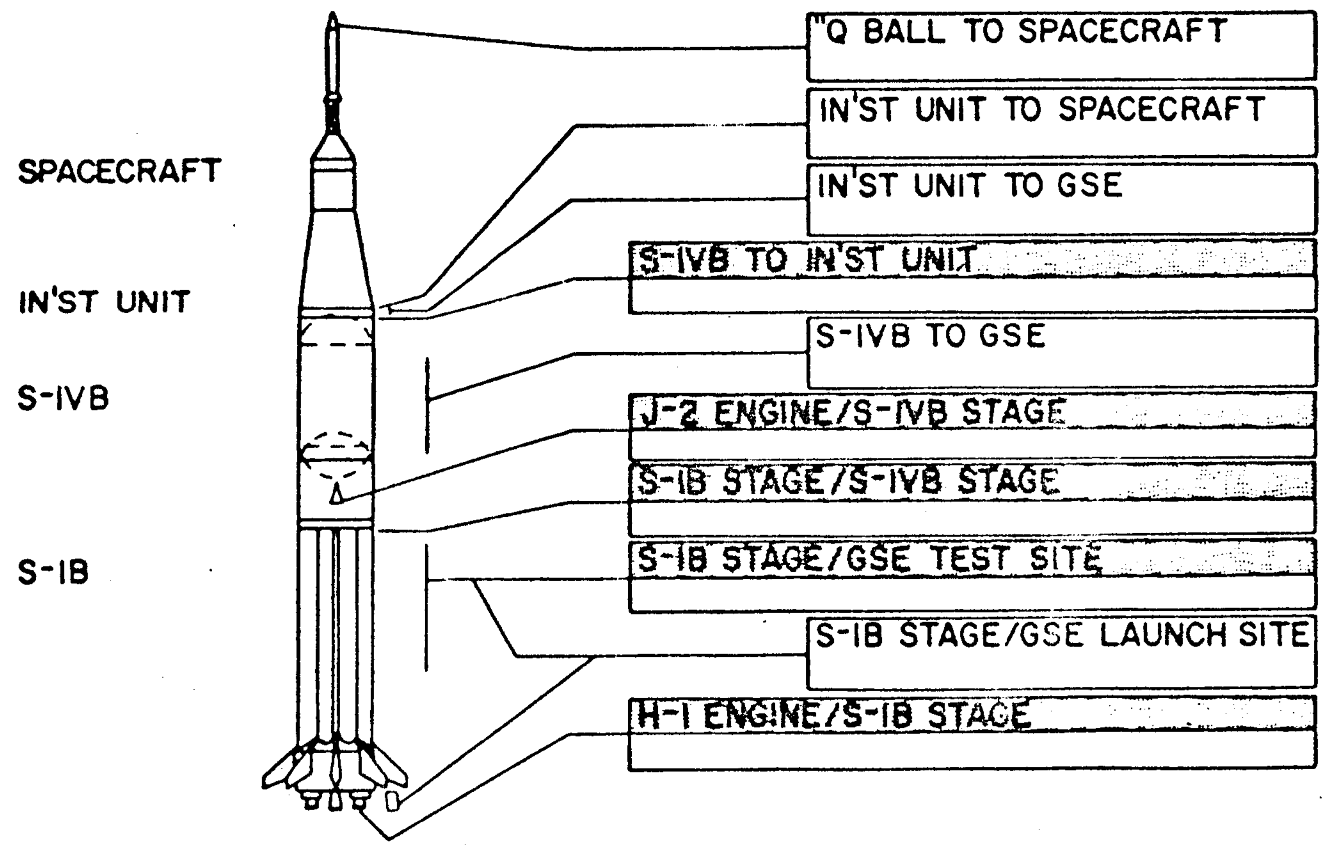
   a) DESIGN COMPATIBILITY OF INTERFACE

   b) DESIGN CRITERIA


VS-101
S/AMIP
VMDIWG
SATURN I
SATURN IB
SATURN V
A-LEVEL ICD'S
B-LEVEL ICD'S
A-LEVEL DATA BOOKS
B-LEVEL DATA BOOKS
PRIMARY INTERFACE CONTROL THRU ICD'S
PROFILE INDEX AND COMPILED INTERFACE INFORMATION

R-P&VE-VSI 4-64

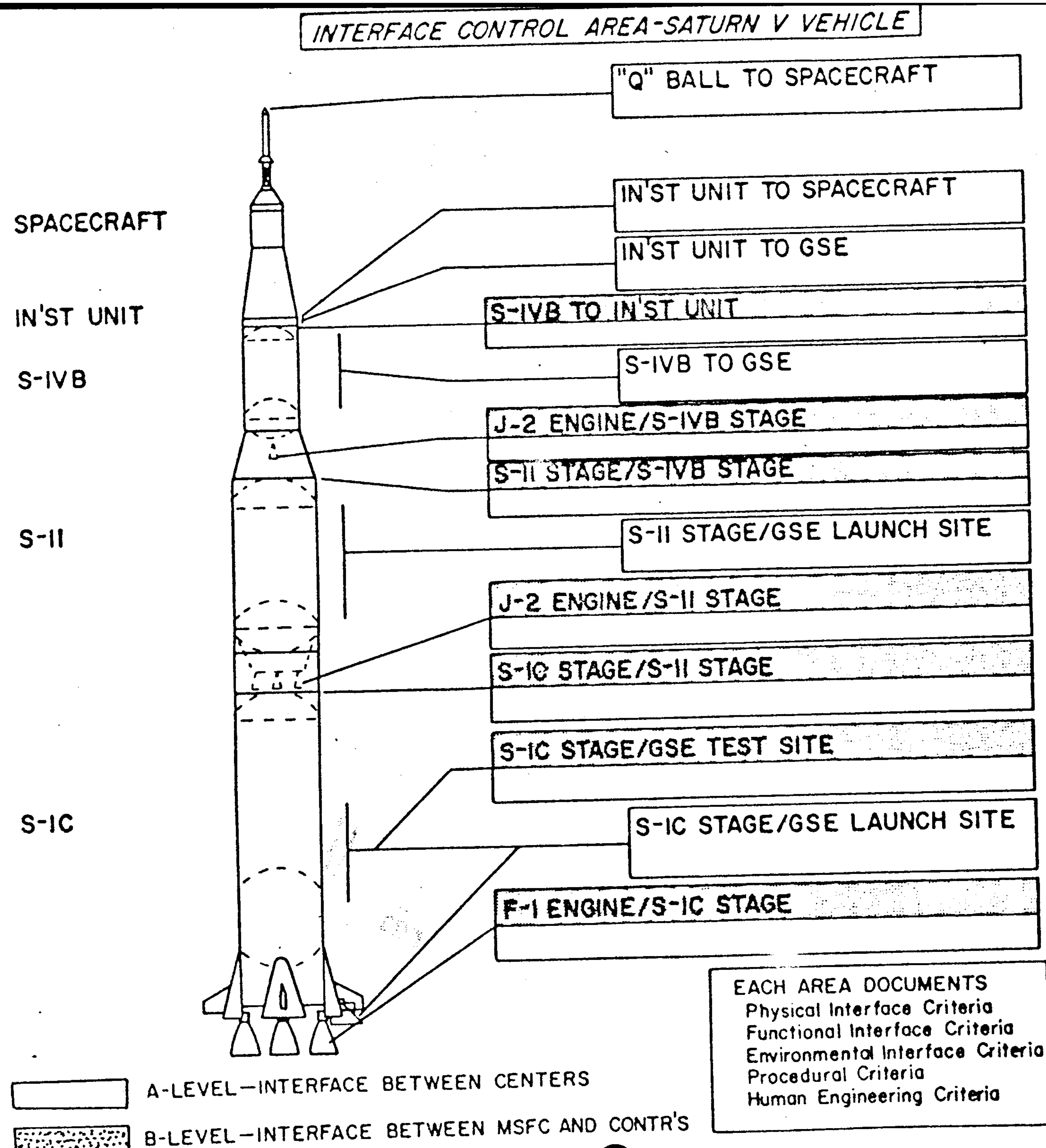
INTERFACE CONTROL AREA-SATURN IB VEHICLE



EACH AREA DOCUMENTS
- Physical Interface Criteria
- Functional Interface Criteria
- Environmental Interface Criteria
- Procedural Criteria
- Human Engineering Criteria

