SNA-8-D-027(II)PT2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CSM/LM [SPACECRAFT OPERATIONAL DATA BOOK,

VOLUME II, LM DATA BOOK:

PART 2— LM6 AND SUBS.
LAUNCH MISSION RULE REDLINES

REVISION 5]

MARCH 9, 1970

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

LED-540-57

INDEXING DATA

DATE	OPR	#	T	PGM	SUBJECT	SIGNATOR	LOC
03-09-70	MSC		R	LM	[(title)]	MSC	[illegible]

REVISIONS

REV LTR	AMEND NO.	DESCRIPTION	DATE	APPROVED
		LM-7 Consumable Guidelines		
	7	1. Remove Appendix A, "Guidelines", pages A-1 through A-4. 2. Remove Appendix B, "Redline Data Sheet Preparation Checklist", pages B-1 through B-5. These data (Items 1 and 2) are contained in "ASPO Handbook for Launch Mission Rules". 3. Remove Appendix C "Guidelines for Mission Dependent Redlines H-1 Type Mission" pages C-1 through C-5. 4. Add Appendix A, "Guidelines for Mission Dependent Redlines H-2 Type Mission" pages A-1 and A-5. 5. Add pages B-1 and C-1 for continuity.	12-24-69	SED
	8	Revision 5 - Volume II Part 2 LM Data Book Replace Volume II, Part 2, dated September 29, 1969, with Revision 5, Volume II, Part 2 dated March 9, 1970. This revision includes the following approved amendments: 7 - LM-7 Consumable Guidelines P3-17 - LM-7 Consumable Guidelines Revision P3-18 - LM-7 ECS Consumables Redlines P3-19 - LM-7 EPS - Battery Redlines P4-44 - LM Update for Prelaunch Redlines (Propulsion) - DPS P4-45 - LM Update for Prelaunch Redlines (Propulsion) - APS P4-46 - LM-7 Update for Prelaunch Redlines (LR Antenna Temp.)	3-9-70	SED

SNA-8-D-027(II)PT2

CSM/LM SPACECRAFT OPERATIONAL DATA BOOK

VOLUME II PART 2

LAUNCH MISSION RULE REDLINES

Prepared By

Grumman Aircraft Engineering Corporation

For

Systems Engineering Division

Apollo Spacecraft Program Office

Manned Spacecraft Center

Contractor Concurrence R. Moncks for
J. W. COURSEN,
Engineering Manager

Concurrence .....
C. C. KRAFT, JR., Director
Flight Operations

Concurrence .....
OWEN E. MAYNARD, Chief
Systems Engineering Division

Concurrence .....
M. A. FAGET, Director
Engineering and Development

Approved by George M. Low 11-21-68
GEORGE M. LOW, Manager
Apollo Spacecraft Program

DATA CHANGE NOTIFICATION FORM
CSM/LM SPACECRAFT OPERATIONAL DATA BOOK
SNA-8-D-027

VOLUME II PART 2 DATE March 9, 1970

AMENDMENT 8 PAGE 1 OF 1

SHORT TITLE OF CHANGE Revision 5 - Volume II Part 2 LM Data Book

CHANGE DESCRIPTION

Replace Volume II, Part 2, dated September 29, 1969, with Revision 5, Volume II, Part 2, dated March 9, 1970. This revision includes the following approved amendments:

Amendment	Title
7	LM-7 Consumable Guidelines
P3-17	LM-7 Consumable Guidelines Revision
P3-18	LM-7 ECS Consumables Redlines
P3-19	LM-7 EPS - Battery Redlines
P4-44	LM Update for Prelaunch Redlines (Propulsion)-DPS
P4-45	LM Update for Prelaunch Redlines (Propulsion)-APS
P4-46	LM-7 Update for Prelaunch Redlines (LR Antenna Temp.)

R. Monaco
CONTRACTOR SUBSYSTEM APPROVAL

PHONE HU3-2457

R. Monaco 3-9-70
CONTRACTOR MANAGEMENT APPROVAL

PHONE

NASA COMMENTS

NASA SUBSYSTEM APPROVAL

PHONE

Donald R Seyer 2457 3/9/70
CHANGE AUTHORITY PD7 EXT

ASPO APPROVAL, R. H. KOHRS, CHIEF, SYSTEMS OPERATIONS BR.

DATE 3/9/70

MSC FORM 1794 (AUG 69) REV 2

PREFACE

This document is the fifth revision of the LM Data Book (Part 2). The fifth revision incorporates MSC Amendment 3-1 through 3-19 and GAC Amendment 4-1 and 4-46. All MSC and GAC amendments released subsequent to publication of this LM Data Book will be numbered sequentially starting with the number nine (9). This LM Data Book provides the launch controller with ready visibility of the redline values with backup values and supporting rationale to assist in real time decisions. All sections of the document are continually undergoing review with the intent to update information where required. A complete description of the contents and amendment procedures is provided in Section 1.0, Introduction.

Volume II LM Data Book
Part 2
Launch Redline Data

1.0 INTRODUCTION

1.0 INTRODUCTION

Volume II LM Data Book
Part 2
Launch Redline Data

1.0 INTRODUCTION

1.1 PURPOSE

This document provides the subsystem requirements and redlines with supporting information for the LM portion of the launch mission rules. The redlines are to be used as the limits specified in the launch mission rules, and the details are presented to support and justify the redlines.

1.2 CONTENT

The complete Data Book for the manned missions will consist of five separate volumes. These are defined as follows:

Volume I - CSM Data Book
- Part 1 - Constraints and Performance
- Part 2 - Launch Mission Rule Redlines

Volume II - LM Data Book
- Part 1 - Constraints and Performance
- Part 2 - Launch Mission Rule Redlines

Volume III - Mass Properties Data Book

Volume IV - EMU Data Book

Volume V - ALSEP Data Book

Volume II, Part 2, is divided into three sections and three appendicies.

1.2.1 Section 1.0 Introduction

The Introduction describes the purpose and scope of Launch Mission Rule Support and summarizes the content of the remaining sections.

1.2.2 Section 2.0 Subsystem Requirements

Section 2.0 defines the subsystem requirements by listing the subsystems and/or subsystem components which are not mandatory (highly desirable).

Volume II LM Data Book
Part 2
Launch Redline Data

1.2.3 Section 3.0 Redline Support Data

Section 3.0 contains the redlines and details of how the redline values were determined and rationale and justification for the assigned redlines.

1.2.4 Appendix A

Appendix A presents the guidelines for mission dependent redlines.

1.2.5 Appendix B

Appendix B presents guidelines for discrete measurement redlines and the supporting rationale.

1.2.6 Appendix C

Appendix C presents CDDT applicable redlines.

1.3 Amendments

Amendments to this document will be made by page additions or replacements. All, i.e., MSC and GAC, amendment submitted will be assigned amendment numbers sequentially. No attempt will be made to distinguish between MSC and GAC changes. Data changed by an amendment will be denoted by an amendment date and number in the upper right-hand corner of the page and a vertical bar in the page margin to locate the change. Where the complete page constitutes a new addition to the data book, no change bar will be placed in the margin. A revision page showing the accumulative changes that have been made will be issued with each amendment. This revision page should be placed just behind the title page and will provide an up-to-date listing of all amendments.

Volume II LM Data Book
Part 2
Launch Redline Data

The LM Data Book shall be updated to continually reflect the latest redline data. Prior to T-2 months for a particular spacecraft, the contractor shall react to a data change request within one week, and the NASA approval cycle shall not require more than one week. From T-2 months to launch, total reaction time for both NASA and the contractor shall be 24 hours. Changes may be initiated by either GAEC or NASA. Contact D. R. Segna PD7, extension 2457, MSC, or G. Benko, extension 1341, GAEC, on questions regarding changes or change procedures.

1.4 SELECTED ABBREVIATIONS AND ACRONYMS

ac	Alternating Current
accum	Accumulator
ACE	Automatic Checkout Equipment
act	Actuator
AGS	Abort Guidance Subsystem
amp	Ampere
APS	Ascent Propulsion Subsystem
A/S	Ascent Stage
ASA	Abort Sensor Assembly
att	Attitude
CDDT	Countdown Demonstration Test
CES	Control Electronics Section
CMD	Commander
CO_2	Carbon Dioxide
CRT	Cathode Ray Tube
CSM	Command Service Module
ctr	Center
cryo	Cryogenic
C&W	Caution and Warning
dc	Direct Current
deg	Degree
DPS	Descent Propulsion Subsystem
D/S	Descent Stage
EKG	Electrocardiogram
eng	Engine
EPS	Electrical Power Subsystem
F	Fahrenheit
FDAI	Flight Director Attitude Indicator
FM	Frequency Modulator

GAC	Grumman Aerospace Corporation
GHe	Gaseous Helium
GN_2	Gaseous Nitrogen
GOx	Gaseous Oxygen
GSE	Ground Support Equipment
G&N	Guidance and Navigation
H_2	Hydrogen
H_2O	Water
HD	Highly Desirable
He	Helium
Hz	Cycles Per Second
IG	Inner Gimbal
IRIG	Inertial Reference Integrating Gyros
KSC	Kennedy Spacecraft Center
LH	Left Hand
LM	Lunar Module
LMP	LM Pilot
LR	Landing Radar
M	Mandatory
max	Maximum
MG	Middle Gimbal
min	Minimum
MMHG	Millimeters of Mercury
MNFLD	Manifold
MSC	Manned Spacecraft Center
N_2	Nitrogen
NR	North American Rockwell
O_2	Oxygen
OCP	Operational Checkout Procedure
OG	Outer Gimbal
OX	Oxidizer
PCM	Pulse Code Modulation
pct	Percent
pg	Page
PGNS	Primary Guidance and Navigation Section
PIPA	Pulse Integrating Pendulous Accelerometer

pos	Position
PQGS	Propellant Quantity Gaging System
PQMD	Propellant Quantity Monitoring Device
press	Pressure
pri	Primary
PSIA	Pounds Per Square Inch Absolute
PSID	Pounds Per Square Inch Differential
PSIG	Pounds Per Square Inch Gage
quan	Quantity
RCS	Reaction Control Subsystem
ref	Reference
RH	Right Hand
SCS	Stabilization and Control Section
sec	Second or Secondary
SM	Service Module
sys	System
temp	Temperature
TM	Telemetry
VAC	Volts, Alternating Current
VDC	Volts, Direct Current
VRMS	Volts, Root Mean Square
WQMD	Water Quantity Measuring Device

2.0 SUBSYSTEM AND REDLINE REQUIREMENTS

2.0 SUBSYSTEM AND REDLINE REQUIREMENTS

2.0 SUBSYSTEM REQUIREMENTS

All the subsystems on LM-7 as presently configured are considered mandatory. Components of such subsystems as the following are considered to be highly desirable:

None

3.0 REDLINE SUPPORT DATA

3.0 REDLINE SUPPORT DATA

3.0 REDLINE SUPPORT DATA

The redline support data contain the logic and values used to generate the redlines assigned to the mandatory prelaunch measurements. The logic is the reason that a measurement is mandatory, and the details how the redline presented was selected. Redline designation is based on the detailed guidelines presented in ASPO Handbook Launch Mission Rules*, and summarized below. The redlines are based on critical limits. The critical limits, if exceeded, are the values which will degrade subsystem performance to a point where the crew's safety is affected or the planned mission may be shortened. The critical limits are corrected for the measurement subsystem inaccuracy to obtain the listed redline values. Some measurements, which have undefined or unobtainable critical limits or which are not considered to be strict critical limits (soft), do not require correction for measurement subsystem inaccuracy and not applicable (NA) is entered in the measurement system error column.

Measurement subsystem accuracy considers the sensor, signal conditioning equipment, and the PCM link for telemetered measurements, and the sensor and signal conditioning equipment for the displays. ACE readout errors are considered in the total errors presented above.

Measurement calibration curves were used to obtain the data range and the value change of each PCM bit (bit value) in the nominal operating range of the measurement.

Pages in this section are arranged by subsystem and numbered sequentially. Figure numbers contain a functional subsystem letter code as follows:

A = Structures
B = Thermodynamics
C = Electric power
F = Environmental Control
G = Navigation & Guidance
H = Stability & Control (CES)
I = Stability & Control (AGS)
L = Instrumentation
M = Mechanical Design
N = Radars
P = Propulsion - Ascent Engine
Q = Propulsion - Descent Engine
R = Reaction Control
T = Communication
Y = Pyrotechnics
Thermal Control

* ASPO HANDBOOK FOR LAUNCH MISSION RULES, MSC-01270, January 28, 1970

ELECTRICAL POWER SYSTEM

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GC 0201 V	Volt, Battery No. 1
GC 0202 V	Volt, Battery No. 2
GC 0203 V	Volt, Battery No. 3
GC 0204 V	Volt, Battery No. 4

Point of Contact - GAC: V. Hollander/S. Feinberg **Ext.** 6106
MSC: B. Bragg **Ext.** 5361

Data		**Data Range**		**Accuracy**		**C & W**	
		PCM	**Meter**	**PCM**	**Meter**		
Units	VDC					**Max**	NA
Bit Value	0.16	0 to 40		% of FS 1.24 Units 49		**Min**	NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	**Nominal Operation**	**Critical Limits**	**Meas System Error**		**Redline Limits**	
			PCM	**Meter**	**PCM**	**Meter**
No O.C. Decay. For total of ∠20 AH of capacity withdrawn, 35.5v reached within 5 min. and rising.	37.1	None	NA		Max None	
		35.5	2(e)		Min (2)	
No O.C. Decay. For total of >20 AH of capacity withdrawn, 32.6v reached immediately and rising.		None	NA		Max None	
		32.6	2(e)		Min (2)	
Underload	35.0	None	NA		Max None	
		31.5	2(e)		Min (2)	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the redlines is indicative of a battery malfunction and may require the removal of the affected battery from the line. Mission success is compromised.

2. Rationale:

   (a) Batteries must read 36.98 VDC prior to installation. Subsequent to installation, all open circuit voltages must either be rising or remain constant until a load is applied.

   (b) The 35.5 VDC open circuit critical low voltage is based on the assumption that less than 20 ampere-hour of the battery capacity has been expended from the four descent batteries. Based on LTA-8 data, the 35.5 VDC value should be reached within 2 minutes after the load is removed and continue in a rising mode. However, no redline is violated until it takes 5 minutes or longer to reach 35.5 VDC.

   (c) The 32.6 VDC open circuit critical low voltage is based on the assumption that more than 20 amper-hour of battery capacity has been expended from the four descent batteries. The 32.6 VDC value should be reached immediately and continue in a rising mode. For the range of 100 amper-hours and greater, this rise may not be discernible.

Measurements GC 0201 V - GC 0204 V (Cont.)

Details: (Cont.)

(d) The 31.5 VDC under-load critical low voltage represents the worst case condition possible for the applied loads at all battery capacities. The value is based on engineering judgement and on LTA-8 test data. The determination of consistent battery behavior is not possible as only limited test data is available for the relatively low loads anticipated. It is expected, and confirmed by LM-3, LM-4 & LM-5 data, that the nominal voltage will be 35.0 VDC during the prelaunch period.

(e) The redline limits must be established at KSC subsequent to an accurate determination of the end-to-end readout accuracies. Refer to Launch Mission Rules for final redline numbers.

3. Backup Values:

No backup values exist.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GC 0205 V	Volt, Battery No. 5
GC 0206 V	Volt, Battery No. 6

Point of Contact - GAC: V. Hollander/S. Feinberg Ext. 6106
MSC: B. Bragg/M. Alexander Ext. 5361/5437

Data Units	VDC	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.16	0 to 40		% of FS 1.24 Units 49		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
No Open Circuit Decay	37.1	None	NA		Max None	
		36.98	*		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redline:

   Violation of the redlines is indicative of a battery malfunction and may require the replacement of the affected battery. Mission success is compromised.

2. Rationale:

   a) The batteries must read 36.98 VDC prior to installation. Subsequent to installation, the open circuit voltage must remain constant until a load is applied. Due to the high peroxide plateau, the absence of low voltage taps, and the relatively low loads applied at the DC buses, the ascent batteries cannot be loaded in the vehicle during the pre-launch operations.

   b) The redline limits must be established at KSC subsequent to an accurate determination of the end-to-end readout accuracies.

3. Battery Capacity Redline

   The value for minimum battery capacity is based upon the LM Consumable Guidelines delineated in Appendix A and was derived as follows:

*KSC Calibration Less 1 PCM Bit

Measurements: GC 0205V, GC 0206V (Cont'd)

Total Capacity per Battery..... 296 AH

Pre-installation checkout..... .70

Capacity required per battery..... 14.87
prior to staging.

Rendezvous from staging through..... 198.5
docking

Energy required for crew transfer..... 5 AH

Degradation of one battery if..... 28.00
the other battery fails

**Unusable battery capacity..... 22.6

Launch Redline..... 269.7AH

Margin..... 26.3 AH/Batt

**The 22.2 amp-hrs unusable capacity of each battery was calculated as follows:

Telemetry uncertainty (1.91 amps x 6.95 hrs)..... 13.5

Uncertainty due to LM out of LOS with earth..... 4.7
(2 amps x 2.33 amp-hrs)

Dispersion (2% of 222.6 amp-hrs)..... 4.4

Total Unusable..... 22.6 AH

Battery Capacity Back-up Value

The minimum battery capacity back-up value is based upon item 1.1.2 of Appendix A and was derived as follows:

Total Capacity for 2 batteries..... 592 AH

Pre-installation checkout..... 1.4 AH

Capacity required prior to staging..... 100.0

Capacity required to complete rendezvous..... 271.4
(staging thru crew transfer)

2 extra hours orbital reserve..... 90.0

Unusable battery capacity..... 32.5

495.3 AH

Total Avail for Prelaunch..... 495.3 AH

96.7 AH

Measurement No.	Description:
GC 0301 V	Volt, Commander's Bus
GC 0302 V	Volt, System Engr's Bus

Point of Contact - GAC : V. Hollander/S. Feinberg Ext. 6106
MSC: A. Campos Ext. 2846

Data Units	VDC	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.16	0 to 40		% of FS 1.36/1.58		Max NA
				Units .55/.63		Min 26.5+0.43

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
LUT Power		32.5	2 (c)		Max 2 (c)	
		22.0	2 (c)		Min 2 (c)	
Internal Power. Evaluate delta voltage >6.5 VDC between battery and bus readings			NA		Max None	
			NA		Min 2 (b)	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redline:

Exceeding the lower limit (see 2(a) below) results in degraded operation of the affected equipment. The possible effect of exceeding the maximum limit has not been determined due to the lack of test data.

2. Rationale:

(a) During the time interval when the LUT is supplying the power, a minimum is required to insure proper operation of the individual equipment being powered. The equipment interface voltage limits, required to insure nominal operation of the equipment connected to the buses during the prelaunch and CDDT periods, are as follows:

Equipment	Max. (VDC)	Min. (VDC)
Operational Instrumentation	32.0 (Spec.)	18 (Test)
IMU HTR (STBY)	33.5 (Spec.)	18 (Test)
ASA HTR (OFF)	34	20 (Anal.)
LR HTR	31.5 (Spec.) *	22 (Spec.)
RR HTR	31.5 (Spec.)*	22 (Spec.)

While permanent damage will not occur to the heater units or operational instrumentation as a result of violating the lower limits, it may be necessary to re-validate the performance of that equipment which has had temperature redlines violated due to a loss of heater power. The decision to re-validate such equipment will be made based on how far and how long the respective temperature redlines have been violated. To exceed the lower voltage limit for operational instrumentation causes inaccurate monitoring of the vehicle parameters but does not damage equipment.

2. Rationale: (Cont'd)

(b) When the LM is on internal power, the low voltage taps of the batteries will provide power to the buses. Based on analysis, it is predetermined that real time evaluation is required should the difference between the battery reading (20 cells) and the bus reading exceed 6.5 VDC. This value accounts for line losses, the TM reading across the 20 cells and instrumentation errors. The violation of this redline is indicative of a multiple feeder failure.

(c) The redline limits must be established at KSC subsequent to an accurate determination of the end-to-end readout accuracies. Refer to LMR for final values.

3. Backup Values:

Backup Values are not required.

4. C & W:

The Caution and Warning level is based on the EPS requirement to provide specification voltages to all equipment. This equipment is not connected to the bus during the preluanch period.

* Line losses between the bus and the heaters are sufficient to insure specification voltages will not be violated.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GC 1201 C	Current, Battery No. 1
GC 1202 C	Current, Battery No. 2
GC 1203 C	Current, Battery No. 3
GC 1204 C	Current, Battery No. 4

Point of Contact - GAC: V. Hollander/S. Feinberg Ext. 6106
MSC: B. Bragg Ext. 5361

Data Units: AMPS	Data Range: PCM: 0 to 60	Data Range: Meter:	Accuracy: PCM: % of FS 1.66, Units .995	Accuracy: Meter:	C & W: Max NA, Min
Bit Value: 0.24					

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
For Internal Power Only Not more than 43.7 AH Consumed Total Calculated to Liftoff. PCM telemetry not used.	3.4 - 5.7	None	NA		Max 12	
		None			Min None	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redline:

Violation of the total-current redline may indicate an instrumentation problem, possible short in any one of the equipment connected to the bus, or a condition where a circuit breaker inadvertently closed at cabin closeout. Mission success is compromised.

2. Rationale:

As the current monitor accuracy is undefined when the individual battery current is below 3 amperes and since the load sharing between batteries can only be calculated, the redline for these parameters is established based on the total current measured during PCM turn-on. Based on engineering judgment, the total current must not exceed 12 amperes. This value includes allowances for instrumentation accuracies. It is expected, however, that the total current will vary (a function of heater duty cycles) between 3.4 to 5.7 amperes based on the following equipment:

Operational Instrumentation:	1.7 amp
ASA Fine Temperature Control:	0.4 amp
INU Standby Heaters:	0.6 to 2.9 amp
Descent ECAs:	0.7 amp
Total expected current	3.4 to 5.7 amp

With the possible exception of the LDG RDR heater (refer to measurement GM7563T), the RDZ RDR, and the S-Band heaters are not expected to cycle at this time due to their low temperature turn-on.

Measurements: GC 1201C to GC 1204C (Cont'd)

3. Battery Capacity Redline

The battery capacity redline is based upon completing the nominal mission with a one battery failure (Ref. Appendix A) and was established as follows:

Maximum power available with 3 batteries	1172 AH
Required for mission (MPAD Prediction)	1038 AH
Unusables	
a) Telemetry Uncertainty (1.64 amps x 46 hrs)	75.5
b) Uncertainty due to LM out of LOS with earth (2 amps x 2.83 hrs)	5.7
c) Dispersion (2% of 1038 AH)	20.7
Total Unusables	101.9 AH

* Launch Redline (Total Min. Capacity) 101.9 AH + 1038 AH = 1140 AH

Maximum Battery Energy Available for Prelaunch: 1140 AH + 32 AH**

4. Backup Value

The backup value for battery capacity is based upon completing the nominal mission plus a 2 hour lunar stay reserve, (no battery failure case), (Ref. Appendix A) , and was established as follows:

Total Capacity Available (4 Batteries)	1600 AH
Requirement for Mission (MPAD Prediction)	1119 AH
Lunar Stay Reserve (2 hours)	90 AH
Unusables	110.2 AH
** Backup Value Total Minimum Capacity	1319.2 AH

Energy Available for Prelaunch: 1319 AH + 281 AH*** = 1600 AH

*A battery failure detected inflight requires that AC loads be turned off after lunar touchdown. Redline based upon no AC loads after touchdown (PGNS in standby and associated DC power-off; example mission timer and integral lighting).

**The backup value is calculated based on having AC equipment remaining on after touchdown and again turning the PGNCS to standby.

***Present prelaunch operations (including recycle) require approximately 12 amp. hrs.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Subs.

REDLINE DATA

Amendment 6
Date: November 12, 1969

Measurement No.	Description:
GC9961U	Battery No. 1 Malfunction
GC9962U	Battery No. 2 Malfunction
GC9963U	Battery No. 3 Malfunction
GC9964U	Battery No. 4 Malfunction

Point of Contact GAC: V. Hollander/S. Feinberg Ext. 6106
MSC: B. Bragg Ext. 5361

Data Units: Event	Data Range: PCM: NA	Data Range: Meter	Accuracy: PCM: % of FS NA	Accuracy: PCM: Units	Accuracy: Meter	C & W: Max (2)
Bit Value: NA						Min (2)

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
On Internal Power to ≈ T-10 min.	off (0)		NA		Max off(0)	
			NA		Min off(0)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redline: The violation of the redline indicates that an overcurrent, overtemperature and/or reverse current anomaly may have developed in the EPS batteries. Such a failure would prevent the successful completion of the planned mission.

2. Rationale: The Battery Malfunction discretes indicate the possible occurrence of the following battery anomalies when the respective batteries are supplying power:

    1. Overtemperature, > 145 ± 5°F
    2. Overcurrent, > 150 amps
    3. Reverse-current, < -10 amps within 4-6 secs.

    During those periods of the countdown when the batteries are not supplying power the battery voltage measurements (GC0201V - GC0204V) serve to indicate the condition of the batteries. From T-30 minutes to T-10 minutes, it is possible that certain overtemperature and/or reverse-current conditions would not be evident on the battery voltage and current measurements while the batteries are underload. For this reason, the appearance of any/or all of the four Descent Battery Malfunction measurements is cause for holding and evaluating the condition of the suspect batteries. By looking at the respective open circuit voltages of each battery, the indication of a battery malfunction can be verified.

    If a battery anomaly does exist, the planned mission cannot be completed and mission success will be compromised.

    As indicated, the open circuit voltage, GC0201V - GC0204V, can be used to verify the indication of a battery malfunction and serve as backup measurements.

SNA-8-D-027(II)PT2

ENVIRONMENTAL CONTROL SUBSYSTEM

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GF 3582 P	Press Ascent O_2 Tank No. 1
GF 3583 P	Press Ascent O_2 Tank No. 2

Point of Contact - GAC: H. Schneider Ext. 1636
MSC: R. Gillen Ext. 4816

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	4	0 to 1000		% of FS ?.03 Units 20.3		Max NA Min 684

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
Serviced for launch - full tank. Figure GF-1 gives specification leak rate	840 psia @ 70° F at fill	877 @ 70° F	-20		Max 857 @ 70° F	
		(2)	NA		Min (2)	
Minimum to complete mission- less than full tank (Based on specification leak rate)	NA	NA	NA		Max NA	
		(2)	NA		Min 548 @ 70° F	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline

Exceeding the maximum redline indicates that the design limit of the tank has been exceeded and that crew safety is being compromised.

