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C66-4617

COPY NO. 37

| CONTRACT REQUIREMENTS | CONTRACT ITEM | MODEL | CONTRACT NO. | DATE |
|---|---|---|---|---|
| Exhibit E, Para.5.15.1 | Line Item 13.0 | LEM | NAS 9-1100 | 12/17/65 |

TYPE II

Primary Code 713

# REPORT

NO. LSR-490-32

DATE: 1 May 1966

## LEM MONTHLY MASS PROPERTY STATUS REPORT (U)

CODE 26512

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REVISIONS

| DATE | REV. BY | REVISIONS & ADDED PAGES | REMARKS |
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AVAILABLE TO NASA HEADQUARTERS ONLY

## INTRODUCTION

This report contains the LEM Mass Properties status as of April 18, 1966 for the Lunar Landed Vehicle. The total weight at Separation is 31,307.1 pounds, which is 59.8 pounds lighter than that previously reported in LSR-490-31, dated 1 April 1966.

A summary of changes since the last report is as follows:

| | | |
|---|---|---|
| A. | Ascent stage inert* weight | + 3.9 pounds |
| B. | Ascent stage propellant | + 3.3 pounds |
| C. | Descent stage inert* weight | -35.3 pounds |
| D. | Descent stage propellant | -31.7 pounds |
| | Total LEM Weight Change at Separation | -59.8 pounds |

A more detailed breakdown of the changes since the last report is included on page 11. Changes in this report are as follows:

A. Incorporation of current Government Furnished Equipment.
B. Additional Super Weight Improvement Program weight savings.
C. General updating of weight based on current data.

The current listing of Government Furnished Equipment (GFE) in this report and the equipment weights are generally in agreement with reference 5. Exceptions to this are the retention of the electrical umbilical and the LEM/CSM docking receptacle on the Government Furnished Equipment listing and a lower drogue weight. These deviations were informally discussed and approved by MSC.

The weight impact resulting from Critical Design Reviews (CDR) #1 and #2 is currently being re-evaluated. Any change in status from that appearing in the current pending changes will be incorporated in subsequent reports, as soon as the data becomes available.

The assumed $\Delta V$ Budget of 13,918 fps. for the LEM Reference Mission remains unchanged since the last report. The distribution of this budget is Ascent $\Delta V$ = 6586 fps. and Descent $\Delta V$ = 7332 fps.. The reference mission requires more propellant than the critical abort mission, which was defined in the August LEM Mass Property Report, LED-490-23.

* Inert weight includes all non-propulsion expendables.

INTRODUCTION - Cont.

The currently reported $\Delta V$ propellant is based on an ascent $I_{sp}$ of 304.3 sec. and a descent $I_{sp}$ of 301.0 sec.. The 304.3 sec., ascent $I_{sp}$, is based on a continuous - burn RCS $I_{sp}$ of 273 sec. and an ascent Propulsion average $I_{sp}$ of 306.3 sec.. The 301.0 sec., descent $I_{sp}$, is based on a descent Propulsion integrated average $I_{sp}$ of 302.1 sec.. The manufacturer's current integrated average nominal $I_{sp}$'s are 310.0 sec. for the ascent engine, and 300.2 sec. for the descent engine. The manufacturer's current continuous burn RCS nominal $I_{sp}$ is 273 sec..

SCRAPE effort on 1032 pounds of ascent structure indicates a current potential weight saving of 136 pounds. The total ascent scrape weight saving incorporated to date is 120.4 pounds. (115.8 pounds was scraped from Vehicle Design Integration drawings and 4.6 pounds was scraped from Crew Provision drawings.) The 923 pounds of descent structure, reviewed and scraped, currently indicates a current potential weight saving of 114 pounds. The 17.0 pounds of saving incorporated in this report brings the total incorporated descent structure weight saving to 104.5 pounds.

Other SWIP items incorporated in this report reduce the ascent stage 5.6 pounds and the descent stage 32.0 pounds. A listing of SWIP items incorporated in weight reports to date is included as Appendix A of this report.

[redacted]



FIGURE 1

# LEM ALLOWABLE STAGE WEIGHT APPORTIONMENT

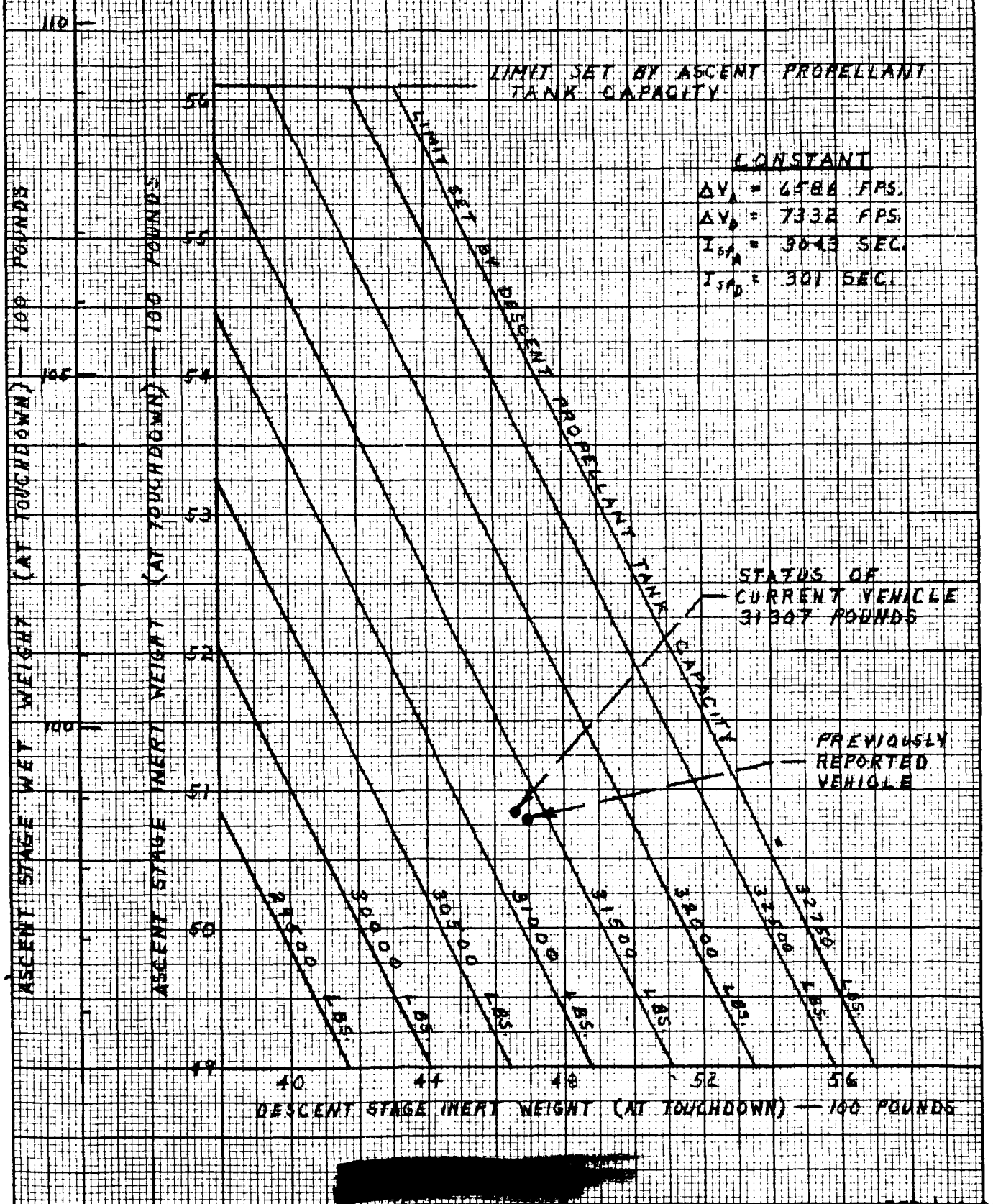


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Table 1

LEM MASS PROPERTY HISTORY

| MISSION PHASE | WEIGHT EARTH POUNDS | CENTER OF GRAVITY STATION INCHES X | CENTER OF GRAVITY DISTANCE FROM THRUST AXIS Y | CENTER OF GRAVITY DISTANCE FROM THRUST AXIS Z | MOMENTS OF INERTIA SLUG FT$^2$ $I_{xx}$ | MOMENTS OF INERTIA SLUG FT$^2$ $I_{yy}$ | MOMENTS OF INERTIA SLUG FT$^2$ $I_{zz}$ | PRODUCTS OF INERTIA SLUG FT$^2$ $I_{yz}$ | PRODUCTS OF INERTIA SLUG FT$^2$ $I_{xz}$ | PRODUCTS OF INERTIA SLUG FT$^2$ $I_{xy}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Translunar Injection | 30753 | 182.4 | 0.7 | -0.7 | 21066 | 23441 | 23624 | 425 | 155 | 162 |
| LEM/CSM Separation | 31307 | 183.8 | 0.8 | 0.1 | 22485 | 24829 | 24832 | 422 | 477 | 190 |
| End Insertion to Hohman -Descent | 30901 | 183.5 | 0.8 | 0.1 | 22229 | 24606 | 24640 | 424 | 477 | 191 |
| Begin Hover | 16287 | 203.8 | 1.4 | 0.4 | 12701 | 15366 | 17475 | 444 | 439 | 98 |
| Lunar Touchdown | 14537 | 212.1 | 1.6 | 0.4 | 11570 | 12413 | 14745 | 446 | 429 | 57 |
| | | | | | | | | | | |
| Lunar Launch (lift-off) | 9765 | 241.8 | 0.4 | 1.5 | 6193 | 3314 | 5518 | 2 | 89 | 79 |
| End Insertion to Hohman -Ascent | 5204 | 254.6 | 0.7 | 2.9 | 3063 | 2772 | 1915 | 8 | 49 | 69 |
| Burnout (docked) | 4902 | 255.4 | 0.7 | 3.0 | 2895 | 2679 | 1672 | 14 | 46 | 69 |
| Completion of Crew Transfer | 4282 | 255.4 | 0.0 | -1.7 | 2614 | 2420 | 1545 | 10 | 62 | 60 |