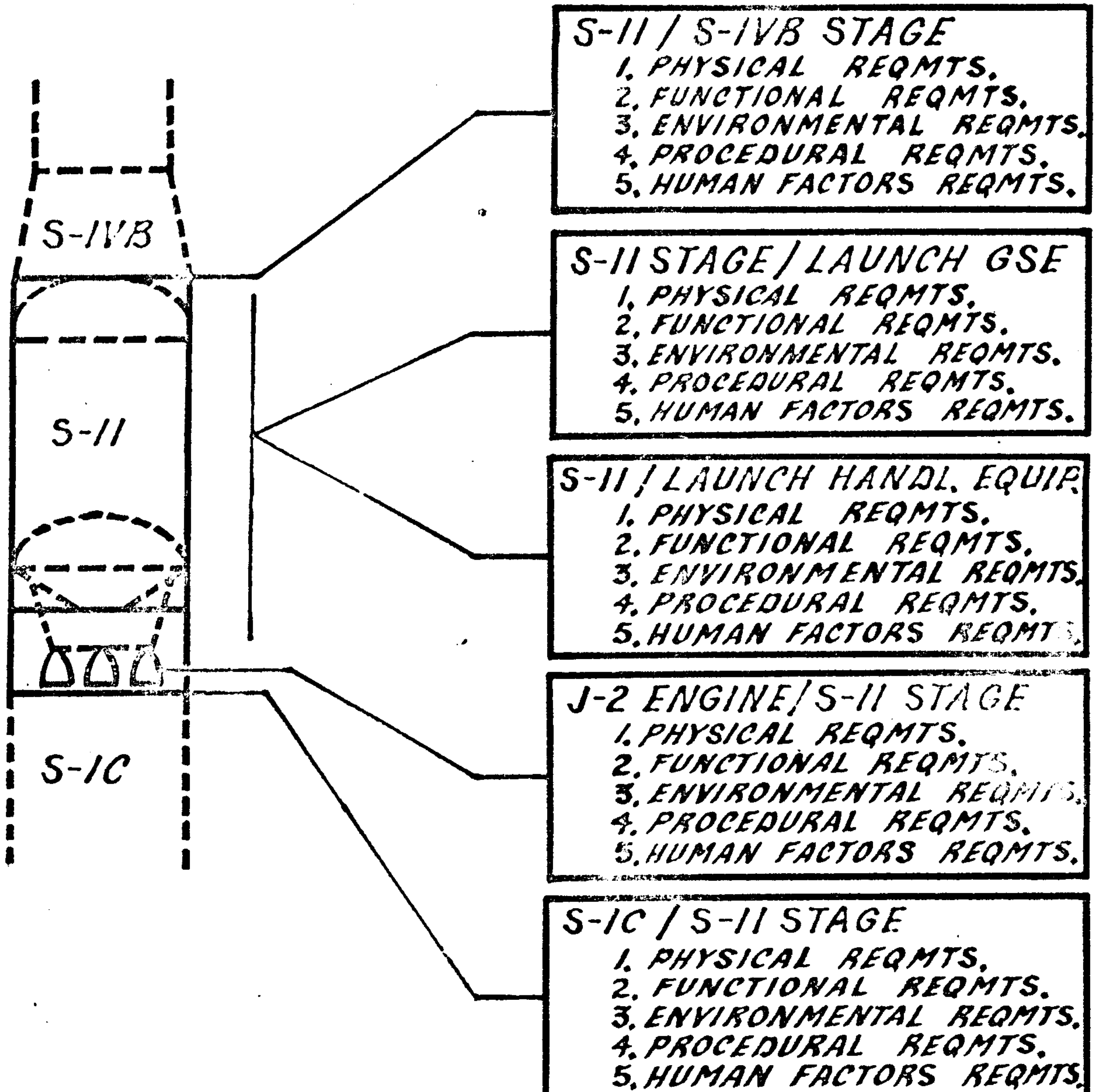
A-LEVEL — INTERFACE BETWEEN CENTERS

B-LEVEL — INTERFACE BETWEEN MSFC AND CONTRACTORS



R-P & VE-VSI 12-63

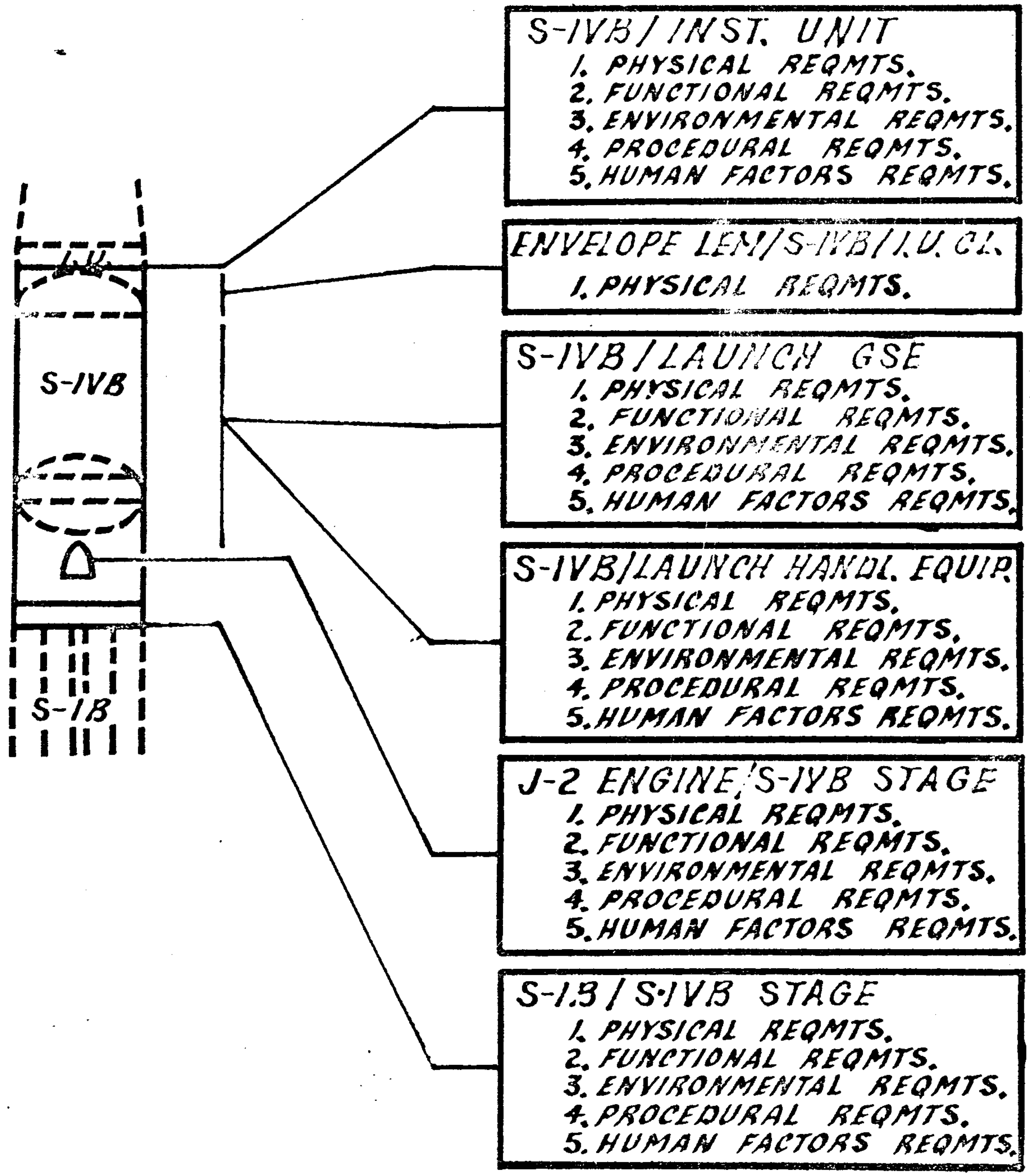
S-II INTERFACE CONTROL AREAS - SATURN V. VEH.



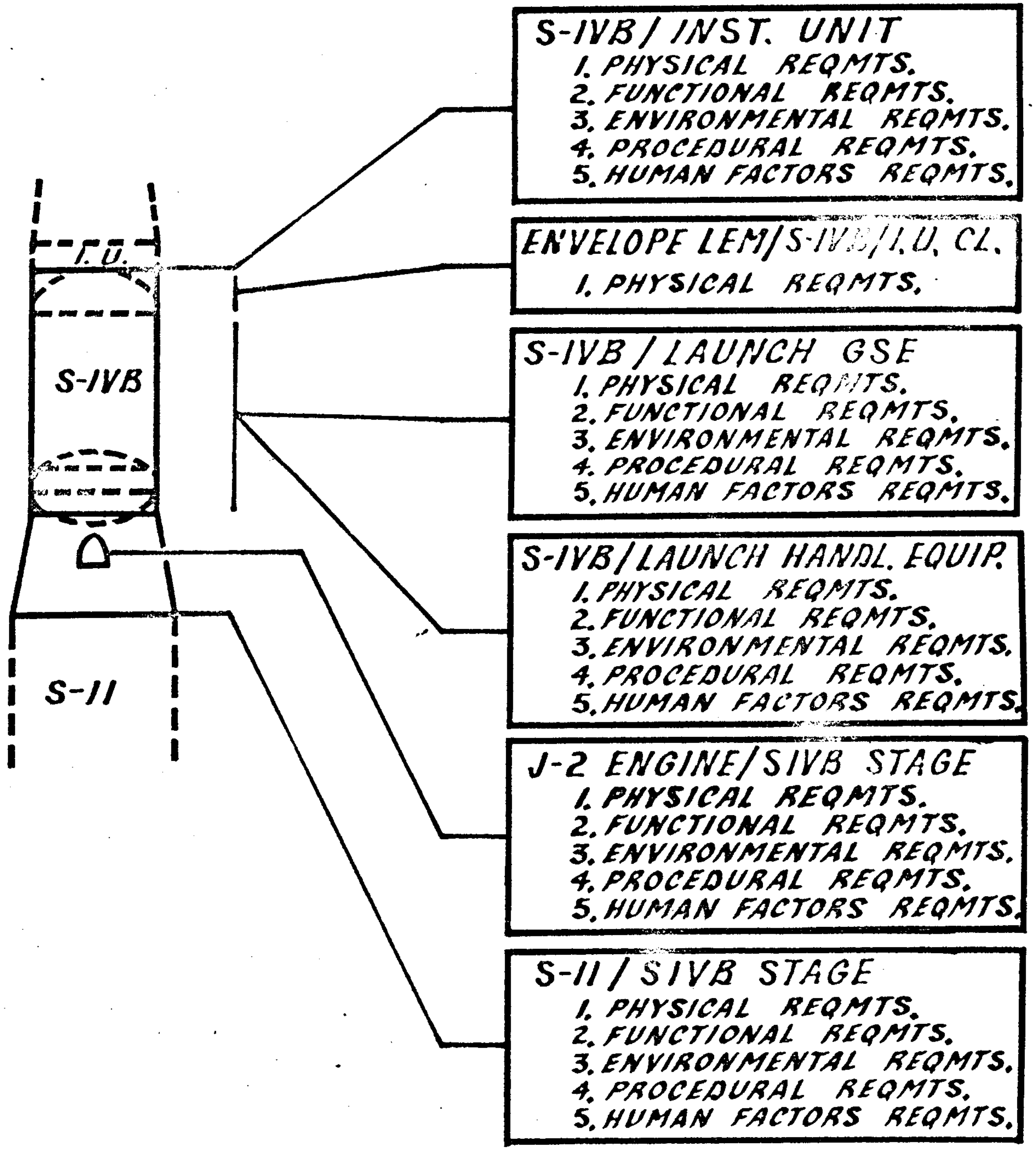
Z-5

R-P&VE-VSI

S-IVB INTERFACE CONTROL AREAS - SATURN IB. VEH.



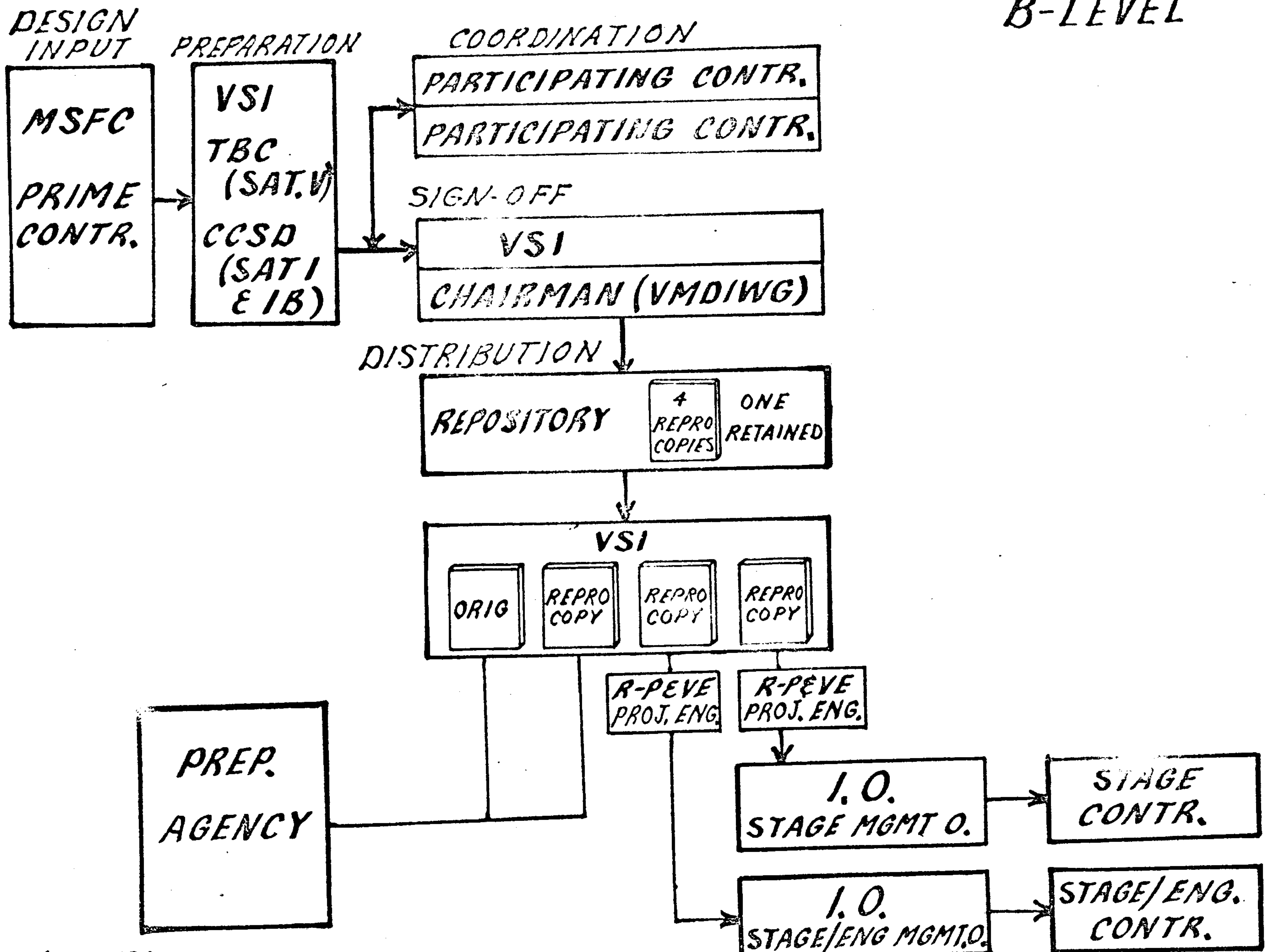
S-IVB INTERFACE CONTROL AREAS - SATURN V. VEH.