To violate the specification leak rate implies a potential insufficiency of O_2 quantity to satisfy mission requirements. To violate the minimum redline precludes the satisfaction of a nominal mission.

2. Rationale:

Figure GF-1 defines the maximum acceptable decay rates based on a nominal (Full tank) fill of 2.43 lbs. and a specification leak rate. For off-nominal loadings, Figure GF-1 may be used as a means of verifing a specification leak rate. Leak rates in excess of the specification leak rate must be evaluated real time relative to the maximum allowable leak rate as indicated in Detail #3. In evaluating possible leak rates the effect of temperature stabilization after loading must be taken into consideration. Approximately 3 hours must be allowed after loading to permit temperatures to reach ambient values. In addition, because of the lack of direct temperature measurements only approximate leak rates will be determinable.

The maximum redline has been defined to prevent exceeding the design limits for pressure and temperature. Reference Figure GF-2 .

Measurements GF 3582P and GF 3583P (Cont'd)

Details (Cont'd)

Minimum Redline

The value for the minimum redline is based upon the worst case condition defined in the LM Consumable Guidelines delineated in Appendix A.

To determine the minimum redline the following numbers were used:

Required for Mission	1.34 lbs
Dispersion (5%)	0.07 lbs
Residual	0.10 lbs
Measurement Error	0.06 lbs
Minimum Required to Launch	1.57 lbs (548 PSIA @ 70°F)

The "Required for Mission" number is based on:

Metabolic Consumption & Cabin Leakage:

(.20 lbs/hr) x (4.22 hrs) = 0.84 lbs

304 Valve Leakage:

(.001 lbs/hr) x (97.0 hrs) = 0.10 lbs

2 hr Orbital Reserve	0.40 lbs
	1.34 lbs

BACKUP VALUE

The backup value is based upon the LM Consumable Guidelines delineated in Appendix A.

To determine the backup value the following numbers were used:

Required for Mission	2.26 lbs
Dispersion (5%)	0.11 lbs
Residual	0.28 lbs
Measurement Error	0.09 lbs
Backup Value(for 2 tanks)	2.74 lbs

(480 PSIA @ 70°F - per tank)

The "Required for Mission" number is based on:

Metabolic Consumption & Cabin Leakage:

(0.20 lbs/hr) x (8.82 hrs) = 1.76 lbs

304 Valve Leakage:

(.001 lbs/hr) x (97.0 hrs) = 0.10 lbs

2 hr Orbital Reserve	0.40 lbs
	2.26 lbs

3. Backup Value

Should a leak rate occur which exceeds that defined in Figure GF-1 a real time evaluation must be made concerning the integrity of the oxygen system. Figure GF-3 has been drawn to show the relation of pressure to mass of oxygen system at selected temperatures. With Figure GF-3 a given decay rate in psia/hr can be equated to a leak rate in lbs/hr and, in turn compared with the maximum allowed leak rate of (a) .0086 lbs/hr or (b) .0035 lbs/hr for an initially full tank. This allowed leak rate is based on a leak beginning at fill and continuing throughout the mission (assuming 120 hrs. prelaunch and 48 hrs hold.)

Measurements GF 3582 P and GF 3583 P (Cont.)

3. Backup Values Continued:

In evaluating the actual leak rate relative to the maximum allowable leak rate, the difference in prelaunch time and any off-nominal fill conditions must be taken into account.

It must be emphasized that this data is based on the assumption that a detected leak will not become greater during launch. For this reason, plus possible other factors not evident at this time, the magnitude of a leak rate may not be the only criteria for deciding to launch or scrub.

Tank Proof Pressure = 1,330 PSIG @ 160°F
Tank Burst Pressure = 1,500 PSIG @ 160°F

4. C&W:

The value of 684 psia is the Caution and Warning trigger level indicating that the Ascent Oxygen Tank #1 and/or #2 have developed a leak. This signal is inhibited after staging.

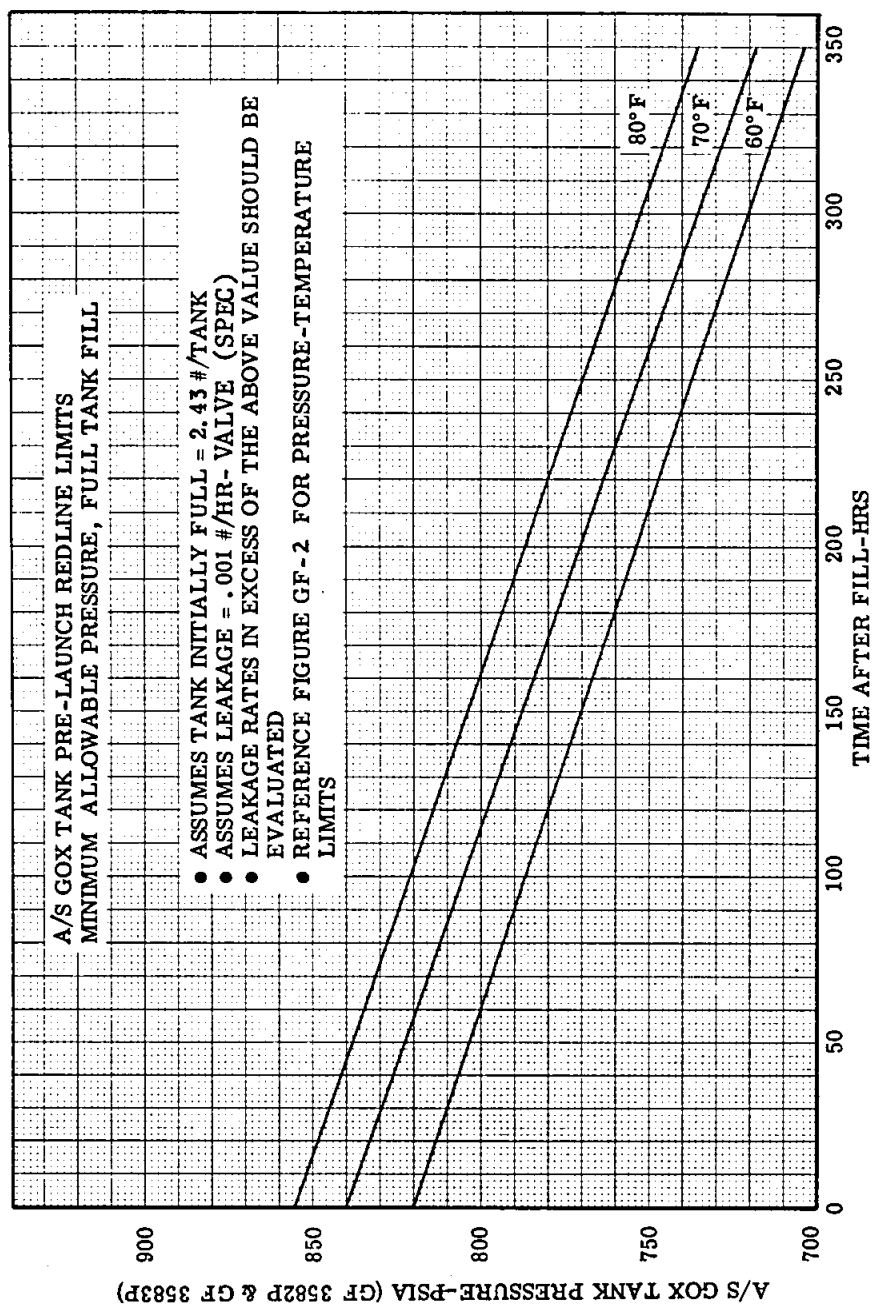


Figure GF-1. A/S GOX Tank Prelaunch Redline Limits

Curve - TBD

Fig. GF-2 Ascent GOX Tank Redlines

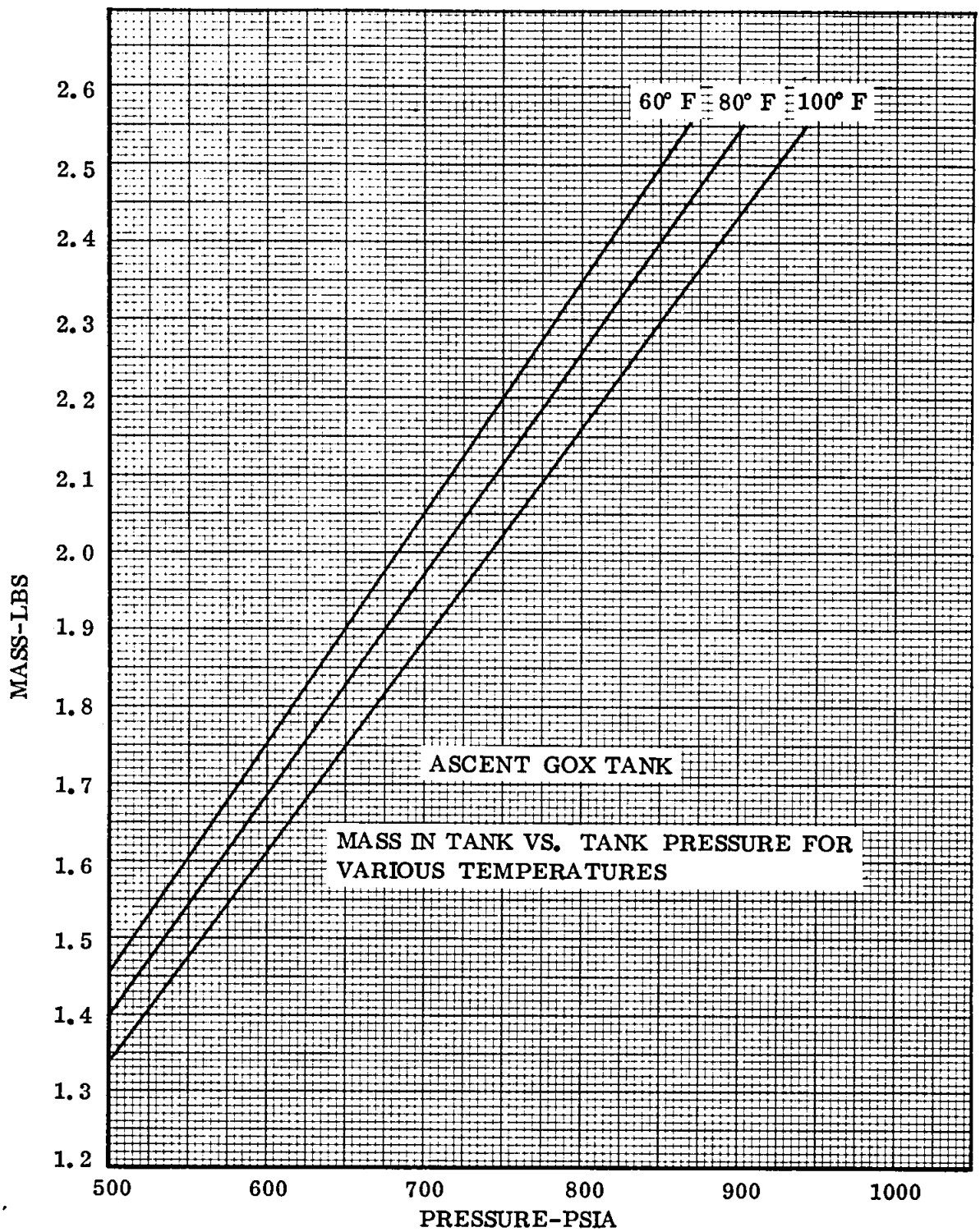


Figure GF-3. A/S GOX: Pressure vs. Mass

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.
GF 3584 P

Description:
Press, Descent O_2 Tank

Point of Contact - GAC: H. Schneider Ext. 1636
MSC: R. Gillen Ext. 4816

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	12	0 to 3000		% of FS 2.1 Units 63.6		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
Serviced for launch-full tank Figure GF-2 gives specification leakage	2690 @ 70°F at fill	2875	-65		Max (2)	
		(2)			Min (2)	
Minimum to complete mission-less than full (Based on Specification leak rate)		NA	NA		Max NA	
		(2)	NA		Min 2355 @ 70°F	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

Exceeding the maximum redline indicates a defective relief valve which compromises crew safety.

To violate the specification leak rate implies a potential insufficiency of O_2 quantity to satisfy mission requirements. To violate the minimum redline precludes the satisfaction of a nominal mission.

2. Rationale:

Figure GF-4 defines the maximum acceptable decay rates based on a nominal (full tank) fill of 48.01 lbs. and a specification leak rate. For off-nominal loading, Figure GF-4 may still be used as a means of verifying a specification leak rate. Leak rates in excess of the specification leak rate must be evaluated real time relative to the maximum allowable leak rate as indicated in Detail #3. In evaluating possible leak rates the effect of temperature stabilization after loading must be taken into consideration. Approximately 3 hours must be allowed after loading to permit the temperature to reach ambient values. In addition, because of the lack of direct temperature measurements only approximate leak rates will be determined.

The maximum redline has been defined to prevent exceeding the relief valve actuation level. Reference Figure GF-5.

Measurement GF 3584 P (Cont.)

Details: (Cont.)

The value for the minimum redline is based upon the LM Consumable Guidelines delineated in Appendix A.

To determine the minimum redline the following numbers were used:

Required for Mission	37.96 lbs
Dispersion (5%)	1.89 lbs
Residual	0.84
Measurement Error	1.23 lbs.
Minimum Required To Launch	41.92 lbs. = 2355 PSIA @ 70°F

The "Required for Mission" number is based on:

Metabolic Consumption & Cabin Leak Rate (0.20 lbs./hr.) x (31.5 hrs.) =	6.30 lbs.
EVA Leak Rate (.06 lbs./hr.) x (8.1 hrs.) =	.5 lbs.
Module and Valve leakage:	
High Pressure - .005 lbs./hr. for 132.7 hrs. =	0.66 lbs.
Low Pressure - .001 lbs./hr. for 97.35 hrs.	.1 lbs.
Required Pressurizations (reserve 6 lbs. for puncture protection 0°F and 300 psia; regulator check, 2.5 lbs.; 3 pressurizations @ 6.62 lbs)	28.4 lbs.
2 hrs. capability at lunar liftoff =	- lbs.
PLSS refills-2 @ 1 lbs. =	2.0 lbs.
	37.96 lbs.

3. Backup Values:

Should a leak rate occur which exceeds that defined in Figure GF-2 a real time evaluation must be made concerning the integrity of the oxygen system. Figure GF-6 has been drawn to show the relation of pressure to mass of oxygen at selected temperatures. With Figure GF-6 a given decay rate in psia/hr. can be equated to a leak rate in lbs./hr. and, in turn, compared with the maximum allowed leak rate of 0.031 lbs./hr. for an initially full tank. This allowed leak rate is based on a leak beginning at fill and continuing throughout the mission (assuming 120 hrs. prelaunch and 48 hrs. hold).

Measurement GF 3584 P (Cont.)

Details: (Cont.)

In evaluating the actual rate relative to the maximum allowable leak rate, the difference in prelaunch time and any off-nominal fill conditions must be taken into account.

It must be exphasized that the use of this data is based on the assumption that a detected leak will not become greater during launch. For this reason plus possible other factors not evident at this time, the magnitude of a leak rate may not be the only criteria for deciding to launch or scrub.

Tank Design Pressure = 3000 PSID @ 160°F
Tank Proof Pressure = 4120 PSIG @ 160°F
Tank Burst Pressure = 4700 PSIG @ 160°F

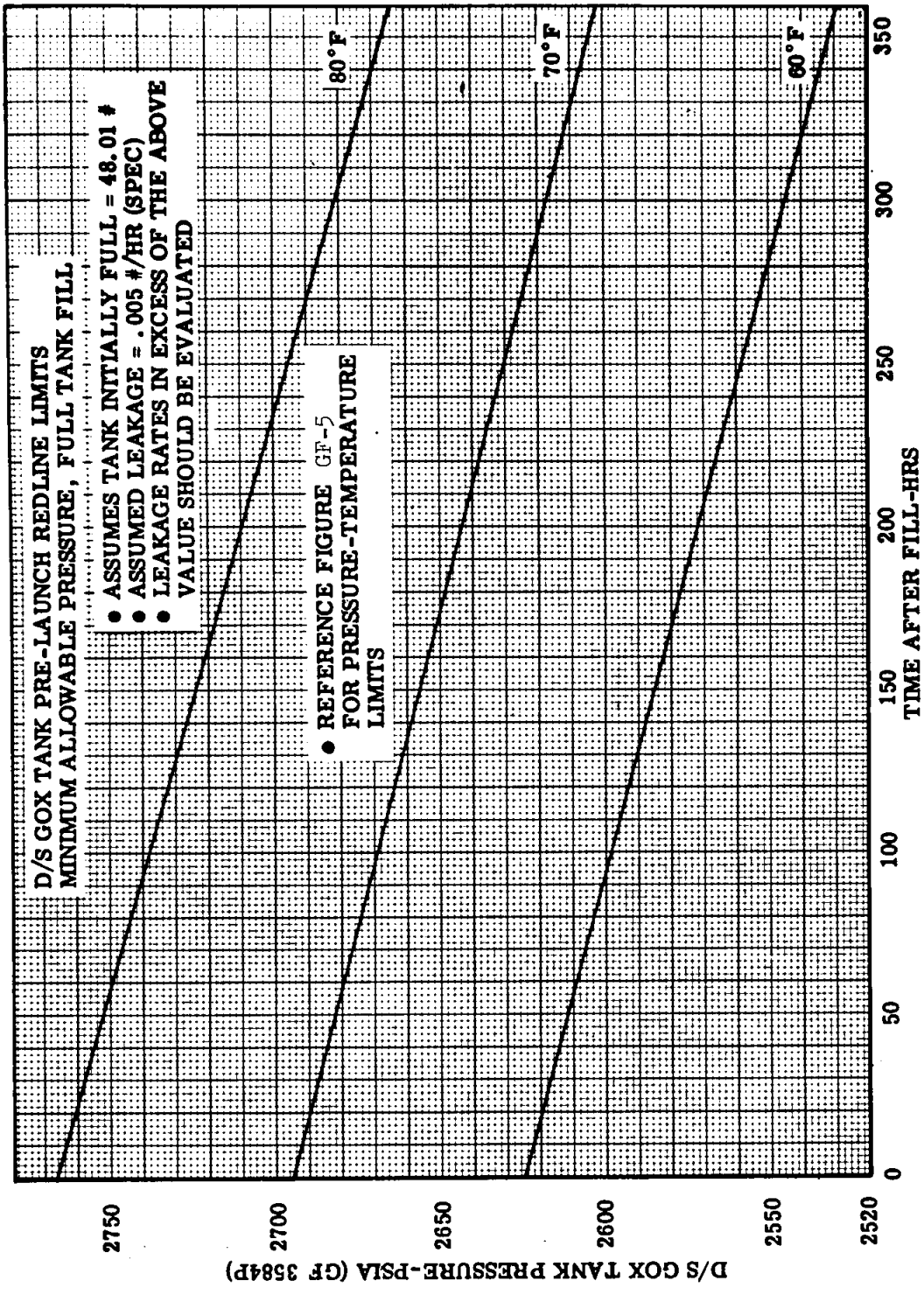


Figure GF-4. D/S GOX Tank Prelaunch Redline Limits

Curve - TBD

Fig. GF-5 D/S GOX Tank Redlines

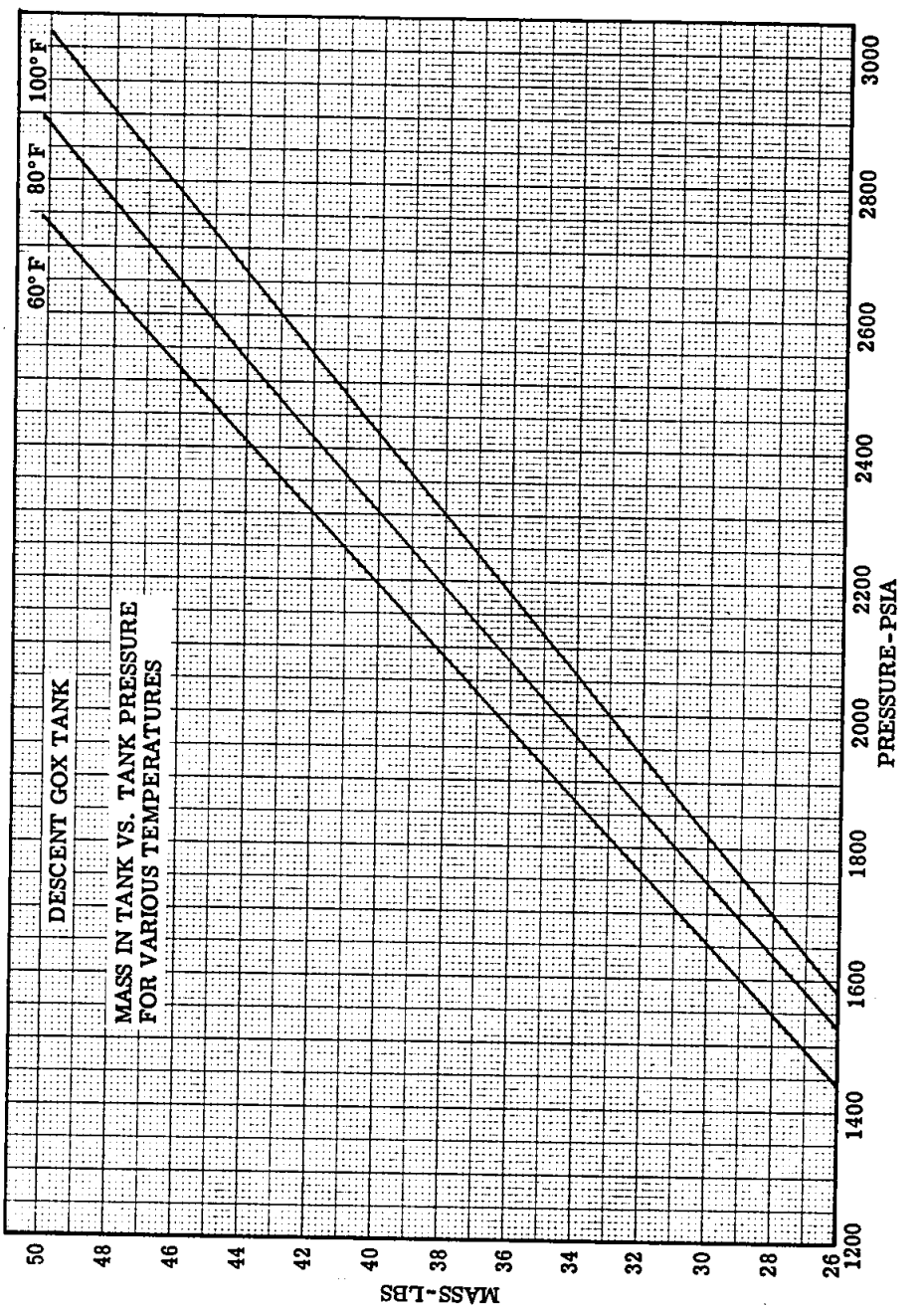


Figure GF-6. D/S GOX: Pressure vs. Mass

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GF 4581 Q	Quantity, Descent Tank Water

Point of Contact · GAC: H. Schneider Ext.: 1636
MSC: R. Gillen Ext.: 4816

Data Units	PCT	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.4	0 to NA lbs. = 0 to 100%		% of FS 2.9 Units 2.9%	NA NA	Max NA Min 15.96% of initial

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
Serviced for launch-full tank See detail 2 for acceptable leak rate.	100%	NA (2)	NA ±(2)		Max NA Min (2)	
Minimum required to complete mission based on conditions in Detail 2 - less than full		NA (2)	NA		Max NA Min 78.5%	
(out-of-spec. leak unacceptable)					Max Min	
					Max Min	

Details:

1. Violation of Redline:

The violation of the minimum quantity redline indicates an insufficient quantity of water to satisfy mission requirements.

Violation of the maximum leak rate redline indicates a deficiency in Nitrogen (any leakage is considered to be a Nitrogen gas leak) with the resulting inability to obtain a sufficient quantity of water to satisfy mission requirements.

2. Rationale:

Figure GF-7 gives the maximum expected decay rate following the N_2 solubility effect. The slope of this curve after 100 hrs. (when N_2 solubility is assumed to be complete) is based on a specification leak rate of 0.06 psi/5 hrs., for a nominal fill. A leak rate in excess of the specification value should be evaluated using Figure GF-8 and extrapolating the WQMD level to launch. If the expected WQMD level at launch is less than the WQMD level indicated in Figure GF-9 for the observed leakage, the redline has been violated. This represents a firm redline which is based on having a minimum of 5% reading on the WQMD at the time of ECS activation thereby providing the crew the ability to verify the capability of properly expelling all of the water. It is noted that a leak rate in excess of the specification value must be evaluated with respect to the risk involved in assuming that the observed leakage rate will not increase.

Measurement GF 4581 Q (Cont.)

Details: (Cont.)

The value for minimum redline is based upon the LM Consumable Guidelines delineated in Appendix A.

To determine the minimum redline the following numbers were used:

Required for mission	=	176.1	
Dispersion (10%)	=	17.6	lbs.
Residual	=	5.2	lbs.
Measurement error	=	9.7	lbs.
Minimum Required to launch	=	208.6	lbs. (78.5 %)

The "Required for Mission" number is based on:

1.	Activation - Separation	(1.92 hr @ 5.66 lb/hr)	=	10.87 lbs
2.	Separation - Touchdown	(4.43hr @ 6.24lb/hr)	=	27.64
3.	Post Landing Checkout	(1.1 hr @ 6.12lb/hr)	=	6.73
4.	Lunar Stay	(1.2 hr @ 5.14lb/hr)	=	6.17
5.	EVA 1 Prep	(2.17hr @ 3.43 lb/hr)	=	7.44
6.	EVA 1	(3.83hr @ 1.63 lb/hr)	=	6.24
7.	Post EVA 1	(1.15hr @ 3.66 lb/hr)	=	4.21
8.	Lunar Stay	(12.6 hr @ 3.13 lb/hr)	=	39.44
9.	EVA 2 Prep	(2.0 hr @ 3.28lb/hr)	=	6.56
10.	EVA 2	(4.0 hr @ 1.73lb/hr)	=	6.92
11.	Post Eva 2	(1.5hr @ 4.02 lb/hr)	=	6.03
12.	Lunar Stay	(3.45 hr @ 5.15lb/hr)	=	17.77
13.	Pre-Launch Prep	(.13 hr @ 5.97 lb/hr)	=	.78
14.	Drink Reqm't During EVA *(8 hrs)	(2 x .37 lbs/hr)	=	6.0
15.	Drink Reqm't Manned Descent **(31.5 hrs)	(2 x 0.08lbs/hr)		5.0
16.	PLSS Refills 2 @ 9.15 lbs		=	18.3
				176.1 lbs

*Based on lifetime of the PLSS.
**Based on urine loss and H_2O produced by the LiOH-CO_2 reaction.

