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SKYLAB EXPERIMENT PERFORMANCE EVALUATION MANUAL

Appendix E: Experiment M512 Materials Processing Facility (MSFC)

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16. ABSTRACT

This appendix contains a series of analyses for Experiment M512, Materials Processing Facility (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.

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APPENDIX E. M-512 MATERIALS PROCESSING FACILITY (MSFC)

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DEFINITION OF SYMBOLS

ADJ	Adjust
ADV	Advance
BAT.	Battery
BATT	Battery
CAM	Camera
cb	Circuit Breaker
CHMBR	Chamber
CONT	Control
cres	Corrosion Resistant Steel
CSTR	Canister
ctr	Center
CUR	Current
$C_3 F_8$	Perfluoropropane Gas
DAC	Data Acquisition Camera
DISCH	Discharge
EBG	Electron Beam Gun
FBD	Functional Block Diagram
FIL	Filament
FO	Functional Objective
HI	High
HOSC	Huntsville Operation Support Center
INTLK	Interlock
LT	Light
lt	Light
MDA	Multiple Docking Adapter
MPF	Materials Processing Facility
MSC	Manned Spacecraft Center

DEFINITION OF SYMBOLS (CONCLUDED)

MSFC	Marshall Space Flight Center
N/A	Not Applicable
NOM	Nominal
OPR	Operator
OWS	Orbital Workshop
P_{f_n}	Net Probability of Failure
P_{f_t}	Total Probability of Failure
PI	Principal Investigator
pot	potentiometer
PRESS	Pressure
P_s	Probability of Success
REPRESS	Repressurization
SEPEM	Skylab Experiment Performance Evaluation Manual
SEQ	Sequence
STS	Structural Transition Section
sw	Switch
TEMP	Temperature
vlv	Valve

SECTION I.

M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 1 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER*	REMARKS
	MIN.	NOM.	MAX.		
3.0 Analyze and predict Skylab M-512 Materials Processing Facility (MPF), facet performance profile.				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 MPF is required to operate and support experiment operations.				N/A	The approximate time in hours and minutes required for the MPF to operate and perform the experiment is: • MPF Preparation Requirements --Crew Time TBD min --Total MPF Time TBD min • Experiment M-551, Metals Melting --Preparation 0:09 --Operation 8:00 (Includes 2.5 hr cooldown time for each of 3 disc) --Termination 0:19 • Experiment M-552, Exothermic Brazing --Preparation 0:04 --Operation 8:16 (Includes 2 hr cooldown time for each of 4 specimens) --Termination 0:06 • Experiment M-553, Sphere Forming --Preparation/Operation 0:39 --Termination 0:22

*Criticality Category Number Definition:

- Category I--MPF equipment whose failure could adversely affect crew safety.
- Category II--MPF equipment whose failure could result in not achieving a primary mission objective, but does not adversely affect crew safety.
- Category IIIa--MPF 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--MPF equipment whose failure could not result in a loss of primary or secondary mission objective and does not adversely affect crew safety.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 2 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.1.1 (Concluded)					• Experiment M-518, Multipurpose Electric Furnace --Crew Time 12:35 --Total Experiment Time 326:49 • Experiment M-555, Single Crystal Growth --Preparation/Operation 124:22 --Crew time required to monitor 1:45 --Termination 0:22 • Experiment M-479, Zero Gravity Flammability --Preparation 0:25 (Total preparation time for all tests) --Operation 4:56 (37 tests) --Termination 0:09 (Equipment and film stowage)
					References 1 and 2.
3.1.2 Specify the types of criteria that are to be maximized or minimized.				N/A	The Functional Objectives (FO's) for M-512 MPF are not defined because M-512 MPF is not an experiment per se. The objective of the M-512 MPF is to provide a common spacecraft interface for a group of experiments in materials science technology. Reference 4.
3.1.3 Specify the percentage of acceptable max./min. for each objective.				N/A	The FO's and relative weights of the FO's for the M-512 MPF are not defined; however, the basic objective of the MPF is • Provide a common spacecraft facility for a group of experiments. It is not considered feasible or meaningful to assign a performance value to this objective because of the difficulty in determining the percentage of the interface requirements that are met for each of the experiments that use the MPF.
3.1.4 Specify experiment constraints: • Musts • Must Nots • Wants • Don't Wants.				N/A	• Musts --The electron beam gun (EBG) must be operated in a space vacuum to prevent the filament from burning out --The experiment battery must be totally discharged when the experiment performance is complete.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 3 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.1.4 *(Concluded)*					• Must Nots --The EBG is not to be operated if the EBG canister pressure is below 24 psia. • Wants --Astronaut voice comments will be recorded and pertinent observations entered in the experiment logbook. • Don't Wants --N/A. References 3 and 4.
3.1.5 Specify experiment operational tolerances: • Musts • Must Nots • Wants • Don't Wants.				N/A	Refer to functional item 3.1.4. Specific tolerances for each constraint in functional item 3.1.4 are: • Musts --Work chamber pressure < 1 x 10^{-4}* torr for experiments requiring the EBG. • Must Nots --Canister pressure < 24 psia for experiments requiring the EBG. • Wants --N/A • Don't Wants --N/A.
3.2 Define decision rules and success criteria for the MPF objectives.				N/A	If the MPF is aborted, then the probability of success (P_s) is equal to 0.0. If the MPF 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 MPF is completed as scheduled, P_s = 1.0. These values are subjective estimates. The success criterion is: • To provide adequate facilities to conduct the Materials Technology experiments.
3.3 Specify experiment priority (numerical statement) for a given Skylab flight designation.				N/A	The scheduling precedence (priority) No. is N/A.

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*There is inconsistency in the documentation for experiment vacuum requirements using the M-512 MPF. This value is based on the most strenuous requirement shown in the Mission Rules (March 1, 1973).

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 4 of 38)

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 subsystem for Experiment M-512.				N/A	Refer to functional items 3.4.1 and 3.4.2.
3.4.1 Describe the major functions.				N/A	The vacuum chamber assembly provides a facility to perform experiments under controlled environmental conditions. The experiments utilizing the vacuum chamber are M-479, M-551, M-552, M-553, M-518, and M-555. The electron beam subsystem is an EBG that emits electrons from a hot filament to cut, melt, and weld metals. The experiments utilizing the EBG are M-551 and M-553. The MPF has two power sources: one is AM Bus 1, and the other is a self-contained battery. The battery is a silver-zinc battery, rated at 28 to 31 Vdc nominal at 100 A. The experiments utilizing battery power are M-551, M-552, and M-553. The water quench facility is used to extinguish burning samples in the vacuum chamber. Experiment M-479 utilizes the water quench system. The control panel facility is used to control the operation of the experiments. The experiments utilizing the control panel facility are M-479, M-551, M-552, M-553, M-518, and M-555. References 3, 4, and 5.
3.4.2 List the major components.				N/A	A Functional Block Diagram (FBD) is submitted as Figure E-1, and is used as a subsystem component listing. The major subsystem components of Experiment M-512 are: • MPF Honeycomb Mounting Panels • EBG Assembly • Vacuum Work Chamber Assembly • Floodlight • Control Panel • Battery • Water Quench System • Vent Valves (2)[4-in. vent valves provided by the Mulitple Docking Adapter (MDA)] • Vent Lines (4-in. vent lines provided by MDA) • Camera Mount

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 5 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.4.2 (Concluded)					• Equipment Storage Container • Flammability Specimen Container. Reference 4.
3.5 Specify the interfaces between the M-512 MPF and the Experiments, Crew, and Carrier. • Physical --Mechanical --Electrical --Communication and Data --Support • Environmental --Natural and Induced --Contamination • Operational --Pointing and Control --Crew Safety --Sequence --Operability.				N/A	An interface block diagram is submitted as Figure E-2 and is used to define the interfaces for the M-512 MPF. Critical subsystem components will be identified and evaluated for failure, and correlated to possible interface problems between the M-512 MPF and the Experiments, Crew, and Carrier. References 3 and 4.
3.5.1 Specify the total probability of failure (P_{f_t}) for the MPF honeycomb mounting panels.		nil		IIIa	The honeycomb mounting panels serve as a mechanical support for the other MPF hardware as well as the hardware for the experiments that use the MPF. The panels are attached to the MDA structure with shock mounts. The panels are made of an aluminum alloy. If the panels should fail, the following condition could occur: • Support --If a structural failure occurred in the mounting panel, the MPF could become poorly supported causing a partial or complete failure of the facility. This failure is unlikely to happen because the mounting panels are secured to the MDA at several attach points. The following indication can be used to determine the failure of the honeycomb mounting panels:

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 6 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.1 (Concluded)					• This failure can be detected by astronaut observation and decisions can be made on whether or not the facility is capable of performing its function. References 3, 4, 6, and 7.
3.5.2 EBG Assembly.				N/A	The electron beam subsystem is a gun that emits electrons from a hot filament. The electrons are accelerated by a high potential of 20 kV and then regulated and focused to bombard the workpiece. The filament serves as the source of electrons which then pass through the cathode bias cup causing them to converge and pass through a hole in the center of the anode. The anode acts much like the plate in a vacuum tube except that the electrons are diverted purposely to avoid hitting it. The velocity of the electrons is a function of the potential between the cathode and anode; the highest velocity is at the anode. The focus coil causes the electron beam to converge on the sample. Refer to functional items 3.5.2.1 through 3.5.2.3.
3.5.2.1 Specify the P_{f_t} and the net probability of failure (P_{f_n}) for the head section.		$P_{f_t} = 0.1$		IIIa	In the head section, the output of a high voltage inverter is rectified, filtered, and fed to the EBG. The head section contains perfluoropropane gas (C_3F_8) that provides better insulation against high voltage than air and allows a more compact system with an extra measure of safety. If the head section should fail, the following condition could occur: • Support --A short or any other electrical malfunction in the head section because of a faulty component could cause a partial or complete failure of Experiments M-551 and M-553. --If the head section developed a leak and allowed the head section pressure to bleed down, the insulating qualities of C_3F_8 would be reduced and could allow high voltage breakdown. This could cause a complete or partial failure of the EBG. The following indications can be used to determine the failure of the head section: • The electrical components are sealed in an electronics canister. An electrical failure would be evident by the EBG being inoperable or operating in a degraded mode. The performance of the EBG can be monitored by the BEAM CUR and voltmeter gages on the ELECTRON BEAM section of the control panel. Electrical malfunctions or failures of the EBG head section will be difficult to detect or troubleshoot. • A leak in the head section could be determined by placing the INSTRUMENTATION CSTR X3 sw in the CSTR X3 position and reading the INSTRUMENTATION PRESS gage. The switch and gage are both located on the INSTRUMENTATION section of the control panel
		$P_{f_n} = 0.08$			
		$P_{f_n} = 0.02$			

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 7 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.2.1 (Concluded)					References 4, 6, and 8.
3.5.2.2 Specify the P_{f_t} and the P_{f_n} for the head section power supply.		P_{f_t} = 0.1		IIIa	The head section power supply contains the electronics to convert the low voltage, high current battery output to a high voltage, low current supply required by the EBG electronics. Both the power supply and the head section contain C_3F_8 for high voltage insulation. For P_{f_n} and failure impacts on interfaces, refer to functional item 3.5.2.1. The following indications can be used to determine the failure of the head section power supply: • The electrical components are sealed in an electronics canister. An electrical failure would be evident by the EBG being inoperable or operating in a degraded mode. The performance of the EBG can be monitored by the BEAM CUR and voltmeter gages on the ELECTRON BEAM section of the control panel. Associating an electrical failure with the head section power supply will be difficult.
		P_{f_n} = 0.08			
		P_{f_n} = 0.02			• The environmental failure could be determined by placing the INSTRUMENTATION CSTR X3 sw in the CSTR X3 position and reading the INSTRUMENTATION PRESS gage. If the PRESS gage reads less than 8 psia, the canister pressure is too low for EBG operation. This switch and gage are both located on the INSTRUMENTATION section of the control panel.
					References 4, 6, and 8.
3.5.2.3 Specify the P_{f_t} for the FILAMENT CHAMBER VENT valve.		0.1			The FILAMENT CHAMBER VENT valve is a hand-operated shuttle valve that closes off the EBG filament from the work chamber. Before the work chamber is exposed to the MDA atmosphere, the valve will be closed to prevent the EBG filament from being contaminated with the MDA atmosphere and causing a possible filament burnout. A microswitch is connected to the valve which serves as a system interlock during normal operations so that the high voltage cannot be applied to the filament when the valve is closed. If the valve should fail, the following conditions could occur:
				IIIa	• Support --If the valve were to fail closed, the filament chamber interlock microswitch (S27) would be open preventing the high voltage from being applied to the EBG filament. Although redundant switching capability is provided by the FIL CHMBR INTLK sw (S13) to provide high voltage to the filament, the valve will physically block the electron beam from the filament to the work piece. This failure will prohibit the use of the EBG.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 8 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.2.3 (Concluded)				IIIb	• Contamination --If the valve were to fail open, the filament chamber interlock microswitch (S27) would be closed allowing the high voltage to be applied to the EBG filament. This would not prohibit the use of the EBG, but this failure could allow the filament to be exposed to the MDA atmosphere when the chamber was repressurized. This could cause a possible filament burnout because of filament oxidation. The following indication can be used to determine the failure of the vent valve: • This failure can be detected by the astronaut when an attempt is made to open or close the valve. References 4, 9, and 10.
3.5.3 Vacuum Work Chamber Assembly.				N/A	The vacuum work chamber assembly provides a facility to perform experiments under controlled environmental conditions. Refer to functional items 3.5.3.1 through 3.5.3.9.
3.5.3.1 Specify the Pf_t for the work chamber.		0.1		IIIa	The work chamber is a sphere designed to withstand a minimum pressure of 1×10^{-6} torr and a maximum pressure of 20 psia. If the metal chamber should fail, the following condition could occur: • Support --If a structural failure occurred and the metal work chamber developed a pressure leak, a partial or complete failure of the MPF would occur. If the two vent valves were open at the time of the rupture, it would expose the MDA atmosphere to the space vacuum. This would cause possible crew hazard until the vacuum vent valves could be closed. The following indications can be used to determine the failure of the work chamber: • Before the first experiment on each mission starts, procedural MPF checkout could point out a pressure leak. • After the experiment starts, the astronaut may be able to detect a pressure leak by monitoring the FIL CHMBR PRESS gage (M3) when the FILAMENT CHAMBER VENT valve is open. • If the peressure leak is large enough, the astronaut may be able to monitor it on the INSTRUMENTATION PRESS gage (M3) or may hear the MDA atmosphere escaping.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 9 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.1 (Concluded)					References 4 and 8.
3.5.3.2 Specify the Pf_t for the work chamber hatch.		0.1		IIIa	The hatch is hinged to the vacuum work chamber and is used to install or remove experiment equipment. If the hatch should fail, the following conditions could occur: • Support --Refer to functional item 3.5.3.1. The following indication can be used to determine the failure of the hatch: • Refer to functional item 3.5.3.1. References 4 and 8.
3.5.3.2.1 Specify the Pf_t for the hatch viewport window.		0.1		IIIa	The hatch has an x-ray proof glass viewing port to protect the astronaut from radiation while observing Experiment M-551 and M-553. The window is 0.25 in. thick. The radiation shielding quality of this window is equivalent to 0.0625 in. of lead. If the window should fail, the following condition could occur: • Support --If the window were to crack, producing a pressure leak, this could cause a partial or complete failure of the MPF. Refer to functional item 3.5.3.1. The following indication can be used to determine the failure of the hatch viewport window: • Refer to functional item 3.5.3.1. References 4, 8, and 11.
3.5.3.3 Specify the Pf_t for the camera port window.		0.1		IIIa	The camera port is located under the chamber with a bayonet adapter attached next to it for mounting the 16mm Data Acquisition Camera (DAC). The window is made of photographic quality lead glass (x-ray lead glass) and is 0.25 in. thick. The radiation shielding quality of this window is equivalent to 0.0625 in. of lead. This window will help protect the film from the electron beam radiation while filming Experiments M-551 and M-553. If the window should fail, the following condition could occur: • Support --If the window were to crack, producing a pressure leak, this could cause a partial or complete failure of the MPF. Refer to functional item 3.5.3.1.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 10 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.3 (Concluded)					The following indication can be used to determine the failure of the window: • Refer to functional item 3.5.3.1. References 4 and 11.
3.5.3.4 Specify the P_{f_t} for the zero-g connector.		0.1		IIIa	The zero-g connector is housed in the vacuum work chamber and serves as the power outlet for all the experiments that use the M-512 facility except M-518 Multipurpose Electric Furnace. If the connector should fail, the following conditions could occur: • Support --The female end of the connector is mounted in the vacuum work chamber. If there is an insulation breakdown inside the connector, causing an arc over between the contacts, this could cause a partial or complete failure of the MPF for the experiments utilizing the facility power outlet. • Electrical --A failure of the connector, which causes an overload condition, would open the M-512 circuit breaker on Panel 202 in the Structural Transition Section (STS). The following indication can be used to determine the failure of the zero-g connector: • This failure may be difficult to determine. If the experiments are not functioning as they should, it may be due to inadequate power. The zero-g connector insulation breakdown may be visible to the astronaut. Reference 4.
3.5.3.5 Specify the P_{f_t} for the heat sink.		0.1		IIIa	The heat sink is a recess in the vacuum work chamber. The purpose of the heat sink is to house experiments, which operate at high temperatures over an extended period of time, and to help remove heat from the work chamber. If the heat sink should fail, the following condition could occur: • Support --Refer to functional item 3.5.3.1. The following indication can be used to determine the failure of the heat sink: • Refer to functional item 3.5.3.1.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 11 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.5 (Concluded)					Reference 4.
3.5.3.6 Specify the Pf_t for the tungsten target.		nil		IIIa	A tungsten shield is permanently mounted in the work chamber. The shield, attached to the chamber wall directly opposite from the EBG, protects the wall from the electron beam. If the target should fail, the following condition could occur: • Support --If a structural failure occurs and the target becomes unattached from the vacuum chamber wall, this could prevent the use of the EBG for Experiment M-553. The only way that the facility would be affected is that the vacuum chamber wall would be exposed to the electron beam. A decision would have to be made on whether or not to continue the EBG experiments. The following indication can be used to determine the failure of the tungsten target. • This failure can be determined by astronaut observation. Reference 4.
3.5.3.7 Specify the Pf_t for the photo light.		0.1		IIIb	The bare filament light or photo light is permanantly mounted inside the vacuum work chamber and is housed in a base assembly. The photo light is used for photographic illumination of Experiment M-551. If the photo light should fail, the following condition could occur: • Communication and Data --If a short, open, or filament burnout occurs in the photo light assembly, this would render the light inoperable. This may degrade the quality of the photography as the floodlight could be used to assist in the photography. The facility could still operate. The following indication can be used to determine the failure of the photo light: • This failure can be determined by astronaut observation. References 4 and 12.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 12 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.3.8 Specify the P_{f_t} and the P_{f_n} for the permanently mounted camera deflection mirror.		P_{f_t} = 0.1 P_{f_n} = 0.01 P_{f_n} = 0.09		IIIb	This mirror is permanently mounted inside the vacuum chamber. The purpose of the mirror is to reflect the camera line of sight from the CAMERA MIRROR to the electron beam and work piece. The mirror is made of fused silica 7940 with dimensions of 1.375 by 0.984 by 0.216 in. If the mirror should fail, the following conditions could occur: • Communication and Data --If a structural failure occurred, cracking, breaking, or detaching the mirror assembly from the vacuum work chamber, photographing Experiment M-551 would be difficult. --If, during the process of performing an experiment, the mirror reflection capability is degraded because of smoke or other residue, the photography of that particular experiment will be degraded. The following indication can be used to determine the failure of the permanently mounted camera deflection mirror: • This failure can be detected by astronaut inspection of the deflection mirror. References 4 and 11.
3.5.3.9 Specify the P_{f_t} for the hatch o-rings.		0.1		IIIa	There are two o-rings that form a seal between the hatch and the vacuum chamber when the hatch is closed and secured. These o-rings are made of Viton A. In simulating the experiment tasks, the hatch has been opened and closed many times without a failure. If the o-rings should fail, the following condition could occur: • Support --If a structural failure occurred, causing the o-rings to break or crack, allowing the MDA atmosphere to escape, this would cause a partial or complete failure of the MPF. A decision can be made on whether or not to continue to use the vacuum facility once it is determined how long the chamber can maintain a vacuum above the allowable level. The following indication can be used to determine the failure of the o-rings: • Refer to functional item 3.5.3.1. References 11 and 13.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 13 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.4 Specify the Pf_t for the floodlight.		0.1		IIIb	The floodlight is mounted on the vacuum chamber next to the camera port, and will be used to illuminate the interior of the chamber. The light will operate on 28 Vdc. This lighting assembly will be enclosed with a protective heat shield. The floodlight is used in Experiment M-479 to film Sample I. D. and it flashes at the end of the time allowed for sample combustion to provide a photographic data reference. If the light should fail, the following conditions could occur: • Operability --If a short, open, or filament burnout occurs in the floodlight assembly, this would degrade the illumination effect inside the chamber which could affect the installation of equipment. Another light source may have to be obtained. • Communication and Data --If the floodlight fails, a portion of Experiment M-479 photographic data will be lost. • Electrical --The POWER CONTROL AM BUS 1 cb on the M-512 control panel should protect the carrier from an overload condition caused by the floodlight when the floodlight is operating on AM BUS 1 power. The following indication can be used to determine the floodlight failure: • The failure can be determined by astronaut observation. References 4 and 14.
3.5.5 Controls and Displays.				N/A	Refer to functional items 3.5.5.1 and 3.5.5.2.
3.5.5.1 Control Panel.		0.1		N/A	The control panel includes most of the controls and displays required for the experiment using the M-512 facility. The panel has a friction-hinged cover that remains open when lifted. The control panel contains the following circuit breakers, switches, gages, lights, and potentiometers: • POWER CONTROL BATT cb (CB2) • POWER CONTROL AM BUS 1 cb (CB4) • POWER FIL BATT cb (CB3) • FLOOD LT sw (S19)

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 14 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.5.1 (Continued)					• INSTRUMENTATION POWER sw (S2) • INSTRUMENTATION PRESS gage (M5) • INSTRUMENTATION TEMP SOURCE selector sw (S9) • INSTRUMENTATION TEMP gage (M4) • INSTRUMENTATION CSTR X3 sw (S1) • INSTRUMENTATION BASE + METER sw (S8) • INSTRUMENTATION BASE TEMP °C selector sw (S5) • ELECTRON BEAM POWER sw (S3) • FIL CHMBR PRESS gage (M3) • FIL/BEAM CONT sw (S12) • FIL CHMBR INTLK sw (S13) • BEAM CUR gage (M2) • PHOTO LT sw (S4) • EXP ADV sw (S16) • READY lt (L4) • ELECTRON BEAM voltage gage (M1) • BEAM CONTROL CUR ADJ pot • BEAM CONTROL FOCUS ADJ pot • BEAM CONTROL ALIGN X pot • BEAM CONTROL ALIGN Y pot • HI VOLT/CAM sw (S14) • EXOTHERMIC POWER sw (S15) • EXOTHERMIC SPECIMEN selector sw (S7) • EXP HOT lt (L2) • EXOTHERMIC TRIGGER sw (S6) • COMPOSITE CASTING POWER sw (S25) • COMPOSITE CASTING THERMAL MODE sw (S26) • CRYSTAL GROWTH POWER sw (S10)

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TABLE E-1. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 15 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.5.1 (Concluded)					• FLAMMABILITY POWER sw (S21) • FLAMMABILITY SAMPLE I.D. sw (S20) • FLAMMABILITY TEST TIME SECONDS selector sw (S22) • FLAMMABILITY TEST TIME ELAPSED lt (L7) • FLAMMABILITY SEQ READY sw (S18) • FLAMMABILITY SEQ READY lt (L6) • FLAMMABILITY SEQ DATA sw (S17). References 4, 10, and 14.
3.5.5.2 Other controls and displays.		0.1		N/A	The M-512 facility contains three circuit breakers and one display not located on the control panel. They are: • MAIN BATTERY cb (CB1) • BATTERY DISCHARGE cb (CB6) • DISCHARGE lt (L8) located on a panel directly above the battery case • CRYSTAL GROWTH HEATING PAD AM BUS 1 cb (CB5) located on the Line Filter box immediately to the right of the M-512 control panel. References 4 and 14.
3.5.6 Specify the Pf_t and the Pf_n for the battery.		0.1		IIIa	The MPF has two power sources; one is AM Bus 1 and the other is a self-contained MPF battery. The battery section contains a silver-zinc battery, rated at 28 to 31 Vdc nominal at 100 A. The battery case is vented to the outside of the MDA through two 5 psia check valves and a hand-operated vent valve on the MDA Panel 103. The vent valve is open at launch and normally remains open. The battery is discharged through the 5 A push-pull BATTERY DISCHARGE circuit breaker (CB6) after the battery operated experiments are completed. If the battery should fail, the following conditions could occur: • Support --If the battery plates short out, this would cause a partial or complete failure of the MPF for the experiments utilizing battery power. Shorting out of the battery plates would degrade the performance of the battery. --If the battery were to overheat and rupture, this would cause a complete failure of the MPF for the experiment utilizing the battery power.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 16 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.6 (Concluded)					The following indication can be used to determine the failure of the battery: • Battery failure may be difficult to determine. The battery is enclosed in the battery case and there is no telemetry or instrumentation to determine the condition of the battery. If battery power cannot be received with the switches and circuit breakers in the proper positions, the battery could have malfunctioned. References 4 and 5.
3.5.7 Water Quench System.				N/A	Experiment M-479 utilizes the water quench system provided by the M-512 MPF to extinguish burning material. The water is supplied from the Orbital Workshop (OWS) water tank No. 6 through an umbilical to the MPF. Refer to functional items 3.5.7.1 through 3.5.7.2.3.
3.5.7.1 Specify the Pf_t and the P_{f_n} for the water ACCUMULATOR.		$Pf_t = 0.1$		IIIb	The water ACCUMULATOR is a reservoir for the water required in the water quench system. This reservoir will hold the 2 oz of water that is required for each quench. When the WATER SPRAY valve is opened, 2 oz of water will be forced into the vacuum chamber to quench the burning specimens.
		$Pf_n = 0.05$			If the ACCUMULATOR should rupture, the following conditions could occur: • Communication and Data --If the water ACCUMULATOR ruptures, this would terminate the water quench portion of Experiment M-479 causing a partial loss of data. • Contamination --If the water ACCUMULATOR ruptures, this would allow water to be dispersed into the MDA atmosphere.
		$Pf_n = 0.05$			If the ACCUMULATOR piston sticks, the following conditions could occur: • Communication and Data --The proper amount of water would not automatically be dispensed into the work chamber. This would cause degradation of Experiment M-479 data. • Operability --The crewman would open the WATER ACCUMULATOR FILL valve and then open the WATER SPRAY valve. This would spray water into the work chamber. The crewman will estimate when the proper amount of water was sprayed into the work chamber and then close the WATER SPRAY valve.