R-P&VE-VSI

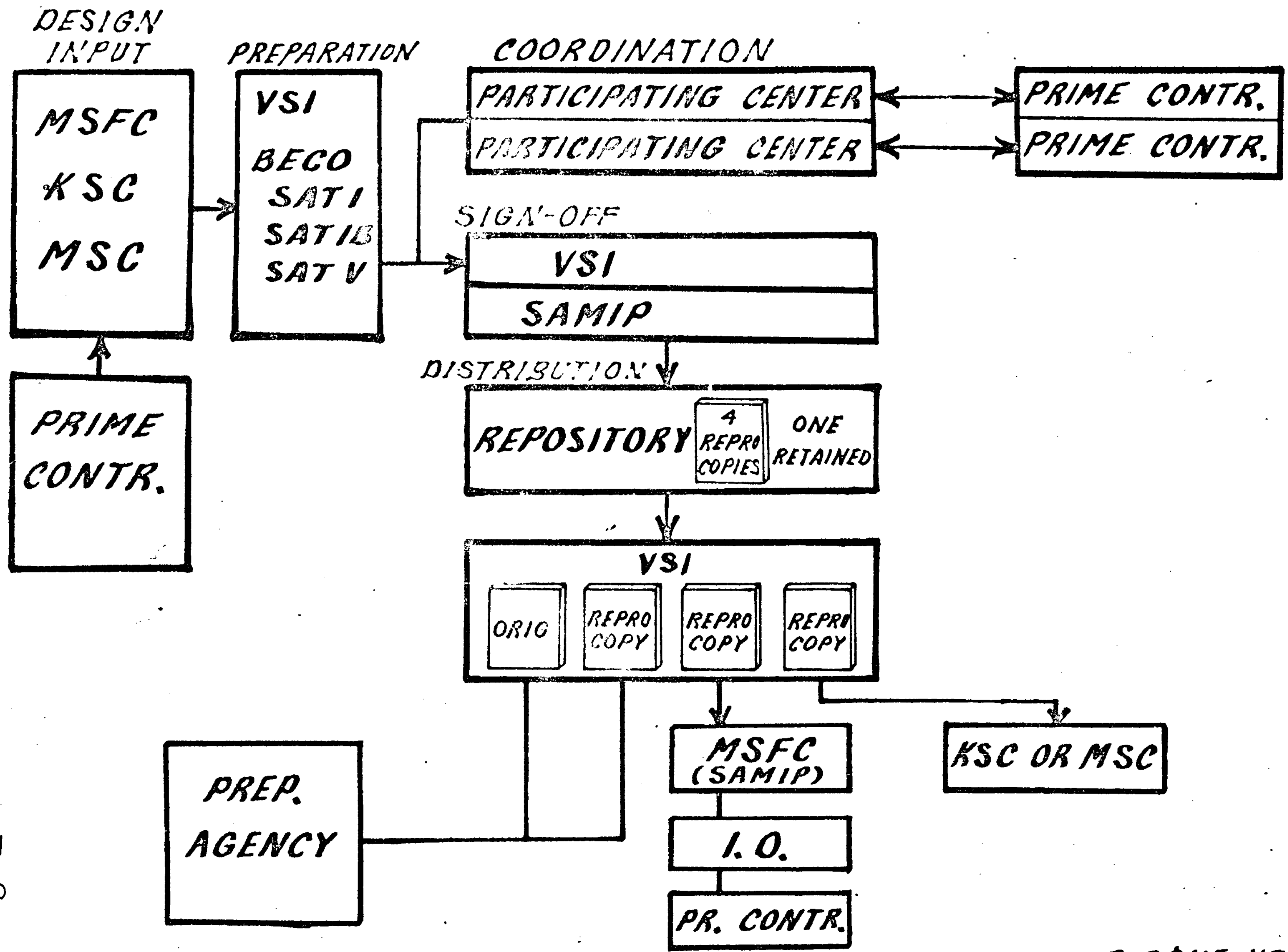
ICD PREPARATION & SUBMITTAL

B-LEVEL



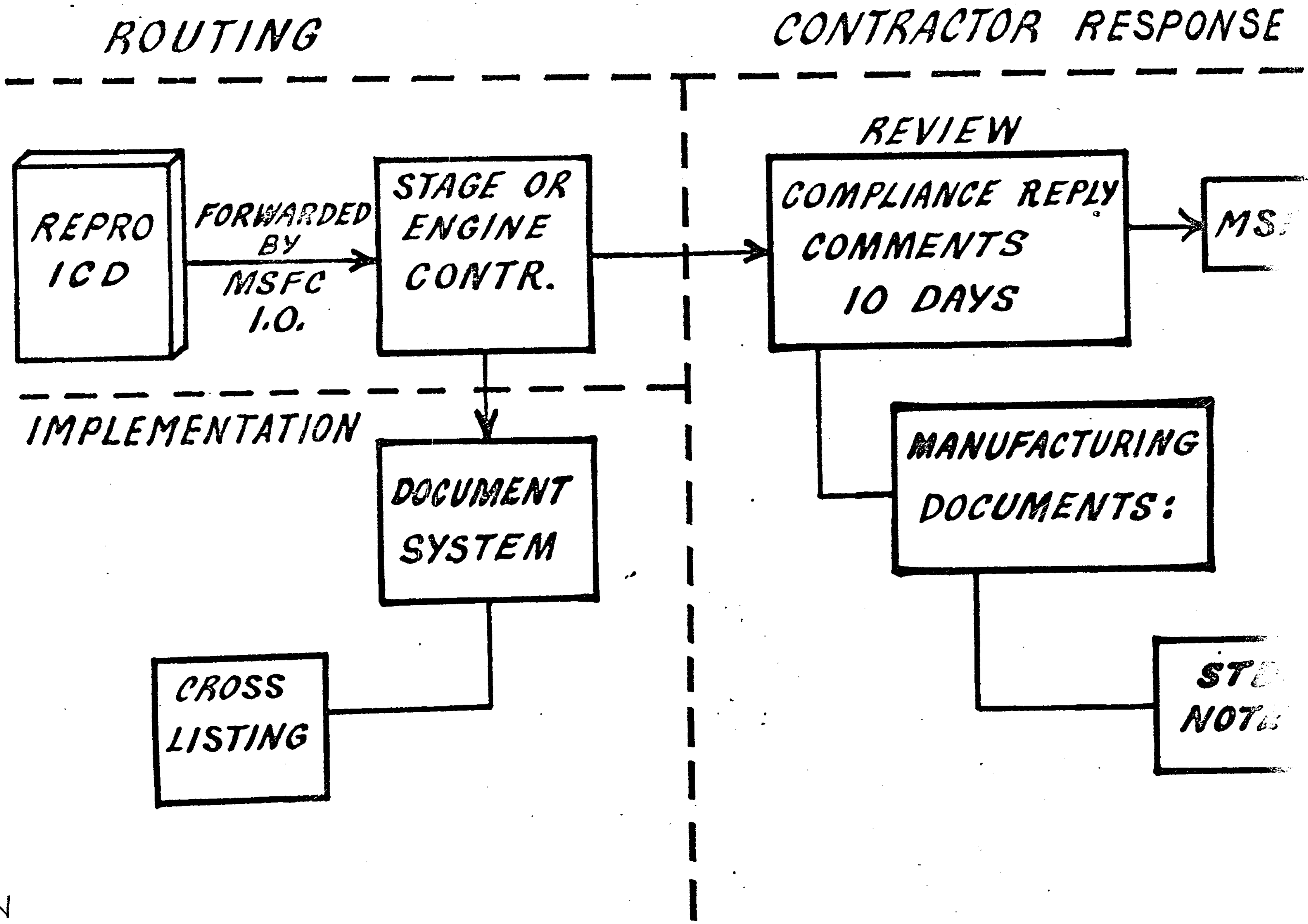
R-P&VE-VSI

ICD PREPARATION & SUBMITTAL A-LEVEL



R-P&VE-VSI

CONTRACTOR ACTIVITY



R-PE

Interface Control

Agenda Item

20c.(1)a DACO Layout 1B38962 was reviewed by Mr. Bob Walters and Bill Cobbs of Structures and by Mr. Lawson of Interface Engineering. A reproducible of the layout was supplied to B. E. Lawson for MSFC use in coordinating with Chrysler Corporation. Space Division (CCSD). The method of attaching the seal to the seal plate must have CCSD and R-P&VE-VSA approval.

20c.(1) b. and c. This item is covered by the DACO Layout 1B38962 listed above

20c(2) a and b. DACO (Mr. Zakian) supplied sketches to Mr. B. E. Lawson which will satisfy these items.

20c.(3) Action Item Required

4103

DAC will supply R-P&VE-VSA with a layout showing the bracket design and location for electrical connector number 9 at the S-IB/S-IVB interface. DACo will also specify the length of cable required from the dACo bracket to the CCSD splice plate. Due Date Sept 15, 1964.

20c.(4) Separation Installation Drawing 1A49540-1 will be released by Sept 15, 1964.

Retro Installation Drawing 1B28933-1 will be released by Oct 31, 1964.

20C.(4) DACo (Mr. Zakian) supplied sketches to B. E. Lawson specifyint the cable length from the EBW Boxes and Pulse Sensors to the S-IB pierce points. Copies will be given to R-P&VE-VSA so that they may supply CCSD the cable length requirements.

20c.(5) DACo (Mr. Bryant) supplied B. E. Lawson a sketch which satisfies this item.

20c.(6) This item was satisfied in discussion with K. Berline, T. J. Quintana of DACo and B. E. Lawson of R-P&VE-VSI

20d.(1) ACTION ITEM REQUIRED
DACo will supply R-P&VE-VSA with a layout showing the bracket design and location for the separation and retro-rocket measurements cable connector at the S-II/S-IVB Interface connect point. DACo will also specify the length of cable required from the DACo bracket to the NAA (S&ID)/DACo interface field splice at station 2519. Approximate angular location of 68° off Pos I toward Pos II. Due Date Sept 15, 1964.

APPENDIX AA

20d. (2) Firing Unit Installation (Retro) Dwg 1A49621 is released
" " " Separation Dwg 1A49566 is released
Pulse Sensor Installation Dwg 1A81163 is released
" " Cable Instal. Dwg 1B36010 will be released Sept 11, 1964
DACo letter number A3-130-4.43.8-L-1441 dated August 13, 1964 specifies the cable lengths as requested by R-P&VE-VSA-64-202

20(d)(3) Same as 20c(5)

AA-2

21.0 CONFIGURATION LIST (SATURN IB/V)

Configuration Lists for the vehicle will be prepared as follows:

a.	Vehicle 1st issue	80 calendar days prior to shipping from A3
b.	Vehicle 2nd issue	15 calendar days prior to shipping from A3
c.	Vehicle 3rd issue	15 calendar days after shipping from A45
d.	Vehicle 4th issue	30 calendar days prior to launch

Schedule

Stage No.	Vehicle No.	1st Issue	2nd Issue	3rd Issue	4th Issue
S-IVB-D	Dynamics (IB & V)	9-14-64	11-18-64	-	-
S-IVB-A/S	All-Systems (IB & V)	11-24-64	1-28-65	-	-
S-IVB/IB-1	SA-201	1-5-65	3-11-65	7-30-65	10-15-65
S-IVB/F	SA-500F	1-19-65	3-25-65	-	-
S-IVB/IB-2	SA-202	3-30-65	6-3-65	10-29-65	1-15-66
S-IVB/IB-3	SA-203	6-22-65	8-26-65	1-28-66	4-15-66
S-IVB/IB-4	SA-204	8-20-65	10-27-65	3-31-66	7-15-66
S-IVB/V-1	SA-501	10-26-65	12-30-65	6-3-66	9-15-66
S-IVB/IB-5	SA-205	12-21-65	2-24-66	7-27-66	10-15-66
S-IVB/V-2	SA-502	2-11-66	4-19-66	9-16-66	1-15-67
S-IVB/IB-6	SA-206	4-5-66	6-9-66	11-2-66	1-15-67
S-IVB/V-3	SA-503	5-24-66	7-28-66	12-22-66	4-15-67
S-IVB/IB-7	SA-207	7-8-66	9-13-66	2-2-67	4-15-67
S-IVB/V-4	SA-504	8-19-66	10-25-66	3-21-67	7-15-67
S-IVB/IB-8	SA-208	9-30-66	12-6-66	4-28-67	7-15-67
S-IVB/V-5	SA-505	11-11-66	1-13-67	6-2-67	10-15-67
S-IVB/IB-9	SA-209	12-13-66	2-16-67	7-7-67	10-15-67
S-IVB/V-6	SA-506	1-16-67	3-22-67	8-11-67	12-15-67
S-IVB/IB-10	SA-210	2-21-67	4-25-67	9-14-67	12-15-67
S-IVB/V-7	SA-507	3-24-67	5-29-67	10-19-67	2-15-68
S-IVB/IB-11	SA-211	4-28-67	6-3-67	11-22-67	2-15-68

Stage No.	Vehicle No.	1st Issue	2nd Issue	3rd Issue	4th Issue
S-IVB/V-8	SA-508	6-2-67	8-7-67	12-28-67	4-15-68
S-IVB/IB-12	SA-212	7-7-67	9-11-67	1-25-68	4-15-68

22.0 SOLID ULLAGE ROCKETS

In order to assure, during the separation that the liquid propellants are settled, solid propellant ullage rocket motors are required.

The parameters related to achieving these results are as follows:

a. The weight of the Saturn IB/S-IVB including its propellants plus the payload was 289,055 lbs.

b. The aerodynamic drag on the Saturn IB/S-IVB and payload during separation of the S-IB stage has been calculated to be 2000 lbs.

c. The required acceleration has been set at .01 g.

d. The duration of thrust, based on time required to start the main engine, is 3.0 sec., minimum.

e. The design provides for a 1 ullage rocket out capability.

f. The thrust vector should pass close to the c.g. of the S-IVB plus payload.

g. The exhaust plume of the solid propellant rockets must not impinge on other components of the stage.

h. The expended ullage rockets should be jettisoned.

i. The ullage rocket motor and the installation must be capable of withstanding flight conditions of temperature, vibration and aerodynamic loading.

Based on S-IV experience, the Thiokol TX-280 rocket motor was tentatively selected and calculations performed to determine its suitability.

Since it had already been established on S-IV that a TX-280 rocket motor mounted in a suitable fairing assembly on the aft skirt of the stage at 35° to the longitudinal centerline would meet the c.g. alignment and exhaust plume impingement requirements, this configuration was analyzed for compatibility with S-IVB requirements.

Calculations of the number of TX-280 rocket motors based on

(a) Axial thrust, $F_A = \left(\frac{W}{g} \times a\right) + \text{drag}$

(b) Total rocket thrust, $F_R = \frac{F_A}{\cos 35°}$ and

(c) Number of rocket required,

$$n = 1 + \frac{F_R}{\text{Min thrust per motor}}$$

$$F_A = \frac{289{,}055 \times .01\ g}{g} + \text{drag}$$

$$= 2900 + 2000 = 4900 \text{ lbs.}$$

$$F_R = \frac{4900}{.819} = 5980 \approx 6000 \text{ lbs.}$$

$$n = 1 + \frac{6000}{3000} = 3$$

On Saturn V, the S-IVB plus payload will weigh approximately 360,000 lbs., and at separation from the S-II stage the drag will be zero.

