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SKYLAB EXPERIMENT PERFORMANCE EVALUATION MANUAL

Appendix G: Experiment M552 Exothermic Brazing (MSFC)

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16. ABSTRACT

This appendix contains a series of analyses for Experiment M552, Exothermic Brazing (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 G. EXPERIMENT M-552, EXOTHERMIC BRAZING (MSFC)

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DEFINITION OF SYMBOLS

ACC	Accessory
ACCESS	Accessory
ADJ	Adjust
ADV	Advance
AM	Airlock Module
BAT.	Battery
BATT	Battery
CAM	Camera
cb	Circuit breaker
CDR	Commander
CHMBR	Chamber
CONT	Control
CSTR	Canister
ctr	Center
CUR	Current
DAC	Data Acquisition Camera
EBG	Electron Beam Gun
EXP	Experiment
FBD	Functional Block Diagram
FBNT	Functional Block Number and Title
FIL	Filament
FO	Functional Objective
HI	High
HOSC	Huntsville Operation Support Center
ID	Identification
INTLK	Interlock
LT	Light

DEFINITION OF SYMBOLS (Concluded)

lt	Light
MDA	Multiple Docking Adapter
MPF	Materials Processing Facility
MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
OA	Orbital Assembly
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
S/I	Speaker/Intercom
SL	Skylab
STS	Structural Transition Section
sw	Switch
TEMP	Temperature
vlv	Valve

SECTION I.

EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 1 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number*	Remarks
	min	nom	max		
3.0 Analyze and predict facet performance profile for Skylab Experiment M-552, Exothermic Brazing.				N/A	Refer to functional item 3.1
3.1 Make explicit statements about objectives in qualitative and quantitative terms.				N/A	Refer to functional item 3.1.1.
3.1.1 Specify duration that the experiment is required to operate and provide useful information.				N/A	The approximate time in hours and minutes required to operate the experiment is: • Preparation 0:04 • Operation 8:16 (Includes 2 hr cooldown time for each of four specimens) • Terminate 0:06 Reference 1.
3.1.2 Specify the types of criteria that are to be maximized or minimized.				N/A	The Functional Objective (FO) for Experiment M-552 is: • FO-1: Perform exothermic brazing operations, and collect data and samples for return to earth. The purposes of the experiment are:

*Criticality Category Number Definition:

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

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 2 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.1.2 (Concluded)					• Test and demonstrate a method of brazing components in space repair and maintenance operations. • Study surface wetting and capillary flow effects in weightless molten metals. • Demonstrate the feasibility of exothermic reaction in space. References 2, 3, and 4.
3.1.3 Specify the percentages of acceptable max./min. for each criterion.	25%	62.5%	100%	N/A	It is subjectively estimated that accomplishment of the following would provide a minimum acceptable amount of experimental data: • FO-1· Ignite one of the four samples in the exothermic package. This is 1/4 of the desired experiment or 25 percent of FO-1. Reference 2.
3.1.4 Specify experiment constraints: • Musts • Must Nots • Wants • Don't Wants.				N/A	• Musts --The experiment must be operated with power from the battery. --The work chamber must be evacuated to space vacuum for experiment operation. • Must Nots --Do not attempt exothermic package recovery until the last specimen has been allowed to cool. • Wants --The magnitude of any acceleration and the time of occurrence will be furnished to the M-552 experiment's Principal Investigator (PI) from available ground telemetered data, if it occurs during the experiment performance. --Recordings will be made of the astronaut's voice comments during the performance of the experiment. --A logbook will be kept on the experiment. • Don't Wants --All vehicle accelerations of any significant magnitude should be avoided during the performance of the experiment.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 3 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.1.4 (Concluded)					References 2, 3, 4, and 5.
3.1.5 Specify experiment operational tolerances. • Musts • Must Nots • Wants • Don't Wants.				N/A	Refer to Functional Block Number and Title (FBNT) 3.1.4. • Musts --The M-512 battery has a minimum "wet stand" life of 90 days after activation (which occurs approximately 57 days prior to SL-1 launch). The experiment must be performed before the battery is too weak to deliver power to the exothermic package. --The work chamber must be evacuated to space vacuum (verify by reading 0 psia on the INSTRUMENTATION PRESS gage (M5)). • Must Nots --Exothermic specimens must not be ignited nor the exothermic package removed from the work chamber while the EXOTHERMIC EXP HOT lt(L2) is illuminating. • Wants --N/A. • Don't Wants --Accelerations greater than 5×10^{-4}g. This can influence the results of the experiment. Reference 6.
3.2 Define decision rules and success criteria for the experiment objectives.				N/A	If the experiment is aborted, then the probability of success (P_S) is equal to 0.0. If the experiment is compromised and minimum information is salvaged, $P_S = 0.1 \rightarrow 0.5$, if the maximum information is salvaged, $P_S = 0.6 \rightarrow 0.9$. If the experiment is completed as scheduled, $P_S = 1.0$. The success criterion is: • Determine the merits of exothermic brazing as applicable to use in a space environment. Reference 2.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 4 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.3 Specify experiment priority (numerical statement) for a given Skylab flight designation.				N/A	Experiment M-552 is assigned to mission SL-1/SL-2 and the experiment priority number is 150. References 7 and 8.
3.4 Briefly describe and list the major subsystems for Experiment M-552.				N/A	Refer to FBNT's 3.4.1 and 3.4.2.
3.4.1 Describe the major functions.				N/A	The major functions of experiment M-552 are: • To test and demonstrate a method of brazing components in space repair and maintenance operations. • To study surface wetting and capillary flow effects in weightless molten metals. Brazing by means of electrically initiated exothermic chemical heating packages is considered for joining operations in space because: • The packages can be made to deliver accurately prescribed amounts of energy and can be thoroughly pretested for any critical operation. • No spacecraft power or auxiliary equipment is required for this method of chemical heating. • Exothermic brazing packages can be sized to produce no more heat than a given operation requires, and can be insulated so that no exposed surface reaches high temperatures during the brazing process. • The packages are stable during long periods of storage, can operate in air, oxygen, or vacuum, and involve only small amounts of gas in operation. This experiment is an engineering test directed toward developing a technique for brazing permanent tube joints in spacecraft systems. Brazing under the weightless conditions of free flight in space involves some uncertainties about molten metal flow characteristics that only a space experiment can resolve. Brazing operations depend on capillary flow of the molten braze alloy between closely spaced parts, this is influenced in a complex way by the braze alloy's surface tension, its wetting characteristics on the base metal, clearance between the parts, and gravity forces on the molten alloy. Significant

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 5 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.4.1 (Concluded)					differences in capillary flow characteristics are to be expected when gravity forces are absent. Optimum conditions for brazing in space may well be different from those found on earth. Four tubes of 0.75-in. diam are to be joined with a silver-copper-lithium braze alloy. An exotherm material will be used as the heat source. *References 3 and 9.*
3.4.2 List the major components.				N/A	The only item of hardware peculiar to Experiment M-552 is the exothermic package containing the four exothermic specimens. In addition to the exothermic package and specimens, performance of the experiment requires the following M-512 Facility hardware: • M-512 Facility hardware --Materials Processing Facility (MPF) Honeycomb Mounting Panels --Vacuum Work Chamber Assembly --Battery --Vent Valves --Vent Lines --M512 FLOOD LIGHT SHIELD --Work Chamber Vent Filter No 1 --M479 WATER SPRAY CONNECTION COVER --M512 ELECTRON BEAM COVER --Controls and Displays A Functional Block Diagram (FBD) is submitted as Figure G-1, and is used as a subsystem component listing. Critical subsystem components will be identified and evaluated for failure and correlated to possible experiment/carrier interface problems. *References 4 and 9.*
3.5 Define the M-552 experiment/carrier system interfaces: • Physical --Mechanical --Electrical --Communications and Data				N/A	Experiment M-552 hardware has no physical interface with the carrier. An interface block diagram is submitted as Figure G-2, and is used to define the various interfaces for Experiment M-552.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 6 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5 (Concluded) --Support • Environmental --Natural and Induced --Contamination • Operational --Pointing and Control --Crew Safety --Sequence --Operability.					
3.5.1 M-512 Materials Processing Facility.				N/A	The M-512 MPF is used to accommodate the performance of Experiments M-479, M-518, M-551, M-552, M-553, and M-555. For more extensive information concerning the M-512 MPF, refer to Skylab Experiment Performance Evaluation Manual (SEPEM) Appendix E. For more information concerning the M-512 MPF associated with Experiment M-552, refer to FBNT's 3.5.1.1 through 3.5.1.10.
3.5.1.1 Specify the total probability of failure (Pf_t) for the MPF honeycomb mounting panels.				IIIa	The Exothermic package is mounted on the honeycomb mounting panel prior to and after the performance of Experiment M-552. For additional information about the honeycomb mounting panels, refer to SEPEM, Appendix E, FBNT 3.5.1.
3.5.1.2 Vacuum Work Chamber Assembly.				N/A	The vacuum work chamber assembly provides a facility to perform Experiment M-552 under controlled environmental conditions. Refer to SEPEM, Appendix E, FBNT's 3.5.3.1, 3.5.3.2, 3.5.3.2.1, 3.5.3.3, 3.5.3.4, 3.5.3.5, and 3.5.3.9.
3.5.1.3 Specify the Pf_t and the net probability of failure (Pf_n) for the battery.				IIIa	Refer to SEPEM, Appendix E, FBNT 3.5.6.
3.5.1.4 Vent Valves.				N/A	The vent valves are used in the pressurization/venting system to obtain the desired atmospheric pressures for Experiment M-552. Refer to SEPEM, Appendix E, FBNT's 3.5.8.1 through 3.5.8.5.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 7 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.5 Vent Lines.				N/A	The vent lines are used in the pressurization/venting system to obtain the desired atmospheric pressures for Experiment M-552. The 4-in. vent line is Multiple Docking Adapter (MDA) hardware, but, because of its importance to the experiment, it is considered with the M-512 MPF. Refer to SEPEM, Appendix E, FBNT's 3.5.9.1 through 3.5.9.3.
3.5.1.6 Specify the Pf_t and the Pf_n for the M512 FLOOD LIGHT SHIELD.				IIIb	The M512 FLOOD LIGHT SHIELD is installed inside the work chamber on the floodlight port to protect the floodlight lens during the performance of the experiments using the MPF The shield was used in Experiments M-551 and M-553 and is still installed in the work chamber. If the floodlight is used, it would be for illuminating the interior of the work chamber. Therefore, a shield failure would not affect the experiment. Refer to SEPEM, Appendix E, FBNT 3.5.11.3.
3.5.1.7 Specify the Pf_t and the Pf_n for work chamber vent filter No. 1.				IIIb	Work chamber vent filter No. 1 is installed in the work chamber in the 4-in. vacuum vent line to trap contaminants from all the experiments using the MPF. The filter was used in Experiments M-551 and M-553 and is still installed in the 4-in. vacuum vent line. Refer to SEPEM, Appendix E, FBNT 3.5.11.20.
3.5.1.8 Specify the Pf_t for the M479 WATER SPRAY CONNECTION COVER.				IIIb	The M479 WATER SPRAY CONNECTION COVER is installed in the work chamber on the end of the water supply line. It is used to keep contaminants out of the water supply line and is not removed until Experiment M-479 is ready to be performed; therefore, a water cover failure would not affect the experiment. Refer to SEPEM, Appendix E, FBNT 3.5.11.12.
3.5.1.9 Specify the Pf_t for the M512 ELECTRON BEAM COVER.				IIIb	Refer to SEPEM, Appendix E, FBNT 3.5.11.14.
3.5.1.10 Controls and Displays.				N/A	Controls and displays are used in performing Experiment M-552. Refer to FBNT's 3.5.1.10.1 and 3.5.1.10.2.
3.5.1.10.1 Control Panel.				N/A	Some of the controls and displays used in performing Experiment M-552 are located on the control panel. Refer to FBNT's 3.5.1.10.1.1 through 3.5.1.10.1.10.
3.5.1.10.1.1 Specify the Pf_t for the POWER CONTROL AM BUS 1 cb (CB4).		0.1			The POWER CONTROL AM BUS 1 cb (CB4) is a push-pull type cb. The CB4 cb receives power from AM BUS 1 through the M512 cb located on panel 202. When closed, power is available to the INSTRUMENTATION POWER sw (S2).