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TABLE E-1. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 17 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.7.1 (Concluded)					The following indication can be used to determine the failure of the water ACCUMULATOR: • The failure can be detected by astronaut inspection of the water ACCUMULATOR. References 4, 7, and 15.
3.5.7.2 Water Valves.				N/A	There are two water valves and one system purge valve in the MPF water quench system. Refer to functional items 3.5.7.2.1 through 3.5.7.2.3.
3.5.7.2.1 Specify the Pf_t for the WATER ACCUMULATOR FILL valve.		0.1		IIIb	The WATER ACCUMULATOR FILL valve is a hand-operated valve that allows the water to be transferred from the lower to the upper part of the ACCUMULATOR. If the valve should fail in the CLOSED position, the following condition could occur: • Communication and Data --This would cause a complete failure of the MPF water quench system. A decision could be made on whether or not to run the water quench portion of the experiment and use the vacuum quench to extinguish the specimens. If the valve should fail in the OPEN position, the following condition could occur: • Refer to functional item 3.5.7.1 under ACCUMULATOR piston failure. The following indication can be used to determine the failure of the valve: • Refer to functional item 3.5.2.3. References 4 and 7.
3.5.7.2.2 Specify the Pf_t for the WATER SPRAY valve.		0.1		IIIb	The WATER SPRAY valve is a hand-operated valve that opens the line from the water ACCUMULATOR to the spray nozzles in the vacuum work chamber. If the valve should fail in the CLOSED position, the following conditions could occur: • Communication and Data --This would cause a complete failure of the MPF water quench system. A decision could be made on whether or not to run the experiment or use the vacuum quench to extinguish the specimens. If the valve should fail in the OPEN position, the following condition could occur:

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 18 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.7.2.2 (Concluded)					• Refer to functional item 3.5.7.1 under ACCUMULATOR piston failure. The following indication can be used to determine the failure of the water spray valve: • Refer to functional item 3.5.2.3. References 4, 7, and 16.
3.5.7.2.3 Specify the P_{f_t} for the SYSTEM PURGE valve.		0.1		IIIb	The SYSTEM PURGE valve is a hand-operated valve that is used to vent the air from the water lines prior to the initial operation of the water system. Once the system has been evacuated, the purge valve is CLOSED and remains CLOSED. If the valve should fail in the CLOSED position, the following conditions could occur: • Communication and Data --Air could not be vented from the lines. Both air and water in the lines would degrade the operation of the MPF extinguishing system. If the valve should fail in the OPEN position, the following condition could occur: • This would cause a partial failure of the MPF water quench system. The water would spray from the purge line rather than from the spray nozzles. The following indication can be used to determine the failure of the system purge valve: • Refer to functional item 3.5.2.3. References 4, 7, and 16.
3.5.8 Vent Valves.				N/A	The vent valves are used in the venting system to obtain the desired atmospheric pressure for the experiments using the MPF. Refer to functional items 3.5.8.1 through 3.5.8.6. The work chamber vent valve is MDA hardware but because of its importance to the experiments, it is considered here with the M-512 MPF.
3.5.8.1 Specify the P_{f_t} for work chamber vent valve.		0.1			The vent valve is a three-position (OPEN, CLOSE, and VENT) hand-operated valve at the work chamber end of the 4-in. vacuum vent line. This valve opens or closes the line from the work chamber to the bulkhead vent valve, and vents the chamber for vacuum quench of Experiment M-479.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 19 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.8.1 (Concluded)				IIIa	If the valve should fail in the CLOSED position, the following condition could occur: • Support --This would cause a complete failure of the MPF.
				IIIb	If the valve should fail in the OPEN or VENT position, the following condition could occur: • Operability --The bulkhead vent valve instead of the work chamber vent valve will be used to vacuum quench Experiment M-479 specimens. The following indication can be used to determine the failure of the work chamber vent valve: • Refer to functional item 3.5.2.3. References 4 and 16.
3.5.8.2 Specify the Pf_t for the bulkhead vent valve.		0.1			The bulkhead vent valve is MDA hardware but because of its importance to the experiments, it is considered here with the M-512 MPF. The bulkhead vent valve is a three-position (OPEN, CLOSE, and VENT) hand-operated valve at the bulkhead end of the 4-in. vacuum vent line. This valve opens and closes the line from the space environment to the work chamber vent valve.
				IIIa	If the vent valve should fail in the CLOSE position, the following condition could occur: • Support --Refer to functional item 3.5.8.1.
				IIIb	If the bulkhead vent valve should fail in the OPEN or VENT positions, the experiments could still be performed. This would eliminate redundant vent valve capability but would not affect the interfaces listed in functional item 3.5. The following indication can be used to determine the failure of the bulkhead vent valve: • Refer to functional item 3.5.2.3. References 4 and 16.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 20 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.8.3 Specify the P_{f_t} for the CHAMBER REPRESS valve.		0.1			The CHAMBER REPRESS valve is a two-position (OPEN and CLOSED) hand-operated valve that vents the work chamber to the MDA atmosphere for pressure equalization.
				IIIb	If the valve should fail in the CLOSED position, the following conditions could occur: • Operability --While the work chamber is under vacuum conditions, this would cause a partial failure of the MPF. The chamber could be repressurized through the vacuum cleaner port.
				IIIa	If the valve should fail in the OPEN position, the following condition could occur: • Support --This would cause a complete failure of the MPF for the experiments requiring a vacuum to operate. The following indication can be used to determine the failure of the repressurization valve: • Refer to functional item 3.5.2.3. References 4, 7, and 16.
3.5.8.4 Specify the P_{f_t} for the battery case 5 psia check valves.		0.1		IIIb	The battery case is vented to the outside of the MDA through two 5 psia check valves and a hand-operated vent valve on the MDA Panel 103. If a valve should fail, the following conditions could occur: • If one check valve were to fail in either the open or closed position, there would be no affect on the interfaces listed in functional item 3.5 since redundant check valves are used. The following indication can be used to determine the failure of a battery case 5 psia check valve: • This failure cannot be detected. References 4 and 16.
3.5.8.5 Specify the P_{f_t} for the M512 BAT.VENT valve.		0.1		N/A	The M512 BAT. VENT VALVE is MDA hardware but because of its importance to the experiments, it is mentioned here with the M-512 MPF.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 21 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.8.5 (Concluded)					The battery case is vented to the outside of the MDA through two 5 psia check velves and the hand-operated vent valve on the MDA Panel 103. The vent valve is OPEN at launch and normally remains OPEN. If the valve should fail, the following conditions could occur: • If the vent valve were to fail in the OPEN position, there would be no affect on the interfaces listed in functional item 3.5 because this is the normal operating position of the valve. • If the vent valve were to fail in the CLOSE position, the battery would not be able to vent to space. This failure should be detected prior to launch and corrected. The following indication can be used to determine the failure of the vent valve: • This failure should be detected prior to launch. References 4 and 16.
3.5.8.6 Specify the Pf_t for the FILAMENT CHAMBER VENT valve.		0.1			Refer to functional item 3.5.2.3.
3.5.9 Vent Lines.				N/A	The 4-in. vent line is MDA hardware but because of its importance to the experiments, it is considered here with the M-512 MPF. The vent lines are used in the venting system to obtain the desired atmospheric pressure for the experiments using the MPF. Refer to functional items 3.5.9.1 through 3.5.9.3.
3.5.9.1 Specify the Pf_t for the 4-in. diam vacuum line.		0.1		IIIa	The vent line connects the work chamber to the MDA bulkhead. This line has two valves, and when the valves are open, the work chamber vents to the space environment. If the line should fail, the following condition could occur: • Support --If the 4-in. diam vent line should rupture, this would cause a complete failure of the MPF for the experiments requiring a vacuum to operate. If this failure occurs, the two vent valves should be closed to prevent the loss of the cluster atmosphere.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 22 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.9.1 (Concluded)					The following indication can be used to determine the failure of the 4-in. diam vent line: • Refer to functional item 3.5.3.1. References 4 and 16.
3.5.9.2 Specify the P_{f_t} for the chamber repressurization vent line.		0.1		IIIa	The chamber repressurization vent line is used to equalize the pressure between the work chamber and the MDA atmosphere. If the line should fail, the following conditions could occur: • Support --If the chamber repressurization vent line should rupture, this would cause a complete failure of the MPF for the experiments requiring a vacuum to operate. The following indication can be used to determine the failure of the chamber repressurization vent line: • Refer to functional item 3.5.3.1. References 4 and 16.
3.5.9.3 Specify the P_{f_t} for the battery case vent line.		nil		I	The battery case vent line is used to vent the battery case to the space atmosphere when the pressure is great enough to activate the battery case 5 psia check valves. Part of the line is considered M-512 MPF and part of it is considered MDA hardware. If the vent line should fail, the following condition could occur: • Crew Safety --If the vent line ruptures between the battery case and the M512 BAT. VENT VALVE, this would allow the MDA atmosphere to escape until the M512 BAT. VENT VALVE could be placed in the CLOSE position. This would allow the battery gases to escape into the MDA and contaminate the atmosphere. --If the vent line ruptures between the M512 BAT. VENT VALVE and the MDA wall, this would allow the MDA atmosphere to escape into space. • Crew Safety --If the MDA vent line should rupture, this would allow the battery case to vent into the MDA and contaminate the atmosphere. The following indication can be used to determine the failure of the battery case vent line:

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 23 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.9.3 (Concluded)					• This failure could be detected by astronaut inspection of the vent line if the rupture caused a hole or crack large enough. If the hole or crack were small, the failure could be hard to detect. References 4, 16, and 17.
3.5.10 Specify the Pf_t for the camera mount.		0.1		IIIb	The camera mount is a bayonet type adapter used to mount the 16mm DAC. The camera mount is located under the work chamber next to the camera viewport. If the camera mount should fail, the following condition could occur: • Communication and Data --If the camera mount had a structural failure and would not hold the camera properly, this could cause partial failure of the MPF for the experiments requiring camera coverage. The experiments could still be run while the astronaut observed and voice recorded his observations. The following indication can be used to determine the camera mount failure: • This failure would be detected by astronaut inspection when the DAC could not properly be installed on the camera mount. References 4 and 8.
3.5.11 Specify the Pf_t for the EQUIPMENT STORAGE CONTAINER.		0.1		IIIb	The EQUIPMENT STORAGE CONTAINER, or accessories container, contains the specimens for the electron beam welding and sphere forming experiments as well as the corollary equipment for conducting the six experiments, M-479, M-551, M-552, M-553, M-518 and M-555), in the work chamber. If the container should fail, the following conditions could occur: • Support --If the container should rupture, hardware required for the performance of some of the experiments could be damaged and the experiments terminated. • Communication and Data --If the container should rupture, hardware required for the performance of some of the experiment could be damaged and the experiment degraded. • Contamination --If the container should rupture and damage some of the protective shields, parts of the M-512 facility could become contaminated with residue from the experiments.

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TABLE E-I. M-521 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 24 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11 (Concluded)					The following indication can be used to determine the failure of the accessories container: • This failure can be detected by astronaut noting the damage to some or all of the hardware stowed in the accessories container and/or inspection of the accessories container. References 4 and 7.
3.5.11.1 Specify the Pf_t for the M551 ELECTRON BEAM WELD MOTOR.		0.1		IIIa	The M551 ELECTRON BEAM WELD MOTOR is attached to a three-legged mounting base and carries the disc-shaped experimental specimens. The motor is a nominal 24 Vdc, 1760 rpm motor, and the gear reduction in the drive mechanism is 300:1. To arrive at the output shaft speed of 2.6 rpm required for the experiment, the motor armature speed is reduced by running at an actual input voltage of only 12 Vdc. The motor will receive power from the M-512 MPF battery. If the motor should fail, the following conditions could occur: • Support --If the motor windings short or open, this would cause a complete failure of the M-551 experiment. --If there is an electrical short in the motor power connector, preventing power from reaching the motor, this would cause a complete failure of the M-551 experiment. • Communication and Data --If the electron beam ground wiper arm on the motor did not make contact with the drive cone and shield assembly, the electron beam would go to ground through the motor assembly but not as easily as through the wiper arm. Therefore, the metal disc could build up a charge and divert the electron beam causing the beam not to impinge on the desired area of the specimen disc. The following indications can be used to determine the failure of the motor: • The motor winding failure would be difficult to determine. It could be presumed that the motor had failed if power was turned on and the motor did not rotate. • The motor power connector failure may be able to be detected by astronaut observation because of an arcing indication between the contacts in the connector. • The wiper arm failure during EBG operation, may be detected by astronaut observing the deflection of the beam impinging on the specimen. The deflection is caused by a charge building up on the disc and repelling the electrons emitted from the EBG. This failure can be detected before or after the experiment by astronaut observation.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 25 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.1 (Concluded)					References 4, 18, and 19.
3.5.11.2 Specify the Pf_t for the M553 SPHERE FORMING MOTOR.		0.1		IIIa	The purpose of the M553 SPHERE FORMING MOTOR is to rotate the specimen disc and place the specimen in the proper position to interface with the electron beam when the EBG is activated. The motor operates on 12 and 24 V. When using 24 V, the motor operates at 1760 rpm, and when using 12 V, it operates at approximately 700 rpm. A drive mechanism (reduction gear of 100:1) is used to rotate the specimen disc. There is a cam on the shaft of the motor that is used to actuate a microswitch in the drive mechanism. The cam-actuated microswitch is used to automatically cut off the motor to properly position the specimen. During each rotation of the sample disc, the indexing motor will draw approximately 2 W for about 5 sec. The motor contains a brush assembly with three wiper arms. These arms make contact with the specimen disc when the disc is mounted on the motor. Two of of these wiper arms are used to complete the electrical circuit used for the EBG. The third wiper arm serves a path to ground the electron beam. If the motor should fail, the following condition could occur: • Support --If the motor windings short or open, this would cause a complete failure of Experiment M-553. --If there is an electrical short in the motor power connector, preventing power from being applied to the motor, this would cause a complete failure of Experiment M-553. --If the microswitch in the drive mechanism fails, the motor would not rotate and this would cause a complete failure of Experiment M-553. --If either one of the two wiper arms on the brush assembly, used in the EBG electrical circuit, did not make contact with the specimen disc, the EBG could not be activated and this would cause a complete failure of Experiment M-553. --If the wiper arm on the brush assembly, used for the electron beam ground, does not make contact with the specimen disc, the electron beam could arc over from the specimen disc to ground. This could also cause the specimen to build up a charge and divert the electron beam from impinging on the specimen. The following indications can be used to determine the failure of the motor: • The motor winding failure would be difficult to determine. If power was turned on and the motor did not rotate, it could be presumed that the motor windings or microswitch had failed. • The motor power connector failure may be detected by astronaut observation because of arcing indications between the contacts in the connector.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 26 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.2 (Concluded)					• The microswitch failure may be difficult to determine. If power was turned on and the motor did not rotate, it could be presumed that the motor windings or microswitch had failed. If the motor started to rotate when power was applied and then stopped and would not rotate again when power was applied, it could be presumed that the microswitch had failed. • The wiper arms, used in the EBG electrical circuit, failure could be detected when the EBG would not operate and could be verified by visual inspection. • The wiper arm, used for the electron beam ground, failure may be detected by the astronaut observing arcing in the specimen disc or observing the deflection of the beam impinging on the specimen or even missing the specimen. References 4, 19, and 20.
3.5.11.3 Specify the P_{f_t} and the P_{f_n} for the M512 FLOOD LIGHT SHIELD.		$P_{f_t} = 0.1$ $P_{f_n} = 0.01$ $P_{f_n} = 0.09$		IIIb	The M512 FLOOD LIGHT SHIELD is installed inside the chamber on the floodlight port to protect the floodlight during the performance of the experiments. The shield is made of Vicor 7913 glass mounted in an aluminum alloy frame. The frame has three ball detents for attaching the shield to the work chamber. If the shield should fail, the following conditions could occur: • Contamination --If a structural failure occurred, detaching, cracking, breaking, or preventing the shield from being installed in the work chamber, the probability of floodlight lens damage would increase because of combustible residue from the experiments. • Communication and Data --If, during the process of performing an experiment, the lens on the shield is degraded because of smoke or other residue, the function of the floodlight would be degraded. The floodlight is used in Experiment M-479 to film the Sample I. D. and it flashes at the end of the time allowed for sample combustion to provide a photographic data reference. The following indication can be used to determine the failure of the shield: • The failures can be detected by astronaut inspection of the shield. References 4 and 19.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 27 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.4 Specify the Pf_t and Pf_n for the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY.		Pf_t = 0.71 Pf_n = 0.01 Pf_n = 0.7		IIIb	The M479 HATCH VIEW-PORT SHIELD FLAMMABILITY is installed over the inner surface of the hatch view-port window to prevent sample combustion contaminants from depositing on the hatch window during Experiment M-479. The shield is constructed of photographic quality glass mounted in an aluminum alloy frame. The frame has three ball detents for attaching the shield to the work chamber hatch. If a structural failure occurred, detaching, cracking, breaking, or preventing the viewport shield from being installed on the hatch, the following conditions could occur: • Contamination --The hatch viewport window could become contaminated because of experiment combustible residue. • Operability --It would be possible to use the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING to attach to the hatch. If the shield should become contaminated with combusion residue, the following conditions could occur: • Communication and Data --The ability of the astronaut to view the experiment processes will be degraded. • Operability --It would be possible to use the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING as a substitute to attach to the hatch. The following indications can be used to determine the failure of the viewport shield: • These failures can be detected by astronaut inspection of the shield. • The contamination failure can also be detected by the astronaut if his view of Experiment M-479 is degraded because of combustible residue impinging on the shield. References 4 and 19.
3.5.11.5 Specify the Pf_t and the Pf_n for the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING.		Pf_t = 0.1		IIIb	The M553 HATCH VIEW-PORT SHIELD SPHERE FORMING is installed inside the chamber on the hatch viewport to protect the viewport during Experiment M-553. The shield is made of photographic quality glass mounted in an aluminum alloy frame. The frame has three ball detents for attaching the shield to the work chamber hatch.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 28 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.5 (Concluded)		Pf_n = 0.01			If a structural failure occurred, detaching, cracking, breaking, or preventing the viewport shield from being installed on the hatch, the following conditions could occur: • Contamination --The hatch viewport window could become contaminated because of experiment residue. • Operability --It would be possible to substitute the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY to attach to the hatch. This could degrade the ability of the astronaut to observe Experiment M-479.
		Pf_n = 0.09			If the shield should become contaminated with experiment residue, the following conditions could occur: • Communication and Data --The ability of the astronaut to view the experiment processes could be degraded. • Operability --It would be possible to substitute the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY to attach to the hatch. This could degrade the ability of the astronaut to observe Experiment M-479. The following indication can be used to determine the failure of the shield: • Refer to functional item 3.5.11.4. References 4 and 19.
3.5.11.6 Specify the Pf_t and the Pf_n for the M553 CAMERA PORT SHIELD SPHERE FORMING.		Pf_t = 0.1		IIIb	The M553 CAMERA PORT SHIELD SPHERE FORMING is installed inside the work chamber over the camera port window to prevent residue on the window during Experiment M-553. The shield is made of photographic quality x-ray lead glass mounted in an aluminum alloy frame. The frame has three ball detents for attaching the shield to the work chamber.
		Pf_n = 0.01			If a structural failure occurred, detaching, cracking, breaking, or preventing the camera port shield from being installed on the camera port, the following conditions could occur: • Contamination --The camera port window could become contaminated because of experiment residue.

