

INDUCTION TO APPENDIX A

- ITEM 1 - TOGGLE SWITCH - ME452-0102-700X
- ITEM 2 - ROTARY SWITCH - ME452-0093
- ITEM 3 - PUSHBUTTON SWITCH - ME452-0060 AND ME452-0061
- ITEM 4 - LIMIT SWITCH - ME452-0123

FAILURE MODES AND CAUSES

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

FAILURE MODE	FAILURES CAUSE	TOGGLE SWITCH	ROTARY SWITCH	P/B SWITCH	LIMIT SWITCH
FAILS OPEN, PREMATURE OPEN	(a) Piece Part 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
FAILS CLOSED, PREMATURE CLOSURE, CONTACT-TO-CONTACT SHORT	(a) Piece Part 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
SHORT-TO-CASE (GROUND)	(a) Piece Part 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
SOLE-TO-SOLE SHORT	(a) Piece Part 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
BROKEN STOP	(a) Piece Part Structural Failure	X	X	X	X
	(e) Processing Anomaly	X	X	X	X
LOSS OF ANNUNCIATOR / LENS ILLUMINATION, FAILS TO ILLUMINATE	(a) Piece Part Structural Failure		X	X	X
	(b) Contamination		X	X	X
	(c) Vibration		X	X	X
	(d) Mechanical Shock		X	X	X
	(e) Processing Anomaly		X	X	X
	(f) Thermal Stress		X	X	X

NOTE: PREMATURES CREATED BY THE TESTING OF TOGGLE SWITCHES ARE REVERSIBLE OR TEMPORARY CONDITIONS.

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APPENDIX A ITEM 4 - LIMIT SWITCH
MC452-0123

DISPOSITION & RATIONALE

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

(A) DESIGN

THE LIMIT SWITCH IS ENCLOSED IN A HERMETICALLY - SEALED, INERT GAS BACKFILLED, STEEL CASE WITH A GLASS HEADER FOR TERMINALS. SWITCH IS A SNAP ACTION TWO POSITION DEVICE WITH NORMALLY CLOSED (NC) AND NORMALLY OPEN (NO) CONTACTS RATED AT 2 AMPERES. APPLICATIONS MEET THE ORBITER PROJECT PARTS LIST (OPPL) DERATING REQUIREMENTS.

THE -0001 SWITCH IS A SOLDER SEALED CONFIGURATION WHILE THE -0002, -0003 AND -0008 ARE A WELDED SEAL CONFIGURATION. THE -0004 WAS A SOLDER SEALED CONFIGURATION WHICH IS NO LONGER UTILIZED.

(B) TEST

QUALIFICATION/CERTIFICATION

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

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
PERFORMANCE (OPER. CHARACTERISTICS)	X	X			X	
TERMINAL STRENGTH	X				X	
STRENGTH OF ACTIVATION STOP	X				X	
THERMAL CYCLE (5 CYCS, 350 TO -320 °F)						X
FLIGHT VIBRATION (2.0 g ² /HZ, 48 MINS)	X		X			
VIBRATION AT LOW TEMPERATURE (2.0 g ² /HZ AT -320 °F)			X			X
SHOCK (20G'S FOR ROCKWELL, 100 G'S FOR MIL-S-8805)	X			X		
ACCELERATION (5 G'S)	X					
SALT FOG (5% 96 HOURS)		X			X	
DIELECTRIC STRENGTH (1000 VRMS)		X			X	
INSULATION RESISTANCE (500 VDC)		X			X	
SEAL (1x10 ⁻⁸ SCC/SEC)		X				
CONTACT BOUNCE	X					
TRANSFER TIME	X					
VOLTAGE DROP	X	X			X	
OPERATING LIFE (25,000 CYCLES)	X				X	
SHORT CIRCUIT (90 AMPERES, 5 TIMES)					X	

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APPENDIX A ITEM 4 CONT'D

ACCEPTANCE AND SCREENING TEST

ALL SWITCHES ARE SUBJECTED TO ACCEPTANCE AND SCREENING TESTS ON A 100% BASIS AND INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
PRE ACCEPTANCE RUN-IN (500 CYCLES)	X	X			X	
EXAMINATION	X	X			X	
LOW TEMPERATURE (-320 °F EXCEPT -0008 WHICH IS -73 °F)					X	X
VIBRATION (SINUSOIDAL 50G'S SWEEP BETWEEN 10 AND 200HZ AND BACK TO 10 HZ IN 8 MINUTES)	X	X	X			
PIND (INITIATED IN FEBRUARY OF 1985)		X				
PERFORMANCE (OPER. CHARACTERISTICS)	X				X	
DIELECTRIC STRENGTH (DWV AT 1000 VRMS)		X			X	
INSULATION RESISTANCE (IR AT 500 VDC)		X			X	
RADIOGRAPHIC (X-RAY)	X	X			X	
LEAKAGE (SEAL, 1×10^{-8} SCC/SEC)		X			X	
CONTACT RESISTANCE	X	X	X	X	X	

ACCEPTANCE TESTS AT THE NEXT ASSEMBLY LEVEL:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
PERFORMANCE (OPER. CHARACTERISTICS)	X	X				
CONTINUITY	X	X				
INSULATION RESISTANCE	X	X			X	

(C) INSPECTION

RECEIVING INSPECTION (FAILURE CAUSE a,b)

TEST RECORDS AND REPORT ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES. RECEIVING INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATION OF ALL INCOMING PARTS.

