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APPENDIX I - NASA STANDARD INITIATOR (NSI)  
SEB-26100001-XXX

**DISPOSITION & RATIONALE**

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

(A) DESIGN

**FAILURE MODE: FAIL TO FUNCTION/LOW OUTPUT.**  
THE NSI HAS RECOMMENDED FIRING CURRENT OF 5 AMP AND AN ALL-FIRE CURRENT OF 3.5 AMP. THE BODY AND HEADER ARE INCONEL 718. CONTACT PINS ARE GLASSED TO THE HEADER, AND THE HEADER IS WELDED TO THE BODY. THIS ENABLES THE NSI TO HAVE AN INTERNAL PRESSURE CAPABILITY OVER 35,000 PSI. OUTPUT PRESSURE IS  $650 \pm 125$  PSI. CONTACT PINS ARE CONNECTED TO A 1-OHM RESISTANCE SINGLE BRIDGEWIRE. A FLANGE-TYPE WELDED WASHER PROVIDES A HERMITICALLY SEALED INTERFACE WHEN INITIATOR IS PERMANENTLY MATED WITH ORDNANCE DEVICES. THE NSI HAS CERAMIC INSULATION, POSITIVE LOCKING CONNECTORS, AND A SERVICE LIFE OF 10 YEARS.

**FAILURE MODE: INADVERTENT OPERATION.**  
THE NSI IS A ONE-WATT, ONE-AMP, NO-FIRE INITIATOR AND HAS ELECTROSTATIC PROTECTION AND ISOLATION UP TO 25,000 VOLTS. FIRING LEADS ARE TWISTED SHIELDED PAIRS OF WIRES FOR PROTECTION AGAINST EMI AND RFI. THE INTERNAL COMPONENTS OF THE INITIATOR ARE COMPOSED OF NONREACTIVE MATERIALS. IT IS DESIGNED TO WITHSTAND LIGHTNING STRIKES AND ELECTROMAGNETIC FIELDS.

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(B) TEST

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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	g	h
<b>CAUSES</b>								
a Handling damage	e Thermal stress							
b Contamination of mix	f Processing anomaly							
c Shock/vibration	g Low firing current (3.5A)							
d Electrostatic discharge	h EMI/RFI (premature firing)							
DIELECTRIC STRENGTH TEST (LEAK CURRENT <500 MICROAMPS)				X				X
NO-FIRE CURRENT TEST 1 AMP - 5 MIN. @ -260°F, AMB, +300°F					X	X		
CONTINUITY CURRENT -25 CYCLES (50 ± 5 MILLIAMPS)	X					X		
HUMIDITY - 10 CYCLES @ 24 HRS/EA (95% RH @ +160°F)		X				X		
VIBRATION, HI-TEMP (+300°F; 27.5 GRMS)		X	X		X	X		
VIBRATION, LO-TEMP (-260°F; 27.5 GRMS)		X	X		X	X		
TEMP CYCLE - 20 CYCLES (+300°F; -260°F)	X	X			X	X		
SHOCK TEST - 6 CYCLES (100 G'S)			X			X		
BRIDGEWIRE TEST & INSUL. RESISTANCE	X		X			X		
FIRING, VACUUM & HI-TEMP (+300°F)		X				X		
FIRING, VACUUM & LO-TEMP (-260°F)		X				X		
ALL FIRE CURRENT (AMBIENT, +300°F, -260°F)		X			X	X	X	
8-FOOT DROP TEST	X					X		
RFI EMISSIONS TEST			X					X
*100% ELECTROSTATIC SENSITIVITY TEST PERFORMED DURING ACCEPTANCE TESTING								

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ACCEPTANCE AND SCREENING

QUALIFICATION AND PRODUCTION LOTS ARE SUBJECTED TO ACCEPTANCE TESTING WHICH INCLUDES:

TEST	CAUSE CONTROL							
	a	b	c	d	e	f	g	h
VISUAL EXAMINATION	X					X		
X-RAY	X	X				X		
BRIDGEWIRE RESISTANCE (1.05 ± .10 OHMS W/20ma MAX)	X		X			X		
HERMETIC SEAL TEST (1 X 10 <sup>-6</sup> CC He/SEC)	X					X		
INSULATION RESISTANCE (>2 MEGOHMS @ 500 VDC)	X		X			X		
ELECTROSTATIC SENSITIVITY (500 pf CAPACITOR @ 25K VDC)						X		X
NEUTRON RADIOGRAPHY	X	X				X		
<u>DLAT</u>								
AMBIENT FIRING, (10% OF LOT)	X	X				X	X	
-260°F FIRING, (20 UNITS)	X	X				X	X	
100 UNIT DLAT SEQUENCE								
TEMP. CYCLE -20 CYCLES (-260°F TO +300°F)	X					X	X	
LOW TEMP. VIBRATION (-260°F, 7½ MIN/AXIS; 27.5 GRMS)	X		X			X	X	
THERMAL SHOCK -4 CYCLES (-320°F; 4TH CYCLE 11 HRS.)	X					X	X	
FIRING (-420°F; PIC)	X	X				X	X	