TABLE E-1. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 29 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.6 (Concluded)					• Operability --It would be possible to substitute the M479 CAMERA PORT SHIELD FLAMMABILITY onto the camera port. This could degrade the ability of the astronaut to observe Experiment M-479. If the shield should become contaminated with experiment residue, the following conditions could occur: • Communication and Data --The photography for the experiment could be degraded. • Operability --It would be possible to substitute the M479 CAMERA PORT SHIELD FLAMMABILITY onto the camera port. This could degrade the photographic quality of Experiment M-479. The following indication can be used to determine the failure of the camera port shield: • This failure can be detected by astronaut inspection of the shield. References 4 and 19.
		P_{f_n} = 0.09			
3.5.11.7 Specify the P_{f_t} and the P_{f_n} for the M479 CAMERA PORT SHIELD FLAMMABILITY.		P_{f_t} = 0.71		IIIb	The M479 CAMERA PORT SHIELD FLAMMABILITY is installed inside the work chamber over the camera port window to prevent combustion product deposition on the window during Experiment M-479. The shield is made of photographic quality x-ray lead glass mounted in an aluminum alloy frame. The frame has three ball detents for attaching the shield to the work chamber. If a structural failure occurred, detaching, cracking, breaking, or preventing the camera port shield from being installed on the camera port, the following conditions could occur: • Contamination --The camera port window could become contaminated because of experiment combustible residue. • Operability --It would be possible to substitute the M553 CAMERA PORT SHIELD SPHERE FORMING onto the camera port. If the shield should become contaminated with combustion residue, the following conditions could occur:

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 30 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.7 (Concluded)					• Communication and Data --The photography for the experiment could be degraded. • Operability --It would be possible to substitute the M553 CAMERA PORT SHIELD SPHERE FORMING onto the camera port. The following indication can be used to determine the failure of the camera port shield: • This failure can be detected by astronaut inspection of the shield. References 4 and 19.
3.5.11.8 Specify the Pf_t and the Pf_n for the M551 DEFLECTION MIRROR.		$Pf_t = 0.1$ $Pf_n = 0.01$ $Pf_n = 0.09$		IIIb	The M551 DEFLECTION MIRROR assembly is installed in the work chamber above the EBG and is positioned so that the observer can see the working face of the electron beam welding discs. The mirror is made of fused silica 7940 and the bracket is aluminum alloy. The bracket has two Calfax fasteners to attach the mirror assembly to the work chamber. If the mirror assembly should fail, the following conditions could occur: • Communication and Data --If a structural failure occurred, detaching, cracking, breaking, or preventing the mirror assembly from being installed in the vacuum work chamber, the astronaut's visual observation part of the experiment would be degraded. --If during the process of performing an experiment, the mirror reflection capability is degraded because of smoke or other residue, the astronaut's visual observation part of the experiment would be degraded. The following indication can be used to determine the failure of the mirror assembly: • The failure can be detected by astronaut inspection of the mirror. References 4, 11, and 19.
3.5.11.9 Specify the Pf_t and the Pf_n for the M551 CAMERA MIRROR.		$Pf_t = 0.1$		IIIb	The M551 CAMERA MIRROR assembly is mounted to the camera port inside the vacuum work chamber. The camera line of sight is reflected from the mirror to the permanently mounted camera deflection mirror and from there reflected to the point of observation. The mirror assembly is constructed of fused silica 7940 with a mounting base of aluminum alloy. The mounting base has three ball detents and two alignment pins for attaching and aligning the mirror assembly to the work chamber.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 31 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.9 (Concluded)		Pf_n = 0.01 Pf_n = 0.09			If the mirror assembly should fail, the following conditions could occur: • Communication and Data --If a structural failure occurred, detaching, cracking, breaking, or preventing the mirror assembly from being installed in the vacuum work chamber, the photography for Experiment M-551 would be difficult. --If, during the process of performing the experiment, the mirror reflection capability is degraded because of smoke or other residue, the photography for Experiment M-551 could be degraded. The following indication can be used to determine the failure of the camera mirror: • These failures can be detected by astronaut inspection of the mirror assembly. References 4, 11, and 19.
3.5.11.10 Specify the Pf_t and the Pf_n for the M551 HATCH VIEW PORT MIRROR.		Pf_t = 0.1		IIIb	The M551 HATCH VIEW PORT MIRROR assembly is attached to the hatch window inside the work chamber. As the astronaut looks into the mirror, his line of sight is reflected to the M551 DEFLECTION MIRROR and from there reflected to the point of observation. The mirror is fused silica 7940, and the mounting base is aluminum alloy. The mounting base has three ball detents and two alignment tabs for attaching and aligning the mirror assembly to the work chamber hatch. If the mirror assembly should fail, the following condition could occur: • Communication and Data --Refer to functional item 3.5.11.8. The following indications can be used to determine the failure of the viewport mirror: • This failure can be detected by astronaut inspection of the mirror assembly. • The contamination failure can also be detected by the astronaut if his view of Experiment M-551 is degraded because of residue impinging on the mirror. References 4, 11, and 19.
3.5.11.11 Specify the Pf_t for the M479 WATER SPRAY NOZZLES.		0.3		IIIb	The M479 WATER SPRAY NOZZLES are installed in the work chamber connected to the water supply system. There are two nozzles connected to a manifold fitting that are oriented to spray both sides of the sample for the water quench during Experiment M-479. Each nozzle contains a check valve which operates with a cracking pressure of 20 ± 0.5 psia.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 32 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.11 (Concluded)					If the nozzles should fail, the following conditions could occur: • Communication and Data --If the nozzles could not be connected in the work chamber, or if a leak occurred between the water supply line and the nozzle connection, the water quench sequence could not be performed or would be degraded. --If a nozzle check valve were to fail open, the water in the supply lines downstream of the WATER SPRAY valve could leak out past the failed valve and interfere with subsequent sample burns. This would degrade the quality of experiment data. --If a nozzle check valve were to fail closed, capability of spraying both sides would be lost and the reduced quench capability would degrade the quality of experiment data. The following indications can be used to determine the failure of the nozzles: • Failure of the nozzle, preventing installation in the work chamber or a poor connection, could be detected by astronaut inspection of the nozzle. • Failure of a check valve in the open position could be detected by the astronaut observing water leaking from the nozzle. • Failure of a check valve in the closed position could be detected by the astronaut observing water spraying from only one nozzle. References 4 and 19.
3.5.11.12 Specify the P_{f_t} for the M479 WATER SPRAY CONNECTION COVER.		0.1		IIIb	The M479 WATER SPRAY CONNECTION COVER is used to cap the end of the water supply line in the work chamber until the water quench system is required for Experiment M-479, at which time it will be removed and placed in a stowage location in the EQUIPMENT STORAGE CONTAINER. The cover is a quick-disconnect fitting made of CRES. If the cover should fail, the following conditions could occur: • Communication and Data --If the cover could not be removed from the work chamber water supply fitting, the use of the water spray nozzles would be precluded, causing a partial loss of data (water quench) for Experiment M-479. The following indication can be used to determine the failure of the water spray connection covers: • The above failure can be detected by astronaut inspection of the cover. References 4 and 19.

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TABLE E-1. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 33 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.13 Specify the Pf_t and the Pf_n for the flammability specimen holder.		$Pf_t = 0.3$ $Pf_n = 0.2$		IIIa	The flammability specimen holder is used to mount the Experiment M-479 fuel samples in the work chamber. The holder provides mechanical support to each sample, and also electrical power from the work chamber electrical connector to the sample igniter. The holder has a zero-g connector on the chamber connector end. If a structural failure occurred, preventing the holder from being installed in the work chamber, the following condition could occur: • Support --If the holder could not be mechanically connected to the work chamber electrical connector, it could not support the fuel samples. This would result in the loss of Experiment M-479. If an electrical failure occurred, the following conditions could occur: • Support --If a short or open occurs in the specimen holder, the loss of Experiment M-479 would result because of the inability to supply power to the sample igniters. • Electrical --The POWER CONTROL AM BUS 1 cb on the M-512 MPF control panel should protect the carrier from an overload condition caused by an electrical malfunction in the specimen holder. The following indications can be used to determine the failure of the flammability specimen holder: • The structural failure could be determined by astronaut inspection of the holder. • The electrical failure may be difficult to determine. If the specimen filament is in tact and the specimen does not ignite when power is applied and/or the POWER CONTROL AM BUS 1 cb opens when power is applied, it may be presumed that the holder has had an electrical failure. If telemetry is available, a supporting indication of electrical failure is AM Bus voltage between 24 and 30 Vdc as indicated by telemetry measurement number M155-513. References 4, 19, and 21.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 34 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.14 Specify the Pf_t for the M512 ELECTRON BEAM COVER.		0.1		IIIb	The M512 ELECTRON BEAM COVER is stored in the EQUIPMENT STORAGE CONTAINER and is mounted over the EBG port in the work chamber after Experiments M-551 and M-553 have been completed. The cover is used to protect the EBG port from debris produced by Experiments M-552, M-518, M-555, and M-479. The cover is constructed of an aluminum alloy frame containing a wire cloth filter. Three Calfax fasteners on the frame attach the cover to the interior of the work chamber. If the cover should fail, the following conditions could occur: • Contamination --If a structural failure occurred, preventing the cover from being mounted in the work chamber, debris could enter the EBG port and deposit on the FILAMENT CHAMBER VENT valve. This could cause a failure of the valve during any future use. The following indication can be used to determine the failure of the electron beam cover: • This failure can be detected by astronaut inspection of the cover. References 4 and 19.
3.5.11.15 Specify the Pf_t for the M479 HEAT SINK COVER.		0.1		IIIb	The M479 HEAT SINK COVER is installed over the work chamber heat sink during Experiment M-479 to prevent combustion debris from entering the heat sink. The cover is constructed of an aluminum alloy frame containing a wire cloth filter. Three Calfax fasteners on the frame attach the cover to the Experiment M-551 and Experiment M-553 motor mount. If the cover should fail, the following conditions could occur: • Contamination --If a structural failure occurred, preventing the cover from being installed in the work chamber, combustion debris could enter the work chamber heat sink. If this debris could not be cleaned out of the heat sink satisfactorily, it could escape from the work chamber at some time when the work chamber hatch was opened. The debris could also interfere with subsequent specimen combustion tests. The following indication can be used to determine the failure of the heat sink cover: • The failure can be detected by astronaut inspection of the cover. References 4 and 19.

TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 35 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.16 Specify the P_{f_t} for the M553 SPHERE CATCHER 1.		0.1		IIIb	M553 SPHERE CATCHER 1 is used to collect the spheres formed from M553 SPHERE FORMING SPECIMEN 1. The sphere catcher inserts into the vacuum cleaner port inside the work chamber. The catcher has small holes in it to allow the passage of air as the vacuum cleaner pulls the spheres into the catcher. The sphere catcher is made of aluminum alloy and has a mylar retainer valve that retains the spheres in the catcher. The valve assembly consists of two mylar discs, each having three tabs, placed together with the tabs and staggered to prevent the escape of spheres from the catcher. If the sphere catcher should fail, the following would happen. • Operability --If the sphere catcher will not physically insert into the vacuum cleaner port inside the work chamber, this will not affect the operation of the experiment until it is time to collect the spheres. A different from normal technique will have to be used to collect the spheres. The following indication can be used to determine the failure of the sphere catcher: • The above failure can be detected by astronaut observation. References 4 and 19.
3.5.11.17 Specify the P_{f_t} for M553 SPHERE CATCHER 2.		0.1		IIIb	M553 SPHERE CATCHER 2 is used to collect the spheres formed from M553 SPHERE FORMING SPECIMEN 2, and is identical to M553 SPHERE CATCHER 1. For description, P_f, effects of failure, and indications of failure, refer to functional item 3.5.11.16.
3.5.11.18 Specify the P_{f_t} for the M553 SPHERE CATCHER INSTALLATION TOOL.		0.1		IIIb	The M553 SPHERE CATCHER INSTALLATION TOOL inserts into the top of the sphere catcher. The tool is turned cw to the tool and catcher together. The tool is used to open the mylar valve in the catcher and as a handle to install and remove the catcher from the vacuum cleaner port inside the work chamber. The tool is made of 321 CRES. If the tool should fail, the following would happen: • Operability --If the tool will not physically connect with the sphere catcher, this will not affect the operation of the experiment until it is time to collect the spheres. The tool is needed to open the mylar valve so that the spheres can enter the sphere catcher and to remove the sphere catcher from the vacuum cleaner port inside the work chamber. A different technique from normal will have to be used to collect the spheres.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 36 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.18 (Concluded)					The following indication can be used to determine the failure of the sphere catcher installation tool: • The failure can be detected by astronaut inspection of the tool. References 4 and 19.
3.5.11.19 Specify the Pf_t for the M554/ M555 CRYSTAL GROWTH/ COMPOSITE CASTING CLAMP.		0.1		IIIb	The M554/M555 CRYSTAL GROWTH/COMPOSITE CASTING CLAMP is used to secure the flange on Experiment M-518 and Experiment M-555 furnaces against the work chamber heat sink for proper heat transfer from the furnace to the heat sink. The clamp is made of aluminum alloy, is annular, and has three Calfax fasteners that interface with the Experiment M-551 and Experiment M-553 motor mount in the work chamber. A portion of the annular clamp is open for clearance around the vent valve and electrical connector on the furnace. If the clamp should fail, the following condition could occur: • Communication and Data --If the clamp could not be installed securely in the chamber, sufficient thermal contact could not be maintained between the furnace flange and the heat sink. Good thermal contact is required for proper thermal gradients to be obtained in the furnaces. The following indication can be used to determine the failure of the clamp: • The failure can be detected by astronaut inspection of the clamp. References 4 and 19.
3.5.11.20 Specify the Pf_t for WORK CHAMBER VENT FILTER 1 & 2.				IIIb	Vent filter No. 1 is installed in the vacuum vent line to trap contaminants from Experiments M-551, M-552, M-553, M-518, M-555, and M-479. The filter is constructed of an aluminum alloy frame containing a coarse filter consisting of 18 meshes/in. of 0.009-in. diam wire. The frame has three detent balls that secure filter No. 1 to the vent port.
Vent filter No. 1		$Pf_t = 0.5$			
Vent filter No. 2		$Pf_t = 0.7$			Vent filter No. 2 is installed into vent filter No. 1 for operation of Experiment M-479, and prevents fine contamination particles from being vented to space. The filter is constructed of an aluminum alloy frame containing a fine filter consisting of 80 meshes/in. of 0.0037-in. diam wire. The frame has three detent balls that secure filter No. 2 to filter No. 1. The Pf_t for filters 1 and 2 is considered high because of combustion residue from Experiment M-479 depositing on the filters. The Pf_t for filter No. 2 is greater than the Pf_t for filter No. 1 because of the smaller physical size of the meshes in filter No. 2.

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TABLE E-I. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 37 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.11.20 (Concluded) For each filter		Pf_n = 0.01			If a structural failure occurred, preventing the filter from being installed in the vent line, the following conditions could occur:
				IIIb	• Contamination --If a decision were made to perform the experiments without the filter being installed, particles could pass through the vent line causing possible vent valve damage and external cluster contamination.
				IIIa	• Support --If a decision were made not to perform the experiment without the installation of the filter, the experiments using the M-512 MPF would be terminated.
Vent filter No. 1		Pf_n = 0.49			If the filter should become clogged with combustion residue, the following conditions could occur:
Vent filter No. 2		Pf_n = 0.69			• Sequence --Clogging of the filter would require longer venting times and would impact the mission timeline.
					• Contamination --If a decision were made to perform the experiments without the filter being installed, particles could pass through the vent line causing possible vent valve damage and external cluster contamination.
					• Support --Clogging of the filter will prevent proper venting of the work chamber and could preclude experiment operation if the clogging were severe.
					The following indications can be used to determine the failure of the vent filter:
					• The structural failure and the clogging of the filter could be detected by astronaut inspectionof the filter.
					• The clogging of the filter could also be detected by the astronaut noting that the work chamber vent time increased from normal.
					References 4 and 19.

TABLE E-1. M-512 MATERIALS PROCESSING FACILITY PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 38 of 38)

FUNCTIONAL BLOCK NUMBER AND TITLE	EXPECTED RANGE AND DIMENSION OF VARIABLES			CRITICALITY CATEGORY NUMBER	REMARKS
	MIN.	NOM.	MAX.		
3.5.12 Specify the Pf_t for the flammability specimen container.		0.1		IIIb	The flammability specimen container contains 37 flammability specimens. These specimens will be used in Experiment M-479. The container is secured closed by four Calfax fasteners, and one side of the container has a lid stop assembly that locks the container lid open. There is a manual vent valve on the bottom of the container that is used to vent the interior to ambient pressure. The flammability specimens inside the container are enclosed in individual protective containers that are held closed by Velcro. If the container should fail, the following condition could occur: • Support --If the container should rupture, this could cause a complete or partial failure of Experiment M-479 because of the damage of the flammability specimens. • Communication and Data --If the container should rupture, some of the specimens used in the performance of the experiment could be damaged and the experiment degraded. The following indication can be used to determine the failure of the flammability specimen container: • This failure can be detected by the astronaut noting the damage to some or all the specimens stowed in the specimen container and/or inspection of the specimen container. References 4 and 7.

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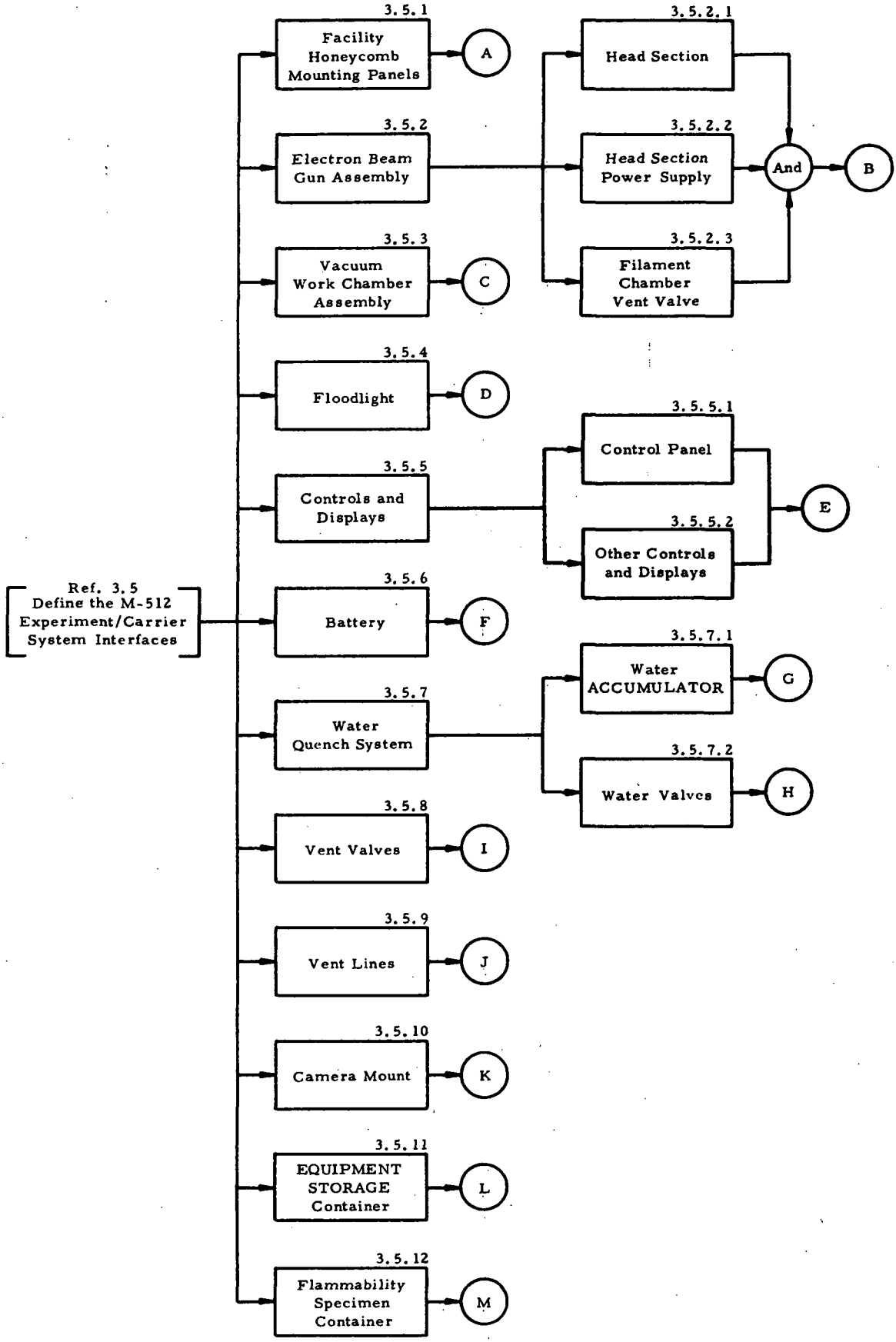

FIGURE E-1. M-512 MATERIALS PROCESSING FACILITY FUNCTIONAL BLOCK DIAGRAM (Sheet 1 of 5)

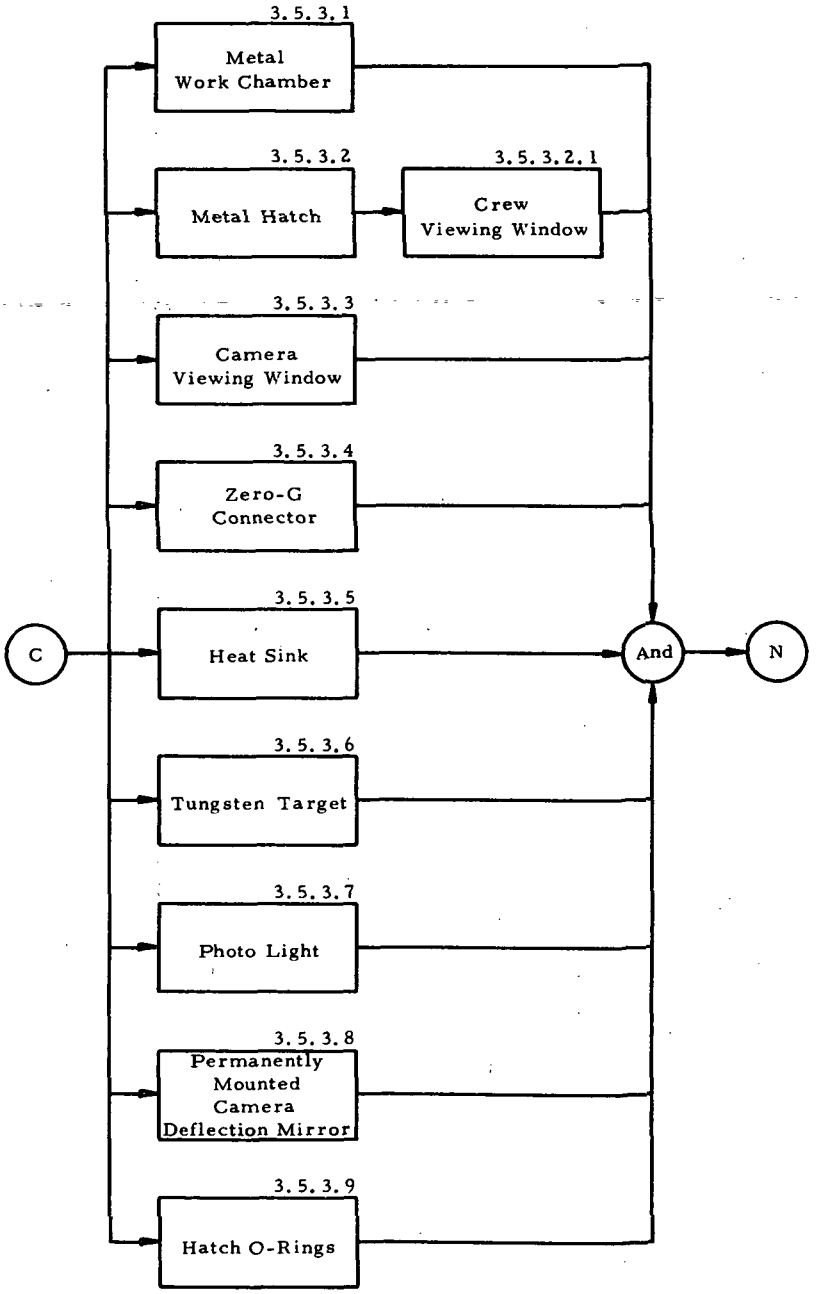

FIGURE E-1. M-512 MATERIALS PROCESSING FACILITY FUNCTIONAL BLOCK DIAGRAM (Sheet 2 of 5)

