

INTRODUCTION TO APPENDIX D

- ITEM 1 - CIRCUIT BREAKER
 ITEM 2 - FUSE, AXIAL LEAD / CARTRIDGE
 ITEM 3 - FUSE, HIGH CURRENT
 ITEM 4 - FUSE, PLUG-IN
- MC454-0026 / MC454-0032
 ME451-0009
 ME451-0016
 ME451-0018

FAILURE MODES AND CAUSES:

THE FOLLOWING TABLE LISTS FAILURE MODES AND CAUSES WHICH WERE CONSIDERED IN DERIVING FAILURE MODES AND EFFECTS ANALYSIS (EMEA'S) FOR THE ITEMS LISTED ABOVE:

FAILURE MODE	FAILURE CAUSE	CIRCUIT BREAKER	FUSE MC451-0009	FUSE MC451-0016	FUSE MC451-0018
FAILS OPEN, FAILS TO CONDUCT, FAILS TO CLOSE	(a) Structural Failure	X	X	X	X
	(b) Contamination	X	X	X	X
	(c) Vibration	X	X	X	X
	(d) Mechanical Shock	X	X	X	X
	(e) Processing Anomaly	X	X	X	X
	(f) Thermal Stress	X	X	X	X
	(g) Thermal Shock	X	X	X	X
FAILS CLOSED FAILS TO OPEN, (MECHANICALLY)	(a) Structural Failure	X	X	X	X
	(b) Contamination	X	X	X	X
	(c) Vibration	X	X	X	X
	(d) Mechanical Shock	X	X	X	X
	(e) Processing Anomaly	X	X	X	X
FAILS TO INTERRUPT UNDER OVERLOAD *	(a) Structural Failure	X			

* SEE NEXT PAGE.

APPENDIX D ITEM 1 - CIRCUIT BREAKER
MC454-0026-XXXX, MC454-0032-XXXX

DISPOSITION & RATIONALE

(A) DESIGN, (B) TEST, (C) INSPECTION, (D) FAILURE HISTORY:

(A) DESIGN

TRIP FREE, TEMPERATURE COMPENSATED, THERMAL CIRCUIT BREAKER.. THIS CIRCUIT BREAKER IS DESIGNED, TESTED AND INSPECTED TO MEET THE REQUIREMENTS OF THE SPACE SHUTTLE PROGRAM DETAILED BY ROCKWELL INTERNATIONAL SPECIFICATION MC454-0031 AND THE REQUIREMENTS OF MILITARY SPECIFICATION MIL-C-5809 (MS3320). THE APPLICATION OF THE PART IS ANALYZED TO ASSURE COMPLIANCE WITH THE WIRE PROTECTION CRITERIA ESTABLISHED BY ROCKWELL ELECTRICAL DESIGN.

(B) TEST

QUALIFICATION/CERTIFICATION

CERTIFICATION TESTING AND ANALYSIS IS COMPLETED AND APPROVED.
TESTS INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
TRIP PERFORMANCE (110%, 145%, 200%)	X				X	
VOLTAGE DROP	X	X			X	
INSULATION RESISTANCE		X			X	
DIELECTRIC STRENGTH (DWV, 1250 Vrms SINGLE PHASE, 1400 Vrms THREE PHASE)		X			X	
ACTUATION FORCE (PULL OUT, PUSH IN)	X				X	
ACTUATOR STRENGTH (25 LBS)	X					
VIBRATION (0.2 g ² /HZ, 3 AXES)	X		X			
THERMAL (-65 TO 190 °F SOAK ALONG WITH 85 TO 190 °F)						X
CABIN ATMOSPHERE (HUMIDITY 80%, SALT FOG 1%, TEMPERATURE 60 TO 120 °F)		X				
SAND AND DUST		X				
INTERRUPTING CAPACITY	X				X	
SHOCK (40 G)				X		
OVERLOAD CYCLING (200%, 100 CYCLES)					X	
LIFE CYCLING (5000 CYCLES, MANUALLY)	X				X	