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 8 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.1 (Concluded)				IIIb	If the CB4 cb should fail open, the following conditions would occur: • Communications and Data --Using AM BUS 1 power, the INSTRUMENTATION PRESS gage (M5) could not be used to measure the work chamber pressure. • Operability --A malfunction operating procedure could be used to provide battery power to the INSTRUMENTATION PRESS gage (M5) to measure the work chamber pressure.
				IIIb	If the CB4 cb should fail closed, there would be no effect on the experiment. The following indications can be used to determine the failure of the CB4 cb: • Failed open --The INSTRUMENTATION PRESS gage (M5) would not read work chamber pressure. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut could verify this failure. • Failed closed --No indication. References 6 and 9.
3.5.1.10.1.2 Specify the P_{f_t} for the POWER CONTROL BATT cb (CB2).		0.1			The POWER CONTROL BATT cb (CB2) is a 5 A push-pull type cb. The CB2 cb receives power from the battery through the MAIN BATTERY cb (CB1). When closed, power is available to ELECTRON BEAM POWER sw (S3).
				IIIb	If the CB2 cb should fail in the closed position, there would be no effect on Experiment M-552.
				IIIa	If the CB2 cb should fail in the open position, the following condition would occur: • Support --A loss of electrical functions for Experiment M-552 would occur, resulting in a total loss of the experiment. The battery discharge circuit does not use the CB2 cb; therefore, the battery could still be discharged.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 9 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.2 (Concluded)					The following indications can be used to determine the failure of the CB2 cb: • Failed closed --No indication. • Failed open --The EXP HOT lt (L2) does not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) has been placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis could be performed by the astronaut to verify this failure. References 6 and 9.
3.5.1.10.1.3 Specify the Pf_t for the ELECTRON BEAM POWER sw (S3).		0.1			The ELECTRON BEAM POWER sw (S3) turns the Electron Beam Gun (EBG) subsystem circuitry off and on. It is a double-pole, double-throw sw with two positions: OFF and ON. The S3 sw is placed in the OFF position when the MPF is inactive and also when performing Experiment M-552. The S3 sw receives power from the battery through the POWER CONTROL BATT cb (CB2). It is placed in the OFF position to apply power to the EXOTHERMIC POWER sw (S15).
				IIIb	If the S3 sw should fail in the OFF position, there would be no effect on the experiment.
				IIIb	If the S3 sw should fail in the ON position, the following conditions would occur: • Communications and Data --This would degrade the performance of Experiment M-552. The four specimens could not be fired using normal operating procedures. • Operability --A malfunction operating procedure could be used to ignite exothermic specimen No. 2. The following indications can be used to determine the failure of the S3 sw: • Failed OFF --No indication.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 10 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.3 (Concluded)					• Failed ON --The EXP HOT lt (L2) does not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) is placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis could be performed by the astronaut to verify this failure. References 6 and 9.
3.5.1.10.1.4 Specify the P_{f_t} for the INSTRUMENTATION POWER sw (S2).		0.1			The INSTRUMENTATION POWER sw (S2) is used to turn the INSTRUMENTATION panel off or on by selecting the desired power source, either the battery or AM BUS 1. It is a double-pole, double-throw sw with three positions: BATT, OFF, and AM BUS 1. The S2 sw is in the AM BUS 1 position when monitoring the work chamber pressure prior to ignition of an Exothermic specimen. It receives AM BUS 1 power through the POWER CONTROL AM BUS 1 cb (CB4). When the S2 sw is in the AM BUS 1 position, power is available to the Power Supply Module.
				IIIb	If the S2 sw should fail in the BATT position, the following conditions would occur: • Communications and Data --Using AM BUS 1 power, the INSTRUMENTATION PRESS gage (M5) could not be used to measure the work chamber pressure. • Operability --A malfunction operating procedure could be used to provide battery power to the INSTRUMENTATION PRESS gage (M5) to measure the work chamber pressure.
				IIIb	If the S2 sw should fail in the OFF position, the following conditions would occur: • Communications and Data --The INSTRUMENTATION PRESS gage (M5) could not be used to measure the work-chamber pressure. • Operability --A malfunction operating procedure could be used involving battery power and the FIL CHMBR PRESS gage (M3) to verify low pressure in the work chamber.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 11 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.4 (Concluded)				IIIb	If the S2 sw should fail in the AM BUS 1 position, this would not affect the experiment. The following indication can be used to determine the failure of the S2 sw: • Failed in BATT --The INSTRUMENTATION PRESS gage (M5) would not read the work chamber pressure. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut could verify this failure. • Failed in OFF --The INSTRUMENTATION PRESS gage (M5) would not read the work chamber pressure. A malfunction analysis by the astronaut would not verify this failure. If the Data Acquisition Camera (DAC) were connected to the MPF, this failure could be verified. • Failed in AM BUS 1 --No indication. References 6 and 9.
3.5.1.10.1.5 Specify the P_{ft} for the INSTRUMENTATION CSTR X3 sw (S1).		0.1			The INSTRUMENTATION CSTR X3 sw (S1) turns the INSTRUMENTATION PRESS gage (M5) off or selects the work chamber or EBG canister pressure for display on the M5 gage. It is a single-pole, double-throw sw with three positions: CSTR X3, OFF, and WORK CHMBR. The S1 sw is placed in the WORK CHMBR position to monitor the work chamber pressure on the M5 gage prior to the performance of Experiment M-552. It receives power from AM BUS 1 through the chamber pressure transducer. With the S1 sw in the WORK CHMBR position, power is applied to the M5 gage.
				IIIb	If the S1 sw should fail in either the CSTR X3 or OFF position, the following conditions would occur: • Communications and Data --The INSTRUMENTATION PRESS gage (M5) could not be used to monitor the work chamber pressure.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 12 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.5 (Concluded)					• Operability --A malfunction operating procedure could be used involving battery power and the FIL CHMBR PRESS gage (M3) to verify low pressure in the work chamber.
				IIIb	If the S1 sw should fail in the WORK CHMBR position, there would be no effect on the experiment.
					The following indications can be used to determine the failure of the S1 sw: • Failed in CSTR X3 --The INSTRUMENTATION PRESS gage (M5) would read approximately 8 psia when power was applied to the Power Supply Module. • Failed in OFF --The INSTRUMENTATION PRESS gage (M5) would not operate. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. • Failed in WORK CHMBR --The INSTRUMENTATION PRESS gage (M5) would indicate the work chamber pressure when the INSTRUMENTATION POWER sw (S2) was placed in the AM BUS 1 position. A malfunction analysis by the astronaut could verify this failure.
					References 6 and 9.
3.5.1.10.1.6 Specify the P_{f_t} for the EXOTHERMIC POWER sw (S15).		0.1			The EXOTHERMIC POWER sw (S15) is used to apply battery power to the EXOTHERMIC section of the control panel. It is used as a double-pole, single-throw sw with two positions: ON and OFF. The S15 sw receives power from the battery through the ELECTRON BEAM POWER sw (S3). When it is in the ON position, power is applied to EXOTHERMIC TRIGGER sw (S6) and relays K6 and K9.
				IIIb	If the S15 sw should fail in the ON position, there would be no effect on the experiment.
				IIIb	If the S15 sw should fail in the OFF position, the following conditions would occur:

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 13 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.6 (Concluded)					• Communications and Data --This would degrade the performance of the experiment. The four specimens could not be fired using normal operating procedures. • Operability --A malfunction operating procedure could be used to ignite specimen No. 2. The following indications can be used to determine the failure of the S15 sw: • Failed in ON --The EXP HOT lt (L2) would stay on when the S15 sw was placed in the OFF position. • Failed in OFF --The EXP HOT lt (L2) would not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) was placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. References 6 and 9.
3.5.1.10.1.7 Specify the P_{f_t} for the EXOTHERMIC TRIGGER sw (S6).		0.1			The EXOTHERMIC TRIGGER sw (S6) initiates the exothermic burning process. It is used as a single-pole, single-throw sw with two positions: TRIGGER and OFF. The S6 sw receives power from the battery through the EXOTHERMIC POWER sw (S15). When it is placed in the TRIGGER position, power is available to the EXOTHERMIC SPECIMEN selector sw (S7).
				IIIb	If the S6 sw should fail in the TRIGGER position, there will be no effect on the experiment. The specimens will be ignited when the EXOTHERMIC SPECIMEN selector sw (S7) is placed in the number position of the specimen to be ignited.
				IIIb	If the S6 sw should fail in the OFF position, the following conditions would occur: • Communications and Data --This would degrade the performance of the experiment. The four specimens could not be fired using normal operating procedures.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 14 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.7 (Concluded)					• Operability --A malfunction operating procedure could be used to ignite specimen No. 2. The following indications can be used to determine the failure of the S6 sw: • Failed in TRIGGER --No indication. • Failed in OFF --The EXP HOT lt (L2) would not illuminate in approximately 3 min after the S6 sw was placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. References 6 and 9.
3.5.1.10.1.8 Specify the Pf_t for the EXOTHERMIC SPECIMEN selector sw (S7).		0.1			The EXOTHERMIC SPECIMEN selector sw (S7) is used to select each exothermic heating sample in the desired sequence. It uses five positions: OFF, 1, 2, 3, and 4. The S7 selector sw receives power from the battery through the EXOTHERMIC TRIGGER sw (S6). Power is available to ignite Exothermic specimens 1, 2, 3, and 4 when the selector sw is placed in positions 1, 2, 3, and 4, respectively.
				IIIb	If the S7 selector sw should fail in the OFF position, the following conditions would occur: • Communications and Data --Exothermic specimens 1, 3, and 4 could not be ignited. • Operability --A malfunction operating procedure could be used to ignite specimen No. 2.
				IIIb	If the S7 selector sw should fail in the specimen No. 1 position, the following conditions would occur: • Communications and Data --Assuming the specimens are ignited in order 1, 2, 3, and 4, only specimen No. 1 can be ignited using the normal operating procedure. Specimen Nos. 3 and 4 cannot be ignited.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 15 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.8 (Continued)					• Operability --A malfunction operating procedure could be used to ignite specimen No. 2.
				IIIb	If the S7 selector sw should fail in the specimen No. 2 position, the following condition would occur: • Communications and Data --Specimen No. 2 could be ignited using the normal operating procedure. Assuming specimen No. 1 has already been ignited, specimen Nos. 3 and 4 could not be ignited.
				IIIb	If the S7 selector sw should fail in the specimen No. 3 position, the following condition would occur. • Communications and Data --Specimen No. 3 could be ignited using the normal operating procedure. Assuming specimen Nos. 1 and 2 have already been ignited, specimen No. 4 could not be ignited.
				IIIb	If the S7 selector sw should fail in the specimen No. 4 position, there would be no effect on the experiment. This is assuming that specimen Nos. 1, 2, and 3 have already been ignited. Specimen No. 4 could be ignited using the normal operating procedure. The following indications can be used to determine the failure of the S7 selector sw: • Failed in OFF --The EXOTHERMIC EXP HOT lt (L2) would not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) was placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. • Failed in specimen Nos. 1, 2, or 3. --Failed in SPECIMEN No. 1 No indication until an attempt was made to ignite SPECIMEN No. 2. --Failed in SPECIMEN No. 2: No indication until an attempt was made to ignite SPECIMEN No. 3.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 16 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.8 (Concluded)					--Failed in SPECIMEN No. 3: No indication until an attempt was made to ignite SPECIMEN No. 4. For these three failures, it is assumed that the exothermic specimens are ignited in order 1, 2, 3, and 4. The EXOTHERMIC EXP HOT lt (L2) does not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) was placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify these failures. • Failed in SPECIMEN No. 4. --No indication. References 6 and 9.
3.5.1.10.1.9 Specify the P_{f_t} for the EXOTHERMIC EXP HOT lt (L2).		0.1			The EXOTHERMIC EXP HOT lt (L2) is an indicator that shows the case temperature has reached at least 105 °F, the maximum temperature for safe handling. It contains two bulbs wired in parallel. The L2 lt receives power from the battery through the EXOTHERMIC POWER sw (S15). It should illuminate in approximately 3 min after an exothermic specimen has been ignited. When power is applied and the L2 lt is illuminating, this indicates that the case temperature is above 105 °F.
				IIIb	If one of the bulbs in the L2 lt should short to ground, the following condition would occur: • Communications and Data --The L2 lt would not illuminate.
				IIIb	If one of the two bulbs burns out, there would be no effect on the experiment. The L2 lt face would not illuminate as brightly as if both bulbs were illuminating, but would be sufficiently illuminated. The following indications can be used to determine the failure of the L2 lt: • Shorts to ground --The L2 lt would not illuminate in approximately 3 min after a specimen was ignited. Failure of other electrical components would give this same indication; a malfunction analysis by the astronaut would not verify this failure.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 17 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.1.9 (Concluded)					• One bulb burns out --The L2 lt face would not illuminate as brightly as if both bulbs were illuminating. --One side of the L2 lt face will illuminate more brightly than the other side References 6 and 9.
3.5.1.10.1.10 Specify the P_{f_t} for the INSTRUMENTATION PRESS gage (M5).		0.1			The INSTRUMENTATION PRESS gage (M5) displays the pressure (psia) in either the work chamber or the EBG canister. In this experiment, the M5 gage will be used to measure the work chamber pressure (0 psia) prior to ignition of the specimens. The M5 gage receives power from the battery through the INSTRUMENTATION CSTR X3 sw (S1).
				IIIb	If the M5 gage should fail, the following conditions would occur: • Communications and Data --The M5 gage could not be used to measure the work chamber pressure. • Operability --A malfunction operating procedure could be used involving AM Bus 1 power and the FIL CHMBR PRESS gage (M3) to verify low pressure in the work chamber. The following indication can be used to determine the failure of the M5 gage: • Open circuit --The M5 gage would not measure the work chamber. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. References 6 and 9.
3.5.1.10.2 Others Controls and Displays.				N/A	Some of the controls and displays used to perform the experiment are not located on the control panel. Refer to FBNT's 3.5.1.10.2.1 through 3.5.1.10.2.4.
3.5.1.10.2.1 Specify the P_{f_t} for the M512 cb.		0.1			The M512 cb is located on panel 202 in the Structural Transistion Section (STS). It receives power from AM BUS 1. When the M512 cb is closed, power is available to the POWER CONTROL AM BUS 1 cb (CB4).

