

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**

**NUMBER: 03-1-0746 -X**

**SUBSYSTEM NAME:** MAIN PROPULSION

**REVISION:** 1 02/20/01

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**PART DATA**

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	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: TRANSDUCER, PRESSURE SOLARTRON, STATHAM DIV.	ME449-0177-2577 PA8106-1M-22128

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

TRANSDUCER, GH2 PRESSURIZATION LINE PRESSURE, 0 TO 1000 PSIA.

**REFERENCE DESIGNATORS:** V41P1490A

**QUANTITY OF LIKE ITEMS:** 1

**FUNCTION:**

PROVIDES INDICATION OF GH2 DISCONNECT PRESSURE. LOCATED ON LINE CONNECTING DELTA PRESSURE TRANSDUCER (MT50) TO ET PRESSURIZATION MANIFOLD.

**FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE**

**NUMBER: 03-1-0746-03**

**REVISION#: 1 10/30/01**

**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: GH2 2" DISCONNECT PRESSURE TRANSDUCER**

**CRITICALITY OF THIS**

**ITEM NAME: GH2 2" DISCONNECT PRESSURE TRANSDUCER**

**FAILURE MODE: 1R2**

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**FAILURE MODE:**

ERRONEOUS INDICATION

**MISSION PHASE: LO LIFT-OFF**

<b>VEHICLE/PAYLOAD/KIT EFFECTIVITY:</b>	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

**CAUSE:**

PIECE PART STRUCTURAL FAILURE, CONTAMINATION

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

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<b>REDUNDANCY SCREEN</b>	A) PASS
	B) FAIL
	C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

FAILS B SCREEN BECAUSE SIGNAL FROM FAILED TRANSDUCER IS INDISTINGUISHABLE FROM THE SIGNAL OF A PROPERLY FUNCTIONING TRANSDUCER

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

NO EFFECT. GH2 PRESSURIZATION DISCONNECT PRESSURE MEASUREMENT IS NOT REQUIRED FOR NOMINAL ASCENT. MEASUREMENT IS ONLY REQUIRED TO SUPPORT FLIGHT RULE IMPLEMENTATION IN THE EVENT OF LOW LH2 ULLAGE PRESSURE.

**(B) INTERFACING SUBSYSTEM(S):**

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SAME AS A

**(C) MISSION:**

FIRST FAILURE - NO EFFECT

**(D) CREW, VEHICLE, AND ELEMENT(S):**

SAME AS C

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

CASE 1: ERRONEOUS HIGH INDICATION

1R/2 2 SUCCESS PATHS. TIME FRAME- ASCENT

1. TRANSDUCER ERRONEOUSLY INDICATES HIGH
2. SUFFICIENT RESTRICTION IN THE ORBITER GH2 PRESSURIZATION SYSTEM  
(COMPLETE BLOCKAGE OF ONE PRESSURIZATION LEG OR MULTIPLE FLOW CONTROL VALVES FAILED LOW)

ET LH2 TANK ULLAGE PRESSURE WILL FALL OUT OF CONTROL BAND (NOMINAL 32-34 PSIA). FLIGHT RULES HAVE MCC USE THE GH2 PRESSURIZATION SYSTEM PRESSURE TO DETERMINE IF THE CAUSE FOR THE LOSS OF ULLAGE PRESSURE IS ORBITER RELATED. FOR THIS CASE, A TRANSDUCER INDICATION ERRONEOUSLY HIGH WOULD INDICATE THAT THE ORBITER IS NOT THE CAUSE OF THE LOW LH2 ULLAGE PRESSURE. MCC WOULD ASSUME THAT THE LOW ULLAGE PRESSURE IS DUE TO AN ULLAGE LEAK. A TAL ABORT WOULD BE INITIATED WHICH LEAVES THE SSME THROTTLES AT NOMINAL MISSION POWER LEVEL. WITHOUT THROTTLING DOWN, NPSP WOULD EVENTUALLY FALL TOO LOW TO SUSTAIN SSME OPERATION. SINCE SSME SHUTDOWN LIMITS ARE MANUALLY ENABLED FOR A TAL ABORT FOR AN LH2 ULLAGE LEAK, ALL THREE SSMES WOULD BE EXPECTED TO SHUTDOWN OVER A VERY SHORT TIME PERIOD ONCE NPSP FALLS BELOW 3.5 PSI. IF THIS OCCURS PRIOR TO REACHING THE REQUIRED TAL MECO VELOCITY, POSSIBLE LOSS OF CREW AND VEHICLE COULD RESULT.