Measurement GF 4581 Q (Cont.)

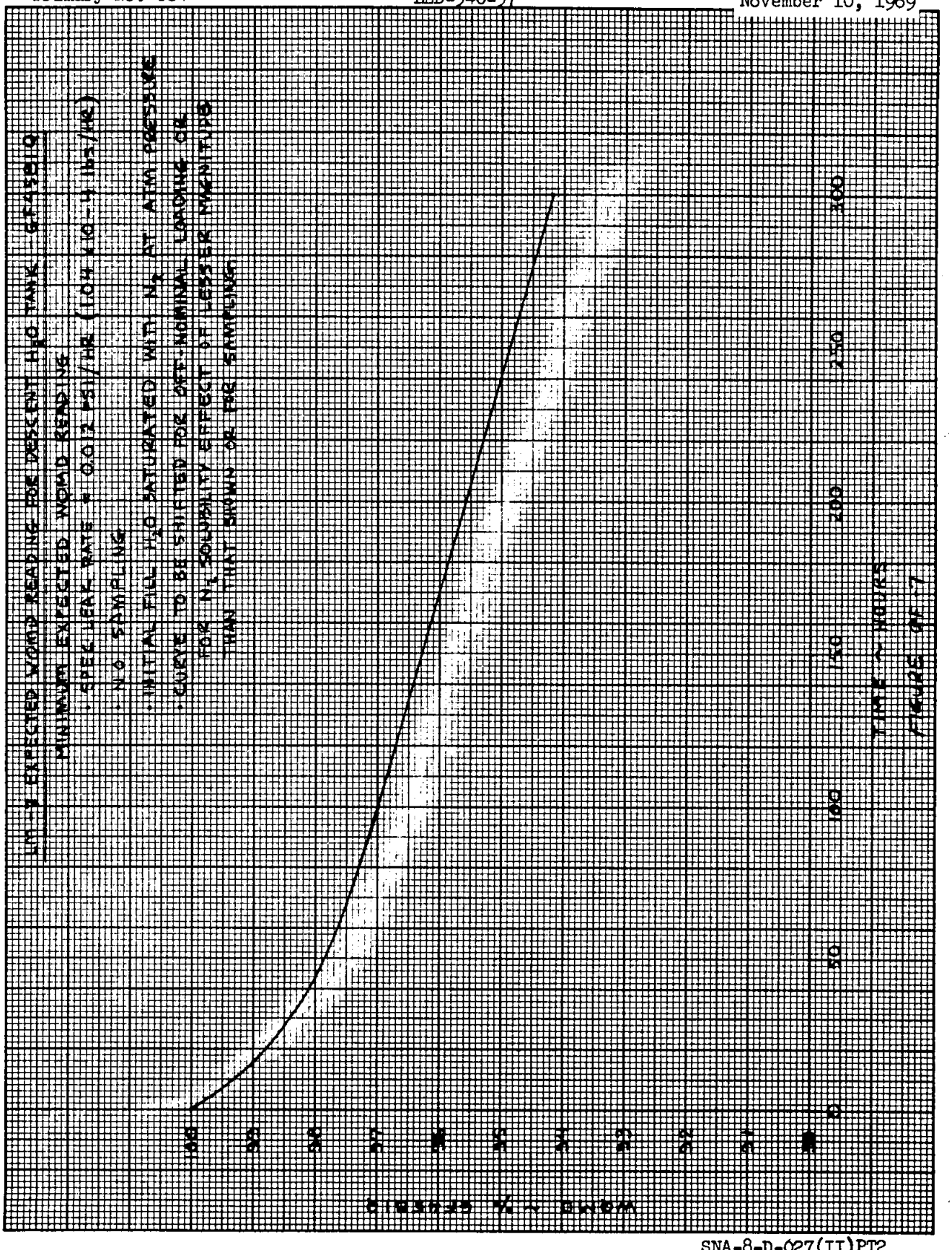
Details: (Cont.)

3. Backup Values:

The maximum allowable leak rate redline is to be utilized for any leakage occuring of an unknown origin, based on the assumption that any leak is a N_2 gas leak. This is based on the nature of the system (i.e., small gas volume) as well as, past experience and is felt to be a realistic approach. Any known water leak would require evaluation due to possible effects on the thermal blankets.

4. C&W:

The caution signal set at 16% of the initial water quantity, is indicative of water depletion.



Curve - TBD

Fig. GF-8 D/S H_2O Gas Leakage On Pad

Curve - TBD

Fig. GF-9 D/S Water Tank GN_2 Leakage vs. WQMD Reading

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GF 4582 Q	Quantity, Ascent Tank No. 1 Water
GF 4583 Q	Quantity, Ascent Tank No. 2 Water

Point of Contact — GAC: H. Schneider, Ext. 1636; MSC: R. Gillen, Ext. 4816

Data Units	PCT	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.4	0 to 42.5 lbs.=0 to 100%		% of FS 2.9 Units 2.9		Max NA Min 95%

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
Serviced for launch - full tank		NA	NA		Max NA	
See Detail 2 for acceptable leak rate	100%	(2)	-2.9		Min (2)	
Minimum to complete mission- less than full (out-of-spec. leak unacceptable)		NA	NA		Max NA	
		(2)	NA		Min 96.5%	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

The violation of the minimum quantity redline indicates an insufficient quantity of water to satisfy mission requirements.

Violation of the maximum leak rate redline indicates a deficiency in Nitrogen (any leakage is considered to be a Nitrogen gas leak) with the resulting inability to obtain a sufficient quantity of water to satisfy mission requirements.

2. Rationale:

Figure GF-10 gives the maximum expected decay rate following the N_2 solubility effect. The slope of this curve after 100 hrs. (when N_2 solubility is assumed to be complete) is based on a specification leak rate of 0.06 psi/5 hrs. If a slight off nominal loading has occurred, or if the effect of N_2 solubility is of a lesser magnitude or if the tank has been sampled then Figure GF-10 with the appropriate shift may still be used to evaluate the actual leak rate relative to the specific leak rate. A leak rate in excess of the specification value should be evaluated using Figure GF-11 and extrapolated to launch. If the expected WQMD level at launch is less than the WQMD level indicated in Figure GF-12 for the evaluated leakage, the redline has been violated. It is noted that a leak rate in excess of the specification value must be evaluated with respect to the risk involved in assuming that the observed leakage rate will not increase.

Measurements GF 4582Q and GF 4583Q (Cont'd)

Details: (Continued)

Minimum Redline

The value for the minimum redline is based upon the worst case condition defined in the LM Consumable Guidelines delineated in Appendix A.

To determine the minimum redline the following numbers were used:

Required for Mission	=	37.04 lbs
Dispersion (5%)	=	1.85 lbs
Residual	=	0.85 lbs
Measurement Error	=	1.23 lbs
Minimum Required to Launch	=	40.97 lbs (for one tank)

The "Required for Nominal Mission" number is based on "Nominal" Thermal Analysis as follows:

1.	PDI to Touchdown (- lbs/hr) (- hrs)	=	- lbs
2.	1 Revolution Stay (- lbs/hr) (- hrs)	=	- lbs
3.	Liftoff to orbit insertion (6.06 lbs/hr) (0.42 hr)	=	2.54 lbs
4.	Orbit insertion to docking (6.0 lbs/hr) (3.5 hr)	=	21.00 lbs
5.	Drink Reqm't manned ascent* (2 x 0.08 lbs/hr) (4.22 hr)	=	0.7 lbs
6.	Orbital reserve (6.4 lbs/hr) (2 hrs)	=	12.8 lbs
			37.04 lbs

*Based on urine loss and H_2O produced by the LiOH-CO_2 reaction.

Measurements GF 4582Q and GF4583Q (Cont'd)

BACKUP VALUE

The backup value for the minimum redline is based upon the LM Consumable Guidelines delineated in Appendix A.

To determine the backup value the following numbers were used:

Required for Mission	=	50.72 lbs
Dispersion (10%)	=	5.07 lbs
Residual	=	0.85 lbs
Measurement Error	=	1.74 lbs
Backup Value	=	58.38 lbs (for two tanks)

The "Required for Nominal Mission" number is based on "Nominal" Thermal Analysis as follows:

1. PDI to Touchdown (6.33 lbs/hr) (.17 hrs) = 1.08 lbs
2. 1 Revolution Stay (6.30 lbs/hr) (2 hrs) = 12.6 lbs
3. Liftoff to orbit insertion (6.06 lbs/hr) (.42 hr) = 2.54 lbs
4. Orbit insertion to docking (6.00 lbs/hr) (3.5 hr) = 21.00 lbs
5. Drink Reqm't manned ascent* (2 x 6.08 lbs/hr) (4.22 hr) = .7 lbs
6. Orbital reserve (6.4 lbs/hr) (2 hrs) = 12.8 lbs

50.72 lbs

*Based on urine loss and H_2O produced by the LiOH-CO_2 reaction.

Measurements CF 4582Q and GF 4583Q (Cont'd)

3. Backup Values:

The maximum allowable leak rate redline is to be utilized for any leakage occurring of an unknown origin, based on the assumption that any leak is a N_2 gas leak. This is based on the nature of the system (i.e., small gas volume) as well as past experience, and is felt to be a realistic approach. Any known water leak would require evaluation due to possible effects on the thermal blankets.

4. C&W

There are two caution conditions associated with the ascent water tanks.

***NASA DATA SOURCE

Prior to staging, the caution light will illuminate if either quantity drops to below 95% indicating a possible leakage. Once staged, a difference in quantity of greater than 15% will illuminate the caution light.

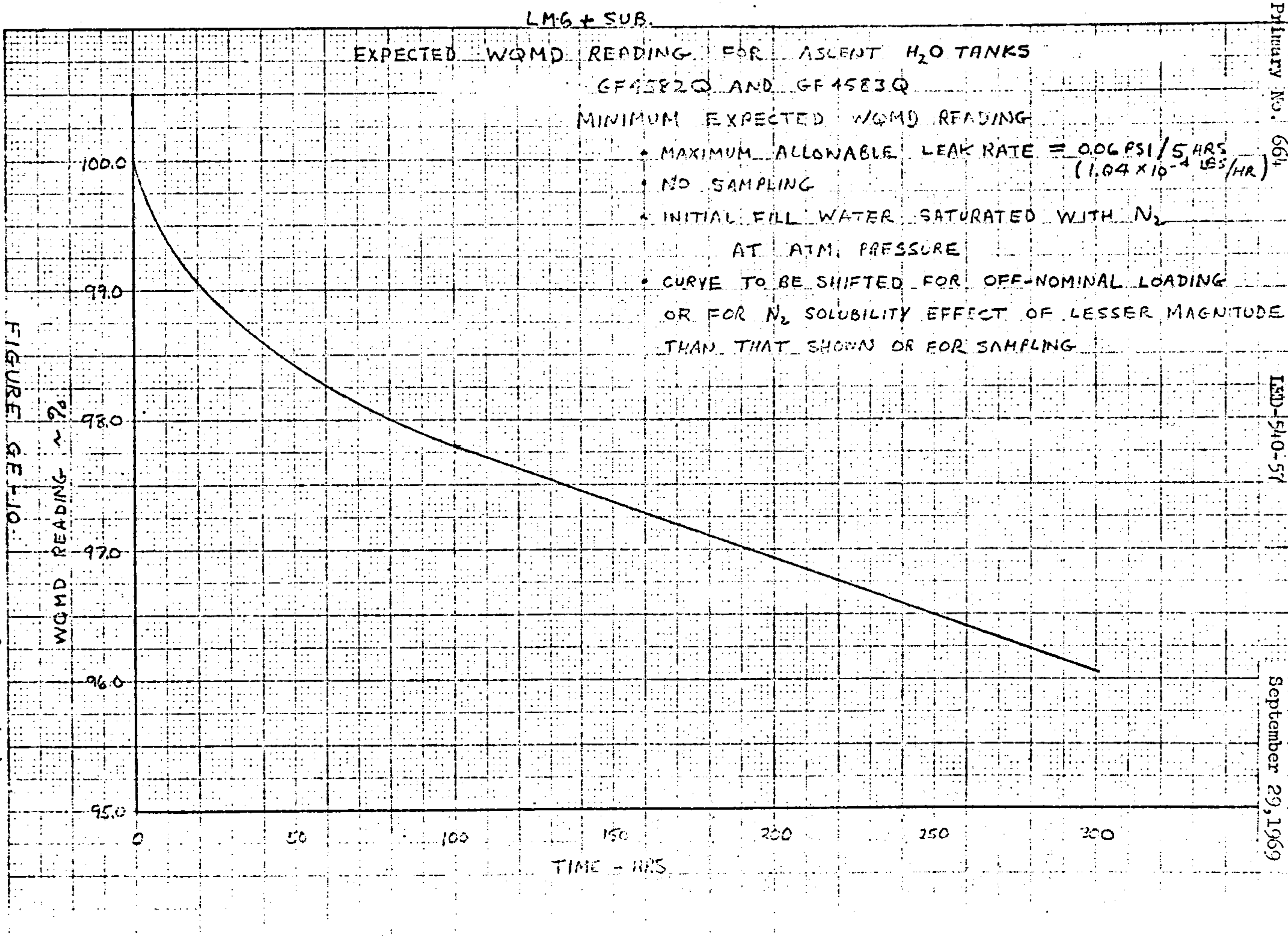

LM-6 + SUB.
EXPECTED WQMD READING FOR ASCENT H_2O TANKS
GF4582Q AND GF4583Q
MINIMUM EXPECTED WQMD READING
• MAXIMUM ALLOWABLE LEAK RATE = 0.06 PSI/5 HRS (1.04×10^{-4} LBS/HR)
• NO SAMPLING
• INITIAL FILL WATER SATURATED WITH N_2 AT ATM. PRESSURE
• CURVE TO BE SHIFTED FOR OFF-NOMINAL LOADING OR FOR N_2 SOLUBILITY EFFECT OF LESSER MAGNITUDE THAN THAT SHOWN OR FOR SAMPLING
WQMD READING ~ %
100.0
99.0
98.0
97.0
96.0
95.0
0
50
100
150
200
250
300
TIME - HRS

FIGURE GE-10.

Curve - TBD

Fig. GF-11 A/S H_2O Tank Gas Leakage On Pad

Curve - TBD

Fig. GF-12 Ascent Water Tank Gas Leakage vs. WQMD Reading

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 & Sub.

REDLINE DATA

LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GF 9997 U	Press, Selected Pump Discharge (when primary pump is selected)

Point of Contact - GAC: H. Schneider **Ext.** 1636
MSC: R. Gillen **Ext.** 4816

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	.24	0 - 60		% of FS 2.12 Units 1.27		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
Primary Loop, No Circulation/ no leakage allowed	24.5 @ 70°	(2)	-1.27		Max (2)	
		(2)	±1.27		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   The violation of the no leakage redline indicates that the integrity of the Primary Coolant Loop has degraded and that crew safety and mission requirements will be compromised.

2. Rationale:

   (a) The occurrence of any glycol leak is not tolerable for the following reasons:

   1. The eventual loss of the Primary Coolant Loop capabilities.
   2. The probable degradation in the thermal insulation of the vehicle due to glycol contaimination of the thermal blankets.
   3. The probable contamination of electronic equipment in the vicinity of the leak.
   4. The depositing of a glycol residue which is flammable and, therefore, compromises crew safety.

   In determining whether or not a leak exists it must be noted that variations in pressure within SLA will be evident on GF 9997 U. Any continuous decay in pressure must be considered a leak and is intolerable.

Measurement GF 9997 U (Cont.)

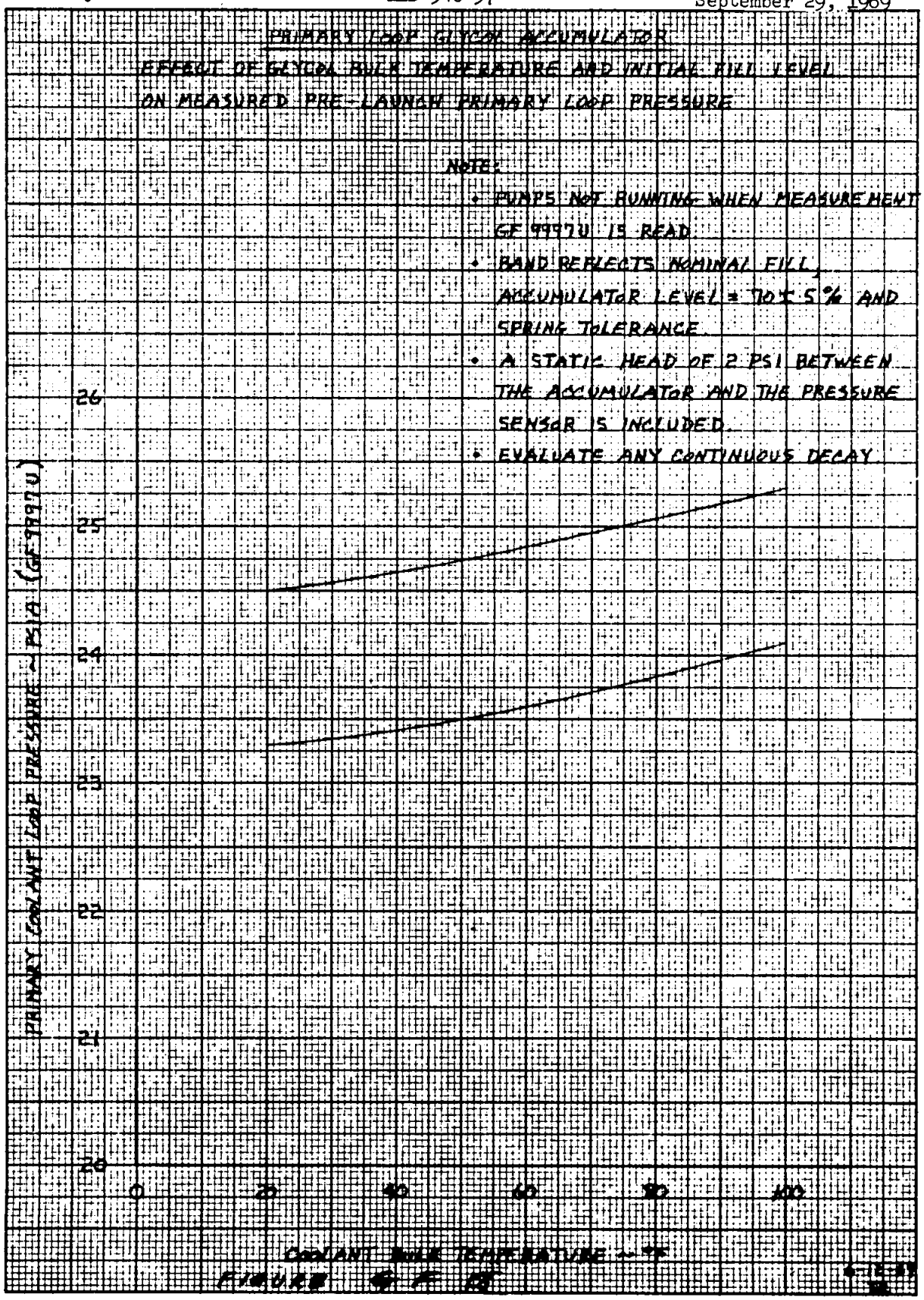
Details: (Cont.)

2. Rationale: (cont.)

(b) The allowable pressure band shown in Figure GF-13 does not include instrumentation error which is 1.27 PSIA. Fig. GF-13 presents the expected range for nominal 70 ± 5% fill with the accumulator spring tolerance added. The pressure reading is to be noted when the accumulator is set to the nominal value (70%). Any reading at fill which falls outside of the band indicates an improper fill and must be evaluated. Any significant change from the pressure at fill, other than due to temperature effects as shown in Fig. GF-13 must be investigated by a direct reading of the accumulator level.

3. Backup Values:

GF 2041 X can be used as a backup in the event of a severe leakage.


PRIMARY LOOP GLYCOL ACCUMULATOR
EFFECT OF GLYCOL BULK TEMPERATURE AND INITIAL FILL LEVEL
ON MEASURED PRE-LAUNCH PRIMARY LOOP PRESSURE
NOTE:
• PUMPS NOT RUNNING WHEN MEASUREMENT GF 9997U IS READ
• BAND REFLECTS NOMINAL FILL ACCUMULATOR LEVEL = 70 ± 5 % AND SPRING TOLERANCE
• A STATIC HEAD OF 2 PSI BETWEEN THE ACCUMULATOR AND THE PRESSURE SENSOR IS INCLUDED.
• EVALUATE ANY CONTINUOUS DECAY
PRIMARY COOLANT LOOP PRESSURE - PSIA (GF9997U)
26
25
24
23
22
21
20
0
20
40
60
80
100
COOLANT BULK TEMPERATURE - °F

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 & Sub.

REDLINE DATA

LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GF 2921 P	Press, Redundant Pump Discharge

Point of Contact - GAC: H. Schneider **Ext.** 1636
MSC: R. Gillen **Ext.** 4816

Data Units	PSIA	**Data Range** PCM	**Data Range** Meter	**Accuracy** PCM	**Accuracy** Meter	**C & W**
Bit Value	.24	0 - 60		% of FS 2.12 Units 1.27		Max NA Min

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	**Nominal Operation**	**Critical Limits**	**Meas System Error** PCM	**Meas System Error** Meter	**Redline Limits** PCM	**Redline Limits** Meter
Secondary Loop, No Circulation/no leakage allowed	25.0 70°F	(2)	-1.27		Max (2)	
		(2)	+1.27		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   The violation of the no leakage redline indicates that the integrity of the secondary Coolant Loop has degraded and that crew safety and mission requirements will be compromised.

2. Rationale:

   (a)

   In determining whether or not a leak exists it must be noted the variations in pressure within SLA will be evident on GF 2921 P. Any continuous decay in pressure must be considered a leak and is intolerable for the following reasons:

   1. The eventual loss of the Secondary Coolant Loop capabilities.
   2. The probable degradation in the thermal insulation of the vehicle due to glycol contamination of the thermal blankets.
   3. The probable contamination of electronic equipment in the vicinity of the leak.
   4. The depositing of a glycol residue which is flammable and, therefore, compromises crew safety.

Measurements GF 2921 P (Cont.)

Details: (Cont.)

2. Rationale: (cont.)

(b) The allowable pressure band shown in Figure GF-14 does not include instrumentation error which is 1.27 PSIA. Fig. GF-14 presents the expected range for a nominal 80 ± 5% fill with the accumulator spring tolerance added. The pressure reading is to be noted when the accumulator is set to the nominal value (80%). Any reading at fill which falls outside of the band indicates an improper fill and must be evaluated. Any significant change from the pressure at fill, other than due to temperature effects as shown in Fig. GF-14, must be investigated by a direct reading of the accumulator level.

(c) GF 2921 P is part of a combination measurement and can not be monitored past closeout because the secondary glycol loop must be selected in order to obtain a reading from this measurement.

3. Backup Values:

GF 2042 can be used as a back up in the event of severe leakage.

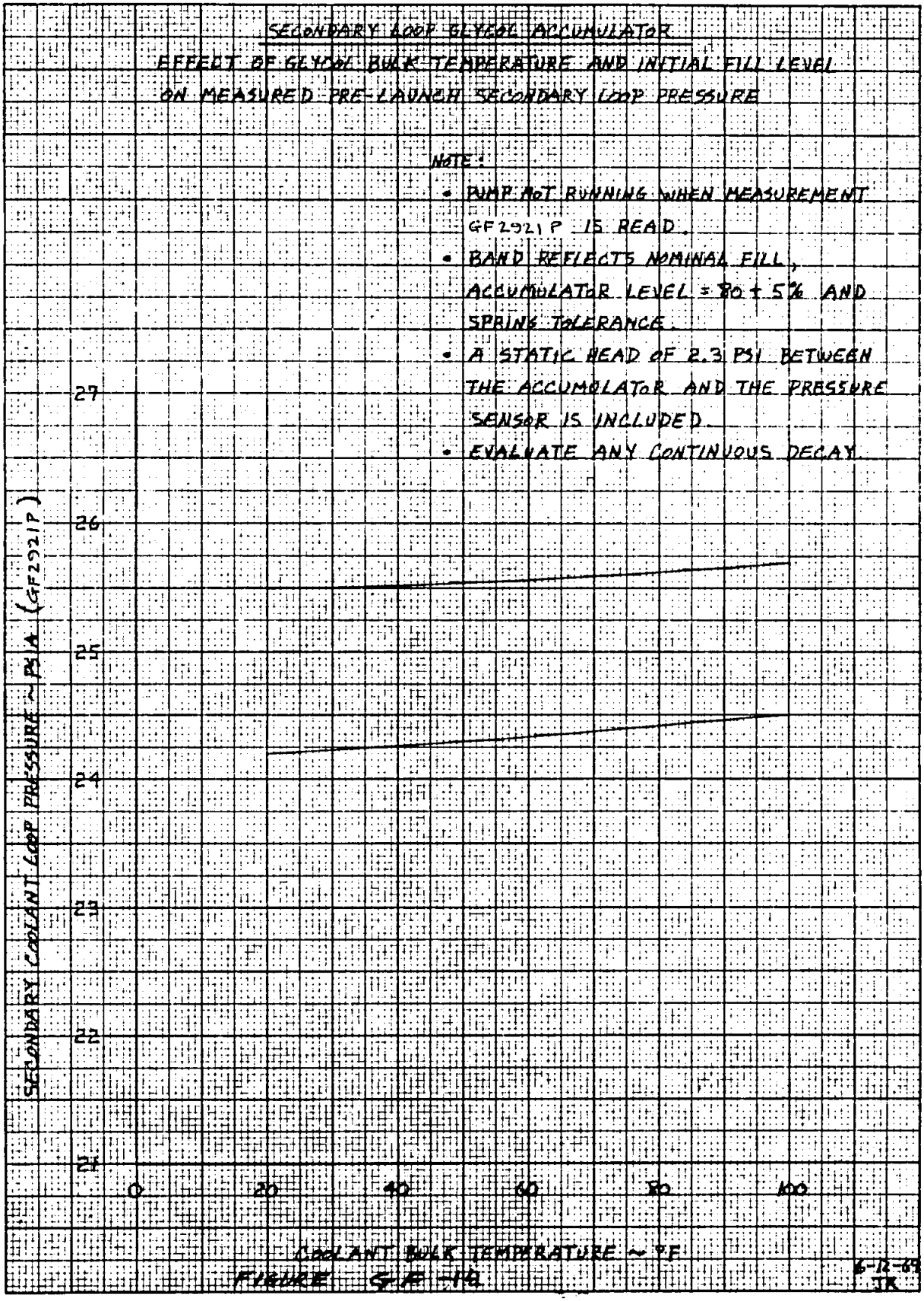


FIGURE 5.F-119

LED-540-57

EXPLANATION OF USE OF GF 8 & 11

In order to determine th WQMD reading required at launch for a given WQMD (%/hr) leakage the following steps are taken:

1. Enter curves for descent or ascent gas leakage GF 8 or 11.

2. Determine WQMD (%/hr) leakage from telemetry.

3. Select appropriate scale on horizontal axis. Take exponent of WQMD leakage and determine value of M, for example: $10^{-5} = 10^{-M+2}$ then M = 7.