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 18 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.2.1 (Concluded)				IIIb	If the M512 cb should fail open, the following conditions would occur: • Communications and Data --Using AM BUS 1 power, the INSTRUMENTATION PRESS gage (M5) could not be used to measure the work chamber pressure. • Operability --A malfunction operating procedure could be used to provide battery power to the INSTRUMENTATION PRESS gage (M5) to measure the work chamber pressure.
				IIIb	If the M512 cb should fail closed, there would be no effect on the experiment. The following indications can be used to determine the failure of the M512 cb: • Failed open --The INSTRUMENTATION PRESS gage (M5) would not measure the work chamber pressure. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would verify this failure. • Failed closed --No indication. References 6 and 9.
3.5.1.10.2.2 Specify the Pf_t for the MAIN BATTERY cb (CB1).		0.1			The MAIN BATTERY cb (CB1) is a 100 A push-pull type cb. It is located on the battery control panel above the battery case. The CB1 cb receives power from the battery When it is in the closed position, battery power is available to the POWER CONTROL BATT cb (CB2).
				IIIa	If the CB1 cb should fail open, the following condition would occur: • Communications and Data --The specimens could not be ignited and the experiment would be terminated.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 19 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.2.2 (Concluded)				IIIb	If the CB1 cb should fail closed, there would be no effect on the experiment. The following indications can be used to determine the failure of the CB1 cb: • Failed open --The EXOTHERMIC EXP HOT lt (L2) would not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) was placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would verify this failure. • Failed closed --No indication. References 6 and 9.
3.5.1.10.2.3 Specify the Pf_t for the BATTERY DISCHARGE cb (CB6).		0.1			The BATTERY DISCHARGE cb (CB6) is a 5 A push-pull type cb used in discharging the battery after the experiment has been completed. It is located on the battery control panel above the battery case. The CB6 cb receives battery power through the MAIN BATTERY cb (CB1). When it is closed, the battery is discharged through the discharge resistors and the DISCHARGE lt (L8).
				IIIb	If the CB6 cb should fail open or closed, there would be no effect on the experiment. If failed open, the battery could not be discharged using normal procedures. The following indications can be used to determine the failure of the CB6 cb: • Failed closed --No indication (The CB6 cb is not closed until after the completion of the experiment). • Failed open --The DISCHARGE lt (L8) does not illuminate when the CB6 cb is closed. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure References 6 and 9.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 20 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.10.2.4 Specify the Pf_t for the DISCHARGE lt (L8).		0.1			The L8 lt is an indicator that illuminates when the battery is discharging. It contains two bulbs connected in parallel. The L8 lt is located on the battery control panel above the battery case. It receives battery power through the BATTERY DISCHARGE cb (CB6).
				IIIb	If one of the bulbs in the L8 lt shorts to ground, the following condition would occur: • Crew Safety --The BATTERY DISCHARGE cb (CB6) could trip and the battery could not be discharged through the discharge circuitry.
				IIIb	If one of the two bulbs burns out, there would be no effect on the experiment. The L8 lt face would not illuminate as brightly as if both bulbs were illuminating, but would be sufficiently illuminated. The following indication can be used to determine the failure of the L8 lt: • One bulb shorts to ground --The L8 lt would not illuminate when the BATTERY DISCHARGE cb (CB6) was closed. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this problem. --The BATTERY DISCHARGE cb (CB6) would trip open. Shorting to ground of either one of the 100 Ω resistors in the battery discharge circuit would give this same indication. A malfunction analysis by the astronaut would not verify this problem. References 6 and 9.
3.5.2.1 Specify the Pf_t and Pf_n for the exothermic package.		0.1			The exothermic package contains four 0.75-in. diam by 0.040-in. wall tubes of Type 304L stainless steel. Each tube is partially slit around its circumference in the center to simulate a pair of tubes to be joined end-to-end. Sufficient uncut area is left to provide mechanical support for the assembly. Surrounding the simulated joint is a sleeve, also of Type 304L stainless steel, which is to be brazed to the tube. The braze alloy, which contains 71.8 percent Ag, 28 percent Cu, and 0.2 percent Li, is in the form of two preformed rings set in grooves in the inner wall of the tube. Each assembly has four brazing packages. The clearance between the sleeve and tube is 0.0025 in. in three packages and 0.02 in. in the fourth.

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 21 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.1 (Continued)					Each sleeve is surrounded by an annular cylinder of exothermic braze material. The igniter material in each package has an electric heater wire embedded in it for initiation, the required initiation temperature is 510 °C (950 °F) attained by applying a 24 V, 120 A current pulse to the heater for 5 msec. The entire exothermic heating module is mounted on the adapter plate in the work chamber by two fasteners. The vent cap on the package is removed before igniting the module. The module is constructed so that sufficient gas would leak through the seals and housing to prevent an explosion even if the vent cap was not removed. Power for initiation of the exothermic reactions is provided by the battery through the EXOTHERMIC SPECIMEN selector sw (S7). The EXOTHERMIC EXP HOT lt (L2) shows that the case temperature has reached at least 105 °F, the maximum temperature for safe handling.
		Pf_n=0.01		IIIb	If a structural failure occurred, preventing the exothermic package from being mounted on the adapter plate in the work chamber, the following conditions would occur: • Mechanical --The package would not be properly mounted in the work chamber and heat transfer from the exothermic package to the heat sink could be affected. • Operability --The astronaut could secure the exothermic package inside the work chamber to perform the experiment.
		Pf_n=0.01		IIIb	If the vent cap on the exothermic package cannot be opened, there will be no effect on the experiment. The exothermic package is designed to operate if the vent cap cannot be opened.
		Pf_n=0.04		IIIb	If the heater wire, embedded in the igniter material, opens, the following condition would occur· • Communications and Data --This would prevent an exothermic specimen from igniting. This would cause a partial failure of the experiment by losing one specimen

TABLE G-I. EXPERIMENT M-552, EXOTHERMIC BRAZING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 22 of 22)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.1 (Concluded)		P_{f_n}=0.04		IIIb	If the thermostat should fail open or closed, the following conditions would occur: • Communications and Data --The EXOTHERMIC EXP HOT lt (L2) could not be used in the performance of the experiment. • Operability --The astronaut would have to time the experiment to know when to ignite the next exothermic specimen or to know when to remove the exothermic package from the work chamber. The following indications can be used to determine the failure of the exothermic package. • Structural failure preventing the exothermic package from being installed in the work chamber --The exothermic package will not mount in the work chamber. • Vent cap failed closed --The vent cap cannot be opened. • Heater wire failed open --The EXOTHERMIC EXP HOT lt (L2) would not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) was placed in the TRIGGER position. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. • Thermostat failed open --The EXOTHERMIC EXP HOT lt (L2) will illuminate when the EXOTHERMIC POWER sw (S15) is placed in the ON position and the L2 lt will remain on until the S15 sw is placed in the OFF position. • Thermostat failed closed --The EXOTHERMIC EXP HOT lt (L2) would not illuminate in approximately 3 min after an exothermic specimen was fired. Failure of other electrical components would give this same indication. A malfunction analysis by the astronaut would not verify this failure. References 3, 6, and 9.

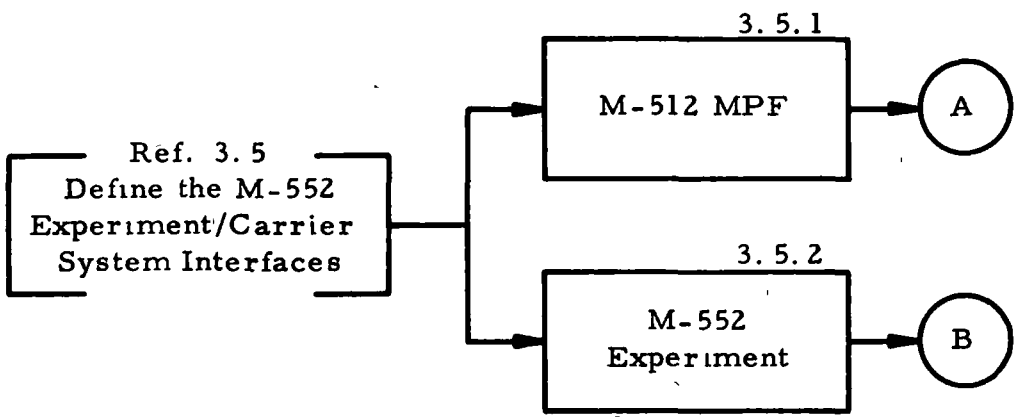


FIGURE G-1. EXPERIMENT M-552, EXOTHERMIC BRAZING FUNCTIONAL BLOCK DIAGRAM (Sheet 1 of 4)

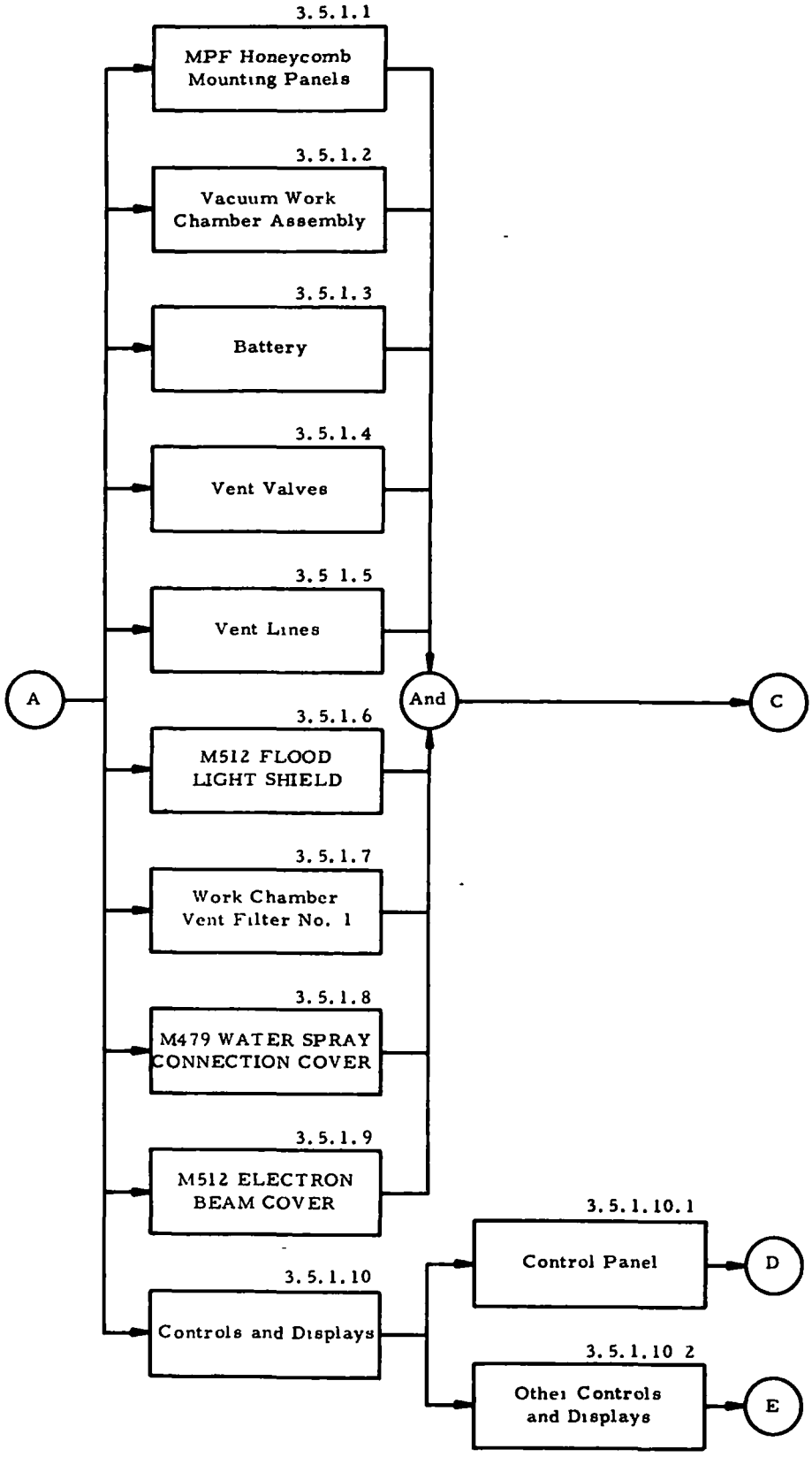


FIGURE G-1. EXPERIMENT M-552, EXOTHERMIC BRAZING FUNCTIONAL BLOCK DIAGRAM (Sheet 2 of 4)

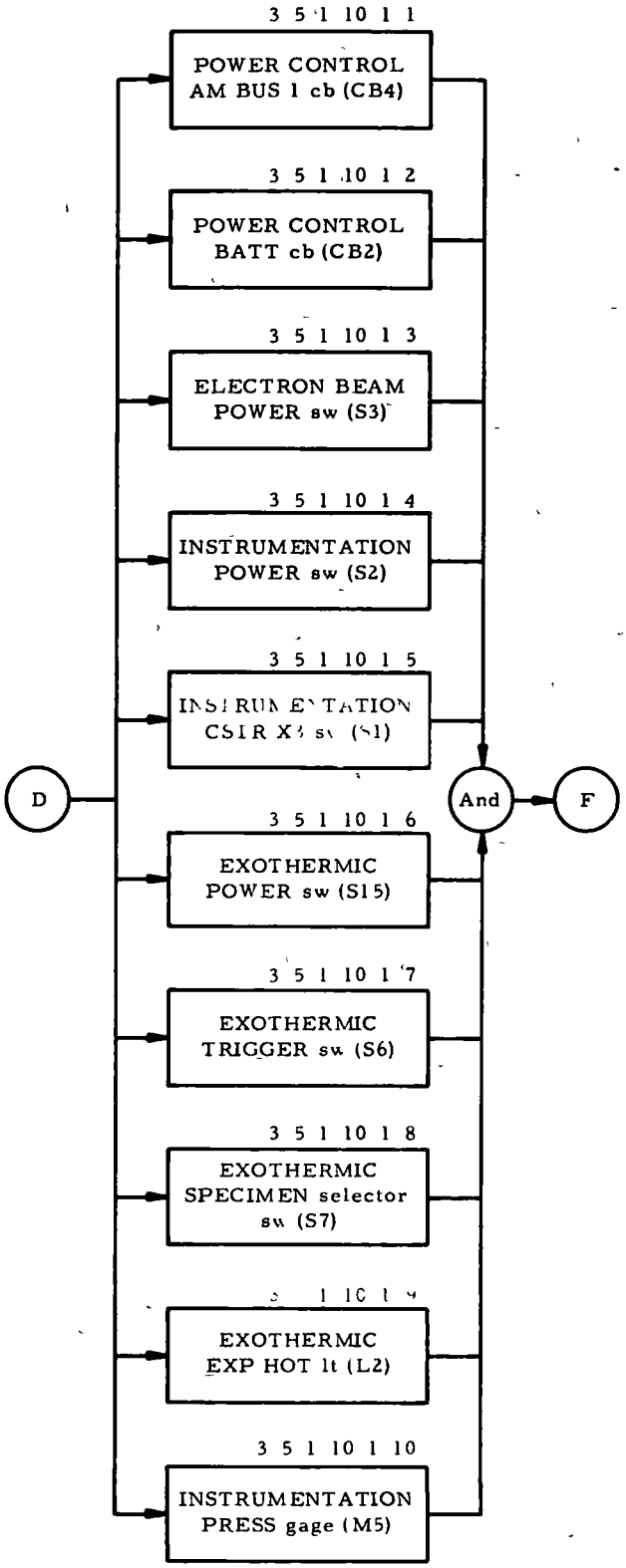


FIGURE G-1. EXPERIMENT M-552, EXOTHERMIC BRAZING FUNCTIONAL BLOCK DIAGRAM (Sheet 3 of 4)

