

05/19/88

APPENDIX H ITEM 1 - PYROTECHNIC INITIATOR CONTROLLER  
MC450-0018-000X

DISPOSITION & RATIONALE

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

(A) DESIGN

FUNCTIONAL DESCRIPTION

THE PYROTECHNIC INITIATOR CONTROLLER (PIC) CONTAINS A SINGLE CHANNEL, CAPACITOR DISCHARGE ENERGY, PYRO-FIRING CIRCUIT; AND BUILT-IN SELF TEST CIRCUITRY FOR A PYROTECHNIC INITIATOR RESISTANCE TEST, AND A PYRO-FIRING LOAD TEST. THE ELECTRICAL, ELECTRONIC AND ELECTRICAL MECHANICAL COMPONENTS ARE SELECTED FROM OR IN ACCORDANCE WITH THE ORBITER PREFERRED PARTS LIST (OPPL) REQUIREMENTS. COMPONENT APPLICATIONS ARE EVALUATED TO ASSURE COMPLIANCE WITH DERATING REQUIREMENTS.

PHYSICAL DESCRIPTION

THE PIC DESIGN CONSISTS OF TWO DOUBLE-SIDED PRINTED CIRCUIT BOARDS ATTACHED TO AN ALUMINUM FRAME AND HARD WIRED TO AN OUTPUT CONNECTOR. THE DESIGN UTILIZES DISCRETE SOLID-STATE COMPONENTS TO SATISFY CIRCUIT REQUIREMENTS.

DESIGN EVOLUTION

THE CERTIFIED PART NUMBERS ARE MC450-0018-0001 THROUGH -0008.

THE -0001 CONFIGURATION WAS ESTABLISHED BY THE ORIGINAL PROCUREMENT SPECIFICATION.

THE -0002 CONFIGURATION IS IDENTICAL TO THE -0001 EXCEPT FOR LARGER EXTRACTOR TOOL HOLE SIZE AND A STATIC CHARGE BLEED RESISTOR VALUE CHANGE (22 MEGOHMS IN LIEU OF 220K OHMS).

THE -0003 CONFIGURATION IS IDENTICAL TO THE -0002 EXCEPT THAT MORE OF THE EXISTING DISCRETE COMPONENTS ARE BONDED TO THE PRINTED CIRCUIT BOARDS. ALSO, A LONGER QUALIFICATION VIBRATION LEVEL WAS REQUIRED.

THE -0004 AND -0005 CONFIGURATIONS ARE IDENTICAL TO THE -0002 AND -0003, RESPECTIVELY, EXCEPT FOR HIGHER RATED (WITHSTAND HIGHER VOLTAGES) FIRE 1 AND FIRE 2 POWER TRANSISTORS, A RESISTOR VALUE CHANGE (A1R22 - 5.6K OHMS FROM 56K OHMS) AND AN ADDED RESISTOR IN SERIES WITH THE COLLECTOR TRANSISTOR. THE -0004 CONFIGURATION IS INTENDED FOR ORBITER USAGE AND THE -0005 CONFIGURATION HAS ENHANCED VIBRATION CHARACTERISTICS FOR SRB/ET/KSC USAGE. THE -0004 AND -0005 PIC'S INTENDED FOR MID-BODY APPLICATIONS ARE ALSO SUBJECTED TO A THERMAL BAKE TO PRECLUDE OUT-GASSING.

05/19/88

APPENDIX H ITEM 1 CONT'D

THE -0006 CONFIGURATION IS IDENTICAL TO THE -0005 EXCEPT THAT EMI FILTERS ON THE ARM SIGNAL POSITIVE AND NEGATIVE INPUTS HAVE BEEN DISCONNECTED FROM THE CIRCUIT.

THE -0007 CONFIGURATION IS IDENTICAL TO THE -0005 EXCEPT THAT RUGGEDIZED EMI FILTERS HAVE BEEN INSTALLED ON THE ARM SIGNAL POSITIVE AND NEGATIVE INPUTS. THE REPLACEMENT FILTERS ARE NECESSARY TO WITHSTAND THE HIGHER VIBRATION LEVELS ENCOUNTERED IN THE RANGE SAFETY DISTRIBUTOR AND SRB CONTROLLER LRU'S.