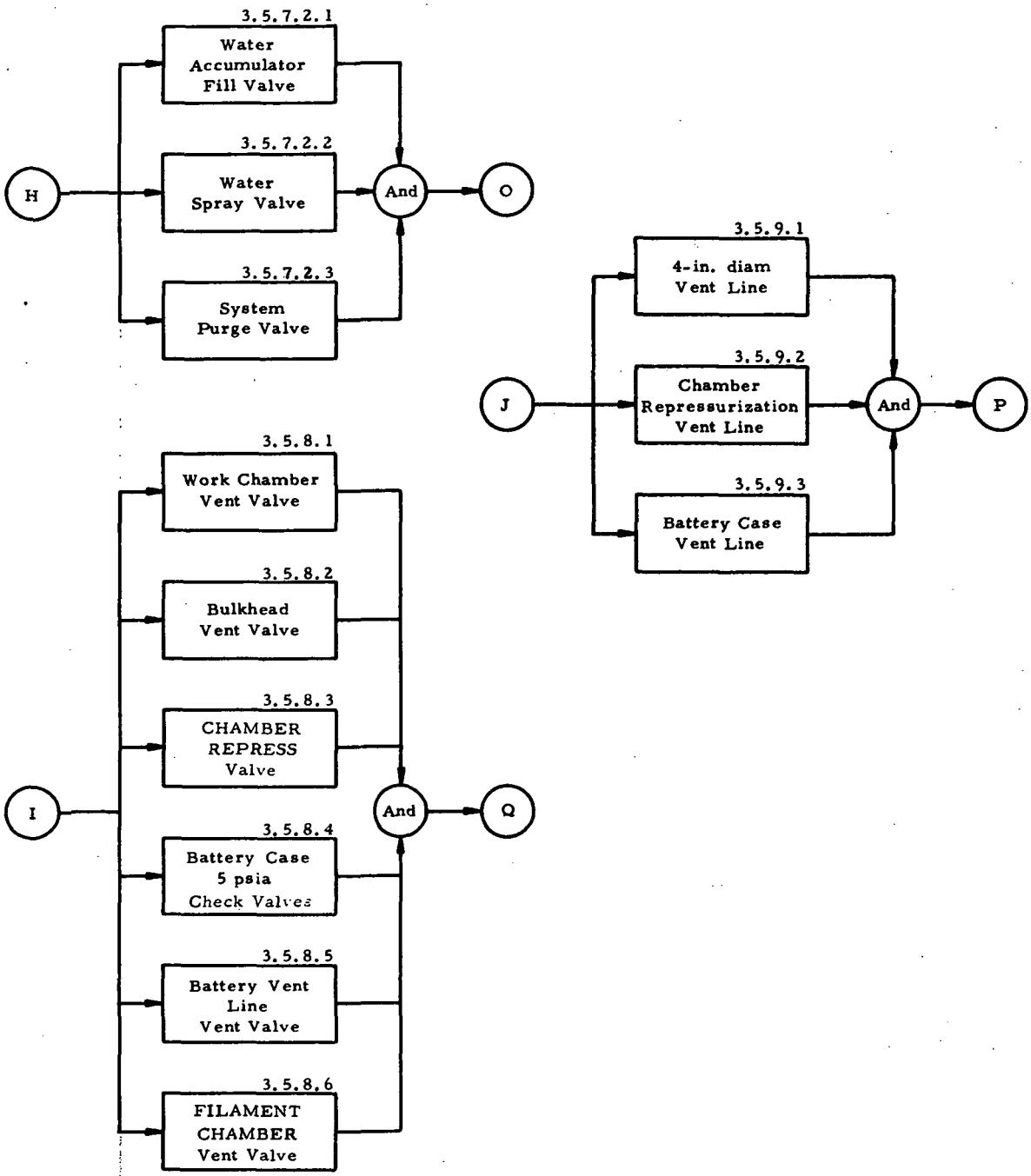

FIGURE E-1. M-512 MATERIALS PROCESSING FACILITY FUNCTIONAL BLOCK DIAGRAM (Sheet 3 of 5)

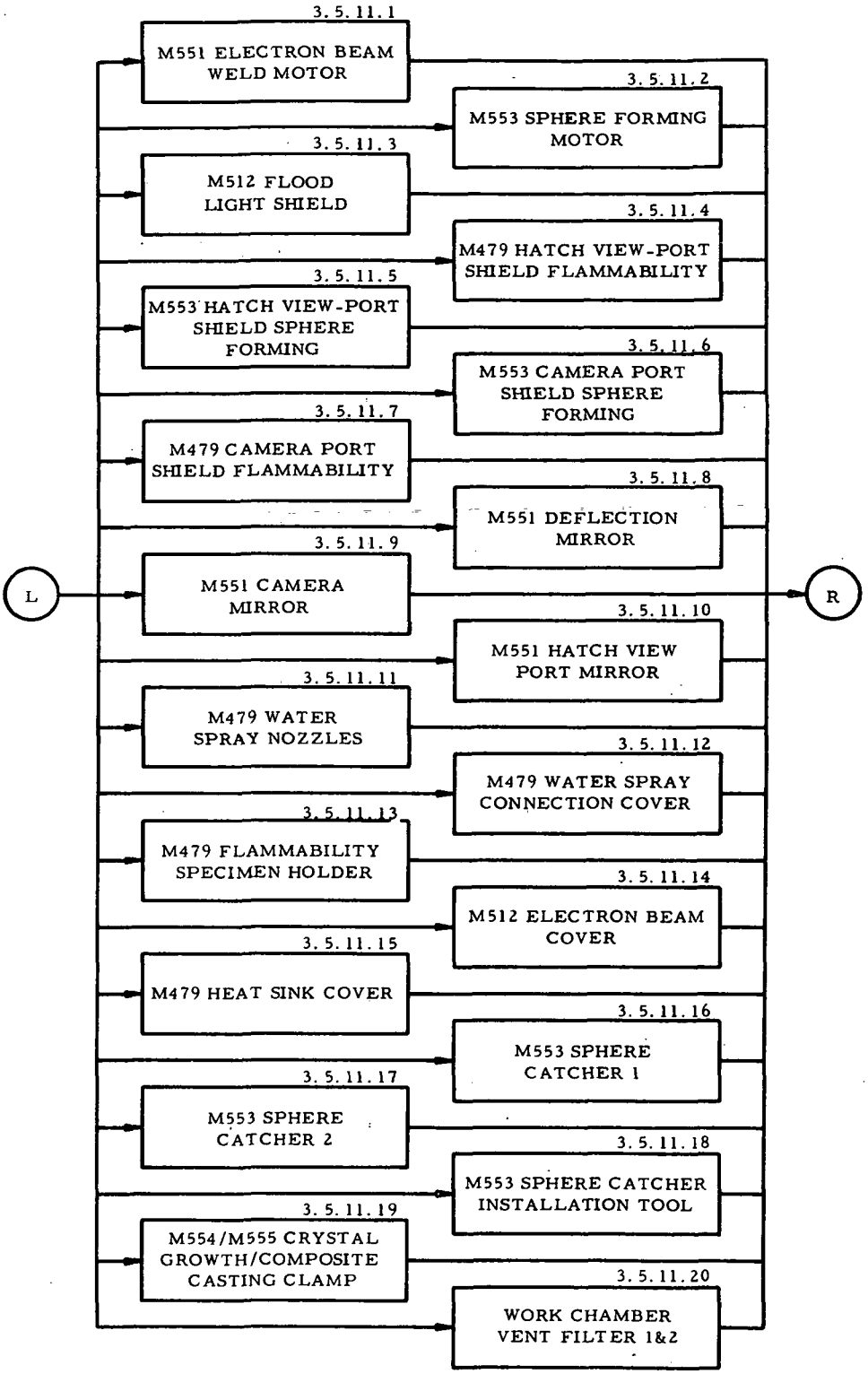

FIGURE E-1. M-512 MATERIALS PROCESSING FACILITY FUNCTIONAL BLOCK DIAGRAM (Sheet 4 of 5)

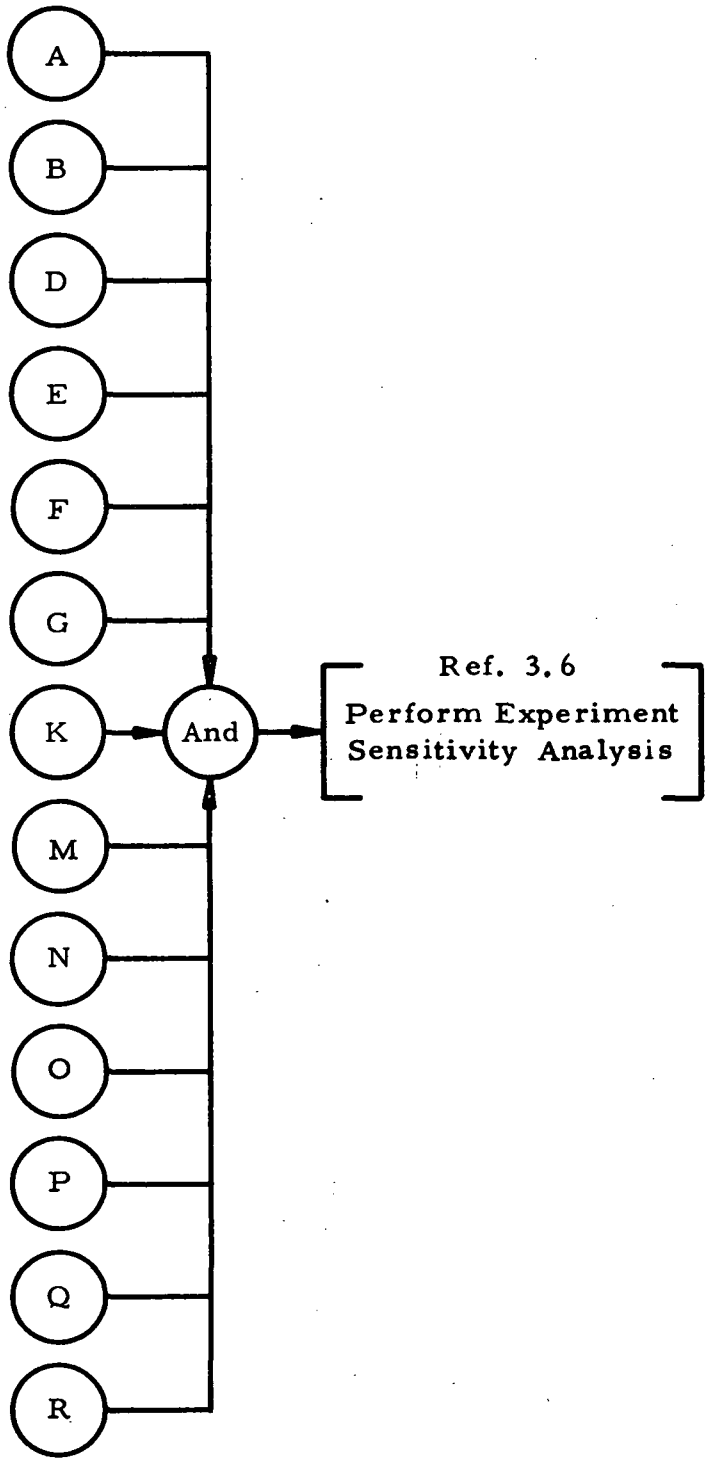

FIGURE E-1. M-512 MATERIALS PROCESSING FACILITY FUNCTIONAL BLOCK DIAGRAM (Sheet 5 of 5)

SECTION II.

M-512 MATERIALS PROCESSING FACILITY INTERFACE BLOCK DIAGRAM

SECTION IV.

M-512 MATERIALS PROCESSING FACILITY DATA REQUIREMENTS SUMMARY

TABLE E-II. M-512 MATERIALS PROCESSING FACILITY DATA REQUIREMENTS SUMMARY

Crew debriefing transcripts will be required at the end of each mission that utilizes the MPF.

SECTION V. M-512 MATERIALS PROCESSING FACILITY DATA REQUEST FORMS

The data required for evaluation of the M-512 MPF consist completely of voice comments by the crewman concerning MPF operations, transcripts of voice comments, and the logbooks for the experiments which use the MPF. General Data Request Forms (DRF's) requesting voice comments and experiment logs for all experiments have been submitted; therefore, a DRF requesting these data specifically for the MPF is not necessary.

SECTION VI. M-512 MATERIALS PROCESSING FACILITY ENGINEERING CHANGE REQUESTS

The Engineering Change Request is placed in this appendix as a matter of record. It was submitted on August 19, 1971 and was disapproved.

ENGINEERING CHANGE REQUEST	DATE: 8-19-71	NUMBER: BGSM 0535	PAGE 1 of 1

TO: J. Waite, PM-SL-DP

THRU:

FROM: L. Vaughan, S&E-ASTN-SDI

TITLE OF CHANGE: Experiment M512 Battery Status-of-Charge Monitoring

RELATED CHANGES (ECR, BCP, CR, etc.) BY NUMBER:

PROGRAM CONTROL NO.: BT-13756

DESCRIPTION OF CHANGE:

A state-of-charge meter is needed to monitor the M-512 battery. A qualified state-of-charge meter is used on panel 206 in the STS to monitor the PCG batteries. The part number for this meter is 61B810002-97. A similar meter should be mounted on the M-512 control panel or experiment structure.

ENCLOSURES:
- [X] ECR ONLY
- [ ] PIRN
- [ ] SCN
- [ ] DRAWING/SKETCH
- [ ] LEVEL A ICD
- [ ] LEVEL A IRN
- [ ] LEVEL B ICD
- [ ] LEVEL B IRN
- [ ] SLCN

JUSTIFICATION FOR CHANGE:

This change permits the Skylab A Mission Evaluation Working Group and Operations Support Planning Group to monitor and assess the adequacy of operating performance among the power source (M-512 battery) and the metals melting, sphere forming, and exothermic heating tasks.

INITIATED BY:
- [ ] PANEL ACTION
- [X] S & E
- [ ] PM
- [ ] PD
- [ ] MSC REQUEST
- [ ] KSC REQUEST
- [ ] OTHER (Explain)

EFFECTS ON:
- [ ] DOCUMENTATION
- [X] HARDWARE
- [ ] SOFTWARE
- [ ] OPERATIONAL COMPUTER PROGRAMS
- [ ] OTHERS (Explain)

PROGRAM AFFECTED:
- [ ] SATURN IB
- [ ] SATURN V
- [X] SKYLAB
- [ ] HEAO
- [ ] ENGINES
- [ ] SPACE SHUTTLE
- [ ] SPACE STATION
- [ ] OTHERS (Explain)

PROJECT/STAGE AFFECTED:
- [ ] S-IB STAGE
- [ ] S-IC STAGE
- [ ] S-II STAGE
- [ ] S-IVB STAGE
- [ ] IU
- [ ] LVGSE
- [ ] OWS
- [ ] AIRLOCK
- [ ] MDA
- [ ] ATM
- [ ] PS
- [X] EXPMTS M-512
- [ ] OTHERS (Explain)

AREAS AFFECTED:
- [ ] SAFETY
- [ ] AIRBORNE ELEC. SYS.
- [ ] TELEMETRY
- [ ] SINGLE POINT FAILURES
- [ ] FLIGHT TAPES
- [ ] GROUND TAPES
- [ ] RELIABILITY
- [ ] ACS
- [ ] STRESS CORROSION
- [ ] ESE
- [ ] GSE(Stage)
- [ ] MGSE
- [ ] GROUND INSTRUMENT
- [ ] QUAL STATUS
- [ ] PAYLOAD WTS.
- [ ] SAS
- [ ] PRODUCT IMPROVEMENT
- [ ] IN PROCESS TEST
- [ ] BREADBOARD
- [ ] PROPULSION
- [ ] STRUCTURES
- [ ] TEST SCHEDULES
- [ ] CRITICAL COMPONENTS
- [ ] STOWAGE
- [ ] REDLINES
- [ ] TEST RQMTS., SPECS & CRITERIA DOC.
- [ ] VEH. WEIGHTS
- [ ] SPARES
- [ ] SPACECRAFT
- [ ] LAUNCH COMPLEX
- [ ] CREW SYSTEMS
- [ ] MISSION OPERATIONS

RECOMMENDED EFFECTIVITY:
- [ ] MANDATORY FOR _____
- [ ] HIGHLY DESIRABLE FOR _____
- [ ] DESIRABLE FOR SL-1

ICD'S AFFECTED:
- [ ] YES (List)
- [ ] NO

PRIORITY (Explain):
- [ ] URGENT
- [X] ROUTINE
- [ ] EMERGENCY
- [ ] COMPATIBILITY

MSFC - Form 2327 (Rev September 1971)

EFFECT OF NONINCORPORATION:

The state-of-charge of the M-512 battery cannot be monitored without this meter.

SCOPE OF WORK: ☐ SEE ATTACHED SKETCH AND/OR DESCRIPTION

ADDITIONAL REMARKS AND DISTRIBUTION:

CONCURRENCE

SIGNATURE & ORGANIZATION	DATE	SIGNATURE & ORGANIZATION	DATE	SIGNATURE & ORGANIZATION	DATE

APPROVAL

LAB SYSTEM ENGR. DIV.	DATE	PRODUCTS OFFICE	DATE	CEN. SYSTEM ENGR.	DATE
LAB PROJECT OFFICE	DATE				

SECTION VII.

M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE

TABLE E-111. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 1 of 9)

Assignments

Mission:

- SL-1, SL-2, SL-3, and SL-4

Carrier:

- The M-512 MPF is located inside the MDA, between longerons four and five in Bay 2, with the c.g. of the Vacuum Work Chamber located at:

  x = 3575.365
  y = 43.6
  z = 0.6

  These coordinates are referenced to the Launch Vehicle Coordinate System.

Conditions

Crew:

- Either the Pilot or Commander, designated as operator (OPR) can operate the facility.

Experiment:

- The MPF will be used to contain and perform M-551, M-552, M-553, M-518, M-555, and M-479:
  --Preparation Phase: 15 min
  --Operation Phase: 15 min
  --Termination Phase: 15 min

Ground Support:

- Prelaunch: Configure the MPF circuit breakers, switches, and valves in the proper position. Activate M-512 battery and install in facility.
- Post-launch: N/A

Requirements

Objectives:

- The following objective is to be accomplished on SL-1, SL-2, SL-3, and SL-4:
  --Provide a common spacecraft interface for a group of experiments in materials science and technology.

M-512 MPF Evaluation Team - Key Personnel Locator

Name	Responsibility	Office Address, Symbol, and Telephone Number
Mr. Gordon Parks	Principal Investigator (PI)	MSFC, Bldg. 4711, S&E-PT-MW, 205-453-2363
Mr. Gordon Parks	Experiment Developer (ED)	MSFC, Bldg. 4711, S&E-PT-MW, 205-453-2363
Mr. Edward Walker	MSFC Experiment Manager (EM)	MSFC, Bldg. 4201, PM-SL-DP, 205-453-3183
Mr. Al Bearskin	S&E Integration Engineer (IE)	MSFC, Bldg. 4610, S&E-ASTN-SDI, 205-453-3811
Mr. Gordon Parks	S&E Experiment Engineer (EE)	MSFC, Bldg. 4711, S&E-PE-MW, 205-453-2363
Mr. W. R. Bock	Technical Discipline Manager (TDM)	MSFC, Bldg. 4610, S&E-ASTN-SDF, 205-453-3810
Mr. O. H. Thomas, Jr.	Experiment Operations Engineer (EOE)	Teledyne Brown Engineering Company, Huntsville, Alabama, ASD-SHI, 205-532-1612
Mr. Steve Buzzard	Experiment Integration Engineer (EIE)	Martin Marietta Corporation, Denver, Colorado, 303-794-5211, ext. 5451
Mr. Charles Gruby	Experiment Flight Controller (EFC)	MSC, Houston, Texas, 713-483-4717

TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 2 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P - 60 min GMT TBD		M-512 MPF Evaluation Team manned and available. Contact M-512 MPF, Technical Discipline Manager, S&E-ASTN-SDF: HOSC Telephone No.TBD, Astronautics Laboratory Telephone No. 453-3810. Reference: Skylab Experiment Operations Handbook, Volume II.				
P - 10 min GMT TBD		Commence M-512 MPF preparation (ground action).				
P 1.0	OPR	Prepare for M-512 MPF integrity check.				
P 1.1	OPR	Don triangle shoes; install M-512 foot restraint.				
P 1.2	OPR	M-512 cb - close (up).				
P 1.3	OPR	Open control panel cover.				
P 1.4	OPR	Obtain and attach checklist and logbook to clipboard and secure to control panel cover.				
P 2.0	OPR	Verify the following: Work chamber vent vlv - CLOSE Bulkhead vent vlv - CLOSE FILAMENT CHAMBER VENT vlv - CLOSE CHAMBER REPRESS vlv - OPEN The chamber repress vlv will be open only for the initial MPF integrity check. WATER SYSTEM PURGE vlv - CLOSED WATER ACCUMULATOR FILL vlv - CLOSED WATER SPRAY vlv - CLOSED Work chamber hatch closed and latched. M-512 BAT. VENT vlv - OPEN MAIN BATTERY cb (CB1) - open				

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

**TP - Test Pilot (Commander)
OBS - Observer (Science Pilot)
PLT - Pilot
ALL - TP/OBS/PLT

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TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 3 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		Note: The Battery Disch cb (CB6) is left open until Experiment M-552 is completed. BATTERY DISCH cb (CB6) - open Note: After the M-555 package has been connected to the M-512 MPF under the EBG canister, cb CB5 is closed to provide power to the M-555 package prior to Experiment M-555 operation. CRYSTAL GROWTH HEATING PAD AM BUS 1 cb (CB5) - open.				
P 3.0	OPR	Verify the following control panel configuration: POWER CONTROL BATT cb (CB2) - open POWER CONTROL AM BUS 1 cb (CB4) - open POWER FIL BATT cb (CB3) - open FLOOD LT sw (S19) - OFF INSTRUMENTATION POWER sw (S2) - OFF INSTRUMENTATION TEMP SOURCE sw (S9) - CHMBR WALL ELECTRON BEAM POWER sw (S3) - OFF FIL/BEAM CONT sw (S12) - OFF FIL CHMBR INTLK sw (S13) - NORMAL INSTRUMENTATION CSTR X3 sw (S1) - OFF INSTRUMENTATION BASE + METER sw (S8) - METER X10 INSTRUMENTATION BASE TEMP sw (S5) - 0 PHOTO LT sw (S4) - OFF EXP ADV sw (S16) - OFF BEAM CONTROL CUR ADJ pot - TBD BEAM CONTROL FOCUS ADJ pot - TBD BEAM CONTROL ALIGN X pot - TBD BEAM CONTROL ALIGN Y pot - TBD HI VOLT/CAM sw (S14) - off (ctr) EXOTHERMIC POWER sw (S15) - OFF EXOTHERMIC SPECIMEN sw (S7) - OFF EXOTHERMIC TRIGGER sw (S6) - OFF				

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TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 4 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		COMPOSITE CASTING POWER sw (S25) - OFF COMPOSITE CASTING THERMAL MODE sw (S26) - HEAT CRYSTAL GROWTH POWER sw (S10) - OFF FLAMMABILITY POWER sw (S21) - OFF FLAMMABILITY SAMPLE ID sw (S20) - OFF FLAMMABILITY TEST TIME sw (S22) - OFF FLAMMABILITY SEQ READY sw (S18) - off (ctr) FLAMMABILITY DATA sw (S17) - off (ctr).				