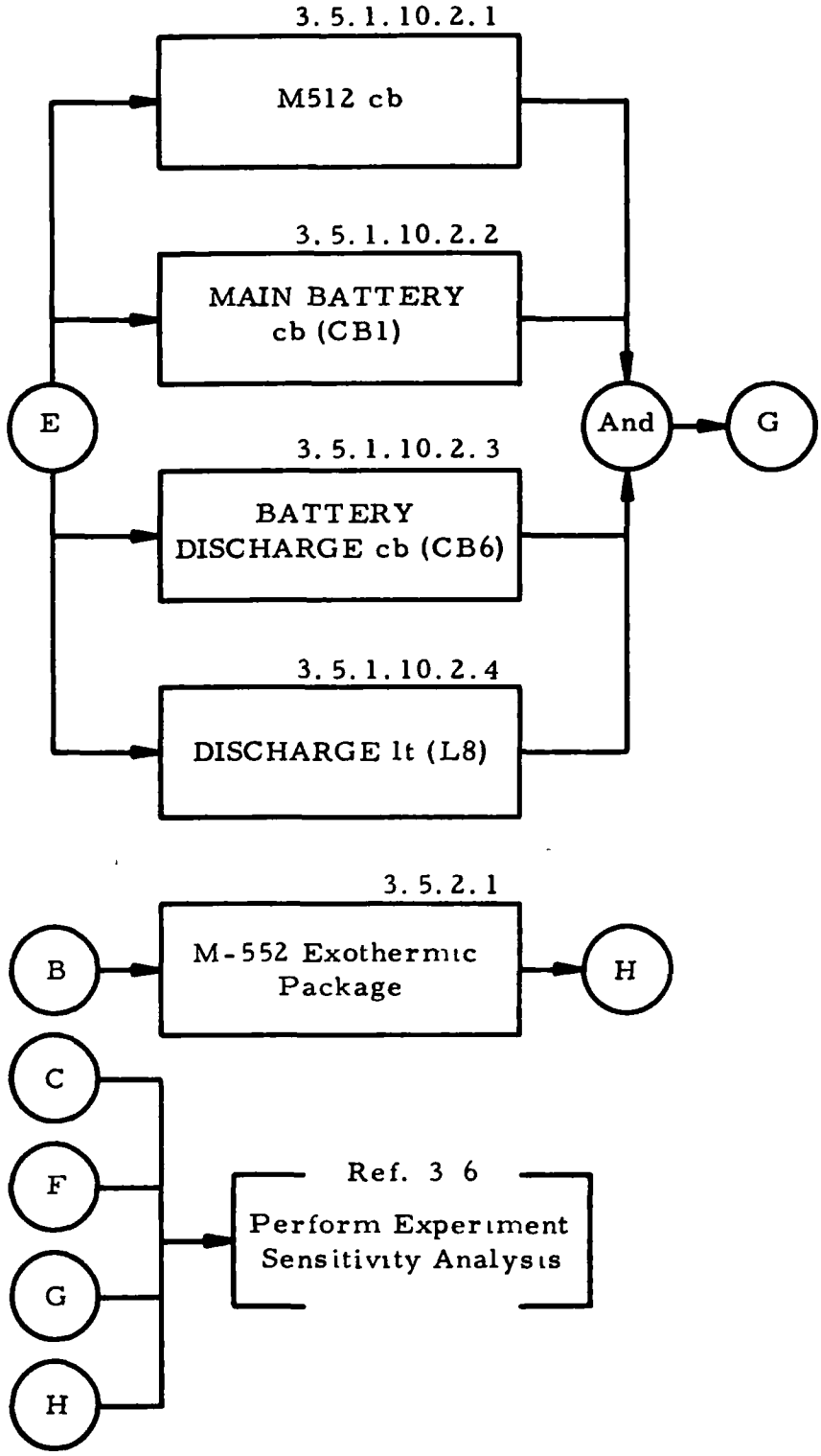


FIGURE G-1. EXPERIMENT M-552, EXOTHERMIC BRAZING FUNCTIONAL BLOCK DIAGRAM (Sheet 4 of 4)

SECTION II.

EXPERIMENT M-552, EXOTHERMIC BRAZING INTERFACE BLOCK DIAGRAM

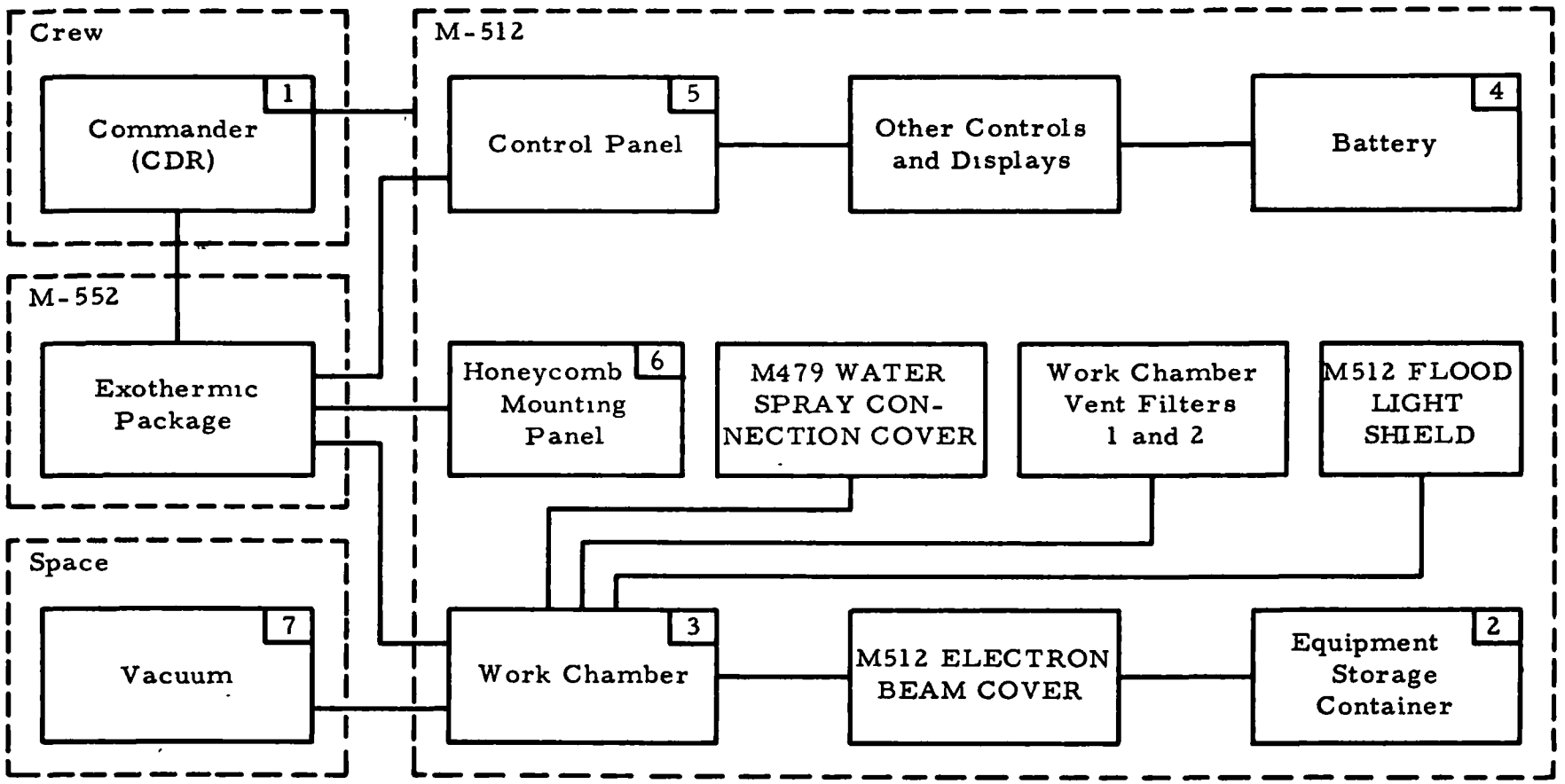


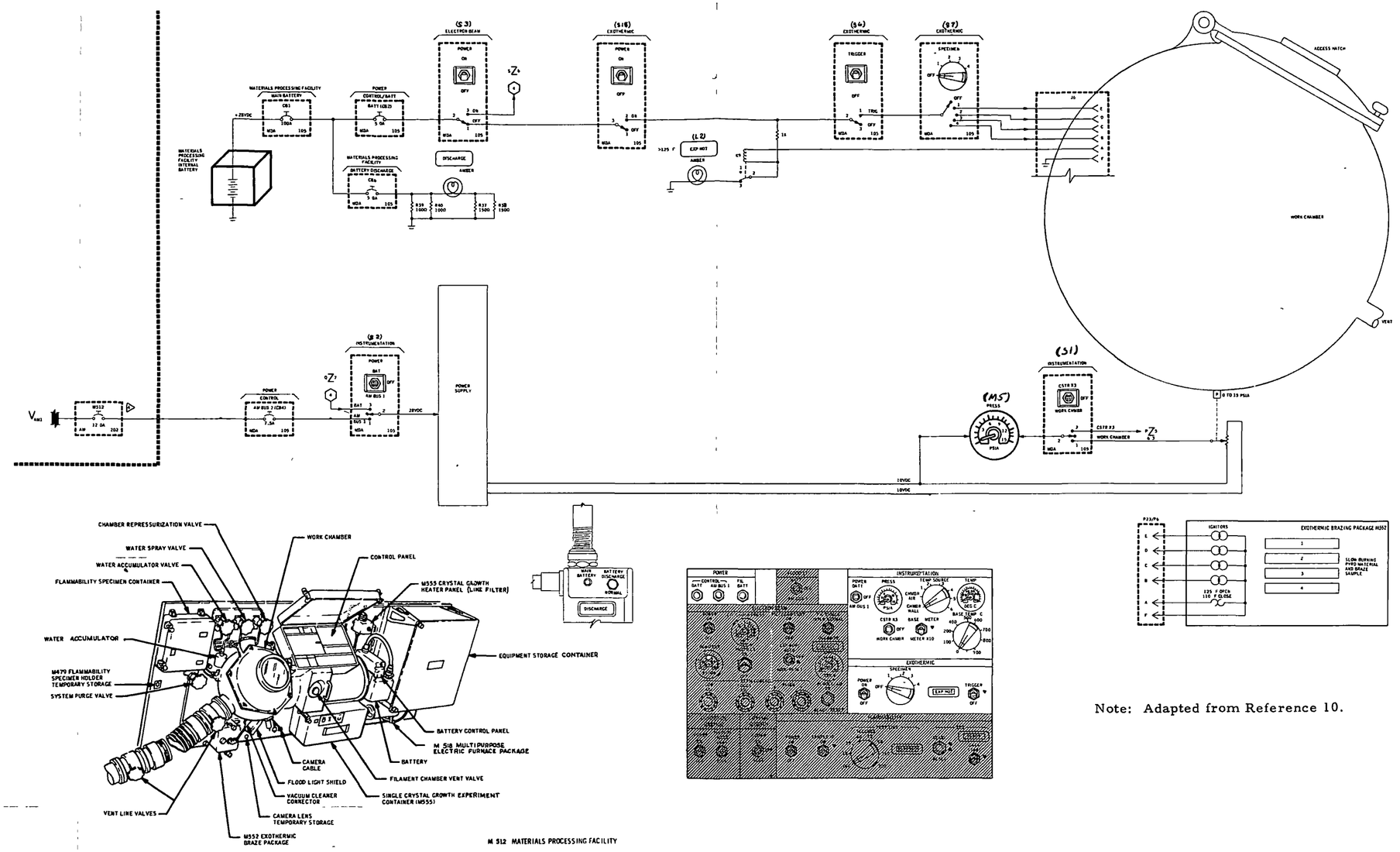
FIGURE G-2. EXPERIMENT M-552, EXOTHERMIC BRAZING INTERFACE BLOCK DIAGRAM AND DEFINITION (Sheet 1 of 2)

FIGURE G-2. EXPERIMENT M-552, EXOTHERMIC BRAZING INTERFACE BLOCK DIAGRAM AND DEFINITION (Sheet 2 of 2)

Code	Data Source	Remarks
1	Crew	There is a crew interface between the CDR and the M-512 MPF and the CDR and the M-552 Exothermic Package The crew removes the exothermic package from the honeycomb mounting panel and the M512 ELECTRON BEAM COVER from the EQUIPMENT STORAGE CONTAINER and mounts the package and the cover in the work chamber (The M512 FLOOD LIGHT SHIELD, M479 WATER SPRAY CONNECTION COVER and vent filter no 1 are already installed in the work chamber) During experiment performance, the crew operates the control panel which supplies control functions to the exothermic package After the experiment performance, other controls and displays are used to discharge the M-512 battery
2	Crew	There is a mechanical interface between the EQUIPMENT STORAGE CONTAINER and the M512 ELECTRON BEAM GUN COVER The cover is removed from the EQUIPMENT STORAGE CONTAINER and installed in the work chamber over the EBG port after Experiments M-551 and M-553 have been performed and prior to the performance of Experiment M-552
3	Crew	During experiment operation, there are mechanical interfaces between the work chamber and each of the following • Exothermic Package (mounted in the work chamber over the heat sink) • M512 FLOOD LIGHT SHIELD (mounted in the work chamber over the floodlight) • M512 ELECTRON BEAM COVER (mounted in the work chamber over the EBG port) • Vent filter no 1 (mounted in the work chamber in the 4-in vent line) • M479 WATER SPRAY CONNECTION COVER (mounted in the work chamber over the water supply line)
4	Crew	There is an electrical interface between the battery and the MAIN BATTERY cb (CB1) Other controls and displays are • M512 cb • MAIN BATTERY cb (CB1) • BATTERY DISCHARGE cb (CB7) • DISCHARGE lt (L8) These controls and displays are not located on the control panel During experiment performance, the M512 cb transfers power from the AM BUS 1 to the POWER CONTROL AM BUS 1 cb (CB4), CB1 cb transfers power from the battery to the control panel After experiment performance, CB1 and CB6 circuit breakers transfer power from the battery to the battery discharge resistors and the L8 lt to discharge the battery
5	Crew	There is an electrical interface between the control panel and the MAIN BATTERY cb (CB1) The CB1 cb transfers power from the battery to the control panel There is also an electrical interface between the control panel and the exothermic package The power required to ignite the exothermic materials is controlled by electrical inputs from the control panel
6	Crew	There is a mechanical interface between the honeycomb mounting panel and the exothermic package The exothermic package is mounted under the work chamber on the honeycomb mounting panel prior to and after the performance of the experiment
7	Crew	During Experiment M-552 operation, there is an environmental interface between the space vacuum and the work chamber and everything mounted in the work chamber Materials mounted in the work chamber are • M512 FLOOD LIGHT SHIELD • M512 ELECTRON BEAM COVER • Vent filter no 1 • M479 WATER SPRAY CONNECTOR COVER • Exothermic Package

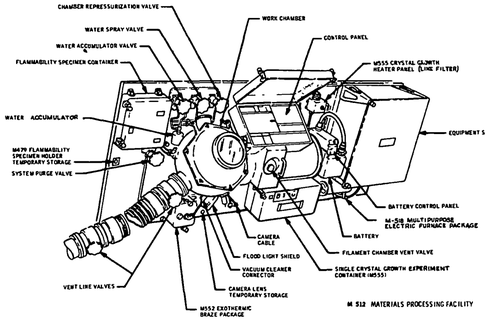
SECTION III.

