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SKYLAB EXPERIMENT PERFORMANCE EVALUATION MANUAL

Appendix F: Experiment M551 Metals Melting (MSFC)

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Prepared for

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16. ABSTRACT

This appendix contains a series of analyses for Experiment M551 Metals Melting (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 F. EXPERIMENT M-551, METALS MELTING (MSFC)

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

DEFINITION OF SYMBOLS

AM	Airlock Module
CCU	Crewman Communications Umbilical
DAC	Data Acquisition Camera
DRF	Data Request Forms
EBG	Electron Beam Gun
FBD	Functional Block Diagram
FO	Functional Objective
FPN	Flight Precedence Number
HOSC	Huntsville Operations Support Center
MDA	Multiple Docking Adapter
MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
P_f	Probability of failure
P_{f_t}	Total probability of failure
P_s	Probability of success

SECTION I.

EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 1 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number*	Remarks
	min	nom	max		
3.0 Analyze and predict Skylab Experiment M-551, Metals Melting, facet performance profile.				N/A	Refer to functional item 3.1.
3.1 Make explicit statements about objectives in qualitative and quantitative terms.				N/A	Refer to functional item 3.1.1.

*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 F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 2 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.1.1 Specify duration that the experiment is required to operate and provide useful information.				N/A	Experiment M-551 requires the use of the M-512 Materials Processing Facility for a total of 8 hr and 28 min, and requires a total crew time of 58 min, as follows.
		0 hr 9 min			• Preparation of the M-512 facility for Experiment M-551 and installation of M551 WELD SPECIMEN 1 in work chamber.
		0 hr 10 min			• Melting of M551 WELD SPECIMEN 1.
		2 hr 30 min*			• Cooldown time (to touch temperature - 105 °F) required by M551 WELD SPECIMEN 1. *
		0 hr 5 min			• Removal of M551 WELD SPECIMEN 1.
		0 hr 10 min			• Installation and melting of M551 WELD SPECIMEN 2
		2 hr 30 min*			• Cooldown time (to touch temperature) required by M551 WELD SPECIMEN 2.*
		0 hr 5 min			• Removal of M551 WELD SPECIMEN 2.
		0 hr 10 min			• Installation and melting of M551 WELD SPECIMEN 3.
		2 hr 30 min*			• Cooldown time (to touch temperature) required by M551 WELD SPECIMEN 3.*
		0 hr 5 min			• Removal of M551 WELD SPECIMEN 3.
		0 hr 4 min			• Reconfiguration of the M-512 facility.
		8 hr 28 min			Total M-512 facility time required.

*Crew not required during this time

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 3 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.1.1 (Concluded)		58 min			Total crew time required (8 hr 28 min - 7 hr 30 min = 58 min). Reference 1.
3.1.2 Specify the types of criteria that are to be maximized or minimized.		35% 35% 30%		N/A	The Functional Objectives (FO) for Experiment M-551, Metals Melting are: • FO-1 --Perform metals melting operations on the stainless steel disc, collect data and sample for return to earth. • FO-2 --Perform metals melting operations on the aluminum disc, collect data and sample for return to earth. • FO-3 --Perform metals melting operations on the tantalum disc, collect data and sample for return to earth. The basic objectives of Experiment M-551 are to study the behavior of molten metals in free fall at low acceleration levels, to characterize the structures formed in metals melted and rapidly solidified in free fall, and to test means of joining metals by electron beam welding in space. The experiment will contribute to the demonstration and evaluation of the merits of molten metal phenomena for manufacturing in a space environment and to the definition of applications of this science to future space programs and to industry. Reference 2.
3.1.3 Specify the percentage of acceptable max /min for each objective.					It is not considered desirable nor feasible to assign subjective weights to accomplishment of portions of each FO for Experiment M-551.
3.1.4 Specify experiment constraints: • Musts • Must Nots				N/A	• Musts --Experiment M-551 must be performed on SL-2 because it uses the M-512 facility battery, which has a limited lifetime. The battery has a minimum "wet stand" life of 90 days after activation (which occurs approximately 57 days prior to SL-1 launch).

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 4 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.1.4 (Concluded) • Wants • Don't Wants.					--The metals melting tasks associated with each of the three specimen discs must be continuous and uninterrupted, however, it is not mandatory that all three discs be processed in a continuous series. --Three vacuum cycles of the M-512 facility work chamber are required for the experiment (one cycle for each specimen disc). --A cooldown period (to touch temperature) of 2.5 hr min. is required for each specimen disc after processing. --Crew comments concerning Experiment M-551 operations are required. The comments will be voice recorded and pertinent observations will be entered in the appropriate section of the Multiple Docking Adapter (MDA) Data File. --The M-512 facility work chamber must be evacuated to a pressure no greater than 10^{-4}* torr for processing of each specimen disc. The experiment requires the use of the M-512 facility Electron Beam Gun (EBG), and the gun requires a vacuum to prevent oxidation and possible premature burnout of the filament. • Must Nots --N/A • Wants --It is desired to photograph the metals melting operations using the 16mm Data Acquisition Camera (DAC) set at 24 frames/sec and one 400-ft cassette of SO-168 color film (the cassette is shared with Experiment M-553, Sphere Forming). --The experiment should be performed and observed by one crewman. --The experiment should be performed in FO numerical sequence. • Don't Wants --All vehicle accelerations of any significant magnitude should be avoided during the performance of the experiment. Reference 2.
3.1.5 Specify experiment operational tolerances. • Musts				N/A	Refer to functional item 3.1.4.

*Reference 2 specifies a value of 10^{-5}, however the crew checklist (Reference 16) and the Flight Mission Rules specify a pressure no greater than 10^{-4} torr. It is expected that Reference 2 will be changed to agree with the latter two documents.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 5 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.1.5 (Concluded) • Must Nots • Wants • Don't Wants.					
3.2 Define decision rules and success criteria for the experiment objectives.				N/A	If the experiment is aborted, then the total 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, $P_s = 0.5 \rightarrow 0.9$ If the experiment is completed as scheduled, $P_s = 1.0$.
3.3 Specify experiment priority (numerical statement) for a given Skylab flight designation.				N/A	Reference 3 assigns Experiment M-551 to SL-2. Reference 4 revises the Flight Precedence Numbers (FPN's) assigned by Reference 3, and assigns an FPN of 190 to Experiment M-551. References 3 and 4.
3.4 Briefly describe and list the major subsystems for Experiment M-551.				N/A	Refer to functional items 3.4.1 and 3.4.2.
3.4.1 Describe the major functions.				N/A	The major functions of Experiment M-551 are: • To cut metal with an electron beam • To weld metal together using an electron beam. Solidification processes in metals are expected to behave differently in space under weightless conditions from what is observed under normal conditions of earth. In space, heat transport should be dominated by conduction and mass transfer should be dominated by diffusion, whereas, on earth both of these processes are heavily influenced by circulating convection currents in melts that contain temperature gradients. The electron beam welding task will investigate the behavior of metals that are melted and rapidly cooled under weightless conditons. An electron beam is used as a high density heat source to melt a bead around a disc-shaped rotating metal specimen. The electron beam will impinge on the specimen approximately 2.25 in. from the center of the specimen. Since the beam power will be about 1.6 kW and will focus on a spot about 0.06 in.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 6 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.4.1 (Concluded)					in diameter, the molten metal at the center of the track will be superheated. There will be a steep temperature gradient from the center to the edge of the molten metal pool. The points on the specimen disc under the electron beam will travel through the beam at a rate of approximately 36.8 in./min and the resultant radial acceleration of the molten metal will be about 3.8×10^{-4} g. As the specimen rotates, the melt left behind the beam will solidify very rapidly because the rest of the specimen will serve as a very effective heat sink. The melt is expected to be stirred vigorously in the beam by gas evolution and beam impingement forces, but outside the impingement area the melt should be quiescent. Motion pictures will be taken of the melting process, and the specimens, film, and written crew comments concerning the experiment will be returned to earth for analysis. Recorded crew observations about the experiment will also be valuable for postflight data analysis. References 5 and 6.
3.4.2 List the major components.				N/A	The only items of hardware peculiar to Experiment M-551 are the three metals melting discs: • M551 WELD SPECIMEN 1 (stainless steel) • M551 WELD SPECIMEN 2 (aluminum) • M551 WELD SPECIMEN 3 (tantalum). In addition to the M-551 hardware listed above, performance of the experiment requires the following M-512 facility and Skylab Operational Support hardware: • M-512 Facility --Work Chamber --Control Panel --Four-in. vent line and valves (supplied by MDA) --CHAMBER REPRESS Valve --EBG --Battery --M551 ELECTRON BEAM WELD MOTOR --M551 HATCH VIEW PORT MIRROR --M551 CAMERA MIRROR --M551 DEFLECTION MIRROR --M479 WATER SPRAY CONNECTION COVER --M512 FLOOD LIGHT SHIELD --Work Chamber Vent Filter No. 1

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 7 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.4.2 (Concluded)					--Work Chamber Camera Mount. • Skylab Operational Support Equipment --Vacuum Cleaner (use is optional. The vacuum cleaner may not be necessary) --16mm DAC, 100mm lens and extender, and right-angle mirror --One 400-ft cassette of SO-168 color film (shared with Experiment M-553) --Empty 16mm film cassette --Film Transport Assembly. A Functional Block Diagram (FBD) is submitted as Figure F-1, and is used as a subsystem component listing for Experiment M-551. Critical subsystem components will be identified and evaluated for failure, and correlated to possible interface problems among Experiment M-551 and the M-512 facility, the crew, and the carrier. References 6 and 7.
3.5 Specify the major interfaces among Experiment M-551, and the M-512 facility, the crew, and the carrier: • Physical --Mechanical --Electrical --Communications and Data --Support • Environmental --Natural and Induced --Contamination • Operational --Pointing and Control --Crew Safety --Sequence --Operability.				N/A	Experiment M-551 hardware has no physical interface directly with the carrier. An Interface Block Diagram is submitted as Figure F-2, and is used to define the interfaces for Experiment M-551.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 8 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1 Experiment M-551.				N/A	Refer to functional items 3.5.1.1 through 3.5.1.3.
3.5.1.1 Specify the total probability of failure (P_{f_t}) for M551 WELD SPECIMEN 1.		nil		IIIb	M551 WELD SPECIMEN 1 is a 6.500-in. diam disc of 321 CRES (Fe + 18 percent Cr and 9 percent Ni), 0.250 in. thick at the rim. The side of the disc on which the electron beam impinges is flat, but the other side is divided into quadrants of different thicknesses: 0.250 in., 0.125 in., 0.050 in., and 0.020 in. The various thicknesses of the disc allow the electron beam to melt and penetrate the disc in some areas, and prohibit the beam from passing through the disc in other (thicker) places. The disc has a tapered hole in the center for mounting the disc on the M551 ELECTRON BEAM WELD MOTOR (the center hole varies from 1.08 in. on the electron beam side to 1.17 in. on the motor side). Within a distance of 0.7 in. around the center hole on the motor side of the disc, the disc is 0.250 in. thick except for a slot 0.125-in. deep by 0.08-in. wide by 0.46-in. long that is used for aligning the disc to the motor. A 0.500-in. diam tungsten target is pressed into the disc on the 0.250-in. quadrant and is used for alignment and focusing of the electron beam prior to beginning the melting operations on the disc. The target contains cross lines inscribed on the electron beam side to aid in alignment and focusing of the beam. Approximately 3/4 of the distance around the disc from the target, in the direction that the metals melting will progress, there is a 0.5-in. long by 0.09-in. wide by 0.06-in. deep slot that indicates to the crewman where the electron beam should be turned off. Between the slot and the target there is a 0.25-in. diam by 0.06-in. deep depression that indicates the area where the disc should be stopped and the beam turned on and allowed to impinge on the disc for approximately 15 sec. No failure modes are considered probable or significant for the M551 WELD SPECIMEN 1 because of its structure and simplicity. Reference 8 and 9.
3.5.1.2 Specify the P_{f_t} for the M551 WELD SPECIMEN 2.		nil		IIIb	M551 WELD SPECIMEN 2 is identical to M551 WELD SPECIMEN 1 except that specimen 2 is made of aluminum alloy 2219 T87 (Al + 6.3 Cu, 2 percent Zr, 1 percent V, and 0.06 percent Ti in a fully hardened "T87" condition). The electron beam is allowed to impinge on the M551 WELD SPECIMEN 2 for 15 sec when the disc is stopped. No failure modes are considered probable or significant for the M551 WELD SPECIMEN 2 because of its structure and simplicity. References 8 and 9.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 9 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.3 Specify the Pf_t for the M551 WELD SPECIMEN 3.		nil		IIIb	M551 WELD SPECIMEN 3 is identical to M551 WELD SPECIMEN 1 except that specimen 3 is made of tantalum (per Aeronautical Material Specifications No. AMS 7849). The electron beam is allowed to impinge on the M551 WELD SPECIMEN 3 for 45 sec when the disc is stopped. No failure modes are considered probable or significant for the M551 WELD SPECIMEN 3 because of its structure and simplicity. References 8 and 9.
3.5.2 M-512 Facility.					Refer to functional items 3.5.2.1 through 3.5.2.14.
3.5.2.1 Vacuum Work Chamber.					Refer to Appendix E, functional items 3.5.3.1 through 3.5.3.4, and 3.5.3.7 through 3.5.3.9.
3.5.2.2 Electron Beam Gun.					Refer to Appendix E, functional item 3.5.2.
3.5.2.3 Vent Valves.					Refer to Appendix E, functional item 3.5.8.
3.5.2.4 Vent Lines.					Refer to Appendix E, functional item 3.5.9.
3.5.2.5 Specify the Pf_t for the camera mount.					Refer to Appendix E, functional item 3.5.10
3.5.2.6 Specify the Pf_t for the M551 ELECTRON BEAM WELD MOTOR.					Refer to Appendix E, functional item 3.5.11.1.
3.5.2.7 Specify the Pf_t for the M551 HATCH VIEW PORT MIRROR.					Refer to Appendix E, functional item 3.5.11.10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 10 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.8 Specify the P_{f_t} for the M551 CAMERA MIRROR.					Refer to Appendix E, functional item 3.5.11.9.
3.5.2.9 Specify the P_{f_t} for the M551 DEFLECTION MIRROR.					Refer to Appendix E, functional item 3.5.11.8.
3.5.2.10 Specify the P_{f_t} for the Work Chamber Vent Filter No. 1.					Refer to Appendix E, functional item 3.5.11.20.
3.5.2.11 Specify the P_{f_t} for the M512 FLOOD LIGHT SHIELD					Refer to Appendix E, functional item 3.5.11.3.
3.5.2.12 Specify the P_{f_t} for the M479 WATER SPRAY CONNECTION COVER.					Refer to Appendix E, functional item 3.5.11.12.
3.5.2.13 Specify the P_{f_t} for the Battery.					Refer to Appendix E, functional item 3.5.6.
3.5.2.14 Control Panel.					Refer to functional items 3.5.2.14.1 through 3.5.2.14.30.
3.5.2.14.1 Specify the P_{f_t} for the MAIN BATTERY circuit breaker CB1.		0.02			The MAIN BATTERY circuit breaker CB1 is a push-pull type that limits the current, from the M-512 facility battery to the control panel, to 100 A. The circuit breaker is located on the battery control panel above the battery case on the M-512 facility. When closed, MAIN BATTERY circuit breaker CB1 permits battery current to reach POWER CONTROL BATT circuit breaker CB2, POWER FIL BATT circuit breaker CB3, and BATTERY DISCHARGE circuit breaker CB6.
				IIIb	Failure of the MAIN BATTERY circuit breaker CB1 in the closed position would have no effect on Experiment M-551 provided another failure did not occur requiring CB1 to trip.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 11 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.1 (Concluded)				IIIa	Failure of the MAIN BATTERY circuit breaker CB1 in the open position would affect the following • Support --A loss of all electrical functions for Experiment M-551 would occur, resulting in a total loss of the experiment. Indication of failure of MAIN BATTERY circuit breaker CB1 is by astronaut observation of the following· • Failed closed --No indication. • Failed open --Circuit breaker cannot be pushed in until the white trip indicator cannot be seen. Nominal reset force required is 15 lb. --No electrical functions for Experiment M-551. References 10 and 11.
3.5.2.14.2 Specify the P_{f_t} for the POWER CONTROL BATT circuit breaker CB2.		0 02			The POWER CONTROL BATT circuit breaker CB2 is a push-pull type that is closed to supply current from MAIN BATTERY circuit breaker CB1 to ELECTRON BEAM POWER switch S3 and the FLOOD LT switch S19. POWER CONTROL BATT circuit breaker CB2 is a 5 A capacity breaker.
				IIIb	Failure of POWER CONTROL BATT circuit breaker CB2 in the closed position would have no effect on Experiment M-551 provided another failure did not occur requiring CB2 to trip.
				IIIa	Failure of the POWER CONTROL BATT circuit breaker CB2 in the open position would affect the following: • Support --A loss of all electrical functions for Experiment M-551 would occur, resulting in a total loss of the experiment. Indication of failure of POWER CONTROL BATT circuit breaker CB2 is by astronaut observation of the following·

TABLE F-1. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 12 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3 5.2.14.2 (Concluded)					• Failed closed --No indication. • Failed open --Circuit breaker cannot be pushed in until the white trip indicator cannot be seen. Nominal reset force required is 10 lb. --No electrical functions for Experiment M-551. References 10 and 11
3.5.2.14.3 Specify the Pf_t for the POWER FIL BATT circuit breaker CB3.		0.02			The POWER FIL BATT circuit breaker CB3 is a push-pull type that is closed to supply current from MAIN BATTERY circuit breaker CB1 to the FIL/BEAM CONT switch S12. Battery current from CB1 to CB3 passes through two 249 Ω, 25 W resistors in parallel that reduce battery voltage to the EBG filament for filament warmup. POWER FIL BATT circuit breaker CB3 is a 7.5 A capacity breaker.
				IIIb	Failure of POWER FIL BATT circuit breaker CB3 in the closed position would have no effect on Experiment M-551 provided another failure did not occur requiring CB3 to trip.
				IIIa	Failure of the POWER FIL BATT circuit breaker CB3 in the open position would affect the following: • Support --Power could not be supplied to the EBG filament current regulator. Neither low-voltage warmup of the filament nor high-voltage EBG operation could be accomplished, thus causing termination of Experiment M-551. Indication of failure of the POWER FIL BATT circuit breaker CB3 is by astronaut observation of the following: • Failed closed --No indication. • Failed open --Circuit breaker cannot be pushed in until the white trip indicator cannot be seen. Nominal reset force required is 10 lb.