[redacted]

Table 2
SUMMARY OF LEM WEIGHT REPORTING MISSION

| MISSION PHASE | ELAPSED TIME FROM EARTH LAUNCH | | REPORTING MISSION (Day Landing) For Loading Expendables | | | |
|---|---|---|---|---|---|---|
| Description | Hours | Minutes | Hours | Minutes | | |
| Prelaunch (Launch Vehicle Fueling) | -10 | 0 | 10 | | Pre-Separation Period | Dormant Period |
| Launch | 0 | 0 | | 12 | | |
| Earth Parking Orbit | | 12 | 2 | 49 | | |
| Translunar Injection | 3 | 1 | | 5 | | |
| Translunar Coast- Prior to Transposition | 3 | 6 | | 15 | | |
| -During Transposition | 3 | 21 | | 30 | | |
| -Subsequent to Transposition | 3 | 51 | 60 | 24 | | |
| Lunar Orbit- Insertion | 64 | 15 | | 6 | | |
| -Coast Prior to Separation | 64 | 21 | 1 | 26 | | |
| -Checkout | 65 | 47 | 2 | 17 | | |
| LEM Separation and Insertion to Descent Transfer Orbit | 68 | 4 | | 20 | Descent* | Active Period |
| Coast in Descent Transfer Orbit | 68 | 24 | | 58 | | |
| Powered Descent (& Hover) | 69 | 22 | | 10 | | |
| Lunar Staytime | 69 | 32 | 34 | 45 | | |
| Powered Ascent | 104 | 17 | | 7 | Ascent** | |
| Parking Orbit Contingency *** | 104 | 24 | | | | |
| Coasting Ascent Transfer | | | | 47 | | |
| Rendezvous | 105 | 11 | | 8 | | |
| Docking | 105 | 19 | | 15 | | |
| Crew Transfer | 105 | 34 | | 10 | | |
| | 105 | 44 | | | | |
| Dormant LEM Time | | | 75 | 47 | | |
| Active LEM Time | | | 39 | 57 | | |
| Post-Separation LEM Time | | | (37) | (40) | | |
| Total LEM Period | | | 115 | 44 | | |

* Descent Period - 1 Hour 28 Minutes
**Ascent Period - 1 Hour 27 Minutes
***The Design Reference Mission (DRM) does not appear to have any Parking Orbit Contg..

Table 3

LEM WEIGHT BY STAGES AT EARTH LAUNCH AND LUNAR ORBIT SEPARATION - DISTRIBUTION OF THE INERT WEIGHT BY PERCENTAGE

| | | WEIGHT | | | PERCENTAGE | | | |
|---|---|---|---|---|---|---|---|---|
| | | ASCENT | DESCENT | TOTAL | EST'D | LAYOUT | CALC'D | ACTUAL |
| 1.0 | Structure | (1179.7) | (1293.6) | (2473.3) | 36.7 | 11.1 | 48.0 | 4.2 |
| | -Ascent | 1179.7 | -- | 1179.7 | 28.5 | 4.9 | 59.2 | 7.4 |
| | -Descent | -- | 1293.6 | 1293.6 | 44.1 | 16.8 | 37.9 | 1.2 |
| 2.0 | Stabilization and Control | 78.7 | 14.2 | 92.9 | 55.9 | -- | 44.1 | -- |
| 3.0 | Navigation and Guidance | 71.3 | 37.8 | 109.1 | -- | .5 | 99.5 | -- |
| 4.0 | Crew Provisions | 73.2 | -- | 73.2 | 45.5 | 3.4 | 51.1 | -- |
| 5.0 | Environmental Control | 283.9 | 108.4 | 392.3 | 6.1 | 14.0 | 57.3 | 22.6 |
| 6.0 | Landing Gear | -- | 477.2 | 477.2 | 27.9 | 1.8 | 70.3 | -- |
| 7.0 | Instrumentation | 125.8 | 5.5 | 131.3 | 12.6 | 15.1 | 72.3 | -- |
| 8.0 | Electrical Power Supply | 736.8 | 637.5 | 1374.3 | 30.6 | .4 | 15.4 | 53.6 |
| 9.0 | Propulsion | 518.0 | 1072.2 | 1590.2 | 3.4 | 5.2 | 49.3 | 42.1 |
| 10.0 | Reaction Control | 280.2 | -- | 280.2 | 35.4 | 1.4 | 4.8 | 58.4 |
| 11.0 | Communications | 110.3 | 17.4 | 127.7 | 22.3 | -- | 77.7 | -- |
| 12.0 | Controls and Displays | 191.6 | -- | 191.6 | 23.7 | 3.0 | 52.1 | 21.2 |
| 13.0 | Explosive Devices | 14.4 | 34.3 | 48.7 | 85.6 | -- | 14.4 | -- |
| | Hardware- Sub-Total | 3663.9 | 3698.1 | 7362.0 | 25.2 | 6.2 | 44.0 | 24.6 |
| 14.0 | Government Furnished Equipment | 457.0 | 190.0 | 647.0 | 80.2 | -- | 19.3 | .5 |
| 15.0 | Liquids and Gases - Excludes Propellant | 118.2 | 322.1 | 440.3 | 65.9 | -- | 34.1 | -- |
| 17.0 | Propellants - Excludes Delta - V | 441.5 | 473.8 | 915.3 | | | | |
| | Inert- Sub-Total | 4680.6 | 4684.0 | 9364.6 | | | | |
| 16.0 | Propellants - Delta - V | (4813.3) | (16575.2) | (21388.5) | | | | |
| | -Propulsion | 4537.6 | 16575.2 | 21112.8 | | | | |
| | -Reaction Control | 275.7 | -- | 275.7 | | | | |
| | Total - Earth Launch | 9493.9 | 21259.2 | 30753.1 | | | | |
| 5.0 | Environmental Control | -1.0 | -- | - 1.0 | | | | |
| 14.0 | Government Furnished Equipment | +567.7 | -- | +567.7 | | | | |
| 15.0 | Liquids and Gases - Excludes Prop. | +6.9 | - 15.2 | - 8.3 | | | | |
| 17.0 | Propellants - Check-out | -4.4 | -- | - 4.4 | | | | |
| | Total - Separation | 10063.1 | 21244.0 | 31307.1 | | | | |



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Table 4

LEM CURRENT WEIGHT MISSION HISTORY BY STAGES

| MISSION PHASE AND CONSUMABLE DESCRIPTION | ASCENT STAGE DRY WEIGHT (LBS) | ASCENT STAGE ΔV-PROPELL. WEIGHT (LBS) | DESCENT STAGE DRY WEIGHT (LBS) | DESCENT STAGE ΔV-PROPELL. WEIGHT (LBS) | TOTAL WEIGHT (LBS) |
|---|---|---|---|---|---|
| EARTH LAUNCH AND TRANSLUNAR INJECTION | 4687.7 | 4813.3 | 4676.9 | 16575.2 | 30753.1 |
| ECS-Umbilical Hardware | -1.0 | | | | |
| GFE-Electrical Umbilical | -3.1 | | | | |
| -Crew | +352.0 | | | | |
| -Crew Equipment | +179.6 | | | | |
| -Scientific Equipment | +31.0 | | | | |
| -Television Camera | +8.2 | | | | |
| Liquids and Gases-Oxygen | | | +5.4 | | |
| -Water | | | -13.7 | | |
| Propellant -Checkout | -4.4 | | | | |
| SEPARATION | 5250.0 | 4813.3 | 4668.6 | 16575.2 | 31307.1 |
| Liquids and Gases -Oxygen | | | - .5 | | |
| -Water | | | -9.4 | | |
| Propellant -Main ΔV | | | | -16575.2 | |
| -Reaction Control ΔV | | - 19.7 | | | |
| -Attitude | -165.6 | | | | |
| LUNAR TOUCHDOWN | 5084.4 | 4793.6 | 4658.7 | | 14536.7 |
| CFE-Hardware | -9.9 | | -3697.9 | | |
| GFE-Crew Equipment | -96.9 | | -20.0 | | |
| -Scientific Equipment | | | -170.0 | | |
| Liquids and Gases -Oxygen | - .2 | | -44.5 | | |
| -Water | -1.6 | | -203.9 | | |
| -Helium | | | -48.6 | | |
| Propellant - Unusable | | | -473.8 | | |
| -Checkout | -4.4 | | | | |
| LUNAR LIFT-OFF | 4971.4 | 4793.6 | | | 9765.0 |
| Liquids and Gases -Oxygen | - .8 | | | | |
| -Water | -11.5 | | | | |
| Propellant -Main ΔV | | -4537.6 | | | |
| -Reaction Control ΔV | | -256.0 | | | |
| -Attitude | -56.6 | | | | |
| BURNOUT (DOCKING) | 4902.5 | | | | 4902.5 |