CASE II: ERRONEOUS LOW INDICATION

1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT.

1. TRANSDUCER ERRONEOUSLY INDICATES LOW
2. ULLAGE LEAK FROM THE ET LH2 TANK

ET LH2 TANK ULLAGE PRESSURE WILL FALL OUT OF CONTROL BAND (NOMINAL 32-34 PSIA). FLIGHT RULES HAVE MCC USE THE GH2 PRESSURIZATION SYSTEM PRESSURE TO DETERMINE IF THE CAUSE FOR THE LOSS OF ULLAGE PRESSURE IS ORBITER RELATED. FOR THIS CASE, A TRANSDUCER INDICATION ERRONEOUSLY LOW WOULD INDICATE THAT AN ORBITER RESTRICTION IS THE CAUSE OF THE LOW LH2 ULLAGE PRESSURE. PRESSING UPHILL WITH MANUAL THROTTLING WOULD BE INVOKED PER THE CRITERIA SET FORTH IN FLIGHT RULES. HOWEVER, SINCE THE REAL CAUSE FOR THE LOW ULLAGE PRESSURE IS AN ULLAGE LEAK, THROTTLING DOWN TO INCREASE NPSP MAY NOT BE EFFECTIVE. SINCE SSME SHUTDOWN LIMITS ARE MANUALLY ENABLED FOR ALL GH2 PRESSURIZATION SYSTEM ANOMALIES EXCEPT FOR A SINGLE FLOW CONTROL VALVE FAILED IN LOW FLOW, ALL THREE SSMES WOULD BE EXPECTED TO SHUTDOWN OVER A VERY SHORT TIME PERIOD ONCE NPSP FALLS BELOW 3.5 PSI. IF THIS OCCURS PRIOR TO REACHING AN ACCEPTABLE MECO VELOCITY, POSSIBLE LOSS OF CREW AND VEHICLE COULD RESULT.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE TRANSDUCER IS BASED UPON A WHEATSTONE BRIDGE CONSISTING OF FOUR DEPOSITED THIN FILM STRAIN GAGES. THE FOUR THIN FILM STRAIN GAGES HAVE BEEN DEPOSITED ON A BENDING BEAM USING MICROCIRCUIT MANUFACTURING TECHNIQUES (VAPOR OR SPUTTER DEPOSITION). THE BENDING BEAM IS CONNECTED TO THE SENSING DIAPHRAGM BY A LINK PIN. THE DIAPHRAGM DEFLECTION DUE TO PRESSURE CHANGES IS TRANSMITTED TO THE BEAM THROUGH THE LINK PIN CAUSING BEAM DEFLECTION. THE STRAIN GAGES RESPOND TO THIS DEFLECTION, GENERATING A DIFFERENTIAL VOLTAGE OF APPROXIMATELY 30 MILLIVOLTS AT A FULL SCALE PRESSURE OF 1000 PSI .

GOLD LEAD WIRES CONNECT THE STRAIN GAGES TO ELECTRICALLY ISOLATED PINS ON A STATIONARY YOKE (STAINLESS STEEL). NICKEL LEADS CONNECT THE PINS ON THE STATIONARY YOKE TO ELECTRICALLY ISOLATED FEEDTHROUGH PINS IN THE VACUUM CASE. THE ELECTRICAL SIGNAL FROM THE WHEATSTONE BRIDGE (STRAIN GAGES) IS THEN CARRIED VIA WIRE FROM THE VACUUM CASE FEEDTHROUGH PINS TO THE COMPENSATION RESISTOR NETWORK AND FINALLY TO THE OUTPUT CONNECTOR WELDED TO THE BODY OF THE PRESSURE TRANSDUCER. THE COMPENSATION RESISTOR NETWORK CORRECTS THE TRANSDUCER OUTPUT FOR ERROR SOURCES SUCH AS MODULUS CHANGES OF THE BENDING BEAM DUE TO TEMPERATURE. THE COMPENSATION RESISTORS ARE WITHIN THE OUTER CASE OF THE TRANSDUCER, BUT EXTERNAL TO THE VACUUM CASE.

