

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Igniters and Sensors
 CIL Item: G100-01
 Component: Spark Igniter
 Part Number: RSD036B5/R0013000
 Failure Mode: Igniter fails to spark/weak or low spark rate

Prepared: M. Oliver
 Approved: T. Nguyen
 Approval Date: 3/30/99
 Change #: 2
 Directive #: CCBD MEJ-01-4894
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Phase	Failure / Effect Description	Criticality Hazard Reference
S 4.2	<p>Failure of both channel A and channel B FPB igniters causing preburner gases not to ignite. This results in fuel pump speed to be below redline value and controller initiated engine shutdown. Oxidizer rich operation. Mission scrub. Loss of vehicle due to LOX-rich operation may result if failure to establish fuel preburner ignition is not detected.</p> <p>Redundancy Screens: IGNITER SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	1R ME-B6S
S 4.4	<p>Failure of both channel A and channel B MCC igniters causing main chamber gases not to ignite. Low main chamber pressure results in failure to satisfy ignition confirmed limits and controller initiated engine shutdown. Mission scrub. Loss of vehicle due to oxidizer duct rupture may result if failure to establish MCC ignition is not detected.</p> <p>Redundancy Screens: IGNITER SYSTEM - SENSOR SYSTEM: UNLIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	1R ME-C3S
M 4.2	<p>Electronic degradation in one or more igniters on both channel A and channel B may cause shorting of the 26 VDC power supply in one or both controller channels and de-energizing all actuator failsafe switches. Controller initiates hydraulic lockup and a MCF indication. Mission abort may result when hydraulic lockup occurs during max Q throttling.</p> <p>Redundancy Screens: IGNITER SYSTEM: LIKE REDUNDANCY</p> <p>A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Pass - Loss of a redundant hardware items is detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.</p>	1R ME-G4M

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SSME EA/CIL
DESIGN

Component Group: Igniters and Sensors
CIL Item: G100-01
Component: Spark Igniter
Part Number: R9003886/R0013000
Failure Mode: Igniter fails to spark/weak or low spark rate.

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Design / Document Reference

FAILURE CAUSE: A: Failure of exciter electronic circuit.

ELECTRONIC, ELECTRICAL, AND ELECTROMECHANICAL PARTS FOR THE CIRCUITS INVOLVED IN THIS FUNCTION HAVE BEEN SELECTED FROM THE CLASS S OR EQUIVALENT APPROVED PARTS SELECTION (1). THE IGNITER ELECTRONICS ARE ENCAPSULATED AND HERMETICALLY SEALED IN THE IGNITER BODY (2). THE ENCAPSULATION PROVIDES EXTRA INSULATION AND HELPS PREVENT VIBRATION OR CORROSION RELATED FAILURES.

(1) 85M03928; (2) RL00031 / RL00761

FAILURE CAUSE: B: Breakdown of spark plug insulation or cracked ceramic.

PRIMARY INSULATION MATERIAL IS ALUMINA CERAMIC (1), SECONDARY MATERIAL IS BERYLIUM CERAMIC (2), BOTH HAVE GRADE INDEXES IN ACCORDANCE WITH GOVERNMENT STANDARDS (1, 2). THESE MATERIALS HAVE HIGH FLEXURAL STRENGTH AND HIGH ELECTRICAL INSULATION PROPERTIES. CERTAIN CRACKS IN THE CERAMIC ARE ACCEPTABLE PER SPECIFICATION (3).

(1) RS003687-007 / R0014013-3; (2) RSC03687-039 / R0014012-3; (3) RL00255

FAILURE CAUSE: C: Plug tip erosion.

THE DESIGN OF THE ELECTRICAL IGNITION SUBSYSTEM PROVIDES FOR DUAL SPARK IGNITION SOURCES SO THAT NO SINGLE POINT FAILURE SHALL RESULT IN THE LOSS OF ENGINE IGNITION SOURCE (1). EACH IGNITER SPARK PLUG ASSEMBLY INCORPORATES A DUAL SPARK GAP DESIGN (2). THE DUAL SPARK GAP OCCURS FROM THE PRIMARY ELECTRODE TO THE SECONDARY ELECTRODE, AND FROM THE SECONDARY ELECTRODE, TO THE SPARK PLUG CASE. THIS ELIMINATES SPARK LOSS DUE TO GROUNDING OF SECONDARY ELECTRODE TO CASE, OR SHORTING OF PRIMARY ELECTRODE TO SECONDARY. SURFACE PITTING OR DISCOLORATION IS ALLOWED BY SPECIFICATION (3). IGNITER TIP EROSION IS CAUSED BY LOCALIZED THERMAL STRESS DURING ENGINE MAINSTAGE OPERATION. THIS LOCAL THERMAL STRESS DOES NOT EXIST DURING THE START PHASE. IGNITION MUST OCCUR PRIOR TO TIP EROSION FAILURE.

(1) DVS-SSME-205 / ECP 717R7; (2) RS003687 / R0014010; (3) RL00296

FAILURE CAUSE: D: Moisture.