TABLE F-1. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 13 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.3 (Concluded)					--EBG filament does not glow when CB3 as well as all other necessary switches and circuit breakers required to apply low voltage are in the proper configuration. References 10 and 11.
3.5.2.14.4 Specify the Pf_t for the INSTRUMENTATION CSTR X3 switch S1.		0.04			The INSTRUMENTATION CSTR X3 switch S1 is a single pole, double throw, three-position switch CSTR X3, OFF, and WORK CHMBR. The switch receives power from the Power Supply Module through the work chamber and EBG canister pressure transducers, and is used to activate the INSTRUMENTATION PRESS gage M5 to display work chamber or canister pressure.
				IIIb	Failure of the INSTRUMENTATION CSTR X3 switch S1 in the CSTR X3 position would not affect performance of Experiment M-551, since work chamber vacuum level could be displayed on FIL CHMBR PRESS gage M3. Some uncertainty would result concerning work chamber pressure status when the pressure was above 10^{-2} torr (the limit of FIL CHMBR PRESS gage M3).
				IIIa	Failure of the INSTRUMENTATION CSTR X3 switch S1 in the OFF or WORK CHMBR position would impact the following interface: • Support --The EBG canister pressure is required to be at least 24 psia (corresponds to a reading of 8 psia on INSTRUMENTATION PRESS gage M5) before the EBG can be operated, since a low canister pressure can allow arcing of EBG components. If INSTRUMENTATION CSTR X3 switch S1 failed in the OFF or WORK CHMBR position, EBG canister pressure status could not be determined, possibly causing termination of Experiment M-551. Indication of failure of the INSTRUMENTATION CSTR X3 switch S1 is by astronaut observation of the following: • Failed in CSTR X3 --When power is supplied to the Power Supply Module, the INSTRUMENTATION PRESS gage M5 reading is approximately 8 psia; even with the work chamber evacuated.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 14 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.4 (Concluded)					• Failed in OFF --When power is supplied to the Power Supply Module, INSTRUMENTATION PRESS gage fails to display work chamber or EBG canister pressure, but INSTRUMENTATION TEMP gage M4 operates normally. • Failed in WORK CHMBR --When power is supplied to the Power Supply Module, with INSTRUMENTATION CSTR X3 switch S1 in CSTR X3 and the work chamber vented to the MDA, the reading on INSTRUMENTATION PRESS gage M5 is approximately 5 psia. With the work chamber vented to space, the reading on gage M5 is 0 psia. (The reading in both cases should be approximately 8 on gage M5. This corresponds to EBG canister pressure of 24 psia).
3 5.2.14.5 Specify the Pf_t for the INSTRUMENTATION POWER switch S2.		0.08			The INSTRUMENTATION POWER switch S2 is a double pole, double throw, three-position switch: BATT, OFF, and AM BUS 1. Experiment M-551 does not use the AM BUS 1 position of the switch. When switch S2 is placed in the BATT position, contacts 2 and 3 are closed to allow power to reach the Power Supply Module for operation of the DAC, INSTRUMENTATION PRESS gage M5, and INSTRUMENTATION TEMP gage M4, contacts 5 and 6 are closed to provide a power ground for the Power Supply Module. Regulated battery power is supplied to the INSTRUMENTATION POWER switch S2 from the 28 ±2 Vdc regulator. The construction of the switch is such that either pole may fail open or closed in any position while allowing the other pole to function normally.
				IIIb	Failure of either pole of the INSTRUMENTATION POWER switch S2 in the BATT position would have no effect on Experiment M-551.
				IIIa	Failure of either pole of switch S2 in the OFF position would affect the following interfaces • Support --Same as INSTRUMENTATION CSTR X3 switch S1 failed in OFF or WORK CHMBR positions. Refer to functional item 3.5.2.14.4. • Operability --If it were determined to continue the experiment without the status of the EBG canister pressure, the DAC would have to be powered through another source, since power could not be supplied to the DAC through the control panel of the M-512 facility.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 15 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.5 (Continued)					• Communications and Data --Work chamber pressure and temperature status would be lost to the crewman. Failure of the INSTRUMENTATION POWER switch S2 in the AM BUS 1 position (either pole) should not occur during Experiment M-551 since the experiment does not use this position. However, if the failure occurred prior to performance of the experiment, the following could occur: • Operability --If pole 1-2-3 failed in the AM BUS 1 position, the DAC and INSTRUMENTATION section of the control panel could be powered from AM BUS 1 by closing POWER CONTROL AM BUS 1 circuit breaker CB4. If this were done, failure of INSTRUMENTATION POWER switch S2 in the AM BUS 1 position would have no effect on Experiment M-551. It is desirable, though, to ensure complete isolation of the M-512 facility battery power from the AM bus by using either battery or bus power, but not both simultaneously. This is to avoid the possibility of applying 20 kV to the AM Bus 1 return should a failure occur in the EBG system. If it were determined not to use bus power to operate the instrumentation and DAC, the effect of the failure of switch S2 in the AM BUS 1 position would be the same as its failure in the OFF position. --If pole 4-5-6 failed in the AM BUS 1 position, battery power could be grounded in the AM bus, since pole 1-2-3 would be free to make contact in the BATT position. This failure would be undetectable, and it is considered highly unlikely to occur. Indication of failure of the INSTRUMENTATION POWER switch S2 is by astronaut observation of the following: • Failed in BATT --(Either pole) No indication. • Failed in OFF --(Either pole) Neither the instrumentation nor the DAC operates when powered from either the BATT or AM BUS 1 position of the switch, but the FIL CHMBR PRESS gage M3 is operating (not reading "AT").

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 16 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.5 (Concluded)					• Failed in AM BUS 1 --(Pole 1-2-3) Instrumentation and DAC do not operate with switch S2 in the BATT position, but do operate when the POWER CONTROL AM BUS 1 circuit breaker CB4 is closed and switch S2 is placed in AM BUS 1. --(Pole 4-5-6) No indication. Reference 10.
3.5.2.14.6 Specify the P_{ft} for the ELECTRON BEAM POWER switch S3.		0.08		IIIb	The ELECTRON BEAM POWER switch S3 is a double pole, double throw two-position switch: ON and OFF. When switch S3 is placed in the ON position, contacts 2 and 3 are closed to provide unregulated battery power to the 28 ±2 Vdc regulator for activation of the EBG control circuitry. Contacts 5 and 6 are closed to provide a power ground to the negative terminal of the battery. The switch construction is such that either pole can fail in any position while allowing the other pole to function normally. Failure of the ELECTRON BEAM POWER switch S3 (either pole) in the ON position would have no effect on Experiment M-551, since the circuit would be broken by the opening of the other pole.
				IIIa	Failure of the ELECTRON BEAM POWER switch S3 in the OFF position (either pole) would have the following result. • Support --Experiment M-551 would be terminated since power could not be provided to the EBG. Indication of failure of the ELECTRON BEAM POWER switch S3 is by astronaut observation of the following: • Failed ON --No indication. • Failed OFF --No instrumentation or electron beam filament glow. --Floodlight illuminates when FLOOD LT switch S19 is placed in the BATT position. Reference 10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 17 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.7 Specify the Pf_t for the PHOTO LT switch S4		0.04			The PHOTO LT switch S4 is a single pole, single throw two-position switch· ON and OFF The switch receives battery power normally through the Filament Chamber Interlock microswitch S27 that closes when the FILAMENT CHAMBER VENT valve is opened. Alternatively, the PHOTO LT switch S4 can receive battery power independently of the position of the Filament Chamber Interlock switch S27 if the FIL CHMBR INTLK switch S13 is placed in the OVERRIDE position. When the PHOTO LT switch S4 is placed in the ON position, the bare filament photo light illuminates for photography of Experiment M-551 metals melting operations. Switch S4 is a lever-lock type with a spring-loaded lever that is locked when in the ON or OFF position. To move the switch from one position to the other, it is necessary to pull out on the switch lever.
				IIIb	Failure of the PHOTO LT switch S4 in the ON position would have no effect on Experiment M-551. The light can be turned on and off through the Filament Chamber Interlock microswitch S27.
				IIIb	Failure of the PHOTO LT switch S4 in the OFF position will affect the following interface· • Communications and Data --Loss of the bare filament photo light would reduce the light level in the work chamber and would degrade photography. The molten metal itself would provide a degree of illumination. (The work chamber floodlight would not aid photography appreciably and could degrade it further because of the arrangement of the work chamber mirror system. The specimen disc itself is between the floodlight and the electron beam.) Indication of failure of the PHOTO LT switch S4 is by astronaut observation of the following· • Fails ON --Photo light does not extinguish when the PHOTO LT switch S4 is placed in the OFF position. • Fails OFF --With battery power supplied to the 28 ±2 Vdc regulator and the FILAMENT CHAMBER VENT valve OPEN (or FIL CHMBR INTLK

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 18 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.7 (Concluded)					switch S13 in OVERRIDE position), the bare filament photo light does not illuminate when PHOTO LT switch S4 is placed in ON. Reference 10.
3.5.2.14.8 Specify the Pf_t for the FIL/BEAM CONT switch S12.		0.08			The FIL/BEAM CONT switch S12 is a double pole, single throw, two-position switch ON and OFF. When switch S12 is placed in the ON position, contacts 2 and 3 are closed to permit reduced battery voltage to be applied to the EBG filament current regulator (through the parallel set of relay contacts K1 1/3 and K1 4/6) for filament warmup and EBG operation. Pole 1-2-3 of switch S12 receives the reduced battery power through the POWER FIL BATT circuit breaker CB3. Pole 4-5-6 of the switch receives regulated battery power from the 28 ±2 Vdc regulator through the Filament Chamber Interlock microswitch S27. When switch S12 is placed in the ON position, contacts 5 and 6 are closed to provide regulated power to the HI VOLT/CAM switch S14, the 26 Vdc regulator, the EBG focus coil current regulator and the EBG deflection coil current regulator. The construction of the FIL/BEAM CONT switch S12 is such that either pole can fail in any position while allowing the other pole to operate normally.
				IIIb	Failure of the FIL/BEAM CONT switch S12 in the ON position would have the following effect: • Operability --(Pole 1-2-3) Low voltage would remain on the EBG filament when switch S12 was switched OFF. This would provide no impact on the experiment. Power could be removed from the filament and reapplied again through ELECTRON BEAM POWER switch S3 and POWER FIL BATT circuit breaker CB3. --(Pole 4-5-6) No effect on the experiment. Power would remain available to the HI VOLT/CAM switch S14 when switch S12 was switched OFF, but would be removed when the ELECTRON BEAM POWER switch S3 was placed in the OFF position.
				IIIa	Failure of the FIL/BEAM CONT switch S12 in the OFF position would affect the following interface • Support --(Pole 1-2-3) Power could not be supplied to the EBG filament current regulator. Neither low-voltage warmup of the filament nor high-voltage

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 19 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.1.14.8 (Concluded)					EBG operation could be accomplished, thus causing termination of the experiment. --(Pole 4-5-6) Power could not be supplied to the HI VOLT/CAM switch S14 for application of high voltage to the EBG filament. The experiment would be terminated. Indication of failure of the FIL/BEAM CONT switch S12 is by astronaut observation of the following • Failed ON --(Pole 1-2-3) EBG filament continues to glow after switch S12 is placed in the OFF position, but READY light L4 goes out. --(Pole 4-5-6) READY light L4 remains illuminated when switch S12 is placed in the OFF position, but the EBG filament glow disappears. • Failed OFF --(Pole 1-2-3) Low voltage cannot be applied to the EBG filament, as indicated by the absence of a filament glow. --(Pole 4-5-6) READY light L4 does not illuminate when HI VOLT/CAM switch S14 is placed in READY/RESET, but photo light does illuminate when PHOTO LT switch S4 is switched ON. Reference 10.
3.5.2.14.9 Specify the Pf_t for the FIL CHMBR INTLK switch S13.		0.04		N/A	The FIL CHMBR INTLK switch S13 is a single pole, single throw two-position switch: NORMAL and OVERRIDE. Power is provided to switch S13 from the 28 $\pm$ 2 Vdc regulator. The switch is left in the NORMAL position until an apparent failure of the Filament Chamber Interlock microswitch S27 has occurred. If switch S27 fails open, preventing the application of high voltage to the EBG filament, the FIL CHMBR INTLK switch S13 can be placed in the OVERRIDE position, thus bypassing switch S27. Because the FIL CHMBR INTLK switch S13 is required to function only in the event of another failure, its failure modes and indications of failure will not be discussed here. Reference 10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 20 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.10 Specify the P_{ft} for the HI VOLT/CAM switch S14.		0.08			The HI VOLT/CAM switch S14 is a double pole, double throw switch: ON, READY/RESET, and a neutral (center) unlabeled position. Power is supplied to switch S14 through pole 4-5-6 of the FIL/BEAM CONT switch S12. When switch S14 is placed in the READY/RESET position, switch contacts 4 and 5 are closed to arm the EBG high voltage control circuits by energizing relay K7. (Relay coil K7 closes contacts K7 4/6 to tie the high voltage control circuits to battery ground. Contacts K7 1/3 close to maintain relay K7 in an energized state when the HI VOLT/CAM switch S14 is returned to the neutral position.) The READY light L4 illuminates when switch S14 is placed in READY/RESET to indicate that the high voltage circuits are ready for application of high voltage to the EBG filament. The READY/RESET position is also used to turn off the electron beam by removing power from relay K3. When switch S14 is placed in the ON position, switch contacts 2 and 3 close to energize relay K8 and relay K3. (Relay K8 starts the DAC and extinguishes the READY light L4, relay K3 allows direct battery voltage to be applied to the EBG 2-kW inverter for activation of the electron beam.) The HI VOLT/CAM switch S14 is a lever-lock type of switch: the switch lever is spring-loaded and locked in the neutral position, and the lever must be pulled out to move it to the ON or READY/RESET position. Switch linkage prevents making both momentary contacts (ON and READY/RESET) simultaneously.
				IIIa	Failure of the HI VOLT/CAM switch S14 in the READY/RESET position would cause the following effect: • Support --High voltage could not be applied to the EBG, causing experiment termination.
				IIIa	Failure of the HI VOLT/CAM switch S14 in the neutral position would cause the following effect: • Support --Same as failed in READY/RESET.
				IIIb	Failure of switch S14 in the ON position would impact the following interface: • Communications and Data --Power could be removed from the HI VOLT/CAM switch S14 by placing either the ELECTRON BEAM POWER switch S3 or the FIL/BEAM CONT

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 21 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.10 (Concluded)					switch S12 in the OFF Position. This would deactivate relay K7, and there would be no way to reenergize it. Relay K7 must be energized before the EBG can be operated again, therefore, Experiment M-551 would have to be terminated. Depending on the number of specimen discs processed when this failure occurred, data from none, one, or two discs would be lost. Indication of failure of the HI VOLT/CAM switch S14 is by astronaut observation of the following • Failed in READY/RESET --READY light L4 does not go out, electron beam does not appear, and DAC does not operate when HI VOLT/CAM switch S14 is placed in ON. • Failed in the neutral position --READY light L4 does not illuminate when HI VOLT/CAM switch S14 is placed in READY/RESET, but photo light illuminates when PHOTO LT switch S4 is placed in ON. --Electron beam does not appear and DAC does not operate when HI VOLT/CAM switch S14 is placed in ON. • Failed in ON --Electron beam does not cut off, READY light L4 does not illuminate, and DAC continues to operate when HI VOLT/CAM switch is placed in READY/RESET. References 10 and 12.
3.5.2.14.11 Specify the P_{f_t} for the EXP ADV switch S16.		0.04		IIIb	The EXP ADV switch S16 is a three-position switch: AUTO, OFF, and MAN/RESET. Power is supplied to the switch through the Filament Chamber Interlock microswitch S27 (when the FILAMENT CHAMBER VENT valve is open) or through the FIL CHMBR INTLK switch S13 (in the OVERRIDE position). Experiment M-551 uses the AUTO position of the EXP ADV switch S16 to supply 10 Vdc (through the Motor Control Reguator) to the M551 ELECTRON BEAM WELD MOTOR for rotation of the specimen discs. Failure of the EXP ADV switch S16 in the OFF position would affect the following:

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 22 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3 5.2.14.11 (Concluded)					• Communications and Data --The specimen disc could not be rotated through the electron beam. Part of the experiment data is obtained by allowing the electron beam to impinge on a stationary spot on the disc, and this part of the data could be obtained.
				IIIb	Failure of the EXP ADV switch S16 in the AUTO position would have the following effect: • Communications and Data --The rotation of the disc could not be stopped to allow the electron beam to impinge on a stationary spot on the disc. This part of the experiment data would be lost. --Any discs to be processed after this failure occurred could not be held stationary while the electron beam was being focused and adjusted (if required). A poorly focused beam would cause loss of experiment data if the beam were not concentrated sufficiently to melt the specimen material. Indication of failure of the EXP ADV switch S16 is by astronaut observation of the following: • Failed OFF --Specimen disc does not rotate when EXP ADV switch S16 is placed in AUTO or MAN/RESET, but photo light illuminates when PHOTO LT switch S4 is placed in ON. • Failed in AUTO --Specimen disc continues to rotate when EXP ADV switch S16 is placed in OFF. Reference 10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 23 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.12 Specify the Pf_t for the Filament Chamber Interlock Switch S27		0.1			The Filament Chamber Interlock switch S27 is a microswitch that is operated by the FILAMENT CHAMBER VENT valve. The purpose of the microswitch is to prevent application of high voltage to the electron beam filament while the EBG filament chamber is separated from the work chamber by the FILAMENT CHAMBER VENT valve When the valve is closed, the Filament Chamber Interlock switch S27 is opened, and when the valve is opened, switch S27 is closed. Power is supplied to the switch from the 28 ±2 Vdc regulator, and when the switch is closed, the power is provided to the PHOTO LT switch S4, the EXP ADV switch S16, and pole 4-5-6 of the FIL/BEAM CONT switch S12.
				IIIb	Failure of the Filament Chamber Interlock switch S27 in the open position would have no effect on Experiment M-551 since redundancy is provided by the FIL CHMBR INTLK switch S13, which can be placed in the OVERRIDE position to bypass switch S27
				IIIb	Failure of switch S27 in the closed position would have no effect on the experiment, per se, because, to activate the electron beam the crewman would still have to perform the following operations • FIL/BEAM CONT switch S12 - ON • HI VOLT/CAM switch S14 - READY/RESET • HI VOLT/CAM switch S14 - ON. Indication of failure of the Filament Chamber Interlock switch S27 is by astronaut observation of the following: • Failed open --With the FILAMENT CHAMBER VENT valve open, the photo light does not illuminate when PHOTO LT switch S4 is placed in ON, and/or READY light L4 does not illuminate when HI VOLT/CAM switch S14 is placed in READY/RESET, both lights operate normally when FIL CHMBR INTLK switch S13 is placed in OVERRIDE. • Failed closed --With the FILAMENT CHAMBER VENT valve closed, the photo light illuminates when PHOTO LT switch S4 is placed in the ON position,

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 24 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.12 (Concluded)					and/or the READY light L4 illuminates when HI VOLT/CAM switch S4 is placed in READY/RESET. It is not likely that these indications will be observed by the crewman unless he is actively trying to verify the failure of the Filament Chamber Interlock switch S27. Reference 10.
3.5.2.14.13 Specify the P_{f_t} for relay K1.		0.05			Relay coil K1 is energized when the ELECTRON BEAM POWER switch S3 is placed in the ON position. The coil activates contacts K1 1/3 and K1 4/6, which are in parallel, to provide a path for low voltage battery current to reach the EBG filament current regulator when the FIL/BEAM CONT switch S12 is switched ON.	
				IIIa	Failure of relay K1 open would have the following effect: • Support --Current could not be supplied to the EBG filament, resulting in termination of Experiment M-551.	
				IIIa	Failure of relay K1 shorted would cause the following effect: • Support --Same as failed open. Indication of relay K1 failure is by astronaut observation of the following: • Failed open --When low voltage is applied normally to the electron beam filament, the filament does not glow; but the FIL CHMBR PRESS gage M3 operates normally. • Failed shorted --POWER CONTROL BATT circuit breaker CB2 may open when the ELECTRON BEAM POWER switch S3 is placed in the ON position. --No electrical functions for Experiment M-551. Reference 10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 25 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.14 Specify the P_{f_t} for relay K3		0.05			Relay coil K3 is energized when the HI VOLT/CAM switch S14 is placed in the ON position. Contacts K3 A1/A2 close to apply direct battery voltage to the EBG 2-kW inverter for activation of the electron beam. Contacts K3 B1/B2 close to maintain relay coil K3 in the energized state when HI VOLT/CAM switch S14 is returned to the neutral position.
				IIIa	Failure of relay K3 open would affect the following • Support --Inability to provide high voltage to the electron beam would cause experiment termination.
				IIIa	Failure of relay K3 shorted would impact the following interface: • Support --Same as failed open.
					Indication of failure of relay K3 is by astronaut observation of the following • Failed open --DAC starts and READY light L4 goes out, but electron beam does not appear when HI VOLT/CAM switch S14 is placed in the ON position. READY light L4 illuminates and DAC stops when switch S14 is returned to the neutral position. • Failed shorted --POWER CONTROL BATT circuit breaker CB2 may open when HI VOLT/CAM switch S14 is switched ON. --READY light L4 goes out, but DAC and electron beam do not start, when HI VOLT/CAM switch S14 is switched ON.
					Reference 10.
3.5.2.14.15 Specify the P_{f_t} for relay K7.		0.05			Relay coil K7 is energized when HI VOLT/CAM switch S14 is placed in the READY/RESET position. Contacts K7 4/6 close to tie the EBG high voltage control circuits to battery ground. Contacts K7 1/3 close to maintain relay coil K7 in an energized state after HI VOLT/CAM switch S14 is returned to the neutral position.
				IIIa	Failure of relay K7 open would have the following effect.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 26 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.15 (Concluded)					• Support --High voltage could not be applied to the EBG caused by lack of ground for relay K3. Experiment M-551 would be terminated.
				IIIa	Failure of relay K7 shorted would have the following effect: • Support --Same as failed open. Indication of failure of relay K7 is by astronaut observation of the following: • Failed open --READY light L4 does not illuminate when HI VOLT/CAM switch S14 is placed in the READY/RESET position, but the photo light illuminates when PHOTO LT switch S4 is placed in the ON position. --Electron beam and DAC do not start when HI VOLT/CAM switch is placed in the ON position. • Failed shorted --POWER CONTROL BATT circuit breaker CB2 may open when HI VOLT/CAM switch S14 is switched to READY/RESET. --Same as failed open. Reference 10.
3.5.2.14.16 Specify the P_{f_t} for relay K8.		0.05			Relay coil K8 is energized when the HI VOLT/CAM switch S14 is placed in the ON position. Contacts K8 1/2 open to extinguish READY light L4, and contacts K8 4/6 close to start the DAC.
				IIIb	Failure of relay K8 open would have the following effect: • Operability --DAC could not be controlled remotely through the M-512 facility control panel
				IIIa	Failure of relay K8 shorted would have the following effect

