

**SSME FMEA/C/L
REDUNDANCY SCREEN**

Component Group: Igniters and Sensors
 CIL Item: J306-01
 Component: LPFTP Discharge Temperature Transducer (F2.3)
 Part Number: RE67002
 Failure Mode: Erroneous output signal.

Prepared: M. Oliver
 Approved: T. Nguyen
 Approval Date: 3/30/99
 Change #: 1
 Directive #: CCBD ME3-01-4994
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Phase	Failure / Effect Description	Criticality Hazard Reference
SM 4.1	Erroneous output signal from one or both sensors within qualification limits will result in off-nominal mixture ratio operation and depletion of propellants during mainstage. Mission abort may result if off-nominal propellant consumption leads to a SLE engine shutdown or premature propellant depletion.	1R ME-G4M
Redundancy Screens: SENSOR SYSTEM - ENGINE SYSTEM: UNLIKE 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.		

**SSME EA/CIL
DESIGN**

Component Group: Igniters and Sensors
CIL Item: J306-01
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Design / Document Reference

FAILURE CAUSE: A: Open in circuit; broken platinum sensing element. Broken leadwire or leadwire connections.

ELECTRONIC, ELECTRICAL, AND ELECTROMECHANICAL PARTS FOR THE TRANSDUCERS INVOLVED IN THIS FUNCTION HAVE BEEN SELECTED FROM THE CLASS S OR EQUIVALENT APPROVED PARTS SELECTION (1). THE TRANSDUCER SENSOR ELEMENT IS MADE FROM REFERENCE PURITY PLATINUM WIRES MOUNTED ON A STRAIN FREE SUPPORT PROTECTED BY CERAMIC INSULATION. SENSING ELEMENT IS PROTECTED BY A PERFORATED STAINLESS STEEL SHIELD REDUCING MECHANICAL OR INSULATION DAMAGE. PERFORATIONS IN THE SHIELD PROVIDES EXPOSURE TO CRYOGENIC LIQUIDS. PROCESS USED FOR BRAZING AND LEADWIRE CONNECTIONS ARE CONTROLLED BY SPECIFICATION (2). LEADWIRE CONNECTIONS ARE BRAZED IN A STRAIN FREE CONFIGURATION AND COVERED WITH AN INSULATING HEAT SHRINK TUBING. UPPER WIRING POTTING PREVENTS WIRE MOVEMENT AND SUBSEQUENT WIRING FAILURES (3).

(1) 85M03928; (2) RC7002; (3) RL10008

FAILURE CAUSE: B: Receptacle pin damage; shorting pin-to-pin or pin-to-shell.

CONNECTOR SELECTION OF THE ASSEMBLIES IS CONTROLLED BY ROCKETDYNE SPECIFICATION REQUIREMENTS (1). THE CONNECTOR DESIGN INCORPORATES FEATURES SUCH AS RUBBER SEALS, CORROSION RESISTANT PINS, LOCKING CONNECTORS, AND CONTROLLED ELECTRICAL CONNECTIONS TO PREVENT MALFUNCTION. THE CONNECTORS ARE IN ACCORDANCE WITH STANDARDS FOR USE ON ROCKET PROPELLED VEHICLES (2). THE PINS ARE NICKEL UNDERPLATED AND GOLD OVERPLATED TO PREVENT CORROSION AND MINIMIZE CONTACT RESISTANCE. THE PLATING IS CONTROLLED PER SPECIFICATION (2). THE CONNECTORS HAVE COMPLETED HARNESS DVS TESTING AND SENSOR DVS TESTING (3).

(1) RC7002; (2) RCT232; (3) DVS-SSME-202, DVS-SSME-203

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

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) RC7002

FAILURE CAUSE: D: Structural failure of probe.

THE CRYOGENIC TEMPERATURE TRANSDUCER (1) IS MADE FROM INCONEL 525. TENSILE STRENGTH, RESISTANCE TO GENERAL CORROSION, WELDABILITY TO 300 SERIES CRES, AND RESISTANCE TO STRESS CORROSION CRACKING ARE PRIMARY REASONS FOR SELECTING THIS MATERIAL (2). HYDROGEN ENVIRONMENT EMBRITTLEMENT IS NOT CONSIDERED A PROBLEM UNDER THIS CONDITION OF USE. THE SHIELD IS GAS TUNGSTEN ARC WELDED TO THE FRONT HOUSING. WELDING IS CONTROLLED BY SPECIFICATION (1).

(1) RES7002; (2) MSFC SPEC-522, RSS-8582-6

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 RES7002-231 SENSORS HAVE COMPLETED DESIGN VERIFICATION TESTING (2), INCLUDING VIBRATION TESTING (3). THE -241 DESIGN IS IDENTICAL TO THE -231 WITH THE ADDITION OF A WORKMANSHIP SCREENING REQUIREMENT. THE RES7002-241 SENSOR HAS BEEN QUALIFIED BY SIMILARITY (4). THE MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (5). THE SENSORS WERE ANALYZED FOR HIGH CYCLE FATIGUE AND LOW CYCLE FATIGUE LIFE AND MEET CEI REQUIREMENTS (6). TABLE J306 LISTS ALL THE FMEACIL WELDS AND IDENTIFIES THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE, AND THOSE WELDS IN WHICH THE ROOT SIDE IS NOT ACCESSIBLE FOR INSPECTION. THESE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (7). THE CONTROLLER MONITOR SYSTEM IS COMPRISED OF REDUNDANT SENSOR ELECTRONICS, REDUNDANT HARNESSES, AND REDUNDANT CONTROLLER CHANNELS (8).