APPENDIX D ITEM 1 CONT'D

ACCEPTANCE AND SCREENING

ACCEPTANCE TEST IS ACCOMPLISHED ON A 100% BASIS FOR ALL CIRCUIT BREAKERS. TESTS INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
ACTUATION FORCE (PULL OUT, PUSH IN)	X				X	
VIBRATION (0.04 g ² /HZ)	X		X			
INSULATION RESISTANCE (IR AT 500 VDC)		X			X	
DIELECTRIC STRENGTH (DWV AT 1250 Vrms SINGLE PHASE, 1400 Vrms THREE PHASE)		X			X	
TRIP PERFORMANCE (110%, 145%, 200%)	X				X	
VOLTAGE DROP	X	X			X	

ACCEPTANCE TEST AT THE NEXT ASSEMBLY LEVEL INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
CONTINUITY		X			X	
ACTUATION (PULL OUT, PUSH IN)	X				X	

(C) INSPECTION

RECEIVING INSPECTION (FAILURE CAUSE a,b)

UPON RECEIPT INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATION OF ALL INCOMING PARTS AND VERIFIES THE MATERIALS USED. RECORDS ARE MAINTAINED CERTIFYING THE MATERIAL AND ITS PHYSICAL PROPERTIES.

CONTAMINATION CONTROL (FAILURE CAUSE b)

ULTRASONIC CLEANING OF DETAIL PARTS PRIOR TO FINAL ASSEMBLY AND A FILTERED CLEAN AIR BLAST ARE VERIFIED.

APPENDIX D ITEM 1 CONT'D

ASSEMBLY/INSTALLATION (FAILURE CAUSE a,b,e)

DETAILED INSPECTION IS PERFORMED ON ALL ASSEMBLIES PRIOR TO THE NEXT OPERATION. INSPECTION UNDER 4X MAGNIFICATION IS PERFORMED PRIOR TO CLOSEOUT. CIRCUIT BREAKERS ARE ASSEMBLED IN A DEDICATED AREA. DETAILED PARTS WITH DEFECTS ARE SCRAPPED WITH NO ATTEMPT TO REWORK.

CRITICAL PROCESSES (FAILURE CAUSE b,e)

MACHINE CONTROLLED SPOT WELDING OF CONTACTS TO TERMINALS AND BRAIDED WIRE TO BI-METAL. SET-UP INSPECTION AND PERIODIC IN-PROCESS INSPECTIONS PERFORMED.

TESTING (FAILURE CAUSE a,b,e,f)

ACCEPTANCE TEST PERFORMED BY CERTIFIED PERSONNEL, OBSERVED AND VERIFIED BY QUALITY CONTROL (QC) INCLUDING VIBRATION, FUNCTIONAL AND A MANUAL OPERATIONAL CHECK FOR BINDING.

HANDLING/PACKAGING (FAILURE CAUSE c,d)

USE OF CUSHIONED TRAYS VERIFIED FOR IN-PROCESS HANDLING. PARTS PACKAGED AND PROTECTED ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS.

(D) FAILURE HISTORY

SINGLE PHASE CONFIGURATION (MC454-0026-XXXX)

FAILURE MODE: FAILS OPEN, FAILS TO CONDUCT, FAILS TO CLOSE

CAR'S A8717, AB0031

FAILS TO CLOSE WHEN ACTUATED. CONTAMINATION, SILICON DIOXIDE, FOUND ON THE CONTACT SURFACES. THE SILICON DIOXIDE WAS FORMED BY A THERMAL REACTION FROM THE SILICON PRIMER USED TO COAT THE EXTERIOR SURFACES OF THE BREAKER. PRIMER ENTERED BREAKER BECAUSE IT WAS APPLIED IN AN INVERTED POSITION. PROCEDURES WERE REVISED TO APPLY PRIMER IN A NON-INVERTED POSITION.

CAR'S AB7060, AC4155, AC7395

WOULD CLOSE ELECTRICALLY BUT WOULD NOT MECHANICALLY LATCH. ANALYSIS DETERMINED THE CAUSE TO BE A BROKEN MOVABLE CONTACT SHORTING BAR. THE BAR WAS BROKEN DUE TO A MISALIGNMENT OF THE CONTACT STRIP, CONTACT MATERIAL, SILVER-CADMIUM, SHEARED OFF AND IMBEDDED INTO THE SOFTER BERYLLIUM COPPER CAUSING THE BERYLLIUM COPPER TO BE THINNER IN THE AREA UNDER THE SHEARED OFF MATERIAL. THE SUPPLIER REVISED QUALITY CONTROL TO INCLUDE A SAMPLE CHECK AND VISUAL INSPECTION OF THE SHORTING BAR FOR CONTACT SHEARING, THINNING AND PITTING.