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 27 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14 16 (Concluded)					• Support --Inability to energize relay K3 to apply high voltage to the EBG filament would cause termination of the experiment. Indication of failure of relay K8 is by astronaut observation of the following • Failed open --DAC does not start and READY light L4 does not go out when HI VOLT/CAM switch S14 is switched ON, but the electron beam does appear. • Failed shorted --POWER CONTROL BATT circuit breaker CB2 may open when HI VOLT/CAM switch S14 is placed in the ON position. --READY light goes out, but DAC and electron beam do not start when HI VOLT/CAM switch S14 is switched ON. Reference 10.
3.5.2.14.17 Specify the Pf_t for the photo light.					The photo light is controlled through the PHOTO LT switch S4 on the M-512 facility control panel (see functional item 3.5.2.14.7). The light itself is located inside the work chamber above the electron beam port. For a description of the light and its Probability of failure (Pf), refer to Appendix E, functional item 3.5.3.7.
3.5.2.14.18 Specify the Pf_t for the READY light L4.		0.03			READY light L4 is illuminated when HI VOLT/CAM switch S14 is placed in the READY/RESET position, and remains illuminated until switch S14 is placed in the ON position. The light indicates to the crewman that the circuits are ready for high voltage to be applied to the EBG filament. The lens of the light is green, and the light itself is composed of two 28 Vdc high reliability bulbs wired in parallel.
				IIIb	If one of the bulbs were to burn out, one-half of the light illumination would be lost, but the light would still be functional. There would be no effect on Experiment M-551.
				IIIa	If one of the bulbs were to short, the following would occur: • Support --Relay K7 could not be energized to close contacts K7 4/6 to tie the high voltage control circuits to ground. This means that high voltage could not be supplied to the EBG filament, thereby causing experiment termination.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 28 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.18 (Concluded)					Indication of failure of the READY light L4 is by astronaut observation of the following • Failed open (one bulb burned out) --Reduced illumination of the light lens. • Failed shorted --POWER CONTROL BATT circuit breaker CB2 may open when HI VOLT/CAM switch S14 is switched to READY/RESET. --DAC and electron beam do not start when HI VOLT/CAM switch S14 is placed in the ON position, but photo light illuminates when PHOTO LT switch S4 is placed in the ON position. References 10 and 13.
3.5.2.14 19 Specify the P_{f_t} for the ELECTRON BEAM Voltage Gage M1.		0.03			The ELECTRON BEAM Voltage Gage M1 indicates the voltage output level of the EBG high voltage rectifier (voltage imposed on the EBG filament). The meter face is lighted, is graduated from 0 to 5 in increments of 1/4 (0, 1, 2, 3, 4, and 5 are marked on the meter face), and is labeled X 5KV. During normal operation of the EBG, the meter indicator reads approximately 4 (20 kV). The M-512 facility control panel face plate has a 0.093-in. wide tab, painted green, that extends over the face of gage M1 at the position of the 4. The tab indicates the normal position of the meter indicator during EBG operation.
				IIIb	Failure of the ELECTRON BEAM Voltage Gage M1 to display the proper voltage reading would have no effect on the experiment. As long as the electron beam could be produced, Experiment M-551 could be continued. The EBG incorporates a high voltage turnoff circuit to protect the EBG and the crewman from over-voltage on the EBG. Indication of failure of the ELECTRON BEAM Voltage Gage M1 is by astronaut observation of the following: • Gage voltage reading is less or more than 4, and electron beam functions normally. References 12, 14, and 15.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 29 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.20 Specify the Pf_t for the BEAM CUR gage M2.		0 03			The BEAM CUR gage M2 indicates the amount of electron beam current produced by the EBG filament The meter face is lighted, is graduated from 0 to 10 in increments of 1/2 (0, 2, 4, 6, 8, and 10 are marked on the meter face), and is labeled X10MA. During normal operation of the EBG for Experiment M-551, the meter indicator reads approximately 8 (80 mA).
				IIIb	Failure of the BEAM CUR gage M2 to display the proper current reading would have no effect on Experiment M-551. The crew checklist contains the BEAM CONTROL CUR ADJ potentiometer R32 setting required to produce the proper beam current. If sufficient beam current can be produced to melt the specimen discs, the experiment can be continued. Indication of failure of the BEAM CUR gage M2 is by astronaut observation of the following • Gage current reading is less than 8 (7 for specimen 3), but the beam melts the metal discs satisfactorily. (This is not necessarily an indication of failure).
3.5.2.14.21 Specify the Pf_t for the FIL CHMBR PRESS gage M3.		0.03			The FIL CHMBR PRESS gage M3 displays the pressure level in the EBG filament chamber. The gage is also used to give an indication of the M-512 facility work chamber pressure level when the work chamber is evacuated and the FILAMENT CHAMBER VENT valve is opened to expose the EBG filament chamber to the work chamber The meter face is lighted and contains the following unequally spaced major graduations· AT, 5, 3, 2, 1, 5, 1, and .01. The meter is labeled $X10^{-3}$ TORR. A red arc is painted on the meter face from AT to .5 (indicates undesirable pressure range for operation of the EBG), and a green arc extends from .5 to .01 (indicates the desirable pressure range). As the pressure decreases, the meter indicator moves from AT toward .01. The FIL CHMBR PRESS gage M3 is activated by a signal from the Vacuum Head through the Vacuum Module.
				IIIa	Failure of the FIL CHMBR PRESS gage M3 to display the proper pressure could impact the following· • Support --Verification of the required pressure level in the work chamber could not be made. Because Reference 2 requires a pressure no greater than 10^{-4}* torr before the EBG can be fired, inability to determine work chamber pressure (torr) could cause termination of Experiment M-551.

*See footnote on page F-10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 30 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.21 (Concluded)					Indication of failure of the FIL CHMBR PRESS gage M3 is by astronaut observation of the following • Gage displays a higher pressure than 10^{-4*} torr(i.e., the gage indicator is within the area circumscribed by the red arc) with the work chamber vent valve, the bulkhead vent valve, and the FILAMENT CHAMBER VENT valve open, and power supplied to the Vacuum Module. If an M-512 facility vacuum integrity check does not reveal a pressure leak, it may be assumed that the FIL CHMBR PRESS gage M3 has failed. References 2, 10, and 14.
3.5.2.14.22 Specify the Pf_t for the INSTRUMENTATION PRESS gage M5.		0.03			The INSTRUMENTATION PRESS gage M5 displays either work chamber or EBG canister pressure, depending on the position of the INSTRUMENTATION CSTR X3 switch S1. The gage is activated by the Power Supply Module through either the work chamber or EBG canister pressure transducer and switch S1. The meter face is lighted, is graduated from 0 to 15 in increments of 1 (0, 3, 6, 9, 12, and 15 are marked on the meter face), and is labeled PSIA. With the work chamber vented to MDA atmosphere, the gage, when activated, should read approximately 5. When the gage is activated to read EBG canister pressure, the indicator should point to 8 or above (8 corresponds to actual EBG canister pressure of 24 psia).
				IIIa	Failure of the INSTRUMENTATION PRESS gage M5 could result in the following: • Support --Because Reference 16 instructs the crewman not to operate the EBG with a canister pressure less than 24 psia (8 on the gage), and, because if gage M5 failed, the canister pressure could not be verified, Experiment M-551 could be terminated. • Sequence --If the decision was made to continue the experiment, the crewman would have to rely on a ground-generated timeline to allow enough time for the work chamber to vent before opening the FILAMENT CHAMBER VENT valve. This is to ensure that the work chamber pressure is sufficiently low so that the EBG filament would not be contaminated by MDA atmosphere.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 31 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2 14.22 (Concluded)					Indication of failure of the INSTRUMENTATION PRESS gage M5 is by astronaut observation of the following • With power provided to the Power Supply Module and the work chamber vented to the MDA, the INSTRUMENTATION PRESS gage M5 does not read approximately 5 psia when INSTRUMENTATION CSTR X3 switch S1 is placed in WORK CHMBR, gage M5 does not display approximately 8 psia when switch S1 is placed in the CSTR X3 position. To verify that the Power Supply module is receiving power, the INSTRUMENTATION TEMP gage M4 should be observed to be operating. References 6, 10, 14, and 16.
3.5.2.14.23 Specify the Pf_t for the BEAM CONTROL FOCUS ADJ potentiometer R31.		0.02		IIIa	The BEAM CONTROL FOCUS ADJ potentiometer R31 is used for focusing the electron beam on the metal disc. The potentiometer R31 requires three turns (1080°) for its maximum resistance of 2000 Ω. The resistance of potentiometer R31 controls the output of the EBG focus coil current regulator. Failure of the BEAM CONTROL FOCUS ADJ potentiometer R31 could have the following effect • Support --If the electron beam cannot be focused on the metal disc, sufficient heat may not be generated to melt the metal. The experiment would be terminated. Termination of the experiment because of this failure is considered unlikely because the potentiometer is set, during prelaunch activities, to a position that will produce an acceptable focus of the electron beam. During normal experiment operations, the potentiometer should require only a minor adjustment to obtain the optimum electron beam focus. Indication of failure of the BEAM CONTROL FOCUS ADJ potentiometer R31 is by astronaut observation of the following: • Rotation of the potentiometer knob has no effect on the electron beam focus. The focus point of the beam should move in a direction from the EBG port to the metal disc as the potentiometer knob is turned cw. References 10, 12, 17, 18, and 19.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 32 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2 14.24 Specify the P_{f_t} for the BEAM CONTROL CUR ADJ potentiometer R32.		0 02			The BEAM CONTROL CUR ADJ potentiometer R32 is used for adjusting the amount of electron beam current produced by the EBG filament. The potentiometer R32 requires three cw turns (1080°) for its maximum resistance of 2000 Ω. The resistance of potentiometer R32 controls the output of the EBG filament current regulator.
				IIIa	Failure of the BEAM CONTROL CUR ADJ potentiometer R32 could have the following effect: • Support --If sufficient electron beam current cannot be produced to melt the metal discs, Experiment M-551 will be terminated. Termination of the experiment because of this failure is considered unlikely because the potentiometer is set, during prelaunch activities, to a position that will produce an acceptable electron beam current. During normal experiment operations, the potentiometer should require only a minor adjustment to obtain the optimum electron beam current. Indication of failure of the BEAM CONTROL CUR ADJ potentiometer R32 is by astronaut observation of the following: • Rotation of the potentiometer knob has no effect on the electron beam current reading on BEAM CUR gage M2. References 10, 12, 17, 18, and 19.
3.5.2.14.25 Specify the P_{f_t} for the BEAM CONTROL ALIGN Y potentiometer R57.		0.02			The BEAM CONTROL ALIGN Y potentiometer R57 is used to deflect the electron beam focus point in the Y direction (using a conventional X-Y coordinate system) on the metal disc so as to position the focus point (in conjunction with the BEAM CONTROL ALIGN X potentiometer R58) on the disc tungsten target. The potentiometer requires 10 cw turns (3600°) for a maximum resistance of 1000 Ω. Regulated 26 Vdc power is provided to the potentiometer R57 from the 26 Vdc regulator, and the resistance of the potentiometer controls the amount of current flowing through the EBG Y-alignment adjustable deflection coil
				IIIb	Failure of the BEAM CONTROL ALIGN Y potentiometer R57 should have no effect on Experiment M-551. The EBG fixed deflection coils should prevent the electron beam from wandering off the metal disc, even if there is no control over the Y-alignment deflection coil. As long as the electron beam focus point remains on the disc, the experiment can be continued. The BEAM CONTROL ALIGN Y potentiometer

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 33 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.25 (Concluded)					R57 is set during prelaunch activities to a position such that orbital operations will require only a minor adjustment. Indication of failure of the BEAM CONTROL ALIGN Y potentiometer R57 is by astronaut observation of the following • Rotation of the potentiometer knob does not cause the electron beam to deflect. References 10, 12, 17, 18, and 19.
3.5.2.14.26 Specify the P_{f_t} for the BEAM CONTROL ALIGN X potentiometer R58.		0.02			The BEAM CONTROL ALIGN X potentiometer R58 is identical to the BEAM CONTROL ALIGN Y potentiometer R57, except that it controls the deflection of the electron beam in the X direction by varying the current flowing through the EBG X-alignment adjustable deflection coil. Refer to functional item 3.5.2.14.25 for failure effects and indications of failure. References 10, 12, 17, 18, and 19.
3.5.2.14.27 Specify the P_{f_t} for the 26-V regulator.		0.03			The 26-V regulator provides adjustable, but regulated, current (0 to 620 mA) to the EBG X- and Y-alignment adjustable deflection coils through the BEAM CONTROL ALIGN X potentiometer R58 and the BEAM CONTROL ALIGN Y potentiometer R57. The 26-V regulator receives a regulated input of 28 $\pm$2 Vdc from the 28 to 30 V regulator through the Filament Chamber Interlock microswitch S27 and pole 4-5-6 of the FIL/BEAM CONT switch S12.
				IIIb	Failure of the 26-V regulator to provide a regulated output to the EBG adjustable deflection coils could affect the following: • Communications and Data --Lack of a constant current through the EBG adjustable deflection coils could cause the electron beam to deflect erratically. The part of the experiment data that is obtained by permitting the beam to impinge on a stationary spot on the specimen disc could be lost or degraded.
				IIIa	Failure of the 26-V regulator to provide any output could cause the following result:

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 34 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.27 (Concluded)					• Support --If the electron beam deviated from the specimen disc, the experiment could be terminated. This is considered unlikely since the EBG fixed deflection coils should prevent the beam from deviating enough to miss the specimen disc. Indication of failure of the 26-V regulator is by astronaut observation of the following • Unregulated output --Electron beam may be observed to deviate intermittently (because of varying currents through the adjustable deflection coils). • No output --Rotation of BEAM CONTROL ALIGN X potentiometer R58 and BEAM CONTROL ALIGN Y potentiometer R57 have no effect on the electron beam deflection. References 10 and 12.
3.5.2.14.28 Specify the P_{ft} for the 26 to 30 V regulator.		0.05			The 26 to 30 V regulator receives unregulated 28 Vdc power from the M-512 facility battery through the ELECTRON BEAM POWER switch S3 and supplies a regulated output of 28 ±2 Vdc to the electron beam and instrumentation circuits.
				IIIa	Failure of the 26 to 30 V regulator to provide a regulated output could impact the following interface: • Support --If a steady electron beam could not be maintained, the experiment could be terminated. • Communications and Data --Fluctuating voltage to the DAC would change the DAC motor drive speed unpredictably and would degrade the experiment film data.
				IIIa	Failure of the 26 to 30 V regulator to provide any output would cause the following result • Support --All electrical functions for Experiment M-551 would be lost. The experiment would be terminated.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 35 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.28 (Concluded)					Indication of failure of the 26 to 30 V regulator is by astronaut observation of the following • Unregulated output --DAC motor speed may be unsteady (can be heard). --Electron beam may cut off after starting (if voltage drop is sufficient to allow relays to reset. Relays will reset at approximately 14 Vdc). References 10 and 12.
3.5.2 14.29 Specify the P_{f_t} for the Vacuum Module.		0.04			The Vacuum Module is an amplifier that receives an input signal from the Vacuum Head and provides an amplified output to the FIL CHMBR PRESS gage M3 for display. The Vacuum Module receives regulated 28 ±2 Vdc from the 26 to 30 V regulator.
				IIIa	Failure of the Vacuum Module to provide an accurate output to the FIL CHMBR PRESS gage M3 would have the following effect • Support --Reference 2 requires a pressure of 10^{-4}* torr in the work chamber/EBG filament chamber before permitting operation of the EBG. The only indication of satisfaction of this requirement is the FIL CHMBR PRESS gage M3, if the gage indicated a higher pressure than 10^{-4}* torr caused by an inaccurate input from the Vacuum Module, the experiment could be terminated.
				IIIa	Failure of the Vacuum Module to provide any output to the FIL CHMBR PRESS gage M3 could cause the following • Support --Experiment M-551 could be terminated because of the inability to verify the satisfaction of the 10^{-5} torr pressure requirement of Reference 2. • Sequence --If it were determined that the pressure sensing circuit had failed, and a decision was made to continue the experiment, the crewman would have to depend on a ground-generated timeline for a sufficient delay between evacuating the work chamber and opening the FILAMENT CHAMBER VENT valve, and operating the EBG to ensure that an acceptable pressure was obtained in the work chamber/EBG filament chamber. As long as the

*See footnote on page F-10.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 36 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.2.14.29 (Concluded)					EBG functioned properly, there would be no effect on the experiment. Indication of failure of the Vacuum Module is the same as indication of failure of the FIL CHMBR PRESS gage M3. Refer to functional item 3.5.2.14.21. References 2, 10, and 12.
3.5.2.14.30 Specify the Pf_t for the Vacuum Head.		0.04		IIIa	The Vacuum Head is an ion-detector vacuum gauge that senses the pressure in the EBG filament chamber and provides a signal to the Vacuum Module. Failure of the Vacuum Head to supply an accurate signal to the Vacuum Module would cause an inaccurate display of pressure on the FIL CHMBR PRESS gage M3. The effects of this failure and its indications are the same as for failure of the Vacuum Module. Refer to functional item 3.5.2.14.29. References 10 and 12.
3.5.3 Operational Support Equipment.					Operational Support Equipment is considered as that hardware provided in the cluster for general use by any experiment or cluster activity. Refer to functional items 3.5.3.1 and 3.5.3.2.
3.5 3 1 Photographic Equipment.					Refer to functional items 3.5.3.1.1 and 3.5.3.1.2.
3.5.3.1.1 Specify the Pf_t for the DAC.		0.04			The DAC used for Experiment M-551 is a 16mm camera that is mounted on the M-512 facility work chamber camera mount so as to view the metals melting operations through the work chamber camera port and the system of mirrors inside the chamber. (The camera requires a right-angle mirror attachment to the lens because when the camera is mounted, the lens faces parallel to the camera port.) The DAC receives M-512 facility battery power through the INSTRUMENTATION POWER switch S2, and is remotely controlled by the HI VOLT/CAM switch S14 on the M-512 facility control panel. A power and a remote control cable (a single Y-shaped cable with separate power and remote control connectors) is connected to the camera when it is mounted on the work chamber (The cable is pigtailed from the M-512 facility) The DAC can be set for the following frame rates: • 2 FPS • 6 FPS

TABLE F-1. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 37 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5.3.1.1. (Concluded)					• 12 FPS • 24 FPS • Time exposure and the following shutter speeds • 1/60 sec • 1/125 sec • 1/250 sec • 1/500 sec • 1/1000 sec. Photography of Experiment M-551 is performed using a frame rate setting of 24 FPS, and three different shutter speeds depending upon the particular specimen disc being processed. (Refer to Section VII for the shutter speeds.)
				IIIb	Failure of the DAC would cause no impact to Experiment M-551 since 11 other identical 16mm DAC's are planned for Skylab. One of these could be substituted for the failed DAC. Indication of failure of the DAC is by astronaut observation of the following: • Green power light on camera illuminates, but camera motor does not operate. • Camera film drive motor cannot be heard operating and power light does not glow. References 10, 12, 16, 20, 21, and 22.
3.5.3.1.2 Specify the P_{ft} for the SO-168 color film.		0.05			Experiment M-551 shares one 400-ft cassette of SO-168 color film with Experiment M-553. This film is basically a high speed ASA 160 film that is usually pushed to ASA 500 during processing. The film has a relatively high sensitivity to radiation, and radiation damage is made more noticeable by pushing.