EXPERIMENT M-552, EXOTHERMIC BRAZING
SYSTEMS DIAGRAM

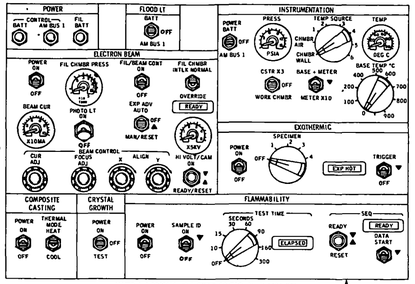


Note: Adapted from Reference 10.

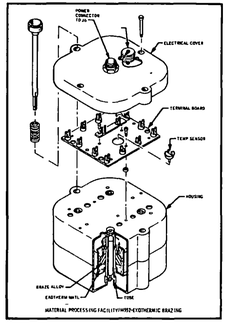
FIGURE G-3. EXPERIMENT M-552, EXOTHERMIC BRAZING ELECTRICAL SYSTEMS DIAGRAM

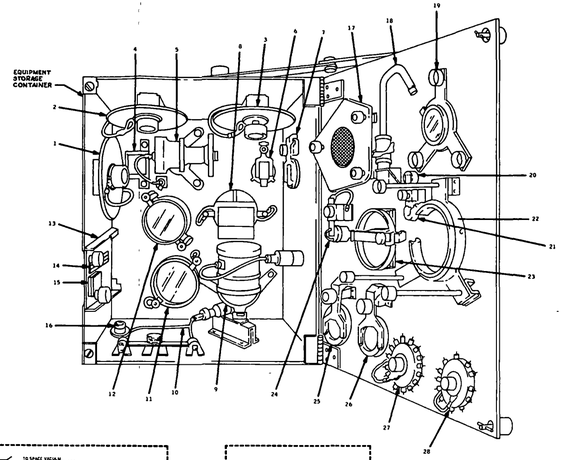


Note: Adapted from Reference 10.



MATERIALS PROCESSING FACILITY CONTROL PANEL (MDA 105)





1 WELD SPECIMEN 1
2 WELD SPECIMEN 2
3 WELD SPECIMEN 3
4 DEFLECTION MIRROR
5 ELECTRON BEAM WELD MOTOR
6 CAMERA MIRROR
*7 FLOOD LIGHT SHIELD
8 HATCH VIEW PORT MIRROR
9 SPHERE FORMING MOTOR
10 WATER SPRAY NOZZLES
11 HATCH VIEW PORT SHIELD FLAMMABILITY
12 HATCH VIEW PORT SHIELD SPHERE FORMING
13 BATTERY ACCESS PANEL
14 COMPOSITE CASTING SPECIMEN STORAGE
15 TOOL STORAGE
*16 WATER SPRAY CONNECTION COVER
*17 ELECTRON BEAM COVER
18 FLAMMABILITY SPECIMEN HOLDER
19 HEAT SINK COVER
20 SPHERE CATCHER 1
21 SPHERE CATCHER 2
22 CRYSTAL GROWTH OR COMPOSITE CASTING CLAMP
**23 WORK CHAMBER VENT FILTER 1 and 2
24 SPHERE CATCHER INSTALLATION TOOL
25 CAMERA PORT SHIELD-SPHERE FORMING
26 CAMERA PORT SHIELD-FLAMMABILITY
27 SPHERE FORMING SPECIMEN 1
28 SPHERE FORMING SPECIMEN 2

*Used when Experiment M-552 is performed.
**Only work chamber vent filter no. 1 is used when performing Experiment M-552

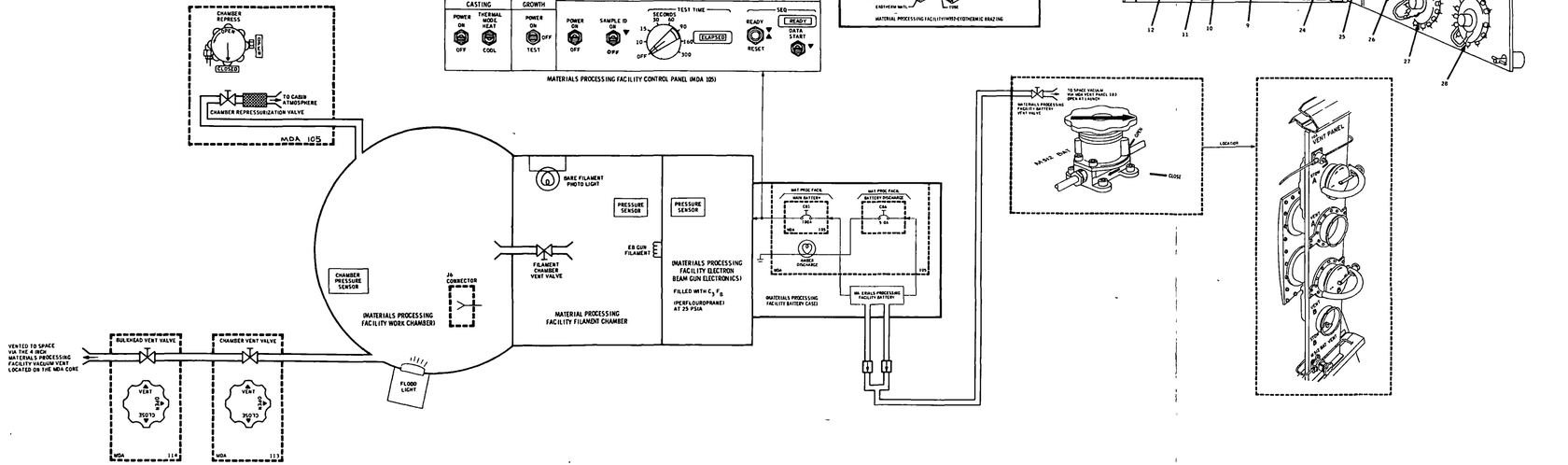


FIGURE G-4. EXPERIMENT M-552, EXOTHERMIC BRAZING MECHANICAL AND FLUID SYSTEMS DIAGRAM

SECTION IV.

EXPERIMENT M-552, EXOTHERMIC BRAZING
DATA REQUIREMENTS SUMMARY

TABLE G-II. EXPERIMENT M-552, EXOTHERMIC BRAZING DATA REQUIREMENTS SUMMARY

Measurement Name	Range and Dimension of Variables	Measurement No.	Telemetry Assignment Channel	Data Return	Data Time	Remarks
Voice Comments	N/A	N/A	N/A	N/A	Real	Recordings will be made of the astronaut's voice comments during the performance of the experiment.
Crew Log	N/A	N/A	N/A	N/A	All	Pertinent observations will be entered in the experiment logbook.

SECTION V. EXPERIMENT M-552, EXOTHERMIC BRAZING DATA REQUEST FORMS

These data required for evaluation of Experiment M-552 consist completely of voice comments by the crewman concerning experiment operations, transcripts of voice comments, and the experiment log. 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 Experiment M-552 is not necessary.

SECTION VI. EXPERIMENT M-552, EXOTHERMIC BRAZING ENGINEERING CHANGE REQUESTS

This Engineering Change Request was written for Experiment M-551, but is also applicable for Experiment M-552. It was submitted on August 19, 1971 and was disapproved for the following reasons:

- No impact from the Product Technology Laboratory
- Not enough justification
- State-of-charge can be calculated based on ground testing.

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, ECP, 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
- [ ] S&S
- [ ] 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

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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.

EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE

TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 1 of 12)

Assignments

Mission

- SL-1/SL-2

Orbital Assembly (OA)

- Multiple Docking Adapter (MDA) (M-512 Facility)

Carrier

- The exothermic brazing package is stowed under and to the left of the work chamber The electron beam port cover is stowed in the Equipment Storage Container

Conditions

Crew

- The CDR will perform M-552, -1, -2, -3. The PLT will perform M-552, -4.

Experiment

- The purposes of the experiment are
  - --Test and demonstrate a method of brazing components in space repair and maintenance operations
  - --Study surface wetting and capillary flow effects in weightless molten metals
  - --Demonstrate the feasibility of exothermic reaction in space

Ground Support

- N/A

Requirements

Functional Objectives·

- FO-1 Perform exothermic brazing and collect data and samples for return to earth

Experiment Evaluation Team - Key Personnel Locator

Name	Responsibility	Office Address, Symbol, and Telephone Number
Mr J. R. Williams	Principal Investigator (PI)	MSFC, Bldg 4711, S&E-PT-M, 205-453-5089
Mr. P G Parks	Experiment Developer (ED)	MSFC, Bldg 4711, S&E-PT-MW, 205-453-2363
Mr E O Walker	MSFC Experiment Manager (EM)	MSFC, Bldg 4201, PM-SL-DP, 205-453-3183
Mr. J C McCaig	S&E Experiment Engineer (EE)	MSFC, Bldg 4711, S&E-PT-MW, 205-453-1649
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 T Jacob	Experiment Integration Engineer (EIE)	Martin Marietta Corporation, Denver, Colorado, 303-794-5211, ext 5451
Mr C Gruby	Experiment Flight Controller (EFC)	MSC, Houston, Texas, 713-483-4717

TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 2 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P - 60 min GMT - TBD		Experiment Evaluation Team manned and available. Contact Experiment M-552, Technical Discipline Manager, S&E-ASTN-SDF Huntsville Operation Support Center (HOSC) Telephone No TBD, Astronautics Laboratory Telephone No. 453-3810 Reference Refer to References 5 and 6.				
P 1.0	CDR	Experiment preparation				
P 1.1		Don triangle shoes, install M-512 foot restraint.				
P 1.2		Set up Speaker Intercom (S/I) to record voice data				
P 1.3		M512 cb - close (verify)				
P 1.4		Open control panel cover				
P 1.5		Obtain and attach checklist and logbook to clipboard and secure to control panel cover				
P 1.6		Verify the following 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 M-512 BAT. VENT vlv - OPEN MAIN BATTERY cb (CB1) - open				

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

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

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

TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 3 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		Note The Battery DISCHARGE cb (CB6) is left open until Experiment M-552 is completed. BATTERY DISCHARGE cb (CB6) - open Note After the M-555 package has been connected to the M-512 MPF under the EBG canister, the CRYSTAL GROWTH HEATING PAD AM BUS 1 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) - close.				
P 1.7		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				

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 4 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		EXOTHERMIC TRIGGER sw (S6) - OFF 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)				
P 1 8		CHAMBER REPRESS vlv - OPEN			P18A1	
P 1.9		Unlatch and open work chamber hatch			P19A1	
P 1.10		CHAMBER REPRESS vlv - CLOSED			P110A1	
P 1.11		Remove dummy connector from the work chamber zero-g connector and place on the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE CONNECTOR.			P111A1	The FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector is located under the flammability specimen container.
P 1.12		Obtain and install the M512 ELECTRON BEAM COVER in the work chamber over the EBG port			P112A1	The M512 ELECTRON BEAM COVER is stowed in the EQUIPMENT STORAGE CONTAINER.
P 1.13		Obtain and install the EXOTHERMIC SPECIMENS package in the work chamber.			P113A1	The package is stowed under and to the left of the work chamber When installed in the work chamber, it is connected to the adapter plate by two fasteners.
P 1.14		Loosen the vent cap on the EXOTHERMIC SPECIMENS package.			P114A1	
P 1 15		Connect electrical cable to the zero-g connector in the work chamber.			P115A1 P115B1	

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 5 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 1.16		Close and latch work chamber hatch.			P116A1	

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 6 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1 0	CDR/PLT	Experiment operation.				
O 1 1		POWER CONTROL AM BUS 1 cb (CB4) - close.				
O 1.2		INSTRUMENTATION POWER sw (S2) - AM BUS 1.				
O 1.3		INSTRUMENTATION CSTR X3 sw (S1) - WORK CHMBR.				
		Note: Operation Step Nos. O 1.4, O 1.5, and O 1.6 apply only for the first specimen. Omit these steps for the other three specimens and proceed with Operation Step No. O 1 7				
O 1.4		Verify INSTRUMENTATION PRESS gage (M5) reading is 5 psia.			O14A1 O14B1 O14C1	
O 1.5		Bulkhead vent vlv - OPEN.			O15A1	
O 1.6		Work chamber vent vlv - VENT.			O16A1	
O 1.7		Verify INSTRUMENTATION PRESS gage (M5) reading is or decreases to 0 psia.			O17A1	
O 1.8		INSTRUMENTATION CSTR X3 sw (S1) - OFF.				
		Note For the first specimen, wait 10 min before igniting the specimen. This 10 min wait is not necessary for the other specimens.				This is to allow the pressure in the work chamber to decrease to 1 x 10^{-5} torr or less before igniting the specimens
O 1.9		INSTRUMENTATION POWER sw (S2) - OFF.				
O 1.10		POWER CONTROL AM BUS 1 cb (CB4) - open.				
O 1.11		MAIN BATTERY cb (CB1) - close.				