THE ENGINE SYSTEM INCORPORATES A SYSTEMS PURGE TO ELIMINATE CONDENSATION IN THE ASI COMPONENTS. THE FUNCTION OF THE SPARK IGNITER IS COMPLETED AFTER START. QUENCHING OR FLOODING DUE TO MOISTURE CREATED FROM HOT FIRE WILL NOT EFFECT THE IGNITER FUNCTION.

FAILURE CAUSE: E: Change of internal resistance caused by moisture, corrosion, or contamination.

IGNITERS ARE HERMETICALLY SEALED TO PROTECT FROM CONTAMINATION. A BACK FILL OF THE IGNITER CAVITY IS DONE TO INCORPORATE AN INERT PURGE. PREVENTING CORROSION OR CONDENSATION IN THE IGNITER. LEAK RATE REQUIREMENTS ARE CONTROLLED PER SPECIFICATION TO PREVENT INDUCTANCE OF FOREIGN SUBSTANCES AND PREVENT LOSS OF THE INERT GAS BACKFILL. INTERNAL POTTING, VARNISHING, AND COATING WITH ADHESIVE PROTECTS FROM INTERNAL CORROSION (1).

DESIGN VERIFICATION TESTING (2) HAS BEEN COMPLETED, INCLUDING THERMAL, AND VIBRATION TESTING (3). HIGH CYCLE AND LOW CYCLE FATIGUE LIFE, AS WELL AS THE MINIMUM FACTORS OF SAFETY FOR THE IGNITER MEET CEI REQUIREMENTS (4).

(1) RL00031 / RL00761

(2) DVS-SSME-205 / VRS-321; (3) RSS-205-4 / VRS-321; (4) RL00532, GP32CR0003B, RSS-8546

SSME FMEA/CIL
INSPECTION AND TEST

Component Group: Igniters and Sensors
 CIL Item: G100-01
 Component: Spark Igniter
 Part Number: RS003685/R0013000
 Failure Mode: Igniter fails to spark/weak or low spark rate.

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SPARK IGNITER POWER MODULE		RS003685 / R0013000 RS003685 / 477-5001-011
	INTEGRITY OF ELECTRONICS	<p>PROCESSES USED IN THE CIRCUIT MANUFACTURE AND ASSEMBLY ARE VERIFIED PER SPECIFICATION AND INCLUDE:</p> <ul style="list-style-type: none"> - SOLDERING OF ELECTRICAL CONNECTIONS. - ELECTRICAL BONDING OF POWER MODULE TO CASE. - ENCAPSULATION OF ELECTRONIC COMPONENTS (TWO METHODS). <p>PERFORMANCE TESTS ARE PERFORMED ON THE IGNITER POWER MODULE PRIOR TO ASSEMBLY INTO THE CASE:</p> <ul style="list-style-type: none"> - MATCHED SET SELECTION OF CRITICAL COMPONENTS FOR OPTIMUM CIRCUIT PERFORMANCE. - CONTINUITY VERIFICATION BETWEEN ELECTRONIC COMPONENTS AND THEIR CIRCUIT PATHS. - IGNITER POWER SUPPLY CURRENT TEST. THIS VERIFIES THAT THE POWER MODULE WILL NOT DRAW MORE CURRENT THAN THE ENGINE CONTROLLER CAN SUPPLY. - CRITICAL COMPONENT OPERATION. THIS TEST VERIFIES THE OPERATION OF EACH CRITICAL ELECTRONIC COMPONENT AFTER CIRCUIT ASSEMBLY. - IGNITER MONITOR OUTPUT WAVEFORM IS VERIFIED TO BE WITHIN SPECIFICATION. - TEMPERATURE STABILITY TESTS. IGNITER POWER MODULE IS TESTED FOR OPERATION DURING THERMAL CYCLE. <p>PERFORMANCE TESTS ARE PERFORMED ON THE IGNITER HYBRID POWER MODULE PRIOR TO ASSEMBLY IN THE CASE.</p> <ul style="list-style-type: none"> - ELECTRICAL MEASUREMENTS. - TEMPERATURE CYCLING. - ACCELERATION. - POWER BURN-IN. - RADIOGRAPHIC INSPECTION. - PARTICLE IMPACT NOISE DETECTION - SEAL LEAK TEST - INTERNAL WATER VAPOR CONTENT. <p>THE FOLLOWING TESTS ARE PERFORMED PRIOR TO ENCAPSULATION (FIRST ASSEMBLY TEST):</p> <ul style="list-style-type: none"> - INSULATION RESISTANCE BETWEEN COMPONENTS IS VERIFIED TO BE WITHIN SPECIFICATION. - CIRCUIT PATH CONTINUITY VERIFICATION IS PERFORMED. - IGNITER INPUT CURRENT IS MEASURED AND VERIFIED TO BE WITHIN ENGINE CONTROLLER REQUIREMENTS. - THE MONITOR OUTPUT IS TESTED FOR AMPLITUDE AND WAVEFORM AND VERIFIED TO BE WITHIN SPECIFICATION. - COMMAND INPUT CURRENT IS MEASURED AND VERIFIED TO BE WITHIN ENGINE CONTROLLER REQUIREMENTS. - THE DELIVERED SPARK ENERGY IS VERIFIED TO BE WITHIN REQUIREMENTS. - QUENCHED AND POST QUENCHED OPERATION IS VERIFIED. THESE TESTS VERIFY THE SPARK SUPPRESSION UNDER PRESSURE LOADS. 	<p>RL10000 RS003685 / R0013000 RA1608-001 RA1108-010</p> <p>RL00119 RL00119 RL00119 RL00119 RL00119 RL00119</p> <p>RC477-5001 RC477-5001 RC477-5001 RC477-5001 RC477-5001 RC477-5001 RC477-5001</p> <p>RL00031 / RL00761 RL00031 RL00031 / RL00761 RL00031 / RL00761 RL00031 / RL00761 RL00031 / RL00761 RL00031 / RL00761</p>