TABLE F-I. EXPERIMENT M-551, METALS MELTING PRE-FLIGHT OPERATIONS EVALUATION ANALYSIS (Sheet 38 of 38)

Functional Block Number and Title	Expected Range and Dimension of Variables			Criticality Category Number	Remarks
	min	nom	max		
3.5 3.1.2 (Concluded)				IIIb	The primary failure mode of the film is radiation damage. During Experiment M-551 EBG operations, radiation is present from the EBG as well as from the ambient orbital environment, but since the work chamber camera viewport is made of 0.25-in. thick lead glass (radiation shielding effect of 0.0625 in. of lead), it provides a measure of radiation protection to the film. The film is stowed in the OWS Film Vault when not being used. Since the film for Experiment M-551 is to remain in orbit only 28 days, it is not considered likely that radiation damage will degrade the photographic data significantly, and in any case, the damage would not be detectable until the film was processed after the mission. References 2, 7, 23, and 24
3.5.3.2 Specify the Pf_t for the vacuum cleaner.		0.04			The vacuum cleaner is used to clean the interior of the work chamber after each specimen disc is processed, if the welding operations produce loose metal particles floating in the work chamber. The vacuum cleaner receives AM Bus power from any HI PWR ACCESS OUTLET (High Power Accessory Outlet--there are two of these in the MDA), and the vacuum cleaner hose is connected to the vacuum cleaner port on the work chamber.
				IIIb	If the vacuum cleaner should fail to operate, it would provide no impact to Experiment M-551 since the vacuum cleaner blower unit is identical to the blower units of the fecal/urine collector and the suit dryer, and one of these could be substituted for the failed unit. Indication of failure of the vacuum cleaner is by astronaut observation of the following: • With HI PWR ACC OUTLETS 1 and HI PWR ACC OUTLETS 2 circuit breakers on AM Panel 202 closed, vacuum cleaner does not operate from either outlet when the outlet switch is turned on, the vacuum cleaner circuit breaker is closed, and the vacuum cleaner power switch is placed in ON or MOM ON. Reference 25

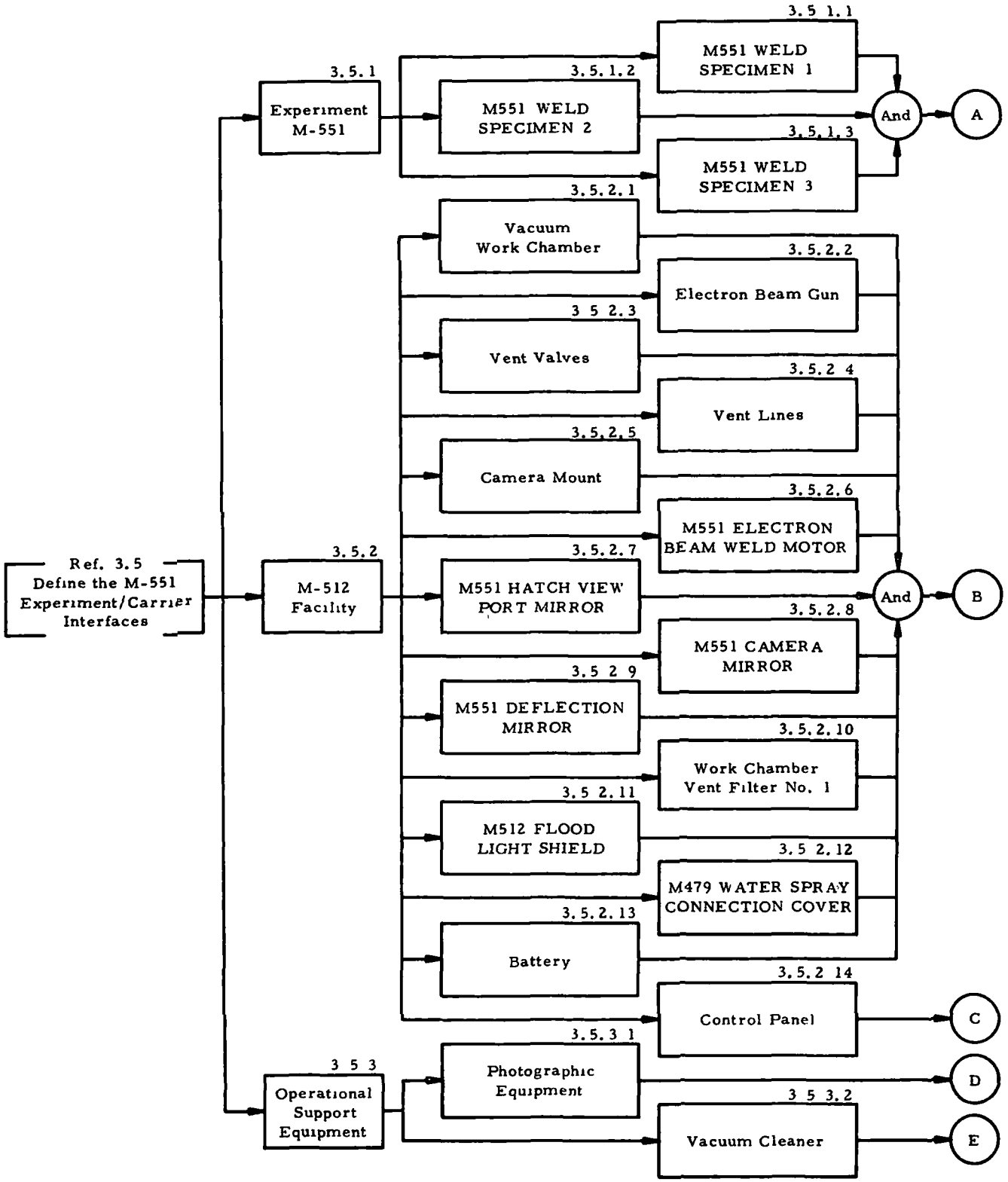


FIGURE F-1. EXPERIMENT M-551. METALS MELTING FUNCTIONAL BLOCK DIAGRAM (Sheet 1 of 3)

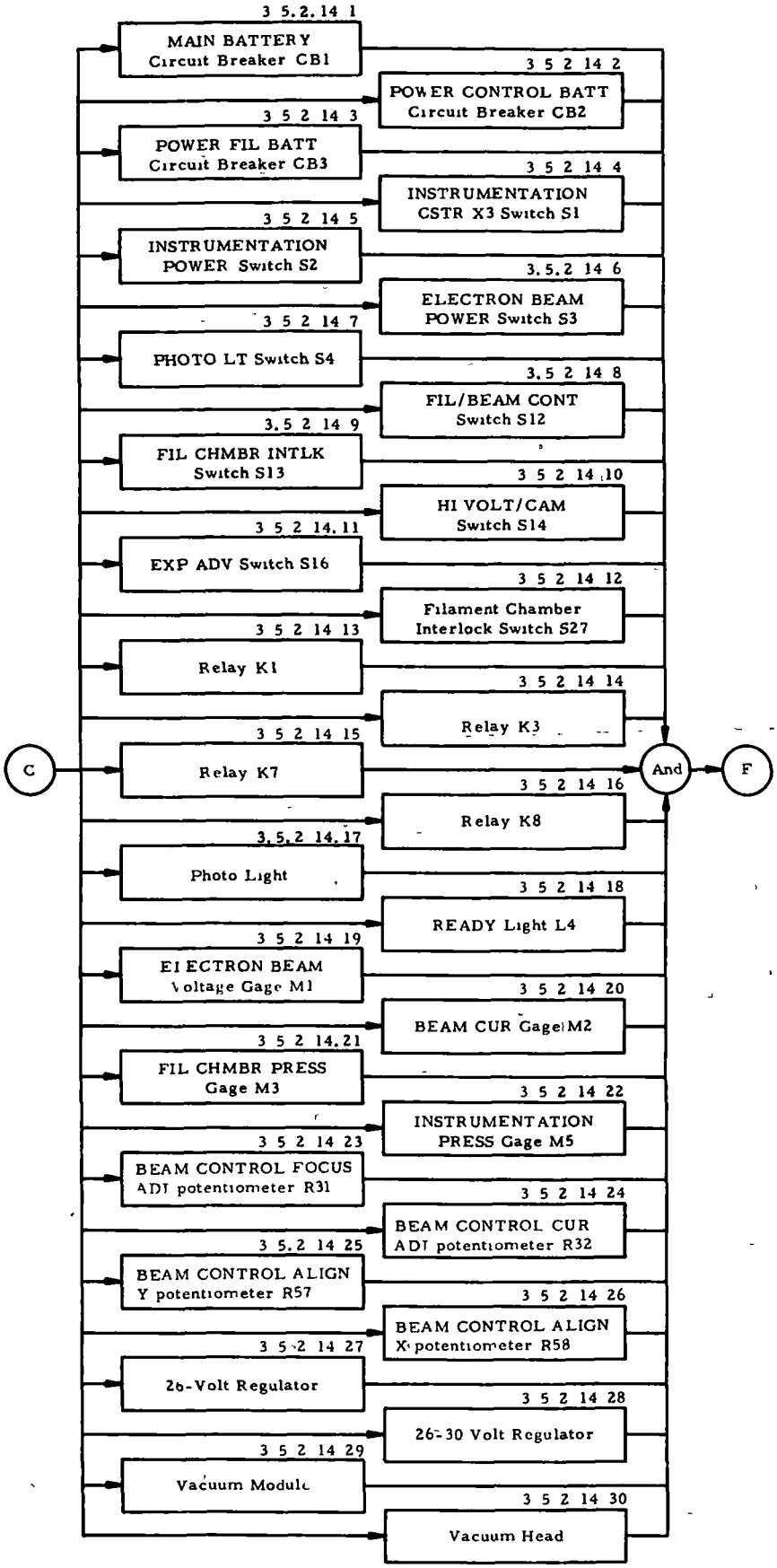


FIGURE F-1. EXPERIMENT M-551, METALS MELTING FUNCTIONAL BLOCK DIAGRAM (Sheet 2 of 3)

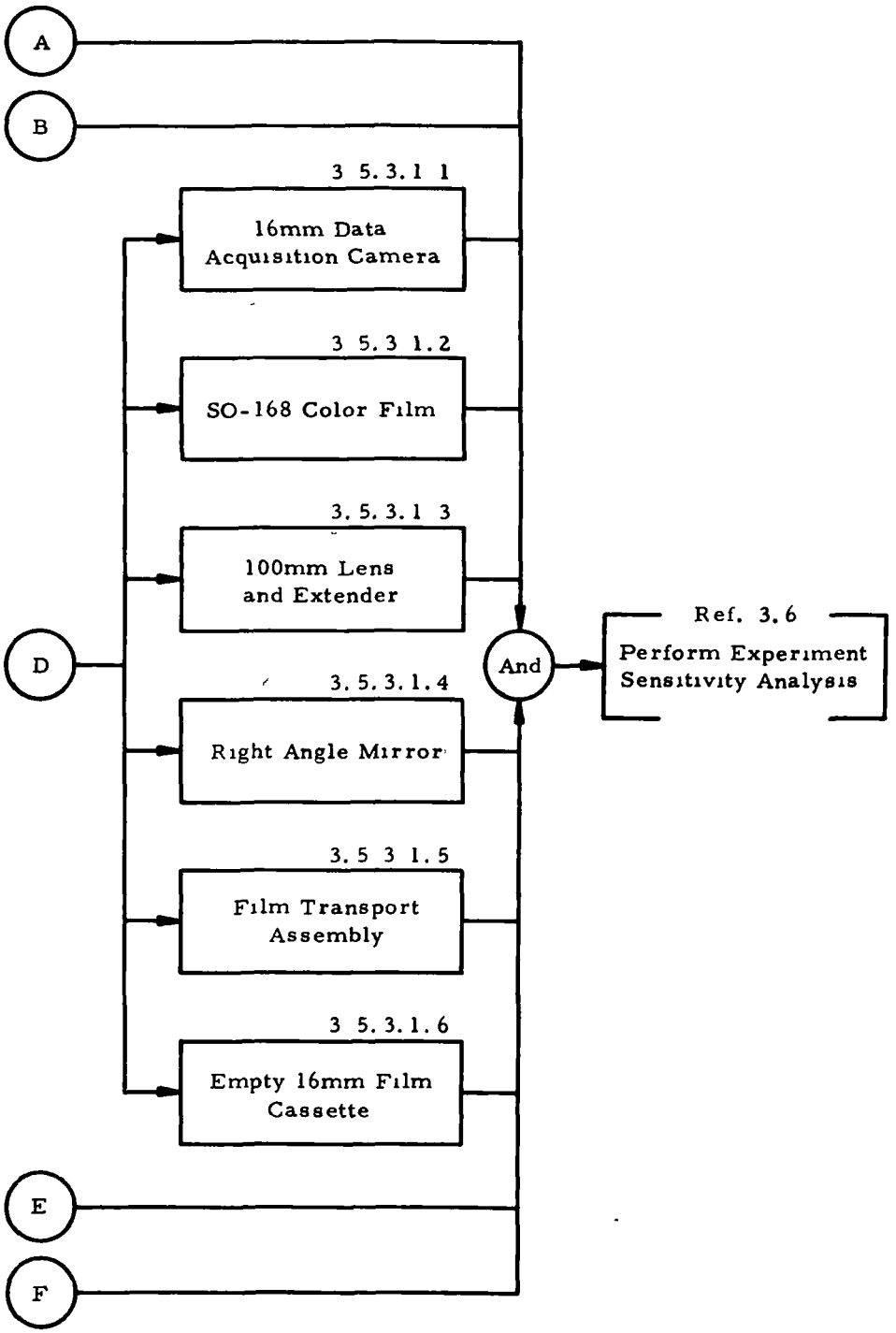
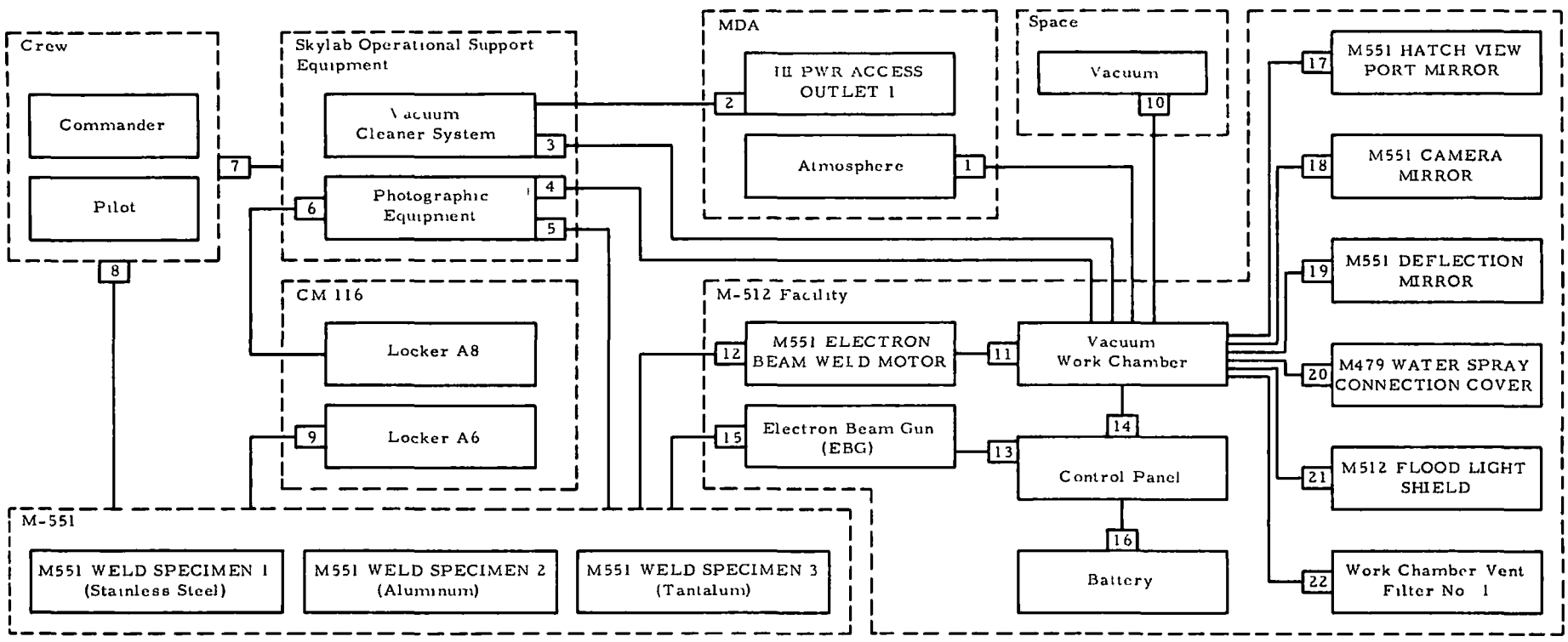


FIGURE F-1. EXPERIMENT M-551, METALS MELTING FUNCTIONAL BLOCK DIAGRAM (Sheet 3 of 3)

SECTION II.