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(C) INSPECTION

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RECEIVING INSPECTION

ALL RAW MATERIALS ARE VERIFIED BY RECEIVING INSPECTION TO ASSURE SPECIFIC SHUTTLE REQUIREMENTS ARE SATISFIED.

CONTAMINATION CONTROL

CONTAMINATION CONTROL AND CORROSION PROTECTION PROCESSES VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

VISUAL INSPECTION, IDENTIFICATION PERFORMED, AND PARTS PROTECTION VERIFIED BY INSPECTION. SELECTED MANUFACTURING/ASSEMBLY STEPS ARE IDENTIFIED BY NASA QUALITY ASSURANCE AND VERIFIED BY GOVERNMENT INSPECTION AS MANDATORY INSPECTION POINTS (MIPS).

NONDESTRUCTIVE EVALUATION

PARTS ARE X-RAYED AND N-RAYED TO VERIFY CORRECT ASSEMBLY AND PRESENCE OF ALL DETAIL PARTS AND EXPLOSIVES. X-RAYS AND N-RAYS ARE REVIEWED BY VENDOR, DCAS, NASA QUALITY, AND ENGINEERING.

CRITICAL PROCESSES

ALL MANUFACTURING PROCESSES, SUCH AS, WELDING, HEAT TREATING, PASSIVATION, AND ANODIZING ARE VERIFIED BY INSPECTION.

TESTING

ATP IS VERIFIED IN ACCORDANCE WITH PROCEDURE.

HANDLING/PACKAGING

HANDLING, PACKAGING, AND STORAGE ENVIRONMENT ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY

FIAR'S JND0013; JND0014

FAILURE - UNIT REJECTION FOR (A) OUT-OF-SPECIFICATION BRIDGEWIRE RESISTANCE AND (B) INSULATION RESISTANCE; DISCOVERED DURING REINSTALLATION KIT CHECKOUT.

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ANALYSIS - (A) TESTS CONDUCTED SUBSEQUENT TO KSC ANOMALIES FOUND BRIDGEWIRES TO BE IN SPECIFICATION. THE INDICATED FAILURE CONDITION WAS CAUSED BY THE ELECTRICAL CONNECTOR USED DURING THE MEASUREMENT. (B) INSULATION RESISTANCE CHANGES OVER TIME DUE TO CONTAMINATION IN THE CONNECTOR SHELL AND SPARK GAP, REPEATED MEASUREMENTS, HUMIDITY, ETC.

RESOLUTION - (A) BRIDGEWIRE RESISTANCE MEASUREMENT CONNECTORS WERE LIMITED TO 500 CYCLES, AND A CONNECTOR LESS SUSCEPTIBLE TO CONTACT RESISTANCE WAS IMPLEMENTED FOR FIELD USE IN 1984. (B) INSULATION RESISTANCE IS CHECKED PRIOR TO KIT BUILDUP AT KSC. FAILURE TO MEET REQUIRED RESISTANCE IS CAUSE FOR INDIVIDUAL UNIT REJECTION, AND THE UNIT IS REPLACED.

FIAR'S JND0015, JND0016, JND0002, JSCEP0007

FAILURE - OUT-OF-SPECIFICATION BRIDGEWIRE RESISTANCE MEASUREMENTS FOLLOWING LOW TEMPERATURE VIBRATION OF DETONATOR/NSI ASSEMBLY.

ANALYSIS - FAILURES RESULTED FROM EXPOSURE TO "OFF LIMITS" ENVIRONMENTS (COMBINED LOW TEMPERATURE AND VIBRATION). POST-TEST DISASSEMBLY OF UNITS REVEALED FRACTURE OF BRIDGEWIRE WELD HEAT AFFECTED ZONE. WELDS WERE DETERMINED TO MEET SPECIFICATION REQUIREMENTS. THIS PROBLEM HAS BEEN NOTED IN HI-SHEAR PRODUCT ONLY.

RESOLUTION - "UMBRELLA" LOW TEMPERATURE VIBRATION TEST (COMBINATION OF WORST CASE VIBRATION WITH -260°F) HAS BEEN REVISED TO BETTER REFLECT ACTUAL VEHICLE APPLICATIONS. WELD DEVELOPMENT TEST PROGRAM IN PROGRESS AT JSC TO RESOLVE DESIGN SENSITIVITY IN HI-SHEAR PRODUCT.