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	INTEGRITY OF ELECTRONICS	AFTER THE IGNITER BODY IS INSTALLED, A LEAK TEST IS PERFORMED TO VERIFY INTEGRITY. THIS PROTECTS AGAINST MOISTURE OR CONTAMINATION ENTERING THE IGNITER.	RL00031 / RL00761
B	SPARK PLUG PRIMARY INSULATOR SECONDARY INSULATOR		RS003687 / R0014010 RS003687-007 / R0014013-3 RS003687-039 / R0014012-3
	ASSEMBLY TESTING	THE FOLLOWING TESTS ARE PERFORMED PRIOR TO CASE INSTALLATION: - PROOF PRESSURE TESTS ARE PERFORMED ON THE SPARK PLUG TO CHECK FOR UNACCEPTABLE CERAMIC DEFECTS. - FUNCTIONAL TEST IS PERFORMED AFTER FINAL ASSEMBLY (SAME AS PRE-ENCAPSULATION TESTS) (SECOND ASSEMBLY TEST). THE CERAMIC INSULATORS ARE VISUALLY INSPECTED FOR CRACKS OR CHIPS AND VERIFIED TO BE WITHIN SPECIFICATION.	RS003687 / R0014010 RL00031 / RL00761 RL00298
C	ELECTRODE		RSC03687-017 / R0014018-3
	TIP INTEGRITY	MINOR EROSION TO THE COPPER FACE AND CRACKS IN THE CERAMIC ARE INSPECTED PER SPECIFICATION REQUIREMENTS. IGNITER TIPS ARE INSPECTED FOR EROSION EVERY MISSION FLOW.	RS003687-037 / R0014017-3 RL00298
D	SYSTEM DRYING	THE SSME PROPELLANT SYSTEM IS DRIED AND VERIFIED DRY AFTER EACH FLIGHT. THE ASI SYSTEM IS MAINTAINED DRY DURING PROPELLANT CONDITIONING PER OMRSD REQUIREMENTS.	OMRSD V41CB0 080 OMRSD V41CB0.081 OMRSD V41CB0.082 OMRSD V41CB0.083 OMRSD S00FR0.300
E	SPARK IGNITER HERMATIC SEAL INTEGRITY	CLEANLINESS REQUIRMENTS ARE VERIFIED PER SPECIFICATION DURING MANUFACTURING OF THE IGNITERS. AFTER THE CASE IS WELDED, HELIUM LEAK TESTS ARE PERFORMED TO VERIFY HERMATIC SEAL	RS003685 / R0013000 RL00031 / RL00761
ALL CAUSES	SPARK IGNITER IGNITER INTEGRITY	AFTER FINAL ASSEMBLY, THE IGNITER IS FUNCTIONAL TESTED (SAME AS PRE-ENCAPSULATION TESTS) (THIRD ASSEMBLY TEST).	RS003685 / R0013000 RL00031 / RL00761
	PRE-FLIGHT CHECKOUT	ALL IGNITER DATA FROM THE PREVIOUS FLIGHT OR GREEN RUN IS REVIEWED. ANY ANOMALOUS CONDITION NOTED REQUIRES FURTHER TESTING OR HARDWARE REPLACEMENT PRIOR TO THE NEXT FLIGHT.	MSFC PLN 1228 RL00461

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Component Group: Igniters and Sensors
 CIL Item: G100-01
 Component: Spark Igniter
 Part Number: RSD03665/R0013000
 Failure Mode: Igniter fails to spark/weak or low spark rate.

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	PRE-FLIGHT CHECKOUT	IGNITER OPERATION IS VERIFIED EVERY MISSION FLOW AND AFTER ANY REPLACEMENT BY CONTROLLER ELECTRICAL CHECKOUTS - IGNITER CHECKOUT, (LAST TEST)	OMRSD S00FA0.213

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/88/308 and Rocketdyne letter B8RC09761
 Operational Use: Not Applicable.