EXPERIMENT M-551, METALS MELTING INTERFACE BLOCK DIAGRAM AND DEFINITION



Code	Measurement No	Remarks
1	Voice Comments	There is an environmental interface between the MDA atmosphere and the M-512 facility vacuum work chamber Experiment M-551 requires the chamber to be vented to space three times (once for each specimen disc), resulting in the loss of approximately 5 4 ft^3 of MDA atmosphere (approximately 1 8 ft^3 per vent)
2	Voice Comments M155-513	There is an electrical interface between the HI PWR ACCESS OUTLET 1, located on the MDA wall (panel 115), and the vacuum cleaner The vacuum cleaner is powered from HI PWR ACCESS OUTLET 1 [or may be powered from HI PWR ACCESS OUTLET 2 (panel 139)] during performance of Experiment M-551 The vacuum cleaner requires a nominal 109 2 W at 28 Vdc (Reference 26)
	Voice Comments	There is a mechanical interface between the HI PWR ACCESS OUTLET 1 and the vacuum cleaner The vacuum cleaner power cable is connected to the zero-g connector on the HI PWR ACCESS OUTLET 1 for operation of the vacuum cleaner in support of Experiment M-551
3	Voice Comments	There is a mechanical interface between the vacuum cleaner and the work chamber The vacuum cleaner hose is connected to the work chamber vacuum cleaner port to remove debris from the work chamber after each specimen disc is processed
4	Voice Comments	There is a mechanical interface between the photographic equipment (DAC) and the work chamber The DAC is mounted on the work chamber camera mount at detent position 1 for Experiment M-551
5	Voice Comments	There is a communications and data interface between the photographic equipment (DAC and SO-168 color film) and Experiment M-551 The film is used as a source of experiment data, motion pictures being made of the processing of each specimen disc
6	Voice Comments	There is a mechanical interface between the photographic equipment (film) and CM 116 Locker A8 The film is stowed in Locker A8 for return to earth
7	Voice Comments	There is an operational interface between the crew and the Skylab Operational Support Equipment The crew (Commander or Pilot) is required to set up and operate the vacuum cleaner system and the photographic equipment in support of Experiment M-551
8	Voice Comments	There is an operational interface between the crew and Experiment M-551 The Commander is required to process two specimen discs, and the Pilot is required to process one disc (Reference 1)
9	Voice Comments	There is a mechanical interface between CM 116 Locker A6 and Experiment M-551 The three specimen discs are stowed in Locker A6 for return to earth after processing
10	Voice Comments (onboard display - FIL CHMBR PRESS gage M3 on M-512 facility control panel)	There is an environmental interface between space vacuum and the work chamber Operation of the M-512 facility EBG in support of Experiment M-551 requires a max pressure of 10^{-4} torr (10^{-5} torr is desirable) in the work chamber
11	Voice Comments	There is an electrical interface between the work chamber and the M551 ELECTRON BEAM WELD MOTOR. The facility provides battery electrical power to the motor at connector J6 to rotate the specimen discs through the electron beam The motor requires a nominal 10 Vdc for operation of Experiment M-551 The electron beam is grounded through the motor to the work chamber heat sink adapter plate
	Voice Comments	There is a mechanical interface between the work chamber and the M551 POWER CABLE (considered a part of the M551 ELECTRON BEAM WELD MOTOR) The power cable zero-g connector (P22) is mechanically mated to the work chamber J6 receptacle for operation of Experiment M-551
12	Voice Comments	There is a mechanical interface between the M551 ELECTRON BEAM WELD MOTOR and Experiment M-551 Each specimen disc is mounted on the motor hub and secured by the hub latching mechanism for processing of the disc
	Voice Comments	There is an electrical interface between the M551 ELECTRON BEAM WELD MOTOR and Experiment M-551 The electron beam current is grounded from the specimen disc to the work chamber heat sink adapter plate through the motor hub, a flat copper spring on the motor that contacts the hub, and a lead wire from the spring to the motor base that is mounted on the heat sink adapter plate This grounding path is necessary to prevent a charge buildup on the specimen disc that would deflect the electron beam
13	Voice Comments (onboard display - ELECTRON BEAM voltage gage M1 and BEAM CUR gage M2 on the M-512 facility control panel)	There is an electrical interface between the M-512 facility control panel and the EBG The facility battery power is supplied to the EBG electronics through the control panel circuit breakers, switches, and relays for operation of the EBG for Experiment M-551
14	Voice Comments	There is an electrical interface between the M-512 facility control panel and the work chamber The switches and circuit breakers on the control panel distribute and control M-512 facility battery power to the work chamber J6 connector during Experiment M-551 operation The control panel also contains the necessary displays used to determine work chamber pressure and temperature status
15	Voice Comments (onboard display - BEAM CUR gage M2 on M-512 facility control panel)	There is an electrical interface between the EBG and Experiment M-551 The electron beam (nominally 80 mA) impinges on the specimen disc during processing of the specimen disc
16	Voice Comments	There is an electrical interface between the M-512 facility battery and the control panel. The battery electrical energy is provided to the control panel for distribution to the EBG electronics and to the work chamber J6 connector for Experiment M-551
17	Voice Comments	There is a mechanical interface between the M551 HATCH VIEW PORT MIRROR and the work chamber For operation of Experiment M-551, the mirror is attached to the inside of the work chamber hatch and is secured in place by three ball detents
18	Voice Comments	There is a mechanical interface between the M551 CAMERA MIRROR and the work chamber The mirror is attached to the interior of the work chamber over the camera port and is secured in place by three ball detents
19	Voice Comments	There is a mechanical interface between the M551 DEFLECTION MIRROR and the work chamber The mirror is attached to the interior of the work chamber above the EBG port and is secured in place with two Calfax fasteners
20	Voice Comments	There is a mechanical interface between the M479 WATER SPRAY CONNECTION COVER and the work chamber The cover is a quick-disconnect fitting that covers the connector for the M479 WATER SPRAY NOZZLES during performance of Experiment M-551
21	Voice Comments	There is a mechanical interface between the M512 FLOOD LIGHT SHIELD and the work chamber The shield is attached to the interior of the work chamber over the floodlight lens, and is secured in place by three ball detents
22	Voice Comments	There is a mechanical interface between work chamber vent filter no 1 (coarse filter) and the work chamber The filter is installed in the work chamber inside the 4-in vent line port, and is secured in place by three ball detents

FIGURE F-2. EXPERIMENT M-551, METALS MELTING INTERFACE BLOCK DIAGRAM AND DEFINITION

SECTION III.

EXPERIMENT M-551, METALS MELTING SYSTEMS DIAGRAM

8. See Reference 29.

7. See Reference 28.

6. Provides regulated gun filament current ≈15 to 17 A dc.

5. Gun filament is heated to approximately 2900 °K for electron emission.

4. Regulator provides constant current ≈46 mA to deflection coils.

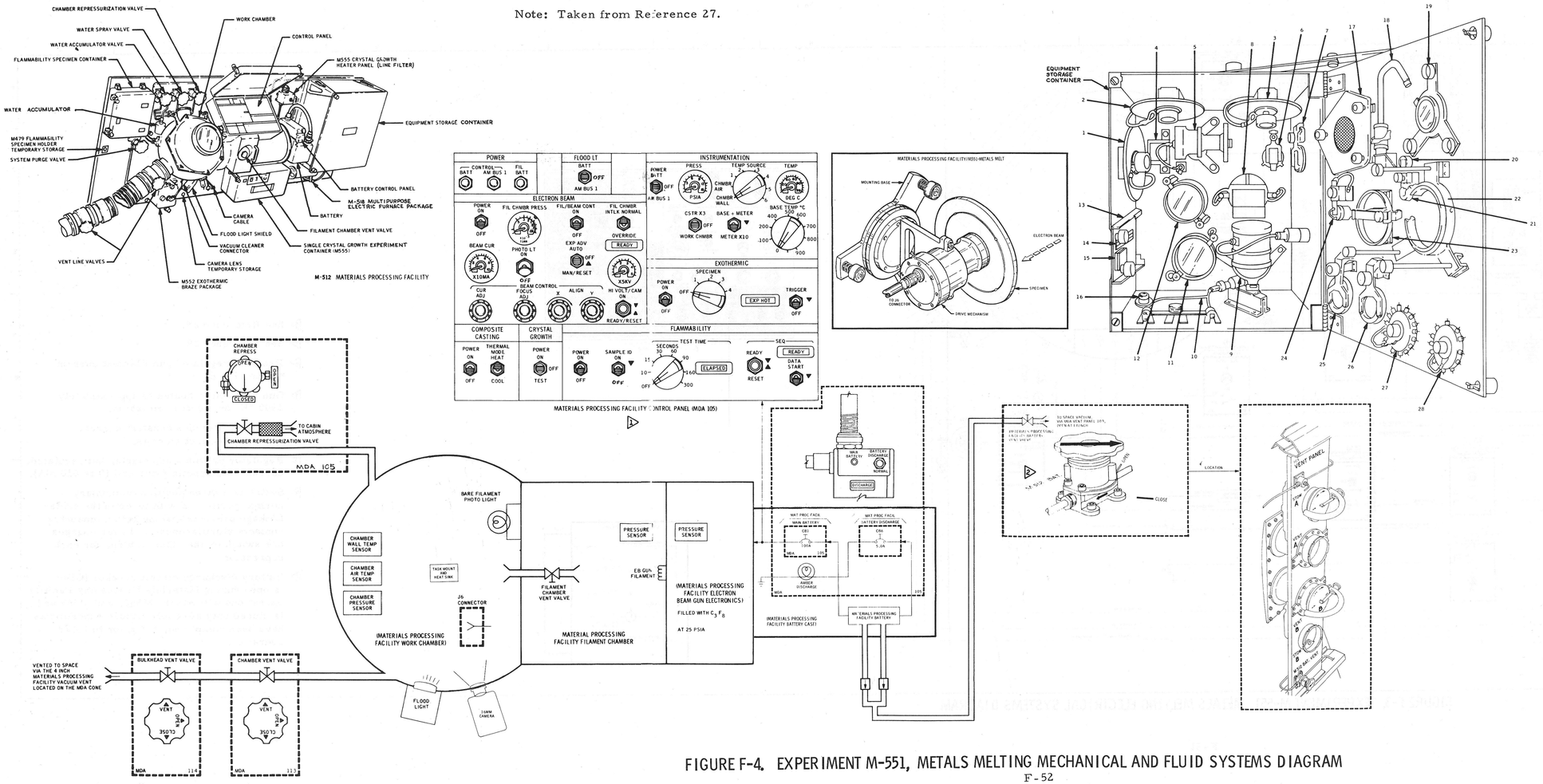
3. Regulator provides adjustable, but regulated, current to magnetic focus coil (0 to 620 mA).

2. Switch is a three position momentary--normal position is with lever in the center. Linkage prevents making both momentary contacts simultaneously. Lever engages one switch or the other in turn, for each depression.

1. Battery discharge circuit breaker (CB6) is open during Materials Processing Facility operations with M551, M552, and M553 and is closed only after all of those experiments have been completed, but prior to M479 operation.

FIGURE F-3. EXPERIMENT M-551, METALS MELTING ELECTRICAL SYSTEMS DIAGRAM

Note: Taken from Reference 27.



*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 for Experiment M-551 or installed in the M-512 facility work chamber during experiment performance.

▷ Until recently, the Materials Processing Facility was called M512, consequently much of its hardware is still labeled M512. The facility is no longer a formal experiment unto itself.

▷ All Materials Processing Facility associated switches, circuit breakers, lights, and valves are listed as being common to MDA Panel 105. The exceptions are the 4-in. vent valves and the battery vent valve. These are MDA hardware.

FIGURE F-4. EXPERIMENT M-551, METALS MELTING MECHANICAL AND FLUID SYSTEMS DIAGRAM

SECTION IV.

EXPERIMENT M-551, METALS MELTING DATA REQUIREMENTS SUMMARY

TABLE F-II. EXPERIMENT M-551, METALS MELTING DATA REQUIREMENTS SUMMARY

Measurement Name	Range and Dimension of Variables	Measurement Number	Telemetry Assignment Channel	Data Return	Data Time	Remarks
• Astronaut Voice Comments						
--Voice loop	N/A	N/A	N/A	Intermittent	Real	GOSS loop
--Voice Transcripts	N/A	N/A	N/A	N/A	All	
--Crew debriefing transcripts	N/A	N/A	N/A	N/A	All	
• Crew Log	N/A	N/A	N/A	N/A	All	

SECTION V. EXPERIMENT M-551, METALS MELTING DATA REQUEST FORMS

The data required for evaluation of Experiment M-551 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-551 is not necessary.

SECTION VI. EXPERIMENT M-551, METALS MELTING ENGINEERING CHANGE REQUEST

The Engineering Change Request is placed in this appendix as a matter of record. 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
- [ ] LVDSE
- [ ] 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
- [ ] E S
- [ ] PRODUCT IMPROVEMENT
- [ ] IN PROCESS TEST
- [ ] BREADBOARD
- [ ] PROPULSION
- [ ] STRUCTURES
- [ ] TEST SCHEDULES
- [ ] CRITICAL COMPONENTS
- [ ] STOWAGE
- [ ] REDLINES
- [ ] TEST RQMTS, SPECS & CRITERIA ECC
- [ ] VEH. WEIGHTS
- [ ] SPARES
- [ ] SPACECRAFT
- [ ] LAUNCH COMPLEX
- [ ] CREW SYSTEMS
- [ ] MISSION OPERATIO

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

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

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

MSC Form 2127 (Rev September 1971)

EFFECT OF NONINCORPORATION

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

SCOPE OF WORK ☐ SEE ATTACHED SKETCH AND/OR DESCRIPTION

ADDITIONAL REMARKS AND DISTRIBUTION

CONCURRENCE

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

APPROVAL

LAB SYSTEM ENGR DIV	DATE	PRODUCTS OFFICE	DATE	CEN. SYSTEM ENG'R.	DATE
LAB PROJECT OFFICE	DATE				

SECTION VII.

EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE

TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 1 of 14)

Assignments

Mission

- SL-1/SL-2

Orbital Assembly

- MDA (M-512 facility)

Carrier

- Launch
  --MDA [specimen discs are stowed in the M-512 facility EQUIPMENT STORAGE CONTAINER, film is stowed in the Orbital Workshop (OWS) film vault]
- Return
  --CM 116 (specimen discs are stowed in Locker A6, film is stowed in Locker A8)

Conditions

Crew

- One crewman is required to prepare, operate, and terminate the experiment

Experiment

- The experiment requires operation in space vacuum (inside the M-512 facility work chamber) using the M-512 facility EBG The experiment must be performed on SL-1/SL-2 (desirably before Experiment M-552) and prior to expiration of the lifetime of the M-512 facility battery (the battery should last until the end of SL-1/SL-2, if not intentionally discharged)
- The experiment specimen discs should be processed in FO numerical order
- Photography of the experiment operations is required using the 16mm DAC and SO-168 color film (one 400-ft cassette of film is shared with Experiment M-553)

Ground Support

- Prelaunch The experiment specimen discs and all required accessory equipment must be installed in the M-512 facility EQUIPMENT STORAGE CONTAINER for launch
- Flight N/A
- Post-Flight No nonstandard facilities are required for recovery of the specimen discs and film

Requirements

Functional Objectives

- FO-1 Perform metals melting operations on the stainless steel disc, collect data and sample for return to earth
- FO-2 Perform metals melting operations on the aluminum disc, collect data and sample for return to earth
- FO-3 Perform metals melting operations on the tantalum disc, collect data and sample for return to earth

Experiment Evaluation Team - Key Personnel Locator

Name	Responsibility	Office Address, Symbol, and Telephone Number
Mr R Poorman	Principal Investigator (PI)	MSFC, Bldg 4612, S&E-ASTN-MM, 205-453-5510
Mr. P G Parks	Experiment Developer (ED)	MSFC, Bldg 4711, S&E-PE-MW, 205-453-2363
Mr. E O Walker	MSFC Experiment Manager (EM)	MSFC, Bldg 4201, PM-SL-DP, 205-453-3183
Mr A. W. Bearskin	S&E Integration Engineer (IE)	MSFC, Bldg 4610, S&E-ASTN-SDI, 205-453-3811
Mr P. G Parks	S&E Experiment Engineer (EE)	MSFC, Bldg 4711, S&E-PE-MW, 205-453-2363
Mr W R Bock	Technical Discipline Manager (TDM)	MSFC, Bldg 4610, S&E-ASTN-SDF, 205-453-3810
Mr M S Byers Mr O H Thomas, Jr	Experiment Operations Engineer (EOE)	Teledyne Brown Engineering Company, Huntsville, Alabama, 205-532-1612
Mr S Buzzard	Experiment Integration Engineer (EIE)	Martin Marietta Corporation, Denver, Colorado, 303-794-5211, ext 5451
Mr. C Gruby	Experiment Flight Controller (EFC)	MSC/FC-4, Houston, Texas, 713-483-4717

TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 2 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P-60 min GMT 1200 Mission Day 138, SL-1/ SL-2		Experiment Evaluation Team manned and available. Contact Experiment M-551 Technical Discipline Manager, S&E-ASTN-SD HOSC Telephone No. 205-453-2200, ext. 311, Astronautics Laboratory Telephone No 205-453-3810. Reference Skylab Flight Plan SL-1/SL-2, Summary Timeline, MSC-0362S, latest revision, and MDA Experiment Checklist and Log, MSC, latest revision.				
GMT 1300 Mission Day 138, SL-1/ SL-2	TP	Commence Experiment Preparation.				
P 1.0		M-512 Facility Verification. Refer to Appendix E, Table E-III.				
P 2 0		M-512 Facility Integrity Check Refer to Appendix E, Table E-III.				
P 3 0		Experiment Preparation.				
P 3 1		Obtain and install M-512 foot restraint and don triangle shoes.				Foot restraint stowage:M127.
P 3.2		Open control panel cover				
P 3.3		Obtain checklist, logbook, and clipboard and attach to control panel cover.				Checklist stowage: M126 Logbook stowage: M126 Clipboard stowage: M126
P 3.4		Obtain the following equipment from OWS stowage lockers or last usage location • 16mm DAC • 100mm lens with extender				 DAC stowage: F527 Lens stowage: F527

*P - Preparation
O - Operations
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 F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 3 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 3.4 (Concluded)		• Right-angle mirror for 100mm lens • Film transport assembly per PHOTO PAD				Mirror stowage· F527 X-port assy. stowage· F510 and F523
P 3.5		Assemble lens and mirror.			P35A1	
P 3.6		Install lens assembly on DAC.			P36A1	
P 3.7		Remove DAC remote control connector dust cover.			P37A1	
P 3.8		Install DAC on work chamber camera mount.			P38A1	
P 3 9		Connect M-512 facility power and remote control cables to DAC.			P39A1	
		Note· DAC power and remote control cables are connected to dummy connectors on the M-512 facility for launch and stowage. The cables are actually a single Y-shaped cable.				
P 3.10		Install film transport assembly on DAC.				
P 3.11		Move DAC to position (detent) 1.			P38A1 P38A2 P38A3	
P 3.12		Verify DAC and lens for the following • 24 FPS • f/5.8, shutter 1/500 (for M551 WELD SPECIMEN 1) • f/5.6, shutter 1/500 (for M551 WELD SPECIMEN 2) • f/32, shutter 1/500 (for M551 WELD SPECIMEN 3).			P312A1	Do not turn 100mm lens f-stop ring past the index mark for f32. If the f32 mark is passed, the lens will close.
P 3.13		cb MAIN BATTERY (CB1) - close				
P 3.14		cb POWER CONTROL BATT (CB2) - close.				

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 4 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 3.15		cb POWER FIL BATT (CB3) - close.				
P 3 16		ELECTRON BEAM POWER (S3) - ON.			P316A1	
P 3.17		INSTRUMENTATION POWER (S2) - BATT.			P317A1	
P 3.18		Test operation of the DAC by pressing operate button on DAC.			P318A1 P318B1	
P 3 19		INSTRUMENTATION POWER (S2) - OFF.				
P 3.20		ELECTRON BEAM POWER (S3) - OFF.				
P 3.21		CHAMBER REPRESS vlv - OPEN.			P321A1	
P 3.22		Open work chamber hatch.				
P 3.23		Remove dummy zero-g connector from work chamber power connector and stow on FLAMMABILITY SPECIMEN HOLDER TEMPORARY STOWAGE.				
P 3.24		CHAMBER REPRESS vlv - CLOSED.			P324A1	
		Note: The equipment listed in Operation Step Nos. P 3.25 through P 3.29 is stowed in the EQUIPMENT STORAGE CONTAINER on the M-512 facility.				
P 3.25		Install work chamber vent filter No. 1 in the 4-in. vent line.			P325A1	
P 3.26		Install the M551 DEFLECTION MIRROR in the work chamber over the EBG port.			P326A1 P326B1	
P 3.27		Install the M551 CAMERA MIRROR in the work chamber over the camera viewport.			P327A1 P327B1	

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 5 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
P 3.28		Install the M512 FLOOD LIGHT SHIELD in the work chamber over the floodlight lens.			P328A1 P328B1	
P 3.29		Install the M551 HATCH VIEW PORT MIRROR over the work chamber hatch viewport surface inside the work chamber.			P329A1 P329B1	
P 3.30		Remove the M551 ELECTRON BEAM WELD MOTOR from the EQUIPMENT STORAGE CONTAINER and mount on M479 flammability specimen container.				
P 3.31		Remove the M551 WELD SPECIMEN 1 from the EQUIPMENT STORAGE CONTAINER and install on the M551 ELECTRON BEAM WELD MOTOR.				
P 3.32		Remove the M551 ELECTRON BEAM WELD MOTOR from the M479 flammability specimen container and install in the work chamber.			P332A1	
P 3.33		Connect the M551 ELECTRON BEAM WELD MOTOR power cable to the work chamber zero-g power receptacle.			P333A1	
P 3.34		Close and latch work chamber hatch.			P334A1	
P 3.35		Obtain lightweight headset and Crewman Communications Umbilical (CCU). Set up Speaker Intercom Assembly (SIA) to record voice data.				Headset stowage· M157 CCU stowage. M124

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 6 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.0	TP	Experiment Operation.				
O 1.1		ELECTRON BEAM POWER (S3) - ON			P316A1	
O 1.2		INSTRUMENTATION POWER (S2) - BATT.			P317A1	
O 1.3		INSTRUMENTATION CSTR X3 (S1) - CSTR X3 (Verify a min. reading of 8 on INSTRUMENTATION PRESS gage M5). Note: If the EBG canister pressure reading is less than 8, place the INSTRUMENTATION CSTR X3 switch S1 in the WORK CHMBR position and verify nominal MDA pressure (approximately 5 psia on INSTRUMENTATION PRESS gage M5). If the MDA pressure reading is not nominal, contact ground. WARNING Do not operate EBG if the INSTRUMENTATION PRESS gage M5 shows EBG canister pressure to be less than 24 psia (8 on the gage).			O13A1	
O 1.4		Work chamber vent vlv - OPEN.			O14A1	
O 1.5		Bulkhead vent vlv - OPEN.			O14A1 O14A2	
O 1.6		BEAM CONTROL CUR ADJ potentiometer R32 - 1.5 (verify).				Potentiometer is set preflight to 1.5. During M551 WELD SPECIMEN 1 processing, the setting could have been changed to obtain an optimum beam. For the second and third disc the setting should be left as it was for the first specimen.

