INTRODUCTION TO APPENDIX C

10/28/87

ITEM 1 -	HYBRID RELAY	MC455-0135
ITEM 2 -	GENERAL PURPOSE RELAY	MC455-0129
ITEM 3 -	LATCHING RELAY	MC455-0128
ITEM 4 -	RELAY MODULE	MC455-0131
ITEM 5 -	GENERAL PURPOSE CONTACTOR	MC455-0134
ITEM 6 -	POWER CONTACTOR	MC455-0126

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

FAILURE MODE / Failure Cause	HYBRID RELAY	GEN PURP RELAY	LATCHING RELAY	RELAY MODULE	GEN PURP CONTACTOR	POWER CONTACTOR
OPEN, FAILS TO CONDUCT, INADVERTANTLY OPENS, FAILS TO TRANSFER						
(a) Piece Part Failure	X	X	X	X	X	X
(b) Contamination	X	X	X	X	X	X
(c) Vibration	X	X	X	X	X	X
(d) Mechanical Shock	X	X	X	X	X	X
(e) Processing Anomaly	X	X	X	X	X	X
(f) Thermal Stress	X	X	X	X	X	X
CLOSED, FAILS TO OPEN, PREMATURELY CLOSES, SHORTS CONTACT-TO-CONTACT						
(a) Piece Part Failure	X	X	X	X	X	X
(b) Contamination	X	X	X	X		X
(c) Vibration	X	X	X	X	X	X
(d) Mechanical Shock	X	X	X	X	X	X
(e) Processing Anomaly	X	X	X	X	X	X
(f) Thermal Stress	X	X	X	X	X	X
SHORT TO STRUCTURE (GROUND)						
(a) Piece Part Failure	X	X	X	X	X	
(c) Vibration	X	X	X	X	X	
(d) Mechanical Shock	X	X	X	X	X	
(e) Processing Anomaly	X	X	X	X	X	
SHORT POLE-TO-POLE						
(a) Piece Part Failure	X	X	X	X		
(c) Vibration	X	X	X	X		
(d) Mechanical Shock	X	X	X	X		
(e) Processing Anomaly	X	X	X	X		

APPENDIX C ITEM 6 - POWER CONTACTOR
MC455-0126-0001

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

(A) DESIGN

THE POWER CONTACTOR IS DESIGNED TO TRANSFER 500 AMP 28 VOLT POWER. IT IS ALSO DESIGNED TO INTERRUPT A CURRENT LOAD OF 6000 AMPS AT 28 VOLTS. THE MAIN AND AUXILIARY CONTACTS ARE TRANSFERRED BY A SHUTTLE MOVED VIA A CAM MECHANISM DRIVEN BY A DC MOTOR. THE MAIN CONTACTS UTILIZE TUNGSTEN CONTACTS TO MAKE AND BREAK THE ARC CREATED BY THE LARGE CURRENT. THE MAIN CONTACTS ALSO USE COPPER FINGERS, CIRCULARLY ARRANGED AROUND THE CONTACT, WHICH SLIDE OVER A STATIONARY COPPER BASE. THIS PROVIDES FOR LARGE CURRENT CARRYING CAPABILITY WITH LOW CONTACT RESISTANCE CHARACTERISTICS THUS REDUCING POWER LOSSES AND HEATING.

THE POWER CONTACTOR IS ENCASED WITHIN A SEALED METAL CASE. SEALING IS ACCOMPLISHED BY A METAL GASKET, MEETING THE REQUIREMENT OF 5 X 10^{-7} SCC/SEC.. THE POWER CONTACTOR IS DESIGNED, TESTED AND INSPECTED TO MEET THE REQUIREMENTS OF THE ROCKWELL INTERNATIONAL SPECIFICATION MC455-0126.

