NASA CONTRACTOR
REPORT

NASA CR-61386

SKYLAB EXPERIMENT PERFORMANCE EVALUATION MANUAL

Appendix S: Experiment T027 Contamination Measurement Sample Array (MSFC)

By B. B. Tonetti
Teledyne Brown Engineering Company
Huntsville, Alabama

January 1973

Prepared for

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-61386		

TITLE AND SUBTITLE	5. REPORT DATE
Skylab Experiment Performance Evaluation Manual. Appendix S: Experiment T027 Contamination Measurement Sample Array (MSFC)	January 1973
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT #
B. B. Tonetti	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Teledyne Brown Engineering Company Huntsville, Alabama	11. CONTRACT OR GRANT NO. NAS8-21804
	13. TYPE OF REPORT & PERIOD COVERED Contractor Report

12. SPONSORING AGENCY NAME AND ADDRESS	14. SPONSORING AGENCY CODE
National Aeronautics and Space Administration Washington, D. C. 20546	

15. SUPPLEMENTARY NOTES

Prepared for Astronautics Laboratory, Science and Engineering

16. ABSTRACT

This appendix contains a series of analyses for Experiment T027, Contamination Measurement Sample Array (MSFC), to be used for evaluating the performance of the Skylab corollary experiments under preflight, inflight, and post-flight conditions. Experiment contingency plan workaround procedure and malfunction analyses are presented in order to assist in making the experiment operationally successful.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Skylab Experiments	Unclassified - Unlimited William Eisen

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	~~100~~ 102	5.75 ~~NTIS~~

MSFC - Form 3292 (May 1969)

APPENDIX S. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY (MSFC)

Prepared By:

B. B. Tonetti

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

DEFINITION OF SYMBOLS

Symbol	Definition
AM	Airlock Module
CCU	Crewman Communications Umbilical
CHAN	Channel
Cur	Current
Exp	Experiment
FBD	Functional Block Diagram
FO	Functional Objective
Freq	Frequency
ICOM/PTT	Intercommunications/Push To Talk
Info	Information
Mbal	Microbalance
OA	Orbital Assembly
OWS	Orbital Workshop
PATK	Portable Astronaut Tool Kit
PDCS	Power Distribution Control System
P_f	Probability of Failure
P_{f_n}	Net Probability of Failure
P_{f_t}	Total Probability of Failure
PI	Principal Investigator
Platf	Platform

DEFINITION OF SYMBOLS (Continued)

Symbol	Definition
P_s	Probability of Success
QCM	Quartz Crystal Microbalance
Qty	Quantity
Qtz	Quartz
SA	Sample Array
SAC	Sample Array Canister
SAL	Scientific Airlock
SAS	Sample Array System
SC	Storage Container
S/I	Speaker/Intercom
TBD	To Be Determined
TBS	To Be Supplied
Xtal	Crystal

SECTION I.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 1 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER*	REMARKS
	MIN.	NOM.	MAX.		
3.0 Analyze and predict facet Performance Profile for Skylab Experiment T-027, Sample Array.				N/A	Refer to functional item 3.1.
3.1 Make explicit statements about objectives in qualitative and quantitative terms.				N/A	Refer to functional item 3.1.1.
3.1.1 Specify duration that the experiment is required to operate and provide useful information.				N/A	The Sample Array System (SAS) will be exposed to the space environment for 5 days. A total of 248 Samples are used, and 95 of these are exposed continuously for 5 days. Seventy-eight samples are placed on three rings located on the lower carrousel and are exposed as follows: • 1 sample is exposed on each of two rings for each 1-hr interval during the first 25 hr for a total of 50 samples. • 24 samples are exposed on the outer ring for 2-hr intervals during the first 25 hr. • 2 samples from the two inner rings and 2 samples on the outer ring are exposed for approximately 5 days. (Total of 4 samples) 30 samples are placed in the upper carrousel and 5 of these are exposed for 24 hr on 5 consecutive days. Five samples in the upper carrousel will be exposed for approximately 20 hr. Forty-five samples are placed internally in the rear section of the T-027 canister as control samples.

*Criticality Category Number Definition:

- Category I--Experiment and equipment whose failure could adversely affect crew safety.
- Category II--Experiment and equipment whose failure could result in not achieving a primary mission objective, but does not adversely affect crew safety.
- Category IIIa--Experiment and equipment whose failure could result in not achieving a secondary mission objective, but which does not adversely affect crew safety or preclude the achievement of any primary mission objective.
- Category IIIb--Experiment and equipment whose failure could not result in a loss of primary or secondary mission objectives and does not adversely affect crew safety.

S&E-ASTN-OT(6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 2 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.1.2 Specify the types of criteria that are to be maximized or minimized.				N/A	The Functional Objective (FO) for the SAS is: • FO-1: Deploy, expose, retrieve, and return the sample array (SA). References 1, 2, and 4.
3.1.3 Specify the percentage of acceptable max./min. for each objective.	Upper Carrousel 18.75%	21.875%	25%	N/A	If Experiment T-027 operations are accomplished as scheduled, FO-1 is maximized at 100 percent. However, if the experiment's performance is compromised, it should not be degraded below 75 percent of planned activities. This value represents an arbitrary completion of 75 percent of the T-027 experiment's objective.
	Lower Carrousel 37.5%	43.75%	50%		
	Other Exposed Samples 18.75%	21.875%	25%		
	Total 75%	87.5%	100%		
3.1.4 Specify the experiment constraints: • Musts • Must Nots • Wants • Don't Wants.				N/A	• Musts --The SAS must be deployed from the solar Scientific Airlock (SAL), and remain deployed for 5 consecutive days. --The internal valve actuator knob must be reinstalled prior to repressurizing the SAL. --The black stripe on the extension rod must be aligned with the green rivet on the latch assembly during extension and retraction. --Experiments T-025, Coronagraph Contamination Measurements; S-149, Particle Collection; S-020, X-Ray/Ultraviolet Solar Photography; S-063, Ultraviolet Horizon Photography; T-027/S-073 Contamination Measurement Photometer and Gegenschein/Zodiacal Light and external color TV must also use the solar SAL. No two experiments can be scheduled concurrently at this SAL. --The sample array canister (SAC) end cover plates and storage container (SC) must be vacuum evacuated after completing the experiment. --Required telemetry measurements must be recorded for subsequent playback and transmission to the ground. • Must Nots --The SAC must not be opened at anytime by ground personnel, other than the Principal Investigator (PI) or his authorized representative. --Experiments M-509, Astronaut Maneuvering Equipment; T-013, Crew/Vehicle Disturbance; and T-020, Foot Controlled Maneuvering Unit must not be operated when the SAS is installed.

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 3 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.1.4 (Concluded)					• Wants --Voice comments will be made and time correlated for all preparation, operation, and post-operation tasks pertinent to T-027 experiment. • Don't Wants --N/A References 1, 2, and 5.
3.1.5 Specify the experiment operational tolerances: • Must • Must Nots • Wants • Don't Wants.				N/A	Refer to functional item 3.1.4.
3.2 Define decision rules and success criteria for the experiment objectives.	3 days	5 days 20 hr	≈6 days	N/A	If the experiment is aborted, the probability of success (P_S) is equal to 0.0. If the experiment is compromised and minimum information is salvaged, P_S = 0.1→ 0.5; if the maximum information is salvaged, P_S = 0.5→ 0.9. If the experiment is completed as scheduled, P_S = 1.0. The sample array will be deployed through the solar SAL and exposed to the space environment for approximately 6 days. All samples are planned to be returned to the Orbital Workshop (OWS) before the start of the sixth day. It is planned that the sample array will be deployed from the solar SAL, as soon as possible, after the initial performance of Experiment T-027/S-073. Experiment T-027 deployment is expected to occur on mission day 125 at GMT 19:00 hr, automatically shut down after 120 hr of operation, and remain exposed for an additional ≈19.5 hr. References 1, 2, 4, and 5.
3.3 Specify experiment priority (numercial statement) for a given Skylab flight designation.				N/A	Experiment T-027 is scheduled for SL-1/SL-2 and assigned a flight priority number of 170. References 6 and 7.

S&E-ASTN-OT(6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 4 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.4 Briefly describe and list the major subsystems for Experiment T-027.				N/A	Refer to functional items 3.4.1 and 3.4.2.
3.4.1 Describe the major functions.				N/A	The T-027 SAS is designed to measure the change in optical properties of various transmissive windows, mirrors, and diffraction gratings due to the deposition of contaminants found about the Orbital Assembly (OA). Once deployed and activated, the SAC lower and upper carrousels automatically expose 108 samples to the space environment for predetermined time intervals by the use of logic timing circuitry and electrically driven stepping motors. Located on the exterior of the upper carrousel, lower carrousel, post, and box are 95 samples that are exposed to the space environment for the entire period of SAS deployment. When the carrousels are retracted into the SAC, all samples are protected from the OWS environment by an internal seal at the SAL interface end. The samples are further isolated from the OWS environment by placing the SAC in the SC. The SC is returned to earth in the Command Module (CM) upon completion of SL-2. References 1, 2, 3, and 4.
3.4.2 List the major components.				N/A	The major subsystem components are: • Sample Array Canister (SAC) • Sample Array (SA) • Storage Container (SC). References 1, 3, and 4.
3.5 Define the T-027 experiment/carrier subsystem interface: • Physical --Mechanical --Electrical --Communications and data --Support • Environmental --Natural and Induced --Contamination				N/A	A Functional Block Diagram (FBD) is submitted as Figure R-1, and provides a subsystem component listing. Critical subsystem components will be identified, evaluated for failure, and correlated to possible experiment/carrier interface problems. References 1 and 3.

S&E-ASTN-OT(6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 5 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5 (Concluded) • Operational --Pointing and Control --Crew Safety --Sequence --Operability					
3.5.1 Sample Array Canister				N/A	Refer to functional item 3.5.1.1.
3.5.1.1 Forward Section				N/A	Refer to functional item 3.5.1.1.1.
3.5.1.1.1 Specify the total probability of failure (Pf_t) for the end plate.		nil		IIIb	Two end plates, one on each end, are attached to the SAC. The end plates provide a vacuum seal seat that protects the samples from contamination by earth atmosphere and OWS internal atmospheric environments. By depressing a vacuum pressure valve located on each end plate, the pressure can be equalized between the canister and end plate. The vacuum valves are also used to evacuate the above cavities after experiment completion. A SAL vacuum flex hose assembly is connected to the vacuum pressure valves and allowed to vent overboard the OWS. The probability of failure (Pf) for an end plate is considered remote. If an end plate should fail, the following situations could occur: • Mechanical --If the Viton seals on the SAC flange are damaged, the end plate cannot be expected to provide a positive seat for sealing. A vacuum cannot be pulled if the end plate is unseated.
		nil			• Contamination --Degradation of the control samples is possible, but not likely, because other seals are internal to the canister assembly.
		nil			• Operability --If the end plates are not properly aligned to the canister flanges and positively sealed, evacuation of the canister and end plate cavities cannot be accomplished.

S&E-ASTN-OT (6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 6 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.1.1 (Concluded)					The following indications can be used to determine the failure of an end plate: • An end plate can be removed after unlocking the roller blocks, without equalizing the cavity pressure between the canister and the end plate using the vacuum pressure valve. However, this is not considered a normal operating procedure, but only a check for vacuum seal fidelity. The vacuum pressure valve on the end plate would normally be depressed to equalize the cavity pressure before removing the end plate from the canister assembly. • An audible hissing sound at the end plates and canister flange interfaces may be detected when evacuating the canister end sections. • A ground inspection of the samples to determine contaminant deposition can be accomplished by the PI only. References 1, 3, 8, 9, 10, 11, 12, 13, and 14.
3.5.1.1.2 Specify the P_{f_t} for the control samples.		nil		IIIa	There are 45 control samples located on the inside of the rear section of the SAC. A set of sliding plates automatically covers about half of these samples when the SA assembly is deployed. When the SA is retracted, all the control samples are exposed to the internal canister environment. The P_f for the control samples is considered remote. If the control sample cover mechanism should fail, the following situation could occur: • Data --Loss of control sample fidelity (caused by contamination) due to seal leakage or mechanical failure of control sample cover mechanism. The following indication can be used to determine the failure of the control samples: • Refer to functional item 3.5.1.1.1. References 1, 3, 8, 11, and 15.
3.5.1.1.3 Specify the P_{f_t} for the canister internal flange seal.		nil		IIIa	The SAC internal flange seal protects the control samples in the rear of the forward section of the canister. The internal flange seal mates against the forward rim of the upper carrousel assembly. The forward rim has a Viton seal that butts against the internal flange. The P_f for the above seal is considered remote. If the canister internal flange and seal should fail, the following situation could occur:

S&E-ASTN-OT (6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 7 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.1.3 (Concluded)					• Contamination --Contamination of the samples is possible but not likely, because the end plates offer protection. The following indication can be used to determine the failure of the internal flange and seal. • Refer to functional item 3.5.1.1.1. References 11 and 12.
3.5.1.1.4 Specify the P_{f_t} for the canister external flange seal.		nil		II	The SAC external flange uses Viton elastomer seals to ensure a leak tight interface with the SAL experiment mounting face. The leak rate between these two surfaces should not exceed 5.9×10^{-2} STD cc/sec gaseous oxygen at 5 psid when the temperature is $70 \pm 5^{\circ}$F. The SAL locking mechanism uses positive action roller cams to align and seat the SAC interface flange. This type of design evenly distributes the bearing flange loads. The P_f for the flange is considered remote. If the SAC external flange should fail, the following situation could occur: • Mechanical --Excessive leakage of the OWS atmosphere out of the SAL could result in the termination of the experiment. This situation would probably be caused by seal failure. The following indication can be used to determine the failure of the canister's external flange: • An audible hissing sound at the SAL and SAC external flange interface may be detected. References 1, 3, 8, 11, and 12.
3.5.1.1.5 Determine the P_{f_t} of interference between the extension mechanism and the OWS micrometeorite shield during sample array deployment.		nil		II	If the OWS micrometeorite shield is not deployed on the solar side, the SA cannot be deployed. The probability of micrometeorite shield failure, however, is considered remote. References 3, 10, 11, and 12.

S&E-ASTN-OT(6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 8 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.1.5.1 Specify the net probability of failure (P_{f_n}) and the P_{f_t} for the anti-rotation assembly.	$P_{f_t} = 0.2$	$P_{f_t} = 0.3$	$P_{f_t} = 0.4$	II	The anti-rotation assembly is designed to inhibit the rotation of the SA with respect to the canister. This device uses links, guides, swivels, and other attaching hardware to form a retractable alignment mechanism that not only inhibits rotational movement, but also deploys, supports, and retracts the electrical cable to the SAC electrical systems. The P_f for the anti-rotation assembly is considered moderate. If the assembly should hang up or fail during deployment or retrieval of the SA the experiment's FO would be seriously jeopardized. The following situations could occur:
	$P_{f_n} = 0.075$	$P_{f_n} = 0.112$	$P_{f_n} = 0.15$		• Mechanical --It is possible to rotationally warp the anti-rotation assembly $\simeq 15°$ either side of the SA radial centerline; thereby causing the SA to be misaligned with the SAC. If this occurs while the upper and lower SA's straddle the forward canister sealing flanges, it is possible to preclude the deployment or retraction of the SA.
	$P_{f_n} = 0.1$	$P_{f_n} = 0.15$	$P_{f_n} = 0.2$		• Natural Environment --Close tolerance fits among links, guides, and swivels could be several affected by the external environment. Cold temperatures could cause surface binding among moving components; hot temperatures could induce excessive expansion of close iftted components and thereby induce warpage of the links or galling of bearing points. In either of the abofe cases the environmental conditions could cause the antirotation assembly to operationally hang up. If this situation occurs, the SA assembly would probably be ejected from the SAL and a significant part of the experiment lost.
	$P_{f_n} = 0.025$	$P_{f_n} = 0.038$	$P_{f_n} = 0.05$		• Operability --If the SA cannot be ejected because of a hangup of the anti-rotation assembly, internal to the canister, all other experiments that use or are constrained by the solar SAL (3.1.4) could not be performed. The following indications can be used to determine the failure of the anti-rotation assembly:

S&E-ASTN-OT(6-71)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 9 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.1.5.1 (Concluded)					• The crew member should deploy and retract the SA by carefully aligning the black stripe on the extension rod with the black rivet (12:00 o'clock) located on the slide housing of the canister control panel. If the rod is not properly indexed with the rivet, twist the rod in the appropriate direction and visually align. • When either extending or retracting the SA, stiffness, binding, and excessive scissor-action link coupling is encountered. A crew member would experience difficulty in pushing or pulling the extension rod. References 1, 3, 8, 9, 11, 16, and 17.
3.5.1.1.5.2 Specify the Pf_t for the extension rod.		0.20		II	The SA is deployed and retracted by manually pushing and retracting an extension rod. Because the anti-rotational assembly does not prevent complete rotation of the SA, care must be exercised when retracting the SA into the SAC. The crew must ensure the proper return alignment of the samples into the canister. During retraction, the extension rod must be properly indexed by aligning the black stripe on the extension rod with the black index rivet on the control panel. The Pf for the extension rod is considered small. If the extension rod should fail, the following situation could occur: • Operability --Refer to functional item 3.5.1.1.5.1. The following indication can be used to determine the failure of the extension rod: • Unable to extend or retract the SA. References 1, 3, 8, 9, 11, and 18.
3.5.1.2.2.1 Specify the Pf_t for the power switch.		nil		II	A power switch (S2) is located on the control panel at the rear section of the SAC. Switch S2 controls power input to the SAC from the SAL utility outlet panel 518. This switch allows the electronics to warm up before the logic circuit start switch (S1) is operated. The power switch also provides power to the two quartz crystal microbalances (QCM's).