## LEM
## WEIGHT STATEMENT

| CODE | ITEM | 4/1/66 WEIGHT AT SEPARATION | CURRENT WEIGHT STATUS: BURN OUT | CONS'D ON ASCENT | JET. ON LURAIN | CONS'D ON DESCENT | TOTAL SEPARATION | X-LUNAR EXPEND-ABLES | EARTH LAUNCH TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1.0 | Structure | 2479.1 | 1179.7 | | 1293.6 | | 2473.3 | | 2473.3 |
| 2.0 | Stabilization and Control | 94.9 | 78.7 | | 14.2 | | 92.9 | | 92.9 |
| 3.0 | Navigation and Guidance | 109.1 | 71.3 | | 37.8 | | 109.1 | | 109.1 |
| 4.0 | Crew Provisions | 73.2 | 73.2 | | | | 73.2 | | 73.2 |
| 5.0 | Environmental Control | 391.9 | 275.3 | | 116.0 | | 391.3 | 1.0 | 392.3 |
| 6.0 | Landing Gear | 482.6 | | | 477.2 | | 477.2 | | 477.2 |
| 7.0 | Instrumentation | 132.5 | 125.8 | | 5.5 | | 131.3 | | 131.3 |
| 8.0 | Electrical Power | 1373.2 | 736.8 | | 637.5 | | 1374.3 | | 1374.3 |
| 9.0 | Propulsion | 1612.8 | 518.0 | | 1072.2 | | 1590.2 | | 1590.2 |
| 10.0 | Reaction Control | 280.4 | 280.2 | | | | 280.2 | | 280.2 |
| 11.0 | Communications | 130.9 | 108.2 | | 19.5 | | 127.7 | | 127.7 |
| 12.0 | Controls and Displays | 191.1 | 191.6 | | | | 191.6 | | 191.6 |
| 13.0 | Explosive Devices | 48.7 | 14.4 | | 34.3 | | 48.7 | | 48.7 |
| Note: | Contractor Furnished Hardware | 7400.4 | 3653.2 | | 3707.8 | | 7361.0 | 1.0 | 7362.0 |

# LEM
## WEIGHT STATEMENT

| CODE | ITEM | 4/1/66 WEIGHT AT SEPARATION | CURRENT WEIGHT STATUS: BURN OUT | CONS'D ON ASCENT | JET. ON LURAIN | CONS'D ON DESCENT | TOTAL SEPARATION | X-LUNAR EXPEND-ABLES | EARTH LAUNCH TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 14.0 | Government Furnished Equipment | 1213.6 | 927.8 | | 286.9 | | 1214.7 | -567.7 | 647.0 |
| 15.0 | Liquids and Gases | 425.1 | 111.0 | 12.3 | 298.8 | 9.9 | 432.0 | 8.3 | 440.3 |
| 16.0 | Propellant - Delta V | (21416.9) | | (4793.6) | | (16594.9) | (21388.5) | | (21388.5) |
| | -Main | 21141.4 | | 4537.6 | | 16575.2 | 21112.8 | | 21112.8 |
| | -RCS | 275.5 | | 256.0 | | 19.7 | 275.7 | | 275.7 |
| 17.0 | Propellant -Non Delta-V | (910.9) | (210.5) | (56.6) | (478.2) | (165.6) | (910.9) | (4.4) | (915.3) |
| | -Unusable | 662.1 | 188.3 | | 473.8 | | 662.1 | | 662.1 |
| | -Attitude and Checkout | 248.8 | 22.2 | 56.6 | 4.4 | 165.6 | 248.8 | 4.4 | 253.2 |
| | | 31366.9 | 4902.5 | 4862.5 | 4771.7 | 16770.4 | 31307.1 | -554.0 | 30753.1 |
| | Burnout Weight | 4899.2 | 4902.5 lbs. | | | | | | |
| | Lift-off Weight | 9758.4 | | 9765.0 lbs. | | | | | |
| | Touchdown Weight | 14564.8 | | | 14536.7 lbs. | | | | |
| | Separation Weight | 31366.9 | | | | | 31307.1 lbs. | | |
| | Earth Launch Weight | 30793.1 | | | | | | | 30753.1 lbs |

Table 5

LEM WEIGHT COMPARISON
AT SEPARATION BY STAGES

| Subsystem | Item | 4/1/66 Weight | Current Weight | Weight |
|---|---|---|---|---|
| A. | Ascent Stage Weight at Separation | 10056.1 | 10063.3 | + 7.2 |
| 1.0 | Structure | 1169.7 | 1179.7 | +10.0 |
| 2.0 | Stabilization and Control | 79.8 | 78.7 | - 1.1 |
| 3.0 | Navigation and Guidance | 72.9 | 71.3 | - 1.6 |
| 4.0 | Crew Provisions | 73.2 | 73.2 | 0 |
| 5.0 | Environmental Control | 282.9 | 282.9 | 0 |
| 6.0 | Landing Gear | -- | -- | -- |
| 7.0 | Instrumentation | 127.0 | 125.8 | - 1.2 |
| 8.0 | Electrical Power Supply | 738.9 | 736.8 | - 2.1 |
| 9.0 | Propulsion System | 523.2 | 518.0 | - 5.2 |
| 10.0 | Reaction Control | 280.4 | 280.2 | - .2 |
| 11.0 | Communications | 113.7 | 110.5 | - 3.2 |
| 12.0 | Controls and Displays | 191.1 | 191.6 | + .5 |
| 13.0 | Explosive Devices | 14.4 | 14.4 | 0 |
| 14.0 | Government Furnished Equipment | 1023.6 | 1024.7 | + 1.1 |
| 15.0 | Liquids & Gases - Excludes Propellant | 118.2 | 125.1 | + 6.9 |
| 16.0 | Propellant - Delta -V | (4810.0) | (4813.3) | (+ 3.3) |
| | -Main | 4534.5 | 4537.6 | + 3.1 |
| | -Reaction Control | 275.5 | 275.7 | + .2 |
| 17.0 | Propellant - Non-Delta -V | 437.1) | (437.1) | ( 0 ) |
| | -Main (Unusable) | 130.3 | 130.3 | 0 |
| | -Reaction Control (58.0# Unusable) | 306.8 | 306.8 | 0 |
| B. | Descent Stage Weight at Separation | 21310.8 | 21243.8 | -67.0 |
| 1.0 | Structure | 1309.4 | 1293.6 | -15.8 |
| 2.0 | Stabilization and Control | 15.1 | 14.2 | - .9 |
| 3.0 | Navigation and Guidance | 36.2 | 37.8 | + 1.6 |
| 4.0 | Crew Provisions | -- | -- | -- |
| 5.0 | Environmental Control | 109.0 | 108.4 | - .6 |
| 6.0 | Landing Gear | 482.6 | 477.2 | - 5.4 |
| 7.0 | Instrumentation | 5.5 | 5.5 | 0 |
| 8.0 | Electrical Power Supply | 634.3 | 637.5 | + 3.2 |
| 9.0 | Propulsion System | 1089.6 | 1072.2 | -17.4 |
| 11.0 | Communications | 17.2 | 17.2 | 0 |
| 13.0 | Explosive Devices | 34.3 | 34.3 | 0 |
| 14.0 | Government Furnished Equipment | 190.0 | 190.0 | 0 |
| 15.0 | Liquids and Gases - Excludes Propellant | 306.9 | 306.9 | 0 |
| 16.0 | Propellant - Delta -V -Main | 16606.9 | 16575.2 | -31.7 |
| 17.0 | Propellant - Propulsion (Unusable) | 473.8 | 473.8 | 0 |
| | Total Separation Weight (A & B) | 31366.9 | 31307.1 | -59.8 |

## DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION

| | Inert* Wt. Chgs. By Stages | | Effective Weight By Responsibility | |
|---|---|---|---|---|
| | Ascent | Descent | GAEC | NASA |
| Current Weight of Government Furnished Equipment | (+1.1) | | | (+3.3) |
| The current individual weights of Government Furnished Equipment are updated in accordance with ref. 5 and informal MSC discussions. | | | | |
| 14.0 Government Furnished Equipment | | | | |
| -Water Waste Fitting | - .1 | | | - .4 |
| -PLSS | -2.2 | | | -6.9 |
| -PLSS LiOH Cartridges | +1.8 | | | +3.8 |
| -TV Camera | + .2 | | | + .8 |
| -Lunar Surface Lens | - .1 | | | - .2 |
| -Telephoto Lens | + .2 | | | + .8 |
| -Isolation -Added | +1.3 | | | +5.4 |
| Super Weight Improvement Program | (-9.0) | (-49.0) | (-142.0) | |
| The current effects of the Super Weight Improvement Program (SWIP) for this reporting period are decreases of 49.0 pounds in the descent stage and 9.0 pounds in the ascent stage. A more detailed breakdown of the SWIP changes are as follows: | | | | |
| Scrape effort on 18 Descent Structure drawings and 30 Ascent Structure drawings indicate weight reductions of 17.0 pounds and 3.4 pounds respectively. | | | | |
| 1.0 Structure | -3.4 | -17.0 | - 50.5 | |
| SWIP change LWSS 390A-52, Optimize General Purpose Inverter, is partially incorporated. | | | | |
| 8.0 Electrical Power | - .8 | | - 3.3 | |

* Inert weight excludes $\Delta V$ propellant.

## DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION - Cont.

| | Inert* Wt. Chgs. By Stages | | Effective Weight By Responsibility | |
|---|---|---|---|---|
| | Ascent | Descent | GAEC | NASA |
| Super Weight Improvement Program - Cont. | | | | |
| SWIP change LWSS 270A-5(b), Aluminum In Lieu Of Steel Diffusers, is incorporated. | | | | |
| 9.0 Propulsion - Helium Diffusers | - .7 | - .6 | -4.2 | |
| SWIP change LWSS 270A-40, Scrape of Ascent Engine, is incorporated. | | | | |
| 9.0 Propulsion - Ascent Engine | -2.9 | | -12.1 | |
| SWIP change LWSS 270A-46, Scrape of Descent Engine, is incorporated. | | | | |
| 9.0 Propulsion - Descent Engine | | -11.4 | -24.3 | |
| SWIP change LWSS 280A-53, Optimize Descent Propellant Tanks, is incorporated. | | | | |
| 9.0 Propulsion - Descent Propellant Tanks | | -20.0 | -42.6 | |
| SWIP change LWSS 380A-11, Scrape of Steerable Antenna, is partially incorporated. | | | | |
| 11.0 Communications - Steerable Antenna | -1.2 | | - 5.0 | |
| Miscellaneous Vendor Weight Changes | (-5.7) | (+17.9) | (+14.4) | |
| Weight changes of Vendored items based on current reported weights are as follows: | | | | |
| 2.0 Stabilization and Control | | | | |
| -Gimbal Drive Actuators (2) | | - .9 | - 1.9 | |
| -Abort Electronic Assembly | -1.1 | | - 4.[illegible] | |
| 3.0 Navigation and Guidance | | | | |
| -Rendezvous Radar - Antenna Assembly | +1.4 | | + 5.9 | |
| -Electronic Assembly | + .5 | | + 2.1 | |
| -Landing Radar - Antenna Assembly | | + 1.3 | + 2.8 | |
| -Electronic Assembly | | + .3 | + .6 | |

* Inert weight excludes $\Delta V$ propellant.

## DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION - Cont.

| | | Inert* Wt. Chgs. By Stages | | Effective Weight By Responsibility | |
|---|---|---|---|---|---|
| | | Ascent | Descent | GAEC | NASA |
| **Miscellaneous Vendor Weight Changes - Cont.** | | | | | |
| 5.0 | Environmental Control - Descent GOX Tank | | - .6 | -1.3 | |
| 7.0 | Instrumentation - Caution and Warning Electronic Assembly | -1.2 | | -5.0 | |
| 8.0 | Electrical Power | | | | |
| | -Batteries - Ascent (2) | -1.6 | | -6.7 | |
| | -Descent (4) | | + 3.2 | +6.8 | |
| 9.0 | Propulsion | | | | |
| | -Propellant Disconnect Couplings | - .2 | | - .8 | |
| | -Engines | -1.9 | + 9.1 | +11.4 | |
| | -Descent Propellant Tanks | | + 4.7 | +10.0 | |
| | -Propellant Quantity Gaging Sensor | | + .8 | + 1.7 | |
| 10.0 | Reaction Control - Propellant Quantity Gaging System | - .2 | | - .8 | |
| 11.0 | Communications | | | | |
| | -VHF Transceiver | + .3 | | + 1.3 | |
| | -S-Band Transceiver | -1.2 | | - 5.0 | |
| | -S-Band Steerable Antenna | -1.0 | | - 4.2 | |
| 12.0 | Controls and Displays - Range Indicator | + .5 | | + 2.1 | |
| | | (+17.5) | (- 4.2) | (+64.5) | |
| **Miscellaneous Weight Changes** | | | | | |
| 1.0 | Structure - Ascent | +1.9 | | + 8.0 | |
| | -Descent | | + 1.2 | + 2.6 | |

In accordance with ref. 10 certain vehicle structure is revised due to increased landing loads. The weight effect of only a portion of this revision is available at this time and is reported as follows:

* Inert weight excludes $\Delta V$ propellant.

## DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION - Cont.

| | Inert* Wt. Chgs. By Stages | | Effective Weight By Responsibility | |
|---|---|---|---|---|
| | Ascent | Descent | GAEC | NASA |
| **Miscellaneous Weight Changes - Cont.** | | | | |
| Continuing review and updating of the vehicle structure and the landing gear structure indicates a 11.5 pound increase in the ascent stage structure and a 5.4 pound decrease in the landing gear structure: | | | | |
| 1.0 Structure - Ascent | +11.5 | | +48.2 | |
| 6.0 Landing Gear | | -5.4 | -11.5 | |
| Current design of the Landing Point Designator is a reticle located on the window. The weight of this etched or decal reticle will be negligible. | | | | |
| 3.0 Navigation and Guidance - Landing Point Designator | -2.0 | | - 8.4 | |
| The weight of the Rendezvous Radar Antenna Deployment Mechanism is reduced based on the calculation of the layout drawing. | | | | |
| 3.0 Navigation and Guidance - Deployment Mechanism | -1.5 | | - 6.3 | |
| The weight of the Fuse Box is increased based on the calculated weight. | | | | |
| 8.0 Electrical Power - Fuse Box | + .3 | | + 1.3 | |
| Added a test point to check the Ascent Engine PreValve for leakage. | | | | |
| 9.0 Propulsion | + .5 | | + 2.1 | |
| Updating of Communication items reflect the following weight changes: | | | | |
| 11.0 Communications - PLSS Test Cable | - .2 | | - .8 | |
| -S-Band In-flight Antenna | + .1 | | + .4 | |

* Inert weight excludes $\Delta V$ propellant.

## DISCUSSION OF WEIGHT CHANGES BY RESPONSIBILITY AND STAGES SINCE LAST REPORT - AT SEPARATION - Cont.

| | Inert* Wt. Chgs. By Stages | | Effective Weight By Responsibility | |
|---|---|---|---|---|
| | Ascent | Descent | GAEC | NASA |
| Miscellaneous Weight Changes - Cont. | | | | |
| The weight of the GOX for the initial pressurization of the LEM cabin from the CSM is incorporated at this time as an accounting correction. | | | | |
| 15.0 Liquids and Gases - Oxygen | +6.9 | | +28.9 | |
| TOTAL INERT WEIGHT CHANGES | +3.9 | -35.3 | | |
| TOTAL EFFECTIVE WEIGHT CHANGES BY RESPONSIBILITY | | | -63.1 | +3.3 |

TOTAL REPORTED WEIGHT CHANGES = -59.8 pounds

* Inert weight excludes $\Delta V$ propellant.

## Pending Changes

| | | Estimated Weight Increment | | |
|---|---|---|---|---|
| | | Ascent (Inert*) | Descent (Inert*) | Separation (Effective) |
| 1. | Incorporate the stowage provisions for additional Government Furnished Equipment. | + 3.4 | - | + 14.2 |
| 2. | Eliminate Landing Gear Thermal Paint since it is not an effective regulation of the honeycomb cartridge temperature. Solutions to this problem are being studied. | - | - | |
| 3. | Incorporate the Optical Tracker Installation in lieu of the Rendezvous Radar and the Alignment Optical Telescope. | -76.6 | | -320.8 |
| 4. | Reduce battery cell cases to .050 in. thickness - SWIP change LWSS 390A-53. | - 4.0 | -8.0 | -33.8 |
| 5. | Resize LUT dead-face relay for LEM 4 and subsequent due to lower power requirements - SWIP change LWSS 390A-17. | - 1.0 | | - 4.2 |
| 6. | Review and revise the unusable propellant philosophy. | + 1.3 | -98.8 | -205.3 |
| 7. | Estimate weight of cluster heaters (8) based on the latest design. | + .5 | | + 2.1 |
| 8. | Add tank vents in Descent Propulsion system to relieve propellant tank pressure on the Lunar surface due to tank capability limitations. | + 1.3 | +7.0 | + 20.3 |
| 9. | Add heater and associated controls to the descent pressurization system to insure helium flow if propellant system is not pressurized. | + 2.0 | +4.8 | +18.6 |
| 10. | Cant Ascent Engine to reduce lateral distance between Engine thrust vector and vehicle's center of gravity, and thus lessen the RCS Control requirements. | + 7.7 | | +32.2 |

* Inert weight excludes $\Delta V$ Propellant.