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 7 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.7		BEAM CONTROL FOCUS ADJ potentiometer R31 - 1.50 (verify).				
O 1.8		INSTRUMENTATION CSTR X3 (S1) - WORK CHMBR (Verify a reading of 0 on INSTRUMENTATION PRESS gage M5 before proceeding).			O18A1 O18B1	
O 1.9		FILAMENT CHAMBER VENT vlv - OPEN. Note: If FILAMENT CHAMBER VENT vlv will not open, terminate the experiment.			O19A1	
O 1.10		Monitor FIL CHMBR PRESS gage M3 for a max. reading of .1 before proceeding.			P316A1 O110A1	
O 1.11		FIL/BEAM CONT (S12) - ON, start Accutron timer (2 min). Note Monitor the specimen disc in the work chamber for the appearance of a reflected glow from the EBG filament. If the glow does not appear, terminate the experiment. The filament power on time is not to exceed 15 min at any one time. If the power is on for 15 min, the power must be removed for 1 1/2 hr to allow the filament and surrounding components to cool. The filament glow will indicate the point on the specimen that the electron beam will strike. If the glow does not reflect from the disc tungsten target, the specimen disc must be rotated until the target falls under the glow by placing the EXP ADV switch S16 in the AUTO position momentarily.			O111A1	

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 8 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.12		PHOTO LT (S4) - ON.			O112A1	
O 1.13		HI VOLT/CAM (S14) - READY/RESET (mom - READY light L4 should illuminate).			O113A1	
O 1.14		HI VOLT/CAM (S14) - ON (mom).			O114A1 O114B1 O114C1	
O 1.15		Verify EBG voltage is approximately 20 kV as indicated by the ELECTRON BEAM voltage gage M1. The gage indicator should point to 4 or be within the range indicated by the green tab that extends over the meter face. Note If the ELECTRON BEAM voltage gage M1 reads 0 and no electron beam appears, place HI VOLT/CAM switch S14 in the READY/RESET position and terminate the experiment. If the electron beam appears, continue, preforming Operation Step Nos. O 1.16 through O 1.19 as rapidly as possible.			O115A1	
O 1.16		BEAM CONTROL CUR ADJ potentiometer R32 - adjust for a BEAM CUR gage M2 reading of 8 (corresponds to 80 mA). For M551 WELD SPECIMEN 3, R32 should be adjusted for a gage M2 reading of 7 (corresponds to 70 mA) Note: If the BEAM CUR gage M2 reads 0 and no electron beam is present, terminate the experiment. If the beam appears, set BEAM CONTROL CUR ADJ potentiometer R32 at 1.5 and continue.			O116A1	
O 1.17		BEAM CONTROL ALIGN X and Y potentiometers R57 and R58 - adjust until beam is centered on disc tungsten target.			O117A1	

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MSFC - One Time Form 19-1 (March 1972)

TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 9 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.18		BEAM CONTROL FOCUS ADJ potentiometer R31 - adjust for optimum focus of beam on the target.			O118A1	
O 1.19		EXP ADV (S16) - AUTO (specimen disc should rotate).			O119A1	
		Note When the electron beam strikes the slot in the specimen disc (approximately 3/4 revolution), proceed to Operation Step No. O 1 20				
O 1.20		HI VOLT/CAM (S14) - READY/RESET.			O120A1 O120B1	
		Note Allow the disc to continue rotating until the cross marks on the specimen disc appear in the M551 HATCH VIEW PORT MIRROR (The filament glow should be centered on the cross marks) then proceed to Operation Step No. O 1.21.				
O 1.21		EXP ADV (S16) - OFF.			O121A1	
O 1 22		BEAM CONTROL FOCUS ADJ potentiometer R31 - 2.50.				
O 1 23		HI VOLT/CAM (S14) - ON.			O114A1 O114B1 O114C1	
		Note Allow the electron beam to impinge on the specimen disc for the following times. • M551 WELD SPECIMEN 1--15 sec • M551 WELD SPECIMEN 2--15 sec • M551 WELD SPECIMEN 3--45 sec. Use the Accutron timer.				
O 1.24		HI VOLT/CAM (S14) - READY/RESET.			O120A1 O120B1	

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 10 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom--aly		
O 1.25		PHOTO LT (S4) - OFF.			O125A1	
O 1.26		EXP ADV (S16) - AUTO				
		Note When filament glow strikes the specimen disc tungsten target, proceed to Operation Step No. O 1.27.				
O 1.27		EXP ADV (S16) - OFF				
O 1.28		FIL/BEAM CONT (S12) - OFF.			O128A1 O128B1	
		CAUTION Wait a min. of 15 min before proceeding to Operation Step No. O 1.29				
O 1.29		FILAMENT CHAMBER VENT vlv - CLOSE.			O129A1	
O 1.30		Work chamber vent vlv - CLOSE.			O130A1	
O 1.31		Bulkhead vent vlv - CLOSE.			O131A1	
O 1.32		CHAMBER REPRESS vlv - OPEN.			P321A1	
		Note: Do not proceed until work chamber and MDA pressure have equalized as indicated by the INSTRUMENTATION PRESS gage M5.				
O 1.33		INSTRUMENTATION CSTR X3 (S1) - OFF.			O133A1	
O 1.34		INSTRUMENTATION POWER (S2) - OFF				
O 1.35		ELECTRON BEAM POWER (S3) - OFF.			O135A1	

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 11 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.36		BEAM CONTROL FOCUS ADJ potentiometer R31 - 1.5.				
O 1 37		CHAMBER REPRESS vlv - CLOSED.			O137A1	
		WARNING Allow 2.5 hr for cooling of the specimen disc before proceeding to Operation Step No. O 1.38.				
O 1.38		Obtain vacuum cleaner.				Vacuum cleaner stowage: E604 Vacuum cleaner power cable is stowed in vacuum cleaner caddy, W750.
O 1.39		CHAMBER REPRESS vlv - OPEN.			P321A1	
O 1.40		Loosen work chamber hatch fasteners.				
O 1.41		Remove work chamber vacuum cleaner port cover and connect vacuum cleaner hose to port.				
O 1.42		Connect vacuum cleaner power cable to HI PWR ACCESS OUTLET 1.			O142A1	Vacuum cleaner power cable may also be connected to HI PWR ACCESS OUTLET 2.
O 1.43		HI PWR ACCESS OUTLET 1 switch - ON.				
O 1.44		Vacuum cleaner cb - close (down) (if open).				
O 1.45		Manually crack work chamber hatch.				
O 1.46		Vacuum cleaner power switch - ON or MOM ON. (Vacuum out as much residue as possible)			O146A1	
O 1.47		Vacuum cleaner power switch - OFF.				
O 1.48		HI PWR ACCESS OUTLET 1 switch - OFF.				

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TABLE F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 12 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1.49		Disconnect vacuum cleaner power cable and restrain to caddy with short strap				
O 1.50		Disconnect vacuum cleaner hose and replace work chamber vacuum cleaner port cover.				
O 1.51		Open work chamber hatch.				
O 1 52		CHAMBER REPRESS vlv - CLOSED.			O152A1	
O 1.53		Disconnect M551 ELECTRON BEAM WELD MOTOR power cable from work chamber zero-g receptacle.				
O 1.54		Remove motor and specimen disc from work chamber and mount on M479 flammability specimen container.				
O 1.55		Close work chamber hatch.				
O 1.56		Remove specimen disc from the motor and stow in the EQUIPMENT STORAGE CONTAINER.				
		Note Operation Step Nos O 1 57 through O 1.64 are performed only if no further Experiment M-551 operations are scheduled for this day.				
O 1.57		Stow vacuum cleaner.				Vacuum cleaner stowage: E604.
O 1.58		Remove M551 ELECTRON BEAM WELD MOTOR from M479 flammability specimen container and stow in EQUIPMENT STORAGE CONTAINER				
O 1.59		Remove and stow checklist, logbook, and clipboard.				
O 1.60		Close control panel cover.				

*P - Preparation
O - Operations
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 F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 13 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
O 1 61		Disconnect power and remote control cables from DAC and connect to dummy connectors on M-512 facility.				
O 1.62		Replace DAC remote control connector dust cover.				
O 1.63		Stow film, DAC, and lens assembly.				Film stowage: F510 DAC stowage: F527 Lens stowage F527
O 1.64		Stow lightweight headset and CCU.				
O 1.65		Repeat Operation Step Nos. P 3.31 through O 1 56 for M551 WELD SPECIMEN 2 and for M551 WELD SPECIMEN 3.				

*P - Preparation
O - Operations
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 F-III. EXPERIMENT M-551, METALS MELTING EVALUATION SEQUENCE (Sheet 14 of 14)

Operation Step Number*	Crewman**	Test Procedure	Evaluation (Check One)		See Contingency Plan Number	Remarks
			Satis-factory	Anom-aly		
T 1 0		Experiment Termination.				
T 1.1		cb MAIN BATTERY (CB1) - open.				
T 1.2		cb POWER CONTROL BATT (CB2) - open.				
T 1.3		cb POWER FIL BATT (CB3) - open.				
T 1.4		CHAMBER REPRESS vlv - OPEN.				
T 1.5		Open work chamber hatch.				
T 1.6		CHAMBER REPRESS vlv - CLOSED.				
T 1.7		Remove the following equipment from the work chamber and stow in the EQUIPMENT STORAGE CONTAINER. • M551 HATCH VIEW PORT MIRROR • M551 CAMERA MIRROR • M551 DEFLECTION MIRROR				
T 1.8		Remove dummy zero-g connector from FLAMMABILITY SPECIMEN HOLDER TEMPORARY STOWAGE and install on work chamber zero-g connector.				
T 1.9		Close and latch work chamber hatch.				
T 1.10		Stow M-512 foot restraint				Foot restraint stowage· M127.

*P - Preparation
O - Operations
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)

SECTION VIII.

EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 1 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.5	Assemble lens and mirror.	P35A Lens and mirror cannot be mated securely.	P35A1 Obtain and assemble another lens/mirror combination.	There are one additional 100mm lens and four additional right-angle mirrors stowed in location F527.
P 3.6	Install lens assembly on DAC	P36A Lens assembly cannot be mated securely to DAC.	P36A1 Perform the following verifications • Ensure lens and camera mount index marks (orange) are aligned for lens insertion. • Ensure bayonet lugs of lens mate properly with seats of lens mount. Index marks may be incorrect. • If lugs mate but lens can be rotated cw only slightly, the bayonet mount on lens is out of adjustment P36A2 Obtain and assemble another DAC/lens combination.	
P 3.7	Remove DAC remote control connector dust cover.	P37A Dust cover cannot be removed.	P37A1 Obtain connector pliers and use to force off dust cover. P37A2 Obtain another DAC and attach lens and mirror assembly.	Pliers are stowed in locations M144 and E623, drawer 2B.
P 3.8	Install DAC on work chamber camera mount	P38A Camera mount detent mechanism does not operate to secure camera in the desired position.	P38A1 Apply greater force to the detent mechanism T-bar handle to pull the handle out, and apply greater torque to the T-bar handle to force the handle to rotate. P38A2 If the DAC can be moved to detent 1 on the camera mount, secure it with pressure-sensitive tape.	Tape is stowed in location E623, drawer 2A.

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 2 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.8 (Concluded)			P38A3 Continue the experiment without film coverage, providing as many voice comments as possible.	
P 3 9	Connect M-512 facility power and remote control cables to DAC.	P39A Power or remote control cable cannot be connected to the DAC.	P39A1 Verify that either pins on DAC power connector or pins on remote cable connector are clean and not bent. If pins are bent, straighten with pin straightener or tweezers. P39A2 Obtain DAC power and remote control cables and use for operation of camera. P39A3 Continue the experiment without the use of the DAC, providing as many voice comments as possible on experiment operation.	Pin straightener is stowed in location E623, drawer 2B. Tweezers are stowed in location E623, drawer 2C. Power cables are stowed in locations F524 and F509, remote control cables are stowed in location F525
P 3.11	Move DAC to position (detent) 1.	Refer to the following Possible Malfunction. • P38A.	Refer to the following Contingency Plans • P38A1 • P38A2 • P38A3.	
P 3.12	Verify DAC and lens for the following • 24 FPS • f/5.8, shutter 1/500 (for M551 WELD SPECIMEN 1) • f/5.6, shutter 1/500 (for M551 WELD SPECIMEN 2) • f/32, shutter 1/500 (for M551 WELD SPECIMEN 3).	P312A DAC cannot be set for 24 FPS.	P312A1 Obtain a replacement DAC. P312A2 Photograph M-551 operations at film speed setting 12 FPS.	Eight additional DAC's are located in stowage position F527.

P

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 3 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.16	ELECTRON BEAM POWER (S3) -ON	P316A FIL CHMBR PRESS gage M3 does not operate.	P316A1 Recycle the following • cb MAIN BATTERY (CB1) • cb POWER CONTROL BATT (CB2) • ELECTRON BEAM POWER (S3). P316A2 Tap on gage face with finger. P316A3 Place INSTRUMENTATION POWER switch S2 in the BATT position and monitor the INSTRUMENTATION TEMP gage M4. • If gage M4 operates, refer to Contingency Plan P316A4. • If gage M4 does not operate, refer to Contingency Plan P316A5. P316A4 A decision must be made whether to continue the experiment.	A failure of the FIL CHMBR PRESS gage M3, the vacuum head or the vacuum module is indicated, all of which prevent the display of work chamber/EBG filament chamber pressure in torr. Reference 2 requires that work chamber pressure not be more than 10^{-4}* torr before operation of the EBG, and without the use of the FIL CHMBR PRESS gage M3 there is no way to verify satisfaction of the requirement. Also indicated is a possible leak of MDA atmosphere into the EBG filament chamber past the FILAMENT CHAMBER VENT valve. This failure should cause no effect on the experiment and can be verified when a work chamber/EBG filament P

ASTN-OT-7 (Feb. 72)

*See footnote on page F-10.

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 4 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.16 (Concluded)				chamber vacuum cycle has been accomplished, the FILAMENT CHAMBER VENT valve closed, and the work chamber repressurized. The FIL CHMBR PRESS gage M3 should then read .1 or less. If the gage reading is observed later to have increased, a leak into the EBG filament chamber is indicated.
			P316A5 Terminate the experiment.	Failure of the MAIN BATTERY circuit breaker CB1, POWER CONTROL BATT circuit breaker CB2, the 26-30 Vdc regulator, or the ELECTRON BEAM POWER switch S3 is indicated, any of which would prevent applying power to the EBG. The failure can be isolated further by switching the FLOOD LT switch S19 to BATT. If the floodlight illuminates, either the 26-30 Vdc regulator or ELECTRON BEAM POWER switch S3 has failed. If the floodlight does not illuminate, the MAIN BATTERY circuit breaker CB1 or the POWER CONTROL BATT circuit breaker CB2 has failed.
P 3 17	INSTRUMENTATION POWER (S2) - BATT.	P317A INSTRUMENTATION TEMP gage M4 does not operate.	P317A1 Recycle INSTRUMENTATION POWER switch S2. P317A2 Tap on gage face with finger. P317A3 Monitor the FIL CHMBR PRESS gage M3.	P

ASTN-OT-7 (Feb. 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 5 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.17 (Continued)			• If gage M3 is operating, refer to Contingency Plan P317A4. • If gage M3 is not operating, refer to the following Contingency Plans. --P316A1 --P316A5. P317A4 Place the INSTRUMENTATION CSTR X3 switch S1 in the CSTR X3 position and monitor the INSTRUMENTATION PRESS gage M5. • If gage M5 operates (reading should be 8), refer to Contingency Plan P317A5. • If gage M5 does not operate, continue the experiment. P317A5 Place the INSTRUMENTATION TEMP SOURCE switch S9 in the CHMBR AIR position and monitor the INSTRUMENTATION TEMP gage M4. • If the gage operates, continue the experiment. • If the gage does not operate, continue the experiment.	Failure of either the INSTRUMENTATION POWER switch S2 or the Power Supply Module is indicated. For photography of experiment operations, the DAC will have to be powered from one of the (4) utility power outlets in the MDA. UTIL OUTLET 2 is suggested. Failure of the work chamber air temperature thermocouple is indicated. Failure of either the INSTRUMENTATION TEMP gage M4 or the P

ASTN-OT-7 (Feb. 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 6 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.17 (Concluded)				Amplifier Module is indicated. There is no requirement to monitor temperature for Experiment M-551, so the experiment can still be performed. If the Amplifier Module has failed, the 26-30 Vdc regulator may not properly operate to regulate the voltage for the EBG circuits, causing improper EBG operation.
P 3.18	Test operation of the DAC by pressing operate button on the DAC.	P318A DAC does not operate.	P318A1 Verify that the power cable (connector P19) is properly connected to the DAC POWER receptacle. P318A2 Verify film cassette is firmly tightened to the camera. P318A3 Verify power to the DAC by monitoring INSTRUMENTATION TEMP gage M4. (The gage indicator deflection will be small since it will indicate 1/10 of the actual work chamber wall temperature, placing INSTRUMENTATION BASE + METER switch S8 in the METER X10 position will expand the scale for easier verification of the gage operation). • If gage M4 operates, refer to Contingency Plan P312A1. • If gage M4 does not operate, refer to Contingency Plan P318A4.	Power to the DAC can also be verified by placing the INSTRUMENTATION CSTR X3 switch S1 in the CSTR X3 position and verifying operation of the INSTRUMENTATION PRESS gage M5. (Gage reading should be 8).