MSFC - One Time Form 17 (March 1972)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 10 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.2.2.1 (Concluded)					The Pf for the power switch is considered remote. If the power switch should fail, the following situations could occur: • Electrical --The carrousel stepping motors B1 and B2 and timing logic cannot be operated if the S2 switch function is inoperative. • Data --Loss of predetermined exposure times for samples in the upper and lower carrousels could occur. However, part of the experiment could still be performed to obtain contamination information on those samples located external to the SA. The following indication can be used to determine the failure of power switch S2: • No upper or lower carrousel information, or QCM telemetry data will be found on the tape recorders after initiating START of the experiment using start switch S1. References 1, 3, 8, 9, 10, 11, 19, 20, 21, 22, 23, and 24.
3.5.1.2.2.2 Specify the Pf_t for the start switch.		nil		II	The start switch (S1) activates the timing and logic circuits that control the rotation of the upper and lower carrousel rings and permits 28 Vdc to be delivered to the QCM's. The Pf for the start switch is considered remote. If the program start switch should fail, the following situations could occur: • Electrical --Refer to functional item 3.5.1.2.2.1. • Data --Refer to functional item 3.5.1.2.2.1. The following indication can be used to determine the failure of the program start switch (S1): • No upper or lower carrousel telemetry. (QCM telemetry nominal) References 1, 3, 8, 9, 10, 11, 19, 20, 21, 22, 23, and 24.
3.5.1.2.2.5 Specify the Pf_t for the array valve actuator.		nil		II	The array valve actuator controls the rotation of the upper carrousel window valve. As the array valve actuator is removed from the control panel, the upper carrousel valve simultaneously rotates and extends to expose 4 sample windows in the upper carrousel. The array valve actuator must be removed before the extension rod can be inserted into the SA control panel, and the array deployed.

MSFC - One Time Form 17 (March 1972)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 11 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.2.2.5 (Concluded)					The P_f for the array valve actuator is considered remote. If the above assembly valve actuator should fail, the following situation could occur: • Operability --If the array valve actuator could not be removed, the SA could not be extended and the experiment would be terminated and removed from the SAL. The following indication can be used to determine the failure of the array valve actuator: • Physically unable to remove the array valve actuator from the control panel. References 1, 3, 8, 11, and 25.
3.5.1.2.3.1 Specify the P_{f_t} for the timing logic.		0.2		II	The timing logic provides the signals for rotating the sample rings in the upper and lower carrousels. The timing logic is basically composed of a clock oscillator, counters, and dividers that provide the 1/hr signals for 26 hr and the 1/day signals for 5 days. If the timing logic loses power for any length of time during this first 24 hr of experiment operation, the experiment must be restarted to unscramble the timing logic circuits. This is accomplished by turning the power switch off for approximately 1 min; power switch back to on; and start switch to on. The P_f for the timing logic is considered to be small. If the timing logic should fail, the following situation could occur: • Operability --The sample rings may not rotate, or not rotate according to the predetermined sequence. The following indications can be used to determine the failure of the timing logic: • There may be no event output telemetry signal, or the telemetry signal may be in error. • The lower carrousel will step each time the power is disconnected from the timing logic, or at the power switch (S2), and the start switch (S1) is recycled to the ON position. References 1, 3, 8, 9, 10, 11, 19, 20, 21, 22, 23, and 24.
3.5.1.2.3.2 Specify the P_{f_t} for the power supply.		nil		II	The power supply provides 28 Vdc to the upper and lower carrousel stepping motors, 2 QCM's, and a 5 Vdc stepdown power supply for the timing logic. A preamplifer and stepdown transformer of the power supply provide regulated dc voltage to 2 chopper subassemblies. The chopper subassemblies input regulated Vdc and output Vac to an output filter. The output filter converts the Vac back into 28 Vdc and 5 Vdc.

MSFC - One Time Form 17 (March 1972)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 12 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1.2.3.2 (Concluded)					The P_f for the power supply is considered remote. If the power supply should fail, the following situations could occur: • Electrical --The stepping motors (B1 and B2) will not drive the upper and lower carrousel. • Data --The sample rings would not rotate as planned and no QCM output would be received. The following indication can be used to determine the failure of the power supply: • No QCM or carrousel telemetry signals are received from the Airlock Module (AM) tape recording dumps. The experiment would continue in a degraded mode. References 1, 3, 8, 11, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, and 31.
3.5.2.1.2 and 3.5.2.3.1 Specify the P_{f_t} for the carrousel stepping motors.	24 Vdc	nil 28 Vdc Standby Power 7.5 W Average Power 8.0 W Peak Power 28.00 W Total Power 960 W-hr	30 Vdc	II	Each upper and lower carrousel contains a stepping motor that rotates the experiment samples in front of the carrousel windows. The stepping motors receive power from the SA power supply, and are controlled by the timing logic in the electronics compartment. The P_f for the stepping motors is considered insignificant. If the stepping motors should fail, the following situation could occur: • Data --The samples in the upper and/or lower carrousel would not be rotated and exposed as planned. The experiment would continue in a degraded mode. The following indications can be used to determine the failure of the stepping motors: • Examination of the carrousel samples by the PI. • Telemetry signals from the timing logic will continue to read correctly if a stepping motor fails. The timing logic telemetry is, therefore, an indication and not evidence of actual stepping motor actuation. • There is no way that the flight crew or ground crew can monitor stepping motor failure when the SA is deployed. References 1, 3, 8, 11, 19, 20, 21, 22, 23, and 24.

MSFC - One Time Form 17 (March 1972)

TABLE S-I. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 13 of 13)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.2.1.5 Specify the P_{f_t} for the quartz crystal microbalance.		0.5		III	There are 2 QCM's, attached to the upper SA assembly, that read contamination buildup: QCM-1 is assigned to read contamination buildup in the orbital plane of the OA; and QCM-2 is assigned to read contamination buildup perpendicular to the orbital plane of the OA. The P_f for the QCM's is indefinite beacuse this instrumentation is relatively new and has not been fully proven to be reliable for Skylab contamination measurement activity. If the QCM's should fail, the following situation could occur: • Electrical --If the 28 Vdc power supply fails or becomes unstable, the QCM's will either fail or input erroneous readings into the telemetry. The following indication can be used to determine the failure of the QCM's: • The thermistors and/or the sensors analog telemetry readout information will not be transmitted if an open circuit occurs. References 1, 3, 8, 11, 22, 24, and 32.

MSFC - One Time Form 17 (March 1972)

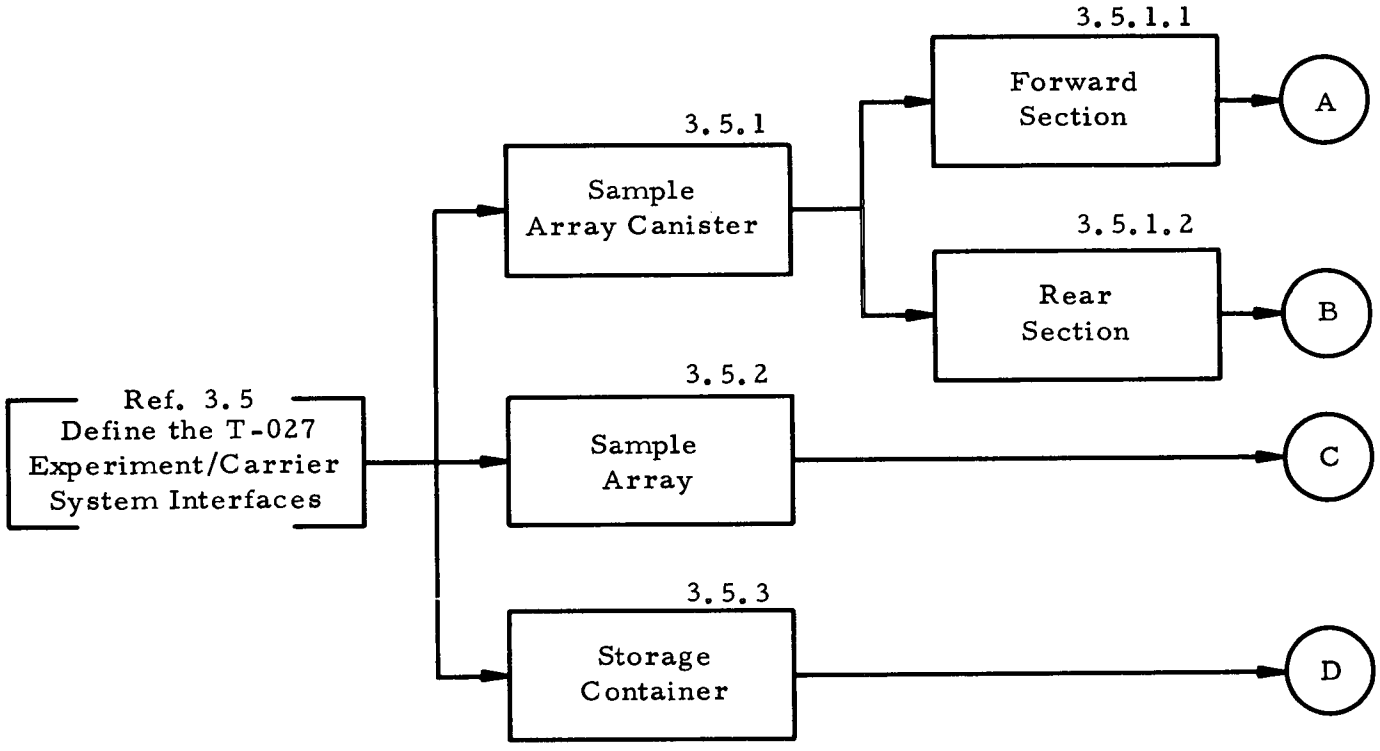


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM (Sheet 1 of 7)

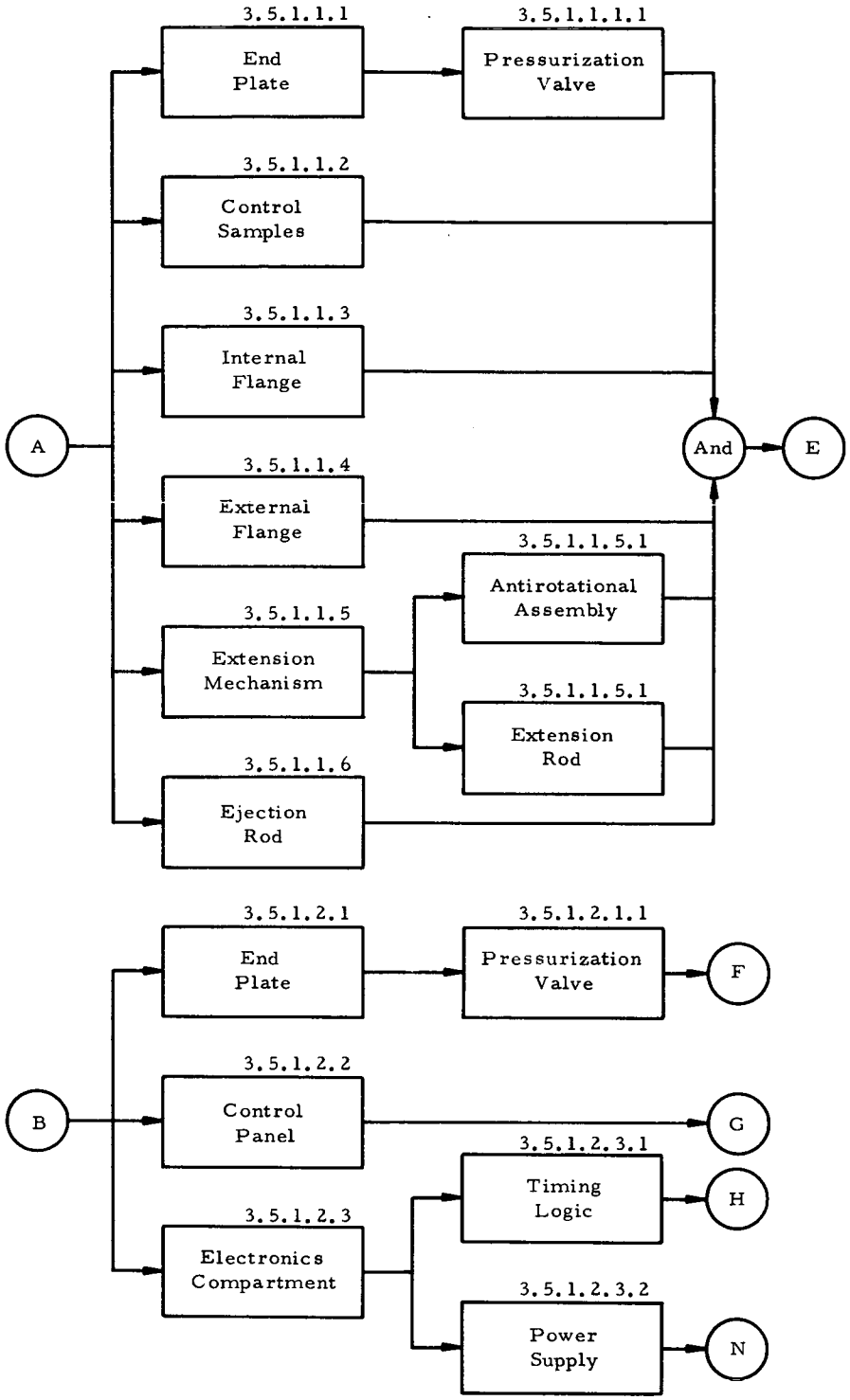


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM (Sheet 2 of 7)

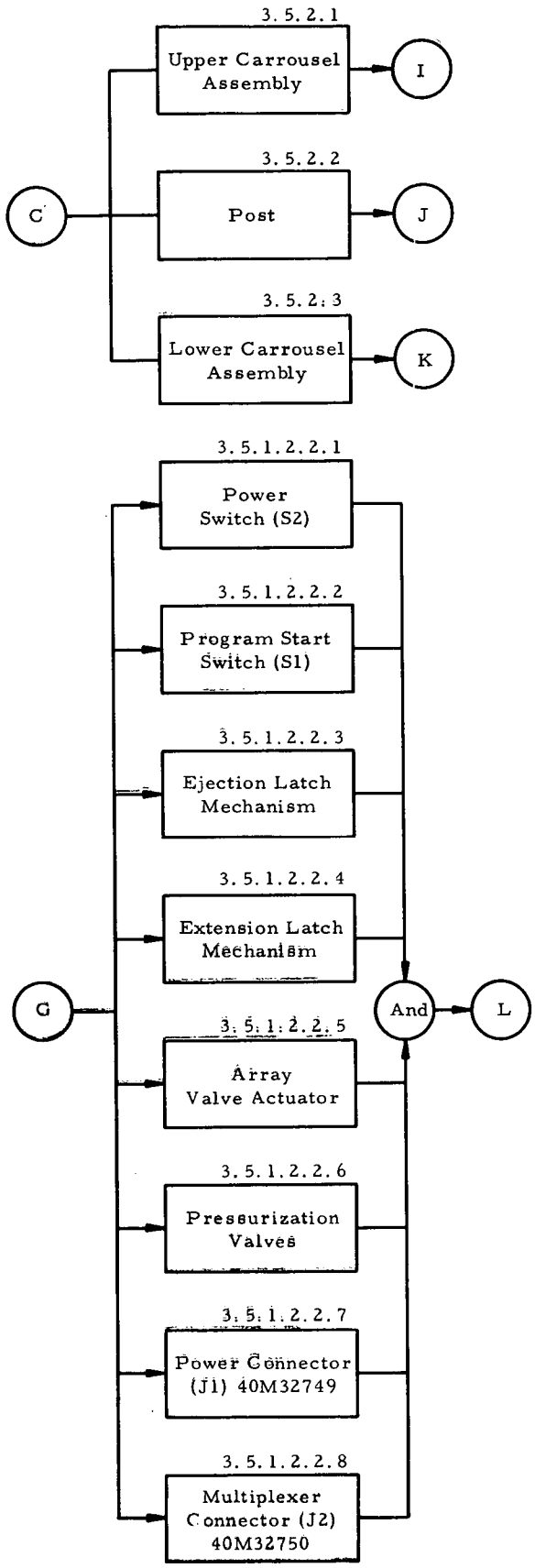


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM (Sheet 3 of 7)

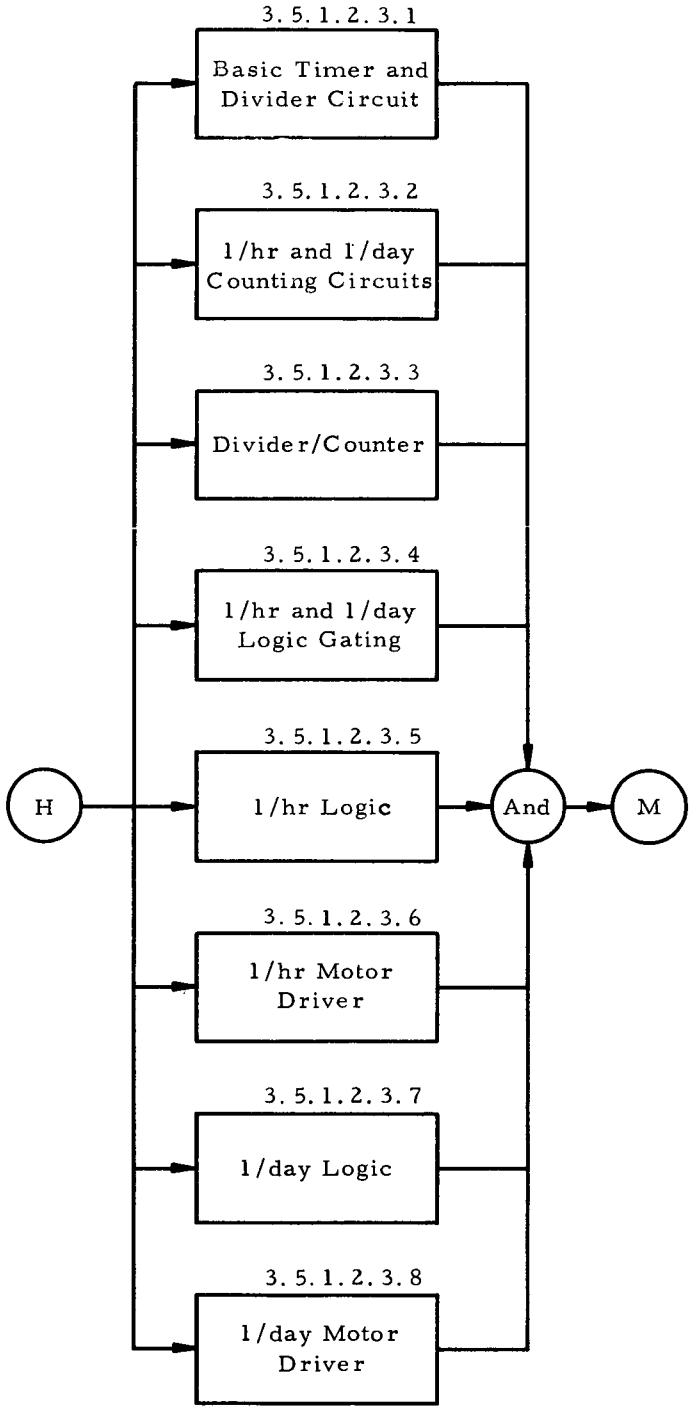


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM (Sheet 4 of 7)