ADDITIONAL INFORMATION - CLOSURE OF JSC EP0007 REFERS TO LOW TEMPERATURE VIBRATION TESTING OF HI-SHEAR PARTS (600 TO NSI REQUIREMENTS/450 TO NSD REQUIREMENTS). TESTS WERE CONDUCTED IN RESPONSE TO BRIDGE FAILURE OF UNCERTIFIED LOT XPS (S/N 1110) AT SPECIFICATION NSI ENVIRONMENTS. DATA INDICATES LOW BRIDGE FAILURE RATE IN TYPICAL NSI LOTS. REMOTE POSSIBILITY OF FAILURE PROMPTED CHANGE IN CRYOGENIC VEHICLE APPLICATIONS. H<sub>2</sub> AND O<sub>2</sub> UMBILICAL FRANGIBLE NUTS WILL USE ONE SOS AND ONE HI-SHEAR NSI IN ACCORDANCE WITH RCN OV-7823 (OMI V55-AM0170).

FIAR JSC EP0008

FAILURE - DETONATOR WITH LOT MPX INITIATOR FAILURE TO FIRE AT -420°F.

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ANALYSIS - FAILURES RESULTED FROM EXPOSURE TO "OFF LIMITS" ENVIRONMENTS (COMBINED LOW TEMPERATURE AND VIBRATION 57 GRMS/-260°F; FIRED AT -420°F). SUBSEQUENT TO FIRING ATTEMPT, BRIDGE WAS OPEN CIRCUIT. INITIATOR WAS DISASSEMBLED REVEALING PARTIALLY INTACT BRIDGEWIRE. THIS OBSERVATION IS NOT CONSISTENT WITH BRIDGE APPEARANCE IN FAILURES ATTRIBUTED TO MIX INSENSITIVITY. IT IS ASSUMED THAT BRIDGE WAS BROKEN BECAUSE OF ENVIRONMENTS AND BROKEN BRIDGE RESULTED IN FAILURE TO FIRE. DISCREPANT BRIDGE WAS NOT DETECTED PRIOR TO FIRING ATTEMPT.

RESOLUTION - PROBLEM ATTRIBUTED TO EFFECTS OF "OFF-LIMIT" ENVIRONMENTAL EXPOSURE.

FIAR JND0003

FAILURE - HELIUM LEAK TEST FAILURES AT VENDOR DURING ACCEPTANCE TESTING.

ANALYSIS - INSPECTION OF WELDED UNITS REVEALED INSUFFICIENT WELD PENETRATION.

RESOLUTION - FLIGHT UNITS FROM HI-SHEAR L/N'S MNF, MNG, AND MNH WERE 100 PERCENT REINSPECTED AND ACCEPTABLE UNITS WERE RECERTIFIED.

ADDITIONAL INFORMATION - STITCH WELD PROCESS WAS REVISED TO INSURE ACCEPTABLE WELDS IN FUTURE PRODUCTION LOTS.

FIAR JSCEP0078

FAILURE - PIN HEADER ASSEMBLIES LEAKED IN TWO NSI'S FROM HI-SHEAR L/N MNT FOLLOWING LOT ACCEPTANCE FIRINGS IN SRB SEPARATION BOLT.

ANALYSIS - INSPECTION OF FIRED NSI REVEALED HEADER TO BODY WELD CRACKS WHICH ALLOWED COMBUSTION PRODUCTS TO LEAK DURING FIRING OF SRB SEPARATION BOLT CARTRIDGES IN CLOSED BOMBS. EACH BODY/HEADER ASSEMBLY PROOF TESTED TO 15,000 PSI (2 PERCENT OF HEADER LOT SUBJECTED TO 40,000 PSI DESTRUCTIVE TEST). ALL NSI ASSEMBLIES HELIUM LEAK CHECKED TO VERIFY HERMETIC SEAL (INCLUDING SUBJECT WELD). FAILED PARTS TESTED OKAY PRIOR TO CARTRIDGE FIRINGS.

RESOLUTION - NEW WELD SCHEDULE IMPLEMENTED BY HI-SHEAR PRODUCED 75 PERCENT DEEPER WELD PENETRATION. CARTRIDGES MANUFACTURED WITH "OLD" WELD PROCESS REMAIN CERTIFIED BECAUSE POSTFIRE LEAK WILL NOT INTERFERE WITH SUCCESSFUL OPERATION OF SEPARATION BOLT.