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

TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 7 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.12		POWER CONTROL BATT cb (CB2) - close.				
O 1.13		EXOTHERMIC POWER sw (S15) - ON				
		Note The EXOTHERMIC SPECIMEN selector sw (S7) is turned to the number of the specimen to be ignited				
O 1.14		EXOTHERMIC SPECIMEN selector sw (S7) - 1, 2, 3, or 4.				It is desirable to fire the exothermic specimens in order 1, 2, 3, and 4.
		Note For exothermic specimens 2, 3, and 4, the EXOTHERMIC EXP HOT lt (L2) should be out before the specimens are ignited				
O 1.15		EXOTHERMIC TRIGGER sw (S6) - TRIGGER (momentary)				This applies power to the exothermic specimen.
		Note The POWER CONTROL BATT cb (CB2) may open when an exothermic specimen is ignited				
O 1.16		POWER CONTROL BATT cb (CB2) - close or close (verify)				
O 1.17		Wait approximately 3 min for EXOTHERMIC EXP HOT lt (L2) to illuminate.			O117A1	
O 1.18		EXOTHERMIC POWER sw (S15) - OFF.				
		WARNING				
		After a specimen has been ignited, do not proceed to next specimen or remove package from the work chamber until after the following minimum cooldown time for each specimen or until after the EXOTHERMIC EXP HOT lt (L2) is out				

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 8 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	*Anom-aly*		
		SPECIMEN NO. Cooldown Time 1 2 hr 15 min 2 2 hr 30 min 3 2 hr 40 min 4 2 hr 45 min				
		To observe the L2 lt, place the EXOTHERMIC POWER sw (S15) in the ON position.				
		Note If the EXOTHERMIC EXP HOT lt (L2) was checked, place the EXOTHERMIC POWER sw (S15) in the OFF position.				
O 1.19		POWER CONTROL BATT cb (CB2) - open.				
O 1.20		MAIN BATTERY cb (CB1) - open				
O 1.21		Repeat Operation Step Nos. O 1.1 through O 1.20 for each of the remaining specimens. If all the specimens have been ignited, proceed with Operation Step No. T 1 0.				

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 9 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1.0	CDR	Termination of experiment.				
T 1.1		POWER CONTROL AM BUS 1 cb (CB4) - close.				
T 1.2		INSTRUMENTATION POWER sw (S2) - AM BUS 1				
T 1.3		INSTRUMENTATION CSTR X3 sw (S1) - WORK CHMBR				
T 1.4		Verify INSTRUMENTATION PRESS gage (M5) reading is zero psia.			T14A1	
T 1.5		Bulkhead vent vlv - CLOSE.			T15A1	
T 1.6		Work chamber vent vlv - CLOSE.			T16A1	
T 1.7		CHAMBER REPRESS vlv - OPEN.			T17A1	
T 1.8		Verify INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia.			T18A1 T18B1	
T 1.9		INSTRUMENTATION CSTR X3 sw (S1) - OFF.				
T 1.10		INSTRUMENTATION POWER sw (S2) - OFF.				
T 1.11		POWER CONTROL AM BUS 1 cb (CB4) - open.				
T 1.12		Unlatch and open work chamber hatch.			T112A1	
T 1.13		CHAMBER REPRESS vlv - CLOSED.			T113A1	
T 1.14		Tighten the vent cap on the EXOTHERMIC SPECIMENS package.			T114A1	
T 1.15		Disconnect electrical cable from the zero-g connector in the work chamber.			T115A1	

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 10 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1.16		Remove the EXOTHERMIC SPECIMENS package from the work chamber and stow.			T116A1	The EXOTHERMIC SPECIMENS package is stowed under and to the left of the work chamber.
T 1.17		Remove the power cable from the EXOTHERMIC SPECIMENS package and stow			T117A1	
T 1.18		Remove the dummy zero-g connector from the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector and place on the zero-g connector in the work chamber.			T118A1	The FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector is located under the flammability specimen container.
T 1.19		Close and latch the work chamber hatch.			T119A1	
T 1.20		MAIN BATTERY cb (CB1) - close.				
T 1.21		BATTERY DISCHARGE cb (CB6) - close.				
T 1.22		Verify battery DISCHARGE lt (L8) illuminates.			T122A1	
T 1.23		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 battery. M-512 BAT. VENT vlv - OPEN				

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 11 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		MAIN BATTERY cb (CB1) - CLOSE BATTERY DISCHARGE cb (CB6) - close Battery DISCHARGE lt (L8) - illuminating Note After the M-555 package has been connected to the M-512 MPF under the EBG canister, the CRYSTAL GROWTH HEATING PAD AM BUS 1 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) - close.				
T 1.24		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 (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				

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TABLE G-III. EXPERIMENT M-552, EXOTHERMIC BRAZING EVALUATION SEQUENCE (Sheet 12 of 12)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
		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 1.25		Remove logbook, checklist and clipboard from control panel and stow.				
T 1.26		Close and latch control panel cover				
T 1.27		Terminate S/I voice record				
T 1.28		Stow M-512 foot restraint, remove traingle shoes and stow.				

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SECTION VIII.

EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE

TABLE G-IV. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P)
(Sheet 1 of 3)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 1.8	CHAMBER REPRESS vlv - OPEN	P18A The CHAMBER REPRESS vlv will not open.	P18A1 Apply a greater amount of force than is normally required to open the CHAMBER REPRESS vlv. P18A2 Continue with the experiment.	The CHAMBER REPRESS vlv is used to repressurize the work chamber after it has been vented to space.
P 1.9	Unlatch and open work chamber hatch.	P18A One or more Calfax fasteners or cam lock latches will not release.	P19A1 Apply a greater amount of force than is normally required to release the Calfax fasteners or cam lock latches. P19A2 Terminate the experiment and reconfigure the MPF to its initial condition.	
P 1.10	CHAMBER REPRESS vlv - CLOSED.	P110A The CHAMBER REPRESS vlv will not close.	P110A1 Apply a greater amount of force than is normally required to close the CHAMBER REPRESS vlv. P110A2 Terminate the experiment and reconfigure the MPF to its initial condition.	If the CHAMBER REPRESS vlv will not close, a vacuum cannot be pulled on the work chamber.
P 1.11	Remove the dummy connector from the work chamber zero-g connector and place on the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector.	P111A The dummy connector will not remove from the work chamber zero-g connector.	P111A1 Apply a greater amount of force than is normally required to remove the dummy connector. P111A2 Terminate the experiment and reconfigure the MPF to its initial condition.	If the dummy connector will not remove, power cannot be delivered to the experiment.

P

ASTN-OT-7 (Feb. 72)

TABLE G-IV. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P)
(Sheet 2 of 3)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 1.12	Obtain and install the M512 ELECTRON BEAM COVER in the work chamber over the EBG port.	P112A The M512 ELECTRON BEAM COVER will not mount in the work chamber over the EBG port.	P112A1 Continue with the experiment.	The M512 ELECTRON BEAM COVER is used to protect the EBG port from debris produced by the experiment.
P 1.13	Obtain and install the EXOTHERMIC SPECIMENS package in the work chamber.	P113A The EXOTHERMIC SPECIMENS package will not mount in the work chamber	P113A1 Use tape to secure the EXOTHERMIC SPECIMENS package in the work chamber and continue with experiment.	
P 1.14	Loosen the vent cap on the EXOTHERMIC SPECIMENS package.	P114A The vent cap will not loosen on the EXOTHERMIC SPECIMENS package.	P114A1 Apply a greater amount of force than is normally required to loosen the vent cap on the EXOTHERMIC SPECIMENS package.	
			P114A2 Continue with the experiment.	The EXOTHERMIC SPECIMENS package is designed to operate even if the vent cap cannot be removed from the package.
P 1.15	Connect electrical cable to the zero-g connector in the work chamber.	P115A The electrical cable pins are bent, thereby preventing cable connection.	P115A1 Straighten pins, connect power cable, and continue with experiment.	
		P115B The elctrical cable connector will not physically connect to the zero-g connector in the work chamber.	P115B1 Terminate the experiment and reconfigure the MPF to its initial condition.	
P 1.16	Close and latch work chamber hatch.	P116A The work chamber hatch will not properly latch.	P116A1 A decision will have to be made concerning whether or not to continue the experiment with or without performing a vacuum integrity check. • Perform vacuum integrity check --Remove the EXOTHERMIC SPECIMENS package from the work chamber	

P

TABLE G-IV. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P)
(Sheet 3 of 3)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			--Close and latch hatch with operating fasteners --Refer to the Skylab Experiment Performance Evaluation Manual (SEPEM), Appendix E, and perform Operation Step Nos. O 2.0 through O 2.13. --If the vacuum integrity check proves that the work chamber will hold a vacuum, reconfigure the facility to its initial condition, mount the EXOTHERMIC SPECIMENS package in the work chamber and continue with the experiment. --If the vacuum integrity check proves that the work chamber will not hold a vacuum, terminate the experiment and reconfigure the MPF to its initial condition.	
			• Do not perform vacuum integrity check --Continue with experiment.	It was determined that the work chamber would hold a vacuum with the hatch not properly latched.

P

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 1 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1 4	Verify INSTRUMENTATION PRESS *gage (M5) reading is 5 psia*	O14A The INSTRUMENTATION *PRESS gage (M5) reading is* zero psia	O14A1 Tap the INSTRUMENTATION *PRESS gage (M5) with finger*	If the INSTRUMENTATION PRESS *gage (M5) reading moves up to* 5 psia, the M5 gage is hung
			O14A2 Recycle the INSTRUMENTATION CSTR X3 sw (S1)	
			O14A3 Verify that the INSTRUMENTATION TEMP gage (M4) is operating	It may be difficult to determine that the INSTRUMENTATION TEMP gage (M4) is operating if the reading is on the extreme low end of the scale (two graduation marks or less on the low end of the scale) Place the INSTRUMENTATION BASE +METER sw (S8) in the BASE +METER position If the M4 gage is operating, the reading should swing upscale
			• INSTRUMENTATION TEMP gage (M4) is greater than 0 °C --Refer to Contingency Plan O14A4.	This would indicate one of the following· • The INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the WORK CHMBR position • The INSTRUMENTATION PRESS gage (M5) has malfunctioned.
			• INSTRUMENTATION TEMP gage (M4) reading is 0 °C, --Refer to Contingency Plan O14A5	This would indicate one of the following· • The Power Supply Module has failed

O

TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 2 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The INSTRUMENTATION POWER sw (S2) failed to make contact in the AM BUS 1 position • The POWER CONTROL AM BUS 1 cb (CB4) has tripped or failed open • The M512 cb has tripped or failed open.
			O14A4 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	The INSTRUMENTATION PRESS gage reading should be 8 psia or above This would represent an EBG canister pressure of 24 psia or above
			• INSTRUMENTATION PRESS gage (M5) reading is 8 psia or above --Continue the experiment without the capability of measuring the work chamber pressure The astronaut can continue with the experiment but will have to wait TBD minutes for the work chamber to depressurize before igniting the exothermic specimens	This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the WORK CHMBR position • The chamber pressure transducer failed
			• INSTRUMENTATION PRESS gage (M5) reading is greater than 0 but less than 8 psia --Refer to the above indication where the M5 gage reading is 8 psia or above	This would indicate one of the following: • The INSTRUMENTATION PRESS gage (M5) has malfunctioned

O

TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 3 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in the WORK CHMBR position • The chamber pressure transducer failed. This would also indicate a low EBG pressure. A single failure other than a malfunctioned INSTRUMENTATION PRESS gage (M5) would not give a low canister pressure and zero reading on the M5 gage This would take a double failure and will not be analyzed in this document
			• INSTRUMENTATION PRESS gage (M5) reading is zero psia --Refer to the above indication where the M5 gage reading is 8 psia or above	This would indicate one of the following: • The INSTRUMENTATION CSTR X3 sw (S1) failed to make contact in both the WORK CHMBR and the CSTR X3 positions • The INSTRUMENTATION PRESS gage (M5) has malfunctioned.
			O14A5 Recycle the INSTRUMENTATION POWER sw (S2)	
			O14A6 Place the FLOOD LT sw (S19) in the AM Bus 1 position and verify that the floodlight illuminates • Floodlight illuminates --Continue the experiment without	This would indicate one of the

O

TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 4 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			the capability of measuring the work chamber pressure using AM BUS 1 power The astronaut can continue with the experiment but will have to wait TBD minutes for the work chamber to depressurize before igniting the exothermic specimens Note that a Contingency Operating Procedure involving the battery could be used to try and measure the work chamber pressure, using the INSTRUMENTATION PRESS gage (M5) Note that if this Contingency Procedure is used, the FILAMENT CHAMBER VENT vlv should be in the CLOSE position and the FIL CHMBR INTLK sw (S13) should be in the NORMAL position If the vlv were open or the filament chamber interlock sw (S27) failed closed or the S13 sw was in the OVERRIDE position, power could be applied to exothermic specimen No 2	following • The Power Supply Module failed • The INSTRUMENTATION POWER sw (S2) failed to make contact in the AM BUS 1 position
			• Floodlight does not illuminate --Refer to Contingency Plan O14A7	This would indicate one of the following • The Power Control AM BUS 1 cb (CB4) has tripped or failed open • The M512 cb has tripped or failed open

TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 5 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			O14A7 On the crystal growth storage container, place the lamp test sw in the LAMP TEST position and verify that the LO TEMP lt illuminates	
			• LO TEMP lt illuminates --Refer to Contingency Plan O14A8	This would indicate that the POWER CONTROL AM BUS 1 cb (CB4) has tripped or failed open
			• LO TEMP lt does not illuminate --Refer to Contingency Plan O14A9	This would indicate that the M512 cb has tripped or failed open
			O14A8 Recycle the POWER CONTROL AM BUS 1 cb (CB4) If the INSTRUMENTATION PRESS gage (M5) reading remains zero psia, refer to Contingency Plan O14A6 under the indication "Floodlight illuminates "	If the INSTRUMENTATION PRESS gage (M5) reading remains zero psia, this would indicate that the POWER CONTROL AM BUS 1 cb (CB4) has failed open
			O14A9 Recycle the M512 cb. If the INSTRUMENTATION PRESS gage (M5) reading remains zero psia, refer to Contingency Plan O14A6 under the indication "Floodlight illuminates "	If the INSTRUMENTATION PRESS gage reading remains zero psia, this would indicate that the M512 cb has failed open
		O14B The INSTRUMENTATION PRESS gage (M5) reading is between 0 and 5 psia	O14B1 Tap the INSTRUMENTATION PRESS gage (M5) with finger	If the INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia, this would indicate that the M5 gage is hung.
			O14B2 Open the CHAMBER REPRESS vlv and monitor the INSTRUMENTATION PRESS gage (M5) for an increase in pressure.	