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

TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 5 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.0	OPR	Commence M-512 MPF pressure integrity check.				
O 1.1	OPR	CHAMBER REPRESS vlv - OPEN.			O11A1	This step does not apply for the initial MPF integrity check. In the initial MPF integrity check, the CHAMBER REPRESS vlv is already open.
O 1.2	OPR	Open work chamber hatch. Visually inspect hatch seals for cracks and chips, and glass window for cracks. Close and latch hatch.			O12A1	
O 1.3	OPR	CHAMBER REPRESS vlv - CLOSED.			O13A1	
O 2.0	OPR	Verify vacuum integrity of work chamber.				
O 2.1	OPR	MAIN BATTERY cb (CB1) - close.				
O 2.2	OPR	POWER CONTROL BATT cb (CB2) - close.			O22A1	
		Note: For the initial integrity check, it is important to open the bulkhead vent vlv before the work chamber vent vlv to release the pressure trapped between the two valves.				
O 2.3	OPR	ELECTRON BEAM POWER sw (S3) - ON.			O23A1	
O 2.4	OPR	INSTRUMENTATION POWER sw (S2) - BATT.			O24A1	
O 2.5	OPR	INSTRUMENTATION CSTR X3 sw (S1) - WORK CHMBR.				
O 2.6	OPR	Monitor INSTRUMENTATION PRESS gage (M5) for 5 psia.			O26A1 O26B1 O26C1	
O 2.7	OPR	Bulkhead vent vlv - OPEN.			O27A1	
O 2.8	OPR	Work chamber vent vlv - OPEN.			O28A1	

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T - Termination
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PLT - Pilot
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MSFC - One Time Form 17-1 (March 1972)

TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 6 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 2.9	OPR	Monitor INSTRUMENTATION PRESS gage (M5) for 0 psia.			O29A1	
O 2.10	OPR	FILAMENT CHAMBER VENT vlv - OPEN.			O210A1	
O 2.11	OPR	Monitor FIL CHAMBR PRESS gage (M3) for reading of 1×10^{-4}▲ torr or less.			O211A1	Allow time for pressure to decrease below 1×10^{-4}▲ torr.
O 2.12	OPR	Work chamber vent vlv - CLOSE.			O212A1	
O 2.13	OPR	Monitor FIL CHMBR PRESS gage (M3) for reading of 1×10^{-4}▲ torr or less.			O213A1	
O 3.0	OPR	Verify vacuum integrity of 4-in. line between vent valves.				
O 3.1	OPR	Bulkhead vent vlv - CLOSE.			O31A1	
O 3.2	OPR	Work chamber vent vlv - OPEN.			O32A1	
O 3.3	OPR	Monitor FIL CHMBR PRESS gage (M3) for a pressure reading of 1×10^{-4}▲ torr or less.			O33A1	
O 4.0	OPR	Verify vacuum integrity of bulkhead vent vlv.				
O 4.1	OPR	FILAMENT CHAMBER VENT vlv - CLOSE.			O41A1	
O 4.2	OPR	CHAMBER REPRESS vlv - OPEN.			O42A1	
O 4.3	OPR	Monitor INSTRUMENTATION PRESS gage (M5) until MDA and work chamber pressure equalize.			O43A1	
O 4.4	OPR	CHAMBER REPRESS vlv - CLOSED.			O44A1	
O 4.5	OPR	Monitor INSTRUMENTATION PRESS gage (M5) for a reading of 5 psia.			O45A1	
O 5.0	OPR	Verify vacuum integrity of work chamber vent vlv.				

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▲ Refer to footnote on page E-10.

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TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 7 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 5.1	OPR	Work chamber vent vlv - CLOSE.			O51A1	
O 5.2	OPR	Bulkhead vent vlv - OPEN.			O52A1	
O 5.3	OPR	Monitor INSTRUMENTATION PRESS gage (M5) for a pressure reading of 5 psia.			O53A1	
O 5.4	OPR	Bulkhead vent vlv - CLOSE.			O54A1	
O 6.0	OPR	Verify EBG canister pressure.				
O 6.1	OPR	INSTRUMENTATION CSTR X3 sw (S1) - CSTR X3				
O 6.2	OPR	Monitor INSTRUMENTATION PRESS gage (M5) for no less than 8 psia (canister pressure 24 psia).			O62A1 O62B1	
O 6.3	OPR	INSTRUMENTATION POWER sw (S2) - OFF.			O63A1	
O 6.4	OPR	ELECTRON BEAM POWER sw (S3) - OFF.			O64A1	
O 6.5	OPR	POWER CONTROL BATT cb (CB2) - open.				
O 6.6	OPR	MAIN BATTERY cb (CB1) - open.				
O 7.0	OPR	Verify AM BUS 1 power available to MPF.				
O 7.1	OPR	POWER CONTROL AM BUS 1 cb (CB4) - close.				
O 7.2	OPR	INSTRUMENTATION POWER sw (S2) - AM BUS 1.				
O 7.3	OPR	Monitor INSTRUMENTATION PRESS gage (M5) for no less than 8 psia (canister pressure 24 psia).			O73A1 O73B1	
O 7.4	OPR	INSTRUMENTATION CSTR X3 sw (S1) - OFF.			O74A1	
O 7.5	OPR	INSTRUMENTATION POWER sw (S2) - OFF.			O75A1	
O 7.6	OPR	POWER CONTROL AM BUS 1 cb (CB4) - open.				

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TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 8 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1.0	OPR	Terminate M-512 MPF pressure integrity check.				
T 1.1	OPR	Verify the following: M-512 cb - close (up) Work chamber vent vlv - CLOSE Bulkhead vent vlv - CLOSE FILAMENT CHAMBER VENT vlv - CLOSE CHAMBER REPRESS vlv - CLOSED WATER SYSTEM PURGE vlv - CLOSED WATER ACCUMULATOR FILL vlv - CLOSED WATER SPRAY vlv - CLOSED Work chamber hatch closed and latched Note: The M-512 BAT. VENT vlv will remain OPEN the entire mission to allow venting of the M-512 MPF battery. M-512 BAT. VENT vlv - OPEN MAIN BATTERY cb (CB1) - open Note: The BATTERY DISCH cb (CB6) is left open until Experiment M-552 is completed. BATTERY DISCH cb (CB6) - open Note: After the M-555 package has been connected to the M-512 MPF under the EBG canister, cb CB5 is closed to provide power to the M-555 package prior to Experiment M-555 operation. CRYSTAL GROWTH HEATING PAD AM BUS 1 cb (CB5) - open.				
T 1.2	OPR	Verify the following control panel configuration: POWER CONTROL BATT cb (CB2) - open POWER CONTROL AM BUS 1 cb (CB4) - open				

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TABLE E-III. M-512 MATERIALS PROCESSING FACILITY EVALUATION SEQUENCE (Sheet 9 of 9)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		POWER FIL BATT cb (CB3) - open FLOOD LT sw (S19) - OFF INSTRUMENTATION POWER sw (S2) - OFF INSTRUMENTATION TEMP SOURCE sw (S9) - CHMBR WALL ELECTRON BEAM POWER sw (S3) - OFF FIL/BEAM CONT sw (S12) -OFF FIL CHMBR INTLK sw (S13) - normal (up) INSTRUMENTATION CSTR X3 sw (S1) - OFF INSTRUMENTATION BASE + METER sw (S8) - METER X10 INSTRUMENTATION BASE TEMP sw (S5) - 0 PHOTO LT sw (S4) - OFF EXP ADV sw (S16) - OFF BEAM CONTROL CUR ADJ pot - TBD BEAM CONTROL FOCUS ADJ pot - TBD BEAM CONTROL ALIGN X pot - TBD BEAM CONTROL ALIGN Y pot - TBD HI VOLT/CAM sw (S14) - off (ctr) EXOTHERMIC POWER sw (S15) - OFF EXOTHERMIC SPECIMEN sw (S7) - OFF EXOTHERMIC TRIGGER sw (S6) - OFF COMPOSITE CASTING THERMAL MODE sw (S26) - HEAT CRYSTAL GROWTH POWER sw (S10) - OFF FLAMMABILITY POWER sw (S21) - OFF FLAMMABILITY SAMPLE ID sw (S20) - OFF FLAMMABILITY TEST TIME sw (S22) - OFF FLAMMABILITY SEQ READY sw (S18) - off (ctr) FLAMMABILITY DATA sw (S17) - off (ctr).				
T 1.3	OPR	Remove logbook, checklist, and clipboard from control panel cover. Close and latch cover. Stow logbook, checklist, and clipboard.				
T 1.4	OPR	Remove M-512 foot restraint and triangle shoes and stow.				

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SECTION VIII.

M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE

TABLE E-IV. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
	No contingency plans are anticipated for the Preparation section of the M-512 Materials Processing Facility.			

P

ASTN-OT-7 (Feb. 72)

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 1 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
O 1.1	CHAMBER REPRESS vlv - OPEN.	O11A The CHAMBER REPRESS vlv will not open.	O11A1 Apply a greater amount of force than is normally required to open the CHAMBER REPRESS vlv.	The CHAMBER REPRESS vlv is used to repressurize the work chamber after it has been vented to space. Note when performing the experiments that use the MPF, that the work chamber cannot be repressurized using the normal procedures.
			O11A2 Continue with a modified MPF integrity check.	The modified MPF integrity check will repressurize the work chamber through the vacuum cleaner port instead of the CHAMBER REPRESS vlv.
O 1.2	Open work chamber hatch. Visually inspect hatch seals for cracks and chips, and glass window for cracks. Close and latch hatch.	O12A The work chamber hatch seals or window are cracked.	O12A1 A decision will have to be made concerning whether or not to continue the MPF integrity check.	
			• Continue with MPF integrity check. --Continue with the MPF integrity check following the normal procedure.	It was determined that this malfunction was not severe enough to cause a crew hazard. The MPF integrity check will continue to determine if a vacuum can be pulled on the work chamber.
			• Discontinue MPF integrity check. --Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	It was determined that this malfunction could create a crew hazard.
O 1.3	CHAMBER REPRESS vlv - CLOSED	O13A The CHAMBER REPRESS vlv will not close.	O13A1 Apply a greater amount of force than is normally required to close the CHAMBER REPRESS vlv.	If the CHAMBER REPRESS vlv will not close, a vacuum cannot be pulled on the work chamber.
			O13A2 Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	

O

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 2 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
O 2.3	ELECTRON BEAM POWER sw (S3) - ON.	O23A The FIL CHMBR PRESS gage (M3) is not operating (pegged full scale).	O23A1 Tap the FIL CHMBR PRESS gage (M3) with finger. O23A2 Recycle the ELECTRON BEAM POWER sw (S3). O23A3 Perform the following: • ELECTRON BEAM POWER sw (S3) - OFF • EXOTHERMIC POWER sw (S15) - ON • Verify EXOTHERMIC EXP HOT 1t (L2) illuminates: --EXOTHERMIC EXP HOT 1t (L2) illuminates. -Continue with a modified MPF integrity check.	If the FIL CHMBR PRESS gage (M3) indicates a pressure reading (not pegged), the M3 gage is hung. This would indicate the following: • The ELECTRON BEAM POWER sw (S3) failed to make contact in the ON position or the 30V max. - 26V min. regulator failed. Either one of these failures would prevent experiments M-551 and M-553 from being performed. The modified MPF integrity check will be performed using AM BUS 1 power. Only the INSTRUMENTATION PRESS gage (M5) will be used to monitor pressure.

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 3 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			--EXOTHERMIC EXP HOT 1t (L2) does not illuminate. -ELECTRON BEAM POWER (S3) - ON -EXOTHERMIC POWER (S15) - OFF -Refer to Contingency Plan No. O23A4	This would indicate one of the following: • The MAIN BATTERY cb (CB1) has failed open • The POWER CONTROL BATT cb (CB2) has failed open • The ELECTRON BEAM POWER sw (S3) failed to make contact in the OFF position.
			O23A4 Place the FLOOD LT sw (S19) in the BATT position and verify that the floodlight illuminates. • Floodlight illuminates --Continue with a modified MPF integrity check.	This would indicate one of the following: • The ELECTRON BEAM POWER sw (S3) failed to make contact in the ON position • The 30V max. - 26V min. regulator failed. Either one of these failures would prevent Experiments M-551 and M-553 from being performed.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 4 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				The modified MPF integrity check will be performed using AM BUS 1 power. Only the INSTRUMENTATION PRESS gage (M5) will be used to monitor pressure.
			• Floodlight does not illuminate. --Recycle the following: -cb MAIN BATTERY (CB1) -cb POWER CONTROL BATT (CB2)	This would indicate one of the following: • The MAIN BATTERY cb (CB1) failed open • The POWER CONTROL BATT cb (CB2) failed open.
			O23A5 Place the BATTERY DISCHARGE cb (CB6) in the DISCHARGE position and verify that the MPF battery DISCHARGE lt (L8) illuminates.	
			• MPF battery DISCHARGE lt (L8) illuminates --Continue with a modified MPF integrity check.	This would indicate that the POWER CONTROL BATT cb (CB2) failed open. This failure would prevent Experiments M-551, M-552, and M-553 from being performed. The modified MPF integrity check will be performed using AM BUS 1 power. Only the INSTRUMENTATION PRESS gage (M5) will be used to monitor pressure.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 5 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			• MPF battery DISCHARGE lt (L8) does not illuminate --Continue with a modified MPF integrity check.	This would indicate that the MAIN BATTERY cb (CB1) failed open. This failure would prevent Experiments M-551, M-552, and M-553 from being performed. It would also prevent the MPF battery from being discharged through the MPF battery discharge resistors and DISCHARGE lt (L8). The modified MPF integrity check will be performed using AM BUS 1 power. Only the INSTRUMENTATION PRESS gage (M5) will be used to monitor pressure.
O 2.4	--INSTRUMENTATION POWER sw (S2) - BATT.	O24A The INSTRUMENTATION TEMP gage (M4) does not indicate a temperature reading. (0 °C).	O24A1 Tap the INSTRUMENTATION TEMP gage (M4) with finger.	If the INSTRUMENTATION TEMP gage (M4) indicates a temperature reading, this would indicate that the M4 gage is hung.
			O24A2 Recycle the INSTRUMENTATION POWER sw (S2).	
			O24A3 Verify that the FIL CHMBR PRESS gage (M3) is receiving power. • The FIL CHMBR PRESS gage (M3) reading is less than full scale (not pegged). --Refer to Contingency Plan No. O24A4.	This would indicate one of the following: • The FIL CHMBR PRESS gage (M3) is receiving power • The INSTRUMENTATION

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 6 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				TEMP gage (M4) has failed • The INSTRUMENTATION POWER sw (S2) failed to make contact in the BATT position • The Power Supply Module failed.
			• The FIL CHMBR PRESS gage (M3) reading is full scale (pegged) --Refer to Contingency Plan No. O23A2. O24A4 Place the INSTRUMENTATION CSTR X3 sw (S1) in WORK CHMBR position and verify that the INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia. • INSTRUMENTATION PRESS gage (M5) reading is 0 psia --Continue with a modified MPF integrity check.	This would indicate one of the following: • The INSTRUMENTATION POWER sw (S2) failed to make contact in the BATT position • The Power Supply Module failed. This would preclude the operation of the INSTRUMENTATION

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 7 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				PRESS gage (M5) when operating experiments requiring MPF battery power. If the INSTRUMENTATION POWER sw (S2) will make contact in the AM BUS 1 position, the EBG canister pressure could be measured using AM BUS 1 power prior to setting up Experiments M-551 and M-553.
			• INSTRUMENTATION PRESS gage (M5) reading is 5 psia. --Refer to Operation Step No. O 2.7 and continue with the MPF integrity check.	This would indicate that the INSTRUMENTATION TEMP gage (M4) has failed. This would cause Experiment M-555 to lose some data.
O 2.6	Monitor INSTRUMENTATION PRESS gage (M5) for 5 psia.	O26A The INSTRUMENTATION PRESS gage (M5) reading is 0 psia.	O26A1 Tap the INSTRUMENTATION PRESS gage (M5) with finger.	If the INSTRUMENTATION PRESS gage (M5) moves up to 5 psia, the M5 gage is hung.
			O26A2 Recycle the INSTRUMENTATION CSTR X3 sw (S1).	
			O26A3 Verify that the INSTRUMENTATION TEMP gage (M4) is operating.	
			• INSTRUMENTATION TEMP gage (M4) temperature reading is greater than 0 °C. --Refer to Contingency Plan No. O26A4.	This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the WORK CHMBR position

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 8 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The INSTRUMENTATION PRESS gage (M5) has malfunctioned.
			• INSTRUMENTATION TEMP gage (M4) reading is 0 °C. --Refer to Contingency Plan No. O26A5.	This would indicate one of the following: • The Power Supply Module has failed • The INSTRUMENTATION POWER sw (S2) failed to make contact in the BATT position • The 30V max. - 26V min. regulator failed • The ELECTRON BEAM POWER sw (S3) failed to make contact in the ON position • The POWER CONTROL BATT cb (CB2) failed to close • The MAIN BATTERY cb (CB1) failed to close.
			O26A4 Place the INSTRUMENTATION CSTR X3 sw (S1) in the CSTR X3 position and verify that the INSTRUMENTATION PRESS gage (M5) reads the EBG canister pressure.	
			• INSTRUMENTATION PRESS gage (M5) reading is 24 psia or above. --Continue with a modified MPF integrity check.	This would indicate

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 9 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			• INSTRUMENTATION PRESS gage (M5) reading is greater than 0 but less than 24 psia. --Continue with a modified MPF integrity check.	that the INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the WORK CHMBR position. The modified MPF integrity check will be performed using only the FIL CHMBR PRESS gage (M3) to monitor pressure. This would indicate one of the following: • The EBG canister pressure is low • The INSTRUMENTATION PRESS gage (M5) has malfunctioned. A single failure would not give a low canister pressure and a zero reading on the INSTRUMENTATION PRESS gage (M5). This would take a double failure and will not be analyzed in this document. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments use the EBG. The EBG will not be operated if the EBG canister pressure is below 24 psia. This pressure cannot be measured if

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 10 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			• INSTRUMENTATION PRESS gage (M5) reading is 0 psia --Continue with a modified MPF integrity check.	the INSTRUMENTATION PRESS gage (M5) has malfunctioned. The modified MPF integrity check will be performed using only the FIL CHMBR PRESS gage (M3) to monitor pressure. This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in both the WORK CHMBR AND CSTR X3 positions • The INSTRUMENTATION PRESS gage (M4) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments use the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be monitored if the INSTRUMENTATION PRESS gage (M5) cannot be used. This modified MPF integrity check will be performed using only the FIL CHMBR PRESS

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 11 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				gage (M3) to monitor pressure.
			O26A5 Verify that the FIL CHMBR PRESS gage (M3) is receiving power. • The FIL CHMBR PRESS gage (M3) reading is less than full scale (not pegged). --Continue with a modified MPF integrity check.	This would indicate one of the following: • The FIL CHMBR PRESS gage (M3) is receiving power • The INSTRUMENTATION POWER sw (S2) failed to make contact in the BATT position • The Power Supply Module failed. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments use the EBG. The EBG will not operate if the EBG beam gun canister pressure is below 24 psia. This pressure cannot be measured if the INSTRUMENTATION PRESS gage (M5) cannot be used. The modified MPF integrity check will be performed using only the FIL CHMBR PRESS gage (M3) to monitor pressure.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 12 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			• The FIL CHMBR PRESS gage (M3) reading is full scale (pegged) --Refer to Contingency Plan No. O23A2.	This would indicate one of the following: • The MAIN BATTERY cb (CB1) failed to close • The POWER CONTROL BATT cb (CB2) failed to close • The ELECTRON BEAM POWER sw (S3) failed to make contact in the ON position • The 30V max. - 26V min. regulator failed.
		O26B The INSTRUMENTATION PRESS gage (M5) reading is between 0 and 5 psia.	O26B1 Tap the INSTRUMENTATION PRESS gage (M5) with finger. O26B2 Open the CHAMBER REPRESS vlv and monitor the INSTRUMENTATION PRESS gage (M5) for an increase in pressure.	If the INSTRUMENTATION PRESS gage (M5) moves up to 5 psia, the M5 gage is hung.
			• The INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia. --Further monitoring of the MPF will be required.	A double failure could occur causing a low work chamber pressure. If the MPF integrity check is to be continued, further monitoring of the MPF will be required to determine what caused the low work chamber pressure. This document does not analyze double failures.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 13 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			• The INSTRUMENTATION PRESS gage (M5) reading does not increase --Refer to Contingency Plan No. O26B3.	This would indicate one of the following: • The INSTRUMENTATION PRESS gage (M5) has malfunctioned. • The MDA pressure was low.
			O26B3 Place the INSTRUMENTATION CSTR X3 sw (S1) in the CSTR X3 position and verify that the INSTRUMENTATION PRESS gage (M5) reads the EBG canister pressure.	
			• INSTRUMENTATION PRESS gage (M5) reading is above 24 psia. --Continue with the normal MPF integrity check.	This would indicate the following: • The INSTRUMENTATION PRESS gage (M5) is operating properly • The MDA pressure was low.
			• INSTRUMENTATION PRESS gage (M5) reading is less than 24 psia. --Continue with a modified MPF integrity check.	This indicates that INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 14 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				The EBG will not be operated if the EBG canister pressure is below 24 psia. This pressure cannot be measured if the INSTRUMENTATION PRESS gage (M5) has malfunctioned. The modified MPF integrity check will be performed using only the FIL CHMBR PRESS gage (M3) to monitor pressure.
		O26C The INSTRUMENTATION PRESS gage (M5) reading is greater than 5 psia.	O26C1 Tap the INSTRUMENTATION PRESS gage (M5) with finger.	If the INSTRUMENTATION PRESS gage (M5) reading decreases to 5 psia, the M5 gage is hung.
			O26C2 Open the CHAMBER REPRESS vlv and monitor the INSTRUMENTATION PRESS gage (M5) for a pressure decrease.	
			• The INSTRUMENTATION PRESS gage (M5) reading decreases to 5 psia. --Continue with the normal MPF integrity check.	This would indicate that the CHAMBER REPRESS vlv was closed and did not allow the work chamber to vent down during launch.
			• The INSTRUMENTATION PRESS gage (M5) reading did not decrease. --Continue with a modified MPF integrity check.	This would indicate that the INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 15 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				require the use of the EBG. The EBG will not be operated if the EBG canister pressure is below 24 psia. The pressure cannot be measured if the INSTRUMENTATION PRESS gage (M5) has malfunctioned. The modified MPF integrity check will be performed using only the FIL CHMBR PRESS gage (M3) to monitor pressure.
O 2.7	Bulkhead vent vlv - OPEN.	O27A The bulkhead vent vlv will not open.	O27A1 Apply a greater amount of force than is normally required to open the bulkhead vent vlv. O27A2 Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	If the bulkhead vent vlv will not open, a vacuum cannot be pulled on the work chamber. This will preclude the performance of the experiments that use the MPF.
O 2.8	Work chamber vent vlv - OPEN.	O28A The work chamber vent vlv will not open.	O28A1 Apply a greater amount of force than is normally required to open the work chamber vent vlv. O28A2 Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	If the work chamber vent vlv will not open, a vacuum cannot be pulled on the work chamber. This will preclude the performance of the experiments that use the MPF.
O 2.9	Monitor INSTRUMENTATION PRESS gage (M5) for 0 psia.	O29A The INSTRUMENTATION PRESS gage (M5) reading did not decrease.	O29A1 Tap the INSTRUMENTATION PRESS gage (M5) with finger. O29A2 Place the INSTRUMENTATION CSTR X3 sw (S1) in the CSTR X3 position and monitor the INSTRUMENTATION PRESS gage (M5) for an increase in pressure.	If the INSTRUMENTATION PRESS gage (M5) reading decreases to zero, the M5 gage is hung.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 16 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			• INSTRUMENTATION PRESS gage (M5) reading does not increase. --Continue with a modified MPF integrity check.	This would indicate that the INSTRUMENTATION PRESS gage (M5) had malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister is below 24 psia. This pressure cannot be monitored if the INSTRUMENTATION PRESS gage (M5) has malfunctioned.
			• INSTRUMENTATION PRESS gage (M5) reading increases to 24 psia or above. --Refer to Contingency Plan No. O29A3. O29A3 Place the INSTRUMENTATION CSTR X3 sw (S1) in the WORK CHMBR position and monitor the INSTRUMENTATION PRESS gage (M5) for a decrease in pressure to 0 psia.	This could indicate that the INSTRUMENTATION PRESS gage (M5) is hung and will only increase in pressure.
			• INSTRUMENTATION PRESS gage (M5) reading decreases to 0 psia.	This would indicate that the INSTRUMENTATION PRESS gage (M5) was hung but was released when the INSTRUMENTATION CSTR X3 sw (S1) was placed in the CSTR X3 position.