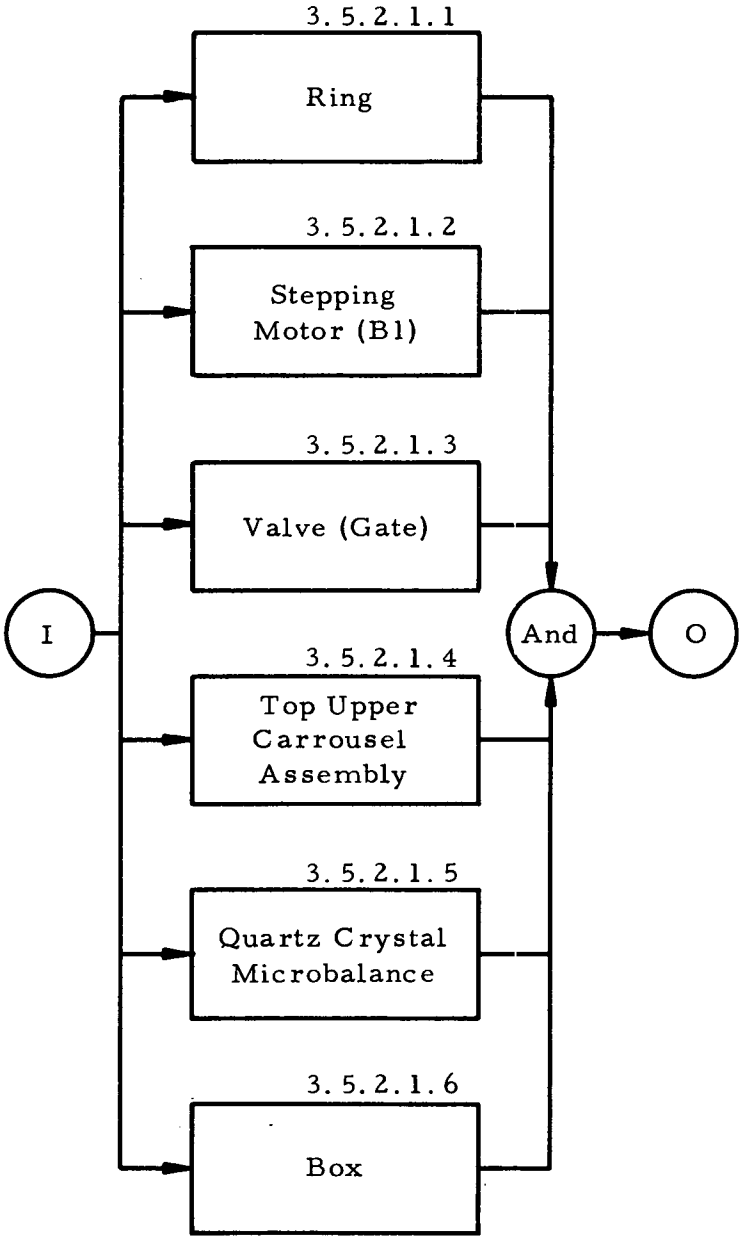


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM
(Sheet 5 of 7)

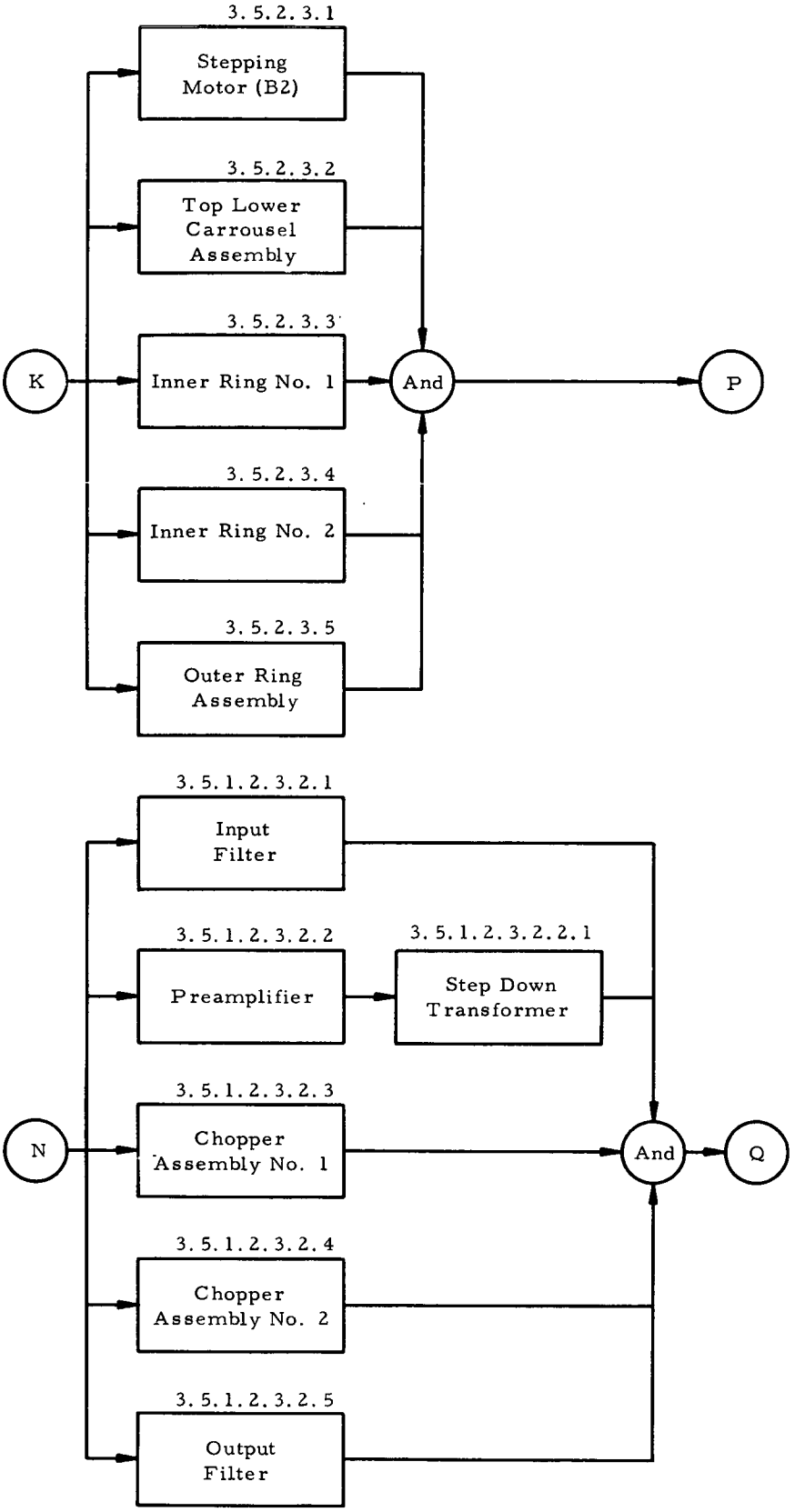


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM (Sheet 6 of 7)

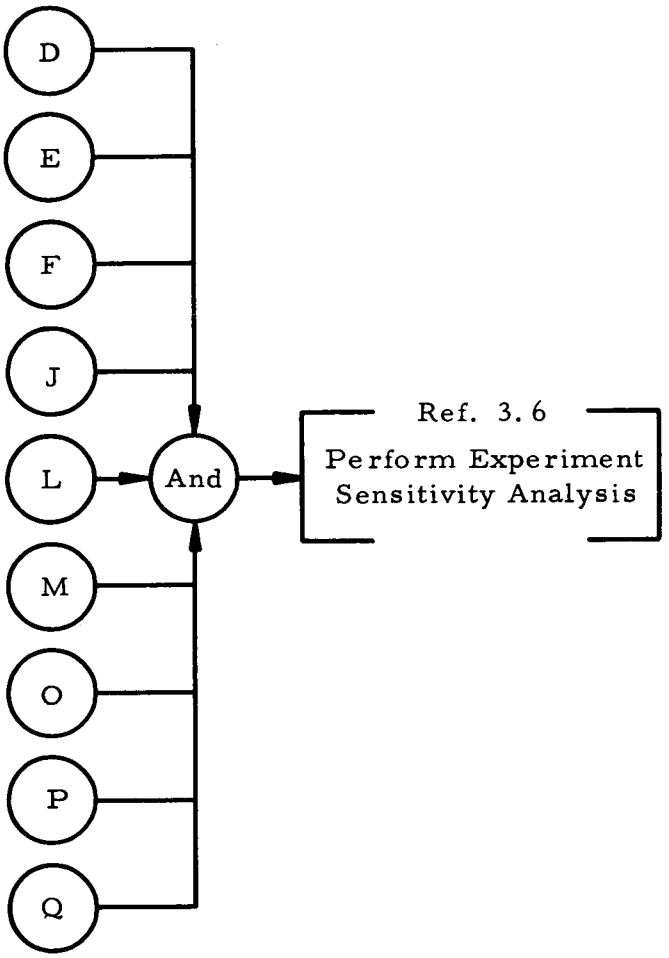
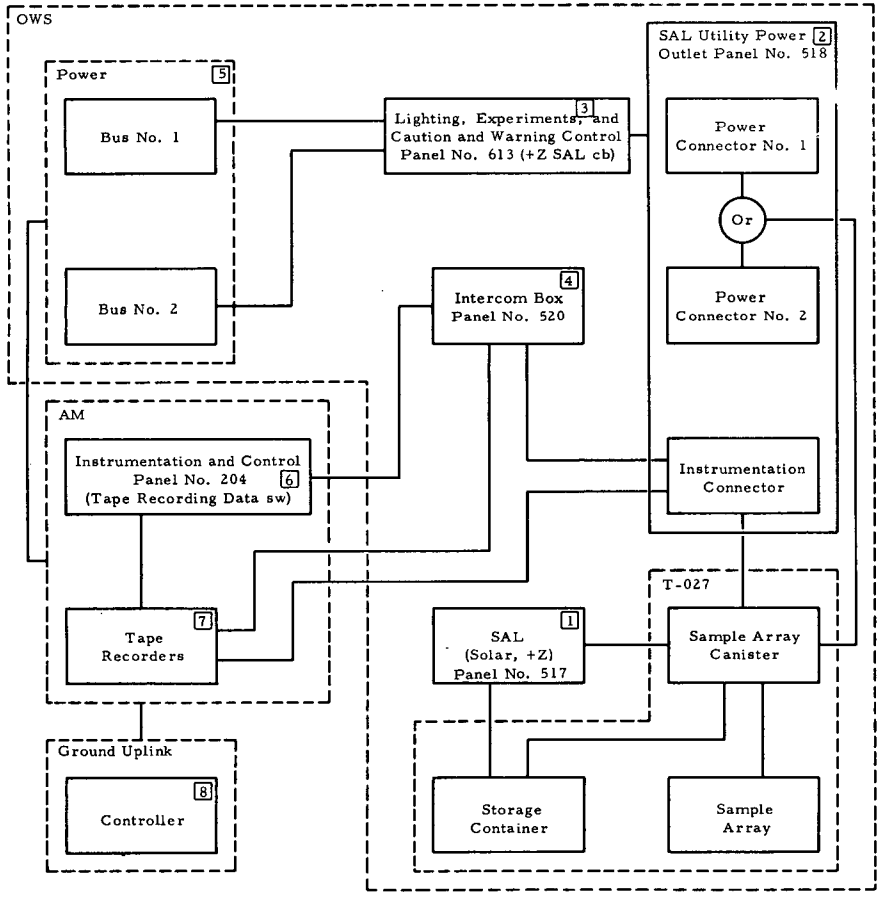


FIGURE S-1. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY FUNCTIONAL BLOCK DIAGRAM
(Sheet 7 of 7)

SECTION II.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT,
SAMPLE ARRAY INTERFACE BLOCK DIAGRAM



Code	Data Source	Remarks
1	Crew	There are several interfaces between Experiment T-027 and the solar SAL. A mechanical interface is established between the SAL and the SAC when the forward flange of the canister is adjoined to the SAL window flange and latched in place by the roller dogs. An environmental, operability, and support interface exists among the SC, SAL, and SAC. After the experiment is completed, the PLT will remove the SAC from the SAL, evacuate each end of the canister and the SC by using a vent line (flex hose) from the SAL. The vent line is part of the SAL equipment.
2	Crew K7315T027 K7314T027 C7309T027 C7310T927 M7016T027 M7017T027	There are electrical, support, and communications and data interfaces between the SAL utility power outlet panel No. 518 and the SAC. The PLT connects an instrumentation and power cable to the experiment. Both cables are supplied by the T-027/S-073 experiment equipment. All experiment telemetry is routed through the instrumentation cable and tied into panel No. 518. The PLT may select either Bus 1 or Bus 2 power.
3	M7002-440 M7003-440 M7004-440 M7005-440	There is an electrical interface between the experiment's panel No. 613 (located in the OWS wardroom at station E) and AM power buses. Panel No. 613 controls electrical power to AM Bus 1, Bus 2, and panel No. 518. Circuit breaker +Z SAL controls the power output to the SAC.
4	Crew	There are electrical, operability, and communications and data interfaces among the AM power buses, data tape recorder, and the intercom box panel No. 520. Electrical power is supplied to panel No. 520 from AM Buses 1 and 2. The PLT uses the intercom panel to initiate experiment actuation time, date of operation, and other comments on the AM DATA tape recorder mode.
5	M7002-440 M7003-440 M7004-440 M7005-440	There is an electrical interface between OWS Bus 1 and 2 and Panel No. 613. The circuit breakers on this panel control the flow of OWS Bus Power to the SAL Utility Panel No. 518.
6		There are electrical and operability interfaces between the instrumentation and control panel No. 204 and the AM tape recorders. The crew can control the power and tape function at panel No. 204.
7 8	Crew/Controller	There are communications and data interfaces among the AM tape recorders, OWS intercom panel No. 520, SAL utility outlet panel No. 518, and the ground controller. The telemetry output data from the contamination experiment is routed through panel No. 518, voice data through panel No. 520, and recorded by the AM tape recorders - DATA mode. The ground controller can select the AM tape recorder to record the experiment data. The tape recording DATA switch on panel No. 204 permits either the Astronaut or the Ground Controller to operate the tape recorder (CMD position - ground control, RECORD position - Astronaut, manual control).

FIGURE S-2. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY INTERFACE BLOCK DIAGRAM

SECTION III.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY SYSTEMS DIAGRAM

FOLDOUT FRAME 1 FOLDOUT FRAME 2 FOLDOUT FRAME 3

Note: Taken from Reference 23.

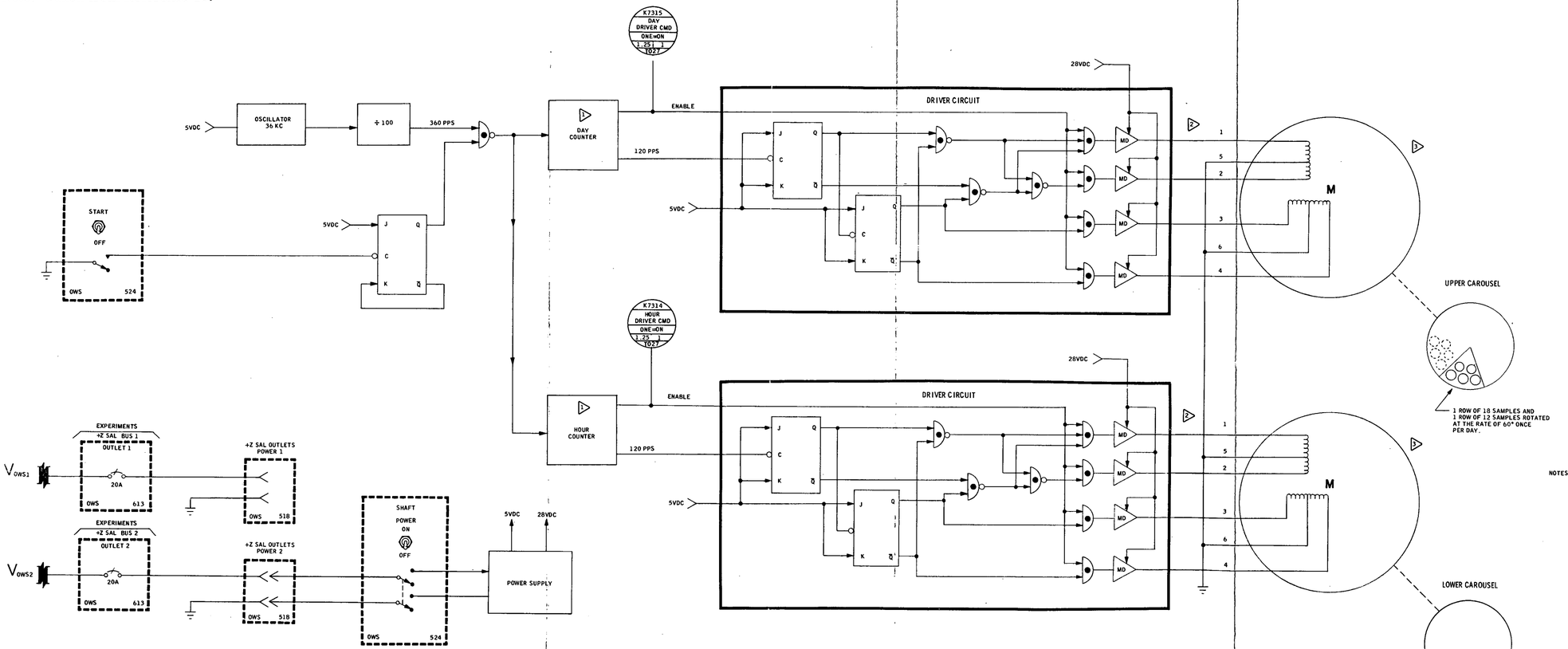


FIGURE S-3. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY SYSTEMS DIAGRAM

LTR	PCN	DR	ENGR	DATE	APPROVAL

COMMENTS:

ALL FLIP-FLOPS ARE INITIALIZED (Q TO ZERO $\bar{Q}$ TO 1) WITH POWER ON SWITCH

C_N		C_{N+1}
J	K	Q
1	1	$\bar{Q}_N$
1	0	1

C_N = STATE PRIOR TO C-PULSE (HI TO LO)

C_{N+1} = STATE AFTER C-PULSE

$\bar{Q}_N$ = Q AND $\bar{Q}$ CHANGES STATE

GEARED STEPPER MOTOR

STEP ANGLE = 90 DEG
GEAR RATIO = 320:1

STEP		TERMINAL EXCITED			
		1	2	3	4
CW ↑	1	1	0	1	0
	2	1	0	0	1
	3	0	1	0	1
	4	0	1	1	0
↓ CCW	5	1	0	1	0

NOTES:

1. THE HOUR COUNTER AND THE DAY COUNTER ARE EACH A SERIES OF FLIP FLOPS AND GATES DESIGNED TO REDUCE THE 360 PPS TO 120 PPS AND SEND THE PULSES TO THE DRIVER CIRCUITS FOR APPROXIMATELY 11 SECONDS ONCE EACH HOUR AND ONCE EACH 24 HOURS RESPECTIVELY. WHEN THE UPPER CAROUSEL HAS BEEN ROTATED 6 TIMES, THE DAY COUNTER AUTOMATICALLY STOPS SENDING PULSES TO THE DRIVER CIRCUIT. THE HOUR COUNTER DOES THE SAME THING TO THE LOWER CAROUSEL AFTER 26 ROTATIONS.