Pending Changes - Cont.

| | Estimated Weight Increment | | |
|---|---|---|---|
| | Ascent (Inert*) | Descent (Inert*) | Separation (Effective) |
| 11. Add hat sections and screens to descent and ascent propellant tanks to insure propellant remains in the main feed lines during "0" G operation and prior to Engine Start. | + 6.0 | + 12.0 | +50.7 |
| 12. Incorporate major Propulsion SWIP items: | | | |
| LWSS 270A-8 - Reduce Descent Engine Ablative Material. | | - 12.0 | -25.6 |
| LWSS 270A-47- Supercritical Helium Tank Weight Reduction. | | - 4.5 | - 9.6 |
| 13. Incorporation of the chits, submitted and approved for Critical Design Review (CDR) #1, reflect the following weight changes: | (+19.5) | (+ 19.4) | (+122.9) |
| Structure | + .5 | + 7.4 | + 17.9 |
| Landing Gear | | + 6.3 | + 13.4 |
| Electro-Explosive Devices | + 7.5 | + 2.5 | + 36.7 |
| Stabilization and Control | - | - | |
| Navigation and Guidance | + 3.3 | | + 13.8 |
| Propulsion | + 4.5 | + 3.2 | + 25.6 |
| Reaction Control | + 3.7 | | + 15.5 |
| 14. Incorporation of the chits, submitted and approved for CDR #2, reflect the following weight changes: | (+18.4) | (+ 5.7) | (+ 89.2) |
| Crew Provisions | + 6.0 | + 1.0 | + 27.2 |
| Environmental Control | + .4 | + 3.2 | + 8.5 |
| Instrumentation | + 4.2 | | + 17.6 |
| Electrical Power Supply | + 1.1 | | + 4.6 |
| Communications | - | - | |
| Controls and Displays | + 6.7 | + 1.5 | + 31.3 |
| 15. Apply the required silicone coating to help maintain the proper emissivity values and thus meet the thermal control requirements. | | | |
| Internal Surface of Cabin Area | +10.2 | | + 42.7 |
| Exterior Surface of Thermal Shielding | + .5 | + .5 | + 3.2 |

* Inert weight excludes $\Delta$V Propellant.

Pending Changes - Cont.

| | | Estimated Weight Increment | | |
|---|---|---|---|---|
| | | Ascent (Inert*) | Descent (Inert*) | Separation (Effective) |
| 16. | Cover the Landing Gear Pads with ablative material to protect the pads from the high temperatures, that are expected to be encountered during the landing phase of the mission. | | + 8.4 | + 17.9 |
| 17. | Relocate two descent batteries to alleviate a c.g. problem. This lateral movement of batteries will reduce head differential in Descent Propellant Tanks and thus minimize the unuseable propellant. This reduction in unuseable propellant is in addition to that shown in Pending Change # 6. | | | |
| | Relocation Hardware | | +23.6 | + 50.3 |
| | Reduction in unuseable propellant | | -73.0 | -155.6 |

* Inert weight excludes $\Delta V$ Propellant.

## GOVERNMENT FURNISHED EQUIPMENT

This report incorporates Government Furnished Equipment Current Weights per reference 5. Table 6 is listings of these GFE items and their weights under the following three categories:

| | | |
|---|---|---|
| A. | Items Aboard LEM at Earth Launch | 647.0 pounds |
| B. | Items Transferred to LEM From CSM | 567.7 pounds |
| C. | Items Returned to Lunar Orbit | 927.8 pounds |

The current weights of the MIT equipment remain unchanged from the previous LEM Mass Property Report and MIT Report E 1142 Revision 42, dated March 1966.

The Government Furnished Equipment changes reflected in this report includes a 26 pound increase in scientific equipment at Earth Launch. This results in a 26 pound reduction of the scientific equipment transferred to the LEM from the CSM.

Table 6 includes an electrical umbilical and a LEM/CSM docking receptacle. These added items and a lower drogue weight deviate from reference 5 based on informal discussions with MSC.

Table 6

GOVERNMENT FURNISHED EQUIPMENT - CURRENT WEIGHT

| Code | Item | Qty | Current Weight |
|---|---|---|---|
| A. | Items Aboard LEM At Earth Launch | | 647.0 |
| 14.1 | Structure | | (17.2) |
| 14.1.1 | Drogue | | 17.2 |
| 14.3 | MIT Equipment | | (253.5) |
| 14.3.2 | -IMU Platform (includes integral coolant facilities) | | 42.1 |
| 14.3.3 | -AOT Telescope | | 23.1 |
| 14.3.4 | -LGC Computer | | 65.0 |
| 14.3.5 | -PSA Servo | | 20.6 |
| 14.3.6 | -Harness "A" | | 14.6 |
| 14.3.7 | -Harness "B" | | 4.5 |
| 14.3.8 | -Navigation Base | | 4.0 |
| 14.3.9 | -PTA Torquer | | 14.8 |
| 14.3.10 | -SCEA | | 7.7 |
| 14.3.11 | -CDU Converter | | 37.3 |
| 14.3.12 | -Lens Cleaning Kit | | .3 |
| 14.3.14 | -DSKY Data Storage Key | | 17.5 |
| 14.3.15 | -AOT Button Box | | 2.0 |
| 14.4 | Crew Provisions | | (151.6) |
| 14.4.1.1.1 | EV Gloves | | 1.7 |
| 14.4.1.1.2 | Thermal Meteoroid Garment - Parka and Trousers | | 9.5 |
| 14.4.1.1.3 | -EV Boots | 2 | 8.0 |
| 14.4.1.1.4 | -EV Mittens | | .4 |
| 14.4.1.1.5 | -Helmet and PLSS Cover | | 1.4 |
| 14.4.1.1.6 | EMU Maintenance Kit | | 2.0 |
| 14.4.1.1.7 | Oxygen Waste Fitting | | .2 |
| 14.4.1.1.8 | Water Waste Fitting | | .2 |
| 14.4.1.1.9 | PGA Waste Fitting | | .2 |
| 14.4.1.1.10 | PLSS Condensate Removal Fitting | | .2 |
| 14.4.1.1.11 | Multiple Gas Connector | 4 | 1.2 |
| 14.4.1.1.12 | Multiple Gas Stowage Plate | 2 | .7 |
| 14.4.1.1.13 | Emergency Oxygen Mounting Pads | 2 | .4 |
| 14.4.1.1.14 | Portable Life Support System - Dry | | 50.8 |
| 14.4.1.1.15 | -Battery | | 5.0 |
| 14.4.1.1.16 | -LiOH Cartridge | | 4.0 |
| 14.4.1.1.17 | -Oxygen | | 1.0 |
| 14.4.1.1.18 | -Water | | 7.6 |
| 14.4.1.1.19 | PLSS LiOH Cartridges | 4 | 16.0 |
| 14.4.1.2.1 | Water Probe | | .5 |
| 14.4.1.2.2 | Food | | 8.8 |
| 14.4.1.2.3 | Fecal Gloves | 6 | 1.1 |
| 14.4.1.3.1 | Inflight Tools | | 1.4 |
| 14.4.1.4.1 | Flight Data Kit-Check lists & Experiments Data | | 6.1 |

Table 6 - Cont.

GOVERNMENT FURNISHED EQUIPMENT - CURRENT WEIGHT

| Code | Item | Qty | Current Weight |
|---|---|---|---|
| 14.4 | Crew Provisions - Cont. | | |
| 14.4.1.4.2 | Sequence Camera | | 1.6 |
| 14.4.1.4.4 | -Magazine | | .6 |
| 14.4.1.4.3 | -Lenses | | .5 |
| 14.4.1.6 | Survey Meter Bracket | | .5 |
| 14.4.11.1 | PLSS Batteries | 4 | 20.0 |
| 14.7 | Instrumentation | | (219.0) |
| 14.7.1 | Scientific Equipment - Specimen Return Containers | 2 | 23.0 |
| 14.7.3.1 | Tape and Film Container | | 16.0 |
| 14.7.3.2 | Sequence Camera Extra | | 10.0 |
| 14.7.11.1.1 | Scientific Equipment - Lunar Surface Experiments | | 150.0 |
| 14.7.11.1.2 | -Lunar Tools | | 20.0 |
| 14.8 | Electrical | | (3.2) |
| 14.8.0 | LEM/CSM-Docking Receptacle | | .1 |
| 14.8.1 | -Electrical Umbilical | | 3.1 |
| 14.11 | Communications | | (2.5) |
| 14.11.1.5.1 | Television Camera - Lunar Surface Lens | | .4 |
| 14.11.1.5.2 | -Portable 9-foot cable | | .6 |
| 14.11.1.5.3 | -Connector, Receptacle | | .2 |
| 14.11.1.5.4 | Isolator | | 1.3 |
| B. | Items Transferred to LEM from CSM | | 567.7 |
| 14.4 | Crew Provisions | | (531.6) |
| 14.4.2.0.1 | Crew - Systems Engineer | | 176.0 |
| 14.4.2.0.2 | -Commander | | 176.0 |
| 14.4.2.1.1 | Pressure Garment Assembly - Commander | | 32.9 |
| 14.4.2.1.2 | -Systems Engineer | | 32.9 |
| 14.4.2.1.3 | EV Visors | 2 | 5.0 |
| 14.4.2.1.4 | EV Gloves | | 1.7 |
| 14.4.2.1.5 | Thermal Meteoroid Garment - Parka & Trousers | | 9.5 |
| 14.4.2.1.6 | -EV Mittens | | .4 |
| 14.4.2.1.7 | -Helmet and PLSS Cover | | 1.4 |
| 14.4.2.1.8 | Liquid Cooled Garment - Commander | | 3.9 |
| 14.4.2.1.9 | -Systems Engineer | | 3.9 |
| 14.4.2.1.10 | Helmet Stowage Containers | 2 | 1.0 |
| 14.4.2.1.11 | Portable Life Support System - Dry | | 50.8 |
| 14.4.2.1.12 | -Battery | | 5.0 |
| 14.4.2.1.13 | -LiOH Cartridge | | 4.0 |

Table 6 - Cont.