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 17 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			• The INSTRUMENTATION PRESS gage (M5) reading does not decrease or does not decrease all the way to 0 psia. --Continue with a modified MPF integrity check.	The INSTRUMENTATION PRESS gage (M5) may now be operating properly but should be monitored periodically to verify that it does not become hung again. This would indicate that the INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be monitored if the INSTRUMENTATION PRESS gage (M5) has malfunctioned. The modified MPF integrity check will be performed using only the FIL CHMBR PRESS gage (M3) to monitor pressure.
O 2.10	FILAMENT CHAMBER VENT vlv - OPEN.	O210A The FILAMENT CHAMBER VENT vlv will not open.	O210A1 Apply a greater amount of force than is normally required to open the FILAMENT CHAMBER VENT vlv.	If the FILAMENT CHAMBER VENT vlv will not open, this will preclude the use of the FIL CHMBR PRESS gage (M3). This failure will prevent the performance of Experiments M-551 and M-553. These experiments require the use of

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 18 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				the EBG. The EBG will not operate when the FILAMENT CHAMBER VENT vlv is closed.
			O210A2 Continue with a modified MPF integrity check.	The modified MPF integrity check will be performed using only the INSTRUMENTATION PRESS gage (M5) to monitor pressure.
O 2.11	Monitor FIL CHMBR PRESS gage (M3) for a reading of 1 x 10^{-4}* torr or less.	O211A The FIL CHMBR PRESS gage (M3) stabilizes at a reading above 1 x 10^{-4}* torr.	O211A1 Tap the FIL CHMBR PRESS gage (M3) with finger.	If the FIL CHMBR PRESS gage (M3) reading decreases to 1 x 10^{-4}* torr or less, the FIL CHMBR PRESS gage (M3) is hung.
			O211A1 Perform Operation Step Nos. O 2.12 and O 2.13 and verify that the FIL CHMBR PRESS gage (M3) reading increases.	
			• FIL CHMBR PRESS gage (M3) reading increases --Terminate the MPF integrity check and reconfigure the MPF to its initial configuration.	This would indicate one of the following: • The work chamber area has a pressure leak • The CHAMBER REPRESS vlv has a pressure leak.
			• FIL CHMBR PRESS gage (M3) reading does not increase. --Refer to Contingency Plan No. O211A2.	This would indicate one of the following: • The 4-in. vacuum vent line has a pressure leak.

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*Refer to footnote on page E-10.

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 19 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The FIL CHMBR PRESS gage (M3) has malfunctioned.
			O211A2 Perform Operation Step Nos. O 3.1, O 3.2, and O 3.3 and verify that the FIL CHMBR PRESS gage (M3) reading increases.	
			• FIL CHMBR PRESS gage (M3) reading increases. --Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	This would indicate a pressure leak in the 4-in. vacuum vent line.
			• FIL CHMBR PRESS gage (M3) reading does not increase. --Continue with a modified MPF integrity check.	This would indicate that the FIL CHMBR PRESS gage (M3) has malfunctioned. The modified MPF integrity check will be performed using only the INSTRUMENTATION PRESS gage (M5) to monitor pressure.
O 2.12	Work chamber vent vlv - CLOSE.	O212A The work chamber vent vlv will not close.	O212A1 Apply a greater amount of force than is normally required to close the work chamber vent vlv.	If the work chamber vent vlv will not close, this will result in loss of 4-in. vacuum vent line vent vlv redundancy.
			O212A2 A decision will have to be made concerning whether or not to continue with the MPF integrity check.	
			• Continue with MPF integrity check --Continue with a modified MPF integrity check.	It was determined that loss of vent vlv redundancy would not

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 20 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				create a crew hazard by continuing the MPF integrity check and operating the experiments that require the MPF. The modified MPF integrity check will be continued using only the bulkhead vent vlv to separate the work chamber from the space vacuum.
			• Discontinue MPF integrity check. --Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	It was determined that loss of vent vlv redundancy could create a crew hazard by continuing the MPF integrity check and operating the experiments that require the MPF.
O 2.13	Monitor FIL CHMBR PRESS gage (M3) for a reading of 1 x 10^{-4}* torr or less.	O213A The FIL CHMBR PRESS gage (M3) reading increases above 1 x 10^{-4}* torr.	O213A1 Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	This would indicate one of the following: • The work chamber has a pressure leak • The CHAMBER REPRESS vlv has a pressure leak.
O 3.1	Bulkhead vent vlv - CLOSE.	O31A The bulkhead vent vlv will not close.	O31A1 Apply a greater amount of force than is normally required to close the bulkhead vent vlv. O31A2 A decision will have to be made concerning whether or not to continue with the MPF integrity check.	If the bulkhead vent vlv will not close, this will result in loss of 4-in. vacuum vent line vent vlv redundancy.
			• Continue with MPF integrity check --Continue with a modified MPF integrity check.	It was determined

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*Refer to footnote on page E-10.

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 23 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				check will be conducted using AM BUS 1 power. It was determined not to apply power to the FIL CHMBR PRESS gage (M3) when the work chamber was pressurized (MDA pressure
O 4.2	CHAMBER REPRESS vlv - OPEN.	O42A The CHAMBER REPRESS vlv will not open.	O42A1 Apply a greater amount of force than is normally required to open the CHAMBER REPRESS vlv. O42A2 Perform the following: • Unscrew the cover from the vacuum cleaner port • Monitor INSTRUMENTATION PRESS gage (M5) until MDA and work chamber pressure equalize • Screw the cover back onto the vacuum cleaner port • Refer to Operation Step No. O 4.5 and continue with the MPF integrity check.	If the CHAMBER REPRESS vlv will not open, the work chamber cannot be repressurize using the normal procedure. The CHAMBER REPRESS vlv is neither opened nor closed for the rest of the MPF integrity check. Its malfunction should be remembered while preparing and performing the experiments using the MPF.
O 4.3	Monitor INSTRUMENTATION PRESS gage (M5) until MDA and work chamber pressure equalize.	O43A The INSTRUMENTATION PRESS gage (M5) reading does not increase or stabilizes at a reading below 5 psia.	O43A1 Tap the INSTRUMENTATION PRESS gage (M5) with finger. O43A2 Perform Operation Step Nos. O 4.4 and O 4.5. • INSTRUMENTATION PRESS gage (M5) reading decreases --Refer to Contingency Plan No. O43A3.	If the INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia, the M5 gage is hung. This would indicate

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 24 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				that the bulkhead vent vlv has a pressure leak.
			• INSTRUMENTATION PRESS gage (M5) reading does not decrease --Continue with a modified MPF integrity check.	This would indicate the INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be measured if the INSTRUMENTATION PRESS gage (M5) has malfunctioned.
			O43A3 A decision will have to be made concerning whether or not to continue with the MPF integrity check.	
			• Continue with MPF integrity check --Refer to Operation Step No. O 5. 0 and continue with the MPF integrity check.	It was determined that loss of vent vlv redundancy would not create a crew hazard by continuing the MPF integrity check and operating the experiments that require the MPF. Remember when operating the experiments that require the MPF that the bulkhead vent vlv has a pressure leak.
			• Discontinue MPF integrity check. --Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	It was determined that loss of

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 25 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				vent vlv redundancy could create a crew hazard by continuing the MPF integrity check and operating the experiments that require the MPF.
O 4.4	CHAMBER REPRESS vlv - CLOSED.	O44A The CHAMBER REPRESS vlv will not close.	O44A1 Refer to Contingency Plan No. O13A1.	
O 4.5	Monitor INSTRUMENTATION PRESS gage (M5) for a reading of 5 psia.	O45A The INSTRUMENTATION PRESS gage (M5) reading begins to decrease below 5 psia.	O45A1 Close the work chamber vent vlv and verify that the INSTRUMENTATION PRESS gage (M5) reading stabilizes.	
			• INSTRUMENTATION PRESS gage (M5) reading stabilizes. --Refer to Contingency Plan No. O45A2.	This would indicate that the bulkhead vent vlv has a pressure leak.
			• INSTRUMENTATION PRESS gage (M5) reading continues to decrease. --Continue with a modified integrity check.	This would indicate that the INSTRUMENTATION PRESS gage(M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 2[illegible] psia. The pressure cannot be measured if the INSTRUMENTATION PRESS gage (M5) has malfunctioned. This would also indicate a double

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 26 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				failure, but double failures are not considered in this analysis; therefore, the INSTRUMENTATION PRESS gage (M5) was considered to have malfunctioned.
			O45A2 A decision will have to be made concerning whether or not to continue with the MPF integrity check.	
			• Continue with MPF integrity check --Continue with the MPF integrity check.	It was determined that loss of vent vlv redundancy would not create a crew hazard by continuing the MPF integrity check and operating the experiments that require the MPF. The normal MPF integrity check will be continued. The bulkhead vent valve will not be used in this MPF integrity check to verify pressure leaks.
			• Discontinue MPF integrity check. --Terminate the MPF integrity check and reconfigure the MPF to its initial condition.	It was determined that loss of vent vlv redundancy could create a crew hazard by continuing the MPF integrity check and operating the experiments that use the MPF.
O 5.1	Work chamber vent vlv - CLOSE.	O51A The work chamber vent vlv will not close.	O51A1 Refer to Contingency Plan No. O212A1.	
O 5.2	Bulkhead vent vlv - OPEN.	O52A The bulkhead vent vlv will not open.	O52A1 Refer to Contingency Plan No. O27A1.	
O 5.3	Monitor the INSTRUMENTATION PRESS gage (M5) for a reading of 5 psia.	O53A The INSTRUMENTATION PRESS gage (M5) reading begins to decrease below 5 psia.	O53A1 Refer to Contingency Plan No. O45A1 and substitute work chamber vent vlv for bulkhead vent vlv and bulkhead vent vlv for work chamber	

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 27 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			vent vlv.	
O 5.4	Bulkhead vent vlv - CLOSE.	O54A The bulkhead vent vlv will not close.	O54A1 Refer to Contingency Plan Nos. O31A1 and O31A2 with the following exceptions in Contingency Plan No. O31A2: • Continue with the normal MPF integrity check instead of a modified MPF integrity check • Disregard remarks about the modified MPF integrity check in the REMARKS COLUMN and replace it with: The normal MPF integrity check can be continued because the bulkhead vent vlv is no longer opened or closed in this MPF integrity check.	
O 6.2	Monitor INSTRUMENTATION PRESS gage (M5) for no less than 8 psia (canister pressure 24 psia).	O62A The INSTRUMENTATION PRESS gage (M5) decreases to 0 psia.	O62A1 Recycle the INSTRUMENTATION CSTR X3 sw (S1). O62A2 Verify that the INSTRUMENTATION TEMP gage (M4) is operating: • INSTRUMENTATION TEMP gage (M4) reading is greater than 0 °C. --Refer to Contingency Plan No. O62A3. • INSTRUMENTATION TEMP gage (M4) reading is 0 °C. --Refer to Contingency Plan Nos. O26A5 through O26A9 with the following exceptions:	O

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 28 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			-Replace the statement "Continue with a modified MPF integrity check" with "Continue with the integrity check." -Disregard all comments in the REMARKS COLUMN about the modified MPF integrity checks. O62A3 Place the INSTRUMENTATION CSTR X3 sw (S1) in the WORK CHMBR position and verify that the INSTRUMENTATION PRESS gage (M5) reads the work chamber pressure. • INSTRUMENTATION PRESS gage (M5) reading is 5 psia. --Continue with a modified MPF integrity check.	This would indicate that the INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the CSTR X3 position. A decision would have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be monitored if the INSTRUMENTATION CSTR X3 sw (S1) will not make contact in the CSTR X3 position. The last operation section of the MPF integrity check verifies if AM BUS 1 power is available.

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 29 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			• INSTRUMENTATION PRESS gage (M5) reading is 0 psia --Continue with a modified MPF integrity check.	to the MPF, the modified MPF integrity check will verify this by using the INSTRUMENTATION PRESS gage (M5) to measure the work chamber pressure instead of the EBG canister pressure. This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) has failed to make contact in both the CSTR X3 and WORK CHMBR positions • The INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision would have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be measured if the INSTRUMENTATION PRESS gage (M5) cannot be used. The last operation section of the MPF integrity check verifies if AM BUS 1 power is available

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 30 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				to the MPF. The modified MPF integrity check will verify this by illuminating the flood-light instead of measuring the EBG canister pressure using the INSTRUMENTATION PRESS gage (M5).
		O62B The INSTRUMENTATION PRESS gage (M5) reading stabalizes below 24 psia.	O62B1 Tap the INSTRUMENTATION PRESS gage (M5) with finger.	If the INSTRUMENTATION PRESS gage (M5) increases to 24 psia, the M5 gage is hung.
			O62B2 Continue with the MPF integrity check.	This would indicate that the EBG canister pressure is below 24 psia. This will preclude the operation of Experiments M-551 and M-553.
O 6.3	INSTRUMENTATION POWER sw (S2) - OFF.	O63A The INSTRUMENTATION PRESS gage (M5) and the INSTRUMENTATION TEMP gage (M4) are indicating pressure and temperature readings.	O63A1 Recycle the INSTRUMENTATION POWER sw (S2).	This would indicate that the INSTRUMENTATION POWER sw (S2) failed to break electrical contact in the BATT position when the S2 sw was placed in the OFF position. If the INSTRUMENTATION POWER sw (S2) failes in the BATT position, the INSTRUMENTATION PRESS gage (M5) and the INSTRUMENTATION TEMP gage (M4) cannot be operated using AM BUS 1 power.
			O63A2 Continue with a modified MPF integrity check.	Remember that the INSTRUMENTATION PRESS gage (M5) and INSTRUMENTATION TEMP gage (M4) will not be used when

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 31 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				performing Experiments M-518, M-555, and M-479. The last operation section of the MPF integrity check verifies if AM BUS 1 power is available to the MPF. The modified MPF integrity check will verify this by using the floodlight instead of measuring the EBG canister pressure using the INSTRUMENTATION PRESS gage (M5).
O 6.4	ELECTRON BEAM POWER sw (S3) - OFF.	O64A The FIL CHMBR PRESS gage (M3) reading is less than full scale (not pegged).	O64A1 Tap the FIL CHMBR PRESS gage (M3) with finger.	This would indicate that the ELECTRON BEAM POWER sw (S3) failed to break electrical contact in the ON position when the S3 sw was placed in the OFF position. If the FIL CHMBR PRESS gage (M3) reading goes to full scale (pegged), this would indicate that the M3 gage is hung.
			O64A2 Recycle the ELECTRON BEAM POWER sw (S3)	If the FIL CHMBR PRESS gage (M3) reading goes to full scale (pegged), this would indicate that the ELECTRON BEAM POWER sw (S3) had failed in the ON position but has released and is now in the OFF position.
			O64A3 Perform Operation Step No. O 6.5 and continue with the MPF integrity check.	If the FIL CHMBR PRESS gage (M3) reading goes to full scale (pegged), this would indicate that the ELECTRON BEAM

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 32 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				POWER sw (S3) had failed to break electrical contact in the BATT position when the S3 sw was placed in the OFF position. This would preclude the normal operation of Experiment M-552. The S3 sw is placed in the OFF position to normally perform Experiment M-552. If the FIL CHMBR PRESS gage (M3) reading does not go to full scale (not pegged), this would indicate that the M3 gage has malfunctioned. This would preclude measuring the low pressure in the work chamber required by some of the experiments that use the MPF.
O 7.3	Monitor INSTRUMENTATION PRESS gage (M5) for no less than 8 psia (canister pressure 24 psia).	O73A The INSTRUMENTATION PRESS gage (M5) reading is 0 psia.	O73A1 Tap INSTRUMENTATION PRESS gage (M5) with finger. O73A2 Verify that the INSTRUMENTATION TEMP gage (M4) is operating: • INSTRUMENTATION TEMP gage (M4) reading is greater than 0 °C --Refer to Contingency Plan No. O73A3. • INSTRUMENTATION TEMP gage (M4) reading is 0 °C --Refer to Contingency Plan No. O73A5.	If the INSTRUMENTATION PRESS gage (M5) reading increases to 24 psia or above, the M5 gage is hung.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 33 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			O73A3 Place the INSTRUMENTATION CSTR X3 sw (S1) in the WORK CHMBR position and verify that the INSTRUMENTATION PRESS gage (M5) reading is 5 psia.	
			• INSTRUMENTATION PRESS gage (M5) reading is 0 psia --Continue with the MPF integrity check.	This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) has failed and will not make contact in either the CSTR X3 or WORK CHMBR positions • The INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia.
			• INSTRUMENTATION PRESS gage (M5) reading is 5 psia --Refer to Contingency Plan No. O73A4.	This would indicate that the INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the CSTR X3 position.
			O73A4 Recycle the INSTRUMENTATION CSTR X3 sw (S1) and continue with the MPF integrity check.	If the INSTRUMENTATION CSTR X3 sw (S1) fails to make

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 34 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				contact in the CSTR X3 position, a decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure cannot be measured.
			O73A5 Recycle the INSTRUMENTATION POWER sw (S2).	
			O73A6 Place the FLOOT LT sw (S19) in the AM BUS 1 position and verify that the floodlight illuminates.	
			• Floodlight illuminates --Refer to Contingency Plan No. O73A7.	This would indicate one of the following: • The INSTRUMENTATION POWER sw (S2) failed to make contact in the AM BUS 1 position • The Power Supply Module failed. Either one of these failures would preclude the operation of the INSTRUMENTATION PRESS gage (M5) and the INSTRUMENTATION TEMP gage (M4) when performing Experiments M-518, M-555, and M-479.
			• Floodlight does not illuminate --Refer to Contingency Plan No. 073A8.	O

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 35 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			O73A7 Perform the following: • POWER CONTROL AM BUS 1 cb (CB4) - open • MAIN BATTERY cb (CB1) - close • POWER CONTROL BATT cb (CB2) - open • ELECTRON BEAM POWER sw (S3) - ON • INSTRUMENTATION POWER sw (S2) - BATT • Monitor the INSTRUMENTATION PRESS gage (M5) for no less than 8 psia (canister pressure 24 psia). --INSTRUMENTATION PRESS gage (M5) reading is 0 psia -Reconfigure the steps in Contingency Plan O73A7 to the way they were and continue with the MPF integrity check.	This would indicate one of the following: • The INSTRUMENTATION POWER sw (S2) has failed to make contact in both the BATT AND AM BUS 1 positions • The Power Supply Module failed. This would preclude the operation of the INSTRUMENTATION PRESS gage (M5) and the INSTRUMENTATION TEMP gage (M4) for the performance of all

TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 36 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				experiments that use the MPF. A decision would have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be measured if the M5 gage cannot be used.
			--INSTRUMENTATION PRESS gage (M5) reading is 24 psia or above -Reconfigure the steps in Contingency Plan O73A7 to the way they were and continue with the MPF integrity check.	This would indicate that the INSTRUMENTATION POWER sw (S2) failed to make contact when placed in the AM BUS 1 position. This will preclude operation of the INSTRUMENTATION POWER gage (M5) and the INSTRUMENTATION TEMP gage (M4) when performing Experiments M-518, M-555, and M-479.
			O73A8 Recycle the following: • POWER CONTROL AM BUS 1 cb (CB4) • M512 cb.	This would indicate one of the following: • The POWER CONTROL AM BUS 1 cb (CB4) failed to make contact when closed • The M-512 cb failed to make contact when closed.

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 37 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			O73A9 Continue with the MPF integrity check.	This will preclude the performance of Experiments M-518, M-555, and M-479. These experiments use AM BUS 1 power.
		O73B The INSTRUMENTATION PRESS gage (M5) reading stabilizes below 24 psia.	O73B1 Tap the INSTRUMENTATION PRESS gage (M5) with finger	The purpose of Operation Step No. O 7.3 was to verify that AM BUS 1 power was available to the MPF. The pressure reading on the M5 gage verifies this but some concern should be placed as to why the pressure reading is not 24 psia or above. These Contingency Plans deal with this problem. If the INSTRUMENTATION PRESS gage (M5) reading increases to 24 psia, this would indicate that the M5 gage is hung.
			O73B1 Continue with the MPF integrity check.	This would indicate one of the following: • The EBG canister pressure is below 24 psia • The INSTRUMENTATION PRESS gage (M5) has malfunctioned. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 38 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be monitored if the INSTRUMENTATION PRESS gage (M5) has malfunctioned.
O 7.4	INSTRUMENTATION CSTR X3 sw (S1) - OFF.	O74A The INSTRUMENTATION PRESS gage (M5) is indicating a pressure reading.	O74A1 Tap the INSTRUMENTATION PRESS GAGE (M5) with finger.	If the INSTRUMENTATION PRESS gage (M5) reading decreases to 0 psia, the M5 gage is hung.
			O74A2 Recycle the INSTRUMENTATION CSTR X3 sw (S1).	This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) failed to break contact in the CSTR X3 position when the S1 sw was placed in the OFF position. • The INSTRUMENTATION PRESS gage (M5) has malfunctioned.
			O74A3 Perform Operation Step No. O 7.5 and continue with the MPF integrity check.	If the INSTRUMENTATION PRESS gage (M5) reading decreases to 0 psia, this would indicate that the INSTRUMENTATION CSTR X3 sw (S1) has failed to break contact in the CSTR X3 position when the S1 sw is placed

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 39 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				in the OFF position. This would preclude measuring the gross pressure in the work chamber. If the INSTRUMENTATION PRESS gage (M5) still indicates a pressure reading, this would indicate that the M5 gage has malfunctioned. This would preclude measuring the gross pressure in the work chamber. A decision will have to be made concerning whether or not to perform Experiments M-551 and M-553. These experiments require the use of the EBG. The EBG will not operate if the EBG canister pressure is below 24 psia. This pressure cannot be measured if the M5 gage has malfunctioned.
O 7.5	INSTRUMENTATION POWER sw (S2) - OFF	O75A The INSTRUMENTATION TEMP gage (M4) is indicating a temperature reading.	O75A1 Tap the INSTRUMENTATION PRESS gage (M5) with finger. O75A2 Recycle the INSTRUMENTATION POWER sw (S2).	If the INSTRUMENTATION TEMP gage (M4) reading decreases to 0 °C, the M4 gage is hung. This would indicate one of the following: • The INSTRUMENTATION POWER sw (S2) has failed to break contact in the AM BUS 1 position when the S2 sw was placed in the OFF position

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TABLE E-V. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 40 of 40)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				• The INSTRUMENTATION TEMP gage (M4) has malfunctioned.
			O75A3 Perform Operation Step No. O 7.6 and continue with the MPF integrity check.	If the INSTRUMENTATION TEMP gage (M4) reading decreases to 0 °C, this would indicate that the INSTRUMENTATION POWER sw (S2) has failed to break contact in the AM BUS 1 position when the S2 sw is placed in the OFF position. This will preclude the operation of the INSTRUMENTATION PRESS gage (M5) and the INSTRUMENTATION TEMP gage (M4) when performing Experiments M-551, M-552, and M-553. These experiments require the MPF battery to operate. Note that AM BUS 1 power could be used to monitor the EBG canister pressure before preparing for Experiments M-551 and M-553 to verify the canister pressure is 24 psia or above. If the INSTRUMENTATION TEMP gage (M4) reading still indicates a temperature reading, this would indicate that the M4 gage has malfunctioned. This would affect Experiment M-555 that uses the M4 gage to obtain some of the data.