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ADDITIONAL INFORMATION - TWO ADDITIONAL LOTS OF SEPARATION BOLT CARTRIDGES HAVE BEEN PROCURED SINCE WELD PROCESS CHANGE. NO REOCCURENCE OF LEAK PROBLEM HAS BEEN NOTED IN 37 FIRINGS.

FIAR JND0017

FAILURE - SOS L/N XCS FAILED POSTFIRE LEAKAGE CURRENT REQUIREMENTS (11 PERCENT OF LOT EXCEEDED 50 ma VERSUS 10 PERCENT MAXIMUM ALLOWED).

ANALYSIS - NO CAUSE OF FAILURE COULD BE FOUND.

RESOLUTION - THE 10 PERCENT LIMIT IS ARBITRARY. POSTFIRE LEAKAGE CURRENT REQUIREMENT IS A DESIGN GOAL.

FIAR'S JSCEP0046, JSCEP0050

FAILURE - FLIGHT UNITS (STS-1 AND STS-4 UMBILICAL DISCONNECT DETONATORS) FAILED TO FIRE. STS-1 HAD ONE FAILURE ON THE H<sub>2</sub> UMBILICAL. STS-4 HAD ONE FAILURE ON BOTH THE H<sub>2</sub> AND O<sub>2</sub> UMBILICALS. ALL UNITS WERE MANUFACTURED BY SOS (L/N MCC).

ANALYSIS - INITIATORS WERE X-RAYED REVEALING A DISTINCT GAP BETWEEN CHARGE CUP AND PROPELLANT SLOG. UNITS WERE DISASSEMBLED AND BRIDGEWIRES WERE FOUND TO BE FUSED. VEHICLE FIRING CIRCUIT SPECIFICATION ALLOWS A MAXIMUM 2 MILLISECONDS DELAY BETWEEN THE REDUNDANT DETONATORS IN EACH FRANGIBLE NUT. FAILURES DETERMINED TO BE RESULT OF SHOCK FROM FIRST NSI/DETONATOR CREATING GAP IN SECOND NSI/DETONATOR BETWEEN PROPELLANT AND BRIDGEWIRE. TESTS CONDUCTED AT JSC SUCCESSFULLY REPRODUCED GAP AND FUNCTIONAL FAILURES AT LOW TEMPERATURE.

RESOLUTION - FAILURE OCCURS AFTER SUCCESSFUL FIRING OF FIRST DETONATOR (NUT SEPARATION). SUCCESSFUL FIRING OF SECOND DETONATOR AT THAT TIME IS NOT REQUIRED.

FIAR JSCEP0083

FAILURE - HI-SHEAR L/N MPB FAILED LOW TEMPERATURE PERFORMANCE TEST (-260°F) DURING LOT ACCEPTANCE (TWO OF EIGHT FAILED).

ANALYSIS - INVESTIGATION PROVIDED NO DEFINITIVE CAUSE FOR FAILURE.

RESOLUTION - FAILURE ATTRIBUTED TO PROPELLANT INSENSITIVITY. ENTIRE LOT REJECTED.

ADDITIONAL INFORMATION - FIFTY ADDITIONAL UNITS (70 TOTAL) FROM PREVIOUS LOT MPA TESTED AT -260°F). ALL FIRED SUCCESSFULLY.

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FIAR'S HBC0108, JSCEP0006

FAILURE - HI-SHEAR L/N XRA FAILED LOW TEMPERATURE PERFORMANCE TEST (-260°F) DURING LOT ACCEPTANCE (2 OF 13 FAILED).

ANALYSIS - ANALYSIS PROVIDED NO DEFINITIVE CAUSE FOR FAILURES.

RESOLUTION - FAILURES ATTRIBUTED TO PROPELLANT INSENSITIVITY BASED ON LOT FIRING DATA. LOT XRA REJECTED. OTHER LOTS TESTED AS A PART OF THE ANALYSIS REVEALED SIMILAR PROBLEMS WITH CERTAIN LOTS OF PREVIOUSLY CERTIFIED HARDWARE. CERTAIN LOTS OF NSI WERE SUBJECTED TO RECERTIFICATION TESTING (IN ACCORDANCE WITH REVISED ACCEPTANCE TEST SEQUENCE, REFERENCE PAGE 3). ALL FLIGHT PARTS IN FIELD HAVE PASSED RECERTIFICATION TESTS. FINDINGS WERE CONFIRMED BY INDEPENDENT TEAM AND REVIEWED BY NASA PYROTECHNIC STEERING COMMITTEE.

APPROVED BY (NASA):

SUBSYSTEM MANAGER  
RELIABILITY AND MAINTAINABILITY  
QUALITY ASSURANCE AND ENGINEERING

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