THE -0008 CONFIGURATION WAS PREVIOUSLY CERTIFIED AS CONTRACTOR FURNISHED EQUIPMENT. IT IS NOW CERTIFIED AS GOVERNMENT FURNISHED EQUIPMENT. THE -0008 CONFIGURATION IS IDENTICAL TO THE -0007 EXCEPT THAT A CAPACITOR TYPE WAS CHANGED. THE -0008 HAS A TANTALUM CASE/TANTALUM CORE CAPACITORS INSTEAD OF THE SILVER CASE/TANTALUM CORE CAPACITORS. THIS CHANGE PRECLUDES THE MIGRATION OF SILVER FROM THE CASE TO THE CORE CAUSING THE CAPACITOR TO SHORT OUT. THIS CHANGE IS NOT CONSIDERED SIGNIFICANT ENOUGH TO INVALIDATE THE PREVIOUS CERTIFICATION, THEREFORE, THE -0008 WAS CERTIFIED BY SIMILARITY.

TO DATE 2,672 PIC'S HAVE BEEN PROCURED AS EITHER CFE (CONTRACTOR - FURNISHED EQUIPMENT) OR GFE (GOVERNMENT-FURNISHED EQUIPMENT) COMPONENTS. A TOTAL OF 121 PIC'S ARE UTILIZED FOR EACH FLIGHT AS FOLLOWS:

ORBITER	53
SOLID ROCKET BOOSTER	38
EXTERNAL TANK	2
GROUND PIC'S	28

## APPENDIX II ITEM 1 CONT'D

## (B) TEST

## QUALIFICATION/CERTIFICATION

CERTIFICATION TESTING AND ANALYSIS ARE COMPLETED AND APPROVED.  
 QUALIFICATION TESTS PERFORMED INCLUDE THE FOLLOWING:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
ACCEPTANCE	X	X	X		X	X
HUMIDITY		X			X	
THERMAL VACUUM (20 TO 165 °F AT $1 \times 10^{-6}$ TORR, 5 CYCLES, 240HRS)						X
QUAL/ACCEPTANCE (QAVT AT $0.067 \text{ g}^2/\text{HZ}$ )	X		X		X	
RANDOM VIBRATION ( $0.5 \text{ g}^2/\text{HZ}$ , 48-MIN/ 3-AXES AND 55 MIN/3-AXES)	X		X		X	
ACOUSTIC NOISE (250 SECONDS)	X	X			X	
DESIGN SHOCK (20G, 18 DROPS/AXIS)				X		
ORDINANCE SHOCK (20 TIMES/AXIS, 2000 g MAXIMUM)				X		
LIFE (5,000 ON/OFF CYCLES, CYCLE EVERY 10 SECONDS)	X				X	
ELECTROMAGNETIC INTERFERENCE	X					
LIGHTNING (2 SHOCKS, 100 & 600 USEC)	X				X	
SALT FOG (48 HOURS, 5% BY WEIGHT)		X			X	
ELECTROMAGNETIC INTERFERENCE (QUAL WITH EMI FILTERS REMOVED)	X					
QUAL/ACCEPTANCE (QAVT, 55 MIN/X AXIS 32.3 grms, Y AXIS 29.5 grms & Z AXIS 29.5 grms COMPOSITES)	X		X		X	

## APPENDIX H ITEM 1 CONT'D

## ACCEPTANCE AND SCREENING

ALL PRODUCTION UNITS ARE SUBJECTED TO 100% ACCEPTANCE TESTING WHICH INCLUDE:

TEST	CAUSE CONTROL					
	a	b	c	d	e	f
VISUAL EXAMINATION	X	X				
INSULATION RESISTANCE		X			X	
DIELECTRIC WITHSTANDING VOLTAGE		X			X	
FUNCTIONAL (INCLUDING ARM CURRENT, FIRE 1 & FIRE 2 CURRENT, OUTPUT WAVESHAPE, OUTPUT LEAKAGE CURRENT, LOAD TEST VOLTAGE, RESISTANCE TEST & CAPACITOR ANALOG VOLTAGE)	X				X	
VIBRATION	X		X		X	
THERMAL						X
FUNCTIONAL (AGAIN AFTER AVT & ATT)	X				X	

## (C) INSPECTION

## RECEIVING INSPECTION (FAILURE CAUSE e)

CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES. RECEIVING INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATIONS OF INCOMING PARTS. ELECTRONIC COMPONENTS ARE FUNCTIONALLY TESTED PRIOR TO ISSUE.

