SSME EA/CIL
REDUNDANCY SCREEN

Component Group: Igniters and Sensors
CIL Item: J301-AA-01, J302-AA-01
Component: HPFTP Turbine Discharge Temp Thermocouple Sensors (G5.1, G5.2)
Part Number: RE1751, RE1751
Failure Mode: Erroneous output signal.

Prepared: M. Oliver
Approved: T. Nguyen
Approval Date: 3/30/99
Change #: 1
Directive #: CCBD ME3-01-4994

Phase	Failure / Effect Description	Criticality Hazard Reference
P 4.3	Erroneous output signals from three or more sensors within qualification limits result in loss of engine start inhibit and LCC protection. Loss of vehicle during start due to HPFTP turbine failure may result if turbine overtemperature condition occurs and is not detected or open air fire or detonation may result if leakage exists and is not detected. Redundancy Screens: SENSOR SYSTEM: LIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event	1R ME-01S,M
S 4.3	Erroneous output signals from all qualified sensors within the redline limits results in loss of redline protection. Loss of vehicle due to HPFTP turbine failure may result if turbine overtemperature condition occurs and is not detected. Redundancy Screens: SENSOR SYSTEM: LIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-01S,M
M 4.3	Erroneous output signals from all sensors outside qualification limits result in sensor disqualification causing a loss of redline monitoring and a MCF indication. Loss of vehicle due to HPFTP turbine failure may result if turbine overtemperature condition occurs and is not detected. Redundancy Screens: SENSOR SYSTEM LIKE REDUNDANCY 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.	1R ME-01S,M
M 4.4	Erroneous output signals from both qualified sensors on the same channel within the redline limits results in loss of redline protection. Loss of vehicle due to HPFTP turbine failure may result if turbine overtemperature condition occurs and is not detected. Redundancy Screens: SENSOR SYSTEM: LIKE REDUNDANCY A: Pass - Redundant hardware items are capable of checkout during normal ground turnaround. B: Fail - Loss of a redundant hardware items is not detectable during flight. C: Pass - Loss of redundant hardware items could not result from a single credible event.	1R ME-01S,M

SSME FMEA/CIL
DESIGN

Component Group:	Igniters and Sensors	Prepared:	M. Oliver
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Design / Document Reference

FAILURE CAUSE: A: Open in circuit; Broken leadwire or leadwire connections.

ELECTRONIC, ELECTRICAL, AND ELECTROMECHANICAL PARTS FOR THE TRANSDUCER INVOLVED IN THIS FUNCTION HAVE BEEN SELECTED FROM THE CLASS S OR EQUIVALENT APPROVED PARTS SELECTION (1). THE TRANSDUCER SENSOR ELEMENT IS MADE FROM TYPE K THERMOCOUPLE WIRES (CHROMEL AND ALUMEL) MEETING THE SPECIAL LIMITS OF ERROR (2). THE THERMOCOUPLE JUNCTION IS PROTECTED BY A METAL OXIDE INSULANT AND A INCONEL 600 SHEATH (2). THE THERMOCOUPLE MEASURING JUNCTIONS ARE FUSION WELDED (2). THE SENSING ELEMENT ASSEMBLY IS BRAZED INSIDE AN INCONEL 625 HOUSING (2). THE HOUSING PROVIDES RESISTANCE TO MECHANICAL/INSTALLATION DAMAGE. PROCESSES USED FOR WELDING IS CONTROLLED BY SPECIFICATION (2). LEADWIRE CONNECTIONS ARE WELDED IN A STRAIN FREE CONFIGURATION AND COVERED WITH AN INSULATING HEAT SHRINK TUBING. UPPER WIRING POTTING PREVENTS WIRE MOVEMENT AND SUBSEQUENT WIRE FAILURE (3).

(1) 85M03928, (2) RC1751; (3) RL10008

FAILURE CAUSE: B: Short in circuit; contamination, loss of insulation.

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

(1) RC1751

FAILURE CAUSE: C: Structural failure of probe.

THE HOT GAS TEMPERATURE SENSOR PROBE IS MADE FROM INCONEL 625. INCONEL 625 WAS SELECTED FOR ITS TENSILE STRENGTH, RESISTANCE TO GENERAL CORROSION, WELDABILITY TO 300 SERIES CRES, AND RESISTANCE TO STRESS CORROSION CRACKING (1), (2). HYDROGEN ENVIRONMENT EMBRITTLEMENT IS NOT CONSIDERED A PROBLEM UNDER THIS CONDITION OF USE. THE PROBE HOUSING IS A ONE PIECE DESIGN ELIMINATING PROBE WELD RELATED FAILURES (3).