P

ASTN-OT-7 (Feb 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 7 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.18 (Concluded)			P318A4 Verify operation of FIL CHMBR PRESS gage M3. • If gage M3 is operating, refer to Contingency Plan P318A5. • If gage M3 is not operating, refer to the following Contingency Plans --P316A1 --P316A5. P318A5 Recycle INSTRUMENTATION POWER switch S2. • If the DAC operates when tested, continue the experiment. • If the DAC does not operate when tested, the experiment may be continued, but film data will be lost. As many voice comments as possible should be provided concerning experiment operations.	Refer to Contingency Plan P316A5, Remarks. Failure of the INSTRUMENTATION POWER switch S2 or the Power Supply Module is indicated.
		P318B DAC starts and immediately stops.	P318B1 Replace film cassette.	This failure indicates the DAC motor overload circuit is operating. The cause is most likely a jammed film cassette.
P 3.21	CHAMBER REPRESS vlv - OPEN.	P321A CHAMBER REPRESS valve fails CLOSED.	P321A1 Apply a greater amount of torque to the valve knob to force the valve to open.	The valve knob is locked in both the OPEN and CLOSED positions and must be pulled out to turn it to the other position. P

ASTN-OT-7 (Feb. 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 8 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3 21 (Concluded)			P321A2 Remove vacuum cleaner port cover to vent chamber interior to MDA pressure.	
P 3 24	CHAMBER REPRESS vlv - CLOSED	P324A CHAMBER REPRESS valve fails OPEN	P324A1 Apply a greater amount of torque to the valve knob to force the valve to close.	Refer to Contingency Plan P321A1, Remarks.
			P324A2 Plug end of repressurization line exterior to the work chamber with an appropriate object and secure it with pressure-sensitive tape. Perform a vacuum integrity check of the chamber. If vacuum integrity is verified, continue, using Contingency Plan P321A2 to repressurize the work chamber.	Pressure-sensitive tape is stowed in locations M144 and E623, drawer 2A.
			Refer to the following Contingency Plan • P316A5.	
P 3.25	Install work chamber vent filter No 1 in the 4-in. vent line.	P325A Vent filter cannot be inserted into the vent line, or cannot be installed securely	P325A1 Place the filter over the vent line opening in the work chamber and secure it with pressure-sensitive tape	Pressure-sensitive tape is stowed in locations M144 and E623, drawer 2A.
			P325A2 Continue the experiment without using the filter.	
P 3.26	Install the M551 DEFLECTION MIRROR in the work chamber over the EBG port.	P326A Mirror cannot be installed with the Calfax fasteners, or cannot be installed securely.	P326A1 If the mirror can be positioned to allow the crewman to view the specimen disc tungsten target through the work chamber hatch viewport and the M551 HATCH VIEW PORT MIRROR, secure it with pressure-sensitive tape.	Pressure-sensitive tape is stowed in locations M144 and E623, drawer 2A. The use of this Contingency Plan will have to be deferred until after the M551 ELECTRON BEAM WELD MOTOR and the specimen disc are installed in the work chamber (Operation Step No. P 3.32).

P

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 9 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.26 (Continued)			P326A2 Continue the experiment without using either the M551 DEFLECTION MIRROR or the M551 HATCH VIEW PORT MIRROR. Install either the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING or the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY in the place of the M551 HATCH VIEW PORT MIRROR.	The two mirrors are used together to direct the crewman's line of sight to the point of impingement of the electron beam on the specimen disc. If the M551 DEFLECTION MIRROR cannot be installed, the M551 HATCH VIEW PORT MIRROR should not be used because it will completely obstruct the crewman's ability to view the specimen disc. The hatch mirror also serves as a shield for the hatch viewport glass, however, and if it is not used, either the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING or the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY should be used over the hatch glass to prevent metal vapor deposition on the glass from EBG operations. Because the crewman will not be able to see the electron beam impinge on the specimen disc without a complete mirror system, he will not be able to adjust the electron beam focus or alignment, nor will he be able to verify that the beam is melting the disc until the disc has been removed from the chamber. The electron beam controls are preadjusted on the ground to a setting that should produce an acceptable beam. The crewman will be able to see the P

ASTN-OT-7 (Feb. 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 10 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.26 (Concluded)				specimen disc rotation, and he can estimate where to stop the disc to allow the beam to impinge on a stationary spot on the disc.
		P326B M551 DEFLECTION MIRROR glass is cracked or broken	P326B1 If the crack does not interfere with viewing the specimen melting operations, install the mirror and continue the experiment. If the structural failure obstructs the crewman's view of the experiment operations, continue the experiment without either the M551 DEFLECTION MIRROR or the M551 HATCH VIEW PORT MIRROR Install the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING or the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY in the place of the M551 HATCH VIEW PORT MIRROR.	Determination of whether the failure interferes with the viewing of experiment operations will be deferred until the M551 ELECTRON BEAM WELD MOTOR and specimen disc have been installed in the work chamber (Operation Step No. P 3.32). Refer to Contingency Plan P326A2, Remarks.
P 3 27	Install the M551 CAMERA MIRROR in the work chamber over the camera viewport.	P327A Mirror cannot be installed or cannot be installed securely.	P327A1 If the mirror can be aligned to allow the DAC to view the tungsten target of the specimen disc through the camera viewport and the permanently mounted camera deflection mirror, secure it with pressure-sensitive tape and continue the experiment. The M551 CAMERA MIRROR can be aligned as follows • Manually adjust the specimen disc until the tungsten target is centered in the field of view of the M551 HATCH VIEW PORT MIRROR	Pressure-sensitive tape is stowed in locations M144 and E623, drawer 2A. The use of this Contingency Plan will have to be deferred until after the M551 ELECTRON BEAM WELD MOTOR and the specimen disc have been installed in the work chamber (Operation Step No. P 3.32).

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ASTN-OT-7 (Feb 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 11 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.27 (Continued)			• Remove the DAC from the camera mount, and, while looking through the camera viewport, adjust the M551 CAMERA MIRROR until the specimen disc tungsten target is centered in the field-of-view of the mirror. Tape the mirror in this position. • Replace the DAC on the camera mount.	
			P327A2 Continue the experiment without using the M551 CAMERA MIRROR. Provide as many voice comments as possible concerning the experiment.	Photographic data will be lost if the M551 CAMERA MIRROR is not used.
		P327B M551 CAMERA MIRROR glass is cracked or broken.	P327B1 Install the mirror in the work chamber, and continue with experiment preparation through Operation Step No. P 3.32. Then perform the following operations. • Align the specimen disc until the specimen tungsten target is centered in the field-of-view of the M551 HATCH VIEW PORT MIRROR. • Remove the DAC from the camera mount and look through the camera port. • If the crack does not interfere with viewing the tungsten target on the specimen disc, replace the DAC and continue the experiment normally.	It may be necessary to turn on the photo light to see the tungsten target.

P

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 12 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.27 (Concluded)			• If the crack does interfere, replace the DAC and continue. Provide as many voice comments as possible concerning experiment operations.	Refer to Contingency Plan P327A2, Remarks.
P 3.28	Install the M512 FLOOD LIGHT SHIELD in the work chamber over the floodlight lens.	P328A The M512 FLOOD LIGHT SHIELD cannot be installed or cannot be installed securely	P328A1 Tape the shield in place with pressure-sensitive tape. P328A2 Continue the experiment without using the shield.	Pressure-sensitive tape is stowed in locations M144 and E623, drawer 2A.
		P328B The M512 FLOOD LIGHT SHIELD glass is cracked or broken	P328B1 If the crack is not too severe, install the shield and continue. Otherwise, continue without using the shield.	Contamination of the floodlight lens by metal vapors could result if the shield is not used.
P 3 29	Install the M551 HATCH VIEW PORT MIRROR over the work chamber hatch viewport surface inside the work chamber	P329A M551 HATCH VIEW PORT MIRROR cannot be installed or cannot be installed securely.	P329A1 Continue the experiment without using the M551 HATCH VIEW PORT MIRROR. Install either the M553 HATCH VIEW-PORT SHIELD SPHERE FORMING or the M479 HATCH VIEW-PORT SHIELD FLAMMABILITY in the place of the M551 HATCH VIEW PORT MIRROR. Remove the M551 DEFLECTION MIRROR from the work chamber and stow it in the EQUIPMENT STORAGE CONTAINER.	It would be extremely difficult and probably time-consuming for the crewman to attempt to align and tape the mirror into position because the hatch must be closed to determine if the mirror is aligned properly, and reopened to reposition the mirror if it is not aligned. Performance of the experiment without the mirror will, however, prevent the crewman from viewing the electron beam impingement on the specimen disc. He would have to rely on the pre-flight electron beam controls adjustment and the experiment checklist to produce an acceptable electron beam. Photography could be accomplished normally. Refer to Contingency Plan P326A2, Remarks. P

ASTN-OT-7 (Feb. 72)

TABLE F-IV. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT PREPARATION (P) (Sheet 13 of 13)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
P 3.29 (Concluded)		P329B The M551 HATCH VIEW PORT MIRROR is cracked or broken.	P329B1 Install the mirror, proceed through Operation Step No. P 3.32, then perform the following operations. • Align the specimen disc until the disc tungsten target can be seen in the mirror. If the target can be seen in the mirror, continue normally. Otherwise proceed according to Contingency Plan P329A1	It may be necessary to illuminate the photo light to see the tungsten target.
P 3.32	Remove the M551 ELECTRON BEAM WELD MOTOR from the M479 flammability specimen container and install in the work chamber.	P332A The motor cannot be installed securely in the work chamber	P332A1 Tighten as many of the (3) Calfax fasteners as possible and use pressure-sensitive tape to secure the loose side(s) of the mounting base. P332A2 Terminate the experiment.	Pressure-sensitive tape is stowed in locations M144 and E623, drawer 2A.
P 3.33	Connect the M551 ELECTRON BEAM WELD MOTOR power cable to the work chamber zero-g power receptacle	P333A The motor power cable will not connect to the work chamber power receptacle.	P333A1 Examine the cable pins and straighten if bent. Use pin straightener. P333A2 Terminate the experiment.	Pin straightener is stowed in location E623, drawer 2B.
P 3.34	Close and latch work chamber hatch	P334A One or more of the hatch fasteners cannot be tightened.	P334A1 Tighten as many of the fasteners as possible and perform an M-512 facility integrity check. Refer to Appendix E, Table E-III If pressure integrity of the work chamber is verified, continue the experiment. P334A2 Terminate the experiment.	

P

ASTN-OT-7 (Feb. 72)

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 1 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.3	INSTRUMENTATION CSTR X3 (S1) - CSTR X3 (Verify a min. reading of of 8 on INSTRUMENTATION PRESS gage M5).	O13A INSTRUMENTATION PRESS gage M5 reading is 0.	O13A1 Recycle INSTRUMENTATION CSTR X3 switch S1. O13A2 Place INSTRUMENTATION CSTR X3 switch S1 in the WORK CHMBR position and verify nominal MDA pressure (5 psia) on INSTRUMENTATION PRESS gage M5. • If the gage M5 reading is still 0, refer to Contingency Plan O13A3 • If the gage M5 displays a reading of 5, a decision will have to be made whether to continue or to terminate the experiment. O13A3 Verify operation of INSTRUMENTATION TEMP gage M4. • If INSTRUMENTATION TEMP gage M4 is operating, a decision must be made whether to continue or to terminate the experiment.	Failure of the INSTRUMENTATION CSTR X3 switch S1 or the EBG canister pressure transducer is indicated. For reasons of crew safety, the EBG should not be operated if the canister insulating gas pressure is below 24 psia; with either of these failures the canister pressure cannot be verified. Failure of either the INSTRUMENTATION CSTR X3 switch S1 or the INSTRUMENTATION PRESS gage M5 is indicated. Either of these failures will prevent the verification of EBG canister pressure. Refer to Contingency Plan O13A2, Remarks.

ASTN-OT-8 (Feb 72)

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 2 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.3 (Continued)			• If INSTRUMENTATION TEMP gage M4 is not operating, refer to Contingency Plan O13A4. O13A4 Press operate button on the front of the DAC • If the DAC operates, a decision will have to be made whether to continue or terminate the experiment. • If the DAC does not operate, refer to Contingency Plan O13A5. O13A5 Verify operation of FIL CHMBR PRESS gage M3. • If gage M3 is operating, refer to Contingency Plan O13A6 • If gage M3 is not operating, refer to Contingency Plan O13A8. O13A6 Recycle INSTRUMENTATION POWER switch S2 and monitor the INSTRUMENTATION PRESS gage M5. • If gage M5 does not operate, refer to Contingency Plan O13A7.	Failure of the Power Supply Module is indicated. This failure will prevent verification of EBG canister pressure. Refer to Contingency Plan O13A2, Remarks.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 3 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.3 (Continued)			• If gage M5 operates and a min. reading of 8 can be verified, continue experiment. O13A7 Perform the following operations: • INSTRUMENTATION POWER (S2) - OFF • ELECTRON BEAM POWER (S3) - OFF • cb POWER CONTROL BATT (CB2) - open. • cb POWER CONTROL AM BUS 1 (CB4) - close • INSTRUMENTATION POWER (S2) - AM BUS 1 • Verify a min. reading of 8 on INSTRUMENTATION PRESS gage M5. --If the INSTRUMENTATION PRESS gage M5 reading is 0, a decision will have to be made whether to continue or terminate the experiment.	Failure of the INSTRUMENTATION POWER switch S2 is indicated. This failure will prevent verification of EBG canister pressure. Refer to Contingency Plan O13A2, Remarks.
			--If gage M5 operates and a min. reading of 8 can be verified, perform the following operations: -INSTRUMENTATION POWER (S2) - OFF. -cb POWER CONTROL AM BUS 1 (CB4) - open -cb POWER CONTROL BATT (CB2) - close	Failure of the INSTRUMENTATION POWER switch S2 is indicated. The experiment can be continued, but the DAC must be powered and controlled from a source other than through the M-512 facility control panel. Use the 16mm DAC power cable (stowage

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 4 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.3 (Continued)			-ELECTRON BEAM POWER (S3) - ON -Continue with the experiment.	location F524) and the 16mm DAC remote control cable (stowage location F525) to operate the DAC for experiment photography. A ground-generated timeline can be used to verify zero pressure in the work chamber prior to opening the FILAMENT CHAMBER VENT valve, or the INSTRUMENTATION PRESS gage M5 can be used to verify zero pressure if it is powered temporarily from AM Bus 1 using the procedure in Contingency Plan O13A7 with the INSTRUMENTATION CSTR X3 switch S1 in the WORK CHMBR position.
			O13A8 Recycle the ELECTRON BEAM POWER switch S3, the POWER CONTROL BATT circuit breaker CB2, and the MAIN BATTERY circuit breaker CB1. Monitor the INSTRUMENTATION PRESS gage M5. • If gage M5 operates and a min. reading of 8 can be verified, continue the experiment normally. • If gage M5 does not operate, terminate the experiment.	Failure of the MAIN BATTERY circuit breaker CB1, the POWER CONTROL BATT circuit breaker CB2, or the ELECTRON BEAM POWER switch S3 is indicated. Either of these failures can prevent battery power O

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 5 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.3 (Concluded)				from being applied to the EBG circuits, thus causing experiment termination. The failure can be further isolated to the ELECTRON BEAM POWER switch S3 by placing the FLOOD LT switch S19 in the BATT position. If the floodlight illuminates, switch S3 has failed. If it does not illuminate, either CB1 or CB2 has failed.
O 1.4	Work chamber vent vlv - OPEN.	O14A Work chamber vent valve fails in the CLOSE position	O14A1 Apply a greater amount of torque to the valve knob to force the valve to open.	
			O14A2 Terminate the experiment.	The work chamber cannot be evacuated.
O 1.5	Bulkhead vent vlv - OPEN.	O15A Bulkhead vent valve fails in the CLOSE position.	Refer to the following Contingency Plans. • O14A1 • O14A2.	
O 1.8	INSTRUMENTATION CSTR X3 (S1) - WORK CHMBR (Verify a reading of 0 on INSTRUMENTATION PRESS gage M5 before proceeding).	O18A INSTRUMENTATION PRESS gage M5 reading remains at 8	O18A1 Recycle INSTRUMENTATION CSTR X3 switch S1. O18A2 Tap on gage face with finger. O18A3 Place INSTRUMENTATION POWER switch S2 in the OFF position and monitor the INSTRUMENTATION PRESS gage M5. • If the gage M5 indicator remains at 8, continue by using ground-generated timelines for evaluation and repressurization times for the chamber.	Failure of the INSTRUMENTATION PRESS gage M5 is indicated.

ASTN-OT-8 (Feb 72)

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 6 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.8 (Concluded)			• If the gage M5 indicator goes to 0, continue by using ground-generated timelines for evacuation and repressurization times for the work chamber. Place INSTRUMENTATION POWER switch S2 in the BATT position.	
		O18B INSTRUMENTATION PRESS gage M5 reading stabilizes between 0 and 8.	O18B1 Tap on gage M5 face with finger.	
			O18B2 Close the work chamber vent valve and monitor gage M5.	
			• If the gage M5 reading increases, terminate the experiment.	A work chamber pressure leak is indicated. The EBG will not be fired if the work chamber cannot be evacuated to a pressure of 10^{-4} torr.
			• If the gage M5 indicator reading does not increase, continue the experiment. Use ground-generated timelines for evacuating and repressurizing the work chamber.	Failure of either the INSTRUMENTATION PRESS gage M5 or the work chamber pressure transducer is indicated.
O 1.9	FILAMENT CHAMBER VENT vlv - OPEN.	O19A FILAMENT CHAMBER VENT valve cannot be opened.	O19A1 Apply a greater amount of torque to the valve knob to force the knob to turn, and a greater amount of force to pull the valve shaft out.	To open the valve, the following operations are performed: • Rotate valve knob ccw • Pull out on knob • Rotate knob ccw.
			O19A2 Terminate the experiment.	The EBG cannot be fired with the valve closed.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 7 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.10	Monitor FIL CHMBR PRESS gage M3 for a max. reading of .1 before proceeding.	Refer to the following possible malfunction • P316A. O110A FIL CHMBR PRESS gage M3 indicator stabilizes at a reading between AT and .1.	Refer to the following Contingency Plan: • P316A1. O110A1 Tap on gage face with finger. O110A2 Verify the following: • Work chamber vent valve - OPEN • Bulkhead vent valve - OPEN • CHAMBER REPRESS valve - CLOSED • Work chamber hatch latched securely • FILAMENT CHAMBER VENT valve - OPEN. If gage M3 reading still is not .1 or less, refer to Contingency Plan O110A3. O110A3 Perform an M-512 facility vacuum integrity check (refer to Appendix E, Table E-III). • If a leak is not detected, a decision must be made whether to continue the experiment.	Failure of the FIL CHMBR PRESS gage M3, the Vacuum Module, or the Vacuum Head is indicated, any of which could prevent verification of the EBG filament chamber pressure. Reference 2 requires verification of 10^{-4}* torr in the EBG filament chamber before the EBG can be operated. O

ASTN-OT-8 (Feb 72)

*See footnote on page F-10.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 8 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.10 (Concluded)			• If a leak is detected, a decision must be made whether to continue or to terminate the experiment based on the degree of vacuum available in the work chamber.	
O 1.11	FIL/BEAM CONT (S12) - ON, start Accutron timer (2 min).	O111A EBG filament glow does not appear reflected from specimen disc.	O111A1 Recycle FIL/BEAM CONT switch S12. O111A2 Recycle POWER FIL BATT circuit breaker CB3. O111A3 Verify FIL CHMBR PRESS gage M3 is operating. • If gage M3 is operating, terminate the experiment. • If gage M3 is not operating, refer to Contingency Plan O111A4. O111A4 Recycle the following: • ELECTRON BEAM POWER switch S3 • POWER CONTROL BATT circuit breaker CB2 • MAIN BATTERY circuit breaker CB1. Monitor FIL CHMBR PRESS gage M3.	Failure of the FIL/BEAM CONT switch S12, POWER FIL BATT circuit breaker CB3, relay coil K1, or the EBG internal circuitry is indicated, any of which can prevent operation of the EBG.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 9 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.11 (Concluded)			• If gage M3 operates, continue the experiment. • If gage M3 does not operate, terminate the experiment.	Failure of MAIN BATTERY circuit breaker CB1, POWER CONTROL BATT circuit breaker CB2, the ELECTRON BEAM POWER switch S3, or the 28-V regulator is indicated. Any of these failures can prevent operation of the EBG. The failure can be further isolated by placing the FLOOD LT switch S19 in the BATT position. If the floodlight illuminates, switch S3 or the 28-V regulator has failed. If it does not illuminate, CB1 or CB2 has failed.
O 1 12	PHOTO LT (S4) - ON.	O112A Photo light does not illuminate.	O112A1 Recycle PHOTO LT switch S4. O112A2 Verify filament glow is reflected from the specimen disc. • If filament glow can be seen, refer to Contingency Plan O112A3. • If filament glow cannot be seen, refer to Contingency Plan O112A4. O112A3 Place the FIL CHMBR INTLK switch S13 in the OVERRIDE position. • If the photo light illuminates, continue the experiment with switch S13 in the OVERRIDE position.	Failure of the filament chamber interlock microswitch S27 is