4. Read up to line for initial WQMD reading used in leakage calculation. Then read across to determine N_2 leakage using M determined in (3).

5. Go to appropriate graph of N_2 Vs WQMD required at launch GF 9 or GF 12.

6. If WQMD reading at launch is equal to or greater than WQMD reading using above method Vehicle is go for launch.

GUIDANCE NAVIGATION AND CONTROL SUBSYSTEM

Contract No. NAS 9-1100
Primary No. 664

REDLINE DATA
LED-540-57

SC Effectivity: LM-6 & Sub.

Date: September 29, 1969

Measurement No.	**Description:**
GG 2300 T	Temp. PIPA

Point of Contact - GAC: R. Kerr — Ext. 1713
MSC: R. Parker — Ext. 4701

Data Units	DEG.F.	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	08	120 to 140		% of FS / Units (2)		Max NA / Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
STDBY: To T-10 min.	130.5	132.1	NA		Max 132.1	
		128.4	NA		Min 128.4	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the redlines could be indicative of a malfunction in the PGNS thermal control circuitry which would result in degraded PGNS guidance performance.

2. Rationale:

   The critical and the redline limits were established based on specification values of the PGNS thermal control circuitry; i.e., 130.5 + 1.5°F - 2.0°F. To account for instrumentation errors, another uncertainty of ±0.1°F was added to arrive at the above redlines of 130.5 + 1.6°F - 2.1°F. These values apply during stabilized conditions only; i.e., when the temperatures have stabilized.

3. Backup Values:

   If the above critical limits (130.5 + 1.6 - 2.1°F) are exceeded, the cause must be understood prior to launch.

   If the limits of 120 or 140°F are exceeded, the inertial parameters must be measured prior to launch and recalibrated.

STABILIZATION AND CONTROL SECTION
CONTROL ELECTRONICS SECTION

Measurement No.	Description:
GH 1230 X	Ascent Engine Arm (from PNL.)

Point of Contact - GAC: D. Anderson Ext. 1874
MSC: D. Shelton Ext. 4701

Data Units: Event	Data Range PCM: NA	Data Range Meter	Accuracy PCM: % of FS NA, Units NA	Accuracy Meter	C & W Max: NA	C & W Min: NA
Bit Value: NA						

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min.	OFF(0)			NA	Max OFF(0)	
				NA	Min OFF(0)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redlines:

   Violation of the redline could be indicative of a malfunction of the Engine Arm Switch 1S1 which could result in premature arming and possibly premature firing of the ascent engine. Crew safety and accomplishment of mission objectives could be comprimised by such a malfunction.

2. Rationale:

   A single point failure, short of one contact of the arm switch, will give the instrumentation indication. When 4CB37, Engine Arm, is energized the ascent engine will arm which will make it possible to prematurely fire the engine should the next associated failure, a shorted contact in K12 or K207 occur. (Reference Figure GH-1.)

   When the instrumentation indication occurs it cannot be distinguished whether it is an instrumentation failure or a hardware failure.

   The GG 0001 X PNGS Downlink Data is a backup measurement but it cannot be utilized during the countdown since the computer is not operating.

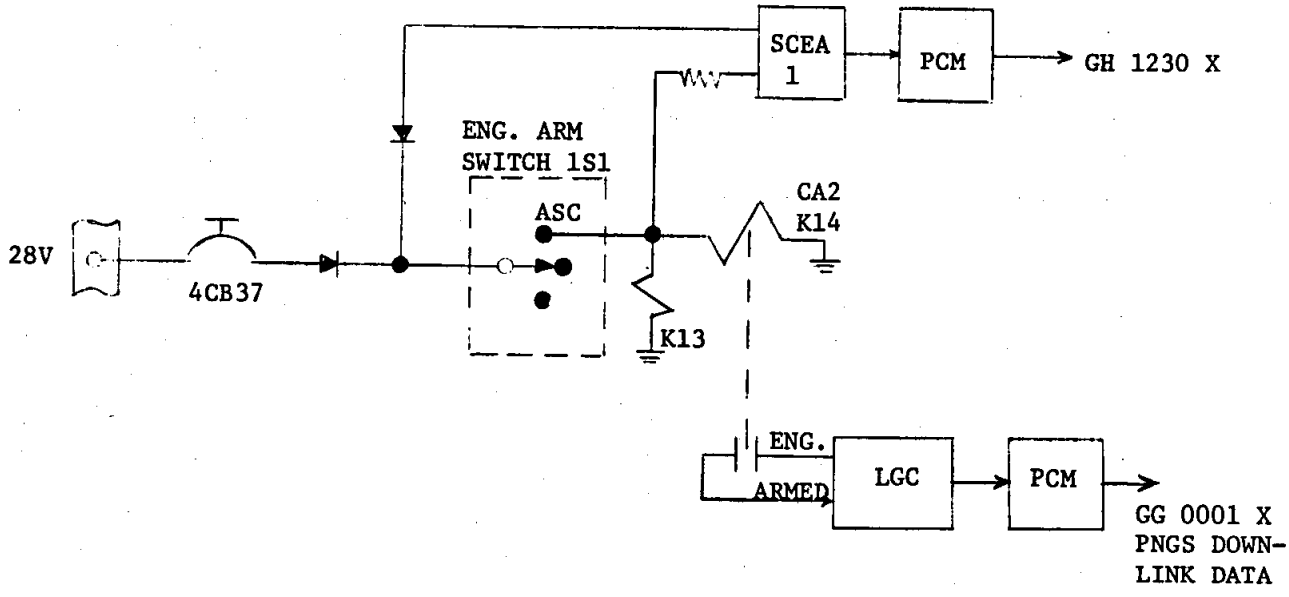


FIGURE GH-1. SCHEMATIC - GH 1230 X ASCENT ENGINE ARM

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 & Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GH 1418 V Through GH 1433 V	Jet Driver Outputs

Point of Contact - GAC: D. Anderson **Ext.** 1874
MSC: D. Shelton **Ext.** 4701

Data Units	Event	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	NA	NA		% of FS NA Units NA		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min.	OFF (0)		NA		Max OFF (0) Min OFF (0)	
					Max Min	
					Max Min	
					Max Min	

Details:

1. Violation of Redlines:

   Violation of the redline would be cause for a hold or scrub in the launch since a change of state could be indicative of either an instrumentation or subsystem failure. Mission success would be compromised by early termination of the planned mission. (Ref. FMR 28-21).

2. Rationale:

   These measurements indicate the status of the ATCA Jet Driver outputs to the RCS engines. Absence of an "on" (1) indication precludes a particular RCS jet from being on when the system is activated. A single point failure could cause the redline violation which cannot be distinguished between an instrumentation or subsystem failure. (Reference Figure GH-2).

   If a subsystem failure did exist, the planned mission could not be performed (ref. FMR 28-21) and mission success would be compromised.

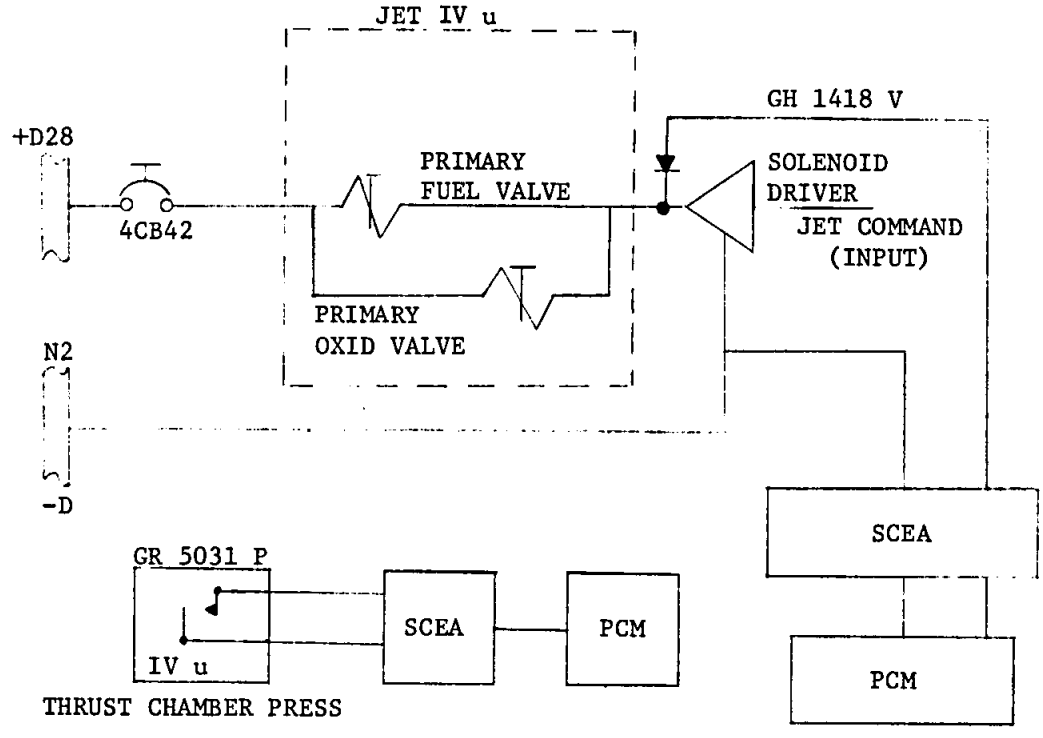
   GH 1418 X thru GH 1433 X Driver Outputs - RCS Jets have experienced false instrumentation indications. Bias resistors have been added to these measurements from the CWEA and Sig. Cond. #1 ckt breakers thus biasing the SCEA buffer ckt off. However during pre-launch the CWEA ckt breaker line does not have power applied while the Sig. Cond. #1 ckt breaker does have power applied. Thus GH 1418, 20, 23, 24, 26, 29, 31, 33 X LMP RCS Jets can have false instrumentation indications on the pad.

Measurements GH 1418 V Through GH 1433 V (Cont.)

Details: (Cont.)

2. Rationale: (cont.)

Alternate measurements are not available during the prelaunch countdown to provide backup data for the above discrete measurements.



(TYPICAL OF ALL JET DRIVER OUTPUTS)

FIGURE GH-2. SCHEMATIC - GH 1412 V THROUGH GH 1433 V

JET DRIVER OUTPUTS

STABILIZATION AND CONTROL SECTION
ABORT GUIDANCE SECTION

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA

LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GI 3301 T	ASA Temp

Point of Contact - GAC: W. Nufer Ext. 1874
MSC: P. Kurten Ext. 4701

Data Units	DEG.F.	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	.78	20 to 200		% of FS / Units		Max NA / Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
OFF (Post-Cabin Closeout)	TBD	TBD / TBD	NA / NA		Max TBD / Min TBD	
Standby/Operate (Pre-Cabin Closeout)	TBD	TBD / TBD	NA / NA		Max TBD / Min TBD	
					Max / Min	
					Max / Min	

Details:

1. Violation of Redline:
Violation of the redlines is indicative of heater temperature control degradation which may compromise completion of mission objectives.

2. Rationale:

AGS in Standby/Operate Mode:

Errors in the ASA temperature reading may be divided into two groups: "Set Point" and "Stability" errors. The Set Point, T_{SET}, is the individual ASA mounting block temperature which is determined by the initial temperature measurement of the individual ASA during vehicle testing. Set Point errors are function of the individual ASA and tend to remain constant. All ASA T_{SET} values will fall within the range of 114.0° to 126.0°F. For LM-7 the actual T_{SET} value has been determined to be TBD . For the stability errors about T_{SET}, the NASA/GAC Joint Panel Meeting #18 on May 18, 1967 established the limits of ±3°F. In effect, once the set point errors for a given ASA-SCEA-PCMTEA combination is established in vehicle testing, the variations from the new readout nominally should remain within ±3°F. Based on the PCM/ACE readout resolution of ±0.8°F the redline has been defined as ±3.2°F.

AGS in OFF Mode:

For the "OFF" condition a T_{SET} value of TBD has been determined for LM-7 with the same redline limits of ±3.2°F.

Measurement GI 3301 T (Cont.)

Details: (cont.)

3. Backup Values:

There will be a degradation of ASA performance with deviation of temperature. This performance degradation cannot be accurately predicted, however should the redlines be violated during the pre-launch period and subsequently returned to normal, there is no reason to suspect that the ASA would not operate properly. ASA temperatures of 30°F and 160°F are presently considered the "destruct temperatures" beyond which permanent damage results.

L - INSTR

SCIENTIFIC INSTRUMENTATION AND EQUIPMENT

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GL 0400 X	Internal Osc. Failure Detect Sig No. 1

Point of Contact - GAC: L. Wolfschmidt **Ext.** 3672
MSC: D. O'Brien **Ext.** 2848

Data Units	Event	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	NA	NA		% of FS NA Units		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
During System Operation	OFF(0)		NA		Max OFF(0) Min OFF(0)	
					Max Min	
					Max Min	
					Max Min	

Details:

1. Violation of Redline:

   Violation of the redline is indicative of either a degradation/failure of the PCMTEA internal oscillator, or a detector failure. The failure of the PCMTEA internal oscillator precludes the transmission of PCM data when the LGC is "OFF" (or failed). A detector failure is of minimum consequence in the mission and/or in the countdown.

2. Rationale:

   When the LGC is OFF and PCM data is being received, then the PCMTEA internal oscillator is operational. The redline value was established in order to detect a possible degradation in the PCMTEA internal oscillator by monitoring the output of the Detector Buffer (downstream of the PCMTEA oscillator). The Detector Buffer output (nominally 6 VDC) is fed to the Schmitt Triggers (Threshold = 2.25 VDC) which feed the Timing Counter Chains required for PCM data. GL 0400 X receives its input upstream of the Schmitt Triggers and has a threshold of 2.0 VDC (i.e., $\geq$ 2.0 VDC = PCM (0), $<$ 2.0 VDC = PCM (1)). Since the threshold for GL 0400 X is only slightly below the threshold required for good PCM data, there is a possibility that GL 0400 X will register a degradation which may otherwise be unnoticed (theoretically, PCM data degradation occurs first).

3. Backup Values:

   Refer to GL 0422 V and GL 0423 V.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	Description:
GL 0401 V	Volt, Calib 85 Pct, HL

Point of Contact - GAC: R. Krimsier Ext. 3672
MSC: D. O'Brien Ext. 2848

Data Units	VDC	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	.02	0 to 5		% of FS .53 Units .027		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 minutes	4.25[a]	4.29	NA		Max 4.29	
		4.21	NA		Min 4.21	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the redlines is indicative of a malfunction which affects the accuracy of all high-level anolog measurements and may result in data reduction problems.

2. Rationale:

   These levels are the high-level signal, obtained from a precision resistor divider, used to calibrate the high speed gate and the coder. Operation outside of these limits indicates a malfunction of the system, which in turn affects the accuracy of all high-level analog measurements and would result in a data reduction problem. The same indication of a malfunction should be seen with measurement GL 0402 V, "Volt, Calib 15 Pct HL". If no such indication is seen and all high-level analog measurements behave nominally, then an instrumentation malfunction in GL 0401 V has occurred.

   Instrumentation accuracies have been included in the critical limit values.

3. Backup Values:

   No backup values exist.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GL 0402 V	Volt, Calib, 15 Pct HL

Point of Contact - GAC : R. Krimsier **Ext.** 3672
MSC: D. O'Brien **Ext.** 2848

Data Units	VDC	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	.02	0 to 5		% of FS .53 Units .027		Max NA Min

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 minutes	.75	.79	NA		Max .79	
		.71	NA		Min .71	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the redlines is indicative of a malfunction which affects the accuracy of all high-level analog measurements and may result in data reduction problems.

2. Rationale:

   These levels are the low high-level signal, obtained from a precision resistor divider, used to calibrate the high speed gate and the coder. Operation outside of these limits indicate a malfunction of the system which in turn affects the accuracy of all high-level analog measurements and would result in a data reduction problem. The same indication of a malfunction should be seen with measurement GL 0401 V, "Volt, Calib 85 Pct HL". If no such indication is seen and all high-level analog measurements behave nominally, then an instrumentation malfunction in GL 0402 V has occurred.

   Instrumentation accuracies have been included in the critical limit values.

3. Backup Values:

   No backup values exist.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	Description:
GL 0422 V	Internal Osc. Failure Detect Sig No. 2
GL 0423 V	Internal Osc. Failure Detect Sig No. 3

Point of Contact - GAC : L. Wolfschmidt Ext. 3672
MSC: D. O'Brien Ext. 2848

Data Units	VDC	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	.02	0 to 5.0		% of FS NA Units		Max NA Min

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
LGC OFF		2.1	NA		Max 2.1	
		1.2	NA		Min 1.2	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the redlines is indicative of either a degradation of the PCMTEA internal oscillator, or a detector failure. The failure of the PCMTEA internal oscillator precludes the transmission of PCM data when the LGC is "OFF" (or failed). A detector failure is of minimum consequence in the mission and/or in the countdown.

2. Rationale:

   When the LGC is OFF and PCM data is being received, then the PCMTEA internal oscillator is operational. The redline values were established in order to detect a possible degradation in the PCMTEA internal oscillator. The "gray" area outside the redlines may indicate such a degradation and may expedite the preparation for the possible replacement of the PCMTEA.

3. Backup Values:

   No backup values, or other analog measurements, exist which confirm a partial degradation of the PCMTEA internal oscillator.

M - RADAR

RADAR

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GN 7563 T	Temp., LR Antenna

Point of Contact - GAC: S. Boles/R. Kreis Ext. 1875/3356
MSC: P. Rozas Ext. 3669

Data Units	DEG.F.	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	1.6	±200		% of FS 1.72		Max NA
				Units 6.88		Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
*Evaluate any increase from ambient SLA Temperature	Ambient	NA	NA		Max *	
		62	-7		Min 55	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redlines:

   Exceeding the redline values is indicative of the LR heater degradation or heater on/off failure. These conditions may compromise the satisfaction of the mission requirements.

2. Rationale:

   The LR antenna temperature measurement reading is nominally ambient. Should the sensor (GN7563T) temperature drop to 62°F or below, the heater low trip-level would be activated driving the temperature up to 66°F. The CRT readings, however, may not correspond to these values as the instrumentation errors are not included.

3. Backup Values:

   Should the LR heater "stick on", the LR antenna electronics package becomes permanently damaged if the temperature at GN 7563 T exceeds 170°F. Operation is questionable between 145°F and 170°F.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 & Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GN 7723 T	Temp., RR Antenna

Point of Contact - GAC: S. Boles/R. Kreis **Ext.** 1874/3356
MSC: R. Fenner **Ext.** 3669

Data Units	DEG.F.	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	1.6	±200		% of FS 1.79 Units 7.15		Max 147.69 Min -54.07

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
Evaluate any increase from ambient	Ambient	NA	NA		Max (2)	
		NA	NA		Min NA	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the redline is indicative of the RR heater degradation or heater ON failure. This condition will compromise the satisfaction of the mission success.

2. Rationale:

   As the RR heater is not expected to cycle, any indicated temperature above ambient is of concern and should be evaluated.

3. Backup Values:

   Should the RR heater "stick on", the RR antenna electronics package becomes permanently damaged if the temperature exceeds 175°F. The RR survival heater is activated when the temperature drops to -35° ±5°F.

4. C & W:

   The Caution & Warning values reflect the critical limits of the RR electronics in Operate Mode.

ASCENT PROPULSION SUBSYSTEM

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 & Sub.

REDLINE DATA
LED-540-57
NASA DATA SOURCE

Date: March 9, 1970

Measurement No.	Description:
GP 0001 P	Press, He Supply Tank No. 1
GP 0002 P	Press, He Supply Tank No. 2

Point of Contact - GAC: J. Salek Ext. 1661
MSC: C. Humphries Ext. 2786

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	16.0	0 to 4000		% of FS 2.14 Units 86.0		Max ____ Min 2775

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 minutes - a detectable leak not acceptable	3120 @ 70°F	*3586 @ 120°F	-86.0		Max (2)	
			+86.0		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the maximum redline increases the possibility of a catostrophic tank failure and compromises crew safety.

   Violation of the minimum quantity redline prevents the completion of required mission objectives.

2. Rationale:

   Figure GP-1 presents the maximum redline limit as a function of temperature for the APS Helium Tanks. In addition, the fracture mechanics ' limit has been presented which establishes the maximum operating pressure as a function of temperature. To establish a maximum redline limit like that given in Figure GP-1 it becomes necessary to assume a maximum inflight temperature under nominal conditions. The maximum allowed inflight temperature for the APS Helium Tank is *120°F.

   The minimum redline shown in Figure GP-1 is based on ascent helium guidelines in Appendix C, Vol. II, Part 2 of the SODB. This quantity has been determined on the assumption of no detectable leakage.

3. Backup Values:

   As the redline defined in Figure GP-1 is exceeded the margin of safety

Details: (cont.)

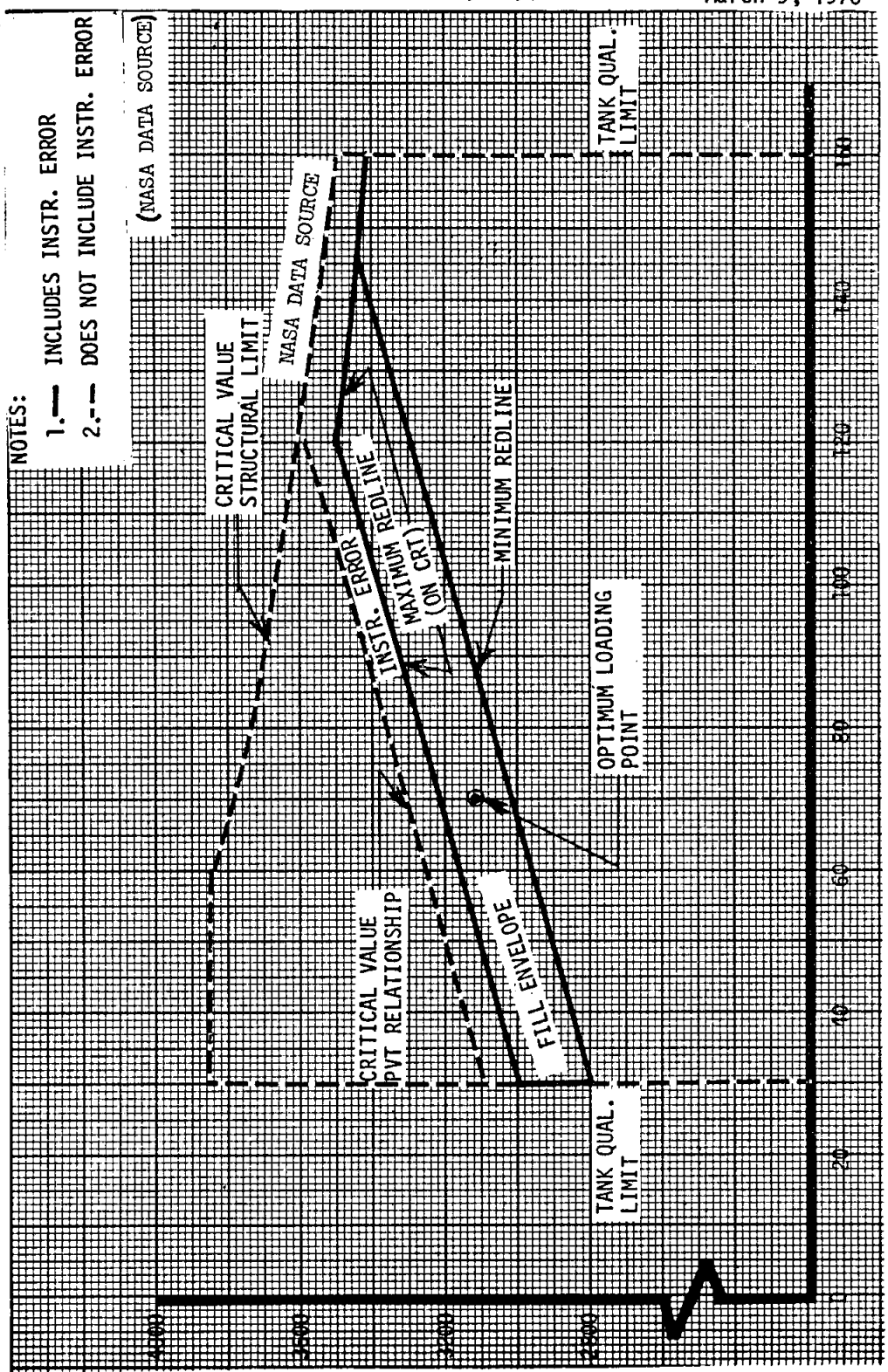
against a catastrophic tank failure becomes less. This is particularly true of the APS Helium Tanks because there is no automatic relief mechanism for excessive pressures. Therefore, although the predicted value (~90°F under nominal configurations) for the tank temperatures lies well below the limit of* 120 °F, it is strongly recommended that the maximum redline limit not be exceeded. This will insure a margin of safety both to the crew and the vehicle against abnormal temperature variations in flight.

Proof Pressure = 4650 psia @ 160°F
Burst Pressure = 5250 psia @ 160°F

4. C & W:

The caution and warning limit alerts the crew to a decay in pressure in the APS Helium Tanks. This function is used primarily prior to lunar ascent. It is not required during countdown activities because of the close monitoring of GP 0001 P and GP 0002 P.