SECTION IV.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY DATA REQUIREMENTS SUMMARY

TABLE S-II. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY DATA REQUIREMENTS SUMMARY

Measurement Name	Range and Dimension of Variable	Measurement Number	Telemetry Assignment Channel	Data Return	Data Time	Remarks
Event - Exp. T027, Upper Platf. Info.	0-5 Vdc	K7315T027	WP1B034A28HD71	Event	Real/All	24 hr driver, upper carrousel
Event - Exp. T027, Lower Platf. Info.	0-5 Vdc	K7314T027	WP1B034A24HD70	Event	Real/All	1 hr driver, lower carrousel
Temp - Exp. T027, Qty. Xtal. Mbal. No. 1.	-6 to 248 °F	C7309T027	WP1B074A15HE60	Continuous	Real/All	Raw input: 28^{+2}_{-4} Vdc Conditioned input: 16.68 Vdc Output: 0-5 Vdc
Temp - Exp. T027, Qty. Xtal. Mbal. No. 2	-6 to 248 °F	C7310T027	WP1B074A23HE62	Continuous	Real/All	Raw input: 28^{+2}_{-4} Vdc Conditioned input: 16.68 Vdc Output: 0-5 Vdc
Freq - Exp. T027, Qty. Xtal. Mbal. No. 1.	0 to 12 kHz	M7016T027	WP1B074A11HE59	Continuous	Real/All	Raw input: 28^{+2}_{-4} Vdc Conditioned input: 16.68 Vdc Output: 0-5 Vdc
Freq - Exp. T027, Qty. Xtal. Mbal. No. 2.	0 to 12 kHz	M7017T027	WP1B074A19HE61	Continuous	Real/All	Raw input: 28^{+2}_{-4} Vdc Conditioned input: 16.68 Vdc Output: 0-5 Vdc
Volt - PDCS, OWS BUS No. 1	0-35 Vdc	M7002-440	WP1B050A21LH05	Housekeeping	All	
Volt - PDCS, OWS BUS No. 2	0-35 Vdc	M7003-440	WP1B010A21LH05	Housekeeping	All	
Cur - PDCS, OWS BUS No. 1	0-140 A	M7004-440	WP1B074A09HE43	Housekeeping	All	
Cur - PDCS, OWS BUS No. 2	0-140 A	M7005-440	WP1B034A01HD41	Housekeeping	All	
Astronaut Comments: • Voice loop • Crew debriefing • Experiment logbook	N/A	N/A	N/A	 • Continuous • N/A • N/A	 • Real • All • All	TBD
OWS Crew Monitor TV				Intermittent	Real/All	TBD

SECTION V.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY DATA REQUEST FORMS

DATA REQUEST FORM

Skylab Program

	DRF Control No.		Date
	Exp/Sys No. ASTN-SD/OWS/T027-003		Revision 01
Mission SL-2, 3	Period of Interest Flt	Op. Need Date	Rev Date 12/16/71

Request Contact	Data Recipient	Date Req
Name T. O. Rankin Organization PM-MO-I Phone 205-453-3657	Name Mr. W. R. Bock Address S&E-ASTN-SDF MSFC, Alabama 35812 Phone 205-453-3810	Qty

Reference Document:

MRD Content

Detailed Requirements:

MOPS Format for Experiment T027

Provide MOPS format for the following parameters associated with T027 Sample Array.

Comments & Explanation:

Originator	Integrator
Name Mr. W. R. Bock Organization MSFC/S&E-ASTN-SDF Phone 205-453-3810 Signature W. R. Bock Date 1-3-72	Name J. R. Riquelmy Organization S&E-ASTN-SDF Phone 205-453-3810 Signature J. R. Riquelmy Date 1-3-72
Request Aproval	**Implementing Agency**
Name Organization Phone Signature Date	Name Organization Phone Signature Date

MSFC - Form 65 (October 1970)

DRF Control No.	Exp/Sys No.	Revision	Date
	ASTN-SD/OWS/T027-003	01	12/16/71

Detailed Requirements:

Meas. No.	Title
M7002-440	VOLTAGE, Ref. High, OWS Bus No. 1
M7003-440	" " " " " " 2
M7004-440	CURRENT, PDCS, OWS Bus 1
M7005-440	" " " " 2
K7314T027	EVENT, Exp T027, Lower Platform Information
K735T027	" " " Upper "
K0502-512	" Onboard Timing (GMT)
C7264-436	TEMP, SAL 1, Temperature 1
C7265-436	" " 1 " 2
C7266-436	" " 2 " 1
C7267-436	" " 2 " 2
C7309T027	" Exp T027, QTZ XTAL MBAL No. 1
C7310T027	" " " " " " " 2
M7016T027	FREQUENCY, Exp T027, QTZ XTAL MBAL No. 1
M7017T027	" " " " " " " 2

DATA REQUEST FORM
Skylab Program

DRF Control No.

Date: 12/16/71

Exp/Sys No.: ASTN-SD/OWS/T027-004

Revision: 01

Mission	Period of Interest	Op. Need Date	Rev Date
SL-2, 3	Flt		

Request Contact	Data Recipient	Date Req
Name: D. A. Schaefer Organization: PM-MO-I Phone: 253-453-3651	Name: Mr. W. R. Bock Address: S&E-ASTN-SDF Phone: MSFC, Alabama 35812 205-453-3810	Qty: 1

Reference Document:

MRD Content

Detailed Requirements:

T027 Experiment Log

Provide a copy of the crew log taken during the operation of experiment T027.

Comments & Explanation:

Originator	Integrator
Name: Mr. W. R. Bock Organization: MSFC/S&E-ASTN-SDF Phone: 205-453-3810 Signature: W R Bock Date 1-3-72	Name: J. R. Riquelmy Organization: S&E-ASTN-SDF Phone: 205-453-3810 Signature: J R Riquelmy Date 1-3-72
Request Approval	**Implementing Agency**
Name Organization Phone Signature Date	Name Organization Phone Signature Date

MSFC - Form 65 (October 1970)

DATA REQUEST FORM
Skylab Program

	DRF Control No.		Date
	Exp/Sys No. ASTN-SD/OWS/EXP-069		Revision
Mission: SL-2, 3, 4	Period of Interest: POST-FLT	Op. Need Date:	Rev Date
Request Contact: Name / Organization / Phone	Data Recipient: Name: Mr. W. R. Bock; Address: S&E-ASTN-SDF; Phone: MSFC, Alabama 35812, 205-453-3810		Date Req / Qty

Reference Documents:

MRD Content:

Detailed Requirements:

Corollary Experiments Debriefing Data

Provide one copy of the crew debriefing transcripts pertaining to all corollary experiments operated during the entire mission

Comments & Explanations:

Originator	Integrator
Name: W. R. Bock	Name: J. R. Riquelmy
Organization: MSFC/S&E-ASTN-SDF	Organization: S&E-ASTN-SDF
Phone: 205-453-3810	Phone: 205-453-3810
Signature: W R Bock Date: 3-27-72	Signature: Date: 3-27-72
Request Aproval	**Implementing Agency**
Name / Organization / Phone / Signature / Date	Name / Organization / Phone / Signature / Date

MSFC - Form 65 (October 1970)

SECTION VI.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY ENGINEERING CHANGE REQUESTS

Engineering Change Requests for Experiment T-027 are N/A.

SECTION VII.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 1 of 14)

Assignments

Mission:

- SL-1/SL-2

Orbital Assembly:

- OWS

Carrier:

- The SAS is stored near Position I at OWS Sta. No. 437.997.
- The experiment is performed through the solar SAL at OWS Sta. No. ≈467.997.

Conditions

Crew:

- The Science Pilot (SPT) and the Pilot (PLT) set up the experiment. The PLT starts the experiment.
- The Commander (CDR) and the PLT stow the experiment after completion.

Experiment:

- Setup occurs on mission day 5, end of 73rd orbital revolution, at ≈18:45 GMT.
- Operation is for 5 consecutive days and starts at the beginning of the 74th orbital revolution at ≈19:30 GMT.
- Termination occurs on mission day 130, near the beginning of the 146th orbital revolution, at ≈18:40 GMT.
- Removal of the SA from the solar SAL occurs on mission day 131, at the end of the 157th orbital revolution, at ≈14:10 GMT.

Ground Support:

- A Ground Controller may interrogate the AM data recording tape for SA carrousel platform information and QCM analog data. A telemetry link can be established if the PLT sets up the AM recording panel switching.

Requirements

Functional Objective:

- FO-1: Deploy, expose, retrieve, and return the SA.

Experiment Evaluation Team - Key Personnel Locator

Name	Responsibility	Office Address, Symbol, and Telephone Number
Dr. J. Muscari	Principal Investigator (PI)	Martin Marietta Corporation, Denver, Colorado, 303-794-2859
Mr. T. Heaton	Experiment Developer (ED)	Martin Marietta Corporation, Denver, Colorado, 303-794-4358
Mr. V. Fogel	MSFC Experiment Manager (EM)	MSFC, Bldg. 4201, PM-SL-DP, 205-453-3184
Mr. W. A. Clarke	S&E Integration Engineer (IE)	MSFC, Bldg. 4610, S&E-ASTN-SDI, 205-453-3811
Mr. W. R. Bock	Technical Discipline Manager (TDM)	MSFC, Bldg. 4610, S&E-ASTN-SDF, 205-453-3810
Mr. B. Tonetti	Experiment Operations Engineer (EOE)	Teledyne Brown Engineering Company, Huntsville, Alabama, 205-532-1612
Mr. A. Flowers	Mission Operations Design Support (MODS)	Martin Marietta Corporation, Huntsville, Alabama, 205-837-5020
Mr. J. Kierein	MMC Experiment Integration Engineer (EIE)	Martin Marietta Corporation, Denver, Colorado, 303-794-3752
Mr. S. E. Sturm	MSC Flight Controller (FC)	Philco-Ford, Houston, Texas, 713-483-4717

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 2 of 14)

Operation Step Number*	Data: Return: Recorder Number	Data: Return: Measurement Name, Number, and Signal	Data: Return: Telemetry Assignment Channel	Data: Return: Function**	Data: Return: Frequency***	Data: Return: Range and Dimension of Variables	Data: Evaluation: Limits of Concern	Data: Evaluation: Check: Satisfactory	Data: Evaluation: Check: Anomaly	Data: Evaluation: Remarks****	Contingencies: See Contingency Plan Number	Remarks
P = -105 min GMT 17:45 for SL-1/ SL-2	Experiment Evaluation Team manned and available. Contact Technical Discipline Manager for Experiment T-027, S&E-ASTN-SD: HOSC Telephone No. TBD, Astronautics Laboratory Telephone No. 205-453-3810.											
	Reference: Skylab Flight Plan, SL-1/SL-2 Summary Timelines, MSC, GC53-72M-156, latest revision, and SLM-1/2, SAL Experiment Checklist, MSC, latest revision.											
P = -60 min GMT 18:30 for SL-1/ SL-2	Commence experiment preparation (ground action).											
P 1.0	Determine carrier/experiment support instrumentation status.											
P 1.1	Acquire status and evaluate the performance for the following measurements:											
P 1.1.1	TBS	Volt - PDCS, OWS Bus No. 1. M7002-440	WP1B050A21LH05	H	C	Range: 0 to 35 Vdc Read: 24 to 30 Vdc	21 to 33 Vdc			$\bar{A}$		Voltage shall not go below or exceed the upper and lower limits of the steady-state voltage of 28 +2-4 volts by more than 3.0 volts and shall return to the steady-state voltage within one second.
P 1.1.2	TBS	Cur - PDCS, OWS Bus No. 1. M7004-440	WP1B074A09HE43	H	C	Range: 0 to 140 A Read: 13 to 46 A	13 to 46 A			$\bar{A}$		
P 1.1.3	TBS	Volt - PDCS, OWS Bus No. 2. M7003-440	WP1B010A21LH05	H	C	Range: 0 to 35 Vdc Read: 24 to 30 Vdc	21 to 33 Vdc			$\bar{A}$		
P 1.1.4	TBS	Cur - PDCS, OWS Bus No. 2		H	C	Range: 0 to 140 A	13 to 46 A			$\bar{A}$		

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**E - Event
H - Housekeeping
A - Analog
D - Digital

***C - Continuous
I - Intermittent
$\bar{D}$ - Discrete
(Specified number of times)

****R - Real Time
N - Near/Real Time
$\bar{A}$ - All Time

ASTN-72-1-OT (Jan 72)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 3 of 14)

Operation Step Number*	Data: Return: Recorder Number	Data: Return: Measurement Name, Number, and Signal	Data: Return: Telemetry Assignment Channel	Data: Return: Function**	Data: Return: Frequency***	Data: Return: Range and Dimension of Variables	Data: Return: Limits of Concern	Data: Evaluation: Check: Satisfactory	Data: Evaluation: Check: Anomaly	Data: Evaluation: Remarks****	Contingencies: See Contingency Plan Number	Contingencies: Remarks
P 1.1.4 (Concluded)		M7005-440	WP1B034A01HD41			Read: 13 to 46 A						

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**E - Event
H - Housekeeping
A - Analog
D - Digital

***C - Continuous
I - Intermittent
D̄ - Discrete
(Specified number of times)

****R - Real Time
N - Near/Real Time
Ā - All Time

ASTN-72-1-OT (Jan 72)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 4 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P = -45 min GMT 18:45 for SL-1/ SL-2	Commence experiment preparation (flight action).					
P 2.0	SPT and PLT	Unstore, set up, and prepare to initiate experiment operations.				
P 2.1		Obtain headset and logbook and restrain near solar SAL (+Z axis).				
P 2.2		Obtain female component for Seaton-Wilson valve (fs-w) vacuum vent fitting.				
P 2.3		Remove protective cap from SC vent valve.				See T-027 SC F590.
P 2.4		Attach fs-w fitting to SC vent valve and equalize pressure for TBD min.			P24A1 P24A2	
P 2.5		Remove fs-w fitting from vent valve and temporarily stow.				
P 2.6		Replace protective cap in SC vent valve.				
P 2.7		Remove SAC and restrain on F590 container lid.				
P 2.8		Remove protective cap from SAC rear end plate vent valve.				
P 2.9		Obtain fs-w fitting, attach to aft end plate vent valve, and equalize pressure for TBD min.			P29A1 P29A2 P29A3	
P 2.10		Remove fs-w vent fitting from rear end plate vent valve and temporarily stow.				
P 2.11		Replace protective cap on rear end plate vent valve.				
P 2.12		Remove rear end plate from SAC and restrain.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 5 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 2.13		Repeat Operation Step Nos. P 2.8 through P 2.12 for forward end plate.			P213A1	
P 2.14		Notify crew that solar SAL (+Z axis) activation is to begin.				CHAN B is to be used for recording data and advance notice is required if CHAN B is to be used for recording other experiment data.
P 2.15		Remove restraints on SAC and install on SAL by using experiment interface installation procedures.			P215A1 P215A2	
P 2.16		Stow front and rear SAC end plates in F590 SC.				
P 2.17		Verify the following switch positions:				
P 2.17.1		• SAL outlet, Bus 1 cb - +Z (panel 613 in OWS)				See panel no. 613 in OWS.
P 2.17.2		• SAL outlet, Bus 2 cb - +Z (panel 613 in OWS)				See panel no. 613 in OWS.
P 2.17.3		• SA POWER - OFF				
P 2.18		Obtain power cable from lid of SC.				Experiment T-027/S-073 is stored in container F591. The power cable (40M32749) is located in the lid portion of the container.
P 2.19		Connect power cable to SA Power connector and to +Z SAL Power 1 or 2 outlet.				See panel no. 518 in OWS.
P 2.20		Obtain instrumentation cable from lid of SC.				The instrumentation cable (40M32750) is located in the lid portion of the F591 container.
P 2.21		Connect instrumentation cable to SA Multiplexer connector and to +Z SAL Instrumentation Outlet.				See panel no. 518 in OWS.