O

TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 6 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			• The INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia. --A decision will have to be made concerning whether or not to continue with the experiment --Continue with experiment --Refer to SEPEM, Appendix E, Section VII, and perform the vacuum integrity check to determine where the pressure leak is --Discontinue experiment --Terminate the experiment and reconfigure the MPF to its initial condition.	A double failure could occur causing a low work chamber pressure (vacuum leak). If the experiment 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
			• The INSTRUMENTATION PRESS gage (M5) reading does not increase. --Refer to Contingency Plan O14B3	This would indicate one of the following: • The INSTRUMENTATION PRESS gage (M5) has malfunctioned • The MDA pressure was low.
			O14B3 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	
			• The INSTRUMENTATION PRESS gage (M5) reading is 8 psia or above. --Continue with experiment	This would indicate one of the following

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 7 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The INSTRUMENTATION PRESS gage (M5) is operating properly • The MDA pressure is low
			• The INSTRUMENTATION PRESS gage (M5) reading is below 8 psia --Continue the experiment without the capability of measuring the work chamber pressure The astronaut can continue with the experiment but will have to wait TBD minutes for the work chamber to depressurize before igniting the exothermic specimens	This would indicate that the INSTRUMENTATION PRESS gage (M5) has malfunctioned This would also indicate a low EBG canister pressure A single failure other than a malfunctioned INSTRUMENTATION PRESS gage (M5) would not give a low work chamber EBG canister pressure reading This would take a double failure and will not be analyzed in this document
		O14C The INSTRUMENTATION PRESS gage (M5) reading is above 5 psia	O14C1 Tap the INSTRUMENTATION PRESS gage (M5) with finger	If the INSTRUMENTATION PRESS gage (M5) reading decreases to 5 psia, this would indicate that the INSTRUMENTATION PRESS gage (M5) is hung
			O14C2 Open the CHAMBER REPRESS vlv and verify that the INSTRUMENTATION PRESS gage (M5) reading decreases to 5 psia	
			• The INSTRUMENTATION PRESS gage (M5) reading does not decrease --Refer to Contingency Plan O14C3	This would indicate one of the following • The INSTRUMENTATION

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 8 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				PRESS gage has malfunctioned • The MDA pressure was high
			• The INSTRUMENTATION PRESS gage (M5) reading decreases to 5 psia. --Double failures will not be analyzed in this document A pressure integrity check can be performed to try and determine where and/or what the problem is A decision can then be made concerning whether or not to continue or terminate the experiment.	A double failure could occur allowing the EBG canister pressure to leak into the work chamber and cause high work chamber pressure Double failure analysis will not be performed in this document
			O14C3 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	
			• The INSTRUMENTATION PRESS gage (M5) reading is 8 psia or above --Continue with experiment	This would indicate that the MDA pressure was high
			• The INSTRUMENTATION PRESS gage (M5) reading is less than 8 psia --Continue the experiment without the capability of measuring the work chamber pressure	This would indicate that the INSTRUMENTATION PRESS gage (M5) has malfunctioned Note that a double failure could cause the EBG canister pressure

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 9 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			The astronaut can continue with the experiment but will have to wait TBD minutes for the work chamber to depressurize before igniting the exothermic specimens	to be low and the work chamber pressure to be high Double failures are not analyzed in this document and, therefore, it is assumed that the INSTRUMENTATION PRESS gage (M5) has failed
O 1 5	Bulkhead vent vlv - OPEN	O15A The bulkhead vent vlv will not open	O15A1 Apply a greater amount of force than is normally required to open the bulkhead vent vlv O15A2 Terminate the experiment 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
O 1 6	Work chamber vent vlv - VENT	O16A The work chamber vent vlv will not open	O16A1 Apply a greater amount of force than is normally required to open the work chamber vent vlv O16A2 Terminate the experiment 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
O 1 7	Verify INSTRUMENTATION PRESS gage (M5) reading decreases to or is zero psia	O17A The INSTRUMENTATION PRESS gage (M5) did not decrease	O17A1 Tap the INSTRUMENTATION PRESS gage (M5) with finger O17A2 Place the INSTRUMENTATION CSTR X3 sw (S1) in the CSTR X3 position and monitor the INSTRUMENTATION PRESS gage (M5) for an increase in pressure • INSTRUMENTATION PRESS gage (M5) reading does not increase	If the INSTRUMENTATION PRESS gage (M5) decreases to zero psia, this would indicate that the M5 gage is hung This would indicate that the

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 10 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			--Continue the experiment without the capability of measuring the work chamber pressure The astronaut can continue with the experiment but will have to wait TBD minutes for the work chamber to depressurize before igniting the exothermic specimens	INSTRUMENTATION PRESS gage (M5) has malfunctioned
			• INSTRUMENTATION PRESS gage (M5) reading increases to 8 psia or above --Refer to Contingency Plan O17A3:	This would indicate that the INSTRUMENTATION PRESS gage (M5) reading will only increase and not decrease
			O17A3 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 zero psia	
			• INSTRUMENTATION PRESS gage (M5) reading decreases to zero psia --Continue with experiment	This would indicate that the INSTRUMENTATION PRESS gage (M5) was hung and the reading would not decrease in pressure, when the INSTRUMENTATION CSTR X3 sw (S1) was placed in the CSTR X3 position, the gage was released
			• INSTRUMENTATION PRESS gage (M5) reading does not decrease or does not decrease all the way to zero psia --Continue the experiment without the capability of measuring the work chamber pressure The astronaut can continue the	This would indicate that the INSTRUMENTATION PRESS gage (M5) has malfunctioned

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 11 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
			experiment but will have to wait TBD minutes for the work chamber to depressurize before igniting the exothermic specimens	
O 1 17	Wait approximately 3 min for EXOTHERMIC EXP HOT lt (L2) to illuminate	O117A The EXOTHERMIC EXP HOT lt (L2) does not illuminate in approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) is placed in the TRIGGER position	O117A1 Verify if the POWER CONTROL BATT cb (CB2) has tripped • POWER CONTROL BATT cb (CB2) is open --Close the CB2 cb and continue with experiment	This would indicate that the exothermic specimen had ignited This would also indicate one of the following • The Exothermic Package thermostat failed closed • The relay K9 contacts failed to close • The EXOTHERMIC EXP HOT lt (L2) had a malfunction that prevented both bulbs from illuminating
			• POWER CONTROL BATT cb (CB2) did not trip open --Refer to Contingency Plan O117A2 Note that if the EXOTHERMIC EXP HOT lt (L2) does not illuminate for any of the four exothermic specimens, there is a possibility that none of the exothermic specimens ignited A	This does not mean that the exothermic specimen did not ignite The POWER CONTROL BATT cb (CB2) will not necessarily trip when an exothermic specimen is ignited This could indicate one of the following

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 12 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			malfunction operating procedure could be used to ignite exothermic specimen No 2 The procedure is: • ELECTRON BEAM POWER sw (S3) - ON • FIL CHMBR INTLK sw (S13) - OVERRIDE Note When the S13 sw is placed in the OVERRIDE position, power is applied to exothermic specimen No 2 • ELECTRON BEAM POWER sw (S3) - OFF. Verify if the EXOTHERMIC EXP HOT lt (L2) illuminates within 3 min. If the L2 lt illuminates, there is a good possibility that exothermic specimens 1, 3, and 4 did not ignite If the L2 lt does not illuminate, wait approximately 2 hr and 45 min, terminate the experiment and reconfigure the facility to its initial condition	• The exothermic specimen did not ignite • The Exothermic Package thermostat failed closed • The relay K9 contacts failed to close • The EXOTHERMIC EXP HOT lt (L2) had a malfunction that prevented both bulbs from illuminating • The EXOTHERMIC SPECIMEN selector sw (S7) failed to make contact in the selected specimen number position • The EXOTHERMIC TRIGGER sw (S6) failed to make contact in the TRIGGER position • The EXOTHERMIC POWER sw (S15) failed to make contact in the ON position • The ELECTRON BEAM POWER sw (S3) failed to make contact in the OFF position • The POWER CONTROL BATT cb (CB2) failed to close

TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 13 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The MAIN BATTERY cb (CB1) failed to close
			O117A2 Recycle the following • EXOTHERMIC SPECIMENS selector sw (S7) • EXOTHERMIC POWER sw (S15)	
			Note Before recycling the ELECTRON BEAM POWER sw (S3), verify that the FILAMENT CHAMBER VENT vlv is in the CLOSE position and that the FIL CHMBR INTLK sw (S13) is in the NORMAL position • ELECTRON BEAM POWER sw (S3) • EXOTHERMIC TRIGGER sw (S6)	This is to prevent applying power to exothermic specimen No 2
			O117A3 Place the FLOOD LT sw (S19) in the BATT position and verify that the floodlight illuminates • Floodlight illuminates --Continue with experiment Refer to Contingency Plan O117A1 under "POWER CONTROL BATT cb (CB2) did not trip open "	This would indicate that both MAIN BATTERY cb (CB1) and POWER CONTROL BATT cb (CB2) were closed This could indicate one of the following • The exothermic specimen

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 14 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				did not ignite • The Exothermic Package thermostat failed closed • The relay K9 contacts failed to close • The EXOTHERMIC EXP HOT lt (L2) had a malfunction that prevented both bulbs from illuminating • The EXOTHERMIC SPECIMEN selector sw (S7) failed to make contact in the selected specimen number position • The EXOTHERMIC TRIGGER sw (S6) failed to make contact in the TRIGGER position • The EXOTHERMIC POWER sw (S15) failed to make contact in the ON position • The ELECTRON BEAM POWER sw (S3) failed to make contact in the OFF position
			• Floodlight does not illuminate --Refer to Contingency Plan O117A4	This would indicate one of the following

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 15 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				• The MAIN BATTERY cb (CB1) has tripped or failed open • The POWER CONTROL BATT cb (CB2) has failed open
			O117A4 Close the BATTERY DISCHARGE cb (CB6) Verify that the DISCHARGE lt (L8) illuminates Open the CB6 cb after this verification	
			• DISCHARGE lt (L8) illuminates --Refer to Contingency Plan O117A5	This would indicate that the POWER CONTROL BATT cb (CB2) has failed open
			• DISCHARGE lt (L8) does not illuminate --If the MAIN BATTERY cb (CB1) is open, refer to Contingency Plan O117A6 --If the MAIN BATTERY cb (CB1) is closed, refer to Contingency Plan O117A7	This would indicate that the CB1 cb has tripped or failed open
			O117A5 Recycle the POWER CONTROL BATT cb (CB2) and verify that the floodlight illuminates	
			• Floodlight illuminates --FLOOD LT sw (S19) - OFF --EXOTHERMIC TRIGGER sw (S6) - TRIGGER --Continue with experiment	This would indicate that the POWER CONTROL BATT cb (CB2) had failed open but closed when recycled When the EXOTHERMIC TRIGGER sw (S6) is placed in the TRIGGER position.

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 16 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
				this should apply power to the selected exothermic specimen and the EXOTHERMIC EXP HOT lt (L2) should illuminate within approximately 3 min
			• Floodlight does not illuminate --FLOOD LT sw (S19) - OFF --A decision will have to be made concerning whether or not to continue the experiment	This would indicate that the POWER CONTROL BATT cb (CB2) has failed open If this is true, power cannot be applied to the experiment A double failure would give this same indication If the timeline is on schedule, it is recommended that the experiment be continued just in case a double failure has occured and the exothermic specimens can still be ignited If the situation is such that another experiment using the MPF will be terminated because enough time is not available to perform the experiment, a decision can be made on whether or not to continue the M-552 Experiment
			O117A6 Close the MAIN BATTERY cb (CB1) and continue the experiment The floodlight should illuminate • FLOOD LT sw (S19) - OFF • Verify that the EXOTHERMIC EXP HOT lt (L2) illuminates within approximately 3 min after the EXOTHERMIC TRIGGER sw (S6) was placed in the TRIGGER position	If the floodlight does not illuminate, a more extensive analysis will have to be performed to determine the problem

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 17 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			--EXOTHERMIC EXP HOT lt (L2) illuminates --Continue with experiment	This would indicate that an exothermic specimen was ignited before the MAIN BATTERY cb (CB1) tripped
			--EXOTHERMIC EXP HOT lt (L2) does not illuminate --Refer to Contingency Plan O117A8	This would indicate that an exothermic specimen did not ignite before the MAIN BATTERY cb (CB1) tripped
			O117A7 Recycle the MAIN BATTERY cb (CB1) and verify that the floodlight illuminates	
			• Floodlight illuminates --FLOOD LT sw (S19) - OFF --EXOTHERMIC TRIGGER sw (S6) - TRIGGER --Continue with experiment	This would indicate that the MAIN BATTERY cb (CB1) had failed open but closed when recycled When the EXOTHERMIC TRIGGER sw (S6) is placed in the TRIGGER position, this should apply power to the selected exothermic specimen and the EXOTHERMIC EXP HOT lt (L2) should illuminate within approximately 3 min If the L2 lt does not illuminate, a more extensive analysis will have to be performed to determine the failure
			• Floodlight does not illuminate --FLOOD LT sw (S19) - OFF --A decision will have to be made concerning whether or not to continue the experiment	This would indicate that the MAIN BATTERY cb (CB1) has failed open If this is true, power cannot be applied to the experiment A double failure would give this same indication If the timeline is on schedule