(1) RC7002; (2) DVS-SSME-202, RSS-8660; (3) RSS-203-11; (4) RSS-8660; (5) RSS-8546, CP320R0003B; (6) RL00532, CP320R0003B; (7) RSS-8756; (8) CP406R0008 3.2 3.6

**SSME FMEA/CIL
INSPECTION AND TEST**

Component Group: Igniters and Sensors
 CIL Item: J308-01
 Component: LPFTP Discharge Temperature Transducer (F2.3)
 Part Number: RES7002
 Failure Mode: Erroneous output signal.

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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	TEMPERATURE TRANSDUCER		RES7002
	COMPONENT INTEGRITY	THE ELEMENT MATERIAL IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RC7002
		PROCESSES USED IN THE TRANSDUCER MANUFACTURE AND ASSEMBLY ARE VERIFIED PER SPECIFICATION AND INCLUDE: - ELECTRICAL CONNECTIONS MADE BY BRAZING. - ENCAPSULATION OF COMPONENTS.	RC7002 RL10009
B	TEMPERATURE TRANSDUCER CONNECTOR RECEPTACLE		RES7002 RES1232
	CONNECTOR INTEGRITY	THE PLATING ON THE CONNECTOR PINS IS INSPECTED PER SPECIFICATION REQUIREMENTS.	RC1232
		THE FOLLOWING TESTS ARE PERFORMED DURING MANUFACTURING AND SENSOR ACCEPTANCE: - TRANSDUCERS ARE CALIBRATED - 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.	RC7002 RC7002 RC7002
C	TEMPERATURE TRANSDUCER		RES7002
	INTERNAL CLEANLINESS	CLEANLINESS REQUIREMENTS ARE VERIFIED PER SPECIFICATION DURING MANUFACTURING OF THE TRANSDUCERS.	RC7002
		INSULATION RESISTANCE BETWEEN CONNECTOR PINS AND CASE IS VERIFIED TO MEET SPECIFICATION REQUIREMENTS.	
	WELD INTEGRITY	ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE.	
	ASSEMBLY INTEGRITY	AFTER THE CASE IS WELDED, HELIUM LEAK TESTS ARE PERFORMED TO VERIFY HERMETIC SEAL	
D	TEMPERATURE TRANSDUCER		RES7002
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS.	RC7002
ALL CAUSES	TEMPERATURE TRANSDUCER		RES7002
	ASSEMBLY INTEGRITY	ALL VENDOR INSPECTION AND TEST CRITERIA IS UNDER ROCKETDYNE APPROVAL AND CONTROL. TRANSDUCERS ARE SUBJECTED TO A WORKMANSHIP SCREENING ACCEPTANCE TEST INCLUDING	RC7002

J-147

Component: Igniters and Sensors
 CIL Item: J326-01
 Component: LPFTP Discharge Temperature Transducer (F2.3)
 Part Number: RES7002
 Failure Mode: Erroneous output signal.

Prepared: M. O'N
 Approved: T. Nguyen
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
ALL CAUSES	ASSEMBLY INTEGRITY	TRANSUCERS ARE CALIBRATED	RC7002
	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	SENSOR OPERATION IS VERIFIED EVERY MISSION FLOW BY SUCCESSFUL COMPLETION OF THE CONTROLLER SENSOR ELECTRICAL CHECKOUT. (LAST TEST)	OMRSD V41AQ0.010 OMRSD S00FAD.213

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21486/308 and Rocketdyne letter 88RC09761.

Operational Use: FAILURE MODE CAN BE DETECTED IN REAL TIME BY THE FLIGHT CONTROL TEAM WHO WILL EVALUATE EFFECTS UPON VEHICLE PERFORMANCE AND ABORT CAPABILITY. BASED ON THIS EVALUATION THE APPROPRIATE ABORT MODE OR SYSTEM CONFIGURATION WILL BE SELECTED. FAILURE DETECTION CUES AND ASSOCIATED SSME PERFORMANCE DATA HAVE BEEN COORDINATED BETWEEN THE ENGINEERING AND FLIGHT OPERATIONS ORGANIZATIONS WITH THE RESPONSES DOCUMENTED IN MISSION FLIGHT RULES.

SSC
WELDING

Component Group: Engines and Sensors
 C. Item: J-152
 Component: LP-10 Discharge Temperature Transducer (F23)
 Part Number: RES7002

Program: 1000000
 Revision: 1000000
 Change: 1
 Direct: 1000000-01-0004
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Component	Basic Part Number	Weld Number	Weld Type	Class	Part Side Not Applied	Critical Initial Low Size Not Detectable		Comments
						HCF	LCF	
TEMPERATURE TRANSDUCER	RES7002	R2	GTAW	II	X			
TEMPERATURE TRANSDUCER	RES7002	R2A	GTAW	II	X			

J-152