TABLE E-VI. M-512 MATERIALS PROCESSING FACILITY MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
	No contingency plans are anticipated for the Termination section of the M-512 Materials Processing Facility.			

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SECTION IX.

M-512 MATERIALS PROCESSING FACILITY MALFUNCTION ANALYSES

The material contained in this section is an excerpt from Reference 22.

6. MATERIALS PROCESSING IN SPACE, M512

The primary M512 operational functions requiring analysis are presented in Table 6.1. Figure 6.1 depicts the relationships used to develop this table.

Table 6.1 Operational Functions and Malfunction Analysis Items, M512

Operational Function	Sub-Function	Malfunction Analysis Item
6.1 Materials Processing Facility	6.1.1 Provide Electron Beam	6.1.1.1 FIL BATT cb, BATT cb, FIL/BEAM CONT sw, HI VOLT/ CAM sw, READY lp, relays K3, K8, or EB POWER sw failures
		6.1.1.2 BEAM CONTROL CUR ADJ, BEAM CUR ind, failure
		6.1.1.3 Provide EB focus
		6.1.1.4 HI VOLT ind failure
	6.1.2 Provide Instrumentation	6.1.2.1 INSTRUMENTATION POWER sw failure
		6.1.2.2 Provide Pressure data
		6.1.2.3 TEMP ind, TEMP SOURCE sw failure
		6.1.2.4 BASE TEMP sw failure
		6.1.2.5 TEMP sw failure
	6.1.3 Provide Chamber	6.1.3.1 Provide Vacuum
		6.1.3.2 Provide Repressurization
		6.1.3.3 Provide EB Filament Chamber Vacuum

Table 6.1 Operational Functions and Malfunction Analysis Items, M512 (Cont'd)

Operational Function	Sub-Function	Malfunction Analysis Item
	6.1.4 Provide Photography	6.1.4.1 Relay K8, 1 pole of HI VOLT/ CAM sw fails open 6.1.4.2 HI VOLT/CAM sw failure 6.1.4.3 PHOTO LT sw, FIL CHMBR INTER-LOCK sw, Photo Light failure 6.1.4.4 FIL CHMBR INTERLOCK sw fail-ure
	6.1.5 Provide Vacuum Cleaner	Same as Section 14.6
	6.1.6 Provide Power	6.1.6.1 Provide Battery 6.1.6.2 AM BUS 1 cb failure
6.2 Perform M551	6.2.1 Provide Weld Speci-men Discs	6.2.1.1 Physical Damage to Discs
	6.2.2 Provide Specimen Drive	6.2.2.1 Motor connector, EXP ADV sw failure 6.2.2.2 EXP ADV sw failure
6.3 Perform M552	6.3.1 Provide Exothermic Package	6.3.1.1 Physical Damage to package
	6.3.2 Control Power	6.3.2.1 EB POWER sw, EXOTH POWER sw, TRIGGER sw, SELECT sw, or connector failure

Table 6.1 Operational Functions and Malfunction Analysis Items, M512 (Cont'd)

Operational Function	Sub-Function	Malfunction Analysis Item
		6.3.2.2 TRIGGER sw failure 6.3.2.3 EXP HOT lp, thermistor, or relay K9 failure
6.4 Perform M553	6.4.1 Provide Specimens	6.4.1.1 Physical Damage for Wheels or Individual Specimens
	6.4.2 Provide Specimen Drive	6.4.2.1 Motor, connector, EXP ADV sw failure 6.4.2.2 EXP ADV sw failure
	6.4.3 Provide Sphere Catchers	6.4.3.1 Physical Damage to Sphere Catchers
6.5 Perform M554	6.5.1 Provide Package	6.5.1.1 Physical Damage to package
	6.5.2 Control Power	6.5.2.1 COMPOSITE CASTING POWER sw failure
	6.5.3 Provide Heat/Cool Cycle	6.5.3.1 THERMAL MODE sw failure
6.6 Perform M555	6.6.1 Provide Package	6.6.1.1 Physical Damage to Package
	6.6.2 Provide Continuous Heating	6.6.2.1 Heating Blanket, CRYSTAL GROWTH AM BUS 1 cb failures, or power drop