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 6 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 2.22		Rotate SA valve actuator knob ccw until array valve actuator assembly can be removed from SA control panel.			P222A1	
P 2.23		Stow SA actuator assembly in F590 container.				
P 2.24		Remove extension rod from lid of F590 container.				
P 2.25		Depress pip pin detent button on end of extension rod, pull down extension rod lock latch mechanism to OPEN, enter extension rod in SAL panel access hole, and gently push until moderate resistance is met.			P225A1 P225A2 P225A3	Enter the rod in SA panel access hole with pip pin button depressed.
P 2.26		Release extension rod lock latch.				
P 2.27		Thread extension rod into the SA extension mechanism.				Ensure that extension rod pip pin button is depressed before threading the rod onto the SA. Complete threading may be accomplished with the pip pin button released. Attempt to unscrew the rod to ensure detents have locked in place.
P 2.28		Open +Z SAL doors using standard operating procedures.			P228A1	
P 2.29		Deploy SA by pushing the extension rod into the control panel. The rod is fully deployed when the lock latch engages into the rod groove.			P229A1 P229A2 P229B1 thru P229B6	During extension, care must be taken to keep the green stripe on the extension rod aligned with the index rivet on the control panel. The rod must also be kept parallel to the floor and perpendicular to the control panel.
P 2.30	PLT	Restrain logbook in usage position.				
P 2.31	PLT	Don headset.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 7 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 2.32	PLT	Speaker Intercom (S/I) recording system activation:				
P 2.32.1		• S/I CHAN B - OFF.				
P 2.32.2		• Connect headset to S/I CHAN B (J4) connector.				
P 2.32.3		• CCV Power and Mode Section - ICOM/PTT.				
P 2.32.4		• Adjust CCV volume control.				
P 2.32.5		• S/I CHAN B - ICOM/PTT.				
P 2.32.6		• S/I RECORD/OFF - RECORD (momentary, green advisory light - on)				
O = 0.0 min GMT 19:20 for SL-1/SL-2	Commence experiment operations:					
O 1.0	PLT	Stand by SA control panel.				
O 1.1		Position the following switches:			O111A1 thru O111A3; O111B1 thru O111B5; O111C1 thru O111C3; O111D1 and O111E1; O112A1 thru O112A3; O112B1 O112C1 thru O112C6; O112D1 and O112D2	
O 1.1.1		• SA Power Switch - ON.				This switch is a lever lock toggle switch and must be pulled to operate.
O 1.1.2		• SA Start Switch - ON.				
O 1.2		Record on tape and in logbook:				
O 1.2.1		• Date				
O 1.2.2		• Actuation time				
O 1.2.3		• Any pertinent comments/data.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 8 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.3		S/I RECORD/OFF - OFF (momentary, green advisory light - off).				
O 1.4		Disconnect and stow headset.				
O 1.5		Stow logbook.				
O 2.0	N/A	Continue experiment operations.				Once the SA has been deployed and activated, it is designed to operate without astronaut participation or monitoring for 5 consecutive days.

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 9 of 14)

Operation Step Number*	Data: Return: Recorder Number	Measurement Name, Number, and Signal	Telemetry Assignment Channel	Function**	Frequency***	Range and Dimension of Variables	Limits of Concern	Evaluation: Check: Satisfactory	Anomaly	Remarks****	Contingencies: See Contingency Plan Number	Remarks
O 2.1	Acquire the following measurements to determine if the SA stepping motors are being signaled to operate, commencing at Operation Step Number O 1.1.1 initiation.											
O 2.1.1	Verify that lower carrousel driver is operating.											
	TBS	Event-Exp. T027, Upper Platf. Info. K7314T027	WP1B034A24HD70	E	I	Range: 0 or 5 Vdc. Read: At initiation read 5 Vdc pulse for 11 sec. Read same pulse at the end of each hour for 25 hr (26 pulses).	0 or 5 Vdc			$\bar{A}$		
	Typical K7314T027 Measurement: Signal Profile Vdc; 5; 0; 25 hr; Initiate Start Switch; Duration (hrs); On; 5 Vdc; Off; 11 sec											
O 2.1.2	Verify upper carrousel driver is operating.											
	TBS	Event-Exp. T027 Upper Platf. Info.		E	I	Range: 0 or 5 Vdc	0 or 5 Vdc			$\bar{A}$		

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**E - Event
H - Housekeeping
A - Analog
D - Digital

***C - Continuous
I - Intermittent
$\bar{D}$ - Discrete
(Specified number of times)

****R - Real Time
N - Near/Real Time
$\bar{A}$ - All Time

ASTN-72-1-OT (Jan 72)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 10 of 14)

Operation Step Number*	Data: Return: Recorder Number	Measurement Name, Number, and Signal	Telemetry Assignment Channel	Function**	Frequency***	Range and Dimension of Variables	Limits of Concern	Evaluation: Check: Satisfactory	Anomaly	Remarks****	Contingencies: See Contingency Plan Number	Remarks
O 2.1.2 (Concluded)		K7315T027	WP1B03A28H071			Read: 11 sec. 5 Vdc pulse at the end of each day for 5 days after experiment start switch initiation (5 pulses).						
		Typical K7315T027 Measurement: Signal Profile Vdc (5, 0); 5 days; Initiate Start Switch; Duration (hrs); ≈20 hr Removed T027 from SAL; On / 5 Vdc / Off; 11 sec										
O 2.2	Acquire the following QCM measurements, as necessary, after initiating Operation Step No. O 1.1.1.											
O 2.2.1	Verify QCM No. 1 frequency output signal.											
	TBS	Freq. -Exp. T027, Qtz. Xtal. Mbal. No. 1		A	C	Range: 0 to 12 kHz	0 to 12 kHz		$\bar{A}$			The QCM telemetry provides cumulative data.
		M7016T027	WP1B074A11HE59			Read: 0 to 12 kHz						

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**E - Event
H - Housekeeping
A - Analog
D - Digital

***C - Continuous
I - Intermittent
$\bar{D}$ - Discrete
(Specified number of times)

****R - Real Time
N - Near/Real Time
$\bar{A}$ - All Time

ASTN-72-1-OT (Jan 72)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 11 of 14)

Operation Step Number*	Data: Return: Recorder Number	Data: Return: Measurement Name, Number, and Signal	Data: Return: Telemetry Assignment Channel	Data: Return: Function**	Data: Return: Frequency***	Data: Return: Range and Dimension of Variables	Data: Return: Limits of Concern	Data: Evaluation: Check: Satisfactory	Data: Evaluation: Check: Anomaly	Data: Evaluation: Remarks****	Contingencies: See Contingency Plan Number	Contingencies: Remarks
O 2.2.2	Verify QCM No. 1 thermistor output signal.											
	TBS	Temp. -Exp. T027, Qtz. Xtal. Mbal. No. 1		A	C	Range: -6 to 284 °F	60° to 190°F			$\bar{A}$		
		C7309T027	WP1B074A15HE60			Read: -6 to 284 °F						
O 2.2.3	Verify QCM No. 2 frequency output signal.											
	TBS	Freq. -Exp. T027, Qtz. Xtal. Mbal. No. 2		A	C	Range: 0 to 12 kHz	0 to 12 kHz			$\bar{A}$		
		M7017T027	WP1B074A19HE61			Read: 0 to 12 kHz						
O 2.2.4	Verify QCM No. 2 thermistor output signal.											
	TBS	Temp. -Exp. T027, Qtz. Xtal. Mbal. No. 2		A	C	Range: -6 to 284 °F	60° to 190 °F			$\bar{A}$		
		C7310T027	WP1B074A23HE62			Read: -6 to 284 °F						

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**E - Event
H - Housekeeping
A - Analog
D - Digital

***C - Continuous
I - Intermittent
$\bar{D}$ - Discrete
(Specified number of times)

****R - Real Time
N - Near/Real Time
$\bar{A}$ - All Time

ASTN-72-1-OT (Jan 72)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 12 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T = +19.5 hr GMT 14:10 for SL-1/SL-2	Commence experiment termination:					
T 1.0	CDR and PLT	Start experiment deactivation, removal, and storage.				Actual experiment carrousel termination occurs on mission day 130 at GMT ≃ 18:40.
T 1.1		Obtain logbook and restrain in usage position.				
T 1.2		Notify crew that experiment deactivation is to begin. CHAN B is to be used for recording of data. Advance notice is required if CHAN B is to be used for recording of other experiment data.				
T 1.3		Don headset.				
T 1.4		S/I recording system activation:				
T 1.4.1		• S/I CHAN B - OFF				
T 1.4.2		• Connect headset to S/I CHAN B (J4) connector				
T 1.4.3		• CCU power and mode selection - ICOM/PTT				
T 1.4.4		• CCU volume control - adjust as required				
T 1.4.5		• S/I CHAN B - ICOM/PTT				
T 1.4.6		• S/I RECORD/OFF - RECORD (momentary, green advisory light - on).				
T 1.5		Position the following switches:				
T 1.5.1		• SA POWER -OFF				
T 1.5.2		• SAL outlet, Bus 2 cb - +Z (panel 613 in OWS)				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 13 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1.5.3		• SAL outlet, Bus 1 cb - +Z (panel 613 in OWS)				
T 1.6		Record on tape and in logbook:				
T 1.6.1		• Date				
T 1.6.2		• Deactivation time				
T 1.6.3		• Pertinent comments/data.				
T 1.7		S/I RECORD/OFF - OFF (momentary, green advisory light - off).				
T 1.8		Disconnect and stow headset.				
T 1.9		Stow logbook.				
T 1.10		Disconnect power cable from SA Power connector and +Z SAL Power 1 or 2 connector.				
T 1.11		Stow power cable in lid of SC F591.				
T 1.12		Disconnect instrumentation cable from SA Multiplexer connector and +Z SAL Instrumentation Outlet.				
T 1.13		Stow Instrumentation cable in lid of SC F591.				
T 1.14		Pull down on extension rod lock latch mechanism.				
T 1.15		Retract SA assembly into canister assembly.			T115A1 thru T115A4 T115B1 and T115B2	As the rod is pulled in, care must be taken to keep the stripe on the extension rod aligned with the index rivet on the control panel.
T 1.16		Close +Z SAL doors using standard operating procedures.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

TABLE S-III. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY EVALUATION SEQUENCE (Sheet 14 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1.17		Depress extension rod pip pin button and unthread from SA. Remove extension rod and store in the F590 container.				Pip pin button may be released after unthreading the extension rod several rotations.
T 1.18		Remove array valve actuator assembly from the SC.				
T 1.19		Attach array valve actuator assembly to SA valve actuator rod at SA control panel.				
T 1.20		Rotate internal valve actuator knob cw until it cannot be rotated further.				
T 1.21		Remove SA end plate from the F590 container and install on aft end of SAC.			T121A1 thru T121A3	
T 1.22		Remove SA front end plate from F590 and temporarily restrain on F591 container.				
T 1.23		Repressurize +Z SAL using standard operating procedures.				
T 1.24		Remove SA canister from +Z SAL and restrain on top of F590 container lid.				
T 1.25		Install forward end plate on SAC.			T125A1	
T 1.26		Evacuate both end plates through the +Z SAL (TBD min each) by using the SAL vacuum hose utilization-experiment evacuation procedures.			T126A1	
T 1.27		Temporarily restrain vacuum hose.				
T 1.28		Store the SAC in the F590 container.				
T 1.29		Evacuate the F590 SC through the +Z SAL (TBD min) by using the SAL vacuum hose utilization-experiment evacuation procedures.			T129A1 T129A2	
T 1.30		Remove vacuum hose from SAL by using the SAL vacuum hose removal procedures, and stow.				

*P - Preparation
O - Operations
T - Termination
L - Lift-off (Booster)

**CDR - Commander
SPT - Science Pilot
PLT - Pilot
ALL - CDR/SPT/PLT

MSFC - One Time Form 17-1 (March 1972)

SECTION VIII.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE

TABLE S-IV. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 1 of 3)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 2.4	Attach fs-w fitting to SC vent valve and equalize pressure for 5 min.	P24A SC will not equalize pressure.	P24A1 Use common screwdriver from the Portable Astronaut Tool Kit (PATK) to force open and offset the front edge of SC lid. This will break the vacuum seal internal to the F590 container. P24A2 Open SC lid and continue the experiment.	
P 2.9	Obtain fs-w fitting, attach to aft end plate vent valve, and equalize pressure for 5 min.	P29A Cavity between SAC and end plate will not equalize pressure.	P29A1 Unlatch the end plate from the SAC. P29A2 Use PATK common screwdriver to force open, by prying, the end plate between the canister control panel flange and the end plate seal interface. P29A3 Remove the end plate and continue the experiment.	
P 2.13	Repeat Operation Step Nos. P 2.8 through P 2.12 for forward end plate.	P213A Cavity between SAC and end plate will not equalize pressure.	P213A1 Reference: • P29A1 • P29A2 • P29A3	
P 2.15	Remove restraints on SAC and install on +Z SAL by using experiment interface installation procedures.	P215A The +Z SAL is not operationally available.	P215A1 Transfer the experiment to the -Z SAL, if it is available, to support the FO. P215A2 Continue the experiment. The experiment's FO will be degraded.	
P 2.22	Rotate SA valve actuator knob ccw until array valve actuator assembly can be removed from SA control panel.	P222A The valve actuator knob cannot be removed from the array valve actuator assembly. The SA cannot be deployed.	P222A1 Terminate the experiment normally (refer to Operation Step Nos. T 1.10 through T 1.31).	P

ASTN-OT-7 (Feb. 72)

TABLE S-IV. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 2 of 3)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 2.25	Depress pip pin detent button on end of extension rod, pull extension rod lock latch mechanism to OPEN, enter extension rod in SAC panel access hole, and thread extension rod until an abrupt tension increase is felt.	P225A The extension rod cannot be deployed through the SA panel access hole.	P225A1 Remove the extension rod, recycle the pip pin detents, and re-enter the rod in the panel access hole. P225A2 Check the extension rod access hole for foreign matter or unseated O-ring seals. Reseat seals, if accessible. P225A3 If the extension rod cannot be deployed, terminate the experiment normally.	
P 2.28	Open +Z SAL doors, using standard operating procedures.	P228A The +Z SAL doors will not open or the SAL pressure cannot be vented overboard.	P228A1 Reference: • P215A1 • P215A2	
P 2.29	Deploy SA by pushing the extension rod into the control panel. The rod is fully deployed when the lock latch engages into the rod groove.	P229A The extension rod cannot be fully deployed. The anti-rotation mechanism links may be binding.	P229A1 Deploy the SA extension rod as far as possible. P229A2 Cut strips of pressure sensitive tape, overlay the tape on the end of the extension rod, and secure the tape to the sides of the SAC. Ensure access to the power and start switches. Finish taping by over-wrapping the tape strip section ends around the SAC.	
		P229B The SA cannot be deployed. The anti-rotation mechanism may be inhibiting the deployment of the extension rod.	P229B1 Ensure that the extension rod black stripe is indexed to the control panel reference rivet. P229B2 If the SA cannot be deployed, terminate the experiment normally. P229B3 Remove SAC from the SAL, restrain assembly of F590 SC, and deploy SA inside the OWS by using the extension rod.	P

TABLE S-IV. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 3 of 3)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 2.29 (Concluded)			P229B4 Inspect SA anti-rotation mechanism for damage or binding. Correct, if possible. P229B5 If SA cannot be deployed, terminate the experiment. Remove the extension rod, reconfigure for storage, and evacuate SAC and SC. P229B6 If SA deployment problem can be corrected, reinitiate SAC/SAL installation procedures, and deploy the SA. Continue the experiment.	P

ASTN-OT-7 (Feb. 72)

TABLE S-V. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 1 of 4)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.1.1	SA Power Switch - ON.	O111A Power Switch fails open, or a short to ground occurs. The following measurements are lost: • K7314T027, Lower Platform Information • K7315T027, Upper Platform Information • C7309T027, QCM No. 1 Temperature • C731-T027, QCM No. 2 Temperature • M7016T027, QCM No. 1 Frequency • M7017T027, QCM No. 2 Frequency	O111A1 Recycle Power Swtich to ON position. O111A2 Verify +Z SAL cb on OWS panel No. 613 is closed. O111A3 Continue the experiment in a degraded mode.	Ground personnel can determine status of power output by monitoring the changes in QCM frequency and temperature measurement numbers.
		O111B The power cable develops an open. The following measurements are lost: • Reference O111A.	O111B1 Open +Z SAL cb on OWS panel No. 613, remove the power cable and inspect plugs and receptacles for bent pins. Straighten as required, and reinstall. O111B2 Position Power Switch - ON. If no changes occur in QCM frequency and temperature measurements, position Power Switch - OFF, open +Z SAL cb on OWS panel No. 613. O111B3 Substitute S-183 experiment power cable for the T-027/S-073 power cable. O111B4 Position Power Switch - ON. If no changes occur in QCM frequency and temperature measurements, position Power Switch - OFF.	The S-183 power cable is located in the experiment support section of OWS storage location F596.

TABLE S-V. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 2 of 4)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.1.1 (Concluded)			O111B5 Continue the experiment in a degraded mode.	
		O111C OWS Bus 1 fails.	O111C1 Open SAL power outlets 1 and 2 cb on OWS panel No. 613, disconnect power cable from Bus 1 outlet, and connect to Bus 2 outlet (OWS panel No. 518).	
			O111C2 Recycle Power Switch - ON, and lock for changes in QCM frequency and temperature measurements to occur.	
			O111C3 If no change in QCM occurs, continue the experiment in a degraded mode.	
		O111D The SA 28 Vdc power supply fails. The QCM frequency and temperature measurements are lost.	O111D1 Reference: • O111C2 • O111C3	
		O111E Power Switch fails closed.	O111E1 Complete the experiment and open the +Z SAL cb at OWS panel No. 613.	
O 1.1.2	SA Start Switch - ON.	O112A The Start Switch fails open. No bit change on upper and lower platform information measurement numbers.	O112A1 Recycle Power Switch - ON. O112A2 Recycle Start Switch - ON.	The lower and upper carrousel will rotate one step each time the Power Switch and Start Switch are recycled - ON.
			O112A3 Continue experiment in degraded mode.	

O

TABLE S-V. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 3 of 4)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
O 1.1.2 (Concluded)		O112B The 5 Vdc power supply on the timers	O112B1 Reference: • O112A1 • O112A2 • O112A3	
		O112C The upper and lower carrousel stepping motors fail.	O112C1 Reference: • O112A1 • O112A2 O112C2 If the stepping motors do not operate, continue experiment in degraded mode. O112C3 Reference: • P229B3 O112C4 Inspect the stepping motor's connectors for defective connection, straighten pins as required, and reinstall on the SAL. O112C5 Perform experiment activation. O112C6 Reference: • O112A1 • O112A2 • O112A3	
		O112D The instrumentation cable develops an open. The following measurements are lost: • Reference O111A.	O112D1 Remove instrumentation cable and inspect plugs and receptacles for bent pins. Straighten as required, and reinstall. O112D2 Check QCM frequency and temperature measurement numbers for changes. If a change does not occur, remove the T-027/S-073 instrumentation cable and replace it with the S-183 instrumentation cable.	The S-183 instrumentation cable is located in the experiment support section at OWS storage location F596.