* NASA DATA SOURCE



THE ABOVE LIMIT LINES DEFINE THE CRITICAL LIMITS OF THE SYSTEM

Figure GP-1. APS Helium Tank

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM 7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GP 0201 T	Temp, He Supply Tank No. 1
GP 0202 T	Temp, He Supply Tank No. 2

Point of Contact - GAC: M. Durcan — Ext. 1641
MSC: C. Humphries/J. Craig — Ext. 2786/3441

Data Units	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
DEG. F	±200		% of FS 1.78		Max NA
Bit Value 1.6			Units 6.86		Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min: *Limits include Instrumentation error.	70°F	(2)	(2)		Max (2)	
		(2)	(2)		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redlines:

   Refer to details for measurements GP 0001 P and GP 0002 P.

2. Rationale

   The maximum allowable inflight temperature is determined from Figure GP-1 based on the fracture mechanics limit as a function of temperature and the amount of helium loaded. The minimum temperature allowed prior to inflight pressurization is 30°F. This lower limit is the temperature value that would cause the temperature to go below -120°F during engine firing. This condition, according to regulator test data, is the point at which the regulator operation becomes unpredictable.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7 & Subs.

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	**Description:**
GP 0718 T	Temp, Fuel Tank Fuel Bulk
GP 1218 T	Temp, Ox Tank Ox Bulk

Point of Contact - GAC: J. Salek /M. Durcan Ext. 1661 /1641
MSC: C. Humphries /J. Craig Ext. 2786 /3441

Data Units	DEG. F.	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.4	20 to 120		% of FS 2.8 Units 2.8		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min: * Limits include Instrumentation error.	70°F	(2) (2)	(2) (2)		Max 75 * Min 65*	
					Max Min	
					Max Min	
					Max Min	

Details:

1. Violation of Redline:

   Violation of the Thermal Control redlines will prevent the necessary inflight response of the passive Thermal Control system to insure proper system/subsystem performance and adherence to the flight plan timeline.

2. Rationale:

   These two measurements are two of four Ascent Stage temperature measurements to be used for the Thermal Control redline. Refer to the Thermal Control Section for supporting rationale.

3. Backup Values:

   Violating the Thermal Control redlines preclude the guarantee of a safe inflight temperature profile. This fact becomes significant in light of the absence of any pressure/temperature monitoring capability during translunar coast and the inability to detect problems.

   The maximum inflight temperature limit for this measurement is 90°F which insures reliable operation of the Ascent Engine.

   The minimum inflight critical limit of 50°F is that temperature for which reliable engine operation has been verified. If the temperature decreases below 50°F, engine operation is possible but less reliable.

Details: (cont.)

The qualification limit is 40°F. Engine tests have been accomplshed as low as 35°F but suffieient data is not available to justify its use as a lower limit.

The temperature differential between the fuel and oxidizer must not exceed 10°F during flight operations.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	**Description:**
GP 1501 P	Press, Fuel Isol VLV Inlet
GP 1503 P	Press, Ox Isol VLV Inlet

Point of Contact - GAC: J. Salek Ext. 1661
MSC: R. Taylor Ext. 2786

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	1.0	0 to 250		% of FS 2.2 Units 5.5		Max ____ Min 120±5.0

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min. - no leakage allowed	Fuel: 162 Ox: 155 @ 70°F	203	-6		Max (2)	
		77	+6		Min 83	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the maximum redline will effect the burst disc operation which would compromise crew safety and may prevent completion of mission objectives.

   Violation of the minimum redline threatens the structural stability of the propellant tanks and compromises crew safety.

2. Rationale:

   Figures GP -2 and GP-3 define the two types of redline limits. The maximum and minimum redlines protect the APS propellant feed system from damage. The typical loading curve has been included to define the pressure/temperature relation so as to allow the determination of leaks.

   In addition, Figure GP-2 and GP-3 indicate the maximum delayed solubility based on the fill envelope.

Details: (cont.)

The maximum redline has been developed to protect the integrity of the propellant tank burst disc. Because the regulator has been designed to accomplish the same function, the regulator lockup value of 203 psia is used in determining the redline limit. Should the pressure exceed the maximum redline limit the burst disc operation will be effected. Prolonged periods at pressures above 203 psia will cause a variation in the performance of the burst disc that could lead to premature rupture at pressures below 226 psia or at nominal operating pressures.

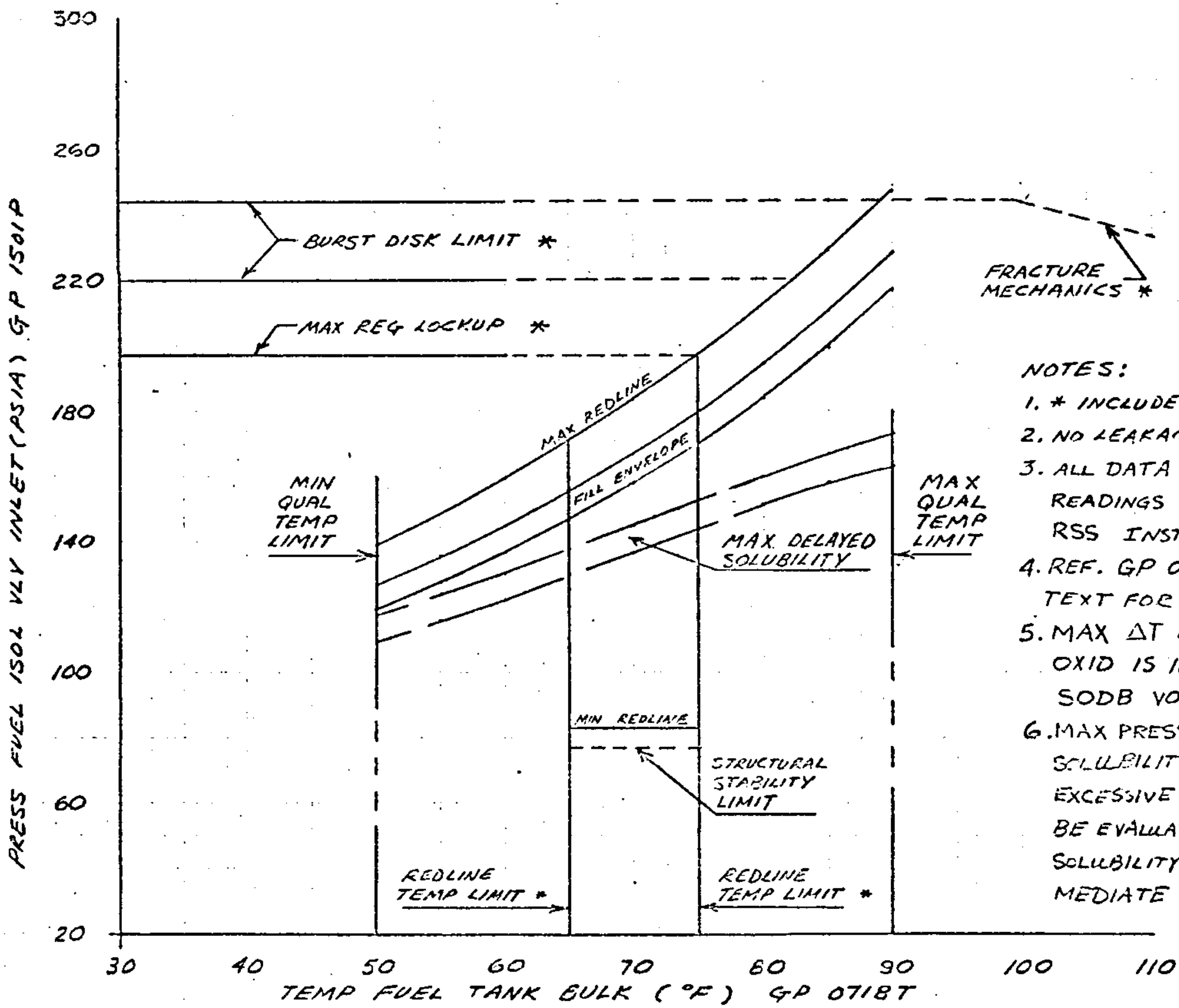
The minimum redline value has been established to insure the structural stability of the propellant tanks during launch, boost phases and touchdown. Should the pressure drop below the redline value, then it is possible for the launch environment to cause a structurel failure of propellant tank wall.

3. Backup Values:

Max. Regulator Lockup	203 psia
Burst Disc Rupture	226 - 250 psia
Proof Pressure	333 psia

4. C & W:

The caution and warning level is related to inflight operation of the APS engine and has no significance during the countdown period.



NOTES:
1. * INCLUDES INSTR ERROR
2. NO LEAKAGE ALLOWED
3. ALL DATA REFLECTS CRT READINGS BASED ON MAX. RSS INSTR. ERROR
4. REF. GP 0718T/GP 1218T TEXT FOR TEMP. REDLINES
5. MAX ΔT BETWEEN FUEL & OXID IS 10°F. REFERENCE SODB VOL. II, PT. 1 SEC. 3.6.
6. MAX PRESS DECAY DEFINED BY SOLUBILITY CURVE, HOWEVER EXCESSIVE DECAY RATES MUST BE EVALUATED CONSIDERING SOLUBILITY EFFECTS FOR INTERMEDIATE POINTS.

FIGURE GP 2 APS FUEL TANK REDLINES

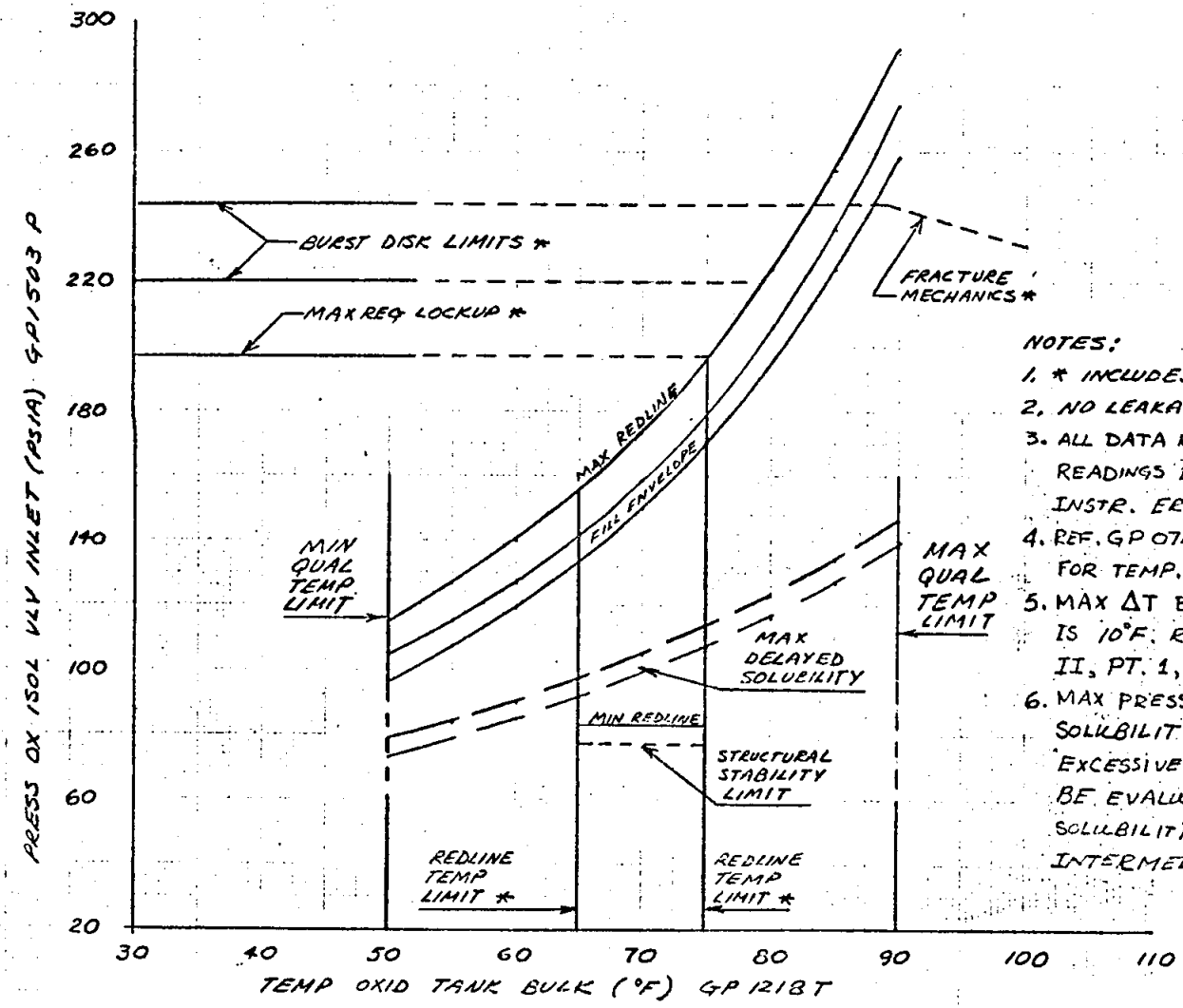


FIGURE GP 3 APS OXID TANK REDLINES

DESCENT PROPULSION SUBSYSTEM

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

NASA DATA SOURCE
REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	**Description:**
GQ 3015 P	Press, Amb. He Pre-Press Bottle

Point of Contact - GAEC: J. Salek **Ext.** 1661
MSC: W. Hammock, Jr. WRH **Ext.** 2786

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	6.9	0 to 1750		% of FS 1.94		Max NA
				Units 32.7		Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 minutes. Evaluate any leakage.	1630 @ 70°F	(2)	NA		Max (2)	
		(2)	NA		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the maximum redline increases the possibility of a catastrophic tank failure and compromises crew safety.

2. Rationale:

   Figure GQ-1 presents the maximum redline limit as a function of temperature for the Ambient Helium Bottle. The maximum redline represents the **upper limit of the transducer for this measurement.**

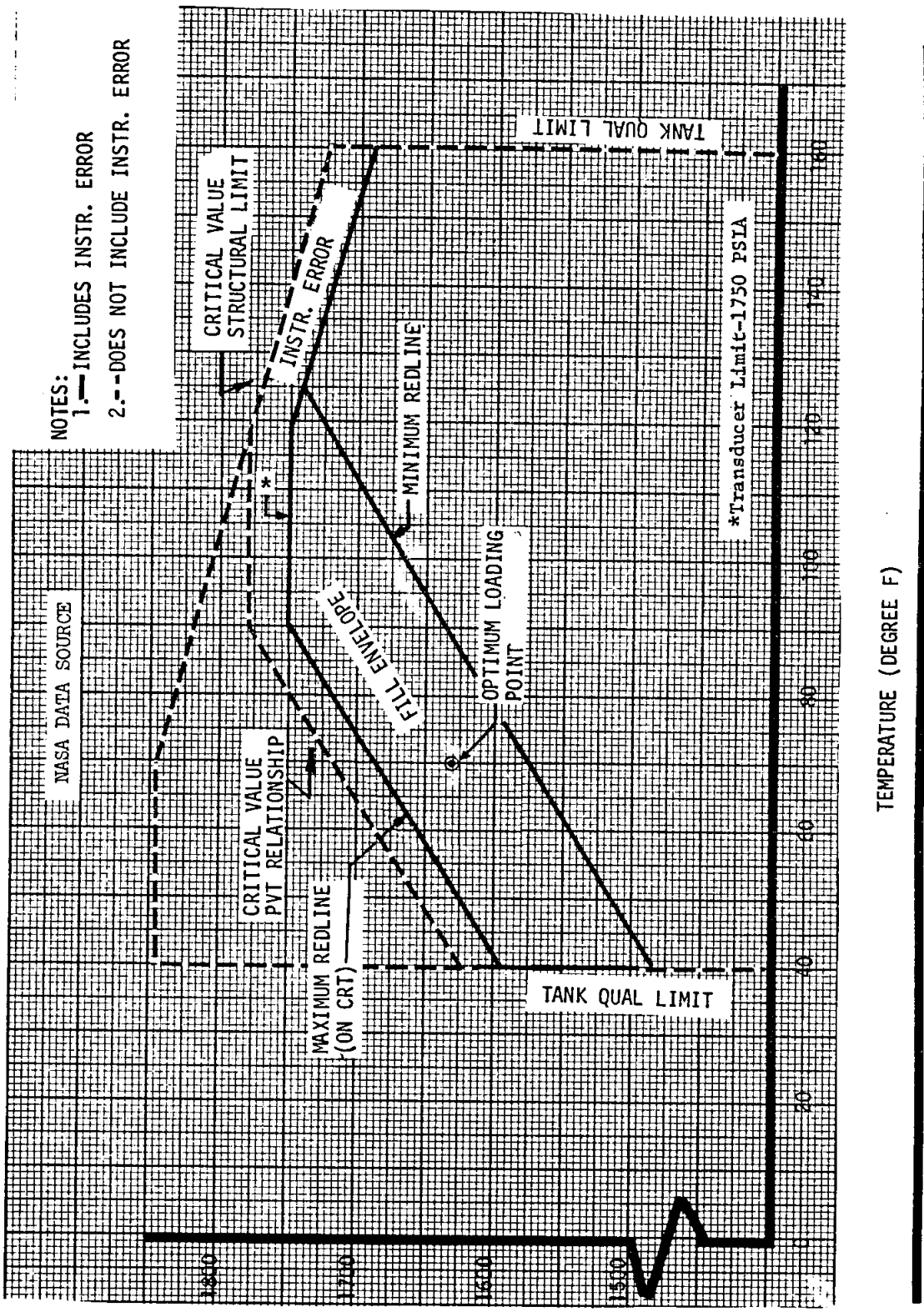
   As the redline is exceeded the margin of safety against a catastrophic tank failure is reduced. This is particularly true for the Ambient Helium Bottle because there is no automatic relief mechanism for excessive pressure. Instrumentation errors are included in the figure.

   Minimum redline is based on providing sufficient start Bottle He to allow engine start.

3. Backup Values:

   Maximum Operating Pressure = 1750 PSIA @ 100°F
   Proof Pressure = 2328 PSIA
   Burst Pressure = 2625 PSIA

* NASA DATA SOURCE



HELIUM PRESSURE (PSIA) GQ 3015 P
THE ABOVE LIMIT LINES DEFINE THE CRITICAL LIMITS OF THE SYSTEM
Figure GQ-1. DPS Ambient Helium Tank

Contract No. NAS 9-1100
Primary NO. 664
SC Effectivity: LM-7 & Subs.

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GQ 3018 P	Press, He Regulator Out Manifold
GQ 3025 P	Press, He Regulator Out Manifold

Point of Contact - GAEC: J. Salek Ext. 1661
MSC: W. Hammock, Jr. Ext. 2786

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	1.2	0 to 300		% of FS 2.03 Units 6.00		Max 260 Min 220

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
After SHe tank top-off. (No decay allowed after top-off)	(2)	TBD NA	-6.0 NA		Max TBD Min (2)	
					Max Min	
					Max Min	
					Max Min	

Details:

1. Violation of Redline:

   Exceeding the maximum redline will adversely affect the inflight regulator performance and compromise the completion of mission requirements.

   Any decay after top-off is indicative of improper manifold configuration (blockage or leak) which may preclude the satisfaction of mission requirements.

2. Rationale:

   The nominal pressure in manifold will be approximately 30 psia based on precluding environmental contamination of the system. Aside from intentional bleed-off, no downward trend is allowable after top-off.

   When the SHe tank is loaded gaseous helium in the SHe tank internal heat exchanger "chills-down" to supercritical temperatures. After SHe top-off, heat leak effects are expected to cause a nominal 1.0 psia/hr pressure increase. The rate of pressure increase is related to the quantity of gaseous helium mass in the manifold at the time of SHe tank top-off. The maximum value at liftoff, based on 242 psia regulator lock-up pressure, is TBD psia including measurement system errors. This maximum pressure value will ensure against regulator lock-up prior to the 1st DPS burn at 103.5hr after launch. Regulator lock-up prior to the 1st DPS burn is not allowable due to the possibility of "back-

Measurements GQ 3018 P and GQ 3025 P (Cont.)

Details: (cont.)

pressuring" the regulator after lock-up. Excessive back-pressure can cause a permanent shift in the regulator lock-up pressure leading to off nominal system operation.

3. Backup Values:

No backup values exist.

4. Caution and Warning levels are indicative of a actual failure: 260 indicates regulator failed open, 220 indicates regulator failed closed.

Contract No. NAS 9-1100
Primary No. 664

REDLINE DATA

SC Effectivity: LM-7 LED-540-57 Date: March 9, 1970

Measurement No.	Description:
GQ 3435 P	Press, Supercritical Helium Supply Tank

Point of Contact - GAC J. Salek Ext. 1661
MSC: W. Hammock, Jr./Z. Kirkland Ext. 2786/4671

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	8.0	0-2000		% of FS 1.48 Units 29.0		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-0 min: acceptable rise rate is 6.5 to 10 psi/hr after stabilization (6hrs after topoff)		967	8****		Max 959 Min	
					Max Min	
					Max Min	
					Max Min	

Details.

1. Violation of Redline

Violation of the redline will exceed the storage tank burst disc rupture pressure during the mission which could result in a compromise of crew safety.
See Note 1 for additional backup data.

2. Rationale

The maximum launch redline value is based upon the SHe tank pressure not exceeding burst disc rupture pressure 1781 psia, (1881 psia less engineering uncertainties of 100 psi).
This value utilizes adjusted pressure rise rates determined from test and analytical results from previous flight data. These values are:

a. For Pad Calculations.....8.55**psi/hr
b. For Inflight Coast Periods.....6.93***psi/hr

The maximum redline is based upon Appendix A, guideline 1.8.1:

Maximum allowable pressure.....1781 psia
Maximum allowable pressure at burn.....1698 psia
(Fig. GQ2A)
Anticipated coast pressure rise rate..... 731 psia
(105.5 hrs x 6.93 psi) ****
Maximum Liftoff Pressure ..... 967 psia
Less Measurement Error***** ..... -8
Launch Redline (max liftoff pressure) 959 psia

3. Backup Value

The backup value is based upon the worst case alternate mission duty cycle defined in Appendix A, guideline 1.8.1

The maximum backup value based upon the TBD case was established as follows:

Maximum allowable pressure	1781 psia
Maximum allowable at 1st DPS Burn (Fig. GQ-2A)	TBD
Anticipated coast pressure rise rate	TBD
TOTAL	TBD psia
Less Measurement Error	-8 psia
Backup value maximum liftoff pressure	TBD psia

Anticipated Liftoff Pressure

Topoff at approximately 31.5 before liftoff 8.55 psi/hr	269 psi
Topoff pressure	120 psi
SHe tank pressure at opening of launch window =	389 psi
3.3 hour launch window x 8.55 psi/hr	28.2 psi
SHe tank pressure at close of launch window -	417 psi

Therefore, redline margin (959-417) =542 psia or 63.4 hrs 8.55 psi/hr of standby time.

Recycle requirements = Anticipated pressure at close of launch window (417 psia)+ (48 hrs x 8.55 psi/hr) = 827 psia
Therefore, the maximum redline (959 psia) allows for a full 48 hour recycle.

4. Additional Data

Figure GQ-2B shows predicted liftoff pressure vs coast pressure rise rates for the nominal and alternate missions.

The critical pressures for the SHe tank are as follows:

Maximum storage tank design pressure	1710 psia
Burst Disc Rupture Pressures	1881 - 1967 psia
Tank Proof Pressure	2274 psia
Tank Burst Pressure	3420 psia

Note 1: A Pressure rise greater than 50 psi within one hour after topoff would be indicative of a problem in the SHe system and must be evaluated. A possible cause of a pressure rise of this magnitude could be a heat exchanger which has been blocked due to frozen contaminant.

**CDDT Value
***CDDT Value adjusted for flight based upon analytical prediction.
****Nominal Mission plus one additional orbit.
*****Calibration of measurement at KSC indicates an error of 5 psi as compared to GSE instrumentation. Since this is less than the minimum bit value and cannot be determined by PCM the minimum bit value of 8 psia was used.