Scope Change S-IVB-1221 directs the use of two Thiokol TX-280 rocket motors on Saturn V/S-IVB. With one rocket inoperative the acceleration will have a nominal value of .0786 g and a minimum value of .0684 g. This is considered to be adequate. Figure shows the ullage rocket fairing and the locations on the S-IVB stage.

In the installation of ullage rockets, no provision for adjustment in thrust alignment has been made, since during the operation (four seconds) of these relatively low thrust rocket motors, the mass of the S-IVB plus the payload is so great that little effect from misalignment should be expected. The analysis of the magnitude of ullage rocket thrust misalignment possible, due to dimensional tolerances, that was made on the S-IV ullage rockets (Ref. Memo K420-M-164 dated 2-22-63) is directly applicable to both Saturn IB and Saturn V because of the similarity of the geometry and the detail hardware. The only differences are; (1) the larger diameter of the S-IVB (260" instead of 220"), and (2) the number of ullage rockets (4 on S-IV, 3 on Sat. IB/S-IVB and 2 on Sat. V/S-IVB). As shown on Figure 82, the total rolling moment possible from one rocket on the S-IVB increases by 18% over the S-IV due to the larger diameter, but the total rolling moment possible from all rockets reduces by 11.4% for Sat. IB and by 41% for Sat. V, because of the lesser number of rockets used. It should be noted that there are a total of thirteen (13) variables in each of the ullage rocket installations (a total of 39 on Sat. IB/SIVB and 26 on Sat.V/SIVB). The probability of all variables being simultaneously adverse in the same direction can be shown to be too remote to justify providing an adjustment.

The design of the ullage rocket fairing assembly was based on the aerodynamic loading as shown in Figure 83 plus 10 g vibration forces simultaneously along all three axes. Load factors were 1.4 times the ultimate stress except in the case of a casting where 1.1 times yield stress was more conservative. The design results in the estimated weight of the fairing assembly plus the electronic equipment is approximately 42 pounds. The loaded motor weighs 90 lbs and during burning 60 lbs. of propellant are consumed. Therefore, the jettisonable weight when the rocket has fired is 42 + 90-60 = 72 lbs. If the rocket failed to fire, the jettisonable weight would be 132 lbs. As shown in Figure , the centerline of the jettisoning spring is a short distance forward of the c.g. This causes a slight clockwise rotation of the ullage rocket (shown in Figure 84) as the principal jettisoning motion is radially outward from the stage. The approximate 0.7 g acceleration of the vehicle causes the jettisoned ullage rockets to fall behind. The jettison spring (mounted in a housing within the jettisonable fairing assembly) has a spring constant of 257 lb/in ± 5% and a travel of 3 inches. From $K.E. = 1/2\ MV^2$, it can be shown that the minimum jettison velocity of an unfired ullage rocket assembly will be 6.2 ft/sec., and the maximum velocity of an expended ullage rocket assembly will be 9.5 ft/sec. The minimum velocity is adequate to avoid a collision with the main engine nozzle of a maneuvering S-IVB under the most adverse maneuver.

ULLAGE ROCKET AERODYNAMIC LOADING

A = 1,610 #
V = 1,870 #
N = 2,305 #

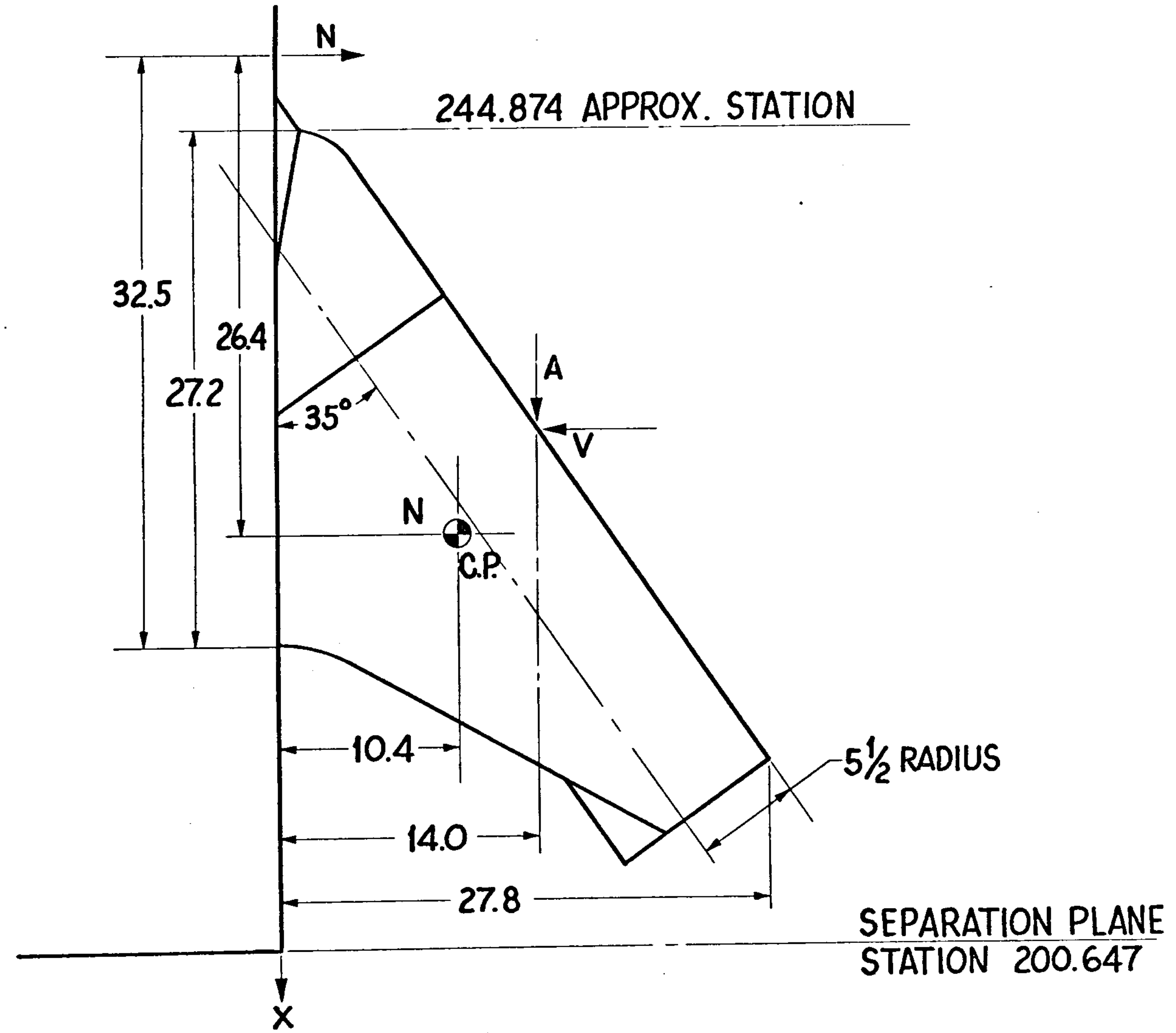


FIGURE 82

ULLAGE ROCKET CONFIGURATION

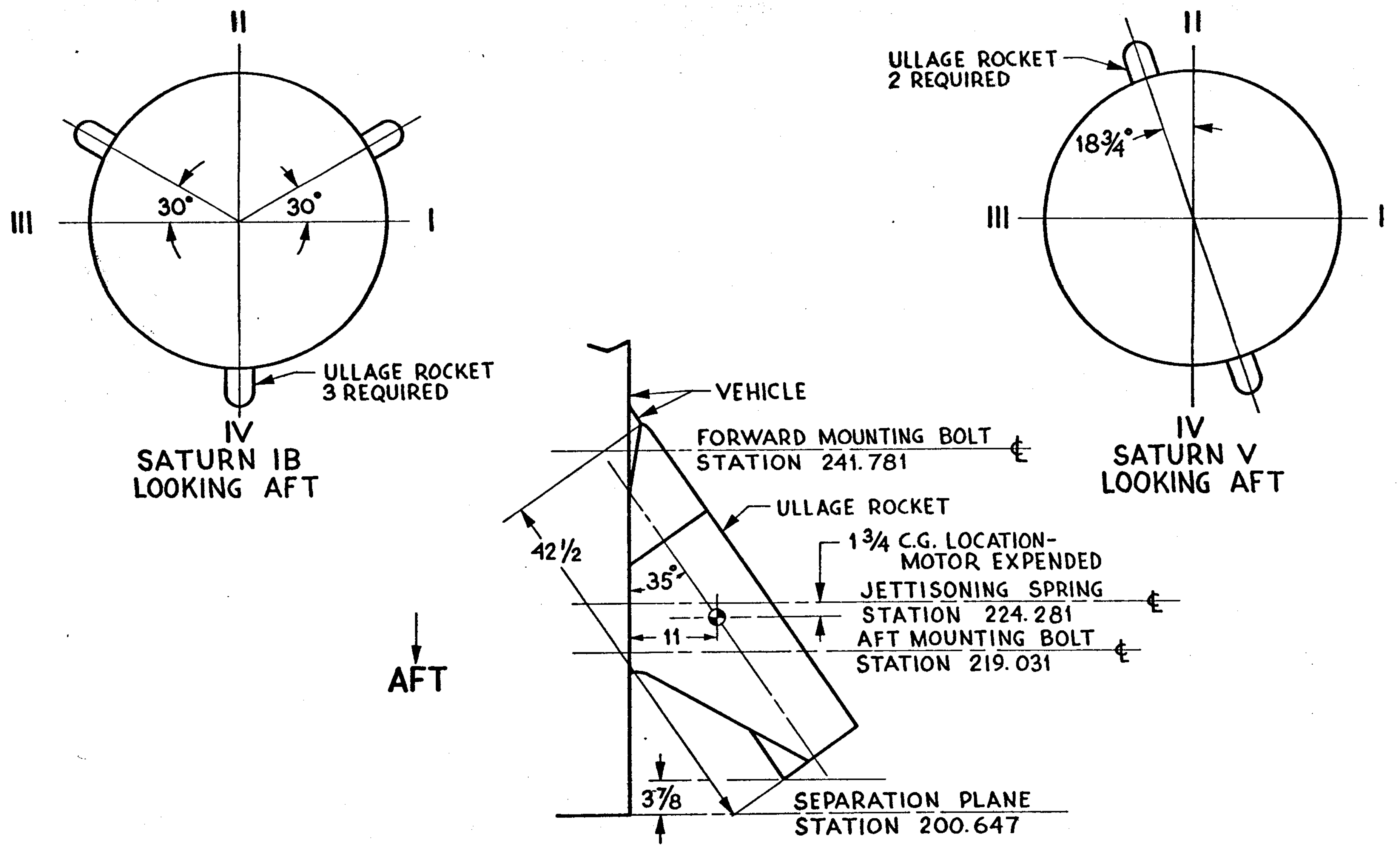
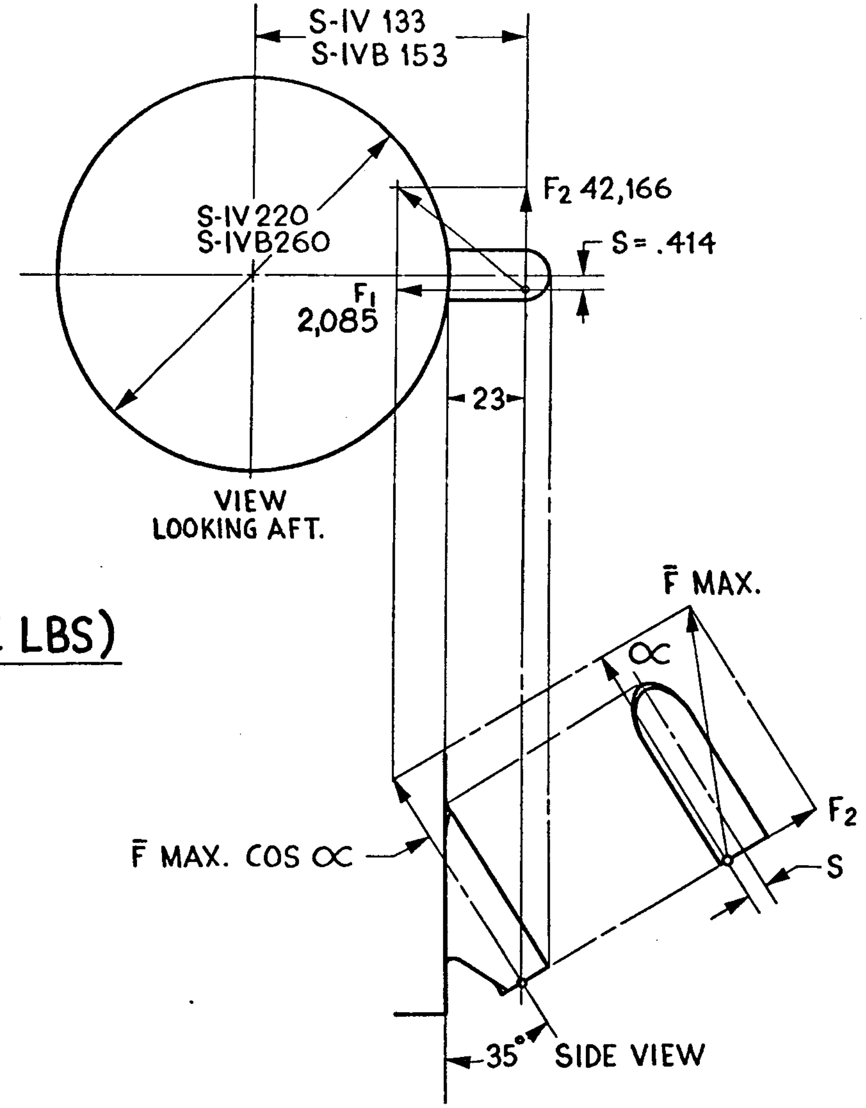


FIGURE 83

ULLAGE ROCKET THRUST VECTOR & COMPONENTS



MAX. ROLLING MOMENTS (FT. LBS)

S-IV	1,582
SAT. IB/SIVB	1,400
SAT. V/S IVB	932

FIGURE 84

23.0 GROUND SUPPORT EQUIPMENT

23.A.2. Modulating Valve Status

Change order 298 deleting the LOC modulating valve system and system performance requirements has been received and is in work. Tests conducted by Pacific Valve Co., indicate that the existing "Wye" type valve on valve complexes S/N 0001 at Sacto cannot meet the performance requirements of Change Order 298 and must be replaced. Two sources are being considered for new hardware. MSFC/DAC agreed that analog-modulating capability GSE would be available at Sacto for All-Systems tests based on use of the current "slip schedule."