## CONTAMINATION CONTROL (FAILURE CAUSE b)

FABRICATION IS ACCOMPLISHED IN A DEDICATED AREA WHICH IS ENVIRONMENTALLY CONTROLLED AND HAS LIMITED ACCESS. CONTAMINATION CONTROL PROCEDURES ARE VERIFIED BY INSPECTION.

## APPENDIX H ITEM 1 CONT'D

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

QUALITY CONTROL VERIFIES PROPER MAINTENANCE OF THE WORK AREA CONTROLS. ASSEMBLY/INSTALLATION OPERATIONS VERIFIED BY INSPECTION. PRINTED CIRCUIT BOARDS ARE INSPECTED UNDER MAGNIFICATION AFTER EACH SOLDERING PROCESS FOR CONFORMANCE TO REQUIREMENTS. PARTS IDENTIFICATION VERIFIED BY INSPECTION. ELECTROSTATIC DISCHARGE PROTECTION IS MAINTAINED. MEASUREMENT STANDARDS AND PROCESSING EQUIPMENT VERIFIED BY INSPECTION. ELECTRICAL TERMINATIONS VERIFIED BY INSPECTION.

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

PRINTED CIRCUIT BOARDS / SOLDERING INSPECTED UNDER MAGNIFICATION.

## CRITICAL PROCESSES (FAILURE CAUSE b,e)

ALL CRITICAL PROCESSES AND CERTIFICATIONS ARE MONITORED AND VERIFIED BY INSPECTION. CRITICAL PROCESSES ARE SOLDERING, CONFORMAL COATING AND BONDING.

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

ACCEPTANCE TEST PROCEDURE IS OBSERVED AND VERIFIED BY QUALITY CONTROL.

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

PARTS PACKAGED AND PROTECTED ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS, INCLUDING ELECTROSTATIC DISCHARGE.

## (D) FAILURE HISTORY

MC450-0018-0002 CONFIGURATION

FAILURE MODE: LOSS OF OUTPUT

CAR'S A9864-PRIME, A9865, A4415 AND AB0409 DURING ACCEPTANCE FUNCTIONAL LOAD TEST, THE PIC FAILED THE TIME DELAY REQUIREMENTS. THE FAILURE ANALYSIS ATTRIBUTED THE PROBLEM TO A COMBINATION OF MARGINAL SELECTION OF THE SELECT AT TEST RESISTORS, TEST TOOL VARIATIONS AND TEST SETUP TOLERANCES. CORRECTIVE ACTION CONSISTED OF PRODUCTION TEST PROCEDURE REVISION WHICH CONTROL RESISTOR SELECTION AND TIGHTENING OF TOLERANCES OF PRODUCTION LOAD TEST TIME. ALL -0002 AND -0003 PIC CONFIGURATIONS WERE MODIFIED TO -0004 AND -0005 BY THE MANUFACTURER. ALL PIC'S WERE SUBJECTED TO ACCEPTANCE TEST WHICH WILL DETECT MARGINAL TIME DELAY PARAMETERS.

05/19/88

APPENDIX H ITEM 1 CONT'D

CAR AC3269

DURING A SAIL TEST, THE PIC OUTPUT VOLTAGE WAS ERRATIC, A DECAYING VOLTAGE THAT WITHIN SECONDS RETURNED TO NORMAL. THE CONDITION REPEATED SEVERAL TIMES. ANALYSIS WAS INCONCLUSIVE, NO CONDITION WITHIN THE PIC COULD POSITIVELY ACCOUNT FOR THE ANOMALY. THE SUSPECTED CAUSE WAS A HIGH IMPEDANCE SHORT WHICH OVERLOADED THE PIC CIRCUIT. THIS WAS POSSIBLY RELATED TO A DENDRITE GROWTH FOUND ON FIVE CAPACITORS WITHIN THE PIC WHICH COULD HAVE MANIFESTED ITSELF AS A HIGH IMPEDANCE SHORT AND THEN DISSIPATE IN THE PIC CIRCUIT. ALTHOUGH THE ACTUAL CAUSE OF THE PROBLEM WAS LATER DETERMINED TO HAVE BEEN A SAIL FACILITY PROBLEM, THE -0008 CONFIGURATION INCORPORATED A CHANGE FROM SILVER/TANTALUM TO TANTALUM/TANTALUM CAPACITORS WHICH GREATLY REDUCES THE LIKELIHOOD OF DENDRITE GROWTH CAUSING A SHORTED CAPACITOR FAILURE. THE ANOMALY IS UNDETECTABLE IN FLIGHT SINCE THE LAST CAPACITOR VOLTAGE TEST IS CONDUCTED DURING GROUND CHECKOUT TESTING ON SOME PIC'S.