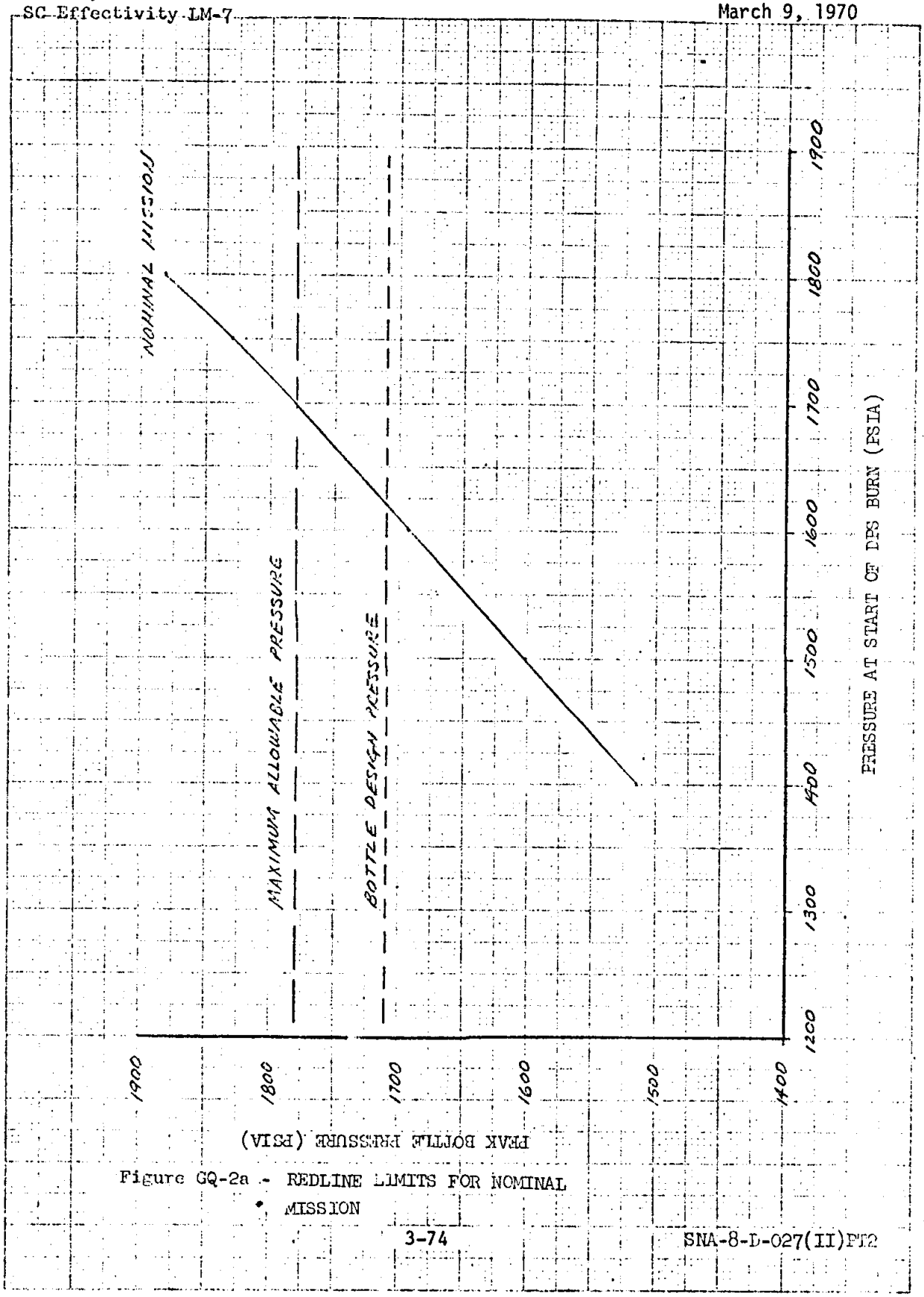


Figure GQ-2a - REDLINE LIMITS FOR NOMINAL MISSION

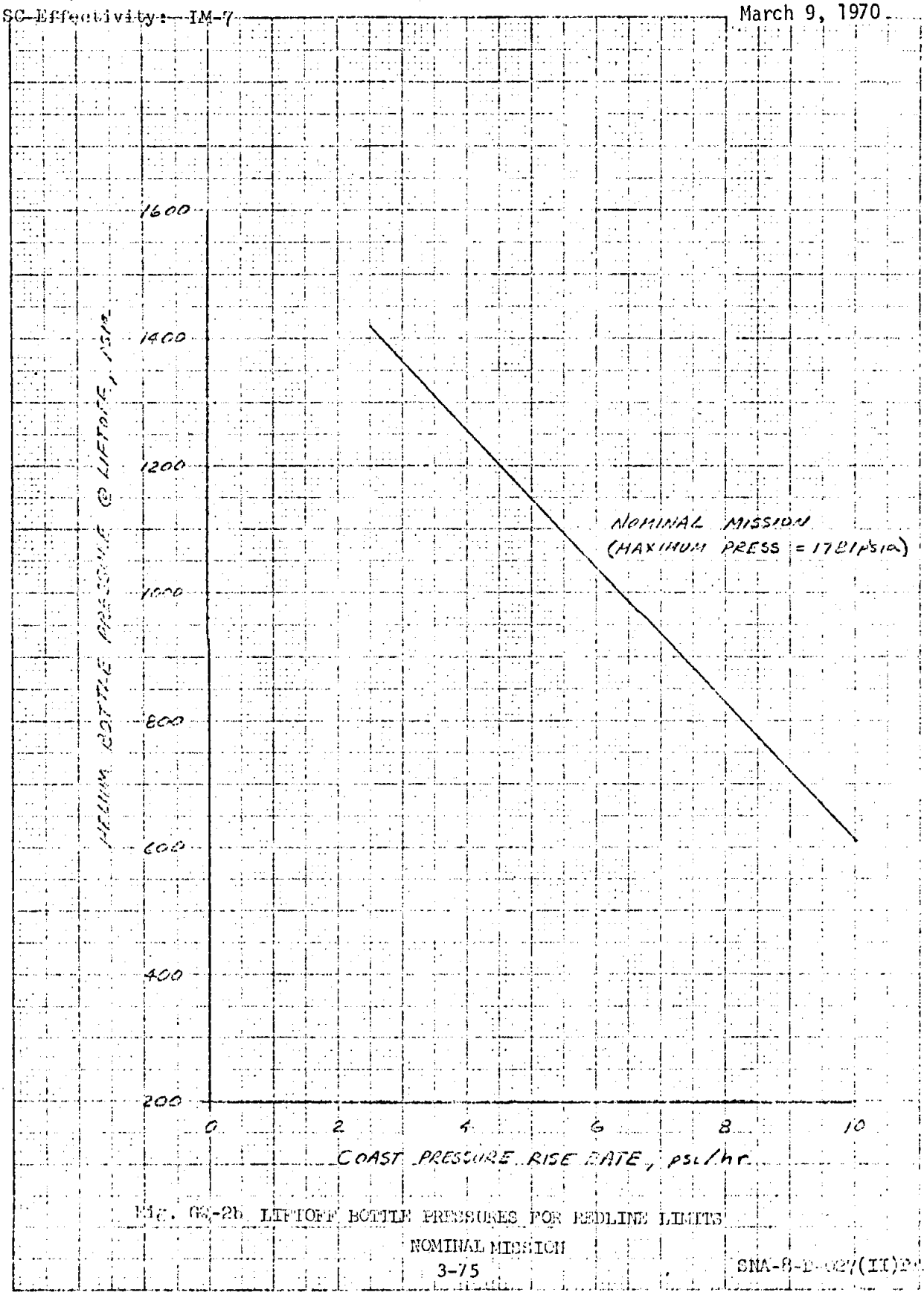


Fig. 6.3-2b LIFTOFF BOTTLE PRESSURES FOR REDLINE LIMITS
NOMINAL MISSION

Primary No, 664 **REDLINE DATA**
SC Effectivity: LM-7 LED-540-57 **Date:** March 9, 1970

Measurement No.	**Description:**
GQ 3611 P	Press Engine Interface Fuel
GQ 4111 P	Press Engine Interface Ox

Point of Contact - GAC: J. Salek **Ext.** 1661
MSC: W. Hammock, Jr. **Ext.** 2786

Data		**Data Range**		**Accuracy**		**C & W**	
		PCM	Meter	PCM	Meter		
Units	PSIA			% of FS 1.94		**Max**	NA
Bit Value	1.2	0 to 300		**Units** 6.0		**Min**	NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	**Nominal Operation**	**Critical Limits**	**Meas System Error**		**Redline Limits**	
			PCM	Meter	PCM	Meter
To T-10 minutes - no leakage allowed	Fuel: 150 Ox: 150 @ 70°F	253 @ 75°F	-6		Max (2) Min (2)	
					Max Min	
					Max Min	
					Max Min	

Details:

1. Violation of Redline:

   Violation of the maximum redline will effect the burst disc operation which would compromise crew safety and may prevent completion of mission objectives.

2. Rationale:

   Figures GQ-3 and GQ-4 present the redline limits for the fuel and oxidizer pressures. These limits are defined by the pre-pressurization curve in each graph.

   In addition to the maximum redline curves, Figures GQ-3 and GQ-4 show the target loading curves with the maximum predicted decay due to helium solubility. Any decay in excess of that indicated must be evaluated with respect to potential leakage. It must be noted, however, that the decay rate due to solubility has been found to be unpredictable because of a sensitivity to environmental variations (thermal and mechanical). In addition, helium solubility effects must be re-evaluated for any loaded pressure significantly different, > 5 - 10 psia, from the target load. An detected leak is unacceptable.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7 & Subs.

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GQ 3718 T	Temp, Fuel Tank #1 Fuel Bulk
GQ 3719 T	Temp, Fuel Tank #2 Fuel Bulk
GQ 4218 T	Temp, Ox Tank #1 Ox Bulk
GQ 4219 T	Temp, Ox Tank #2 Ox Bulk

Point of Contact - GAEC: J. Salek /M. Durcan Ext. 1661 /1641
MSC: W. Hammock, Jr./J. Craig Ext. 2786 /3441

Data Units	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
DEG. F.	20 to 120		% of FS		Max NA
Bit Value 0.4			Units (2)		Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min. *Limits include Instrumentation error.	70°F	(2)	(2)		Max 75*	
		(2)	(2)		Min 65*	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   Violation of the Thermal Control redlines will prevent the necessary in-flight response of the passive Thermal Control required to insure proper system/subsystem performance. Exceeding the upper redline also violates the fracture mechanics limits imposed on the oxidizer tanks.

2. Rationale:

   The DPS propellent bulk temperature measurements are used for the Thermal Control Redline. Refer to the Thermal Control Section for the supporting rationale.

3. Backup Values:

   Violating the Thermal Control redline precludes the guarantee of a safe inflight temperature profile. This fact becomes significant in light of the absence of any pressure/temperature monitoring capability during translunar coast and the inability to detect problems.

   The maximum temperatures are determined from Figures GQ-3 and GQ-4 based on fracture mechanics analysis corresponding to the maximum operating pressure of 275 psia (max. burst disc limit). The minimum critical value of 50°F is that temperature for which reliable engine operation has been verified. As temperatures drop below 50°F the operation of the engine becomes less reliable.

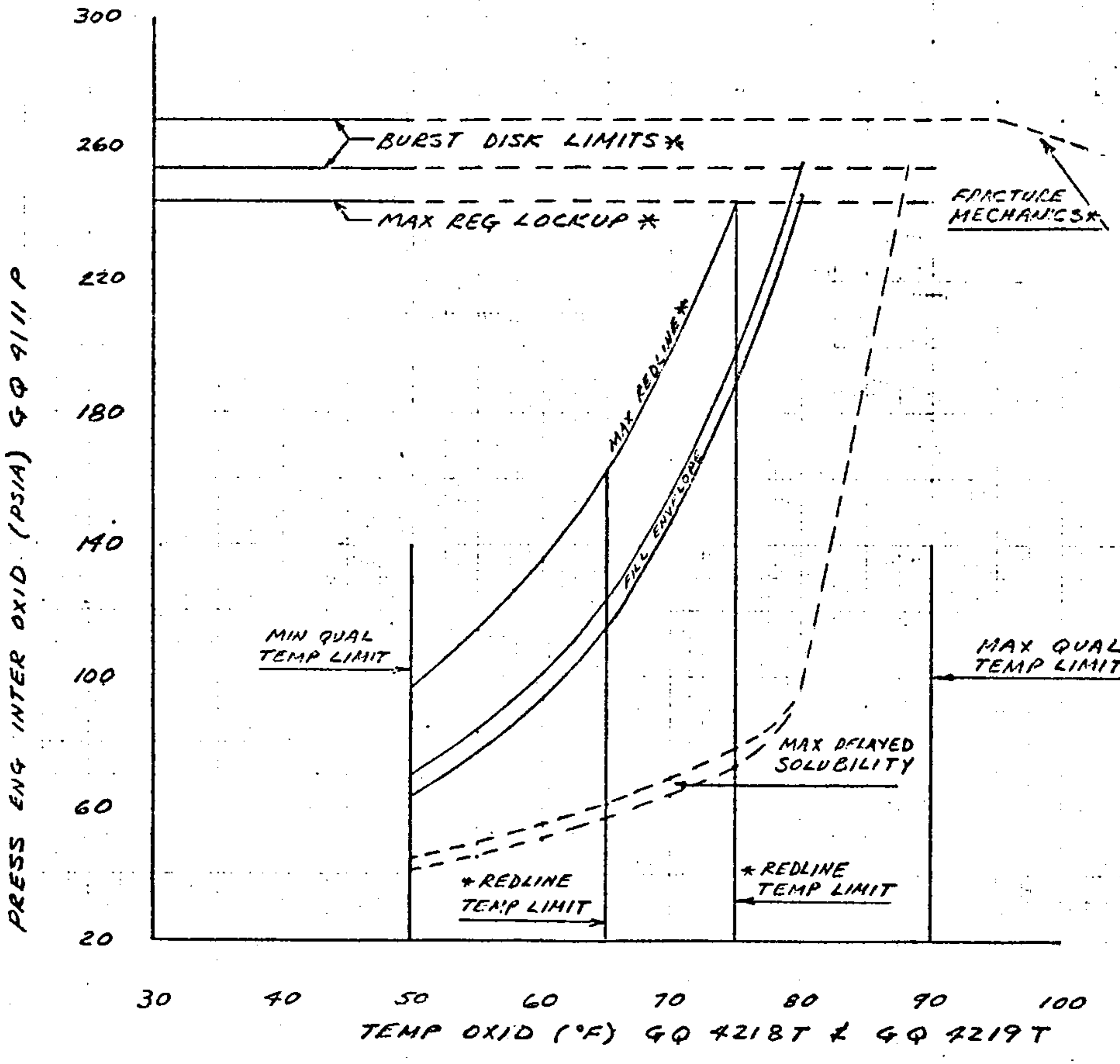


FIGURE GQ 3 DPS OXIDIZER TANK REDLINES

NOTES:

1. LM 7 PROP QUAN PER AMEND 75 VOL III SODB
2. *INCLUDES INSTR ERROR
3. NO LEAKAGE ALLOWED
4. MAX EXPECTED PRES. DECAY IS DEFINED BY THE MAX. DELAYED SOLUBILITY CURVES. THE DETECTION OF EXCESSIVE PRESS DECAY DURING PRE-LAUNCH OPERATIONS MUST BE EVALUATED WITH RESPECT TO POSSIBLE LEAKAGE.
5. INITIAL FILL POINTS FALLING OUTSIDE THE DESIRED FILL ENVELOPE MUST BE EVALUATED REAL TIME TO INSURE THAT THE TOTAL SOLUBILITY AT DPS PRESSURIZATION WILL NOT PRODUCE A DELTA-P OF 50 PSID (USE "AS READ" CRT NUMBERS TO DETERMINE DELTA-P).

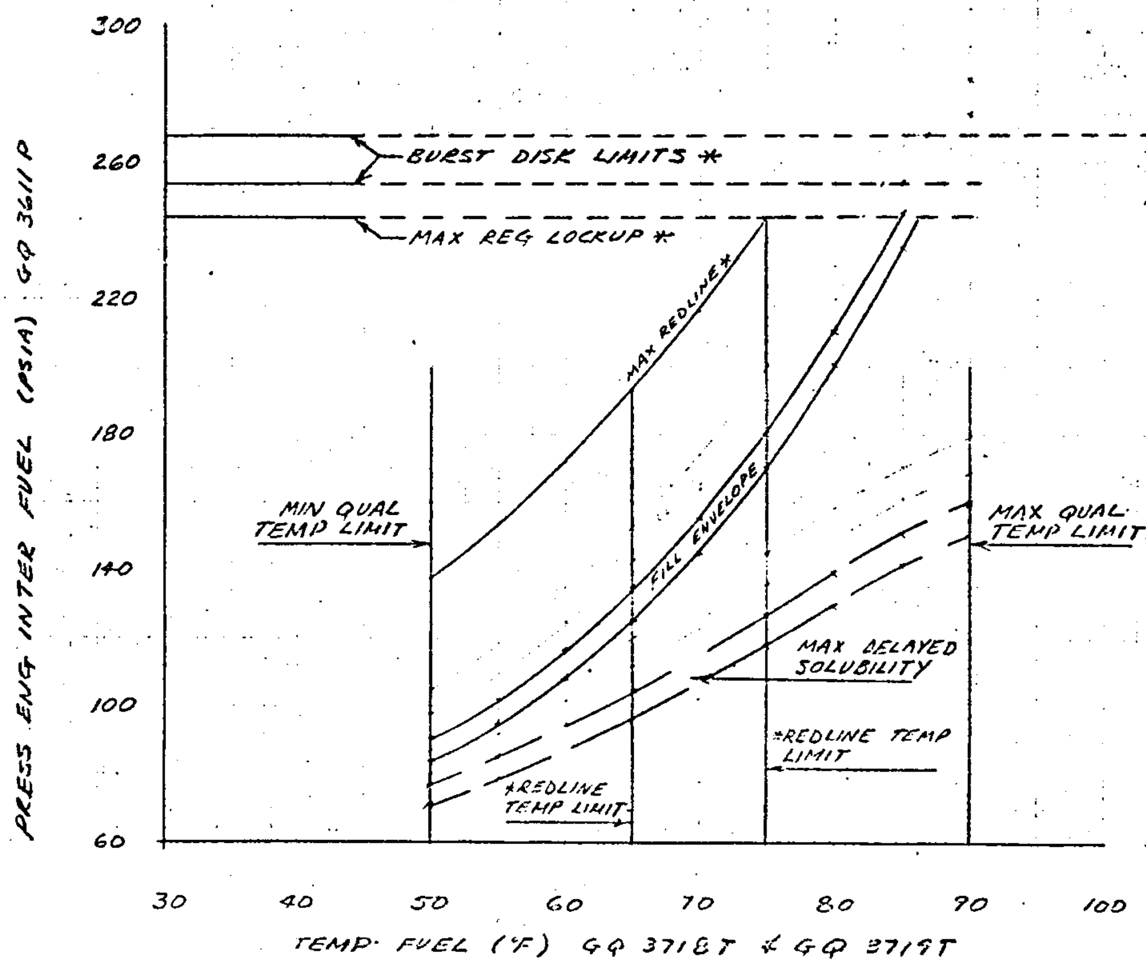


FIGURE GQ 4 DPS FUEL TANK REDLINES

NOTES:

1. LM 7 PROP QUAN PER AMEND 75 VOL III 5008
2. *INCLUDES INSTR ERROR
3. NO LEAKAGE ALLOWED.
4. MAX. EXPECTED PRESS DECAY IS DEFINED BY THE MAX. DELAYED SOLUBILITY CURVES. THE DETECTION OF EXCESSIVE PRESSURE DECAY DURING PRE-LAUNCH OPERATIONS MUST BE EVALUATED WITH RESPECT TO POSSIBLE LEAKAGE.
5. INITIAL FILL POINTS FALLING OUTSIDE THE DESIRED FILL ENVELOPE MUST BE EVALUATED REAL TIME TO INSURE THAT THE TOTAL SOLUBILITY AT DPS PRESSURIZATION WILL NOT PRODUCE A DELTA-P OF 50 PSID (USE "AS READ" CRT NUMBERS TO DETERMINE DELTA-P).

REACTION CONTROL SUBSYSTEM

Measurement No.	Description:
GR1101 P	Press He Tank A
GR1102 P	Press He Tank B

Point of Contact - GAC : J. Dunn Ext. 1681
MSC: W. Karakulko Ext. 4971

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	14	0 to 3500		% of FS 2.03 Units 71.0		Max NA Min 1700 ± 65

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 minutes - no allowable leakage	3050 70°F	(2)	-71		Max (2)	
		(2)	NA		Min (2)	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

Violation of the maximum redline increases the possibility of a catastrophic tank failure and compromises crew safety.

Violation of the minimum quantity redline prevents the completion of required mission objectives.

2. Rationale:

Figure GR-1 presents the maximum pressure redline limit as a function of temperature for the RCS Helium Tanks. The maximum allowed temperature after loading is determined by the intersection of the PVT relationship for the particular load and the critical structural limit for the tanks. The temperature design specifications for the RCS Fuel and Oxidizer Compartment structure which houses the RCS Helium Tank is 30° to 130°F. However, since the 130°F temperature is not expected to be reached during flight, the maximum (Hot case) predicted temperature of 100°F is used to define the critical PVT relationships. It is highly desirable to stay within the fill envelope to reduce the inaccuracy in the PQMD (every 1% overfill results in a 2% PQMD error with respect to 3050 psia at 70°F).

The minimum quantity redline is based on the criteria to deplete RCS propellants at specification regulator inlet pressures with specification leak rates. In addition, it is required that a pressure of 500 psia be remaining in the helium tank at the time of propellant depletion.

Measurements GR 1101 P and GR 1102 P (Cont.)

Details: (cont.)

3. Backup Values:

As the redline defined in Figure GR-1 is exceeded the margin of safety against a catastrophic tank failure becomes less. This is particularly true of the RCS Helium Tanks because there is no automatic relief mechanism for excessive pressures.

Figure GR-2 defines the allowable leak rates as a function of time in the countdown the leak begins. It must be emphasized that this type of analysis assumes that the leak will not become greater during launch. Because of this fact and other factors that are not evident now, it may be necessary to apply other criteria for launching or scrubing during the real time evaluation of a detected leak.

The leak rates defined in GR-2 will continue throughout the mission (145 hrs. 40 min., lift-off through docking). The maximum leak rates acceptable are a function of the time-in-the countdown the leak originated. The point at which a curve intersects the time-coordinate is the time the leak started. The graph was developed based on the following ground rules:

1) Constant area leak (leak rate will not increase as a result of the launch environment).
2) Complete expulsion of propellants and 500 psia final pressure remaining at the end of the mission.
3) Helium temperature remains constant, $\leq$ 70°F.
4) Temperature of ullage is constant at $\geq$ 40°F.
5) Rate of propellant consumption is linear and occurs over a total of 8 hrs. (RCS active period)

Proof Pressure - 4650 psia
Burst Pressure - 5250 psia

4. C & W:

The low level Caution alerts the crew to a decay in pressure in the RCS Helium tanks. This condition may arise as a result of exessive propellant consumption or leakage. This function is not required during the countdown activities because of the close monitoring of GR 1101 P and GR 1102 P.

(Details for GR 1101 P and GR 1102 P continued)

III DEVELOPMENT OF MINIMUM HE TANK PRESSURE REDLINE ASSUMING NO HELIUM LEAKAGE.

1- Maximum Effective Propellant Tank Volume (Oxid and Fuel, System A or B) = 7424 in.^{3} (Ref. LMO-310-315, 7 October 1966)

2- Assume entire system at 40°F (worst nominal case) with the regulator output pressure at the maximum nominal value of 184 psia.

3- When all the effective propellant is expelled, the amount of helium in the ullage is:

$$m = \frac{PV}{RT} = \frac{(184)\ (7424)}{(12)\ (386.3)\ (500)} = 0.58936 \text{ lbm}$$

4- Initial ullage volume (minimum) = 336.5 in.^{3}. Prior to pressurization, the amount of helium in the ullage is:

$$m = \frac{PV}{RT} = \frac{(50-6.4)\ (336.5)}{(12)\ (386.3)\ (500)} = 0.00633 \text{ lbm}$$

Hence, the actual mass required to expell the propellant is (0.58936) - (0.00633) = 0.5830 lbm

5- At propellant depletion, 500 psia helium tank pressure is required or a mass of:

$$m = \frac{PV}{RT} = \frac{(500)\ (920)}{(12)\ (386.3)\ (500)} = 0.1985 \text{ lbm}$$

Therefore, the total helium required in the helium tank prior to pressurization is:

$$(0.1985) + (0.5830) = 0.7815 \text{ lbm at } 40^{\circ}F$$

6- The conversion from the required helium tank mass to the corresponding helium tank pressure is as follows:

$$\frac{V}{m} = \frac{RT}{P} + B_0 \qquad B_0 \approx 0.046$$

$$P = \frac{mRT}{V - B_0 m} = \frac{(0.7815)\ (386.3)\ (500)}{(0.553) - (0.046)\ (0.7806)}$$

$$P = 2.9199 \times 10^5 \text{ lb/ft}^2$$

$$P = 2027.7 \text{ psia @ } 40^{\circ}F$$

The minimum helium tank pressure redline is determined by adding the instrumentation accuracy of 71 psia to insure the availability of the minimum helium requirement:

P (redline) = 2027.7 + 71 = <u>2098.7 psia @ 70°F</u>

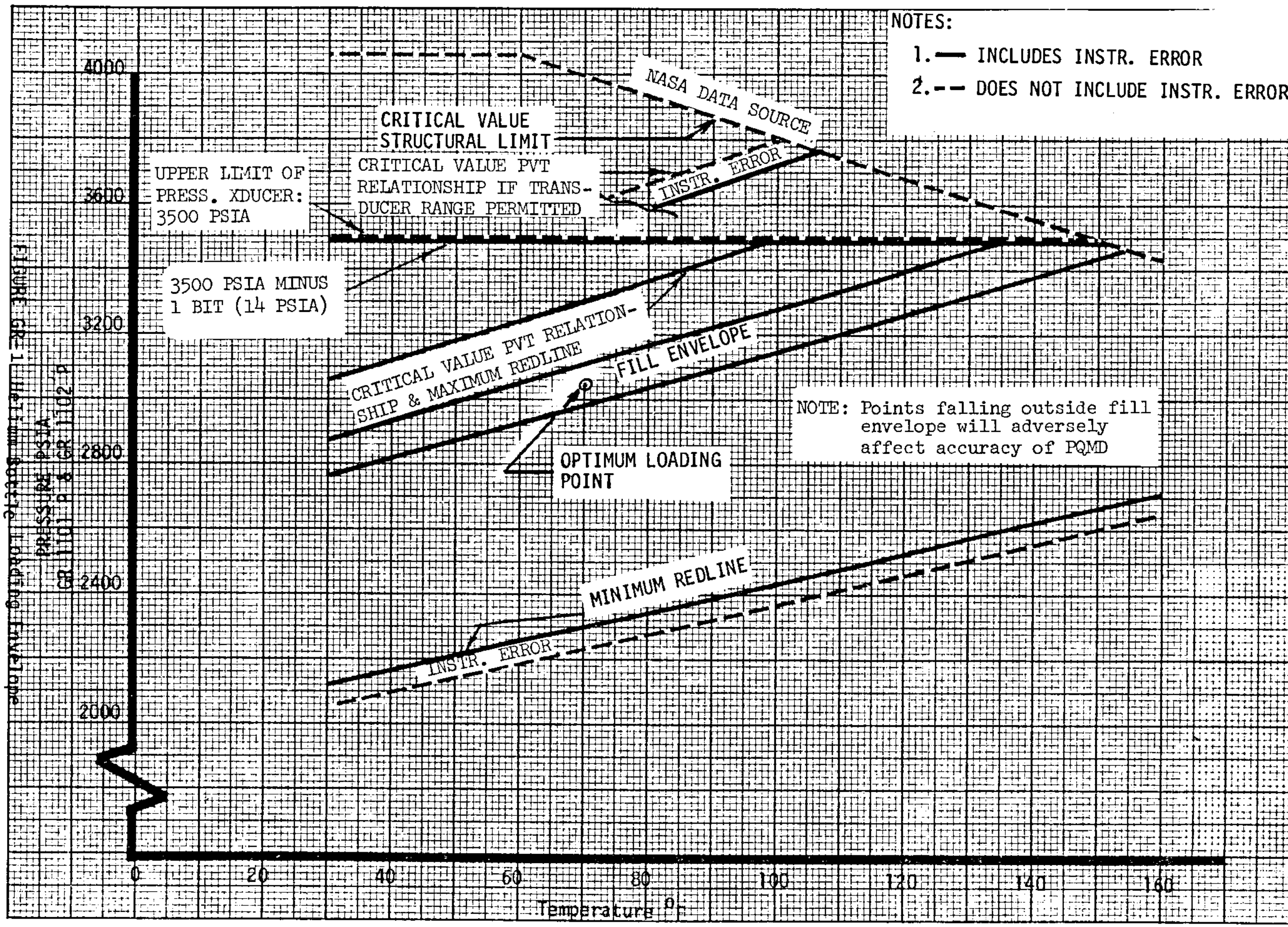


FIGURE GR-1 Helium Bottle Loading Envelope

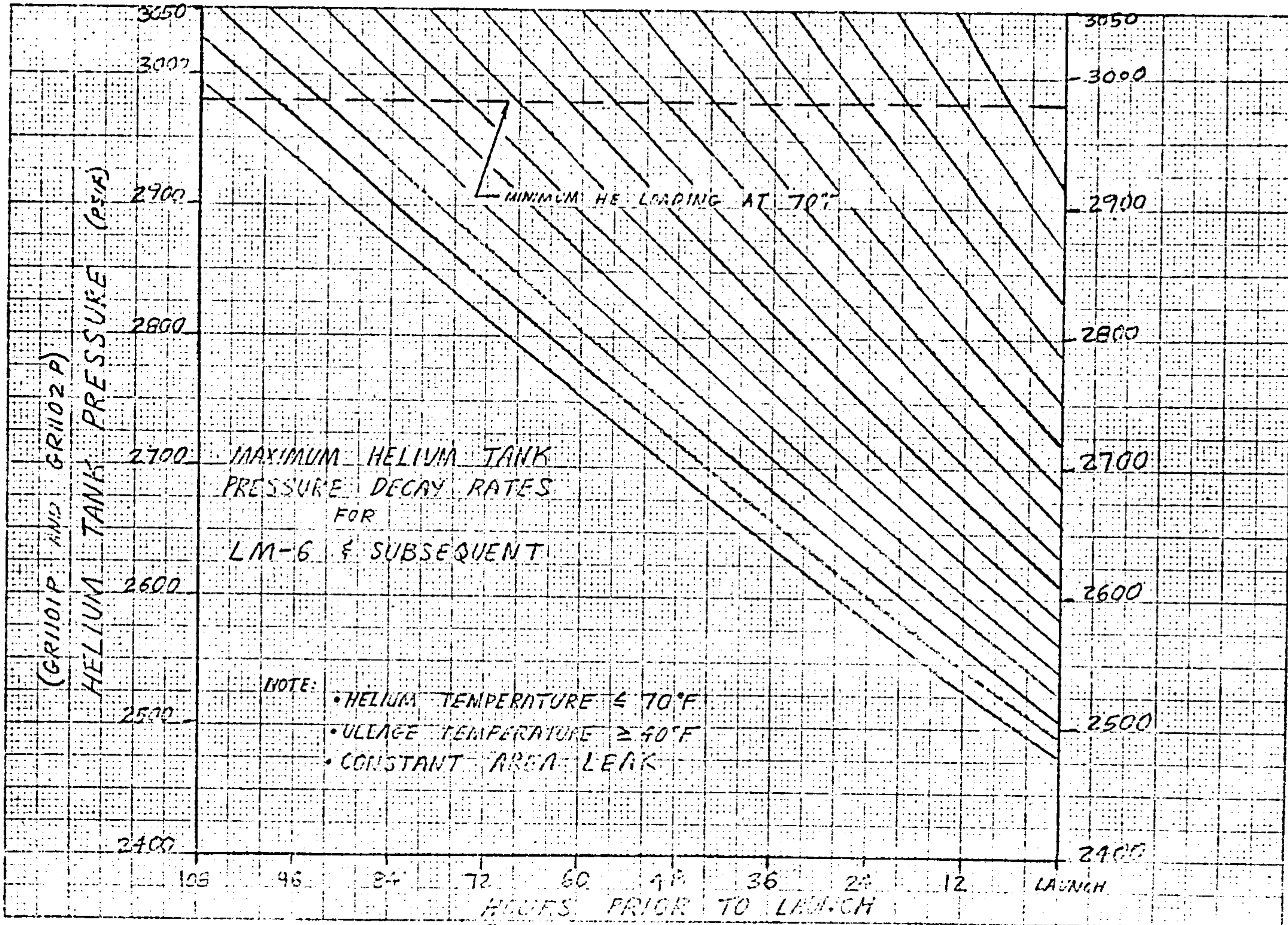


FIGURE GR-2

He Tank pressure decay rates for LM6 and subs.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7 & Subs.