23.A.3. Other Problem Areas and Proposed Resolution

MSFC drawings 13M20098 (SIB) and 13M50098 (SV) S-IVB stage fluid requirements will be reviewed relative to C/O 298 direction regarding replenish flow rates. New hardware will dictate maximum values.

23.B.1. Propellant Tank Positive Pressurization System

This document presents a conceptual design of a new item of GSE to provide a positive differential pressure within the propellant tank of the S-IVB stage during handling, shipping and storage. A study was requested by MSFC letter I-V-S-IVB-64-A-76, dated 27 April 1964.

23.B.2. Design Requirements

There is a NASA proposed requirement that under no circumstance shall a negative differential pressure, with respect to ambient, be allowed in the propellant tanks of the S-IVB stages during handling, shipping and storage. The pressurization media shall be GN_2 with helium capability.

23.B.3. Technical Discussion

To conserve tank pressurization media it is proposed that the propellant tanks pressures be controlled within upper and lower limits set so that maximum anticipated diurnal thermal pressure changes will not crack the support system relief valves. (See Graph Figure 85)

From the formula:

$$\frac{P1\ V1}{T1} = \frac{P2\ V2}{T2}$$

Volume is constant, V1 = V2

Assume daily differential temperature of 140°F + 10°F Minimum, +150°F maximum.

It is proposed that the propellant tanks be pressurized to the following approximate values:

Regulator Setting 1 1/4 psig

Relief Valve Setting 6.3 ± 0.3 psig

A lower differential between tank control pressure and the proposed tank relief pressure, will result in pressurization media loss as shown by the graph. (See Figure 86)

See Schematic (Figures 87 and 88)

The GN_2 from the storage bottles or facility source is reduced from 3000 psig to 100 psig to the pressure control units.

GN_2 from a facility source at 100 to 150 psig may be used and supplied directly to the pressure control units.

The GN_2 is filtered and press reduced to 1 1/4 psig through a two (2) stage regulator system to the stage tanks.

A by-pass manually adjustable regulating valve allows rapid tank filling (3 hours) and allows pressurization to 6 psig when necessary.

Relief valves and vacuum bleeder valves provide system protection.

Gages are provided for pressure readout.

Valves are provided for system bleeding.

An alarm and light system indicate high (7 psig) and low (1 psig) pressures. A manual, (automatic reset) alarm disable switch is provided.

23.B.4. Description

(See Chart Figures 89 and 90)

(a) Pressure Storage Unit has:

Hoist and fork lift capability

Hose storage area

Pressure control unit storage area

10 ft 3 at 3000 psig GN_2 storage capacity

Height	39 inches
Length	54 inches
Width	36 inches
Weight	800 pounds

(b) Pressure Control Units

Height	15 inches
Length	54 inches
Width	24 inches
Weight	80 pounds

23.B.5. Operational Usage

One main control unit and pressure source and two tank pressure control units (the tank pressurization kit) will be used with each S-IVB stage to maintain the desired positive tank pressure during transportation, handling, and storage.

An external source of GN_2 will be required for initial LO_2 and LH_2 tank pressurization, LO_2 and LH_2 tank re-pressurization after energy for inspection, etc., and for excessive periods of operation to augment the source in the main control unit and pressure source.

The main control unit and pressure source and two pressure control units or the tank pressurization kit is first utilized at Huntington Beach (A3) at the time the LO_2 and LH_2 tanks are completed and cleaned during manufacturing. Initial tank pressurization will be accomplished through the tank pressurization kit from an external source. The main control unit is moved by forklift or by the lifting eyes. The tank pressure control units accompany the stage as required. Stage lifting (short duration) will be accomplished with the two pressure control units detached from the main control unit or with stage tanks pressurized, sealed and control units detached.

The tank pressurization kit would be handled in a manner similar to DSV-4B-304, Transport Kit, Protective and Tie Down. A similar number of units would be required with additional tank pressurization kits for usage during the manufacturing phase.

The operational logistics portion of this presentation is preliminary. A more complete study of the handling procedure will be made and the concept outlined above changed as necessary to allow more advantageous usage of the tank pressurization kit.

23.B.6. Problem Areas

No stage connection points presently available for tank pressurization. (See Chart (Figures 91 and 92)

APPENDIX BB

23.C PRIME TECHNICAL PROBLEMS FOR EACH GSE ITEM NOT ON SCHEDULE

MODEL	DESCRIPTION	SCHED DELIV	PREDICTED DELIV	REMARKS
130	Stimuli Conditioner	26 June 64	Sept 18 or later	To be modified per Analog Modulating Valve
253A	Aux. Dist. Unit	27 Nov 64	Open	" " " " " " "
331	LO_2 Valve Skid	S/N 1 Comp	Feb '65	Modify on Beta 1 Stand after B/S to add modulating valve mod
		S/N 2 Oct 30 '64	Jan '65	Modify at factory to add modulating valve mod
332	LH_2 Valve Comp	S/N 1 Comp	Feb ' 65	Modify on Beta 1 Stand after B/S to add modulating valve mod
		S/N 2 Oct 30 '64	JAN '65	MODIFY AT FACTORY TO ADD MODULATING VALVE MOD
179	Propellant Loading CNSL	13 Nov '64	Late Dec	Req'd for Modulating Valve Operation
372	APS Fuel Valve Assy	9 Oct '64	Jan '65)	
373	APS Oxid Valve Assy	9 Oct '64	Jan '65)	Further definition of test objectives and
374	APS Pneu Dist Assy	9 Oct '64	Jan '65)	equipment capabilities is required
375	APS Pneu REG. Assy	9 Oct '64	Jan '65)	

BB-1

23.C PRIME TECHNICAL PROBLEMS FOR EACH GSE ITEM NOT ON SCHEDULE

MODEL	DESCRIPTION	SCHED DELIV	PREDICTED DELIV	REMARKS
248	P.U. Assy Calib. Unit	9 Oct. '64	Feb '65	Redesign for Prog. ~~Mkt.~~ MIXT. Ratio
248	" " " " (MSFC B/S)		MAR '65 ?	" " " " "
359	Liquid Thermoconditioner	28 Aug 64	Open	On-Mark Coupling
432	Pneu Cnsl "A", Launcher	16 April 64	21 May 65	Late start plus design req't changes
433	Pneu Cnsl "B", Launcher	16 April '64	21 May '65	" " " " " "
438	Gas Heat Exch, Launcher	16 April '64	21 May '65	" " " " " "
286	Pneu Cnsl T.S., Launcher	16 April '64	21 May '65	" " " " " "
402	Forward Section Access Kit	5 March 65	Open	Late start plus no LEM access definition
469	Bulkhead Protection Kit	5 March '65	Open	Late start

BB-2

BB-2

23. C. PRIME TECHNICAL PROBLEMS FOR EACH GSE ITEM NOT ON SCHEDULE

(1) Model DSV-4B-432 S-IVB Pneumatic Console "A"
No MSFC authority to proceed with detail design.

(2) Model DSV-4B-433 S-IVB Pneumatic Console "B"
No MSFC authority to proceed with detail design.

(3) Model DSV-4B-438 S-IVB Gas Heat Exchanger.
No MSFC authority to proceed with detail design.

