INTRODUCTION TO APPENDIX A

ITEM 1 - TOGGLE SWITCH - ME452-0102-7XXX
ITEM 2 - ROTARY SWITCH - ME452-0093
ITEM 3 - PUSHBUTTON SWITCH - ME452-0060 AND ME452-0061
ITEM 4 - LIMIT SWITCH - MC452-0123

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	FAILURE 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
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
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
POLE-TO-POLE SHORT	(a) Piece Part Structural Failure	X	X		
	(b) Contamination	X	X		
	(c) Vibration	X	X		
	(d) Mechanical Shock	X	X		
	(e) Processing Anomaly	X	X		
BROKEN STOP	(a) Piece Part Structural Failure		X		
	(e) Processing Anomaly		X		
LOSS OF ANNUNCIATOR / LENS ILLUMINATION, FAILS TO ILLUMINATE	(a) Piece Part Structural Failure			X	
	(b) Contamination			X	
	(c) Vibration			X	
	(d) Mechanical Shock			X	
	(e) Processing Anomaly			X	
	(f) Thermal Stress			X	

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

APPENDIX A ITEM 3 - PUSHBUTTON SWITCH
ME452-0061-XXXX

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

(A) DESIGN

THE DEVICES ARE ILLUMINATED PUSHBUTTON SWITCHES, WITH ENVIRONMENTALLY SEALED CONTACT ENCLOSURE, AND DUAL LAMPS FOR EACH LEGEND. THE DEVICES ARE DESIGNED, TESTED AND INSPECTED TO MEET THE REQUIREMENTS OF ROCKWELL INTERNATIONAL SPECIFICATION MC452-0060. THE SWITCH DESIGN IS A RUGGEDIZED VERSION OF THE MIL-S-22885. CHANGES TO THE BASIC MILITARY PART CONSIST OF PROVIDING A SECOND ENCLOSURE FOR IMPROVED DEBRIS PROTECTION AND LOWER VOLTAGE LAMP FILAMENTS CAPABLE OF WITHSTANDING HIGHER VIBRATION AND SHOCK LEVELS. THE ME452-0060 SWITCHES HAVE TWO POLES AND ARE RATED AT 5 AMPS. THE ME452-0061 SWITCHES HAVE FOUR POLES AND ARE RATED AT 1 AMP. THE APPLICATION OF THE PART IS ANALYZED TO ASSURE COMPLIANCE WITH THE 25% DERATING CRITERIA OF THE ORBITER PROJECT PARTS LIST (OPPL).

(B) TEST

QUALIFICATION/CERTIFICATION

QUALIFICATION TESTING AND ANALYSIS COMPLETED. TESTS INCLUDE:

TEST	CAUSE CONTROL				
	a	b	c	d	e
FUNCTIONAL	X	X			
COLOR AND BRIGHTNESS	X	X			X
DIELECTRIC WITHSTANDING VOLTAGE (DWV 1000 V RMS)		X			X
INSULATION RESISTANCE (IR AT 500 VDC)		X			X
CONTACT RESISTANCE	X	X	X	X	X
VIBRATION (0.2 g^2/HZ)	X		X		
CABIN ATMOSPHERE	X				X
TERMINAL STRENGTH (10 LB PULL AND 5 OUNCE INCHES)	X				
WINDOW IMPACT (5 FOOT POUNDS)	X			X	

APPENDIX A ITEM 3 CONT'D

QUALIFICATION/CERTIFICATION

THE FOLLOWING TEST REQUIREMENTS WERE SATISFIED BY ANALYSIS OF THE APOLLO PROGRAM PUSHBUTTON SWITCH:

TEST	CAUSE CONTROL				
	a	b	c	d	e
SHOCK (78 G'S IN EACH DIRECTION ALONG EACH OF 3 AXES)	X			X	
VACUUM (600 CYCLES AT 1 X 10^{-4} MILLIMETERS OF MERCURY FOR 100 HOURS)	X				X
TEMPERATURE (40 oF FOR 50 HOURS AND 135 oF FOR 50 HOURS)					X
ENDURANCE (5000 CYCLES)	X				X
SHORT CIRCUIT (65 AMPERES)					
OVERLOAD (10 CYCLES AT 150% OF RATED CURRENT)					

ACCEPTANCE AND SCREENING

ALL UNITS ARE SUBJECTED TO ACCEPTANCE AND SCREENING TESTS WHICH INCLUDE:

TEST	CAUSE CONTROL				
	a	b	c	d	e
VISUAL					
DIELECTRIC WITHSTANDING VOLTAGE (DWV, AT 1000 V RMS)	X	X			X
CONTACT VOLTAGE DROP	X	X			X
CONTACT RESISTANCE	X	X	X	X	X
BRIGHTNESS	X	X			X
VIBRATION (0.04 g^2/HZ)	X		X		X
MANUFACTURING TESTS INCLUDE 250 CYCLES	X	X			X

APPENDIX A ITEM 3 CONT'D

ACCEPTANCE TESTS AT THE NEXT ASSEMBLY:

TEST	CAUSE CONTROL				
	a	b	c	d	e
PERFORMANCE	X	X			
CONTINUITY	X	X			X
INSULATION RESISTANCE		X			X

(C) INSPECTION

RECEIVING INSPECTION

UPON RECEIPT, INSPECTION PERFORMS VISUAL, ELECTRICAL 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)

QUALITY CONTROL (QC) VERIFIES APPROPRIATE PROCEDURES/SHOP PRACTICES ARE UTILIZED FOR CONTAMINATION CONTROL. ULTRASONIC CLEANING IS VERIFIED BY INSPECTION.