0

TABLE S-V. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 4 of 4)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
O 2.0	Continue experiment operations.	O20A The SA day and hour telemetry signals indicate no carrousel rotation.	O20A1 If the indications occur during the first 24 hr of the experiment, check for power interrupt. If power interrupt has occurred, reinitialize power and start switches. If telemetry indicates no carrousel rotation after the first 24 hr, do not attempt to reinitialize SA.	
		O20B The hour telemetry signal for the lower carrousel indicates rotation continuing after the first 25 hr of SA deployment.	O20B1 Turn SA power switch to OFF. Wait 10 sec and turn power to ON. Do not reinitialize start switch. This action will stop further carrousel rotation while continuing to provide power to the QCM's.	

O

TABLE S-VI. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 1 of 2)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
T 1.15	Retract SA assembly into canister assembly.	T115A The SA assembly cannot be manually retracted into the canister assembly.	T115A1 Apply hand torque and a push/pull motion to release possible anti-rotation mechanism binding. Index the extension rod green stripe with the alignment rivet. T115A2 Try to retract SA assembly into canister assembly. T115A3 Eject SA, using experiment ejection procedures. T115A4 Secure the SAL and terminate the experiment.	
		T115B The SA carrousels interfere with the canister forward flange section. The SA is half-in and half-out of the canister.	T115B1 Rotate the extension rod so as to align the green index stripe with a reference rivet. T115B2 Terminate the experiment normally.	
T 1.21	Remove SA end plate from the F590 container and install on aft end of SAC.	T121A The end plate will not seat evenly against the canister aft flange.	T121A1 Remove end plate from canister flange and check both for evidence of prying, broken seals, and damaged surfaces. T121A3 Reinstall the end plate on the canister flange and lock in place. If the end plate does not fit the flange and allow a sealing surface (severly damaged and cannot lock the end plate), return it to the storage container. Continue with experiment termination.	

T

TABLE S-VI. EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 2 of 2)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
T 1.25	Install forward end plate on SAC.	T125A Reference: • T121A	T125A1 Reference: • T121A1 • T121A2 • T121A3	
T 1.26	Evacuate both end plates through the +Z SAL for 5 min each, using the SAL vacuum hose and experiment evacuation procedures.	T126A The end plates cannot be evacuated.	T126A1 Place SAC in SC and evacuate SC.	
T 1.29	Evacuate the F590 SC through the +Z SAL for 5 min, using the SAL vacuum hose and experiment evacuation procedures.	T129A The SC cannot be evacuated.	T129A1 Ensure that the SC and lid mating surfaces are aligned and undamaged. Ensure that the seals are undamaged and seated. Repair as necessary.	

T

SECTION IX.

EXPERIMENT T-027, CONTAMINATION MEASUREMENT, SAMPLE ARRAY MALFUNCTION ANALYSES

The material contained in this section is an excerpt from Reference 33.

2. CONTAMINATION MEASUREMENT, T027

The T027 experiment consists of two separate hardware systems, each retrieving different and independent data. One system is the Sample Array, and the other system is the Photometer.

The primary Sample Array and Photometer operational functions requiring analysis are presented in Table 2.1. Figure 2.1 thru 2.3 depict the relationships used to develop this table and also presents those items analyzed in this issue of the document.

Table 2.1 Operational Functions and Malfunction Analysis Items, T027

Operational Function	Sub-Function	Malfunction Analysis Item
2.1 Provide Sample Array	2.1.1 Provide Power	2.1.1.1 Power Failure
	2.1.2 Provide Access to Space	2.1.2.1 Failure to Deploy 2.1.2.2 Failure to Retract 2.1.2.3 Sample Array Jams Half In, Half Out of SAL
	2.1.3 Provide T/M Data	2.1.3.1 Instrumentation Cable Failure
	2.1.4 Provide Timed Exposure Sequence	2.1.4.1 Time Fails or 5V Power Fails or Start Switch Fails Open 2.1.4.2 Stepper Motors Fail 2.1.4.3 Start Switch Fails
	2.1.5 Provide QCMB Data	2.1.5.1 QCMB Fails 2.1.5.2 QCMB Connector Fails

Table 2.1 Operational Functions and Malfunction Analysis Items, T027 (Continued)

Operational Function	Sub-Function	Malfunction Analysis Item
2.2 Provide Photometer System	2.2.1 Provide Electronics	2.2.1.1 PMT Failure 2.2.1.2 PMT Shutter Control Failure 2.2.1.3 PMT Cap Control Failure 2.2.1.4 FOV Control Failure 2.2.1.5 Filter Wheel Control Failure 2.2.1.6 Polarizer Wheel Control Failure 2.2.1.7 Trunnion Control Failure 2.2.1.8 Shaft Control Failure 2.2.1.9 Camera Control Failure
	2.2.2 Provide Power and Timing	2.2.2.1 TBS
	2.2.3 Provide Mechanical	2.2.3.1 TBS
	2.2.4 Provide Optics	2.2.4.1 TBS

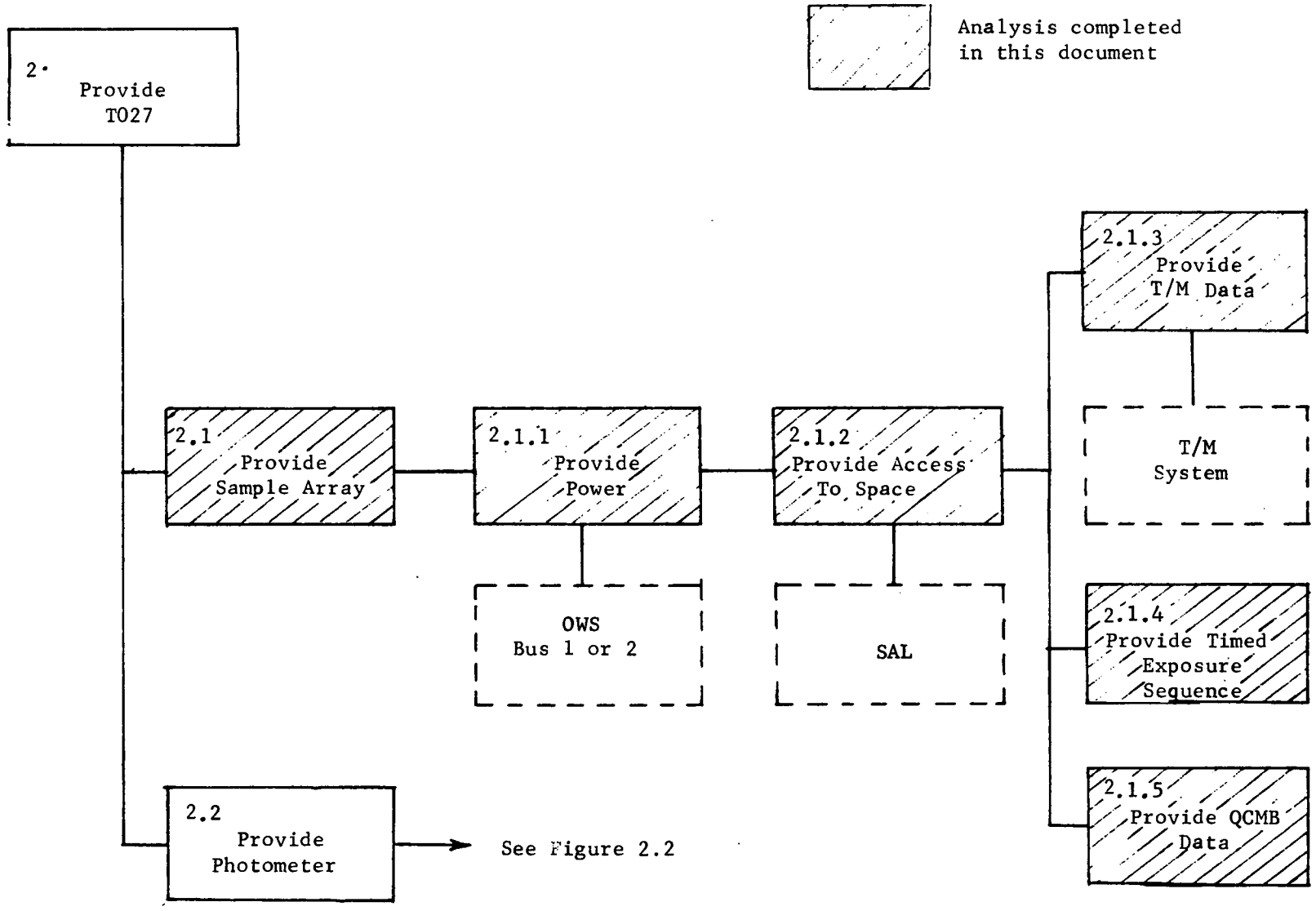


Figure 2.1 T027 Functional Flow Diagram
and Sample Array Malfunction Analysis Diagram

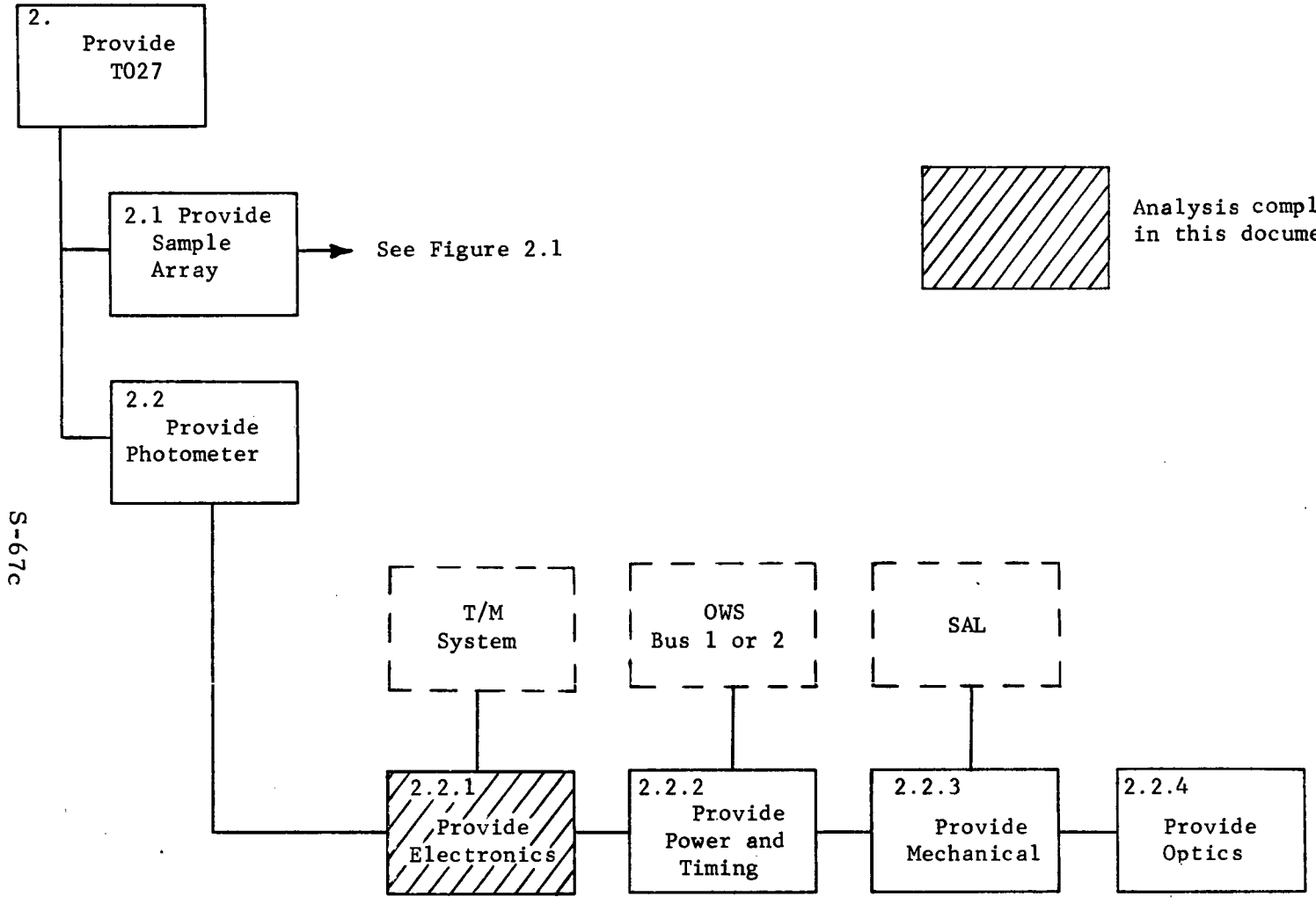


Figure 2.2 Functional Flow Diagram, T027 Photometer

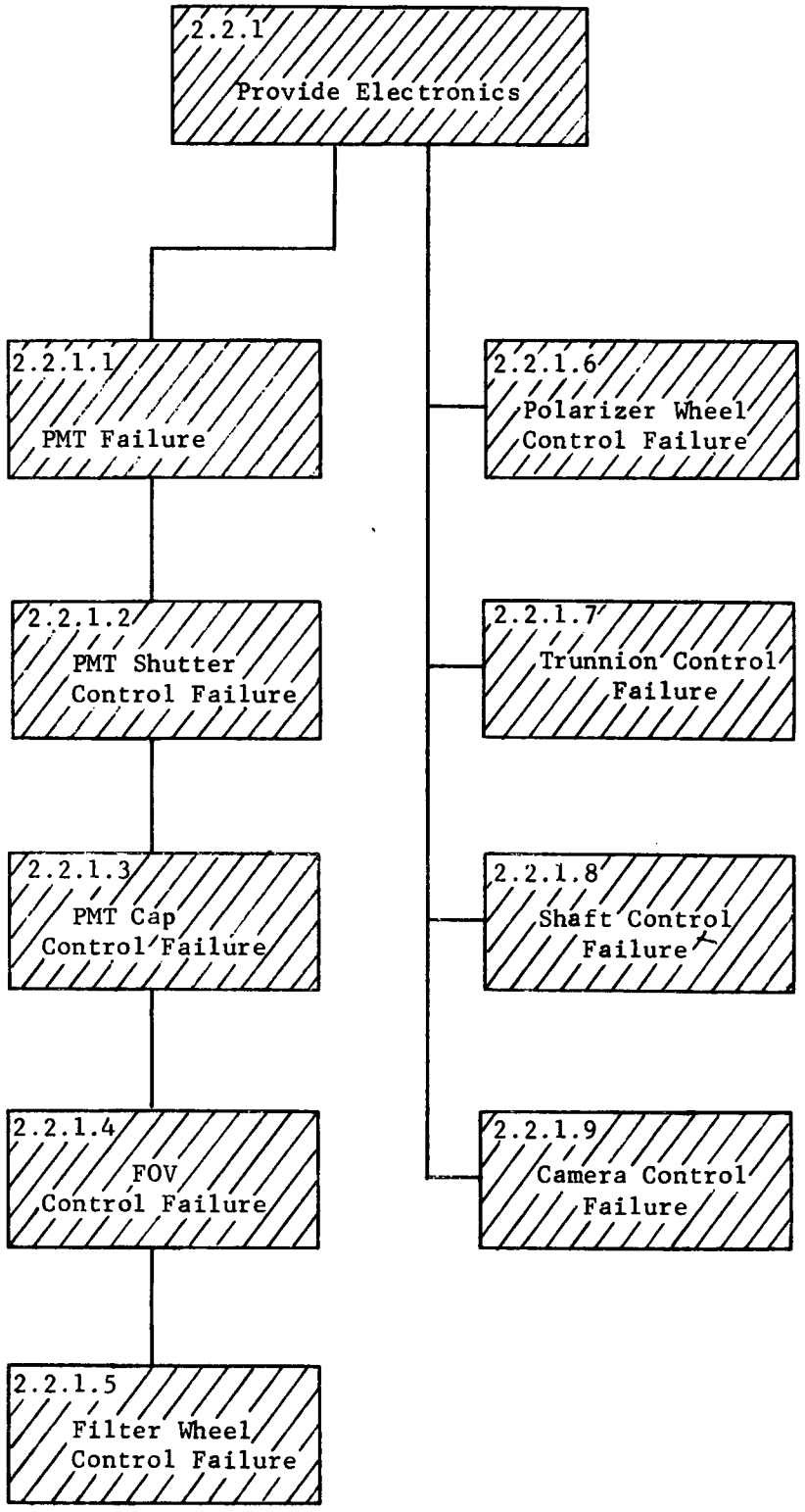


Figure 2.3 Malfunction Analysis Diagram,
T027 Photometer Electronics

MALFUNCTION ANALYSIS CHART T027 SAMPLE ARRAY

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.1.1 Provide Power						Ground Action: None Crew Action: Phase D
2.1.1.1 Power Failure Case I (Power Switch fails open or short to ground, or faulty power cable	K7314 Lower Plat Info (U): No bit chg K7315 Upper Plat Info (U): No bit chg M7016 QCMB No. 1 Out (U): 0 Vdc M7017 QCMB No. 2 Out (U): 0 Vdc C7309 QCMB No.1 Temp (U): Off Scale Low C7310 QCMB No.2 Temp (U): Off Scale Low	Crew Sensing-Audible (U) No indication of exposure change at 1/hr intervals	Mission: None Crew: None	Loss of timed-exposures of optical samples and loss of QCMB data	Possible loss of power cable redundancy for T027/ S073 and S183	1. Recycle POWER sw, and 2. Check SAL cb on CIRCUIT BREAKER panel No.1 (613), verify closed, and: 3. Open SAL cb on CIRCUIT BREAKER panel No. 1 (613), remove power cable and inspect plugs and receptacles for bent pins, straighten as required and reinstall, and 4. Open SAL cb on CIRCUIT BREAKER panel No.1 (613), remove power cable and replace with S183 power cable, and: 5. Terminate experiment nominally
Case II (OWS Bus 1 fails)	M7002 OWS Bus 1 Voltage (U): < 12 Vdc	M7004 OWS Bus 1 Current (U): Proportionately low value	Mission: None Crew: Timeline	Loss of timed exposures of optical samples and loss of QCMB data	None	1. Open SAL outlet 1 and outlet 2 cb on CIRCUIT BREAKER panel No.1 (613), disconnect power cable from Bus 1 outlet and connect to Bus 2 outlet.
Case III (Power supply 28v output fails)	M7016 QCMB No.1 Out (U): 0 Vdc M7017 QCMB No.2 Out (U): 0 Vdc C7309 QCMB No.1 Temp (U): Off Scale Low C7310 QCMB No.2 Temp (U): Off Scale Low	K7314 Lower Plat Info (U): Normal bit chg K7315 Upper Plat Info (U): Normal bit chg Crew Sensing-Audible (U): No indication of exposure change at 1/hr and 1/day intervals	Mission: None Crew: None	Loss of timed exposure of optical samples and loss of QCMB data	None	1. Recycle POWER sw, and 2. Terminate experiment nominally
Case IV (Power switch fails closed)	M7016 QCMB No.1 Out (U): 0 Vdc prior to normal experiment start M7017 QCMB No.2 Out (U): 0 Vdc prior to normal experiment start	None	Mission: None Crew: None	None	None	1. Complete experiment, and open SAL cb (outlet 1 or outlet 2) at CIRBUIT BREAKER panel No. 1 (613) SAL.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART TO27 SAMPLE ARRAY