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
GR 2121 T	Temp, RCS Fuel Tank A
GR 2122 T	Temp, RCS Fuel Tank B

Point of Contact - GAC: M. Durcan Ext. 1641
MSC: W. Karakulko/J. Craig Ext. 4971/3441

Data Units	Bit Value	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
DEG. F.	0.4	20 to 120		% of FS 2.8 Units 2.8		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 Min: * Limits include Instrumentation error. GR 2121 T	70°	(2) (2)	(2) (2)		Max 80* Min 65*	
To T-10 Min: *Limits include Instrumentation error. GR 2122 T	70°	(2) (2)	(2) (2)		Max 80* Min 65*	
					Max Min	
					Max Min	

Details:

1. Violation of Redline:

   Violation of the Thermal Control redlines will prevent the necessary inflight response of the passive Thermal Control system required to insure proper system/subsystem performance.

2. Rationale:

   These two measurements are two of **four** Ascent Stage temperature measurements to be used for the Thermal Control redline. Refer to the Thermal Control section for the supporting rationale.

3. Backup Values:

   Violating the Thermal Control redline precludes the guarantee of a safe inflight temperature profile. This fact is significant in light of the absence of any pressure/temperature monitoring capability during translunar coast and the inability to detect problems.

   The minimum and maximum inflight temperature limits for these measurements are 40° - 100°F based on reliable RCS engine performance.

Measurement No.	Description:
GR 2201 P	Press A Fuel Manifold
GR 2202 P	Press B Fuel Manifold
GR 3201 P	Press A Oxid Manifold
GR 3202 P	Press B Oxid Manifold

Point of Contact - GAC : M. Durcan Ext. 1641
MSC: W. Karakulko Ext. 4971

Data Units	PSIA	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	1.4	0 to 350		% of FS 1.94 Units 6.8		Max NA Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T - 10 min. - no pressure decay allowed*	50 @ 70°F	(2)	NA		Max (2)	
		(2)	NA		Min (2)	
Fuel- allowed increase * in 28 hrs(no press. in - crease>.25 psi/hr)					Max 7.0	
					Min	
Oxidizer- allowed increase* in 28 hrs (no press. in- crease>.15 psi/hr).					Max 4.2	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

   The violation of this redline may compromise crew safety and/or the satisfaction of mission requirements.

2. Rationale:

   The occurrence of a pressure increase in any of the RCS manifolds must be evaluated with respect to the ability of the Interconnect valves to effectively isolate the APS and RCS systems. Such a lack of isolation is important with respect to possible helium ingestion by the RCS manifold during translunar coast, which could lead to improper thruster operation. The redline rate of pressure increase prior to opening the Isolation valves has been determined to indicate when a leak is capable of allowing a detrimental amount of helium ingestion during the "zero - g," translunar coast period. The redline rate of pressure increase is valid from the time of RCS manifold loading to T - 10 minutes. For the same liquid leak rate, opening the Isolation valves has a small effect on the rate of pressure increase. Based on this fact it is not necessary to change the redline rate after the Isolation valves have been opened.

* Allow for the following:
  (1) 0.9 psi/°F in all manifolds
  (2) 24 hrs. for solubility stabilization after filling manifold.

LED-540-57

Measurements GR 2201 P, GR 2202 P, GR 3201 P, and GR 3202 P (cont.)

Rationale: (cont.)

Should the redline rate of increase be violated it is recommended that the Interconnect valve configuration be altered such that the open set of Interconnect valves be closed and the closed set opened. It must be emphasized that temperature effects must be accounted for in evaluating either pressure increase or decrease. It is also necessary to allow sufficient time, approximately 24 hours, for solubility stabilization after the manifolds have been loaded.

The occurrence of a decay in pressure due to leakage is objectionable from the standpoint it could be due to a propellant leak, and, therefore, may compromise launch crew safety. However, a helium leak from the RCS tank ullage volume would have the same effect on pressure as a propellant leak. The probability of a helium leak is greater than that of propellant. The existence of a helium or propellant leak is objectionable from the standpoint that it is occurring at a pressure less than operating pressure. Any such leak will be increased upon system pressurization and at that time may exceed what is allowable to complete the mission or may endanger crew safety.

The pressure/temperature relationship for the manifolds is shown in figures GR-3 and GR-4 and is based on the quantity of propellant loaded. These curves allow evaluation of variations in parameters which may occur. Any pressure variations observed during the countdown should be in consonance with the trend shown in figures GR-3 and GR-4. Pressure increases higher than those shown could be indicative of leakage from the He Supply into the propellant tanks or through the interconnect valves. Pressure decay greater than shown could be indicative of He leakage or propellant leakage.

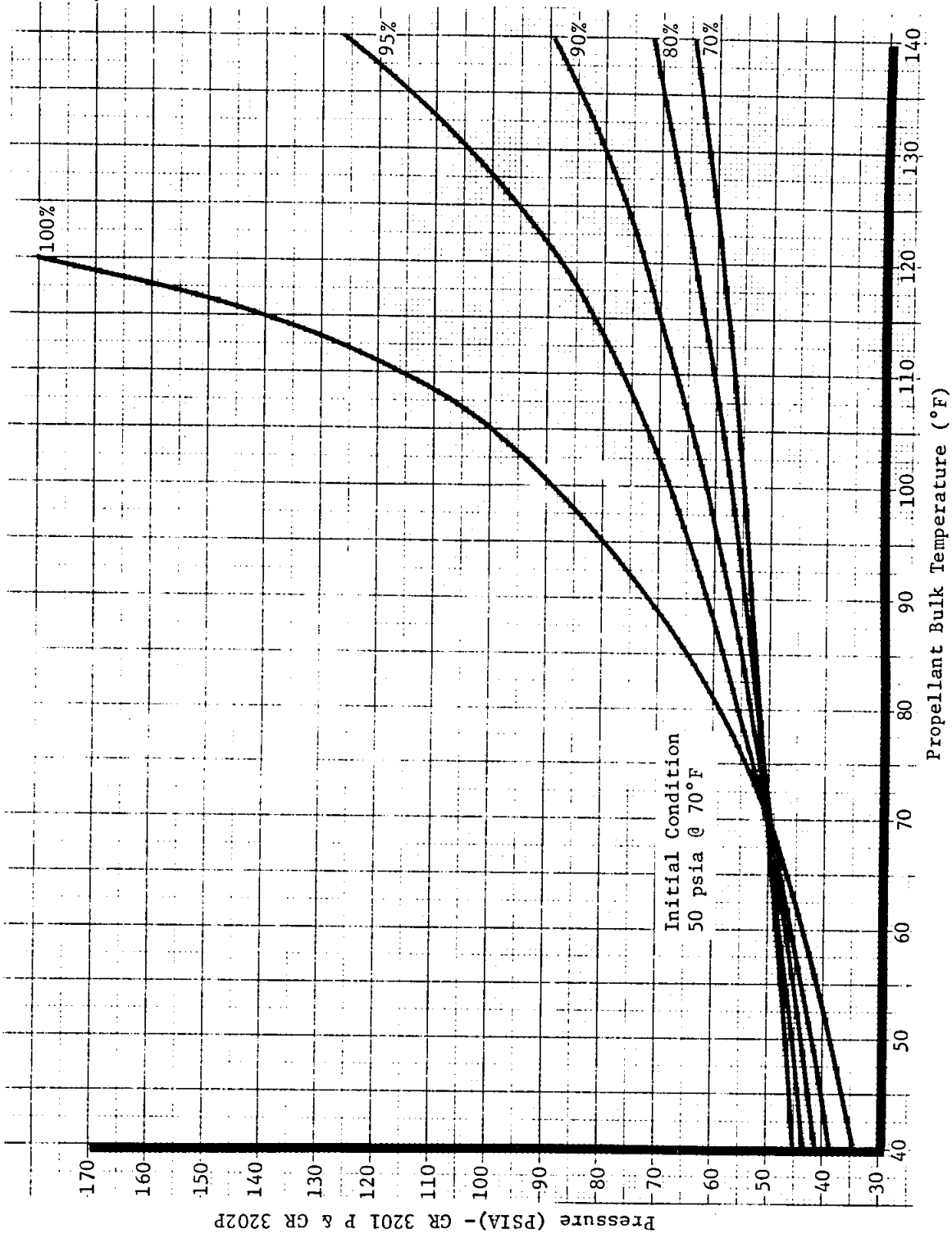


Figure GR-3, Variation of Ullage Pressure vs. Propellant Temperature with Quantity of Oxidizer

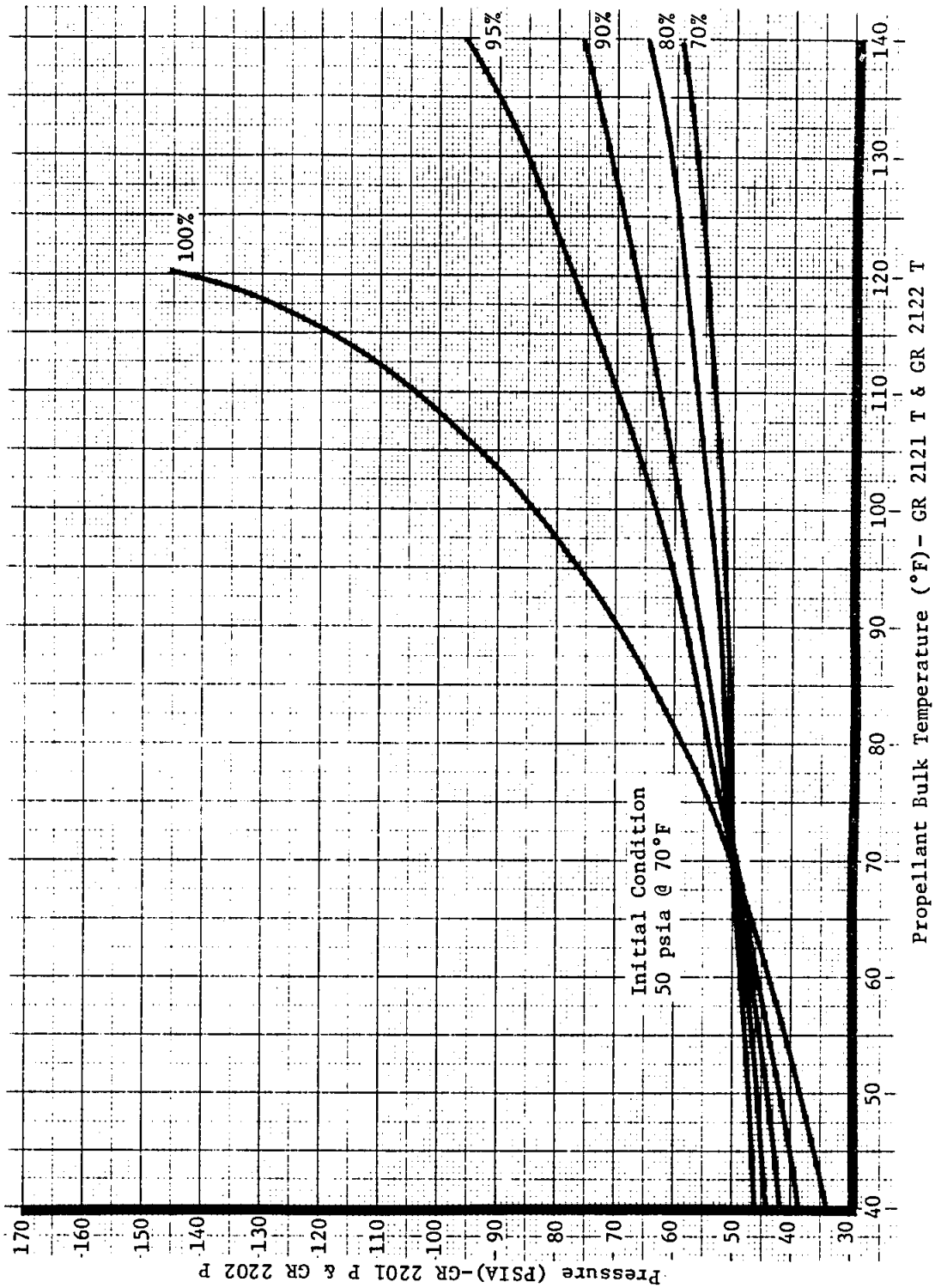


Figure GR-4, Variation of Ullage Pressure vs.
Propellant Temperature with Quantity of Fuel

COMMUNICATIONS & INSTRUMENTATION

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 & Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GT 0454 T	Temp, S-Band Steerable Ant.

Point of Contact - GAC: P. Bender **Ext.** 3356
MSC: R. H. Dietz/D. Rhoades **Ext.** 4063

Data Units	DEG.F.	**Data Range** PCM	**Data Range** Meter	**Accuracy** PCM	**Accuracy** Meter	**C & W**
Bit Value	1.6	±200		% of FS 2.94 Units 11.76		Max 154 Min -60

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	**Nominal Operation**	**Critical Limits**	**Meas System Error** PCM	**Meas System Error** Meter	**Redline Limits** PCM	**Redline Limits** Meter
Evaluate any increase from ambient	Ambient	Max NA Min NA	NA NA		Max (2) Min NA	
		Max Min			Max Min	
		Max Min			Max Min	
		Max Min			Max Min	

Details:

1. Violation of Redline:

   Exceeding the redline value is indicative of the S-Band steerable heater degradation or heater on/off failure. These conditions may compromise the satisfaction of the mission requirements.

2. Rationale:

   The S-Band steerable antenna is not expected to cycle. Any indicated temp above ambient is of concern and should be investigated.

3. Backup Values:

   Should the S-Band heater stick on the antenna electronics package will be permanently damaged if temp exceeds 195°F.

PYROTECHNIC

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-6 and Sub.

REDLINE DATA
LED-540-57

Date: September 29, 1969

Measurement No.	**Description:**
GY 0201 X	ED System A Relay Transfer
GY 0202 X	ED System B Relay Transfer

Point of Contact - GAC: - W. Sloan Ext. 1381
MSC: - A. Campos Ext. 2846

Data Units	Event	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	NA	NA		% of FS NA Units		Max NA Min

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 minutes	OFF (0)		NA NA		Max OFF(0) Min OFF(0)	
					Max Min	
					Max Min	
					Max Min	

Details: An OFF(0) indication is required throughout the countdown to verify system status. PCM "0" indicates that none of the relays of EED System A/B (K1 to K6) have inadvertently transferred. PCM "1" indicates that one or more of the relays (K1 to K6) may have inadvertently transferred.

Prior to cabin closeout an anomalous GY 0201 X or GY 0202 X must be investigated. Subsequent to cabin closeout, an "ON" indication cannot be considered as an instrumentation failure and must be investigated. The appearance of an "ON" means that the "Pyro Bus A and/or B" may have been inadvertently powered up and that any subsequent inadvertent relay closure would cause unwanted pyrotechnic ignition leading to total or partial staging.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7 & Subs.

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
A/S *	Bulk Fluid Temperatures

Point of Contact - GAC : M.Durcan Ext. 1641
MSC: J.Craig/A.Joslyn Ext. 3441

Data Units	DEG.F	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.4	(2)	NA	% of FS / Units *		Max NA / Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min:* Limits include Instrumentation error.	70°F	(2)	*		Max (2)*	
		(2)	*		Min (2)*	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details:

1. Violation of Redline:

Violation of the upper redline limit can result in overpressurization of pressure vessels during the mission. Violation of the lower redline limit can result in exceeding minimum allowable equipment temperatures.

2. Rationale:

The maximum redline limit is established based on LTA-8 test results and mission thermal analysis which indicate that "hot case" conditions (i.e., limit of attitude envelope) can result in pressure spikes which could result in overpressurization of pressure vessels during the mission. Similar analysis indicate exceeding the lower redline limit could result in freezing water lines and exceeding other subsystem temperature limits. Actual tank temperatures must not exceed redline limits at launch.

To insure that the above requirements are satisfied at launch, the following measurements are to be used to determine the ascent stage temperatures.

	Data Range	Redline Min	Redline Max
GP 0718 T Temp, Fuel Tank (Bulk)	20 to 120	65°F	75°F
GP 1218 T Temp, Ox Tank (Bulk)		65°F	75°F
GR 2121 T Temp, RCS Fuel Tank A	20 to 120	65°F	80°F
GR 2122 T Temp, RCS Fuel Tank B		65°F	80°F

* Accuracy determination to be made by KSC. Refer to LMR for corrected values.

Contract No. NAS 9-1100
Primary No. 664
SC Effectivity: LM-7 & Subs.

REDLINE DATA
LED-540-57

Date: March 9, 1970

Measurement No.	Description:
D/S *	Bulk Fluid Temperatures

Point of Contact - GAC: M. Durcan Ext. 1641
MSC: J.Craig/A.Joslyn Ext. 3441

Data Units	DEG.F	Data Range PCM	Data Range Meter	Accuracy PCM	Accuracy Meter	C & W
Bit Value	0.4	20-120	NA	% of FS		Max NA
				Units **		Min NA

Subsystem Configuration/Condition (Launch Rules: Time Period/ Action Notes)	Nominal Operation	Critical Limits	Meas System Error PCM	Meas System Error Meter	Redline Limits PCM	Redline Limits Meter
To T-10 min: **Limits include Instrumentation error.	70°F	75	**		Max 75**	
		65	**		Min 65**	
					Max	
					Min	
					Max	
					Min	
					Max	
					Min	

Details.

1. Violation of Redline:

Violation of the upper redline limit can result in overpressurization of pressure vessels during the mission.
Violation of the lower redline limit can result in exceeding minimum allowable equipment temperatures.

2. Rationale:

The maximum redline is established based on LTA-8 test results and mission thermal analysis which indicate that "hot case" conditions (i.e.,limit of attitude envelope) can result in pressure spikes which could result in overpressurization of pressure vessels. Similar analysis indicate that exceeding the lower redline limit could result in exceeding minimum subsystem temperature limits.

Actual tank temperatures must not exceed the critical limits.

* To insure that the above requirements are satisfied,the following measurements are used during prelaunch;

GQ 3718 T Temp Fuel Tank #1 (Bulk)
GQ 3719 T Temp Fuel Tank #2 (Bulk)
GQ 4218 T Temp Ox Tank #1 (Bulk)
GQ 4219 T Temp Ox Tank #2 (Bulk)

** Accuracy determination to be made by KSC during propellant loading. Refer to LMR for corrected values.

Backup Value:

The maximum redline value may be exceeded during countdown provided the tank conditions are returned to within acceptable limits at liftoff. A temperature (and corresponding pressure) excursion of this type constitutes an additional pressure cycle, therefore the allowable contingency cycles must be reduced accordingly.

In no event, however, is the maximum redline value to be in violation at liftoff.

No backup value exists for the minimum redline value imposed by thermal control.

THERMAL CONTROL

THERMAL CONTROL

APPENDIX A

APPENDIX A

GUIDELINES FOR MISSION DEPENDENT REDLINES

APPENDIX A

GUIDELINES FOR MISSION DEPENDENT REDLINES H-2 TYPE MISSION

The guidelines described herein are to be used to establish H-2 Mission redline values for Mission Dependent Consumables. The guidelines are based on a nominal mission as described in the Apollo 13 Flight Plan and Flight Mission Rules or an alternate mission, whichever is worse, with a single point failure. Requirements for PLSS refills shall be based upon the latest revisions to the CSM/LM SODB, Volume II, Part 1 LM Data Book and Volume IV, EMU Data Book.

Mandatory objectives which are to be considered in developing the redlines, as well as Section 2.0, Subsystem Requirements, are those beginning with objective F, "Photographs of Candidate Exploration Sites" (Censorinus only) and higher priorities. The priority listing of these objectives are contained in the H-2 Mission Requirements document, SPD9-R-053, latest date of issue.

1.0 LM-7 Consumable Guidelines

1.1 Ascent Batteries - Redline to be based on the worst of either case outlines in 1.1.1 and 1.1.2 below.

1.1.1 A minimum battery energy capacity shall be established to allow completion of powered descent to the lunar surface; ascent from the lunar surface at T2 (PDI + 23 min); rendezvous, docking and crew transfer. Rendezvous thru docking requires 5.6 hours. This determination shall be based on the failure of one ascent battery immediately after committing to land and the assumption that lift-off from the lunar surface will occur in the powered-up mode at T2 (approximately 55 amp average), with switchover to a LM active powered-down mode (approximately 40 amp average), as soon as possible without compromise to crew safety. See SODB Vol. II Part 1, Section 4.4, for the rated amp-hrs for a one-battery two-bus configuration.

1.1.2 A minimum battery energy capacity redline shall be established to accomplish a 2-hour lunar stay (in-phase lift-off) rendezvous; docking, crew transfer, plus an orbital reserve of 2 hours based on loss of all descent battery capacity during the latter part of the lunar landing or anytime during lunar stay. Lift-off and rendezvous will occur in the powered-up mode.

1.2 Descent Batteries

1.2.1 The minimum battery capacity shall be established based upon conducting a nominal mission with a failure of one battery at launch.

1.2.2 A backup value for battery capacity shall be established based upon conducting a nominal mission with lunar stay reserve of 2 hours in powered-up mode.

1.2.3 Assumptions

For the redline case, assume that the AC loads are turned-off and associated DC power-off at lunar touchdown.

For the backup value, assume that the AC loads remain on after touchdown.

1.3 Ascent Water

1.3.1 A minimum redline shall be established based on one of the following conditions, whichever is worse.

1.3.2 The minimum redline shall be established based on allowing completion of the nominal mission profile through landing; with lift-off at the first revolution opportunity; plus an orbital reserve of 2 hours; with the loss of the descent tank immediately after PDI.

1.3.3 Failure of one ascent tank at switchover prior to nominal ascent.

1.3.4 A minimum GN_2 redline shall be established based upon displacing the ascent water requirement established in 1.3.2 or 1.3.3.

1.3.5 A backup value for GN_2 shall be established based upon displacing the nominal load ascent water.

1.4 Descent Water

1.4.1 A minimum redline shall be established based on completing a nominal mission profile (2 hour capability of water capacity remaining at lunar lift-off available in A/S tanks).

1.4.2 A maximum redline shall be established based upon fill requirements for the mission. The value established will have provisions for satisfying water sampling requirements.

1.4.3 A minimum GN_2 redline shall be established based upon displacing the descent water established in 1.4.1

1.4.4 A backup value for GN_2 shall be established based upon displacing the nominal load descent water less samples.

1.5 Ascent Oxygen

1.5.1 A minimum redline shall be established based on one of the following two conditions whichever is worse:

1.5.2 Sufficient ascent oxygen to allow completion of powered descent to the lunar surface, accomplish a 2-hour lunar stay (in-phase lift-off), rendezvous, docking, crew transfer, plus an orbital reserve of 2 hours operating in an open suit loop mode. This determination shall be based on the failure of the descent oxygen tank immediately after circularization; or

1.5.3 Sufficient ascent oxygen to allow rendezvous, docking and crew transfer and a 2-hour reserve in the event of a failure of an ascent oxygen tank at switchover from the descent oxygen tank just prior to launch. Assume the open suit loop mode for rendezvous, docking, crew transfer, plus a 2-hour reserve.