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TABLE G-V. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 18 of 18)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions,corrections,results)
				it is recommended that the experiment be continued just in case a double failure has occured and the exothermic specimens can still be ignited If the situation is such that another experiment using the MPF will be terminated because enough time is not available to perform the experiment. a decision can then be made on whether or not to continue the M-552 Experiment
			O117A8 Place the EXOTHERMIC TRIGGER sw (S6) in the TRIGGER position and continue with experiment Monitor the MAIN BATTERY cb (CB1) for tripping The EXOTHERMIC EXP HOT lt (L2) should illuminate within approximately 3 min	If the MAIN BATTERY cb (CB1) trips or the EXOTHERMIC EXP HOT lt (L2) does not illuminate within 3 min after the EXOTHERMIC TRIGGER sw (S6) is placed in the TRIGGER position a more extensive analysis will have to be performed to determine the trouble

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TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 1 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
T 1 4	Verify INSTRUMENTATION PRESS gage (M5) reading is zero psia	T14A The INSTRUMENTATION PRESS gage (M5) reading is above zero psia.	T14A1 Tap the INSTRUMENTATION PRESS gage (M5) with finger	If the INSTRUMENTATION PRESS gage (M5) reading decreases to zero psia, the gage is hung.
			T14A2 Place the INSTRUMENTATION CSTR X3 sw (S1) in the CSTR X3 position and verify that the INSTRUMENTATION PRESS gage (M5) reading is 8 psia or above. After the verification, place the S1 sw in the work CHMBR position.	
			• INSTRUMENTATION PRESS GAGE (M5) reading is 8 psia or above --Continue the termination	This would indicate that the INSTRUMENTATION PRESS gage (M5) was operating properly and that the MPF had developed a pressure leak. The termination of the experiment can be continued but an MPF vacuum integrity check should be performed before using the MPF again. Refer to SEPEM, Appendix E, Table E-III, for a vacuum integrity check procedure
			• INSTRUMENTATION PRESS gage (M5) reading is below 8 psia. --Continue the termination.	This would indicate that the INSTRUMENTATION PRESS gage (M5) has malfunctioned. The termination of the experiment can be continued without the use of the M5 gage.
T 1.5	Bulkhead vent vlv - CLOSE.	T15A The bulkhead vent vlv will not close.	T15A1 Apply a greater amount of force than is normally required to close the bulkhead vent vlv.	If the bulkhead vent vlv will not close, this will result in loss of the 4-in. vacuum vent line vent redundancy. T

TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 2 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			T15A2 Continue the termination.	A decision will have to be made concerning whether or not to perform the other experiments using the MPF. If the decision is in favor of continuing the other experiments, loss of the 4-in. vacuum vent line vent vlv redundancy would not create a crew hazard.
T 1.6	Close the work chamber vent vlv.	T16A The work chamber vent vlv will not close.	T16A1 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 the 4-in. vacuum vent line vent vlv redundancy.
			T16A2 Continue the termination.	A decision will have to be made concerning whether or not to perform the other experiments using the MPF. If the decision is in favor of continuing the other experiments, loss of the 4-in. vacuum vent line vent vlv redundancy would not create a crew hazard.
T 1.7	CHAMBER REPRESS vlv - OPEN.	T17A The CHAMBER REPRESS *vlv will not open*	T17A1 Apply a greater amount of force *than is normally required* to close the CHAMBER REPRESS vlv.	The CHAMBER REPRESS vlv is used to repressurize the work chamber after it has been vented to space.
			T17A2 Perform the following	
			• Remove the vacuum cleaner housing assembly cap	This will allow the work chamber to repressurize through the vacuum cleaner housing assembly.
			• Wait until the work chamber and MDA pressure have equalized [INSTRUMENTATION PRESS gage (M5) reading is 5 psia].	T

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TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 3 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			• Replace the vacuum cleaner housing assembly cap. • Refer to Table III, Operation Step No. T 1.9 and continue the termination.	
T 1.8	Verify INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia.	T18A The INSTRUMENTATION PRESS gage (M5) reading remains at zero psia.	T18A1 Refer to Contingency Plans O14A1 through O14A9 to determine the cause of the failure.	
		T18B The INSTRUMENTATION PRESS gage (M5) reading is between 0 and 5 psia.	T18B1 Tap the INSTRUMENTATION PRESS gage (M5) with finger	If the INSTRUMENTATION PRESS gage (M5) reading increases to 5 psia, this would indicate the M5 gage is hung. If the M5 gage reading does not increase to 5 psia, this would indicate that the M5 gage has malfunctioned. Low pressure in the work chamber would also give this same indication but it is not being considered as feasible here because the CHAMBER REPRESS vlv is open.
			T18B2 Continue the termination when the work chamber and MDA pressure have equalized.	
T 1.12	Unlatch and open work chamber hatch.	T112A One or more Calfax fasteners or cam lock latches will not release.	T112A1 Apply a greater amount of force than is normally required to release the Calfax fasteners or cam lock latches. T112A2 A decision will have to be made concerning whether or not to use some tools to open the hatch and take a chance of damaging the MPF.	T

TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 4 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
T 1.13	CHAMBER REPRESS vlv - CLOSED.	T113A The CHAMBER REPRESS vlv will not close.	T113A1 Apply a greater amount of force than is normally required to close the CHAMBER REPRESS vlv. T113A2 Continue the termination.	If the CHAMBER REPRESS vlv will not close, the MPF cannot hold a vacuum.
T 1.14	Tighten the vent cap on the EXOTHERMIC SPECIMENS package.	T114A The cap will not tighten on the EXOTHERMIC SPECIMENS package.	T114A1 Leave the cap loose and continue the termination.	
T 1.15	Disconnect electrical cable from the zero-g connector in the work chamber.	T115A The electrical cable will not disconnect from the zero-g connector in the work chamber.	T115A1 Disconnect the electrical cable from the EXOTHERMIC SPECIMENS package and continue the termination.	The other experiments requiring power through the zero-g connector in the work chamber cannot be performed until the electrical cable is disconnected from the zero-g connector.
T 1 16	Remove the EXOTHERMIC SPECIMENS package from the work chamber and stow.	T116A One or both of the fasteners will not release to remove the EXOTHERMIC SPECIMENS package from the work chamber.	T116A1 Apply a greater amount of force than is normally required to release the fasteners. T116A2 Obtain appropriate tool to release fasteners and continue with termination.	
T 1.17	Remove the power cable from the EXOTHERMIC SPECIMENS package and stow.	T117A The power cable will not remove from the EXOTHERMIC SPECIMENS package.	T117A1 Apply a greater amount of force than is normally required to remove the power cable from the EXOTHERMIC SPECIMENS package. T117A2 Stow EXOTHERMIC SPECIMENS package with cable and continue the termination.	

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TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 5 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
T 1.18	Remove the dummy zero-g connector from the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector and place on the zero-g connector in the work chamber.	T118A The dummy zero-g connector will not remove from the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector.	T118A1 Apply a greater amount of force than is normally required to remove the dummy zero-g connector from the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector. T118A2 Continue the termination.	If the dummy zero-g connector cannot be removed from the FLAMMABILITY SPECIMEN HOLDER TEMPORARY STORAGE connector, it cannot be placed on the zero-g connector in the work chamber. Therefore, it would be possible for particles to enter the zero-g connector and could cause a poor contact for the other experiments requiring the use of the zero-g connector.
T 1.19	Close and latch the work chamber hatch.	T119A The work chamber hatch will not properly latch	T119A1 Latch the fasteners that will latch, and continue the termination.	Before the other experiments that use the MPF are performed, an MPF vacuum integrity check should be performed. The procedure for a vacuum integrity check in the SEPEM, Appendix E, Table E-III, uses the battery. If this procedure is used, the battery should not be discharged until after the vacuum integrity check has been completed.
T 1.22	Verify battery DISCHARGE lt (L8) illuminates.	T122A The battery DISCHARGE lt (L8) does not illuminate	T122A1 Recycle the BATTERY DISCHARGE cb (CB6) and verify that the battery DISCHARGE lt (L8) illuminates • Battery DISCHARGE lt (L8) illuminates --Continue the termination	This would indicate that the BATTERY DISCHARGE cb (CB6) had failed open but closed when recycled.

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TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 6 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			• Battery DISCHARGE lt (L8) does not illuminate. --Refer to Contingency Plan T122A2.	This would indicate one of the following • The BATTERY DISCHARGE cb (CB6) failed open • The MAIN BATTERY cb (CB1) has tripped or failed open.
			T122A2 Verify position of MAIN BATTERY cb (CB1).	
			• MAIN BATTERY cb (CB1) is open --Close the CB1 cb and continue the termination	This would indicate that the MAIN BATTERY cb (CB1) had tripped. When the CB1 cb is closed, the battery DISCHARGE lt (L8) should illuminate. If it does not illuminate, a more extensive analysis will have to be performed to determine the failure.
			• MAIN BATTERY cb (CB1) is closed. --Refer to Contingency Plan T122A3.	
			T122A3 Perform the following	
			• POWER CONTROL BATT cb - close	
			• FLOOD LT sw (S19) - BATT	
			• Verify that the floodlight illuminates	

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TABLE G-VI. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T) (Sheet 7 of 7)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
			• Floodlight illuminates --Place the FLOOD LT sw (S19) in the OFF position, open the POWER CONTROL BATT cb (CB2) and continue with the termination. A decision will have to be made concerning whether or not to try and discharge the battery by other means.	This would indicate that the BATTERY DISCHARGE cb (CB6) has failed open. This will not enable the battery to discharge through the discharge circuit. A decision will have to be made concerning whether or not to try and discharge the battery by other means. The photo lt and floodlight could be used to discharge the battery. Note that the floodlight is used to obtain data in Experiment M-479.
			• Floodlight does not illuminate --Refer to Contingency Plan T122A4.	This would indicate that the MAIN BATTERY cb (CB1) has failed open.
			T122A4 Recycle the MAIN BATTERY cb (CB1) and verify that the floodlight illuminates.	
			• Floodlight illuminates --FLOOD LT sw (S19) - OFF --POWER CONTROL BATT cb (CB2) - open --Continue the termination. The DISCHARGE lt (L8) should illuminate.	This would indicate that the MAIN BATTERY cb (CB1) had failed open but closed when recycled. If the battery DISCHARGE lt (L8) does not illuminate, a more extensive analysis will have to be performed to determine the problem.
			• Floodlight does not illuminate --Continue the termination.	This would indicate that the MAIN BATTERY cb (CB1) had failed open. If this is true, the battery could not be discharged.

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SECTION IX. EXPERIMENT M-552, EXOTHERMIC BRAZING MALFUNCTION ANALYSES

Refer to SEPEM, Appendix E, Section IX for the malfunction analyses for Experiment M-552.

SECTION X. CONCLUSIONS AND RECOMMENDATIONS

1. Experiment M-552 will be terminated if the battery fails.

2. The following valve failures will result in termination of Experiment M-552:

   - Bulkhead vent vlv fails closed
   - Work chamber vent vlv fails closed
   - CHAMBER REPRESS vlv fails open.

   If any one of these three failures occurs, a vacuum cannot be pulled on the work chamber.

3. The following switch failures will result in partial termination of Experiment M-552:

   - ELECTRON BEAM POWER sw (S3) fails on
   - EXOTHERMIC POWER sw (S15) fails off
   - EXOTHERMIC TRIGGER sw (S6) fails off.

   If one of these three failures occurs, power cannot be applied to SPECIMENS 1, 3, and 4.

   - EXOTHERMIC SPECIMEN selector sw (S7): If the S7 selector sw:
     --Fails off, only SPECIMEN 2 can be fired
     --Fails in position 2, only SPECIMEN 2 can be fired
     --Fails in positions 1, 3, or 4, SPECIMEN 2 and the number of the SPECIMEN that the S7 selector sw fails in can be fired.

   It was assumed for the above four switch failures that power could still be applied to SPECIMEN 2 by using a contingency procedure. The contingency procedure is:

   - Place the ELECTRON BEAM POWER sw (S3) in the ON position
   - Place the FIL CHMBR INTLK sw (S13) in the OVERRIDE position.

This will apply power to SPECIMEN 2.

If the EXOTHERMIC SPECIMEN selector sw (S7) should fail in position No. 2, the normal operating procedure would ignite SPECIMEN 2.

4. The following circuit breaker failures will result in termination of Experiment M-552:

   - MAIN BATTERY cb (CB1) fails open
   - POWER CONTROL BATT cb (CB2) fails open.

5. The following circuit breaker failures will result in the inability of the battery to discharge through the discharge circuit:

   - MAIN BATTERY cb (CB1) fails open
   - BATTERY DISCHARGE cb (CB6) fails open.

6. The following preflight test activities are recommended:

   - Determine if the vacuum cleaner port cover can be removed while the work chamber is in a vacuum condition. If the vacuum cleaner port cover can be removed, this will serve as a backup procedure to repressurize the work chamber if the CHAMBER REPRESS vlv fails closed. The analysis performed in this document assumed that this task could be accomplished.
   - Determine if SPECIMEN 2 can be ignited by performing the following:
     --MAIN BATTERY cb (CB1) - close
     --POWER CONTROL BATT cb (CB2) - close
     --ELECTRON BEAM POWER sw (S3) - ON
     -Note: Perform either one of the following steps:
     --FIL CHMBR INTLK sw (S13) - OVERRIDE
     --FILAMENT CHAMBER VENT vlv - OPEN
     When the FILAMENT CHAMBER VENT vlv is open, the FIL CHMBR INTERLOCK sw (S27) is closed. This would complete the electrical circuit to SPECIMEN 2 as would placing the FIL CHMBR INTLK sw (S13) in the OVERRIDE position.

The analysis performed in this document assumed that this task could be accomplished. The FIL CHMBR INTLK sw (S13) was used.

- Determine if the floodlight and/or photo light could be used to discharge the battery if the battery discharge circuit could not be used. If so, determine how long it would take to discharge the battery.

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