(B) TEST

QUALIFICATION/CERTIFICATION TEST AND ANALYSIS ARE COMPLETED AND INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
LEAKAGE (5X10^{-7} SCC/SEC)		X			X	
DIELECTRIC STRENGTH (DWV, 1000 Vrms FOR MAIN CONTACTS & 500 Vrms FOR AUX. CONTACTS & MOTOR CIRCUIT)		X			X	
INSULATION RESISTANCE (IR, 500 VDC)		X			X	
FUNCTIONAL TESTS	X	X			X	
TERMINAL STRENGTH	X				X	
OPERATING LIFE (5000 CYCLES)	X				X	
VIBRATION (0.15 g^2/HZ)	X		X			
QUAL/ACCEPTANCE (QAVT AT 0.067 g^2/HZ)	X		X			
THERMAL SOAK (720 HRS, 500 AMPS, AT 160 ^{o}F & 1X10^{-6} TORR, CYCLE POWER)	X					X
RUPTURE TEST (6000 AMPS AT 28 VOLTS)	X				X	
SHOCK (20 G)				X		

APPENDIX C ITEM 6 CONT'D

ACCEPTANCE AND SCREENING

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

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
LEAKAGE (5×10^{-7})		X			X	
DIELECTRIC STRENGTH (DWV, 1250 Vrms FOR MAIN CONTACTS & 500 Vrms FOR AUX. CONTACTS & MOTOR CIRCUIT)		X			X	
INSULATION RESISTANCE (IR, 500 VDC)		X			X	
CONTACT VOLTAGE DROP		X			X	
FUNCTIONAL TESTS (OPERATING VOLTAGE, MOTOR CURRENT, TRANSFER TIME)	X	X			X	
BURN-IN (250 CYCLES)					X	
VIBRATION	X		X			

ACCEPTANCE TEST AT THE NEXT ASSEMBLY:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
FUNCTIONAL	X	X			X	
CONTINUITY		X			X	
INSULATION RESISTANCE		X			X	
VIBRATION (0.04 g^2/HZ)	X		X			

(C) INSPECTION

RECEIVING INSPECTION (FAILURE CAUSE a,b)

RECEIVING INSPECTION IS PERFORMED ON MATERIALS USED FOR CONTACTORS. MATERIAL CERTIFICATIONS ARE CONTROLLED AND REVIEWED BY RECEIVING INSPECTION. 100% DETAIL INSPECTION VERIFICATION IS PERFORMED ON INCOMING PARTS. CASTINGS ARE 100% DIMENSIONALLY AND VISUALLY INSPECTED BY RECEIVING INSPECTION.

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CONTAMINATION CONTROL (FAILURE CAUSE b)

QUALITY CONTROL (QC) VERIFIES THAT REQUIRED PROCEDURES AND SHOP PRACTICES ARE UTILIZED FOR CONTAMINATION CONTROL. PARTS ARE MAINTAINED IN PLASTIC BAGS FROM RECEIVING THROUGH ASSEMBLY STAGES. A FINAL VISUAL INSPECTION IS PERFORMED PRIOR TO SEALING FOR CONFORMANCE TO CLEANLINESS REQUIREMENTS.

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

VISUAL INSPECTIONS ARE PERFORMED DURING ASSEMBLY STAGES. CRITICAL DIMENSIONS AND PROCESSES ARE INSPECTED FOR COMPLIANCE TO THE PROCUREMENT SPECIFICATION AND APPLICABLE DRAWINGS. TORQUE REQUIREMENTS ARE VERIFIED BY INSPECTION. INSPECTION VERIFIES LOCK WIRING OF EXTERNAL CONNECTORS.

NONDESTRUCTIVE EVALUATION (NDE) (FAILURE CAUSE a,b,e)

THE STRUCTURAL CASTING HAS RADIOGRAPHIC AND PENETRANT INSPECTION CERTIFICATIONS.

CRITICAL PROCESSES (FAILURE CAUSE a,b,e)

SOLDERING/CERTIFICATION PERFORMED IN ACCORDANCE WITH NHB 5300.4(3A) REQUIREMENTS.

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

PROOF PRESSURE TEST PERFORMED AFTER MACHINING OPERATION AND VERIFIED BY QUALITY CONTROL (QC). THE ACCEPTANCE TEST IS PERFORMED BY QC.

HANDLING/PACKAGING (FAILURE CAUSE c,d)

IN-PROCESS OPERATIONS ARE VERIFIED BY QC TO PROTECT PARTS AND PRECLUDE MISHANDLING. PARTS ARE PACKAGED, PROTECTED, AND VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS AT THE SUPPLIER.