LH2 SKID CONTROL

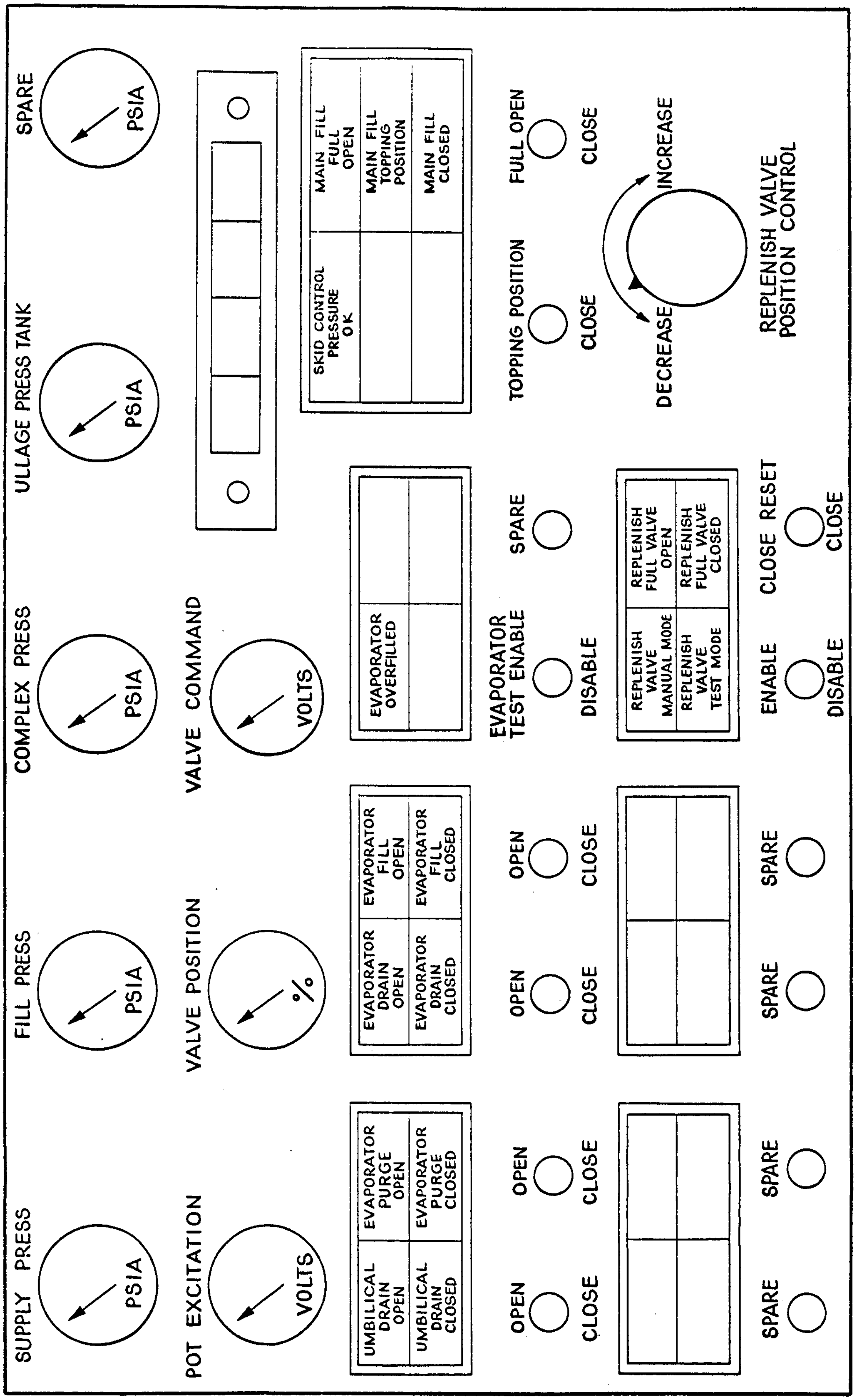


FIGURE 85

PROPELLANT LOADING

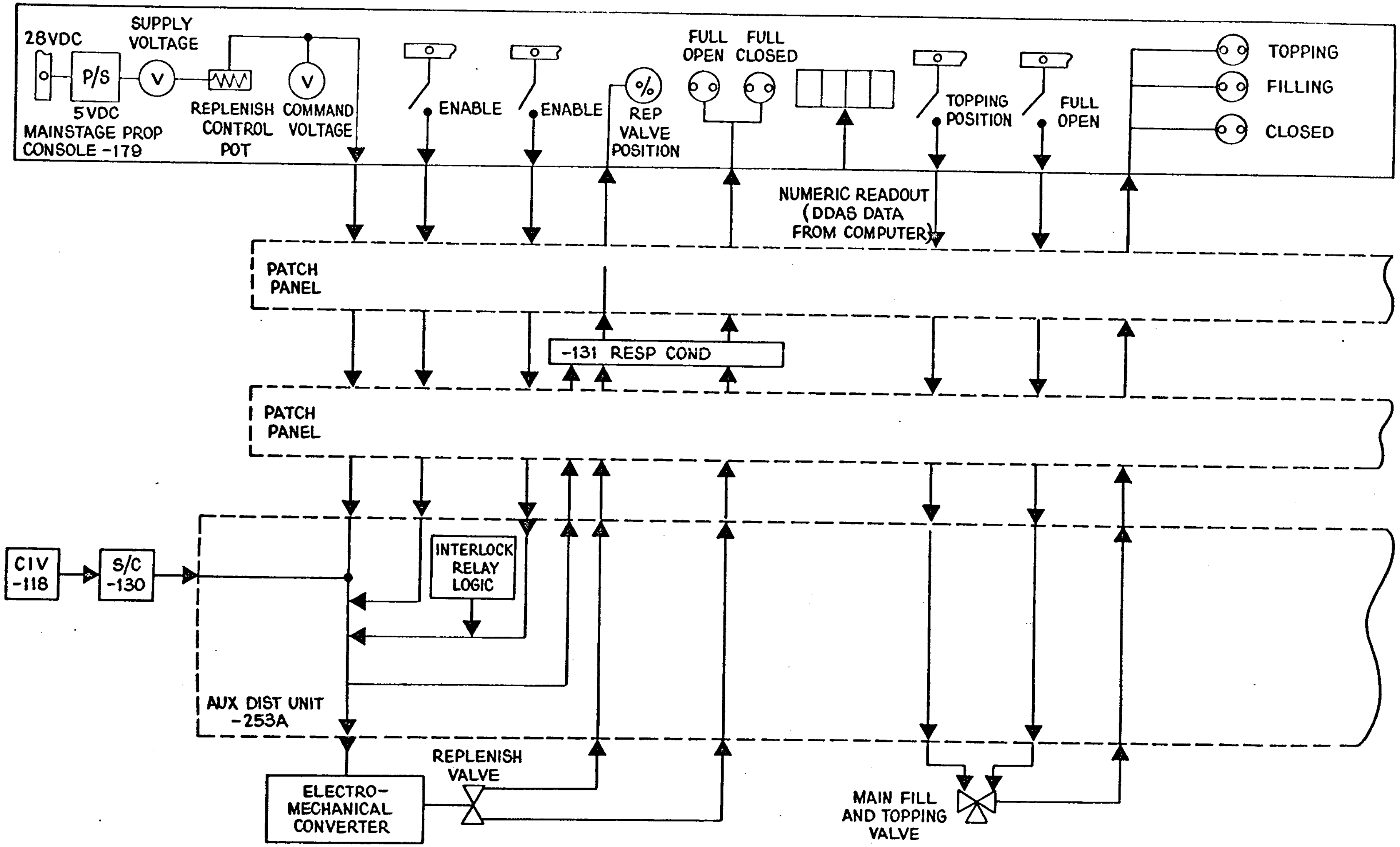
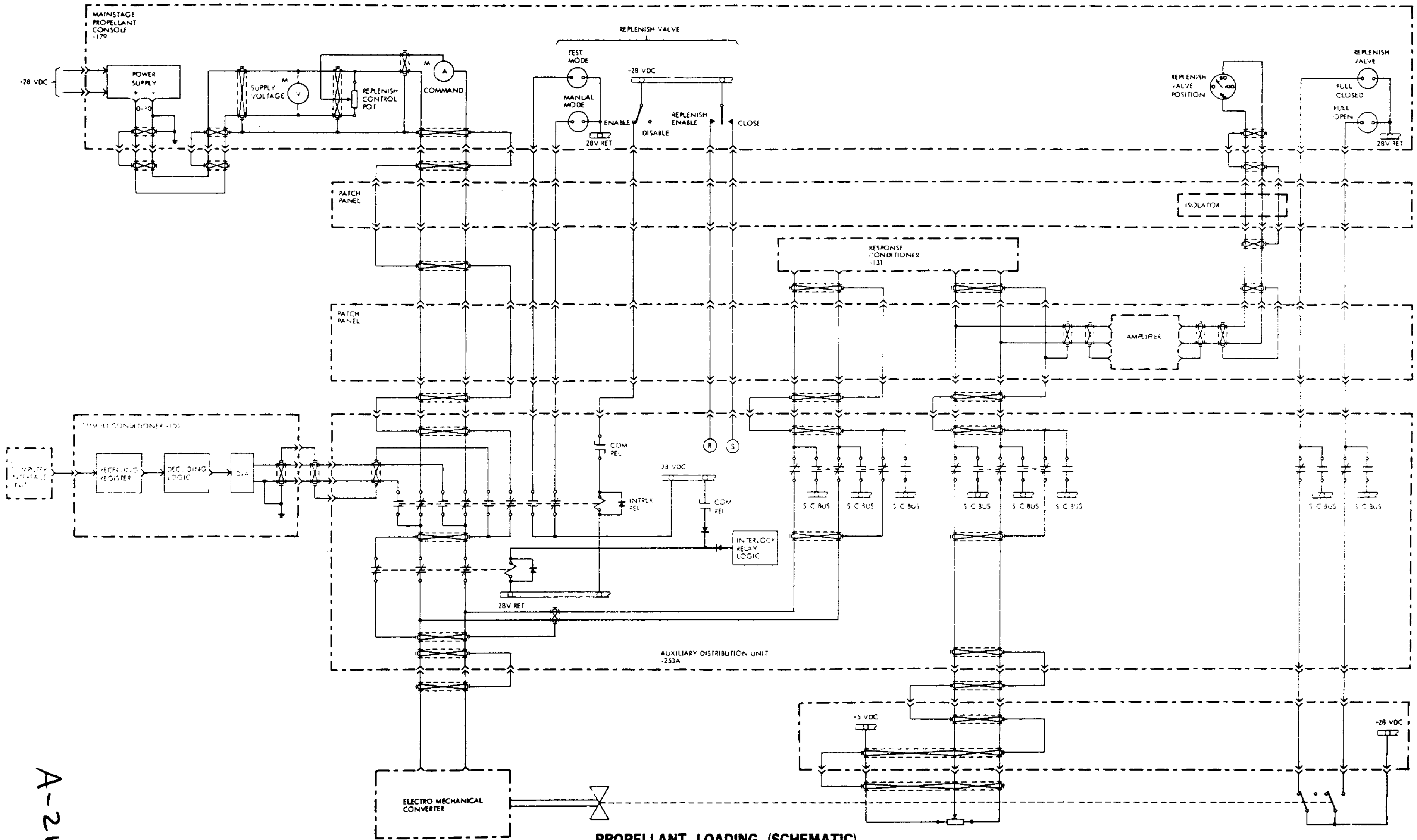


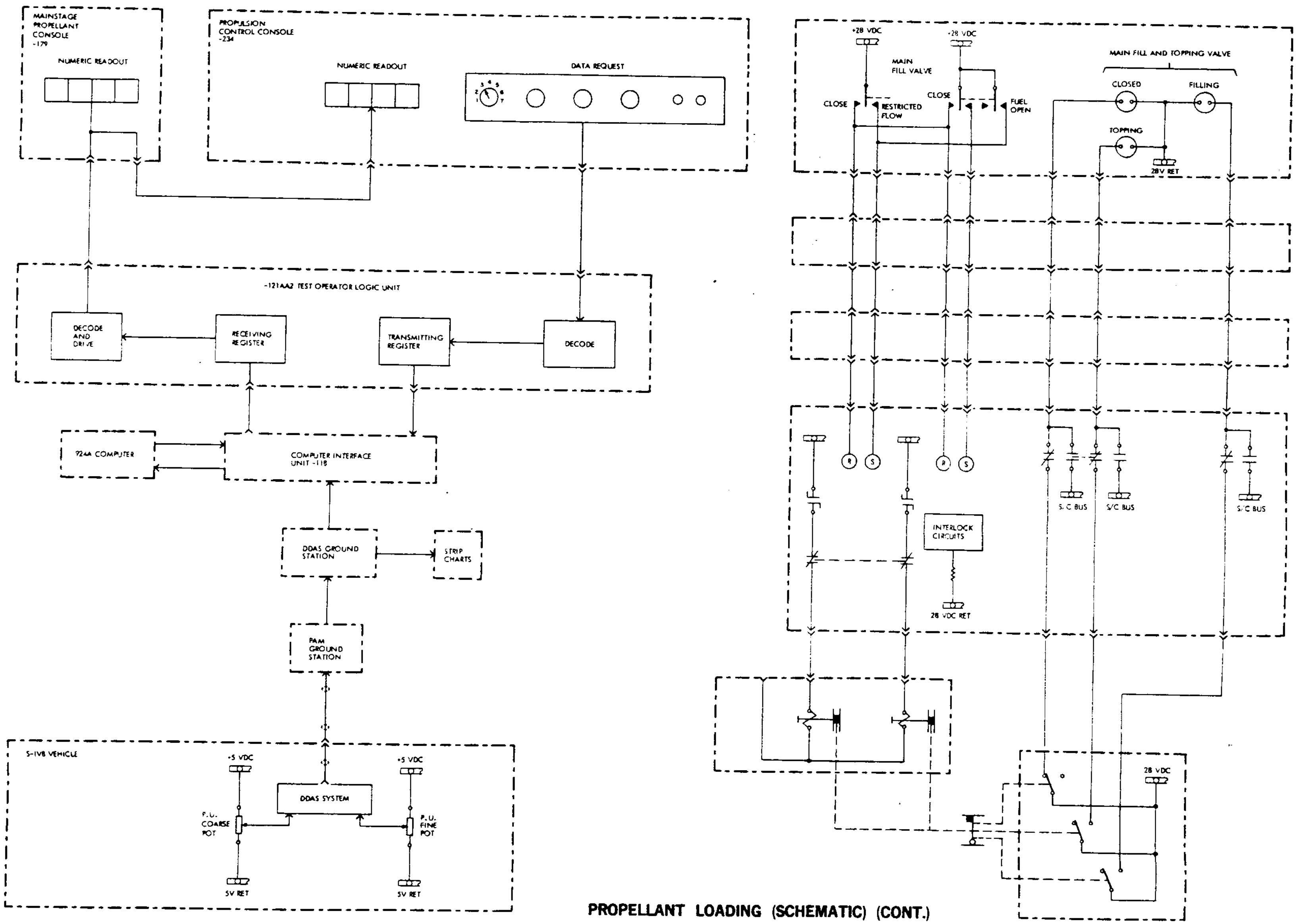
FIGURE 86



PROPELLANT LOADING (SCHEMATIC)

FIGURE 87

A-213



PROPELLANT LOADING (SCHEMATIC) (CONT.)

FIGURE 88

TANK PRESSURIZATION KIT

PRESSURE STORAGE UNIT

PROVIDES 10FT^3 GN_2 AT 3000 PSIG

PROVIDES HOSE STORAGE AREA

PROVIDES STORAGE AREA FOR PRESSURE CONTROL UNITS

HEIGHT	39
LENGTH	54
WIDTH	36
WEIGHT	800 LBS.

PRESSURE CONTROL UNITS

HEIGHT	15
LENGTH	26
WIDTH	24
WEIGHT	80 LBS.