MC450-0018-0003 CONFIGURATION

FAILURE MODE: LOSS OF OUTPUT, PREMATURE OUTPUT

CAR A6285

DURING ATP, ELEVEN PIC'S FAILED THE INSULATION RESISTANCE REQUIREMENTS. ANALYSIS ISOLATED THE BREAKDOWN TO MARKING INK (NAZ-DAR) USED ON PRINTED CIRCUIT BOARDS (PCB'S) THAT WAS CONDUCTIVE BETWEEN CIRCUITS ON PCB'S. THE SUPPLIER CORRECTIVE ACTION WAS TO REVISE PCB DRAWINGS TO SPECIFY CAT-L-INK FOR MARKINGS AND REWORK ALL BOARDS REMOVING NAZ-DAR INK FROM AREAS THAT WOULD TEND TO ELECTRICALLY SHORT BETWEEN ADJACENT CIRCUITS. ACCEPTANCE TESTS WOULD READILY DETECT DEFECTIVE BOARDS.

MC450-0018-0004 CONFIGURATION

FAILURE MODE: LOSS OF OUTPUT

CAR AB6861, AB4627

DURING QUAL TEST VIBRATION OF THE MIDBODY JETTISON CONTROLLER ASSEMBLY (MJCA), THE PIC FAILED TO PRODUCE AN OUTPUT VOLTAGE. ANALYSIS DISCLOSED A BROKEN BASE LEAD TO A TRANSISTOR. THE FAILURE WAS ATTRIBUTED TO EXCESSIVE VIBRATION IMPOSED ON THE PIC DURING MJCA TESTS, WHERE THE MJCA EXHIBITED HIGH Q'S. CORRECTIVE ACTION REQUIRED MODIFICATION OF THE MJCA FOR PIC'S USED ON OV-102 AND OV-099, PIC CONFIGURATION -0005 (COMPONENTS EPOXIED TO PRINTED CIRCUIT BOARDS) IS USED ON OV-103 AND SUBS.

05/19/88

APPENDIX H ITEM 1 CONT'D

THE MJCA WAS NOT USED FOR STS-1, BUT THE 8 PIC'S USED ON STS-1 WERE DETERMINED SATISFACTORY FOR USE.

THE SHUTTLE PROGRAM HAS EXPERIENCED ONLY 18 PIC FAILURES WHICH COULD RESULT IN EITHER A LOSS OF OUTPUT OR A PREMATURE OUTPUT. WITH 2,672 PIC'S HAVING BEEN PROCURED, THIS REPRESENTS A VERY LOW FAILURE RATE ESPECIALLY IN VIEW OF THE FACT THAT ALL BUT ONE OF THESE FAILURES WAS DETECTED IN EITHER ATP OR QUALIFICATION TESTING. NO PIC FAILURES HAVE OCCURRED IN FLIGHT.

APPROVED BY (NASA):

SUBSYSTEM MANAGER  
RELIABILITY  
QUALITY

*J. E. Starn 6/24/88*  
*Robert Wood 6/24/88*

THE PYRO INITIATOR CONTROLLERS ARE SUPPLIED TO THE SHUTTLE PROGRAM AS GOVERNMENT FURNISHED EQUIPMENT, AND, THUS, ROCKWELL DESIGN ENGINEERING DOES NOT HAVE DIRECT RESPONSIBILITY FOR THIS HARDWARE. ACCORDINGLY, THIS DISPOSITION AND RATIONALE STATEMENT IS SIGNED BY THE RESPONSIBLE NASA PERSONNEL ONLY.