11/20/87 (11:04am)

APPENDIX D ITEM 1 CONT'D

CAR'S AB0766, AC1091, AC9246, AD0200
DURING ORBITER CHECKOUT TESTS SOME EQUIPMENT FAILED TO OPERATE OR
TURN "ON" DURING THE POWER-UP SEQUENCE. SUBSEQUENT
TROUBLESHOOTING FOUND THE CONDITION BEING CORRECTED WITH
MECHANICAL CYCLING OF THE ASSOCIATED CIRCUIT BREAKER. WHILE THE
FAILURES WERE NOT DUPLICATED, ANALYSIS REVEALED TRACES OF BRAZING
FLUX (BORO SILICATE) RESIDUE ON THE CONTACT SURFACES IN SOME
CASES. THIS RESIDUE COULD ACCOUNT FOR THE REPORTED ANOMALY,
ESPECIALLY SINCE IN THESE APPLICATIONS THE LOAD CURRENT IS VERY
LOW, LESS THAN 65 MILLIAMPERES.

TRAINING SESSIONS FOR INSPECTORS, ASSEMBLY AND SUPERVISOR
PERSONNEL ARE CONDUCTED PRIOR TO PRODUCTION RUNS TO REINFORCE
CLEANLINESS PRACTICES. IN ADDITION, ORBITER OPERATIONAL
PROCEDURES NOW REQUIRE CYCLING OF THE CIRCUIT BREAKERS (FIVE
TIMES) TO CLEAR HIGH CONTACT RESISTANCE CONDITIONS OF THIS
NATURE.

THERE ARE NO UNRESOLVED GENERIC ISSUES.

THREE PHASES CONFIGURATION (MC454-0032-XXXX)

FAILURE MODE: FAILS OPEN, FAILS TO CONDUCT, FAILS TO CLOSE

CAR AB8733

BREAKER WILL NOT LATCH DOWN. CAUSED BY INTERNAL CONTAMINATION OF
RTV PRIMER. THE PRIMER WAS APPLIED WITH THE BREAKER IN AN
INVERTED POSITION WHICH IS IMPROPER. PROCEDURE HAS BEEN REVISED
TO APPLY PRIMER IN AN NON-INVERTED POSITION.

CAR AC1737, AC2250

FAILED TO LATCH MECHANICALLY WHEN ACTUATING BUTTON WAS PUSHED IN.
THE BREAKER WAS DAMAGED BY THE USED OF "CAPS" (DEVICE INSTALLED
ON BREAKER HANDLE) WHICH WERE INSTALLED BY TEST PERSONNEL.
CAUTION NOTE ADDED TO ALL KSC AND PALMDALE PROCEDURES
RESTRICTING THE USE OF "CAPS".

CARS AC5128, AC5857, AC5951, AC7052, AC7053

BREAKER WILL NOT LATCH DOWN. CAUSED BY DAMAGE TO CLEVIS THAT WAS
CAUSED BY THE USE OF A TOOL TO OPEN/CLOSE BREAKERS. PROCEDURES
HAVE BEEN CHANGED TO PROHIBIT THE USE OF TOOLS ON CIRCUIT
BREAKERS.

CAR 02F019

DURING STS-2 OSTA PALLET PUMP PRESSURE WAS NOT HIGH ENOUGH.
COULD NOT VERIFY FAILURE. PROBLEM COULD HAVE BEEN CAUSED BY
RESIDUE ON CIRCUIT BREAKER CONTACTS. THE CREW WILL BE ADVISED TO
TRY CYCLING BREAKER IF A SIMILAR PROBLEM SHOULD OCCUR.

THERE ARE NO UNRESOLVED GENERIC ISSUES.

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APPENDIX D ITEM 1 CONT'D

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