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.1.2 Provide Access to Space						Ground Action: None Crew Action: Phase D
2.1.2.1 Failure to Deploy	Crew sensing (U): Manual deployment not possible	None	Mission: None Crew: Timeline	Loss of all subsequent tests	None	1. Remove assembly from SAL and inspect for and correct possible mechanical jamming. Do not apply torque to extension rod and; 2. Terminate experiment nominally.
2.1.2.2 Failure to Retract	Crew sensing (U): Manual retraction not possible	None	Mission: None Crew: Timeline	Loss of exposed optical samples	None	1. Apply torque (without the aid of tools) to extension rod, and; 2. Eject experiment device and terminate experiment.
2.1.2.3 Sample Array Jams Half In, Half Out of SAL	Crew sensing-touch (U): Manual deployment or retraction not possible. Crew sensing-visual (U): Alignment line on side at extension tube not aligned with alignment mark (anodized rivet on case)	None	Mission: None Crew: Safety-the extension rod remains partially extended into the OWS providing a hazard to maneuvering and definitely precluding operation of T020 and M509	Loss of exposed samples	Loss of all subsequent experiments which use the affected SAL. Note: This malfunction will not allow the experiment to be ejected or retracted.	1. Apply combined torque and in-out motion to the extension tube to realign the alignment line on the tube with the alignment reference. Use padded vise-grip pliers if necessary. Note: Application of CCW torque could unscrew extension rod from mechanism. Withdrawal of disconnected extension rod will result in loss of cabin pressure.
2.1.3 Provide T/M Data						Ground Action: None Crew Action: Phase D
2.1.3.1 Instrumentation Cable Failure	One or more of the following measurements unacceptable (U): Combined with one or more acceptable (A) K7314 Lower Plat Info. (U): No bit change (A): 1 bit chg/day K7315 Upper Plat Info. (U): No bit chg (A): 1 bit chg/hr M7016 QCMB No.1 Out (U): 0 Vdc (A): .05 Vdc to 5 Vdc	Crew sensing-audible (U): Indication of normal exposure changes	Mission: None Crew: None	Loss of data	Loss of instrumentation cable redundancy for T027/S073 and S183	1. Remove instrumentation cable and inspect plugs and receptacles for bent pins, straighten as required, reinstall, and; 2. Remove and replace with S183 instrumentation cable, and; 3. Continue experiment in degraded mode.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027 SAMPLE ARRAY

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
	M7017 QCMB No.2 Out (U): 0 Vdc (A): .05 Vdc to 5 Vdc C7309 QCMB No.1 Temp (U): Off scale low (A): -10°C to +110°C C7310 QCMB No.2 Temp (U): Off scale low (A): -10°C to +110°C					
2.1.4 Provide timed exposure sequence						Ground Action: None Crew Action: Phase D
2.1.4.1 Time fails or 5V power supply fails or START switch fails open	K7314 Lower Plat Info (U): No bit change K7315 Upper Plat Info (U): No bit change Note: These measures are inconclusive without the presence of the following nominal meas: M7016 QCMB No.1 Out .05 Vdc to 5.0 Vdc M7017 QCMB No.2 Out .05 Vdc to 5.0 Vdc C7309 QCMB No. Temp -10°C to +110°C C7310 QCMB No.2 Temp -10°C to +110°C Note: Timer failure could result in failure of either or both 1/hr and 1/day exposures	Crew sensing-audible (U): No indication of exposure change at 1/hr and/or 1/day intervals	Mission: None Crew: None	Loss of timed exposures of optical samples	None	
2.1.4.2 Stepper motors fail (either 1/hr or 1/day or both)	K7314 Lower Plat Info (A): 1 bit chg/day K7315 Upper Plat Info (A): 1 bit chg/hr	Crew sensing-audible (U): No indication of exposure change at 1/hr and/or 1/day	Mission: None Crew: None	Loss of timed exposures of optical samples	None	1. Recycle POWER sw and START sw, and 2. Remove experiment hardware from SAL in nominal fashion, extend inside OWS, inspect motor connectors for bent pins, straighten as required, and reinstall experiment, and;

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART TO27 SAMPLE ARRAY

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
						3. Continue experiment in degraded mode.
2.1.4.3 START switch fails closed or short to ground	K7314 Lower Plat Info (U): Premature bit change K7315 Upper Plat Info (U): Premature bit change	None	Mission: None Crew: None	None	None	None
2.1.5 Provide QCMB data						Ground Action: None Crew Action: Phase D
2.1.5.1 QCMB fails a) QCMB No. 1	M7016 QCMB No.1 Out (U): 0 Vdc C7309 QCMB No.1 Temp (U): OFF scale High of Low	None	Mission: None Crew: None	Loss of QCMB data	None	1. Recycle POWER sw and START sw, and 2. Continue experiment in degraded mode.
b) QCMB No. 2	M7017 QCMB No.2 Out (U): 0 VDC C7310 QCMB No.2 Temp (U): OFF scale High or Low	None				
2.1.5.2 QCMB connector fails	one or more of the following measurements unacceptable (U). M7016 QCMB No.1 Out (U): 0 Vdc M7017 QCMB No.2 Out (U): 0 Vdc C7309 QCMB No.1 Temp (U): OFF scale Low C7310 QCMB No.2 Temp (U): OFF scale Low	None	Mission: None Crew: Timeline	Loss of QCMB data	None	1. Remove experiment hardware from SAL in nominal fashion, extend inside OWS, inspect QCMB connectors for bent pins, straighten as required, and reinstall experiment, and; 2. Continue in degraded mode.

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CH T, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2 Provide Photometer System 2.2.1 Provide Electronics 2.2.1.1 PMT Failure						Ground Action: Phases D, F, and H Crew Action: Phases D, F, and H
a. PMT Output Failure (PMT Package, Amp on T/M Bd)	M7072S073/M7074T027-PMT Current (U): $\leq .01$ or $\geq .99$ μamps in conjunction with K7277S073/K7265T027-PMT Shutter Bit State 0 (open).	INTENSITY ind (U): Does not change in reading when changing FOV or FW and shutter open.	Mission: None Crew: Timeline effect.	Loss of Photometer System.	Same as system effect for S073.	1. Recycle or change GAIN sw position, or 2. Recycle PMT SHUTTER sw, and 3. Terminate Photometer portion and take 16 mm camera data only.
b. Voltmeter Failure (Amp on Unique Bd, Voltmeter)	M7072S073/M7074T027-PMT Current (U): .01 thru .99 μamps in conjunction with INTENSITY ind reads 0 or does not change in reading when changing FOV or FW.	None	Mission: None Crew: Timeline effect.	Loss of information on PMT output for proper FOV sw and GAIN sw operation.	Same as system effect for S073.	1. Tap on INTENSITY ind face, or 2. Keep close contact with ground as to the quality of PMT output data and needed gain and/or FOV changes.
c. Gain Control Failure (GAIN sw Short/Open, Gain Relays, PMT Package)	M7072S073/M7074T027-PMT Current (U): PMT current does not change in conjunction with K7279S073/K7267T027-Med PMT Gain or K7278S073/K7266T027-High PMT Gain Bit State change	INTENSITY ind (U): Does not change reading in conjunction with operating GAIN sw but does change reading in conjunction with a FOV or FW change.	Mission: None Crew: Timeline effect.	Loss of gain control on PMT for keeping output current within scale.	Same as system effect for S073.	1. Recycle GAIN sw, and 2. Use different FOV settings to keep INTENSITY ind on scale (use higher FOV setting for off scale high position).

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.2 PMT Shutter Control Failure						
a. Fails to Open	K7277S073/K7265T027-PMT Shutter (U): Bit state 1 (closed)	M7072S073/M7074T027 PMT Current (U): < .01 μamps or PMT SHT lt (U): On	Mission: None Crew: Timeline effect.	Loss of shutter control, no light gets to PMT and Photometer System is lost.	Same as system effect for S073.	
	In conjunction with shutter commanded open.					
Case I. Programmer Control (PROGRAM sw Open/Short, Programmer, OR Gate, Flip Flop Control Ckt on Relay Driver Bd Including Relays, Shutter Solenoid)						1. Recycle PROGRAM sw, and 2. a. Recycle POWER sw when FW and FOV not moving, i.e. does not change positions for 20 sec, and b. Use different programmer modes, and 3. a. Remove cable from J10 on Manual Control Panel and replace with shorting plug P10A, and b. Operate Photometer System manually, or 4. Terminate Photometer portion of experiment, take 16 mm camera data only.
Case II. Manual Control (PMT SHUTTER sw Short/Open, Flip Flop Ckt, OR Gate, PMT Shutter Control Ckt on FW Bd, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Shutter Solenoid).						1. Recycle PMT SHUTTER sw, and 2. Return to programmer control nominally, and 3. Use filter wheel program control nominally, or 4. Terminate Photometer portion of experiment, take 16 mm camera data only.

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.2 PMT Shutter Control Failure (Continued) a. Fails to Open (Continued) Case III. FW Program Control (FW Bd Gates, PROGRAM sw Open/Short, OR Gate, PMT Shutter Control Ckt on FW Bd, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Shutter Solenoid).						1. Recycle PROGRAM sw, and 2. Return to programmer control nominally, and 3. Push PMT SHUTTER sw to OPEN, or 4. Terminate photometer portion of experiment, take 16 mm camera data only.
Case IV. Mechanical Failure (Shutter Closed, FW Between Filters).						1. a. Remove from SAL nominally, and b. Extend one rod length, and c. Utilizing ball peen hammer, (Ref 6) tap on photometer head, or d. Utilizing hammer (step c) strike photometer head with medium force, or 2. a. Disassemble photometer head, and b. Manually manipulate components, and c. Reassemble photometer head, and d. Apply power to verify operation, or 3. Apply power and strike with hammer (step c), or 4. Same as step 4, Case III, 2.2.1.2a.

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.2 PMT Shutter Control Failure (Continued)						
b. Fails to Close	K7277S073/K7265T027-PMT Shutter (U): Bit state C (open)	M7072S073/M7074T027-PMT Current (U): > .01 μamps or PMT SHT lt (U): OFF	Mission: None Crew: Timeline effect.	Loss of shutter control, possible to get too much light to PMT and burn it out.	Same as system effect for S073.	
	In conjunction with shutter commanded closed.					
Case I. Programmer Control (Programmer, Input on OR Gate)						1. Push PMT SHUTTER sw to close, and 2. Same as step 2, Case I, 2.2.1.2a, and 3. Use filter wheel control nominally. Note: This will operate the system and sequence FW-A through all 5 filters before closing shutter.
Case II. Manual Control (PMT SHUTTER sw Open' in CLOSE Position, Input on OR Gate)						1. Recycle PMT SHUTTER sw, and 2. Same as step 3, Case I, 2.2.1.2b, and 3. Use programmer control nominally.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.2 PMT Shutter Control Failure (Continued) b. Fails to Close (Continued) Case III. FW Program Control (FW Bd Gates, Input on OR Gate)						1. Push PMT SHUTTER sw to CLOSE, and 2. Use programmer control nominally.
Case IV. All of the Above Cases (Output on OR Gate, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Shutter Solenoid, Mechanical Hang-up)						1. Same as steps 1, and 3, Case I and step 3, Case II, 2.2.1.2b, or 2. Continue operating Photometer System manually with extreme care not to point at bright objects. Note: Close cap when not taking data or PMT overvoltage i.e., INTENSITY ind full scale.
2.2.1.3 PMT Cap Control Failure a. Fails to Open	K7276S073/K7264T027-PMT Cap (U): Bit state 1 (closed) in conjunction with cap commanded open.	M7072S073/M7074T027-PMT Current (U): No change when shaft or trunnion is moved but does change with changes in optic path. PMT CAP lt (U): ON in conjunction with cap commanded open INTENSITY ind (U): Does not change when shaft or trunnion is moved but does change in conjunction with different FOV or FW settings.	Mission: None Crew: Timeline effect.	Loss of cap control, no outside light gets to PMT and Photometer System is lost.	Same as system effect for S073.	

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.3 PMT Cap Control Failure (Continued) a. Fails to Open (Continued) Case I. Programmer Control (Programmer, OR Gate, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Cap Solenoid)						1. a. Recycle POWER sw when FW and FOV not moving, i.e. does not change positions for 20 sec, and b. Use different programmer modes, and 2. Push PMT CAP sw to OPEN, and 3. a. Put shorting plug P10A on J10 Manual Control Panel, and b. Put FILTER WHEEL AUTO sw in pos FW-A, and c. Operate PROGRAM sw, or 4. Terminate photometer portion of experiment nominally, take 16 mm data only.
Case II. Manual Control (PMT CAP sw Short/Open, OR Gate, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Cap Solenoid)						1. Recycle PMT CAP sw, and 2. Return to programmer control nominally, and 3. Use filter wheel program control nominally, or 4. Terminate photometer portion of experiment, take 16 mm camera data only.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.3 PMT Cap Control Failure (Continued) a. Fails to Open (Continued) Case III. FW Program Control (OR Gate, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Cap Solenoid)						1. Push PMT CAP sw to OPEN, then release, and 2. Return to programmer control nominally, or 3. Terminate photometer portion of experiment, take 16 mm data only.
Case IV. Mechanical Hang-up						1. Same as steps 1, 2, and 3, Case IV, 2.2.1.2a, or 2. Terminate photometer portion of experiment nominally. Take 16 mm data only.
b. Fails to Close	K7276S073/K7264T027-PMT Cap (U): Bit state 0 (open) in conjunction with cap commanded closed.	M7072S073/M7074T027-PMT Current (U): Changes in conjunction with shaft or trunnion moving and shutter is open. PMT CAP lt (U): OFF when cap should be closed INTENSITY ind (U): Changes in conjunction with shaft or trunnion moving and shutter is open.	Mission: None Crew: Timeline effect.	Loss of cap control, calibration source can not be used, therefore degraded data because of no PMT calibration.	Same as system effect for S073.	

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.3 PMT Cap Control Failure (Continued) b. Fails to Close (Continued) Case I. Programmer Control (Programmer, Input on OR Gate)						1. Push PMT CAP sw to CLOSE, and 2. Same as step 2, Case I, 2.2.1.2a, and 3. Use filter wheel control nominally. Note: This will operate the system and sequence FW-A through all 5 filters before closing cap.
Case II. Manual Control (PMT CAP sw, Open in CLOSE Position, Input on OR Gate)						1. Recycle PMT CAP sw, and 2. Use programmer control nominally, and 3. Same as step 3, Case I, 2.2.1.3b.
Case III. FW. Program Control (FW Bd Gates, PROGRAM START sw, Input on OR Gate)						1. Push PMT CAP sw to CLOSE, and 2. Use programmer control nominally.
Case IV. All of the Above Cases (Output on OR Gate, Flip Flop, Control Ckt on Relay Driver Bd Including Relays, Cap Solenoid, Mechanical Hang-up)						1. Same as steps 2 and 3, Case III and step 3 Case I, 2.2.1.3b, or 2. Continue nominal operation with the exclusion of calibration.

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART, T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.4 FOV Control Failure a. Fails to Advance (FOV sw Short, FOV Control Ckts on Camera-FOV Bd, Sequential Pulse Generator for Stepper Motor, Drivers, FOV Motor, Mechanical Hang-up).	K7288S073/K7275T027-FOV Wheel 2° (U): No bit change In conjunction with FOV being stepped.	M7072S073/M7074T027-PMT Current (U): Does not change FOV ind (U): Does not change INTENSITY ind (U): Does not change	Mission: None Crew: Timeline effect.	Loss of FOV control. Depending on position stuck in, too much or too little light may reach the PMT causing some loss of data.	Same as system effect for S073.	1. Recycle FOV sw, and 2. Use appropriate GAIN sw settings to keep INTENSITY ind on scale, and 3. Keep pointing control in sky areas with proper light intensity and operate in degraded mode.
b. Continuous Advancing (FOV sw Open, Flip Flop Stuck in Set Position).	K7288S073/K7275T027-FOV Wheel 2° (U): Bit change every 4 sec.	FOV ind (U): Changes reading every 4 sec.	Mission: None Crew: Timeline effect.	FOV wheel keeps turning causing loss of most/all PMT data.	Same as system effect for S073.	1. When FW not moving, i.e. does not change positions for 20 sec, recycle POWER sw immediately following a FOV ind change, and 2. Take fixed pointing data, and 3. Terminate photometer portion of experiment, take 16 mm camera data only.
c. Fails to Indicate Position			Mission: None Crew: Timeline effect.	Loss of FOV position information for proper FOV control.	Same as system effect for S073.	
Case I. Onboard Only (Readout Control Ckt, FOV ind).	FOV ind (U): Not illuminated. (U): Does not change reading when FOV wheel stepped in conjunction with INTENSITY ind changes reading.	None				1. Keep close Track of last position FOV left in, and 2. Check with ground to verify position.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.4 FOV Control Failure (Continued) c. Fails to Indicate Position (Continued) Case II. Onboard and T/M (0-5 Position Counter, Micro sw, Micro sw Ckt)	FOV ind (U): Does not change reading when FOV wheel stepped in conjunction with INTENSITY ind changing reading. (U): Does not track with FOV wheel, i.e FOV ind goes to higher number and INTENSITY ind reads higher.	None				1. Keep close track of last position left in. (FOV in position 0 when INTENSITY ind has much higher indication in new FOV setting.)
2.2.1.5 Filter Wheel Control Failure a. Fails to Advance FW-A	K7282S073/K7270T027-Filter Wheel A2° (U): No bit change when FW-A is stepped.	M7072S073/M7074T027-PMT Current (U): Does not change in conjunction with FW A being stepped and K72775073/ K7265T027 PMT Shutter bit state 0 (open). FW-A ind (U): Does not change when F.W. A is stepped. INTENSITY ind (U): Same as PMT current above.	Mission: None Crew: Timeline effect.	Loss of FW-A control. If failed in 0 position then 5 filters usable on wheel B. If failed in position 1-5 then that is only filter available (restricts data to filter(s) available)	Same as system effect for S073.	