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 10 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.12 (Continued)				indicated. The failure has no effect on the experiment since redundancy is provided by switch S13.
			• If the photo light does not illuminate, continue the experiment, providing as many voice comments as possible concerning experiment operations	Failure of the photo light is indicated. This failure will degrade the quality of photography.
			O112A4 Recycle the following:	
			• ELECTRON BEAM POWER switch S3	
			• POWER CONTROL BATT circuit breaker CB2	
			• MAIN BATTERY circuit breaker CB1.	
			If the photo light illuminates and the EBG filament glow reflects from the specimen disc, continue the experiment. Otherwise, terminate the experiment.	Failure of the MAIN BATTERY circuit breaker CB1, the POWER CONTROL BATT circuit breaker CB2, the ELECTRON BEAM POWER switch S3, or the 28-V regulator is indicated. Any of the failures can prevent operation of the EBG. The failure can be further isolated by placing the FLOOD LT switch S19 in the BATT position. If the floodlight illuminates, either switch S3 or the 28-V regulator has failed. If

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 11 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.12 (Concluded)				the floodlight does not illuminate, CB1 or CB2 has failed.
O 1.13	HI VOLT/CAM (S14) - RFADY/RESET (mom - READY light L4 should illuminate).	O113A RFADY light L4 does not illuminate.	O113A1 Recycle HI VOLT/CAM switch S14. O113A2 Verify photo light is illuminated. • If photo light is illuminated, refer to Contingency Plan O113A3. • If photo light is not illuminated, refer to Contingency Plan O113A4. O113A3 Recycle FIL/BEAM CONT switch S12, and place the HI VOLT/CAM switch S14 in the READY/RESET position. • If RFADY light L4 illuminates, continue the experiment. • If RFADY light L4 does not illuminate, terminate the experiment. O113A4 Place the FIL CHMBR INTLK switch S13 in the OVERRIDE position. • If the photo light illuminates, continue the experiment with switch S13 in the OVERRIDE position.	Failure of the FIL/BEAM CONT switch S12, the HI VOLT/CAM switch S14, or relay K7 is indicated. Any of these failures can prevent application of high voltage to the EBG. Failure of the filament

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 12 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.13 (Concluded)				chamber interlock microswitch S27 is indicated. This failure will not affect performance of the experiment because redundancy is provided by switch S13.
			• If the photo light does not illuminate, refer to Contingency Plan O112A4.	
O 1.14	HI VOLT/CAM (S14) - ON (mom).	O114A Electron beam does not appear.	O114A1 Recycle HI VOLT/CAM switch S14.	
			O114A2 Terminate the experiment.	Failure of the HI VOLT/CAM switch S14, relay K3, or internal EBG circuitry is indicated. Any of these failures can prevent application of high voltage to the EBG. The failure can be further isolated as follows: • If READY light L4 remained illuminated when HI VOLT/CAM switch S14 was switched ON, switch S14 failed. • If light L4 extinguished when switch S14 was switched ON, relay K3 or the EBG internal circuitry failed.
		O114B DAC does not start.	O114B1 Recycle HI VOLT/CAM switch S14.	
			O114B2 Verify READY light L4 is not illuminated.	
			• If light L4 is illuminated, place HI VOLT/CAM switch S14 in READY/RESET.	Failure of relay K8 is indicated.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 13 of 24)

Operation Step Number	*Experiment/Crew Tasks*	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.14 (Continued)			Obtain 16mm DAC power and remote control cables and use to operate the DAC, or operate the DAC by pressing the DAC operate button (24 FPS is a semi-automatic camera mode, so the button must be kept depressed to keep the DAC running). • If light L4 is not illuminated, place HI VOLT/CAM switch S14 in READY/RESET. Refer to Contingency Plan O114B3. O114B3 Verify power to the DAC by pressing the operate button on the DAC. • If the DAC operates, obtain the 16mm DAC power and remote control cables and use to operate the DAC, or operate the DAC by pressing the DAC operate button (24 FPS is a semi-automatic camera mode, so the button must be kept depressed to keep the DAC running). • If the DAC does not operate, refer to Contingency Plan O114B4.	Power cables are stowed in locations F524 and F509, remote control cables are stowed in location F525. Failure of relay contacts K8 4/6 is indicated. This failure would prevent remote control of the DAC from the M-512 facility. DAC power cables are stowed in locations F524 and F509, remote control cables are stowed in location F525.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 14 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.14 (Continued)			O114B4 Monitor the INSTRUMENTATION TEMP gage M4.	
			• If gage M4 is operating, obtain a replacement DAC.	Eight additional DAC's are stowed in location F527.
			--If the replacement DAC operates, continue the experiment.	Failure of the original DAC is indicated.
			--If the replacement DAC fails to operate, refer to Contingency Plan O114B5.	
			• If gage M4 is not operating, refer to Contingency Plan O114B6.	
			O114B5 Obtain a replacement film cassette (SO-168 film), and install on the DAC.	Film is stowed in location F510.
			• If the DAC operates, continue the experiment normally.	Failure (jamming) of the original film cassette is indicated.
			• If the DAC does not operate, obtain 16mm DAC power and remote control cables and use to operate the DAC.	Failure of the M-512 facility DAC power cable or cable connector is indicated.
				16mm DAC power cables are stowed in locations F524 and F509, remote control cables are stowed in location F525.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 15 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.14 (Concluded)			O114B6 Recycle INSTRUMENTATION POWER switch S2, and monitor the INSTRUMENTATION TEMP gage M4. • If gage M4 operates, continue the experiment normally. • If gage M4 does not operate, obtain 16mm DAC power and remote control cables and use to operate the DAC.	Failure of the INSTRUMENTATION POWER switch S2 is indicated. The DAC cannot be powered from the M-512 facility. 16mm DAC power cables are stowed in locations F524 and F509; remote control cables are stowed in location F525.
		O114C READY light L4 does not extinguish.	O114C1 Verify that the electron beam appears and the DAC starts. • If the beam and DAC start, continue the experiment. • If the beam appears, but the DAC does not start, refer to the following Contingency Plan: --O114B1. • If the DAC starts but the beam does not appear, refer to the following Contingency Plan: --O114A1.	Failure of the relay contacts K8 1/2 is indicated. This failure will cause no effect to the experiment.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 16 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.15	Verify EBG voltage is approximately 20 kV as indicated by the ELECTRON BEAM voltage gage M1.	O115A ELECTRON BEAM voltage gage M1 indicates a voltage less than 20 kV (gage should read 4 to indicate a voltage of 20 kV).	O115A1 Tap on the gage face with finger. O115A2 Verify the presence of the electron beam. • If the electron beam appears satisfactorily, continue the experiment. • If an acceptable electron beam is not obtained, terminate the experiment.	This may be, but is not necessarily, an indication of failure of the ELECTRON BEAM voltage gage M1. Failure of EBG internal circuitry is indicated.
O 1.17	BEAM CONTROL ALIGN X potentiometer R58 and BEAM CONTROL ALIGN Y potentiometer R57 - Adjust until electron beam is centered on the specimen disc tungsten target.	O117A Rotation of the potentiometer knob (either R58 or R57) has no effect on the electron beam position on the specimen disc, or the beam cannot be centered on the disc tungsten target.	O117A1 Verify that the electron beam is impinging on the specimen disc. • If the beam is not impinging on the disc, and cannot be made to impinge on the disc, terminate the experiment. • If the beam is impinging on the disc, or can be made to impinge on the disc, position the beam as close as possible to the target and continue. Provide as many voice comments as possible concerning experiment operations.	Failure of the BEAM CONTROL ALIGN X potentiometer R58, the BEAM CONTROL ALIGN Y potentiometer R57, or the internal EBG circuitry is indicated. If the point of impingement of the beam is out of the field of view of the M551 CAMERA MIRROR, photography will be lost.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 17 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.18	BEAM CONTROL FOCUS ADJ potentiometer R31 - Adjust for optimum focus of beam on the target.	O118A Rotation of the potentiometer knob has no effect on the beam focus, or the beam cannot be focused sufficiently to melt the specimen disc.	O118A1 Verify that the electron beam will melt the specimen disc. • If the beam melts the disc, continue. • If the beam does not melt the disc, terminate the experiment.	Failure of the BEAM CONTROL FOCUS ADJ potentiometer R31 or the internal EBG circuitry is indicated. See Remarks above.
O 1.19	EXP ADV (S16) - AUTO (Specimen disc should rotate).	O119A Specimen disc does not rotate.	O119A1 Recycle the EXP ADV switch S16. O119A2 Verify the presence of the electron beam. • If the electron beam is visible, refer to Contingency Plan O119A3. • If the electron beam is not present, refer to Contingency Plan O119A5. O119A3 Place the EXP ADV switch S16 in the MAN/RESET position. • If the specimen disc rotates, continue the experiment using the MAN/RESET position of EXP ADV switch S16. The M551 ELECTRON BEAM WELD MOTOR will rotate the specimen disc faster with switch S16 in the MAN/RESET position, so it may be necess-	Failure of the EXP ADV switch S16, the Motor Control Module, or the Regulator and Motor Control Module is indicated.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 18 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.19 (Continued)			ary to increase the electron beam current (using the BEAM CONTROL CUR ADJ potentiometer R32) in order to melt the disc in only one revolution. • If the specimen disc does not rotate, refer to Contingency Plan O119A4. O119A4 Perform the following operations: • HI VOLT/CAM (S14) - READY/RESET • PHOTO LT (S4) - OFF • FIL/BEAM CONT (S12) - OFF • FILAMENT CHAMBER VENT valve - CLOSE • Work chamber vent valve - CLOSE • Bulkhead vent valve - CLOSE • CHAMBER REPRESS valve - OPEN (Equalize MDA and work chamber pressure) • Open work chamber hatch • Unlock specimen disc on motor hub and manually align the disc so that the electron beam can impinge on the disc cross marks	Failure of the M551 ELECTRON BEAM WELD MOTOR is indicated.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 19 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.19 (Concluded)			• Repeat procedure for depressurizing the work chamber and activating the electron beam. Allow the beam to impinge on the stationary disc for the time indicated in the experiment checklist for each specimen. • Repeat the procedure in this Contingency Plan for the remaining discs.	
			O119A5 Place FIL CHMBR INTLK switch S13 in the OVERRIDE position and verify that the photo light illuminates.	At this point, the photo light should be out, although the PHOTO LT switch S4 is ON. Otherwise a double failure has occurred.
			• If the photo light illuminates, continue the experiment.	Failure of the filament chamber interlock microswitch S27 is indicated. This will cause no significant impact to the experiment because redundancy is provided by switch S13.
			• If the photo light does not illuminate, refer to Contingency Plan O111A4.	
O 1.20	HI VOLT/CAM (S14) - READY/RESET.	O120A Electron beam does not cut off. (DAC will continue to operate and READY light L4 will not illuminate).	O120A1 Recycle HI VOLT/CAM switch S14.	
			O120A2 Place FIL/BEAM CONT switch S12 in the OFF position, and terminate the experiment.	Failure of the HI VOLT/CAM switch S14 is indicated. This failure will prevent further EBG operations.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 20 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.20 (Concluded)		O120B READY light L4 does not illuminate.	O120B1 Continue the experiment without the READY light L4.	Failure of relay contacts K8 1/2 is indicated. This will not affect performance of the experiment.
O 1.21	EXP ADV (S16) - OFF.	O121A Specimen continues to rotate.	O121A1 Recycle EXP ADV switch S16.	
			O121A2 Place the FIL/BEAM CONT switch S12 in the OFF position. Terminate operations on the specimen disc in the work chamber.	Failure of the EXP ADV switch S16 is indicated. Switching the FIL/BEAM CONT switch S12 to OFF will stop the specimen rotation and turn off the EBG filament power. The impingement of the electron beam on a stationary spot on the specimen disc cannot be accomplished, although the remaining discs can be processed in the rotating mode. For future operations, the specimen disc will begin to rotate when the HI VOLT/CAM switch S14 is placed in READY/RESET, making it impossible to align and focus the beam, if required, on the specimen disc tungsten target.
O 1.25	PHOTO LT (S4) - OFF.	O125A Photo light remains illuminated.	O125A1 Recycle PHOTO LT switch S4.	
			O125A2 Continue. The photo light will go out when Operation Step No. O 1.28 is accomplished.	Failure of the PHOTO LT switch S4 is indicated. For future operations, the photo light will illuminate when the FILAMENT CHAMBER VENT valve is opened.

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 21 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.28	FIL/BEAM CONT (S12) - OFF.	O128A READY light L4 remains illuminated.	O128A1 Recycle FIL/BEAM CONT switch S12.	
			O128A2 Continue. The READY light L4 will go out when Operation Step No. O 1.29 is accomplished.	Failure of pole 4-5-6 of the FIL/BEAM CONT switch S12 is indicated. This will cause no impact to experiment operations.
		O128B Filament glow continues to be reflected from the specimen disc.	Refer to the following Contingency Plan: • O128A1.	
			O128B1 Place the ELECTRON BEAM POWER switch S3 in the OFF position and open POWER FIL BATT circuit breaker CB3. The ELECTRON BEAM POWER switch S3 may then be returned to the ON position to allow the instrumentation to operate.	Failure of pole 1-2-3 of the FIL/BEAM CONT switch S12 is indicated. For future operations care must be taken to ensure that the ELECTRON BEAM POWER switch S3 and the POWER FIL BATT circuit breaker CB3 are not both closed until the work chamber is evacuated and the FILAMENT CHAMBER VENT valve is open.
O 1.29	FILAMENT CHAMBER VENT vlv - CLOSE.	O129A The FILAMENT CHAMBER VENT valve fails OPEN.	O129A1 Apply a greater amount of torque to the valve knob to force the knob to turn, and a greater amount of force to push the valve shaft in.	To close the valve, the following operations are performed: • Rotate valve knob cw • Push in on valve knob • Rotate knob cw.
			O129A2 Continue, after the EBG filament has cooled. Use ground-generated timeline to determine when EBG filament has cooled sufficiently to allow atmosphere into the work chamber (and EBG filament chamber).	Failure of the FILAMENT CHAMBER VENT valve in the

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 22 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.29 (Concluded)				OPEN position should not affect the experiment, provided that contamination of the EBG filament by MDA atmosphere does not cause premature EBG filament failure.
O 1.30	Work chamber vent vlv - CLOSE.	O130A Work chamber vent valve fails OPEN.	O130A1 Apply a greater amount of torque to the valve knob to force the valve to close. O130A2 Continue. The work chamber will be isolated from the space environment when Operation Step No. O 1.31 is accomplished.	
O 1.31	Bulkhead vent vlv - CLOSE.	O131A Bulkhead vent valve fails OPEN.	Refer to the following Contingency Plan • O130A1. O131A1 Continue. Redundancy is provided by the work chamber vent valve.	
O 1.33	INSTRUMENTATION CSTR X3 (S1) - OFF.	O133A INSTRUMENTATION PRESS gage M5 continues to operate.	O133A1 Recycle INSTRUMENTATION CSTR X3 switch S1. O133A2 Continue. Power will be removed from the gage when Operation Step No. O 1.34 is accomplished.	Failure of the INSTRUMENTATION CSTR X3 switch S1 is indicated.
O 1.35	ELECTRON BEAM POWER (S3) - OFF.	O135A FIL CHMBR PRESS gage M3 continues to operate.	O135A1 Recycle ELECTRON BEAM POWER switch S3. O135A2 Continue. Power will be removed from switch S3 when Operation Step No. T 1.1 is accomplished.	Failure of the ELECTRON BEAM POWER switch S3 is indicated.

TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 23 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.37	CHAMBER REPRESS vlv - CLOSED	O137A CHAMBER REPRESS valve fails OPEN.	O137A1 Apply a greater amount of torque to the valve knob to force the valve to close. For future operations, refer to the following Contingency Plans • P324A2 • P316A5.	The valve knob is locked in both the OPEN and CLOSED positions, and the knob must be pulled out to place the valve in the other position.
O 1.42	Connect vacuum cleaner power cable to HI PWR ACCESS OUTLET 1.	O142A Vacuum cleaner power cable cannot be connected to HI PWR ACCESS OUTLET 1 zero-g receptacle.	O142A1 Check power cable pins and straighten if bent. Use pin straightener.	Pin straightener is stowed in location E623, drawer 2B.
			O142A2 Connect cable to HI PWR ACCESS OUTLET 2, and power the vacuum cleaner from this outlet.	Use of the vacuum cleaner is not a requirement to Experiment M-551.
			O142A3 Continue the experiment without vacuum cleaning operations if the metals melting residue is not severe. Otherwise, terminate all further experiment operations.	
O 1.46	Vacuum cleaner power switch - ON or MOM ON.	O146A Vacuum cleaner does not operate.	O146A1 Recycle the following: • Vacuum cleaner power switch • Vacuum cleaner circuit breaker • HI PWR ACCESS OUTLET 1 switch. Refer to the following Contingency Plan: • O142A2.	

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TABLE F-V. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT OPERATION (O) (Sheet 24 of 24)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
O 1.46 (Concluded)			O146A2 Obtain blower unit from fecal/urine collector or suit dryer and substitute for vacuum cleaner blower unit. Continue.	
O 1.52	CHAMBER REPRESS vlv - CLOSED	O152A CHAMBER REPRESS valve fails OPEN	O152A1 Apply more torque to the valve knob to force the valve to close. O152A2 If more specimen discs are to be processed, refer to the following Contingency Plans • P324A2 • O152A3. If no more discs are to be processed, continue the normal procedure, leaving the CHAMBER REPRESS valve in the OPEN position. O152A3 Terminate the experiment.	See Contingency Plan P321A1; Remarks.

TABLE F-VI. EXPERIMENT M-551, METALS MELTING MALFUNCTION AND CONTINGENCY PLAN OUTLINE - EXPERIMENT TERMINATION (T)

Operation Step Number	Experiment/Crew Tasks	Possible Malfunction	Contingency Plan	Remarks (malfunctions, corrections, results)
	No contingencies are anticipated for the Termination portion of the experiment			

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ASTN-OT-9 (Feb 72)

SECTION IX. EXPERIMENT M-551, METALS MELTING MALFUNCTION ANALYSES

Refer to Appendix E, Section IX for Experiment M-551 malfunction analyses.

SECTION X. CONCLUSIONS AND RECOMMENDATIONS

1. The analyses performed in Sections I and VIII resulted in confidence that any possible hardware failures will cause no significant impact to the carrier systems or to the crew (this does not include hardware failures analyzed in Appendix E, M-512 Materials Processing Facility, and referenced by this document). Provided that the EBG functions satisfactorily, it is considered that Experiment M-551 has a good probability of success.

2. At the time this Appendix was prepared, a conflict in the available reference documentation existed: Reference 2 requires a pressure no greater than 10^{-5} torr in the M-512 facility vacuum work chamber before the EBG can be operated. Reference 16 indicates to the crew that the EBG can be operated if the pressure is as low as 10^{-4} torr (10 times greater than the Reference 2 requirement). It is anticipated that the requirement in Reference 2 will be changed to agree with the crew procedures of Reference 16.

3. The analysis of experiment operational procedures in Sections VII and VIII showed that if the FIL/BEAM CONT switch S12 was failed in the ON position, or was inadvertently placed in the ON position, before checkout of the DAC, the EBG filament warmup power could be turned on when the DAC was powered up. This would occur at a time when the work chamber was pressurized and the FILAMENT CHAMBER VENT valve was closed and when several items of equipment remain to be installed in the work chamber before the chamber is depressurized and the FILAMENT CHAMBER VENT valve is opened. The heat from the filament could damage the valve o-ring seals and permit MDA atmosphere to contaminate the filament and possibly cause premature filament failure.

   To preclude the possibility of inadvertent EBG filament warmup, it is suggested that closure of the POWER FIL BATT circuit breaker CB3 (see Section VII, Operation Step No. P 3.15) be deferred until after the FILAMENT CHAMBER VENT valve is opened (see Section VII, Operation Step No. O 1.9).

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