(D) FAILURE HISTORY

FAILURE MODE: OPEN

CAR AC7702
DURING ACCEPTANCE VIBRATION TEST OF THE NEXT ASSEMBLY LEVEL, THE POWER CONTACT FAILED TO TRANSFER FROM OPEN POSITION. THIS FAILURE WAS ISOLATED TO A MS ROLL PIN WHICH HAD BACKED OUT OF A DRIVE GEAR

APPENDIX

APPENDIX C ITEM 6 CONT'D

OF THE BOARD CAM. THIS CONDITION ALLOWED THE BOARD OR SHUTTLE TO BIND-UP. ANALYSIS DISCLOSED THAT THE ROLL PIN HAD BEEN REUSED, I.E. INSTALLED ONCE, REMOVED AND RE-INSTALLED. THIS WAS IN VIOLATION OF ESTABLISHED PROCEDURES AND WAS CONSIDERED TO BE AN ISOLATED INSTANCE.

CAR AB3969 (NONFLIGHT CONFIGURATION)
DURING SAIL SYSTEMS TEST ONE POWER CONTACTOR FAILED TO TRANSFER TO THE CLOSED POSITION. FAILURE ANALYSIS DISCLOSED A SOLDER PARTICLE IN THE CAM GEAR. THE SOLDER PARTICLE WAS CAUSED BY EXCESSIVE HEATING WHICH ALLOWED SOLDER REFLOW. THIS CONDITION WAS CREATED BY A HIGH RESISTANCE CONNECTION BETWEEN THE CONTACTOR TERMINAL AND THE NEXT ASSEMBLY BUS BAR. THE BUS BAR DID NOT REST ON THE TERMINAL AS REQUIRED AND A STEEL WASHER WAS UTILIZED.

THE NEXT ASSEMBLY FLIGHT CONFIGURATIONS WERE NOT ALLOWED TO UTILIZE STEEL WASHERS. FURTHER, ALL FLIGHT ASSEMBLIES WERE INSPECTED TO ASSURE PROPER ALIGNMENT. DRAWINGS FOR OV-099, OV-103 AND SUBSEQUENT ORBITERS WERE REVISED TO INCLUDE A DETAILED VIEW WHICH DELINEATES THE BUS BAR AND CONTACTOR TERMINAL BUILDUP.

FAILURE MODE: DIELECTRIC STRENGTH BREAKDOWN

CAR'S AB6282 AND AC3655
DURING ACCEPTANCE TESTS AT THE NEXT ASSEMBLY LEVEL, TWO INSTANCES OF DIELECTRIC BREAKDOWN FAILURES WERE EXPERIENCED WHICH WERE ISOLATED TO THE POWER CONTACTOR MOTOR CIRCUITRY. THE FIRST FAILURE WAS ISOLATED TO ONE OF THE ARMATURE WINDINGS SHORTING TO A SEGMENT OF THE ARMATURE. CONDITION WAS CAUSED BY WORKMANSHIP WHERE A WINDING WAS TRAPPED BETWEEN THE PLASTIC WEDGE AND ADJACENT ARMATURE SEGMENT. THE SECOND FAILURE WAS ALSO ATTRIBUTED TO WORKMANSHIP WHERE A WINDING WAS WOUND TOO TIGHT AROUND THE ARMATURE, RESULTING IN SUBSEQUENT BREAKDOWN.

THE PRODUCTION TRAVELERS FOR THE ARMATURE WERE REVISED TO INCLUDE AN INSPECTION UNDER 10X MAGNIFICATION PRIOR TO IMPREGNATION OF THE WINDINGS. THIS WAS IMPLEMENTED IN MAY OF 1980.

POWER CONTACTORS DELIVERED ARE CONSIDERED SATISFACTORY FOR THEIR INTENDED USAGE AS THE NEXT ASSEMBLY LEVEL ACCEPTANCE TEST SERVES AS AN EFFECTIVE SCREEN.

PREPARED BY:		APPROVED BY:	APPROVED BY (NASA):
DESIGN	R. THOMAS	DES 11/4/87	SSM 11/3/87
RELIABILITY	M. HOVE	REL 11-3-87	REL
QUALITY	J. COURSEN	QE	QE

A4P