GOVERNMENT FURNISHED EQUIPMENT - CURRENT WEIGHT

| Code | Item | Qty | Current Weight |
|---|---|---|---|
| 14.4 | Crew Provisions - Cont. | | |
| 14.4.2.1.14 | -Oxygen | | 1.0 |
| 14.4.2.1.15 | -Water | | 7.6 |
| 14.4.2.1.16 | Emergency Oxygen | 2 | 6.0 |
| 14.4.2.2.1 | EV Crew Transfer | | 6.0 |
| 14.4.2.2.2 | Bioinstrumentation | 2 | 2.2 |
| 14.4.2.4.1 | Flight Data Kit - LEM Flight Plan | | .9 |
| 14.4.2.4.2 | Sequence Camera - Magazine | | .6 |
| 14.4.2.6 | Personal Whole Body Dosimeters | | .9 |
| 14.4.2.6.3 | Survey Meter | | 1.8 |
| 14.4.2.6.4 | Passive Dosimeters | | .2 |
| 14.7 | Instrumentation | | (31.0) |
| 14.7.1.1 | Scientific Equipment - Still Camera Package | | 15.0 |
| 14.7.1.2 | -Undefined | | 16.0 |
| 14.8 | Electrical | | (-3.1) |
| 14.8.1 | LEM/CM - Electrical Umbilical | | -3.1 |
| 14.11 | Communications | | (8.2) |
| 14.11.2.5.1 | Television Camera | | 7.2 |
| 14.11.2.5.2 | -Telephoto Lens | | 1.0 |
| C. | Items Returned to Lunar Orbit | | 927.8 |
| 14.1 | Structure | | (17.2) |
| 14.1.1 | Drogue | | 17.2 |
| 14.3 | MIT Equipment | | (253.5) |
| 14.3.2 | -IMU platform (includes integral coolant facilities) | | 42.1 |
| 14.3.3 | -AOT Telescope | | 23.1 |
| 14.3.4 | -LGC Computer | | 65.0 |
| 14.3.5 | -PSA Servo | | 20.6 |
| 14.3.6 | -Harness "A" | | 14.6 |
| 14.3.7 | -Harness "B" | | 4.5 |
| 14.3.8 | -Navigation Base | | 4.0 |
| 14.3.9 | -PTA Torquer | | 14.8 |
| 14.3.10 | -SCEA | | 7.7 |
| 14.3.11 | -CDU Converter | | 37.3 |
| 14.3.12 | -Lens Cleaning Kit | | .3 |
| 14.3.14 | -DSKY Data Storage Key | | 17.5 |
| 14.3.15 | -AOT Button Box | | 2.0 |

Table 6 - Cont.

GOVERNMENT FURNISHED EQUIPMENT - CURRENT WEIGHT - Cont.

| Code | Item | Qty | Current Weight |
|---|---|---|---|
| C. | Items Returned to Lunar Orbit - Cont. | | |
| 14.4 | Crew Provisions | | (566.7) |
| 14.4.1.1.1 | EV Gloves | | 1.7 |
| 14.4.1.1.2 | Thermal Meteoroid Garment - Parka and Trousers | | 9.5 |
| 14.4.1.1.4 | -EV Mittens | | .4 |
| 14.4.1.1.5 | -Helmet and PLSS Cover | | 1.4 |
| 14.4.1.1.7 | Oxygen Waste Fitting | | .2 |
| 14.4.1.1.8 | Water Waste Fitting | | .2 |
| 14.4.1.1.9 | PGA Waste Fitting | | .2 |
| 14.4.1.1.10 | PLSS Condensate Removal Fitting | | .2 |
| 14.4.1.1.11 | Multiple Gas Connector | 4 | 1.2 |
| 14.4.1.1.12 | Multiple Gas Stowage Plate | 2 | .7 |
| 14.4.1.1.13 | Emergency Oxygen - Mounting Pads | 2 | .4 |
| 14.4.1.2.1 | Water Probe | | .5 |
| 14.4.1.2.2 | Food | | 8.8 |
| 14.4.1.2.3 | Fecal Gloves | 6 | 1.1 |
| 14.4.1.3.1 | Inflight Tools | | 1.4 |
| 14.4.1.4.1 | Flight Data Kit - LEM Flight Plan | | .9 |
| 14.4.1.4.2 | Sequence Camera-Magazine | | .6 |
| 14.4.1.6.1 | Survey Meter Bracket | | .5 |
| 14.4.2.0.1 | Crew - Systems Engineer | | 176.0 |
| 14.4.2.0.2 | -Commander | | 176.0 |
| 14.4.2.1.1 | Pressure Garment Assembly - Commander | | 32.9 |
| 14.4.2.1.2 | -Systems Engineer | | 32.9 |
| 14.4.2.1.3 | EV Visors | 2 | 5.0 |
| 14.4.2.1.4 | EV Gloves | | 1.7 |
| 14.4.2.1.5 | Thermal Meteoroid Garment - Parka and Trousers | | 9.5 |
| 14.4.2.1.6 | -EV Mittens | | .4 |
| 14.4.2.1.7 | -Helmet and PLSS Cover | | 1.4 |
| 14.4.2.1.8 | Liquid Cooled Garment - Commander | | 3.9 |
| 14.4.2.1.9 | -Systems Engineer | | 3.9 |
| 14.4.2.1.10 | Helmet Stowage Containers | 2 | 1.0 |
| 14.4.2.1.11 | Portable Life Support System - Dry | | 50.8 |
| 14.4.2.1.12 | -Battery | | 5.0 |
| 14.4.2.1.13 | -LiOH Cartridge | | 4.0 |
| 14.4.2.1.14 | -Oxygen | | 1.0 |
| 14.4.2.1.15 | -Water | | 7.6 |
| 14.4.2.1.16 | Emergency Oxygen | 2 | 6.0 |
| 14.4.2.2.1 | Crew Transfer | | 6.0 |
| 14.4.2.2.2 | Bioinstrumentation | 2 | 2.2 |
| 14.4.2.4.1 | Flight Data Kit - Check lists & Experiments Data | | 6.1 |
| 14.4.2.4.2 | Sequence Camera-Magazine | | .6 |
| 14.4.2.6 | Personal Whole Body Dosimeters | | .9 |
| 14.4.2.6.3 | Survey Meter | | 1.8 |
| 14.4.2.6.4 | Passive Dosimeters | | .2 |