(1) RSS-8562; (2) MSFC-SPEC-522, (3) RC1751

FAILURE CAUSE: ALL CAUSES

SENSOR SYSTEM DESIGN PROVIDES REDUNDANCY TO THE ELECTRICAL COMPONENTS TO PRECLUDE ALL SINGLE POINT FAILURES OF THE CONTROL FUNCTIONS. THE SENSORS ARE A VENDOR ITEM, DRAWING SPECIFICATION AND MANUFACTURING PROCESSES ARE CONTROLLED BY ROCKETDYNE (1). ALL SENSOR DESIGNS ARE SUBJECTED TO A CRITICAL DESIGN REVIEW. ANY DESIGN CHANGES ARE RE-REVIEWED (1). THE RE1751-01 SENSORS HAVE COMPLETED USEFUL LIFE TESTING (1), INCLUDING VIBRATION TESTING (1). THE MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (2). THE SENSORS WERE ANALYZED FOR HIGH CYCLE FATIGUE AND LOW CYCLE FATIGUE LIFE AND MEET CEI REQUIREMENTS (3) THE CONTROLLER MONITOR SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESSES, AND REDUNDANT CONTROLLER CHANNELS (4).

(1) RC1751; (2) RSS-8546 CP320R0003B; (3) RL00532, CP320R0003B; (4) CP406R0008 3 2.3.5

SSME FMECIL
INSPECTION AND TEST

Component Group:	Igniters and Sensors	Prepared:	M. Oliver
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Component:	HPFTP Turbine Discharge Temp Thermocouple Sensors (G5.1, G5.2)	Approval Date:	3/30/95
Part Number:	RE1751, RE1751	Change #:	1
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	TEMPERATURE TRANSDUCER		RE1751
	COMPONENT INTEGRITY	THE THERMOCOUPLE ALLOYS ARE INSPECTED PER SPECIFICATION REQUIREMENTS	RC1751
		PROCESSES USED IN THE TRANSDUCER MANUFACTURE AND ASSEMBLY ARE VERIFIED PER SPECIFICATION AND INCLUDE: - ELECTRICAL CONNECTIONS MADE BY WELDING. - ENCAPSULATION OF COMPONENTS. - ELEMENT CONSTRUCTION IS RADIOGRAPHICALLY INSPECTED.	RC1751 RL10008 RC1751
B	TEMPERATURE TRANSDUCER CONNECTOR RECEPTACLE		RE1751 RES1231
	CONNECTOR INTEGRITY	THE PLATING ON THE CONNECTOR PINS IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RC1231
		THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND SENSOR ACCEPTANCE: - VISUAL INSPECTION. - INSULATION RESISTANCE BETWEEN PINS AND THE CASE IS VERIFIED TO BE WITHIN SPECIFICATION. - DIELECTRIC VOLTAGE TESTS MEASURE THE CURRENT LEAKAGE BETWEEN PINS AND CASE AND VERIFY THEM TO BE WITHIN SPECIFICATION.	RC1751 RC1751 RC1751
C	TEMPERATURE TRANSDUCER		RE1751
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RC1751
ALL CAUSES	TEMPERATURE TRANSDUCER		RE1751
	ASSEMBLY INTEGRITY	ALL VENDOR INSPECTION AND TEST CRITERIA IS UNDER ROCKETDYNE APPROVAL AND CONTROL.	RC1751
		TRANSDUCERS ARE SUBJECTED TO A WORKMANSHIP SCREENING ACCEPTANCE TEST INCLUDING VIBRATION AND THERMAL CYCLE.	
		TRANSDUCERS ARE CALIBRATED PER SPECIFICATION REQUIREMENTS.	
	HOT FIRE ACCEPTANCE TESTING (GREEN RUN)	SENSOR OPERATION IS VERIFIED THROUGH HOT FIRE ACCEPTANCE TESTING.	RL00461
	DATA REVIEW	ALL CONTROLLER DATA FROM THE PREVIOUS FLIGHT OR HOT FIRE IS REVIEWED. ANY ANOMALOUS CONDITION NOTED REQUIRES FURTHER TESTING OR HARDWARE REPLACEMENT PRIOR TO THE NEXT FLIGHT	MSFC PLN 1228
	PRE-FLIGHT CHECKOUT	SENSORS ARE TESTED FOR INSULATION RESISTANCE AFTER EACH HOT FIRE.	OMRSD V41BU0.250
		SENSORS ARE VISUALLY INSPECTED.	OMRSD V41BU0.020

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	PRE-FLIGHT CHECKOUT	SENSOR OPERATION IS VERIFIED EVERY MISSION FLOW BY SUCCESSFUL COMPLETION OF THE CONTROLLER SENSOR ELECTRICAL CHECKOUT. (LAST TEST)	OMRSD V41AQ0.010 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 88RC09751.

Operational Use: Not Applicable.