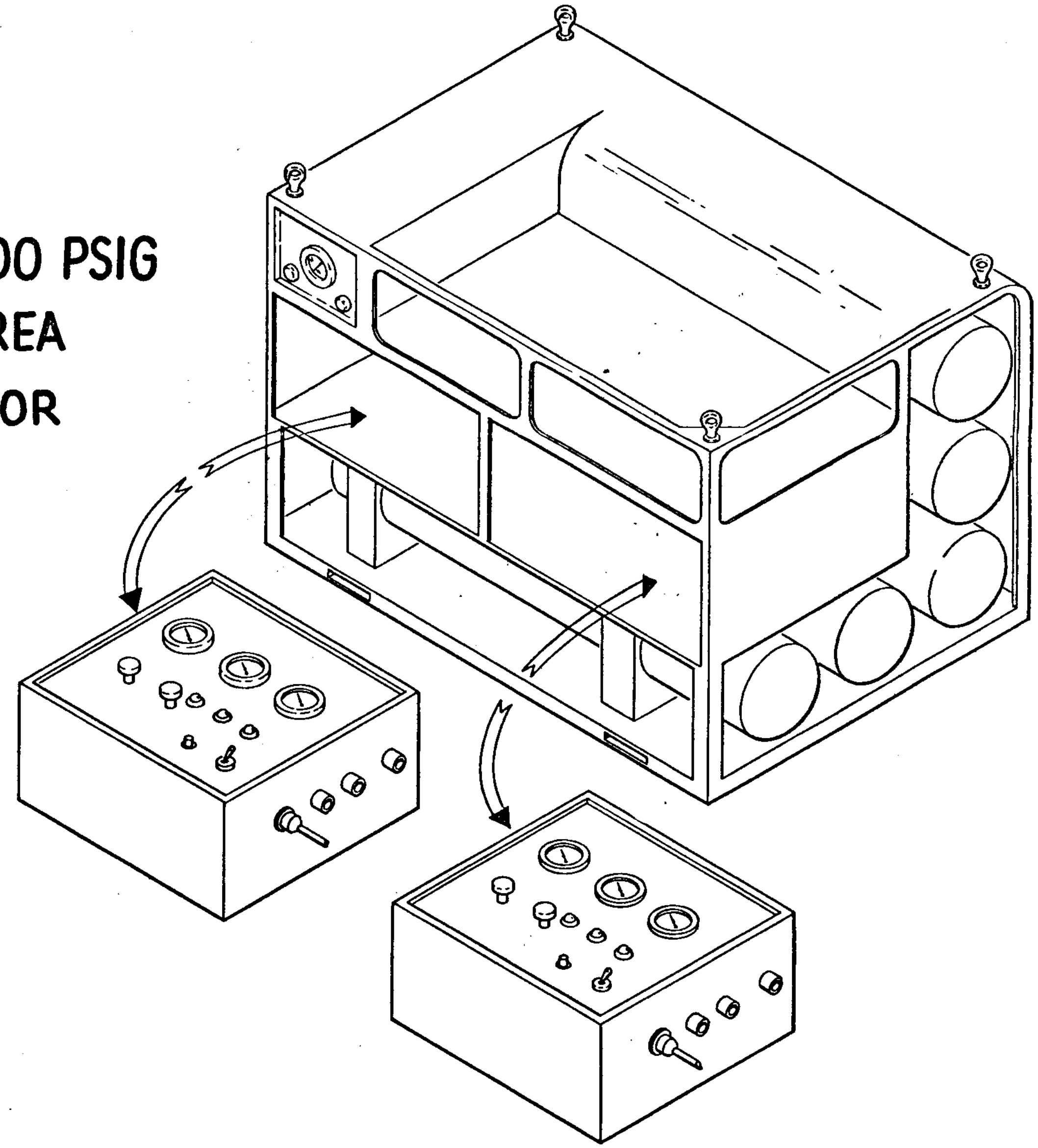


FIGURE 89

SCHEMATIC STAGE TANK PRESSURIZATION SYSTEM

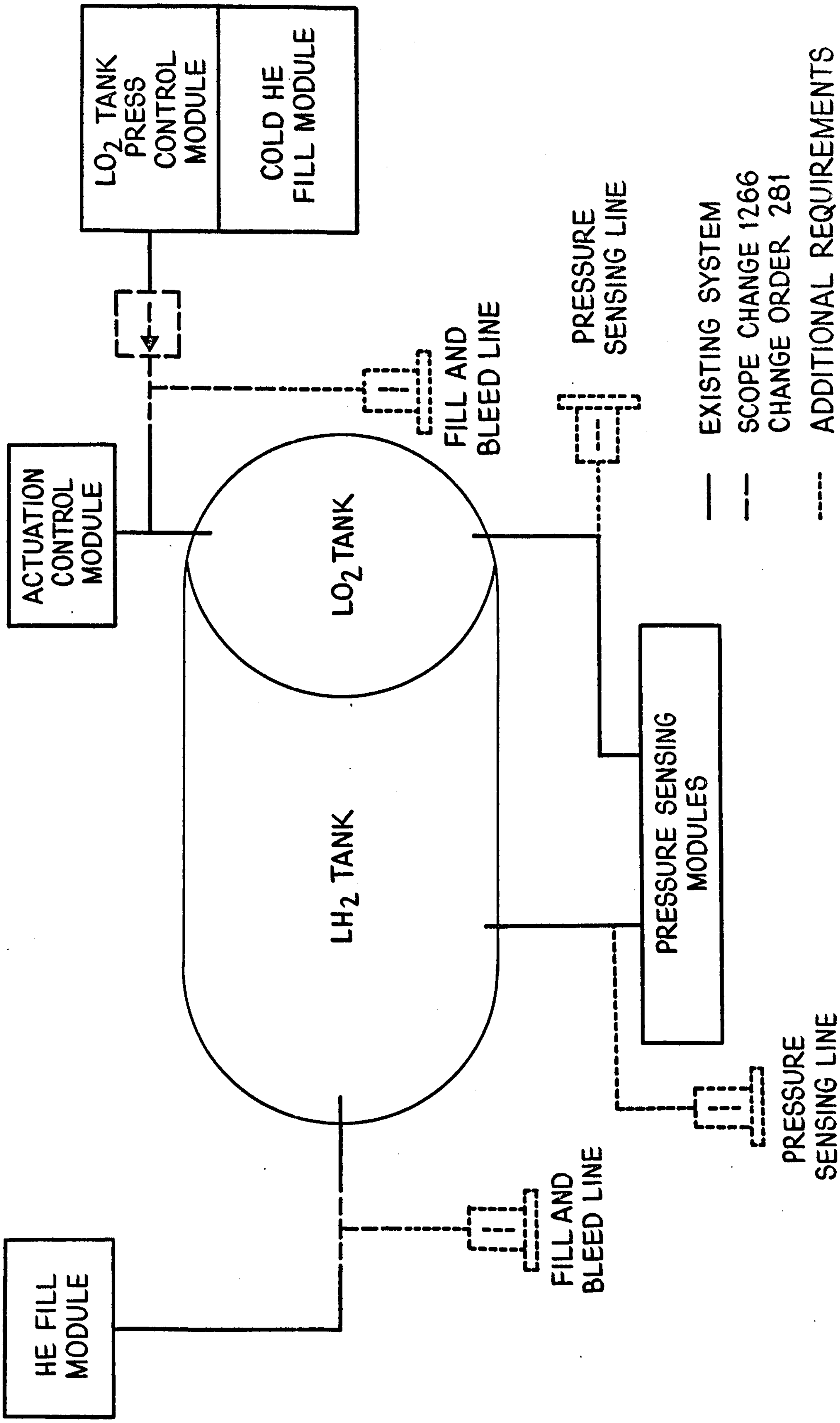


FIGURE 90

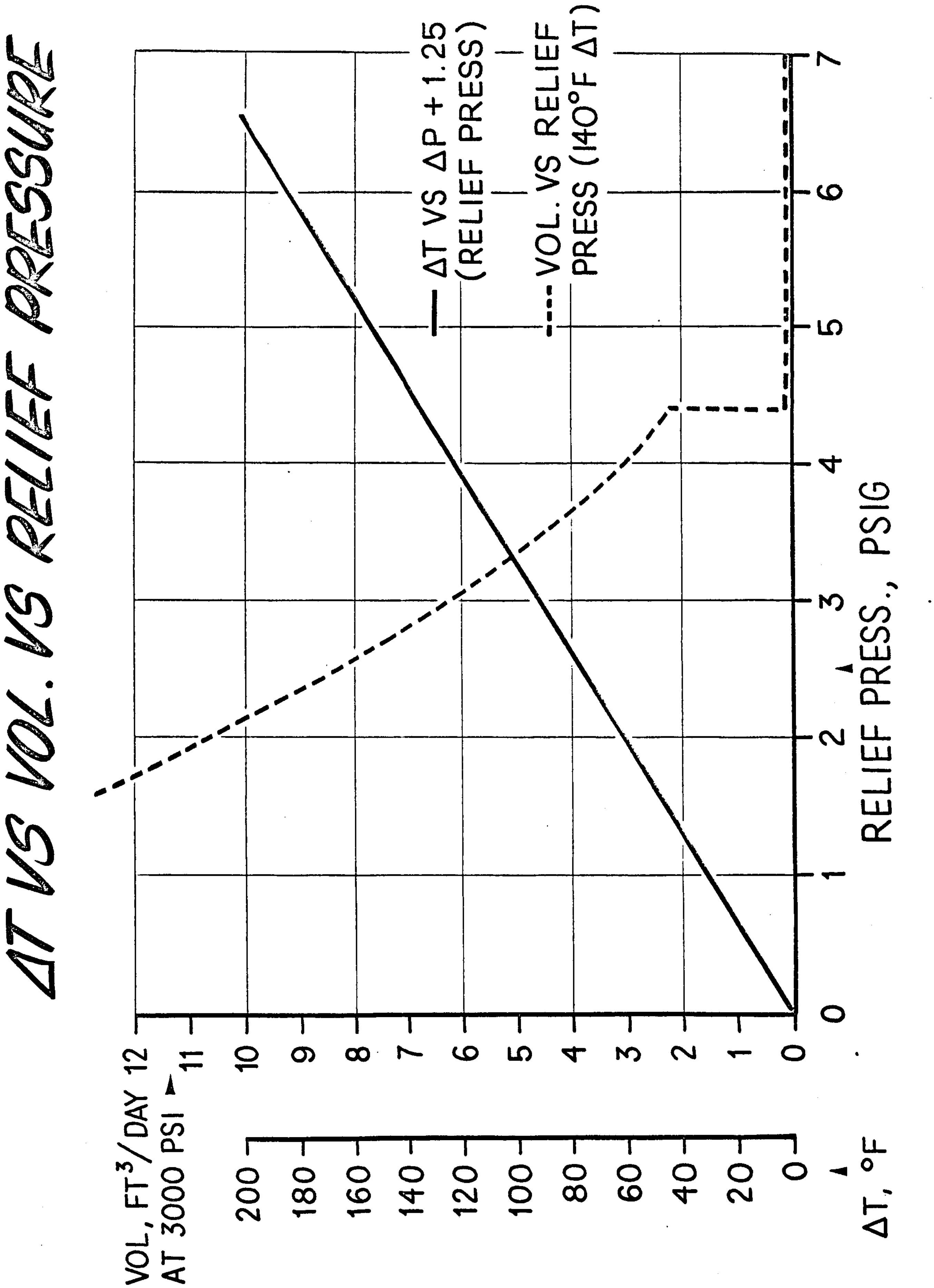

ΔT VS VOL. VS RELIEF PRESSURE
ΔT VS ΔP + 1.25 (RELIEF PRESS)
VOL. VS RELIEF PRESS (140°F ΔT)
VOL, FT³/DAY AT 3000 PSI
ΔT, °F
RELIEF PRESS., PSIG
0
1
2
3
4
5
6
7
8
9
10
11
12
20
40
60
80
100
120
140
160
180
200