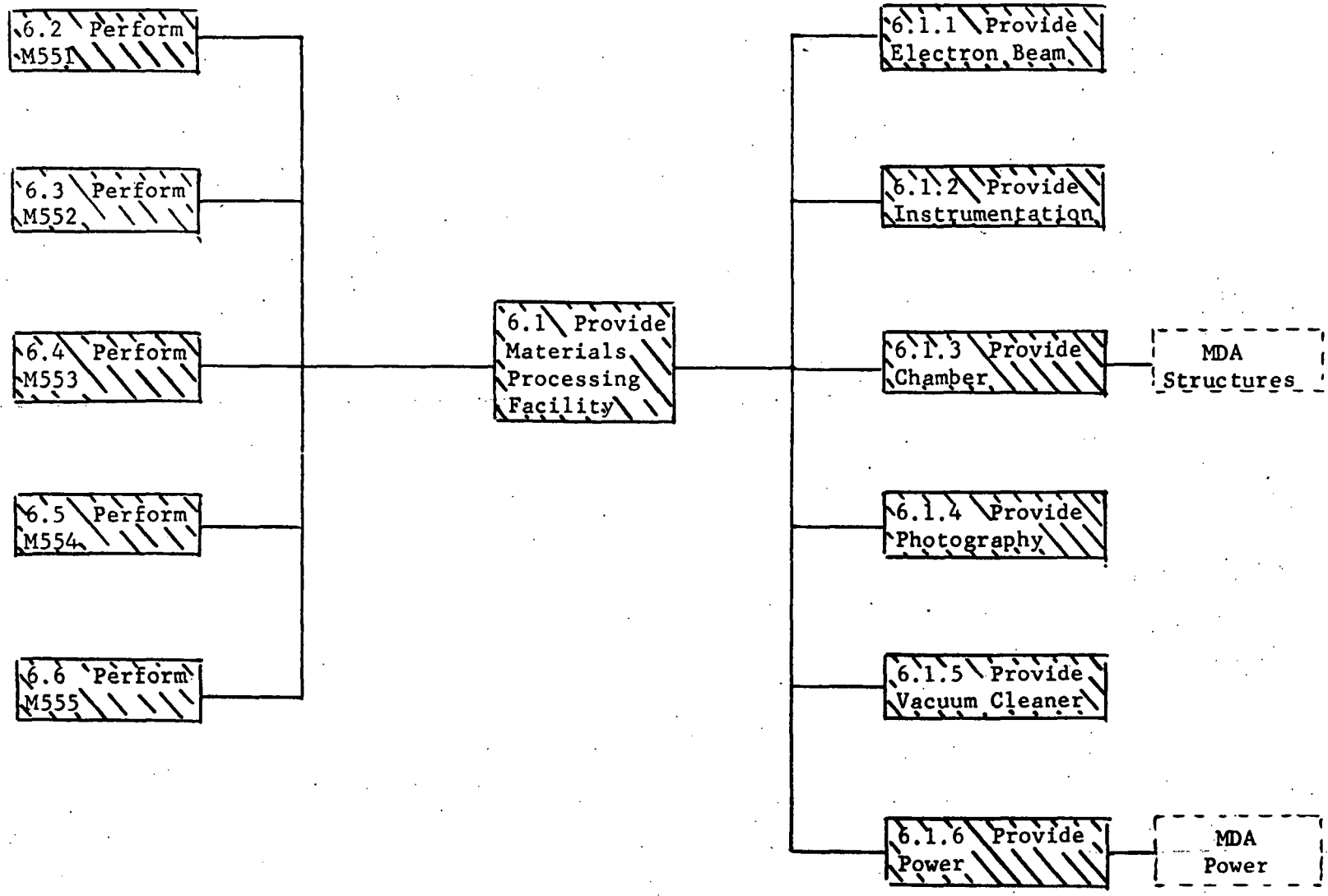

Figure 6.1 Functional Flow Diagram, M512

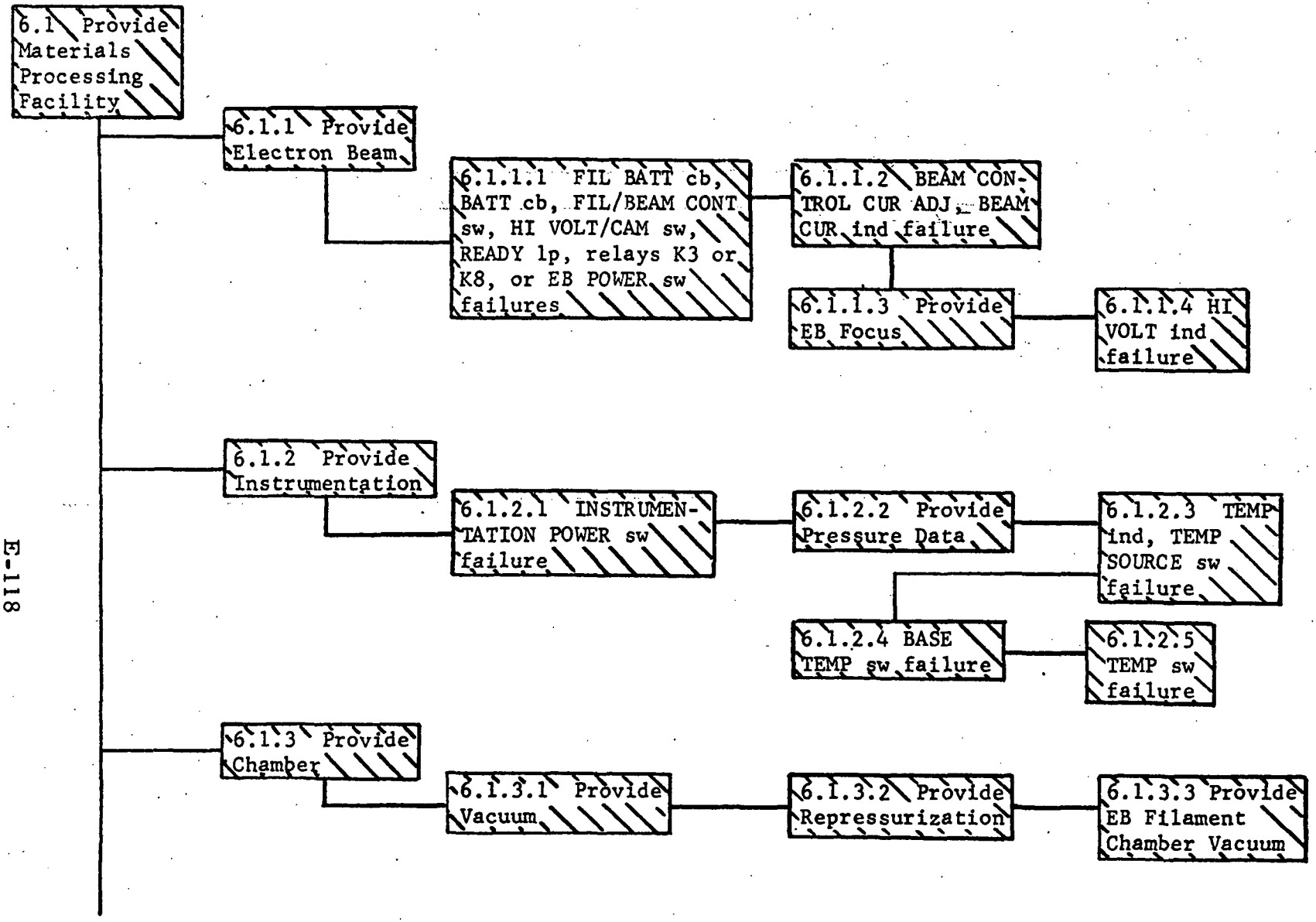

Figure 6.2 Malfunction Analysis Diagram, M512

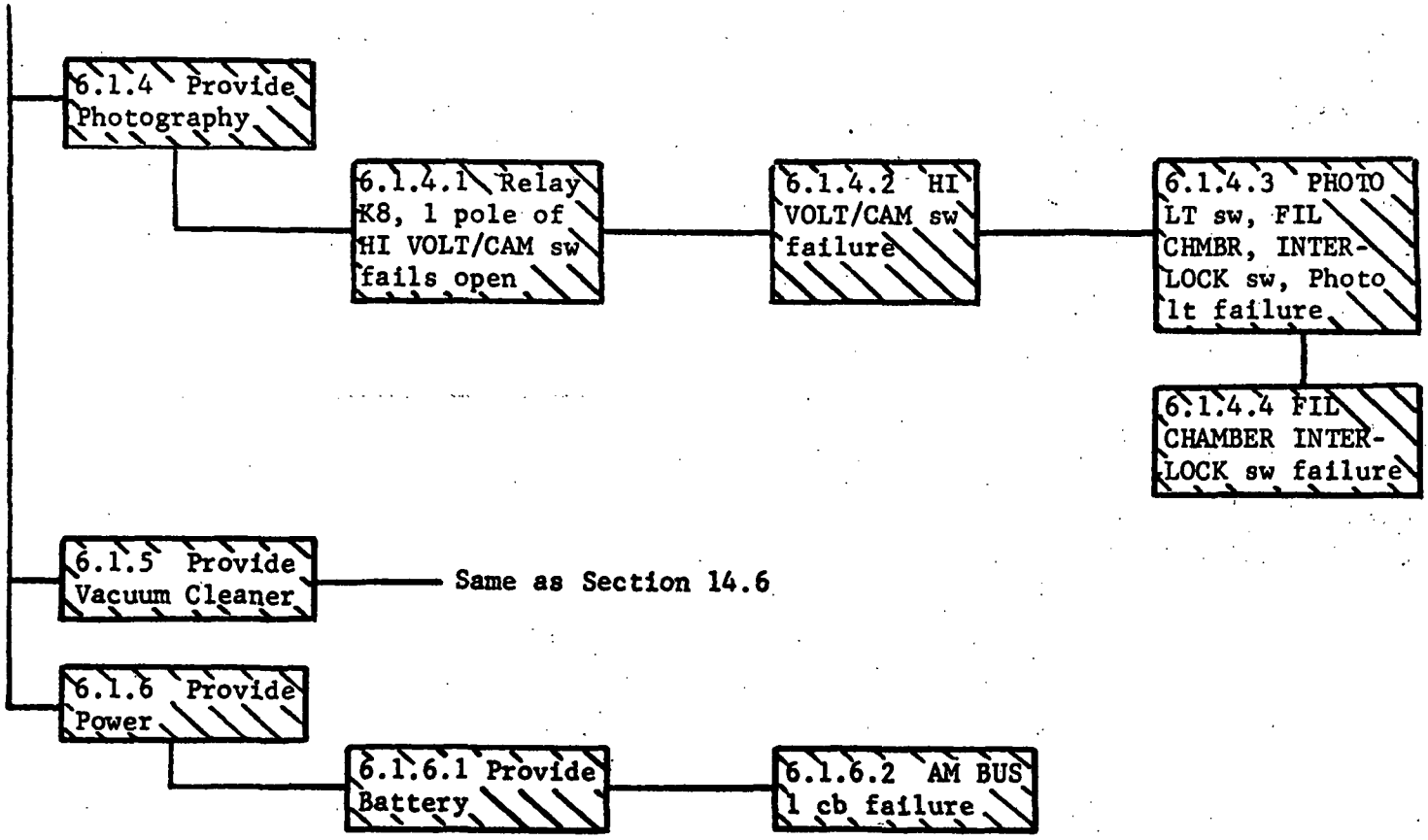

Figure 6.3 Malfunction Analysis Diagram, M512

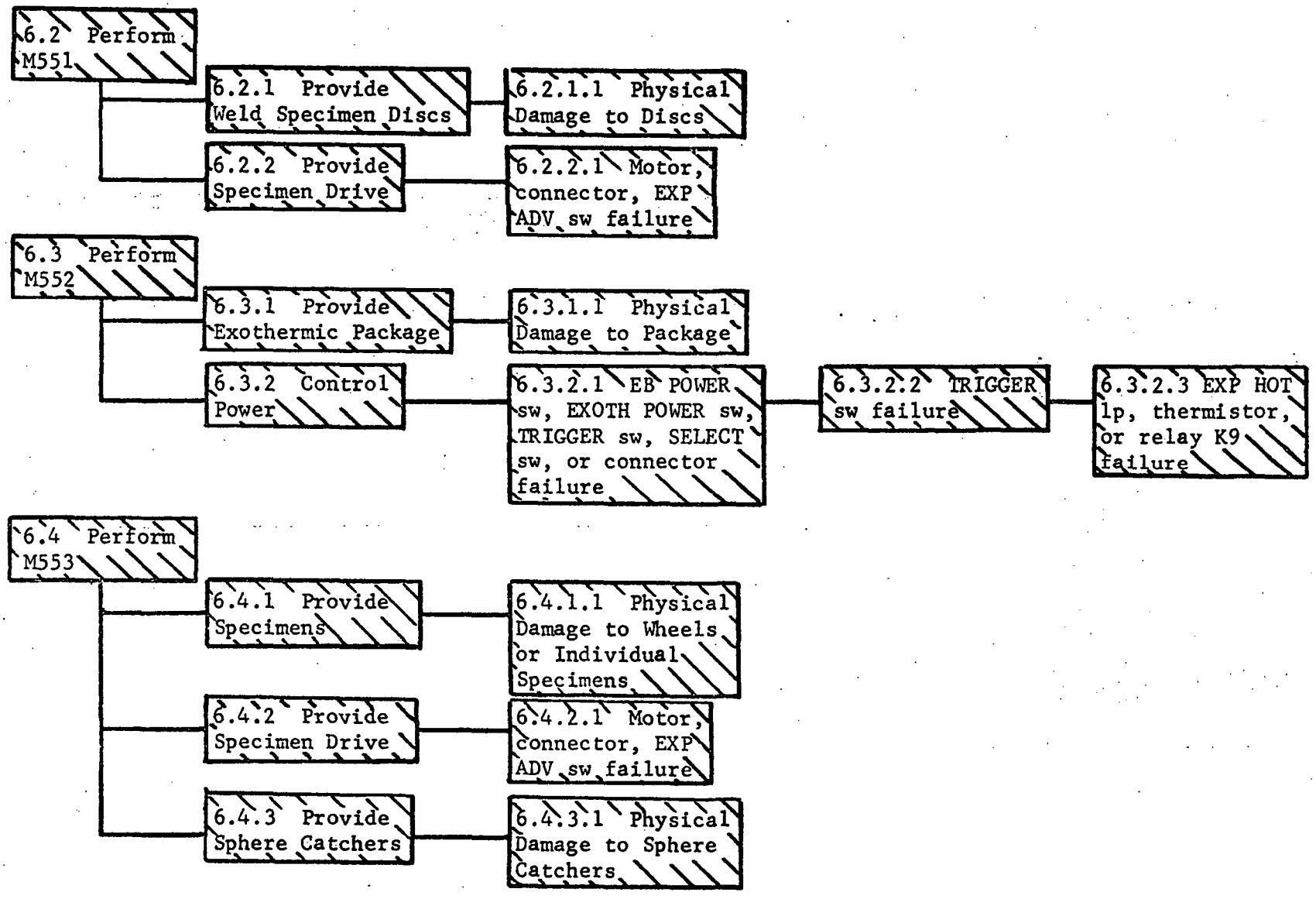

Figure 6.4 Malfunction Analysis Diagram, M512

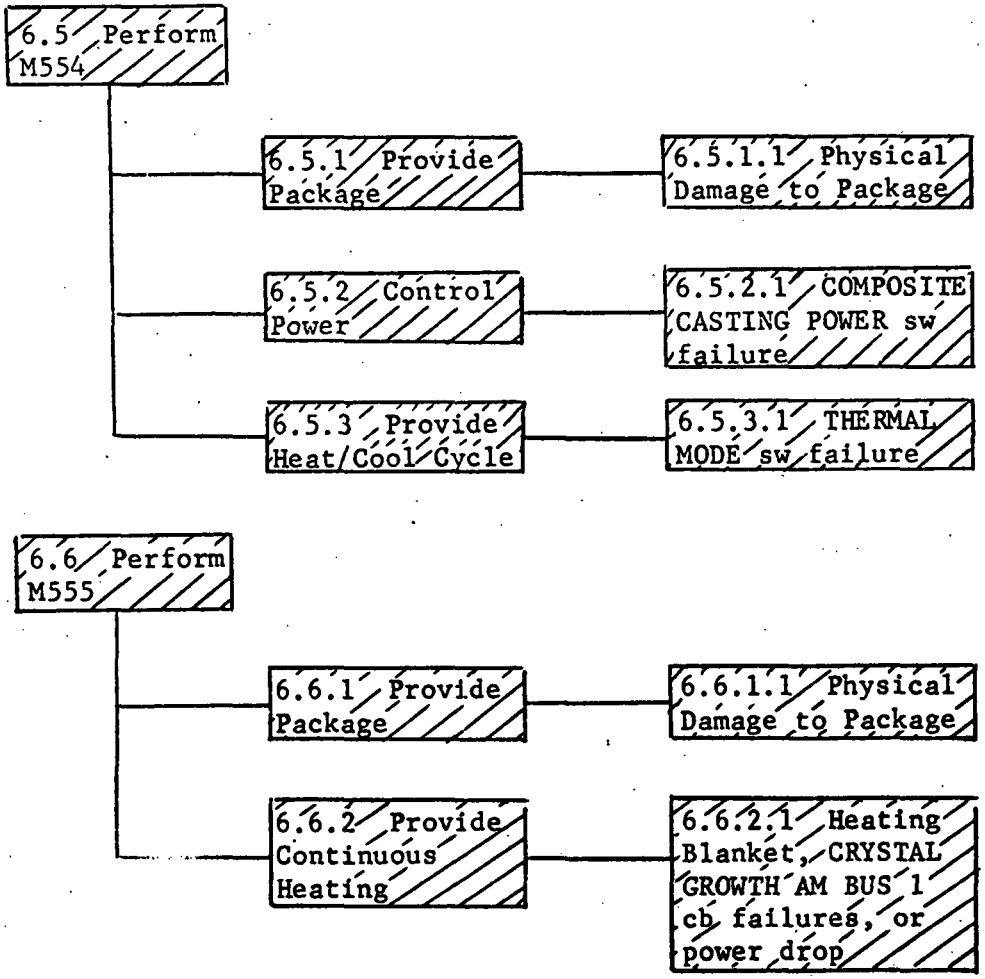

Figure 6.5 Malfunction Analysis Diagram, M512

MALFUNCTION ANALYSIS CHART, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR GROUND
6. Materials Processing in Space 6.1 Materials Processing Facility 6.1.1 Provide Electron Beam (EB) 6.1.1.1 EB Failure						Ground Action: None Crew Action: Phase D
Case I: READY lt Illuminates (FIL BATT cb fails open, relay K1 or K3 failure).	Crew Sensing,Visual, (U): EB does not impinge on specimen with HI-VOLT/CAM sw ON and READY lt does not go out with HI-VOLT/CAM sw ON (no visible glow from filament).	Camera operates.	Mission: None Crew: Timeline impact.	Loss of EB: Loss of M551, M553.	None	1. Recycle a. FIL BATT cb CLOSED, and b. FIL/BEAM CONT sw ON, and c. HI-VOLT/CAM sw ON.
Case II: READY lt Does Not Illuminate (EB POWER sw fails OFF, relay K7 fails, BATT cb fails open, MAIN BATT cb fails open, HI VOLT/CAM sw fails in READY/RESET, FIL/BEAM CONT sw fails OFF). Note: Failure of READY lt, HI-VOLT/CAM sw ON, FIL BATT cb in closed position, BATT cb in closed position, FIL/BEAM CONT sw in ON position, EB POWER sw in ON position, MAIN BATT cb fails closed will not effect operation of EB. See 6.3.2.1 for effect of EB POWER sw failure on M552.	Crew Sensing,Visual, (U): EB does not impinge on specimen with HI-VOLT/CAM sw ON (no visible glow from filament).	Camera does not operate. Loss of all instrumentation functions.	Mission: None Crew: Timeline impact.	Loss of EB: Loss of M551, M553.	None	1. Visually check for glow of EB filament, and 2. Recycle a. BATT cb closed, and b. EB POWER sw ON, and c. HI-VOLT/CAM sw ON.
6.1.1.2 BEAM CONTROL CUR ADJ Failure, BEAM CUR ind Failure.	BEAM CUR ind, (U): Current cannot be set at desired level.	(U): EB does not melt specimen in desired time for CUR ADJ failure; EB does melt specimen in desired time for BEAM CUR ind failure.	Mission: None Crew: Possible timeline impact if EB fails completely.	Degraded operation: longer melting time requiring manual operation or at worst loss of EB.	None	1. a. Readjust CUR ADJ cont, and b. Use EXP ADV sw in MAN/RESET to allow more than one revolution, or 2. Terminate M551, M553 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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.1.1.3 Provide EB Focus: FOCUS ADJ, ALIGN X, ALIGN Y Failures.	Crew visual sensing (U): Inability to focus EB on specimen.	None	Mission: None Crew: Possible timeline impact.	Melting rate will be reduced or eliminated depending upon amt of misalignment.	None	1. Focus as close as possible and continue with EXP/ADV sw AUTO, and 2. a. Focus as close as possible, and b. Use EXP ADV sw in MAN/RESET to allow more than one revolution, or 3. Terminate M551, M553 nominally
6.1.1.4 HI VOLT ind Failure	Erroneous or unexpected reading, (U): Not between 18-20 KV.	EB melts specimen in desired time and BEAM CUR is nominal.	Mission: None Crew: Possible timeline impact.	Uncertainty about operation.	None	1. If no other failure are detected continue nominally, and 2. Terminate M551, M553.
6.1.2 Provide Instrumentation 6.1.2.1 INSTRUMENTATION POWER sw e. Fails in OFF Position						
Case I: INSTRUMENTATION POWER sw in BATT Position.	(U): All readings 0 when in BATT position and EB operates properly.	Loss of camera during M551, M553.	Mission: None Crew: Loss of touch temp data: possible crew hazard.	Loss of temp & press data for M551, M552, M553. Loss of photo data for M551, M553.	None	1. Recycle INSTRUMENTATION POWER sw, and 2. Use M487 exp thermistor thermometer to check touch temp's, or 3. Terminate only M554, M555, *or
Case II: INSTRUMENTATION POWER sw in AM BUS 1 Position.	(U): All readings 0 in conjunction with M155 AM BUS 1= 28 $\pm$ 4 VDC.	None		Loss of temp & press data for M554, M555.		4. Terminate all tasks. *Caution: Some components may exceed touch temp (105°F) during operation of M554, M555.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.1.2.1 INSTRUMENTATION POWER sw (Continued)						
b. Fails in BATT Position	(U): All readings 0 in AM BUS 1 position in conjunction with M155 AM BUS 1= 28 ± 4 VDC.	None	Mission: None Crew: Possible timeline impact.	Loss of temp and press data for M554, M555 only.	None	1. Same as 6.1.2.1a Case II steps 1-4.
c. Fails in AM BUS 1 Position.	(U): All readings 0 when in BATT position in conjunction with proper EB operation.	Loss of camera for M551, M553.	Mission: None Crew: Possible timeline impact.	Loss of temp and press data for M551, M552, M553 only. Loss of photo data for M551, M553.	None	1. Recycle INSTRUMENTATION POWER sw, and 2. a. Place INSTRUMENTATION POWER sw in AM BUS 1. b. Close AM BUS 1 cb, and 3. Same as 6.1.2.1, step 2.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.1.2.2 Provide Pressure Data. (PRESS ind failure, or PRESS sw failure in OFF position).	Erroneous readings on PRESS ind when chamber is pressurized.	FIL CHMBR PRESS ind reads 0 after chamber has been evacuated 3 min (during M551, M552, M553 only).	None	Loss of gross press data.	None	1. a. Recycle PRESS sw, and b. Tap PRESS ind face with finger, or 2. Continue, using FIL CHMBR PRESS ind to read chamber vacuum during M551, M552, M553.
6.1.2.3 Temp ind Failure; TEMP SOURCE sw Failure in Position 1, 2, 3, 4, 5 or 6.	TEMP ind, (U): Reading of 0 or different than anticipated. Verify existence of press. reading.	None	None	Loss of temp data.	None	1. Recycle TEMP SOURCE sw, and 2. Continue logging press. readings only and log any anomalies.
6.1.2.4 BASE TEMP sw Failure in One or More of Nine Positions.	TEMP ind, (U): METER X10 reading does not agree with BASE + METER reading.	(U): BASE + METER reading does not respond consistently and logically in different positions.	None	Partial loss of temp data.	None	1. Recycle BASE TEMP sw. 2. Use METER X10 reading to isolate which BASE TEMP position(s) have failed and use METER X10 readings for temps within the ranges of the failed positions.
6.1.2.5 TEMP Sw Failure						
a. In BASE + METER Position	TEMP ind, (U): No reading when switched to METER X10.	None	None	Loss of temp quick look capability.	None	1. Recycle TEMP sw, and 2. Continue exp using BASE + METER only for temp readings.
b. In METER X10 Position	TEMP ind, (U): No reading when switched to BASE + METER.	None	None	Loss of fine reading capability.	None	1. Recycle TEMP sw. 2. Continue exp with METER X10 only for temp readings.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR GROUND
6.1.2.6 TEMP SOURCE Sw Failure						
a. In CHMBR AIR Position	TEMP ind, (U): No change in reading on TEMP ind when sw to CHMBR AIR.	None	Mission: None Crew: Loss of chmbr wall meas precludes the crewman being able to determine if the chamber has reached touch temp: possibility of burn.	Loss of chamber wall temp meas.	None	1. Recycle TEMP SOURCE sw, and 2. Continue exp with CHMBR AIR only, allowing sufficient time (TBD) for chamber to cool and being cautious about touching chamber, or 3. Use M487 thermistor thermometer to check temp.
b. In CHMBR WALL Position	(U): No change in reading on TEMP ind when sw to CHMBR AIR.	None	None	Loss of air temp data for post flight analysis.	None	1. Recycle TEMP SOURCE sw, and 2. Continue exp with CHMBR WALL temp only.
6.1.3 Provide Chamber						Ground Action: None Crew Action: Phase D or F.
6.1.3.1 Provide Vacuum						
a. Vacuum Vent Valves						
Case I: 1 or 2 Fail in Closed Position.	(U): PRESS ind 0 FIL CHMBR PRESS ind 10^{-3} TORR.	Crew sensing of vlv operation.	Mission: None Crew: Timeline impact.	Cannot vent toxic combustion products to space - loss of all subsequent tests - SPF.	None	1. Terminate M479. Caution: Do not open chamber door, repress vlv or vacuum cleaner vlv.
Case II: 1 Fails in Open Position	Crew sensing of vlv operation.	None	None	Loss of redundant valve.	None	1. Continue without redundant valve.
Case III: 2 Fail in Open Position	(U): Crew sensing of vlv operation.	(U): Hissing noise continued for more than 5 sec after repress vlv is opened.	Mission: None Crew: Loss of cabin atmos if repress or vacuum cleaner valves are opened.	Unable to repress - loss of all subsequent tasks.	None	1. Terminate M479. Caution: Do not open chamber door, repress vlv or vacuum cleaner valve.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.1.3.1 Provide Vacuum						
b. Leaks: Vent Line, Flanges, Chamber Door, Valves, etc.	Crew Sensing, (U): Hissing noise when bulkhead vent vlv is opened.	(U): FIL CHMBR PRESS ind $>10^{-3}$ TORR. If leak has equivalent cross sectional area 1.58 sq in. then ********** K368-512 EVENT EMERG DELTA (P/T) CLOSURE 1 **********	Mission: None Crew: Loss of cabin atmosphere.	Can't maintain chamber pressure - loss of all subsequent tests.	None	1. Close both vent vlv's, and 2. Use MDAC leak detector and cluster repair kit to fix leak (Ref 6, TRN 143), and 3. Terminate exp nominally.
6.1.3.2 Provide Repressurization						
a.. Repress Valve Failure						
Case I: Fails in Closed Position	(U): FIL CHMBR PRESS ind $<10^{-3}$ TORR.	(U): Crew sensing of vlv operation.	None	Can't repress chamber.	None	1. Disconnect vacuum cleaner and open vacuum cleaner vlv to repress.
Case II: Fails in Open Position	(U): Crew sensing of operation.	(U): Hissing noise if vent vlv's are opened.	Mission: None Crew: Loss of cabin atmos if vent vlv's are opened.	Can't evacuate chamber - loss of subsequent tests.	None	1. Terminate M479. Caution: Do not open door or valves.
b. Leaks: Vent Line, Flanges, Door, Valves, etc.	(U): Visible combust products escaping from leak during test.	None	Mission: None Crew: Contamination of cabin atmos if test is run.	Can't maintain chamber integrity - loss of all subsequent tests.	None	1. a. Evacuate chamber momentarily. b. Same as 14.2.12 step 2, and 2. Terminate exp 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, M512

MALFUNCTION	INDICATION		EFFECT			[illegible]
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.1.3.3 Provide EB Filament Chamber Vacuum						
a. Filament Keeper Valve Fails in Closed Position	Crew Sensing, (U): Cannot move handle.	None	Mission: None Crew: Timeline impact.	Loss of EB.		1. Try forcing handle operation. Caution: Do not force to the point of breakage, or 2. Terminate M551, M553.
b. Filament Keeper Valve Fails in Open Position	Crew Sensing, (U): Cannot move handle.	None	Mission: None Crew: Timeline impact.	Contamination of EB filament: degraded operation to possible loss of EB.		1. Try forcing handle operation. Caution: Do not force to the point of breakage, or 2. Continue until EB fails to melt specimens and terminate M551, M553.
6.1.4 Provide Photography						Ground Action: None Crew Action: Phase D
6.1.4.1 Failure of Relay K8	(U): Camera does not operate with HI VOLT/CAM sw ON in conjunction with proper EB operation.	Camera operates when powered from a utility outlet and READY lt doesn't go out with HI VOLT/CAM sw ON.	Mission: None Crew: None	Loss of photography.	None	1. a. Verify camera operation, and b. For subsequent tests use the DAC power cord plugged into a utility outlet and operate the camera manually (i.e., use OFF/ON sw on camera) in conjunction with HI VOLT/CAM sw ON.
6.1.4.2 HI VOLT/CAM sw Failure (See 6.1.1.1)						
6.1.4.3 PHOTO LT sw Failure in OFF Position, FIL CHMBR INTERLOCK sw Failure in "Open" Position, Photo Light Failure	(U): Photo Light does not illuminate with PHOTO LT sw ON Filament Keeper valve open.	READY lt will not illuminate with HI VOLT/CAM sw READY/RESET.	None	Loss of photography, loss of gross specimen alignment capability.	None	1. Recycle PHOTO LT sw, or 2. Use M151 floodlight to provide photographic illumination through chamber hatch viewport, or 3. Turn on all MDA lights and stand away from chamber so as not to block light, and photograph with ambient light, or 4. Terminate photography.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.1.5 Provide Vacuum Cleaner (Same as 14.6)						Ground Action: None Crew Action: Phase D or F
6.1.6 Provide Power						
6.1.6.1 Provide Battery						
a. Battery Failure: Internal Open or Short, MAIN BATTERY cb Fails in Open Position.	Crew Observation, (U): No electrical functions with INSTRUMENTATION POWER sw in BATT; Instrumentation operates with INSTRUMENTATION POWER sw in AM BUS 1 and AM BUS 1 cb closed.	None	Mission: None Crew: Timeline impact.	Loss of M551, M552, M553.	None	1. Recycle a. MAIN BATT cb, and b. BATT cb, and c. INSTRUMENTATION POWER sw to BATT pos, and d. ELECTRON BEAM POWER sw ON, or 2. Terminate M551, M552, M553.
6.1.6.2 AM BUS 1 cb Failure in Open Position. (Failing in Closed Position Will go Undetected and Will Have no Effect on Nominal Exp Operation.)	Crew Sensing, (U): No electrical functions with INSTRUMENTATION POWER sw in AM BUS 1.	None	Mission: None Crew: Timeline impact.	Loss of M554, M555, M479	None	1. a. Recycle AM BUS 1 cb, and b. Recycle INSTRUMENTATION POWER sw AM BUS 1. 2. Terminate M554, M555, M479, 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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.2 Perform M551						
6.2.1 Provide Weld Specimen Discs						Ground Action: None Crew Action: Phase D
6.2.1.1 Physical Damage to Discs	Crew Sensing: visual inspection.		Mission: None Crew: Timeline impact.	Degradation of test		1. Attempt repair, or 2. Run test with damaged specimen.
6.2.2 Provide Specimen Drive						Ground Action: None Crew Action: Phase D
6.2.2.1 Motor Failure, Damage to Connector or Failure of EXP ADV sw in OFF Position.	(U): Specimen does not rotate with EXP ADV sw in AUTO or MAN/ RESET.	Visual inspection in the case of damaged connector.	Mission: None Crew: Timeline impact.	Loss of M551		1. Recycle EXP ADV sw to AUTO, or 2. a. Place EXP ADV sw in MAN/ RESET to rotate specimen, and b. Turn EB POWER sw OFF to stop specimen at desired time, or 3. a. Check for bent pins, straighten and plug back in, and b. Recycle EXP ADV sw to AUTO, or 4. Terminate M551
6.2.2.2 EXP ADV sw Fails in AUTO Position or MAN/RESET.	(U): Specimen will rotate as soon as EB POWER sw ON with EXP ADV sw in OFF position and filament chamber vlv is open.	Crew Observation: Motor will rotate faster in MAN/RESET than in AUTO.	None	Degradation of sample since EB filament will not be warmed up and specimen will not heat uniformly.	None	1. Recycle EXP ADV sw to OFF, and 2. Allow specimen to rotate more than 1 rev to allow EB to warm up properly, and perform weld sequence as fast as possible.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.3 Perform M552						
6.3.1 Provide Exothermic Package						Ground Action: None Crew Action: Phase D
6.3.1.1 Physical Damage to Package (Broken Internal Wire, etc.)	Crew Sensing, (U): Damage to package.	EXP HOT lt does not illuminate within 3 min of ignition.	None	Loss of 1 to 4 samples.	None	1. Perform test with damaged package, or 2. Attempt repair and then perform test.
6.3.2 Control Power						Ground Action: None Crew Action: Phase D
6.3.2.1 EB POWER sw Fails in ON Position, EXOTH POWER sw Fails in OFF Position, TRIGGER sw Fails in OFF Position, SPECIMEN sw Fails in One Position, or Damage to Package Power Connector. (EB POWER sw Fails in OFF Position, EXOTH PWR sw Fails in ON Position, Will go Undetected and Have no Effect.)	(U): EXP HOT lt does not illuminate within 3 min of activation of TRIGGER.	Temp ind, (U): Indicates no temp rise in chamber (With INSTRUMENTATION POWER sw in BATT). (This is a weak cue since the chamber may not heat enough nominally to register on the TEMP ind)	Mission: None Crew: Timeline impact.	Loss of 1 or more M552 samples.		1. Recycle a. EB POWER sw b. EXOTH POWER sw c. SPECIMEN sw d. TRIGGER sw, or 2. a. Repressurize chamber. b. Check connectors and connections. c. Evacuate chamber. d. Repeat 1a through 1d, or 3. a. Place EB POWER sw ON, and b. Place FIL CHMBR INTLK sw OVERRIDE, or (Note: This will fire specimen #2) 4. Terminate M552 nominally.
6.3.2.2 TRIGGER sw Fails in TRIGGER Position.	(U): Sample fires as soon as SPECIMEN sw is ON and TRIGGER sw is OFF.	None	None	None	None	1. a. Turn EXOTH PWR sw OFF, and b. SPECIMEN sw to next sample, and c. EXOTH PWR sw ON.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.3.2.3 EXP HOT lt Failure, Thermistor Failure Closed. Note: Thermistor failure open or relay K9 failure will cause EXP HOT lt to illuminate as soon as power is applied to TRIGGER sw but will not effect the operation of the package.	(U): EXP HOT lt does not illuminate within 3 min of ignition and smoke has emanated from package.	TEMP ind shows a temp rise in chamber (weak que).	Mission: None Crew: Possible hazard, no indication of package touch temp.	No indication when package has cooled.	None	1. a. Use M487 thermistor thermometer to determine package temp, and b. Allow 2 hrs for cool-down and be cautious in touching package
6.4 Perform M553						
6.4.1 Provide Specimens						Ground Action: None Crew Action: Phase
6.4.1.1 Physical Damage to Wheels or Individual Specimens.	Crew Sensing:Visual inspection, (U): Physical damage	None	Mission: None Crew: Timeline impact.	Possible degradation of 1 or more samples.		1. Attempt repair and continue nominally.
6.4.2 Provide Specimen Drive						Ground Action: None Crew Action: Phase D
6.4.2.1 Motor Failure, Damage to Connector, Failure of EXP ADV sw in OFF Position.	(U): Specimen does not rotate with EXP ADV sw in AUTO or MAN/RESET positions.		Mission: None Crew: Timeline impact.	Loss of M553.	None	1. Recycle EXP ADV sw to AUTO, or 2. Repress chamber, check connector and connections, evacuate and recycle EXP ADV sw, and 3. Terminate M553 nominally.
6.4.2.2 EXP ADV sw Fails in AUTO Position, or MAN/RESET.	(U): Specimen rotates as soon as EB POWER sw is ON.	Motor will not reset	None	Possible degradation of 1 sample.	None	1. Allow specimen to remain in position and allow time for EB to warm up and redo specimen.
6.4.3 Provide Sphere Catchers						Ground Action: None Crew Action: Phase D
6.4.3.1 Physical Damage to Sphere Catchers.	Crew Sensing: Visual inspection, (U): Physical damage	None	Mission: None Crew: Timeline impact.	None	None	1. After repressurizing, capture spheres by hand and place in the sphere catcher.

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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMMAND
6.5 Perform M554						
6.5.1 Provide Package						
6.5.1.1 Physical Damage to Package	Crew Sensing:Visual inspection, (U): Physical damage	Instrumentation does not indicate a temp rise after ignition sequence.	None	Degradation or loss of M554.	None	Ground Action: None Crew Action: Phase D or F. 1. Attempt repair and continue nominally.
6.5.2 Control Power						
6.5.2.1 COMPOSITE CASTING POWER sw Fails in OFF Position.	(U): Instrumentation TEMP ind indicates no temp rise in package.	None	None	Loss of M554.	None	Ground Action: None Crew Action: Phase D or F. 1. 1. Recycle COMPOSITE CASTING POWER sw, and 2. Recycle THERMAL MODE sw, and 3. Terminate M554 nominally.
6.5.3 Provide Heat/Cool Cycle						
6.5.3.1 COMPOSITE CASTING THERMAL MODE sw Fails in COOL or HEAT Positions,Failure of Relays K11, K13.	(U): Instrumentation TEMP ind indicates improper heat/cool cycle.	None	None	Degradation or loss of M554.	None	Ground Action: None Crew Action: Phase D or F. 1. Recycle THERMAL MODE sw, and 2. Terminate M554 nominally.
6.6 Perform M555						
6.6.1 Provide Package						
6.6.1.1 Physical Damage to Package	Crew Sensing:Visual inspection, (U): Physical damage	None	None	Degradation or loss of M555.	None	Ground Action: None Crew Action: Phase D or F 1. Attempt repair and continue 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, M512

MALFUNCTION	INDICATION		EFFECT			ACTION
MALFUNCTION OR CONDITION	PRIMARY MEASUREMENTS	SUPPORT MEASUREMENTS	MISSION/CREW	SYSTEM/SUBSYSTEM	SYSTEM/ INTERACTION	CREW OR COMPUND
6.6.2 Provide Continuous Heating During Storage (LOW TEMP TEST sw fails in OFF or LO TEMP TEST positions, LO TEMP lt burns out, CRYSTAL GROWTH AM BUS 1 cb fails open).	(U): LO TEMP lt does not illuminate with LO TEMP TEST sw in LAMP TEST position.	None	Mission: None Crew: Timeline impact.	Degradation or loss of M555.	None	Ground Action: Crew Action: 1. Perform M555 within 30 min, or 2. Plug back into CSM storage receptable until M555 can be performed.
6.6.3 Provide Heat Cool Cycle During Performance.						Ground Action: Crew Action:
6.6.3.1 COMPOSITE CASTING PWR sw Fails in ON Position, or XTAL GROWTH POWER sw Fails in OFF Position.	(U): INSTRUMENTATION TEMP ind does not indicate a temp rise from any thermocouple position.	None	Mission: None Crew: Timeline impact.	Degradation or loss of M555.	None	1. Recycle a. COMPOSITE CASTING PWR sw OFF, and b. XTAL GROWTH PWR sw ON, and 2. Terminate M555.
6.6.3.2 XTAL GROWTH PWR sw Fails in TEST Position.	(U): INSTRUMENTATION TEMP ind shows a temp rise much more rapid than expected. TBD °/hr.	CRYSTAL GROWTH AM BUS 1 cb will open after 30 min.	Mission: None Crew: Timeline impact.	Degradation or loss of M555.	None	1. a. Recycle XTAL GROWTH PWR sw ON, and b. Verify rate of temp rise, or 2. Using temp meas to approximate the proper heating cycle, use COMPOSITE CASTING PWR sw ON/OFF to control power to Crystal Growth Package. 3. Terminate M555.

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. The M-512 MPF is a facility that is used to accomodate the performance of Experiments M-479, M-551, M-552, M-553, M-518, and M-555. The contingency plans for the switches, circuit breakers, and valves were primarily concerned with the MPF integrity check and not the effects on the experiments that use the MPF. These experiments will be discussed in separate appendices.

2. The MPF uses power from AM Bus 1 and a self contained battery.

3. In Table E-I, F.B.No. 3.5.9.3, the battery case vent line failure was classified as a Category I failure. If the vent line ruptures between the battery case and the M512 BAT VENT VALVE, this would allow the MDA atmosphere to escape until the M512 BAT VENT VALVE could be placed in the CLOSE position. The battery gases could escape into the MDA and contaminate the atmosphere when the 5 psia check valves opened. If the vent line ruptures between the M512 BAT VENT VALVE and the MDA wall, this would allow the MDA atmosphere to escape into space.

4. The following failures would terminate the MPF integrity check:

   - The CHAMBER REPRESS vlv failing to close
   - The work chamber hatch window or seals cracking, preventing the work chamber from holding a vacuum
   - The bulkhead vent vlv failing to open
   - The work chamber vent vlv failing to open
   - A pressure leak in the vent line between the bulkhead and work chamber vent valves
   - A pressure leak in the wall of the work chamber.

5. The following failures could terminate the MPF integrity check:

   - The work chamber hatch window and/or seals being cracked
   - The bulkhead vent vlv failing to close

- The work chamber vent vlv failing to close

6. It is recommended that on the initial opening of the bulkhead vent vlv and the work chamber vent vlv, the bulkhead vent vlv be opened first. There will be standard atmosphere and pressure trapped between the two valves. This will prevent possible damage to the work chamber by venting the atmosphere and pressure to space.

7. It is recommended that the astronaut have voice communication with the ground when performing the MPF integrity check.

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