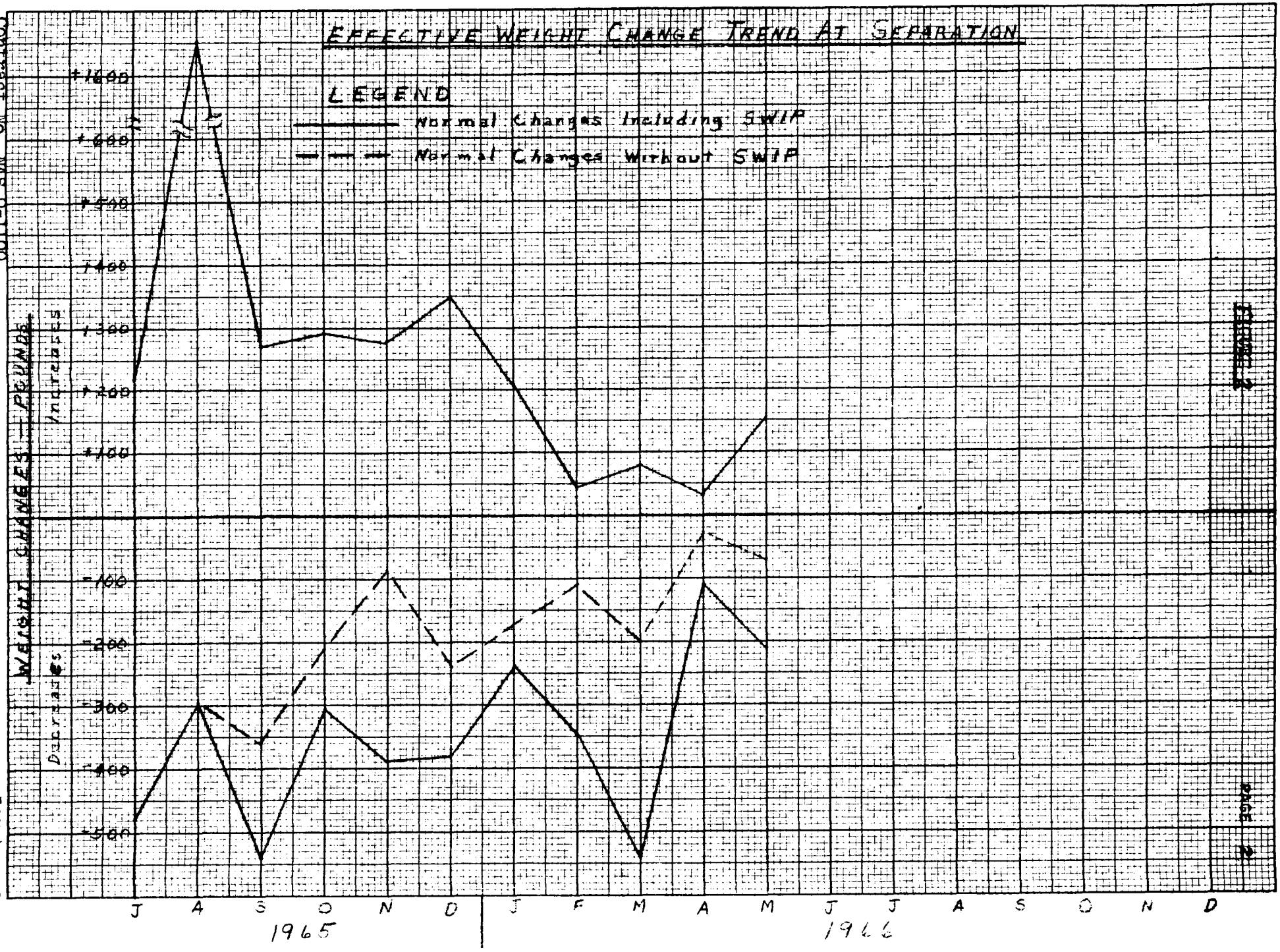
Table 6

GOVERNMENT FURNISHED EQUIPMENT - CURRENT WEIGHT - Cont.

| Code | Item | Qty | Current Weight |
|---|---|---|---|
| 14.7 | Instrumentation | | (80.0) |
| 14.7.1 | Sample Containers | 2 | 23.0 |
| 14.7.1.3 | Scientific Equipment - Lunar Samples | | 31.0 |
| 14.7.2.1 | Tape and Film Container | | 16.0 |
| 14.7.2.2 | Sequence Camera Extra | | 10.0 |
| 14.8 | Electrical | | ( .1) |
| 14.8.0 | LEM/CM-Docking Receptacle | | .1 |
| 14.11 | Communications | | (10.3) |
| 14.11.1.5.2 | Television Camera - Portable 9-foot cable | | .6 |
| 14.11.1.5.3 | -Connector, Receptacle | | .2 |
| 14.11.2.5.1 | -Camera | | 7.2 |
| 14.11.2.5.2 | -Telephoto Lens | | 1.0 |
| 14.11.1.5.4 | Isolator | | 1.3 |

TOTAL GOVERNMENT FURNISHED EQUIPMENT AT SEPARATION = 1214.7 lbs.

TOTAL GOVERNMENT FURNISHED EQUIPMENT RETURNED TO LUNAR ORBIT = 927.8 lbs.


EFFECTIVE WEIGHT CHANGE TREND AT SEPARATION
LEGEND
Normal Changes Including SWIP
Normal Changes Without SWIP
+1600
+1500
+1400
+1300
+1200
+1100
-100
-200
-300
-400
-500
Increases
Decreases
J A S O N D J F M A M J J A S O N D
1965
1966

## LEM -1 STATUS

### CURRENT WEIGHT BREAKDOWN BY STAGES AT EARTH LAUNCH AND COMPARISON WITH CONTROL WEIGHT

| | | WEIGHT | | |
|---|---|---|---|---|
| | | ASCENT | DESCENT | TOTAL |
| 1.0 | Structure | (1304.3) | (1328.8) | (2633.1) |
| | -Ascent | 1304.3 | -- | 1304.3 |
| | -Descent | -- | 1328.8 | 1328.8 |
| 2.0 | Stabilization and Control | 78.7 | 14.2 | 92.9 |
| 3.0 | Navigation and Guidance | 71.3 | 37.8 | 109.1 |
| 4.0 | Crew Provisions | 73.2 | -- | 73.2 |
| 5.0 | Environmental Control | 283.2 | 108.4 | 391.6 |
| 6.0 | Landing Gear | -- | 477.2 | 477.2 |
| 7.0 | Instrumentation | 125.8 | 5.5 | 131.3 |
| 8.0 | Electrical Power Supply | 829.3 | 649.3 | 1478.6 |
| 9.0 | Propulsion | 525.3 | 1096.6 | 1621.9 |
| 10.0 | Reaction Control | 295.7 | -- | 295.7 |
| 11.0 | Communications | 106.2 | 4.5 | 110.7 |
| 12.0 | Controls and Displays | 191.6 | -- | 191.6 |
| 13.0 | Explosive Devices | 14.4 | 34.3 | 48.7 |
| | Hardware- Sub-Total | 3899.0 | 3756.6 | 7655.6 |
| 14.0 | Government Furnished Equipment | 351.3 | -- | 351.3 |
| 15.0 | Liquids and Gases -Excludes Propellant | 118.2 | 322.1 | 440.3 |
| 17.0 | Propellant-Unusable | 188.3 | 473.8 | 662.1 |
| 19.0 | R&D Equipment & Misc. | 643.5 | 286.0 | 929.5 |
| | Inert-Sub-Total(No Useable Propellant) | 5200.3 | 4838.5 | 10038.8 |

Ref. 4 states the control weights for LEM-1 in the Manned and Unmanned condition. A comparison of the Control Weight and the Current Weight for the Unmanned condition is as follows:

| | Control Weight | Current Weight |
|---|---|---|
| Ascent stage inert at Earth Launch | 5540 | 5200.3 |
| Descent stage inert at Earth Launch | 5200 | 4838.5 |
| RCS Propellant | 550* | 540.0 |
| Ascent Main Propellant | 5015* | 5070.0 |
| Descent Main Propellant | 17000* | 17513.0 |
| Total Vehicle - Earth Launch | 33305** | 33161.8** |

* Ref. 4 indicates that the propellant requirements are approximate.

** Design Weight at Earth Launch is 32,000 pounds.

## LEM -2 STATUS

### CURRENT WEIGHT BREAKDOWN BY STAGES AT EARTH LAUNCH AND COMPARISON WITH CONTROL WEIGHT

| | | WEIGHT | | |
|---|---|---|---|---|
| | | ASCENT | DESCENT | TOTAL |
| 1.0 | Structure | (1305.7) | (1293.6) | (2599.3) |
| | -Ascent | 1305.7 | -- | 1305.7 |
| | -Descent | -- | 1293.6 | 1293.6 |
| 2.0 | Stabilization and Control | 78.7 | 14.2 | 92.9 |
| 3.0 | Navigation and Guidance | 71.3 | 37.8 | 109.1 |
| 4.0 | Crew Provisions | 73.2 | -- | 73.2 |
| 5.0 | Environmental Control | 283.2 | 108.4 | 391.6 |
| 6.0 | Landing Gear | -- | 477.2 | 477.2 |
| 7.0 | Instrumentation | 125.8 | 5.5 | 131.3 |
| 8.0 | Electrical Power Supply | 829.3 | 649.3 | 1478.6 |
| 9.0 | Propulsion | 525.3 | 1076.2 | 1601.5 |
| 10.0 | Reaction Control | 295.7 | -- | 295.7 |
| 11.0 | Communications | 106.2 | 4.5 | 110.7 |
| 12.0 | Controls and Displays | 191.6 | -- | 191.6 |
| 13.0 | Explosive Devices | 14.4 | 34.3 | 48.7 |
| | Hardware- Sub-Total | 3900.4 | 3701.0 | 7601.4 |
| 14.0 | Government Furnished Equipment | 388.2 | -- | 388.2 |
| 15.0 | Liquids and Gases -Excludes Propellant | 118.2 | 322.1 | 440.3 |
| 17.0 | Propellant-Unusable | 188.3 | 473.8 | 662.1 |
| 19.0 | R&D Equipment and Miscellaneous | 687.5 | 16.0 | 703.5 |
| | Inert-Sub-Total (No usable Propellant) | 5282.6 | 4512.9 | 9795.5 |

The comparison of the proposed LEM-2 Control Weight and the LEM-2 Current Weight for the manned condition is as follows:

| | Control Weight | Current Weight |
|---|---|---|
| Ascent Stage inert at Earth Launch | 5310 | 5282.6 |
| Descent Stage inert at Earth Launch | 4680 | 4512.9 |
| RCS Propellant | 540* | 540.0 |
| Ascent Main Propellant | 5090* | 5070.0 |
| Descent Main Propellant | 17355* | 17513.0 |
| Total Vehicle - Earth Launch | 32975** | 32918.5** |

* Propellant requirements are approximate.
** Design Weight at Earth Launch is 32,000 pounds.