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART TO27

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.5 Filter Wheel Control Failure (Continued) a. Fails to Advance FW-A (Continued) Case I. Programmer Control (Programmer, Auto A Flip Flop, All Common F.W. A Ckts)						1. a. Recycle POWER sw when FW and FOV not moving, i.e. does not change positions for 20 sec, and b. Use different programmer modes, and 2. Push FILTER WHEEL STEP sw to MAN A, and 3. Use FW sequencing nominally, and 4. a. If in position 0, use FW-B nominally, and b. If in position other than 0 keep FW-B in position 0 and continue experiment, and c. If between positions remove from SAL, take apart head and manually move FW-A to position 0.
Case II. Manual Control (FILTER WHEEL STEP sw Open/Short, Man A Flip Flop, All Common FW-A Ckts)						1. Recycle FILTER WHEEL step sw, and 2. Use FW sequencing nominally, and 3. Use programmer control nominally. 4. Same as step 4, Case I, 2.2.1.5a.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.5 Filter Wheel Control Failure (Continued) a. Fails to Advance FW-A (Continued) Case III. Auto Sequencing (FILTER WHEEL AUTO sw Shorted in Position B, PROGRAM sw Short/Open, Auto Sequencing Ckt, all Common FW-A Ckts)						1. a. Recycle FILTER WHEEL AUTO sw, and b. Recycle PROGRAM sw, and 2. Push FILTER WHEEL STEP sw to MAN A, and 3. Use programmer control nominally, and 4. Same as step 4, Case I, 2.2.1.5a.
b. FW-A Does Not Stop Advancing (A ON Flip Flop Stuck in Set State)	K7282S073/K7270T027-Filter Wheel 2° (U): Bit change every 4 sec	K7277S073/K7265T027-PMT Shutter (U): Bit state 1 (closed) (This is not conclusive by itself) FW-A ind (U): Changes every 4 sec PMT SHUTTER lt (U): ON (This is not conclusive by itself)	Mission: None Crew: Timeline effect.	Loss of Photometer System.	Same as system effect for S073.	1. Recycle POWER sw immediately following a FW-A ind change. 2. Terminate photometer portion of experiment, take 16 mm camera data only.
c. Fails to Advance FW-B Same Cases and Causes as 2.2.1.5a, (Substitute B for A)	K7285S073/K7268T027-Filter wheel B2° (U): No bit change when FW-B is stepped.	Same as 2.2.1.5a (substitute for FW-A).	Mission: None Crew: Timeline effect.	Same as 2.2.1.5a (substitute B for A and A for B)	Same as system effect for S073.	Same as 2.2.1.5a (substitute B for A and A for B).

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.5 Filter Wheel Control Failure (Continued)						
d. FW-B Does Not Stop Advancing (B ON Flip Flop Stuck in Set Position)	K7285S073/K7268T027-Filter Wheel B2° (U): Bit change every 4 sec.	Same as 2.2.1.5b (substitute FW-B for FW-A).	Mission: None Crew: Timeline effect.	Loss of Photometer System.	Same as system effect for S073.	Same as 2.2.1.5b (substitute FW-B for FW-A).
e. FW-A/B Fails to Indicate Position			Mission: None Crew: Timeline effect.	Loss of FW position information for proper FW control.	Same as system effect for S073.	
Case I. Onboard Only (Readout Control Ckt, FW ind).	FW ind (U): Not illuminated. (U): Does not change reading when FW stepped in conjunction with INTENSITY ind changes reading.	None				1. Keep close track of last position FW-A/B left in, and 2. Check with ground to verify position.
Case II. Onboard and T/M (0-5 Position counter, Micro sw, Micro sw Ckt)	FW ind (U): Does not change reading when FW stepped in conjunction with INTENSITY ind changes reading. (U): Does not track with FW, i.e. INTENSITY ind reads much higher (pos 0) and FW-A/B indicates 1-5.	None				1. Keep close track of last position FW-A/B left in. (FW-A and B position 0 when INTENSITY ind has much higher indication in new FW setting.

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.6 Polarizer Wheel Control Failure (EXPERIMENT SELECT sw Shorted in S149 Position, Programmer (When Connected), and Gate, Relay Driver and Relays, Polarizer Motor)	K7171S073/K7170T027-Polarizer Wheel Sync (U): No bit change	M7072S073/M7074T027 PMT Current (U): Output level vs time is constant over any .5 sec period, (with polarizer wheel turning, output will vary with a 2 CPS rep rate) in conjunction with K7277S073/K7265T027 PMT Shutter bit state 0 (open) and K7276S073/ K7264T027-PMT Cap bit state 0 (open)	Mission: None Crew: Timeline effect	No polarization information of the data is obtained.	Same as system effect for S073.	1. Recycle EXPERIMENT SELECT sw, or 2. Put shorting plug P10A on J10 of Manual Control Panel and operate experiment manually, or 3. a. Put S149 sw in OPEN position and b. Put EXPERIMENT SELECT sw in S149 position, and c. Operate experiment manually, and d. Put EXPERIMENT SELECT sw in T027/S073 position before moving shaft or trunnion, return to S149 position after moving shaft/ trunnion to take data, and 4. Operate photometer system without the polarization.
2.2.1.7 Trunnion Control Failure		TRUNNION ind (U): Does not change when trunnion should be moving (common sensor with primary cue).				
a. Fails to Move (Either or Both Directions)	G7053S073/G7016T027 Trunnion Position (U): No bit change when trunnion should be moving.	M7072S073/M7074T027-PMT Current (U): Does not change in reading when trunnion should be moving and cap and shutter are open. (Inconclusive indication of this failure)	Mission: None Crew: Timeline effect.	Incomplete data. Also, if failed in any position other than TRUNNION ind 000 the boom cannot be retracted into the SAL, and must be ejected	Loss of data and UXM. UXM cannot be used for S073, S149 or ECTV.	

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.7 Trunnion Control Failure (Continued)						
a. Fails to Move (Either or Both Directions) (Continued)		INTENSITY ind (U): Does not change in reading when trunnion should be moving. (Inconclusive indication of this failure.)				
Case I. Programmer Control (Programmer, Auto Control Ckt, Encoder, EXPERIMENT SELECT sw Shorted in S149 Position, Relay K3, Trunnion Motor Control Ckt, Drivers, Relays, Trunnion Motor)						1. Recycle EXPERIMENT SELECT sw, and 2. Recycle POWER sw when FW and FOV not moving, i.e. does not change positions for 20 sec, and 3. Place shorting plug P10A on J10 of Manual Control Panel and place TRUNNION sw in INCR/DECR position, and 4. a. Take all possible data within limits of operation, and b. End experiment nominally if TRUNNION ind 000, and c. Eject nominally after taking all possible data if TRUNNION ind not 000.
Case II Manual Control (TRUNNION sw Open/Short, Manual Control Ckt, EXPERIMENT SELECT sw Shorted in S149 Position, Relay K3, Trunnion Motor Control Ckt, Drivers, Relays, Trunnion Motor)						1. Recycle EXPERIMENT SELECT sw, and 2. Recycle TRUNNION sw, and 3. Use programmer control nominally, or 4. Same as step 4, Case I, 2.2.1.7a.

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.7 Trunnion Control Failure (Continued)						
b. Fails to Indicate Position (Encoder, Amps, 7 Bar Ckt, TRUNNION ind)			Mission: None Crew: Timeline effect.	Loss of proper control of trunnion and pointing information.	Same as system effect for S073	
Case I. Static or No Reading	TRUNNION ind (U): Does not read (U): Does not change reading when trunnion moves (INTENSITY ind changes reading)	None				1. Use programmer control, and 2. Trunnion moves at 4 deg/sec. Use this to calculate time motor should be on to move desired number of degrees. Check with ground for results.
Case II. Incompatible Readout	TRUNNION ind (U): Does not track with trunnion (mechanical end stops do not read 000 and 120)	None				1. a. Take all possible data within limits of operation, and b. Eject nominally after taking all possible data.
2.2.1.8 Shaft Control Failure						
a. Fails to Move (Either or Both Directions) Note: Same cases and causes as 2.2.1.7a, (substitute shaft for trunnion).	G7015S073/G7025T027 Shaft Position (U): Same as 2.2.1.7a (substitute shaft for trunnion).	Same as 2.2.1.7a (substitute shaft for trunnion)	Mission: None Crew: Timeline effect.	Incomplete data. Also, if failed in any position other than SHAFT ind 040 the boom cannot be retracted into the SAL, and must be ejected.	Same as 2.2.1.7a.	Same as 2.2.1.7a substitute shaft for trunnion, and 040 for 000 (the position for retracting the UXM).

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.8 Shaft Control Failure (Continued)						
b. Fails to Indicate Position Same Cases and Causes as 2.2.1.7b (Substitute Shaft for Trunnion)	Same as 2.2.1.7b (substitute shaft for trunnion, and 000, 374 for 000, 120 as the end stops).	None	Mission: None Crew: Timeline effect.	Loss of proper control of shaft, and pointing information.	Same as system effect for S073.	Same as 2.2.1.7b (substitute shaft for trunnion).
2.2.1.9 Camera Control Failure	K7308S073/K7309T027-Camera Exposure, inconclusive, sample rate too low.	CAMERA SHT lt (U): ON when camera should be operating; or OFF when camera should not be running.	Mission: None Crew: Minimum timeline effect.	Loss of 16 mm camera information.	Same effect for S073 as system effect.	
Case I. Programmer Control (Programmer, Input on OR Gate)						1. Put SEQ sw to START, and 2. Operate CAMERA SHUTTER sw nominally to open and close shutter, and 3. Operate photometer experiment nominally, discontinue 16 mm camera operation.
Case II. Manual Control (CAMERA SHUTTER sw Short/Open, "Man" Flip Flop, Input on OR Gate).						1. Recycle CAMERA SHUTTER sw, and 2. If camera shutter closed, operate SEQ sw nominally, or 3. a. If camera shutter open, operate SEQ sw when FOV and FW not moving, and b. Turn POWER sw to OFF when shutter closes (CAMERA SHT lt on), wait 15 sec, and c. Turn POWER sw to ON, and d. Recycle SEQ sw to operate camera, and

MISSION PHASES: A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

MALFUNCTION ANALYSIS CHART T027

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
2.2.1.9 Camera Control Failure (Continued) Case II. Manual Control (CAMERA SHUTTER sw Short/Open, "Man" Flip Flop, Input on OR Gate). (Continued)						4. Use programmer control of experiment nominally, or 5. Operate photometer experiment nominally, discontinue 16 mm camera operation.
Case III. Auto Sequence (SEQ START sw, F.W. Program Start Ckt, "Seq" OR Gate, Auto Sequencer Ckt, Input on OR Gate)						1. Recycle SEQ sw, and 2. Operate camera manually via CAMERA SHUTTER sw, and 3. Use programmer control nominally, or 4. Operate photometer experiment nominally, discontinue 16 mm camera data.

MISSION PHASES:
A. All Phases
B. Boost to Orbit
C. Activation
D. 1st Visitation
E. 1st Storage
F. 2nd Visitation
G. 2nd Storage
H. 3rd Visitation

SECTION X. CONCLUSIONS AND RECOMMENDATIONS

1. Successful performance of the T-027 Sample Array experiment requires a minimum of astronaut time and involvement. Aside from installation and removal of the experiment from the Solar SAL and stowage in the CM, no active crew participation is required.

2. It is expected that any malfunctions which cannot immediately be corrected by the crew, will result in experiment postponement. If crew time and scheduling constraints permit, ground malfunction procedures may be attempted to continue the performance of the experiment.

REFERENCES

1. Experiment Requirements Document for T-027, Repository No. SE-010-028-2H, Marshall Space Flight Center, Huntsville, Alabama, May 28, 1971.

2. Mission Requirements for Skylab Missions SL-1/SL-2, Vol. I-III, 1-MRD-001E, Marshall Space Flight Center, Huntsville, Alabama, Manned Spacecraft Center, Houston, Texas, June 14, 1972.

3. Skylab Experiment Operations Handbook. Vol. I: Experiment Descriptions, MSC-00924, Manned Spacecraft Center, Houston, Texas, November 19, 1971.

4. Skylab Program Operational Data Book. Vol. I: Experiments Performance Data, Experiment S-009, MSC-01549, Manned Spacecraft Center, Houston, Texas, September 1970.

5. Skylab Flight Plan for SL-1/SL-2, SL-3, and SL-4. Rev. Undefined, GC53-72M-156, Manned Spacecraft Center, Houston, Texas, May 2, 1972.

6. Flight Scheduling Precedence List. NASA, Office of Manned Space Flight, Washington, D. C., October 25, 1972.

7. Skylab Program Directive No. 43B. M-D ML3200.125, NASA Office of Manned Space Flight, Washington, D. C., March 27, 1972.

8. Operating, Maintenance and Handling Procedures for T-027 Sample Array System Flight Hardware. MCR-70-140 (Rev. 1), Martin Marietta Corporation, Denver, Colorado, September 10, 1971.

9. Skylab Program Payload Integration - Experiment Operational Nomenclature Data. ED-2002-1482, Martin Marietta Corporation, Denver, Colorado, May 31, 1972.

10. Mission Level Failure Modes and Effects Analysis - Appendix I, Corollary Experiments. ED-2002-1374, Volume X, Marshall Space Flight Center, Huntsville, Alabama, November, 1971.

11. Assembly Complete - Sample Array. Dwg. No. 89900000100 (Rev. F), Martin Marietta Corporation, Denver, Colorado, February 1, 1971.

12. Seals - Sample Array and Photometer. Dwg. No. 8900000104 (Rev. E), Martin Marietta Corporation, Denver, Colorado, August 27, 1970.

13. Sample Array Assembly. Dwg. No. 89900000110 (Rev. G), Martin Marietta Corporation, Denver, Colorado, January 2, 1972.

14. Cover Plate - Sample Array. Dwg. No. 89900000123 (Rev. F), Martin Marietta Corporation, Denver, Colorado, November 6, 1970.

15. Sample Installation and Sample Details - Sample Array. Dwg. No. 89900000124 (Rev. A), Martin Marietta Corporation, Denver, Colorado, January 19, 1972.

16. Inboard Profile Orbital Workshop. Dwg. No. 1B77075, McDonnell Douglas Corporation-Western Division, Huntington Beach, California, November 10, 1969.

17. Anti-Rotation Assembly Sample Array. Dwg. No. 89900000112 (Rev. E), Martin Marietta Corporation, Denver, Colorado, December 7, 1970.

18. Extension Tube - Sample Array. Dwg. No. 89900000115 (Rev. E), Martin Marietta Corporation, Denver, Colorado, May 9, 1972.

19. Sample Array Logic Diagram. Dwg. No. 89900000167 (Rev. C), Martin Marietta Corporation, Denver, Colorado, September 14, 1970.

20. Schematic Sample Array Power Supply. Dwg. No. 89900000176 (Rev. A), Martin Marietta Corporation, Denver, Colorado, October 29, 1969.

21. Sample Array Electronics Installation. Dwg. No. 89900000177 (Rev. F), Martin Marietta Corporation, Denver, Colorado, January 19, 1971.

22. Sample Array Block Diagram. Dwg. No. 89900000185 (Rev. E), Martin Marietta Corporation, Denver, Colorado, December 31, 1970.

23. Skylab Experiments Systems Handbook. Manned Spacecraft Center, Houston, Texas, October 29, 1971.

24. Acceptance Test Procedures for T-027 - Test and Checkout Procedure. Dwg. No. 1B86432 (Rev. A), McDonnell Douglas Corporation-Western Division, Huntington Beach, California, March 23, 1972.

25. Sample Array, Valve Actuator Assembly. Dwg. No. 89900000118 (Rev. B), Martin Marietta Corporation, Denver, Colorado, September 11, 1970.

26. Input Filter Assembly, Power Supply. Dwg. No. 89900000183 (Rev. D), Martin Marietta Corporation, Denver, Colorado, July 22, 1970.

27. Inductors and Transformers, Power Supply. Dwg. No. 89900000186 (Rev. E), Martin Marietta Corporation, Denver, Colorado, November 23, 1970.

28. Preamp Assembly, Power Supply. Dwg. No. 89900000188 (Rev. D), Martin Marietta Corporation, Denver, Colorado, July 12, 1970.

29. Chopper No. 1 Assembly, Power Supply. Dwg. No. 89900000190 (Rev. C), Martin Marietta Corporation, Denver, Colorado, July 22, 1970.

30. Output Filter Assembly, Power Supply. Dwg. No. 89900000196 (Rev. C), Martin Marietta Corporation, Denver, Colorado, July 21, 1970.

31. Chopper No. 2 Assembly, Power Supply. Dwg. No. 89900000200 (Rev. B), Martin Marietta Corporation, Denver, Colorado, July 21, 1970.

32. Operational Plan for the Quartz Crystal Microbalance on the T-027 Sample Array. TM-015-002-2H, Marshall Space Flight Center, Huntsville, Alabama, April 19, 1971.

33. Wilcoxson, C. B., et al: Mission Operations Design Support, Volume III. OWS Experiments Malfunction Analyses, Rev. A, ED-2002-1244, Martin Marietta Corporation, Denver, Colorado, May 12, 1972.

*U.S.GOVERNMENT PRINTING OFFICE: 1973-746-827/4778