1.6 Descent Oxygen

1.6.1 A minimum redline shall be established based on completing a nominal mission (2 hours capability of oxygen remaining at lunar lift-off in A/S tanks).

1.7 Ascent Helium (APS)

1.7.1 A minimum redline shall be established based on conducting a nominal mission with failure of one helium tank after landing.

1.7.2 A backup value shall be established based on depletion of APS propellant tanks in a blowdown mode maintaining the chamber pressure at 114 psia or higher to preclude engine combustion instability.

1.8 Descent Helium (SHe Tank)

1.8.1 A maximum redline shall be established such that the SHe tank pressure does not exceed 1781 psia for the nominal mission duty cycle as delineated in the latest issue of the Flight Plan, plus one extra orbit capability.

1.8.2 A backup value shall be established based upon the worst case duty cycle for an alternate photography mission which utilizes the DPS engine providing this mission is more restrictive than the nominal mission. The 1781 psia maximum pressure is applicable as in para. 1.8.1.

1.8.3 The maximum coast pressure rise during DPS nonburn periods shall be based upon the results of previous flight data.

1.8.4 The maximum pressure rise prior to lift-off shall be based upon the data in Volume II, Part 1 of the SODB and updated after CDDT.

1.9 RCS Helium

1.9.1 A minimum redline shall be established based on depletion of all RCS propellants at specification regulator inlet pressures with specification leakage.

1.10 LM Propellants

1.10.1 Propellant loading for DPS, APS and RCS shall be in accordance with propellant requirements shown in Vol. III of the Spacecraft Operational Data Book. The redlines shall be based on nominal/alternate mission requirements and the requirement that any difference in loaded propellant quantity must be explainable.

APPENDIX B

APPENDIX B

PART 1 - GUIDELINES FOR DISCRETE MEASUREMENT REDLINES

Appendix D

The attached pages are the results of an investigation into the classification of all LM-5 mandatory discretes performed by GAC systems Reliability (They include Table II and Figures 1 through 28 of GAC LED 550-174 revision A, 11 June 1969). Although this study was done for LM-5 discretes it is fully applicable to LM-6 through LM-9. The purpose of this study was to determine by circuit and mission review if these measurements could be downgraded to the Highly Desirable or Desirable Category. This would further minimize real time rationalization required when non-nominal situations occur during launch countdown since in no case will a launch be scrubbed for the loss of any single highly desirable item.

The following guidelines were utilized in this study:

1. The period of time considered is after LM closeout (approx. T-24 hours). It is assumed that all switches, circuit breakers, valves, etc. are in their prelaunch closeout configuration.

2. The following items were considered as double or more failures:
   (a) The simultaneous closure or opening of all contacts of a switch.
   (b) A non-latching relay changing state and remaining in changed state is considered a double failure.
   (c) A wire breakage and simultaneous short to bus is considered a double failure.

*3. If the failure of an element results in an instrumentation discrete and this same element is used in the subsystem function then the failure is considered as a subsystem failure.

4. Discrete measurements will be included in the launch mission rules if they meet all of the following requirements:
   (a) No more than one failure need be proposed for a PCM indication to be the real indication of a problem within the subsystem being monitored.
   (b) The subsystem failure constitutes a hazard to crew safety or a determent to mission success.
   (c) An acceptable in-flight work-around to the failure(s) does not exist.

5. Any PCM indication at the ACE station is attributable to the LM vehicle since the ACE station can be interrogated for errors within itself.

6. Wherever two or more subsystem failures are required to get a light it is considered to have been caused by an instrumentation failure.

Appendix D
(Cont'd)

7. In the case where it is decided that the light is due to an instrumentation failure, the measurement is to be deleted from the mandatory category only upon explanation of why the crew can fly without the availability of this measurement.

8. Rationale for all discretes which affect crew safety and mission success will be provided either in Section 3.0 or Appendix D, Part 2, of this data book. Rationale for discretes which satisfy the guidelines shall appear in the appropriate subsystem areas of Section 3.0. All other rationale for discretes which do not satisfy the guidelines, but which are crew safety and mission success items, shall be incorporated in Appendix D, Part 2.

*If in flight work around can be described which does not impact crew loading - then this measurement may be deleted from mandatory.

APPENDIX D

PART 2 - DISCRETE RATIONALE

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

EPS

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GC9961U	Battery 1 Malfunction	(a) If descent batteries are off: 1. LV or HV contact feeding power to descent ECA Power Supply fails closed. 2. Current monitor in ECA fails in such a way that it sets the reverse current (RC) relay or the over current (OC) relay. or 1. 4CB8 or 4CB9 (DES ECA CONT) ckt breaker fails closed. 2. HV or LV switch fails closed in the ON position. 3. The associated feeder line shorts or the battery develops an over temperature (OT) condition.	(a) If descent batteries are off: 1. RC contact or OC contact in descent ECA fails closed or buffer amplifier output (closure) in SCEA 2 fails closed.	(a) Batteries can be turned on and checked out using GC0201V-GC0204V, GC1201C-GC1204C, GC4361X-GC4368X, GC0301V & GC0302V. If the OC relay is set, battery cannot be turned on. If battery is on, hardware failure has occurred.	No effect on mission. Battery Caution Light would remain on until vehicle is staged. DC Bus warning light, BUS FAULT component light, battery voltages (GC0201V-GC0204V), battery currents (GC1201C-GC1204C), battery status (GC4361X-GC4368X), and bus voltages (GC0301V and GC0302V) are backup measurements. Note: Over temperature (OT) malfunction will be detected in the following manner. An OT condition can be caused only by loss of glycol cooling to the battery or by an internal short in the battery. In the former case, water glycol temperature, pressure, or quantity measurements will indicate loss of water glycol cooling. In the latter case, if the battery is on the line alone, both the voltage and current will drop from previous values; if the battery is in parallel with others, current will drop to low level or reverse current will occur.
		(b) If descent batteries are on (T-30 minutes to T-0): 1. A feeder line shorts or the battery develops an OT or RC (e.g. an internal short in battery or under voltage.)	(b) If descent batteries are on (T-30 minutes to T-0): 1. RC contact or OC contact in battery fails closed, or buffer amplifier output (closure) in SCEA 2 fails closed.	(b) GC0201V-GC0204V, GC1201C - GC1204C, GC4361X - GC4368X, GC0301V & GC0302V.	
GC9962U	Battery 2 Malfunction	Same as above	Same as above	Same as above	Same as above
GC9963U	Battery 3 Malfunction	Same as above	Same as above	Same as above	Same as above
GC9964U	Battery 4 Malfunction	Same as above	Same as above	Same as above	Same as above

NOTE: These measurements GC9961U thru GC9964U are updated to a Mandatory Status November 10, 1969 and are included in Section 3 under EPS.

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

EPS

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GC9965U	Battery 5 Malfunction	1. NORM feed contact or ALT feed contact feeding power to the ascent ECA power supply fails closed. 2. Current monitor fails in such a way that it sets the RC relay or the OC relay. or 1. NORM feed main feed contactor ON signal line shorts to ground (battery will turn on). 2. The asociated feeder line shorts or the battery develops an over temperature condition.	1. RC contact or OC contact in ascent ECA fails closed or buffer amplifier output (closure) fails closed.	None for the first case of 2 hardware failures. For the second case, if the ascent battery stays on, GC0205V or GC0206V, GC1205C or GC1206C, GC4369X - GC4372X can be used; if a shorted feeder line occurs, GSE power or descent batteries could be affected.	No effect on mission. Battery Caution light would remain on and, thus, would be useless. DC Bus Warning Light, Bus Fault component light, battery voltages (GC0205V and GC0206V), battery currents (GC1205C and GC1206C), battery status (GC4369X - GC4372X), and bus voltages (GC0301V and GC0302V) are backup measurements. Note: Over temperature (OT) malfunction will be detected in the following manner. An OT condition can be caused only by loss of glycol cooling to the battery or by an internal short in the battery. In the former case, water glycol temperature, pressure, or quantity measurements will indicate loss of water glycol cooling. In the latter case, if the battery is on the line alone, both the voltage and current will drop from previous values; if the battery is in parallel with others, current will drop to low level or reverse current will occur.
GC9966U	Battery 6 Malfunction	Same as above	Same as above	Same as above	Same as above

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

ECS

MEAS NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GF9986U	Selected Coolant Accumulator Low Level	1. Leakage of glycol from Primary or Secondary Coolant Loop Plumbing	Shorted low level switch contact or SCEA failure	GF9997U selected pump discharge pressure indicates head pressure provided by accumulator on the primary loop. GF2921P redundant pump discharge pressure indicates head pressure provided by accumulator on the secondary loop.	None - Sufficient backup instrumentation is available in flight. (1) GF9997U selected pump discharge pressure feeds T/M and glycol pressure meter 7M5. (2) GF9998U selected coolant loop temperature feeds T/M and glycol temperature meter 7M5. (3) GF2936X selected coolant loop fail feeds T/M and component caution light 7DS3 glycol pump. (Indicates low delta P across pump). (4) GF2021P delta pressure primary coolant loop feeds T/M. (Indicates low delta pressure across pump). (2), (3), (4) apply to the primary coolant loop only.

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

CES

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GH1260X	AE ON/OFF to Prop.	1. Ckt Breaker closed (one of two, 4CB40, 4CB41). 2. Shorted contact on one of two relays K11, K13. 3. Shorted contact on one of two relays K12, K207.	Shorted contact on one of two relays or SCEA failure.	GY0201X GY0202X	None - Crew can sense when engine is fired. Also GI0001X serves as a backup measurement.
GH1283X	Abort Stage Cmded	1. Ckt Breaker closed, 4CB3 2. SW. contact shorted (Abort Stage SW.)	Shorted contact on one relay or SCEA failure.	GC4370X GC4371X	None - GG0001X and GI0001X serve as backup measurements to this measurement.
GH1286X	Eng. Fire Override	1. Ckt Breaker closed, 4CB106 2. Shorted SW. (momentary, Eng. Start SW.)	Shorted contact on one relay or SCEA failure.	None	None - Still requires two hardware failures to effect the safety of the crew.
GH1323X GH1330X	Trim Fail (Pitcher Roll)	1. Ckt Breaker closed, 4CB69 2. Shorted Relay Contact K1 or K23 3. Shorted Relay Driver (DECA)	Shorted relay contact or SCEA failure	None	None - GI0001X serves as backup to this measurement.
*GH1348X	Desc. Eng. Armed	1. Shorted contact on one of two relays (K1, K23 in DECA)	SCEA failure	None	None - GH1313V, GH1314V and GQ6806H serve as backup measurements. If it is determined that K23 or K1 are shorted, leave 4CB69 open until DE arming is to be performed; then close 4CB69 and arm DE. This would preclude continuous +28V to the TVA.
GI3306X	AGS Condition Standby	1. Two contacts on AGS Status SW. 12S17 shorted (Instr. & Function Contacts	Shorted SW. contact or SCEA failure	GI3305	None - Backup measurements, GI3305 & GI0001X are available. Crew can verify mode of operation by checking AGS operation. Based on Guideline #2, the functional portion of this switch 12S17 is impaired.

*Note: Measurements GH1348X DE Armed and GH1418X thru GH1433X Driver Outputs - RCS Jets have experienced false instrumentation indications. Bias resistors have been added to these measurements from the C & WEA and Sig. Cond. #1 ckt breakers thus biasing the SCEA buffer ckt off. However, at pre-launch the C & WEA ckt breaker line does not have power applied while the Sig. Cond. #1 ckt. breaker does have power applied; therefore, GH1418, 20, 23, 24, 26, 29, 31 33X LMP RCS Jets (8) can have false instrumentation indications on the pad. Additional investigation required to assure that the indication at ACE is not the result of noise problems on the vehicle.

NON-MANDATORY DISCRETE MEASURENTS (LM-6 & SUBS)

CES

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GH1621X	Guidance Select (AGS)	1. CKT Breaker Closed (4 CB20) 2. Shorted Switch Contact (Guid. Cont. Sw.)	Shorted contact on one relay or SCEA failure	None	None - Back-up measurement GI0001X AGS Downlink Data available
GH1628X	Roll Att. Control Select (Pulse/Direct)	1. CKT Breaker Closed (4CB59) 2. Shorted Switch Contact (Att. Cont. SW - Roll)	Same as above	None	None - This measurement depicts a status. The crew can detect a switch contact failure which would result in drift in this axis. The procedure would be the same with or without the measurement. Pull 4CB59 and continue mission.
GH1629X	Pitch Att. Control Select (Pulse/Direct)	Same as above. (4CB59) (Att. Cont. SW - Pitch	Same as above	None	Same as above
GH1630X	Yaw Att. Control Select (Pulse/Direct)	Same as above. (4CB59) (Att. Cont. SW - Yaw	Same as above	None	Same as above
GH1893X	X Trans Override	1. Open SW. Contact (+X Trans SW.)	Same as above	None	None - One contact on the X translation switch 1S12 failing in the make position will give the instrumentation indication. This will also fire an RCS jet if 4CB59 is energized. If this switch is failed, continue the mission with 4CB59 open, however direct and pulse modes will be disabled. PGNS and AGS modes are still available for vehicle attitude control. If SCEA failure, disregard instrumentation.
GH1896X	Unbalanced couples	1. Two contacts on balance couple SW. shorted (Instr. & Function Contact)	One contact shorted on 1S9, or SCEA failure	None	None - In the event GH1896X is present in flight it can be disregarded. Measurement used for information only during AGS Ascent Engine Burn. Not mandatory based on Ground Rule #2.
GH1641X	AGS Mode Cont (Auto)	1. Two contacts on AGS Mode Control SW. shorted (Instr. & Function Contact)	Shorted SW. Contact or SCEA failure	None	None - Based on Ground Rule #2, the functional portion of this switch 11S25 is not impaired in the event GH1641X or GH1642X are present in flight, the AGS Downlink Data, GI0001X, is available. The crew can verify mode of operation by interrogating the AEA via DEDA.
GH1642X	AGS Mode Cont. (Att. Cont.)	Same as above	Same as above	None	None - Same as above
GH1643X	PGNS Mode Cont. (Auto)	1. Two contacts on PGNS Mode Cont. SW. shorted (Instr. & Function Contacts)	Same as above	None	None - Based on Guideline #2, the functional portion of this switch 11S24 is not impaired. In the event GH1643 or GH1644 are present in flight, the PGNS Downlink Data, GG0001X, is available, the crew can verify mode of operation by interrogating LGC via DSKY.

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

CES

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GH1644X	PGNS Mode Cont. (Att. Cont.)	1. Two contacts on PGNS Mode Cont. SW. shorted (Instr. & Function Contacts)	Shorted SW. Contact or SCEA failure	None	None - Based on Guideline #2, the functional portion of this switch 11S24 is not impaired. In the event GH1643 or GH1644 are present in flight, the PGNS Downlink Data GG0001X, is available, the crew can verify mode of operation by interrogating LGC via DSKY.
GY0050X	Abort Cmded.	1. SW. contact shorted (Abort Switch)	SCEA failure	None	None - Based on Guideline #2, the remaining contacts on the abort switch have not failed. In flight leave the Descent Engine Control Breaker (4CB80) open until just before De-Arming. This will prevent the premature arming of the DE should the switch contact be shorted. In addition, in flight the measurements GH1348X, GH1313V and GH1314V can be used as backup and to indicate if a short or a SCEA failure has occurred.
GH1204X	ACA Out of Detent	1. CKT Breaker Closed (one of two, 4CB230, 4CB81) 2. One of six out of Detent SWS. closed or wire short to GND (S1-S6).	Short on one of two relay contacts or SCEA failure.	None	None - This measurement depicts a status. The crew can detect a switch contact failure which would result in drift in all axes. Measurements GG0001X and GI0001X serve as backups. Two subsystem failures are required for a legitimate instrument indication.
GH1214X	Auto Eng on CMD	1. Two contacts on relay K18 or one contact each on K18 and K24 (S & C #1) failed shorted.	Short on one relay contact or SCEA failure	None	None - This measurement is a status measurement which MCC uses to determine if the computer failed to issue an auto engine on. On the other hand, the inadvertent presence of an auto engine on, which requires at least two computer failures, would result in an early firing of the engine when it is armed.
GH1217X	Auto Eng Off CMD	1. Two contacts on relay K17 or one contact each on K17 and K25 (S & C #1) failed shorted.	Same as above	None	None - This measurement is a status signal used by MCC to determine if the computer failed to issue an auto engine off. All burns can be completed manually.

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

INSTR.

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GL0400X	Internal Oscillator Failure Detection Signal No. 1	1. Temperature Compensated Oscillator in PCMTEA or 2. Amplifier	1. Inadvertent output from PCM channel.	All ACE Monitored Downlink Data	None - Since LGC timing and oscillator timing is still available. Requires the loss of the above timing sources for a mission abort.
GL4026X	CES AC Power Supply Failure	C & WEA Ckt. Breaker 4CB99 failed closed.	1. SCEA Buffer emits 5V output or shorted relay contact.	If Ckt. Breaker 4CB99 fails closed, other master alarms will be initiated at ACE; GL4027X GL4028X	Can verify the proper operation of 800Hz ATCA power supply by exercizing ACA in AGS Mode and performing RGA self test. Therefore, can determine that an instrumentation failure and not a hardware failure has occurred. Rate meters can be used as failure detection for 800Hz power supply GH1247V, 1248V, 1249V, Yaw, Pitch and Roll logic input error.
GL4027X	CES DC Power Supply Failure	C & WEA Ckt. Breaker 4CB99 failed closed	1. SCEA Buffer emits 5V output or shorted relay contact.	Same as above except GL4026X will be initiated.	Can verify proper operation of DC voltages when D. E. is armed. Therefore, can determine that the ATCA DC Power Supply is operating properly.
GL4028X	AGS Power Supply Fail	1. C & WEA Ckt. Breaker 4CB99 failed closed. 2. AGS Status SW. 12S17 failed out of off position.	1. SCEA Buffer emits 5V output or shorted relay contact.	Same as above except GL4026X GL4027X will be initiated.	Can verify proper operation of the AGS by comparing PGNS and AGS outputs and checking the AGS Downlink Data GI0001.

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

RCS

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GR2461X GR3461X (GR9609U)	Main Shutoff Valves "A" Closed.	4CB72 closed 8S7 short	Inadvertent output of the buffer or Switches fail short (2 switches GR2461X and GR3461X).	None	Valves are nominally open. Rise in manifold pressures (GR3201P, GR2201P, GR3202P, GR2202P) when RCS system is initially pressurized will verify that valves are in the open position. Should any of the valves inadvertently close during the mission these same measurements would indicate a pressure decay following RCS firings.
GR2462X GR3462X (GR9610U)	Main Shutoff Valves "B" closed.	4CB73 closed 8S9 short	Inadvertent output of the buffer or Switches fail short (2 switches GR2462X and GR3462X).	None	The valves are nominally closed during powered ascent. If a valve is actually open the worst effect would be to consume RCS propellant. This propellant consumption would indicate that the valve may be inadvertently open. Consumption of this propellant would not affect crew safety or the success of the mission.
GR4261X GR4269X (GR9661U)	TCA Isol Valves 4A closed.	4CB67 closed 8S16 short	Inadvertent output of the buffer or Switches fail short (2 switches GR4261X and GR4269X).	None	These measurements normally indicate the closure of a pair of TCA isolation valves (fuel and oxidizer). Should a pair of TCA isolation valves inadvertently close during the mission, this anomaly would be indicated by the lack of thrust chamber pressure when the jets are commanded to fire. This backup indication feeds caution and warning and is also telemetered.
GR4262X GR4270X (GR9662U)	TCA Isol Valves 4B closed.	4CB49 closed 8S18 short	Same as above (GR4262X and GR4270X)	None	Same as above
GR4263X GR4271X (GR9663U)	TCA Isol Valves 3A closed.	4CB67 closed 8S15 short	Same as above (GR4263X and GR4271X)	None	Same as above
GR4264X GR4272X (GR9964U)	TCA Isol Valves 3B closed.	4CB49 closed 8S17 short	Same as above (GR4264X and GR4272X)	None	Same as above
GR4265X GR4273X (GR9665U)	TCA Isol Valves 2A closed.	4CB67 closed 8S12 short	Same as above (GR4265X and GR4273X)	None	Same as above

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

RCS

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GR4266X GR4274X (GR9666U)	TCA Isol Valves 2B closed.	4CB49 closed 8S14 short	Inadvertent output of the buffer or Switches fail short (2 switches (GR4266X and GR4274X)	None	These measurements normally indicate the closure of a pair of TCA isolation valves (fuel and oxidizer). Should a pair of TCA isolation valves inadvertently close during the mission, this anomaly would be indicated by the lack of thrust chamber pressure when the jets are commanded to fire. This backup indication feeds caution and warning and is also telemetered.
GR4267X GR4275X (GR9667U)	TCA Isol Valves 1A closed.	4CB67 closed 8S11 short	Same as above (GR4267X and GR4275X)	None	Same as above
GR4268X GR4276X (GR9668U)	TCA Isol Valves 1B closed.	4CB49 closed 8S13 short	Same as above (GR4268X and GR4276X)	None	Same as above

NON-MANDATORY DISCRETE MEASUREMENTS (LM-6 & SUBS)

ED

MEAS. NO.	DESCRIPTION	HARDWARE FAILURES REQUIRED FOR FUNCTION ACTIVATION	INSTRUMENTATION FAILURES REQ'D FOR FALSE INDICATION	ADDIT. PRELAUNCH MEASUREMENTS	IN-FLIGHT EFFECT OF LOSS OF INSTRUMENTATION
GY0231X	Sys A Relays K7-K15 K7 - RCS He K8 - Land Gear K8A - " " K9 - DPS Supercrit. He K10 - ASC #1 He K11 - ASC #2 He K12 - " " K12A - APS Compatibility K13 - DPS Vent K14 - DPS Ambient He K15 - DPS Compatibility	1. Arming Relay K1 latches close. 2. Logic power breaker 4CB76 (4CB75) fails close. 3. Switch fails close 2S2 for K7 2S10 for K8 and K8A 2S4 for K10, K11, K12 and K12A 2S6 for K13 2S1 for K14 2S9 for K15 or 1. Arming Relay K1 latches close. 2. Non-latching relay (K7 - K15) must transfer. 3. Relay (K7 - K15) must remain transferred.	Inadvertent output of the buffer. or 1. The normally closed instrumentation contacts of a non-latching relay must open up. 2. The contacts must remain open.	None	None - Although this indication does not distinguish which of the relays has transferred, the successful completion of the functions connected with these relays can be verified by instrumentation on the related subsystem. (e.g. successful RCS pressurization in flight can be verified from pressure measurements on the RCS subsystem).
GY0232X	Sys. B Ed Relays K7 - K15	(Same as above for System B)	(Same as above for System B)	None	(Same as above for System B)

APPENDIX C

APPENDIX C

PRELAUNCH REDLINE APPLICABILITY FOR COUNTDOWN DEMONSTRATION TEST

This appendix delineates the prelaunch redline applicability to the Countdown Demonstration Test (CDDT). Rather than include a separate and, in most cases, identical documentation of redlines for CDDT, this appendix will define those prelaunch redlines of Section 3 which are not applicable, the rationale and the new redline values, if any. Therefore, those redlines not presented in Table C-1 are considered to be valid for CDDT as defined in Section 3.

TABLE C-1

REDLINE EXCEPTIONS FOR CDDT

MEAS/TM NO.	DESCRIPTION	CDDT EFFECTIVITY	COMMENTS
GC 0201 V	Volt, Battery No. 1	Min. 31.6 VDC	Open Circuit immediately after load removed. No open circuit decay.
GC 0202 V	Volt, Battery No. 2		
GC 0203 V	Volt, Battery No. 3		
GC 0204 V	Volt, Battery No. 4		
GC 0205 V	Volt, Battery No. 5	Minimum - none	No open circuit decay
GC 0206 V	Volt, Battery No. 6		
GF 3582 P	Press Ascent O_2 Tank No. 1	NA	Due to residuals, some pressure may be experienced
GF 3583 P	Press Ascent O_2 Tank No. 2	NA	
GF 3584 P	Press, Descent O_2 Tank	NA	
GF 4581 Q	Qty., Descent Tank Water	NA	Residuals may be present.
GF 4582 Q	Qty., Ascent Tank No. 1 Water	NA	
GF 4583 Q	Qty., Ascent Tank No. 2 Water	NA	
GP 0001 P	Press, He Supply Tank No. 1	NA	
GP 0002 P	Press, He Supply Tank No. 2	NA	
GP 0718 T	Temp, Fuel Tank Fuel Bulk	NA	Temp not critical since only pad press during CDDT
GP 1218 T	Temp, Ox Tank Fuel Bulk	NA	
GP 1510 P	Press, Fuel Isol. Vlv. Inlet	NA	Pad press during CDDT
GP 1503 P	Press, Ox. Isol, Vlv. Inlet	NA	
GQ 3018 P	Press, He Reg Out Manifold	NA	Pad Pressure
GQ 3025 P	Press, He Reg Out Manifold	NA	
GQ 3435 P	Press, Supercritical He Supply	Max. press NA	Req'd only for launch
GQ 3611 P	Press Engine Interface Fuel	NA	Pad pressure only for CDDT
GQ 4111 P	Press Engine Interface Ox	NA	

TABLE C-1 (Cont'd)

MEAS/TM NO.	DESCRIPTION	CDDT EFFECTIVITY	COMMENTS
GQ 3718 T	Temp, Fuel Tank No. 1 Fuel Bulk	NA	Temp not critical since only pad pressure during CDDT
GQ 3719 T	Temp, Fuel Tank No. 2 Fuel Bulk	NA	
GQ 4218 T	Temp, Fuel Tank No. 1 Ox Bulk	NA	
GQ 4219 T	Temp, Fuel Tank No. 2 Ox Bulk	NA	
GR 1101 P	Press He Tank A	NA	Residual He may result in some pressure.
GR 1102 P	Press He Tank B		
GR 2201 P	Press A Fuel Manifold	NA	Pad press only during CDDT
GR 2202 P	Press B Fuel Manifold	NA	
GR 3201 P	Press A Oxid	NA	
GR 3202 P	Press B Oxid Manifold	NA	