FIGURE 91

SCHEMATIC
TANK PRESSURIZATION KIT

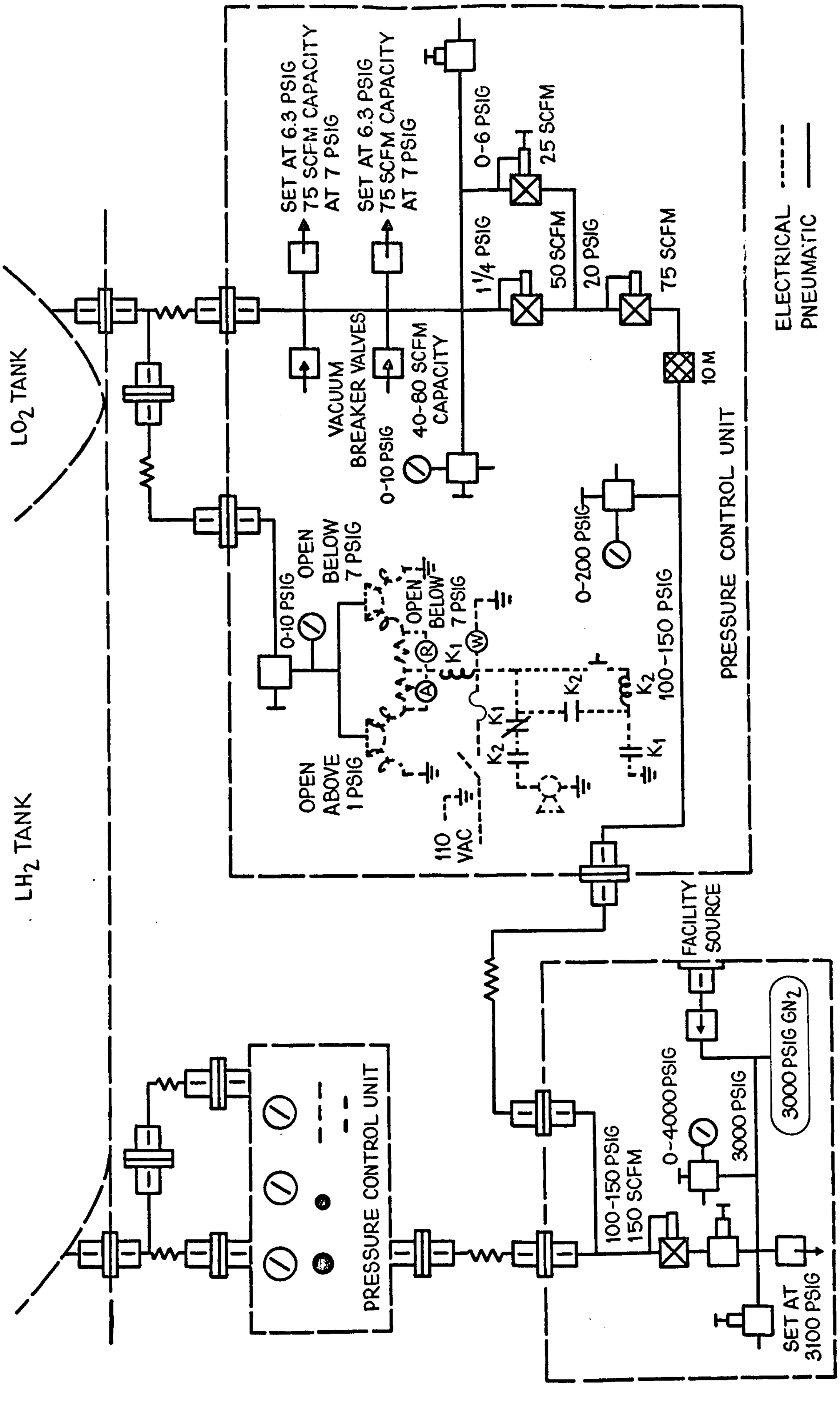


FIGURE 92

24.0 MAJOR PROBLEM AREAS

Change Order 313, authorizing DAC to perform additional testing and analysis on a cryogenic APS/repress system, has been received. However, if the system proves feasible and desirable, connections in the LH_2 and LO_2 tanks must be provided. This requires changing the aft LOX dome to provide pads to make the attachments. No authorization has yet been received to add these pads to the aft LOX dome. Since this is a long lead time item, immediate authorization is required to accomplish this change on 501.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION/SPACE SYSTEMS CENTER
5301 BOLSA AVENUE, HUNTINGTON BEACH, CALIFORNIA

SEP 15 1964 A3-850-K031-1.17.8-L-786

Subject: NAS7-101 - S-IVB - SIXTH VEHICLE MECHANICAL DESIGN INTEGRATION WORKING GROUP MEETING, AUGUST 26-27, 1964

To: National Aeronautics & Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Attention: Mr. R. E. Godfrey, I-V-S-IVB

Through: NASA/MSFC Resident Management Office
Douglas Aircraft Company, Inc.
Space Systems Center
Huntington Beach, California

Attention: Mr. R. H. Young, I-I/IB-S-IVB-L

Gentlemen:

1. Enclosed herewith is one (1) reproducible copy of errata sheets representing corrections to the DAC handout presented to attendees at the subject meeting.

Very truly yours,

MISSILE & SPACE SYSTEMS DIVISION
Douglas Aircraft Company, Inc.

T. J. Gordon
Asst. Director - Saturn Programs
Saturn Systems Development

RES/mm
Enclosure: As noted

cc: Mr. J. C. McCulloch, I-I/IB-S-IVB
Mr. R. F. Griner, R-P&VE-VJ
Mr. R. H. Young, I-I/IB-S-IVB-L
Mr. H. T. Gibbs, I-I/IB-DAC
Mr. M. B. Sundstrom, I-CO-I/IBD
Mrs. D. Bolin, AFPR-RWRXQA

NASA/MSFC Resident Management Office
Douglas Aircraft Company, Inc.
Huntington Beach, California
Date 9-17-64 R. H. Young
S-IVB Resident Stage Manager

Data Distribution:

Mr. R. E. Godfrey, I-V-S-IVB, 1 reproducible copy
Mr. R. H. Young, I-I/IB-S-IVB-L, 1 copy

APPENDIX CC

CC-1

ERRATA

6th VMDIWG Meeting

August 26-27 1964

Page iv	On fifth line from bottom, second word should be "MIXTURE".
Page 3	Under Status for Item No. 2104, first word in line five should be "REL".
Page 10	Under Status for Item No. 4030, first sentence should read "Closing action per agenda item 6.D."
Page 15	After last sentence of status description for Item No. 4069 add "See Figures 1, 2 and 3".
Page 63	On line two the fourth word should be "NON-PROPULSIVE".
	In paragraph two on line nine, add the word "BE" between "cannot" and "directed". Figure "18" should be Figure "19" and Figure "19" should be Figure "18".
Page 64	On the first line, add the number "20" after "Figure".
Page 75	Under 8.A.5.2. a. General Discussion, change the third sentence to read "This objective; however, cannot be fully realized until sufficient information is available on minimum required engine firing sequences."
Page 76	On fourth line of chart, replace "Thermolag" with "De Soto". Lines 6, 7, 10 and 14 should read "ALSI PAINT".
Page 77	Fourth line of chart should read "ALSI PAINT".
Page 79	Under (2) Propellant Lines, add the number "27" after "Figure".
Page 80	The last sentence on the page should be a separate paragraph.
Page 81	Delete the character "B" from the chart title.
Page 82	Delete the character "B" from the chart title.
Page 85	Add the word "EXTERIOR" after "FAIRING" in two places.
Page 86	Add the word "EXTERIOR" after "FAIRING" in two places.
Page 94	Under Earth Orbit, Item 6, the third word should be "DISTURBANCE".

CC-2

Page 104	Under 9.B.2 Saturn 5 Full Tank Pressure on the second line, the fourth word should be "THAN".
Page 105	The last paragraph on this page should be the last paragraph of item 9.A.5 on page 103.
Page 110	On the top line of the chart "Design Pressure" should be "Required Tank Pressure". On the same line under Saturn IB, "44" should be "36" and under Saturn 5, "44" should be "38.8".
Page 111	Under 10.B Maximum J-2 Thrust Calculations, change the second and third sentences to read "The effects of off nominal pump inlet conditions, pressurization, calibration, and P.U. excursion effects, when taken into consideration, yield a total thrust of 241,100 lb. The design limit thrust load used for design of the thrust structure and casting is 246,000 lb."
Page 117	On the third line, the twelfth word should be "ATTACH".
Page 142	Under Refer to Plate 4: (Figure 64), on the ninth line, "692,000 BTU's" should be "693,000 BTU's".
Page 144	On the seventeenth line, the sixth word should be "WILL".
Page 149	On the last line of the chart, "693,500 BTU" should be 693,000 BTU".
Page 153	Under 13.B.2.1 Phase I, the second sentence should read "The liner consists of a 181 style glass fabric impregnated with 50 percent ERL 2795/2807 epoxy resin by weight".
Page 154	Under 8-Foot Scale Tank Tests, starting with the fifth sentence, change the balance of the paragraph to read "As a result of the 25 percent reduction in resin content, no cracking or crazing of the liner (a serious problem with the S-IV liner) was observed. Ultrasonic inspection performed throughout the test gave no indication of the 3-D foam debonding from the tank wall.
Page 155	Under 8-Foot Scale Tank Tests, on the fourth line, the sixth word should be "FOAM".
Page 156	In paragraph two at the end of the second sentence, "Table 6" should be "Table 5". In the same paragraph on the fifth line, the first word should be "CONDUCTIVITY".
	Under 13.B.3 Effectivity, insert the number "6" after Table.
Page 166	On line two, the fifth and eighth words should be "ABSORPTIVITY" and "HYDROGEN" respectively.
Page 186	Between the eighth and ninth printed lines, insert the title "Documents Presently Being Used for S-IVB/IB Interstage Venting Design".

Page 200	In the second paragraph following the calculations, on the third line, ".0786g" should be ".00786g" and ".0684g" should be ".00684g". On the fourth line, insert the number 83 after "Figure".
	In the third paragraph,on the tenth line, "Figure 82" should be "Figure 84".
Page 201	In the second paragraph, on the second line, "Figure 83" should be "Figure 82". On the fifth line, the word "is" should be "being". On the ninth line, insert the number "83" after "Figure". On the tenth line the word "shown" should be "as seen". On the eleventh line, "Figure 84" should be "Figure 83".
Page 206	Under 23.B.3. Technical Discussion, on the fourth line, "Figure 85" should be "Figure 91".
Page 207	On the seventh line, "Figure 86" should be "Figure 91". On the eighth line, "Figures 87 and 88" should be "Figure 92".
Page 208	On the second line, "Figures 89 and 90" should be "Figure 89". In the last paragraph the word "energy" should be "entry".
Page 209	On the last line, "Figures 91 and 92" should be "Figure 90".
Page 218	Figure 92 - Revised chart to add relief valve and modify schematic.

Handout for agenda Item 23.C "Prime Technical Problems For Each GSE Item Not On Schedule" is revised as follows:

Model 375 description should be "APS PNEU REG ASSY"

Model 248 under REMARKS comment should be "REDESIGN FOR PROG. MIXTURE RATIO".

Add model 248 REDESIGN, P.U. ASSY CALIB. UNIT MSFC B/S - PREDICTED DELIV APRIL '65

SCHEMATIC
TANK PRESSURIZATION KIT

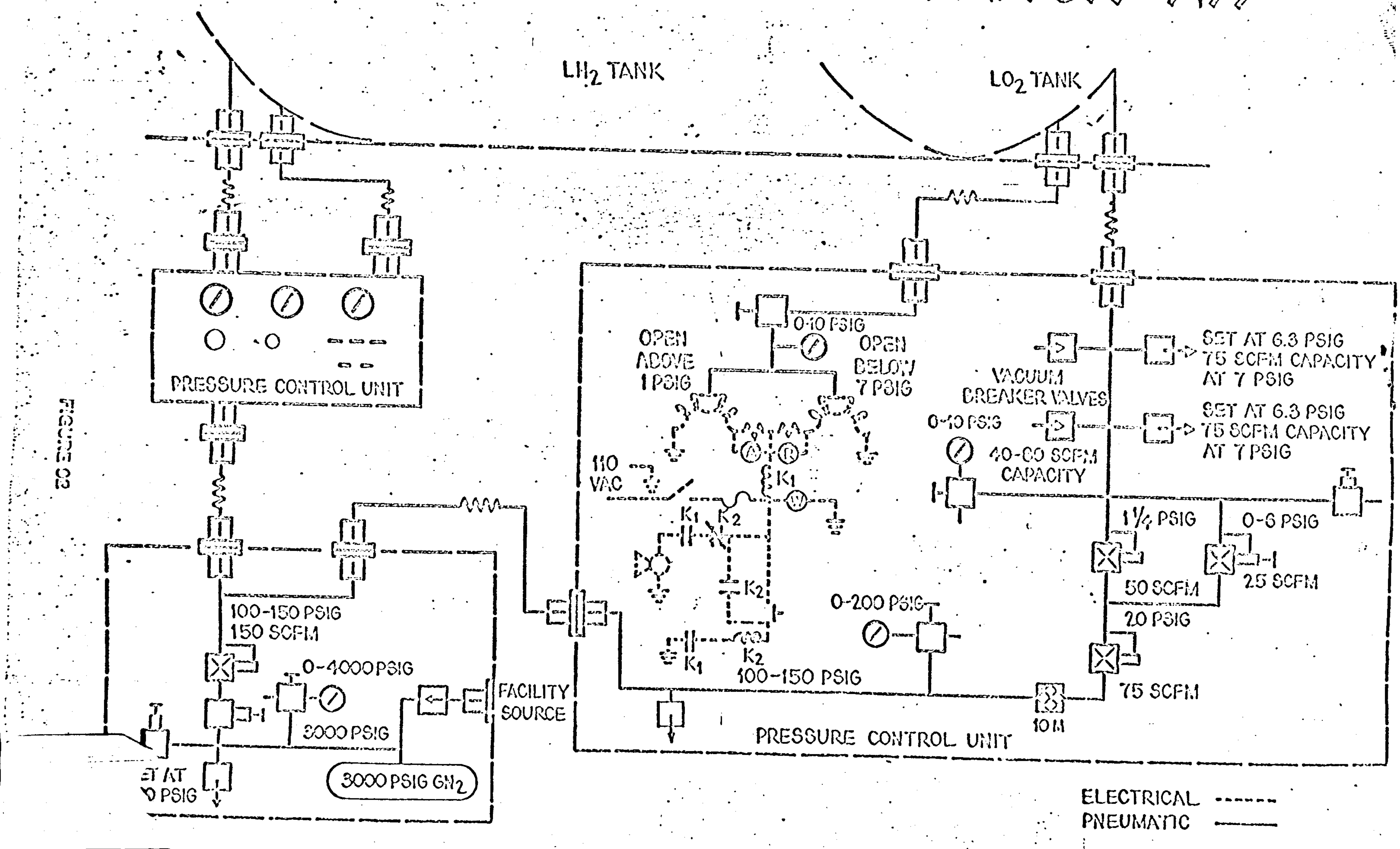


FIGURE 92