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CONTAMINATION CONTROL (FAILURE CAUSE b)

QUALITY CONTROL VERIFIES PROPER MAINTENANCE AND OPERATION OF THE ENVIRONMENTALLY CONTROLLED MANUFACTURING AREA. ULTRASONIC CLEANING VERIFIED BY INSPECTION. CONTAMINATION CONTROL PROCEDURES INCLUDING USE OF COVERED TOTE PANS IS VERIFIED.

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

DETAILED INSPECTION PERFORMED ON ALL PARTS PRIOR TO NEXT ASSEMBLY.

NONDESTRUCTIVE EVALUATION (FAILURE CAUSE a, b, e)

X-RAY INSPECTION UNDER MINIMUM 7X MAGNIFICATION FOR EVIDENCE OF WELD FLASH, LOOSE PARTS, AND ASSEMBLY ANOMALIES.

CRITICAL PROCESSES (FAILURE CAUSE a,b,e)

CRITICAL PROCESSES INCLUDING WELDING, BRAZING, AND PASSIVATION ARE MONITORED AND VERIFIED BY INSPECTION.

TESTING

ACCEPTANCE TESTING IS OBSERVED AND VERIFIED BY QUALITY CONTROL INCLUDING VIBRATION TEST; THERMAL (MECHANICAL OPERATION TO SPECIFICATION); LEAK TEST (HERMETIC); INSULATION RESISTANCE/DIELECTRIC STRENGTH; RUN-IN TEST PRIOR TO ATP, PIND TESTS.

HANDLING/PACKAGING (FAILURE CAUSE a,c,d)

PARTS PACKAGED AND PROTECTED ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS.

(D) FAILURE HISTORY

FAILURE MODES: OPENS OR FAILS TO CONDUCT, PREMATURE CLOSURE AND SHORTS-TO-GROUND.

CAR 13F001-110 (PRIME)

TWENTY TWO FLIGHT ANOMALIES WERE ATTRIBUTED TO LIMIT SWITCHES FAILING OPEN (FAILED TO CONDUCT), PREMATURELY CLOSING OR EXHIBITING A SHORT-TO-GROUND. NOT ALL OF THESE ANOMALIES WERE CONFIRMED, HOWEVER, A LARGE PERCENTAGE DID CONTAIN PARTICLE CONTAMINATION, BOTH METALLIC AND NON-METALLIC. ALL OF THESE FAILURES WERE ATTRIBUTED TO THE MC452-G123-0004 LIMIT SWITCH CONFIGURATION; A SOLDER SEAL CONSTRUCTION. THE METALLIC PARTICLES WERE WELD EXPULSIONS AND SOLDER PARTICLES. THE NON-METALLIC PARTICLES WERE FIBERS AND GLASS.

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APPENDIX A ITEM 4 CONT'D

AS A RESULT OF THESE FAILURES, MULTIPLE STEPS WERE INITIATED TO PRECLUDE PARTICLES. THESE INCLUDED ESTABLISHING AN ENVIRONMENTALLY CONTROLLED MANUFACTURING AREA, REVISED AND IMPROVED CLEANING PROCEDURES, AND REVISED AND MODIFIED BACKFILLING EQUIPMENT. FURTHER, PIND TESTING WAS ALSO IMPLEMENTED AS A SCREENING TEST TO ASSURE THAT THE SWITCHES ARE FREE OF PARTICLES.

THE MC452-0123-0004 CONFIGURATION WAS REDESIGNED TO INCORPORATE A WELDED CONSTRUCTION LIMIT SWITCH. THIS NEW CONFIGURATION IS IDENTIFIED AS A -0008. FURTHER, ALL OF THE APPLICATIONS OF THE -0004 IN THE REACTION CONTROL AND ORBITER MANEUVERING SUBSYSTEMS HAVE BEEN RETROFITTED WITH PIND TESTED -0004'S OR THE -0008 CONFIGURATION.

THE OTHER LIMIT SWITCH CONFIGURATIONS WERE CONSIDERED SATISFACTORY FOR THEIR INTENDED USAGE. THIS WAS BASED UPON THEIR CRITICALITY ASSESSMENT, THEIR FAILURE HISTORY AND ACTUAL USAGE.

FAILURE MODES: CLOSED OR FAILED TO OPEN

DR/CAR'S AD2353 AND AD2354

DURING ORBITER OV-104 SUBSYSTEM CHECKOUT TESTING, THE MAIN LANDING GEAR INDICATOR FAILED TO FUNCTION PROPERLY. INVESTIGATION ISOLATED THE PROBLEM TO THE ASSOCIATED LIMIT SWITCHES. ANALYSIS REVEALED THAT THE SWITCHES HAD BEEN DAMAGED BECAUSE OF MISADJUSTMENT OF THE SWITCH ACTUATORS; A WORKMANSHIP PROBLEM.

ADJUSTMENT PROCEDURES WERE REVIEWED WITH INSTALLATION PERSONNEL. FAILURES OF THIS NATURE ARE NORMALLY DETECTED DURING THE FUNCTIONAL TEST FOLLOWING THE ADJUSTMENT PHASE.

THERE ARE NO UNRESOLVED SWITCH FAILURES.

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