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

INSPECTION VERIFIES PROPER SWITCH ASSEMBLY AND PHYSICAL DIMENSIONS. SOLDERING IS INSPECTED DIRECTLY TO NHB 5300.4 (3A) CRITERIA. INSPECTION UNDER 10X MAGNIFICATION IS PERFORMED PRIOR TO CLOSEOUT.

CRITICAL PROCESSES (FAILURE CAUSE b, e)

MONITORING OF SOLDERING AND OPERATOR CERTIFICATIONS IS PERFORMED PER QC AUDIT INSTRUCTION.

TESTING

ACCEPTANCE TESTS ARE OBSERVED AND VERIFIED BY QC.

APPENDIX A ITEM 3 CONT'D

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

PARTS SEGREGATED/SEALED IN PLASTIC BAGS. PARTS ARE PACKAGED, PROTECTED , AND VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS.

(D) FAILURE HISTORY

FAILURE MODE: LOSS OF ANNUNCIATOR/LENS ILLUMINATION, FAILS TO ILLUMINATE

CAR A9803
DURING PANEL FUNCTIONAL TEST, THE PUSHBUTTON SWITCH ANNUNCIATOR LENS FAILED TO ILLUMINATE. TERMINAL 1 SPRING CONTACT REMAINED DEPRESSED, PREVENTING CONTACT. FAILURE CAUSED BY A MISSING INTERNAL PART (PUSHBUTTON STOP) WHICH ALLOWED EXCESSIVE OVERTRAVEL OF PUSHBUTTON ASSEMBLY. ASSEMBLY TRAVELER CHANGED TO INCLUDE INSPECTION FOR "STOP" INSTALLATION.

CAR AB5924
DURING ORBITER OV-102 CHECKOUT TESTS, IT WAS OBSERVED THAT THE PUSHBUTTON SWITCH LENS PROTRUDED. THIS FAILURE CAUSED BY DAMAGE TO THE SPRING USED TO HOLD THE LENS IN PLACE. THIS WIRE SPRING WAS DAMAGED BY THE USE OF A FOREIGN OBJECT, POSSIBLY A SCREWDRIVER. PROCEDURES NOW CAUTION OPERATORS ABOUT THE USE OF FOREIGN OBJECTS WHEN WORKING ON THESE SWITCHES.

CAR AB8835
DURING A PANEL FUNCTIONAL TEST, IT WAS OBSERVED THAT THE PUSHBUTTON LENS WAS CRACKED. MANUFACTURER RETOOLED (GLASS TO PLASTIC LENS) AND INADVERTENTLY OMITTED A SPACER. MANUFACTURING REVISED DRAWINGS TO INCLUDE AN INSPECTION STEP. ALL DEFECTIVE SWITCHES RETURNED FOR CORRECTIVE ACTION. SUBSEQUENT FAILURE, CAR AC9772 (CRACKED LENS) REQUIRED DRAWING REVISION TO SPECIFY A NEW METHOD OF INSTALLING SPACER.

FAILURE MODE: FAILS OPEN, PREMATURE OPEN

CAR AB0862
DURING MANUFACTURING VERIFICATION TEST AT THE PANEL LEVEL, (PRE ATP) ONE POLE OF A PUSH BUTTON SWITCH FAILED TO CLOSE. CAUSED BY SMALL AMOUNT OF CONTAMINATION WITHIN THE SWITCH. SIMILAR PROBLEM PREVIOUSLY ENCOUNTERED AND RESOLVED. THIS SWITCH WAS BUILT PRIOR TO THE IMPLEMENTATION OF CORRECTIVE ACTION GENERATED BY CAR A7170. CORRECTIVE ACTION, FOR CAR A7170,

APPENDIX A ITEM 3 CONT'D

INCLUDED MODIFICATIONS TO THE SWITCH SOLDERING FIXTURE TO PRELUDE ENTRY OF FLUX CONTAMINATION AND THE ADDITION OF ANOTHER 250 CYCLES OF PRE-ATP RUN IN.

CARS AB8914 AND AC6374
DURING SHUTTLE AVIONICS INTEGRATION LAB (SAIL) SYSTEMS TEST, ONE OF FOUR SWITCH POLES SLOW TO TRANSFER. TECHNICIAN NOT DEPRESSING SWITCH ENOUGH. MANUFACTURER IN FEB, 1975 IMPOSED A NEW MANUFACTURING SEQUENCE THAT ASSURES ALL FOUR POLES TRANSFER CLOSER TO EACH OTHER.

THERE ARE NO UNRESOLVED GENERIC ISSUES.

PREPARED BY:		**APPROVED BY:**	**APPROVED BY (NASA):**
DESIGN	H. TURNER	DES	SSM
RELIABILITY	M. HOVE	REL	REL
QUALITY	J. COURSEN	QE	QE