## LEM-3 STATUS

### CURRENT WEIGHT BREAKDOWN BY STAGES AT EARTH LAUNCH AND COMPARISON WITH CONTROL WEIGHT

| | | WEIGHT | | |
|---|---|---|---|---|
| | | ASCENT | DESCENT | TOTAL |
| 1.0 | Structure | (1183.0) | (1293.6) | (2476.6) |
| | -Ascent | 1183.0 | -- | 1183.0 |
| | -Descent | -- | 1293.6 | 1293.6 |
| 2.0 | Stabilization and Control | 78.7 | 14.2 | 92.9 |
| 3.0 | Navigation and Guidance | 71.3 | 37.8 | 109.1 |
| 4.0 | Crew Provisions | 73.2 | -- | 73.2 |
| 5.0 | Environmental Control | 283.5 | 108.4 | 391.9 |
| 6.0 | Landing Gear | -- | 477.2 | 477.2 |
| 7.0 | Instrumentation | 125.8 | 5.5 | 131.3 |
| 8.0 | Electrical Power Supply | 829.3 | 649.3 | 1478.6 |
| 9.0 | Propulsion | 524.6 | 1076.2 | 1600.8 |
| 10.0 | Reaction Control | 280.2 | -- | 280.2 |
| 11.0 | Communications | 106.2 | 4.5 | 110.7 |
| 12.0 | Controls and Displays | 191.6 | -- | 191.6 |
| 13.0 | Explosive Devices | 14.4 | 34.3 | 48.7 |
| | Hardware- Sub-Total | 3761.8 | 3701.0 | 7462.8 |
| 14.0 | Government Furnished Equipment | 397.0 | 20.0 | 417.0 |
| 15.0 | Liquids and Gases -Excludes Propellant | 118.2 | 322.1 | 440.3 |
| 17.0 | Propellant - Unusable | 188.3 | 473.8 | 662.1 |
| 19.0 | R&D Equipment and Miscellaneous | 467.5 | 16.0 | 483.5 |
| | Inert-Sub-Total (No usable Propellant) | 4932.8 | 4532.9 | 9465.7 |

The comparison of the proposed LEM-3 Control Weight and the LEM-3 Current Weight for the manned condition is as follows:

| | Control Weight | Current Weight |
|---|---|---|
| Ascent Stage inert at Earth Launch | 5225 | 4932.8 |
| Descent Stage inert at Earth Launch | 4845 | 4532.9 |
| RCS Propellant | 540* | 540.0 |
| Ascent Main Propellant | 5090* | 5070.0 |
| Descent Main Propellant | 17585* | 17513.0 |
| Total Vehicle - Earth Launch | 33285** | 32588.7** |

* Propellant requirements are approximate.

** Design Weight at Earth Launch is 32,000 pounds.

## LIST OF REFERENCES


1. MSC letter PL2-13-64-571, dated 26 October 1964, "Contract NAS 9-1100, Transmittal of the Apollo Lunar Landing Design Reference Mission Trajectory."

2. MSC letter PP6-13-64-646, dated 20 November 1964, "Contract NAS 9-1100, LEM Weight Report."

3. MSC letter PL2-13-77/13-64-704, dated 14 December 1964, "Contract NAS 9-1100, Resolution of M-5 Mockup Review Chits 1-16 and 1-20."

4. MSC letter PS5/L231-13-65-1077, dated 9 December 1965, "Contract NAS 9-1100, Control Weights for LEM-1 (U)."

5. MSC letter PD3/L3004-13-66-211, dated 24 March 1966, "Contract NAS 9-1100, Current and Specification Weights of GFE."

6. LED-490-23, dated 1 August 1965, "LEM Mass Property Report (U)."

7. LSR-490-31, dated 1 April 1966, "LEM Mass Property Report (U)."

8. LED-490-100 Revision B, Re-issued 15 February 1965, Allocation of Propellants and $\Delta V$ to Meet the $\Delta V$ Budget."

9. LAV-500-155, dated 6 July 1965, "Required $\Delta V$ for Abort Using the Ascent Engine."

10. LMO-280-97, dated 7 February 1966, "Required Revisions To Vehicle Structure For Increased Landing Loads."

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13. LMO-500-352, dated 6 December 1965, "Estimated RCS Propellant Required for LEM Attitude Maneuvers and Control for a Typical Lunar Mission."

14. LMU-340-50025, dated 25 September 1964, Inboard Profile.

15. LDW-280-10050, Revision E, dated 26 May 1965, "Geometry Ascent Stage -2 Tank" Drawing.

16. LDW-280-17000, Revision C, dated 17 June 1965, "General Arrangement Descent Stage" Drawing.

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# APPENDIX A

## SWIP ITEMS INCORPORATED IN WEIGHT REPORTS

A breakdown of the SWIP items incorporated to date in the LEM Weight Report is as follows:

| LWSS Number | SWIP Items | Inert Weight By Stage Ascent | Inert Weight By Stage Descent | Effective Weight |
|---|---|---|---|---|
| | LED-490-25 Scrape Effort | -22.1 | | -93.0 |
| | LED-490-26 Scrape Effort | -62.2 | -12.5 | -288.2 |
| | LED-490-27 Scrape Effort | -13.9 | - 8.8 | -77.3 |
| | LED-490-28 Scrape Effort | - 8.7 | - 9.2 | -56.1 |
| | LED-490-29 Scrape Effort | - 4.6 | -26.6 | -76.0 |
| | LED-490-30 Scrape Effort | | - 8.8 | -18.8 |
| | LSR-490-31 Scrape Effort | - 5.5 | -21.6 | -69.1 |
| | LSR-490-32 Scrape Effort | - 3.4 | -17.0 | -50.5 |
| 270A-5(b) | Aluminum in lieu of Steel Diffusers. | - .7 | - .6 | - 4.2 |
| 270A-40 | Scrape of Ascent Engine | - 2.9 | | -12.1 |
| 270A-46 | Scrape of Descent Engine | | -11.4 | -24.3 |
| 270B-8 | Remove redundancy of helium pressurization regulators. | | - 4.0 | - 8.5 |
| 270B-16 | Delete baffles in LEM propellant tanks. | - 8.8 | -38.0 | -146.8 |
| 280A-20 | Trim excess weight on cold plates in aft equipment bays. | - 1.6 | | - 6.7 |
| 280A-53 | Optimize Descent Propellant Tanks | | -20.0 | -42.6 |
| 280A-58 | Re-arrange equipment on aft rack to eliminate ECA overhang and shorten wire runs. | - 1.0 | | - 4.2 |
| 310B-1 | Removal of redundant RCS pressurization components. | -13.1 | | -54.9 |
| 310B-2 | Reduction in safety factor on RCS pressurization bottles from 2.0 to 1.5. | - 5.4 | | -22.6 |
| 310B-6 | Delete latching solenoid valve from two RCS helium pressurization systems. | - 4.4 | | -18.5 |

## APPENDIX A

### SWIP ITEMS INCORPORATED IN WEIGHT REPORTS - Cont.

| LWSS Number | SWIP Items | Inert Weight By Stage Ascent | Inert Weight By Stage Descent | Effective Weight |
|---|---|---|---|---|
| 320A-10 | Replace compression deployment spring and surrounding can with curved leaf spring. (Descent Corner Post portion - * This 1.6 pounds was reported as scrape effort in LED-490-29.) | | - 1.6 | - 3.4 |
| 340B-5 | Reduce weight of GFE thermal/meteoroid garment. | -11.0 | | -46.3 |
| 360A-2 | Optimize Data Storage Electronics Assembly. | - .1 | | - .4 |
| 360A-3 | Optimize Caution and Warning Electronics Assembly. | - .5 | | - 2.1 |
| 360A-5 | Optimize Signal Conditioner Electronics Assembly. | -10.6 | | -44.3 |
| 360B-2 | Optimize Pulse Code Modulation and Timing Electronics Assembly. | -14.3 | | -59.9 |
| 370A-2 | Eliminate stroke adjustment on gimbal drive actuator. | | - .4 | - .8 |
| 380A-11 | Scrape of Steerable Antenna | - 3.8 | | -15.9 |
| 380B-2 | Delete 80-foot cable for use of external TV. Also delete tripod and 10-inch cable. | - 1.3 | - 3.0 | -10.2 |
| 390A-21 | Reduce functional requirements of lighting control assembly. | - 9.0 | | -37.6 |
| 390A-52 | Optimize General Purpose Inverter | - .8 | | - 3.3 |
| 390B-2 | Single Wire Electrical System using LEM Structure as ground. | -14.8 | | -62.0 |
| 390B-12 (Phase 2) | Eliminate automatic switchover circuitry for ECS glycol pumps. | - 1.5 | | - 6.3 |
| 510A-1 | Replace thermal paint with etched surface treatment on thermal shields. | -24.0 | -24.0 | -150.0 |

## APPENDIX A

### SWIP ITEMS INCORPORATED IN WEIGHT REPORTS - Cont.

| LWSS Number | SWIP Items | Inert Weight By Stage Ascent | Inert Weight By Stage Descent | Effective Weight |
|---|---|---|---|---|
| 520B-1 | Landing Velocity envelope reduction to: 10-7-4 Design. | | -26.6 | -56.7 |
| 540B-2 | Eliminate Delta V indicator. | - 1.8 | | - 7.5 |
| | INCORPORATED SWIP CHANGES - Total Weight | -251.8 | -234.1 | -1581.1 |