MATERIALS AND PROCESSES USED ARE COMPATIBLE WITH THE ENVIRONMENTAL CONDITIONS. THE TRANSDUCER IS CAPABLE OF WITHSTANDING 1.5 TIMES MAXIMUM OPERATING PRESSURE WITHOUT A SHIFT IN ITS CALIBRATION.

ERRONEOUS OUTPUT (HIGH OR LOW) IS DEFINED AS THE TRANSDUCER FALSELY INDICATING A PRESSURE HIGHER OR LOWER THAN THE ACTUAL PRESSURE. ERRONEOUS OUTPUT CAN BE CAUSED BY AN ELECTRICAL FAULT: SHORT/OPEN/FAULT IN THE WHEATSTONE BRIDGE CIRCUITRY/COMPENSATION RESISTOR NETWORK, OUTPUT CONNECTOR, EXCITATION SUPPLIED TO THE TRANSDUCER, WIRING EXTERNAL TO THE TRANSDUCER; OR BY A MECHANICAL FAULT: DIAPHRAGM RUPTURE OR EXTERNAL LEAKAGE INTO THE VACUUM CASE. "STICTION" TYPE FAILURE OF THIS TRANSDUCER IS CONSIDERED NON CREDIBLE DUE TO THE SMALL TRAVEL OF THE DIAPHRAGM (0.001 INCH).

**(B) TEST:**

ATP

EXAMINATION OF PRODUCT

PERFORMANCE TESTS

INSULATION RESISTANCE

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PROOF PRESSURE  
PRIMARY AND SECONDARY BARRIER  
1.5 TIMES MAXIMUM OPERATING PRESSURE

CALIBRATION  
0, 20, 40, 60, 80, 100, 80, 60, 40, 20 AND 0 PERCENT OF FULL SCALE PRESSURE (1000 PSIA)  
AT 77 DEG F, +350 DEG F, -250 DEG F, AND +77 DEG F. RECORD ERROR DUE TO  
TEMPERATURE EFFECTS, LINEARITY, RESIDUAL IMBALANCE, REPEATABILITY, AND  
SENSITIVITY.

CERTIFICATION

BY SIMILARITY  
THE TRANSDUCER WAS CERTIFIED BY SIMILARITY, DESIGN ANALYSIS, AND TESTING, AND  
IS SIMILAR IN DESIGN AND CONSTRUCTION TO TRANSDUCERS CERTIFIED BY BELL  
AEROSYSTEMS, MCDONNELL DOUGLAS, GENERAL ELECTRIC, AND MARTIN MARIETTA.  
THE PREVIOUS TEST LIMITS EXCEEDED ORBITER SPECIFICATION REQUIREMENTS.

BY TEST  
OFF-LIMITS VIBRATION TESTING WAS SUCCESSFULLY PERFORMED WITH NASA DESIGN  
AND RELIABILITY CONCURRENCE ON AN ME449-0179-0173 TRANSDUCER AFTER REDESIGN  
FOR THE HIGHER VIBRATION ENVIRONMENT EXPERIENCED BY SOME MPS PRESSURE  
TRANSDUCERS.

BURST TEST  
PRIMARY AND SECONDARY BARRIER  
MINIMUM OF 3 TIMES MAXIMUM OPERATING PRESSURE

OMRSD  
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

RECEIVING INSPECTION  
ALL RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIALS AND PROCESS  
CERTIFICATION.

CONTAMINATION CONTROL  
CLEANLINESS LEVEL IS VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY  
INSPECTION.

ASSEMBLY/INSTALLATION  
PARTS ARE INSPECTED VISUALLY, DIMENSIONALLY, AND INCREMENTALLY PER  
REQUIREMENTS. TOOL CALIBRATION IS VERIFIED BY INSPECTION. MANDATORY  
INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCESS.

CRITICAL PROCESSES  
THE FOLLOWING ARE VERIFIED BY INSPECTION:

SOLDERING  
HEAT TREATMENT  
PARTS PASSIVATION

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WELDING

TESTING

ATP, INCLUDING PROOF PRESSURE TEST, IS OBSERVED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING SPECIAL

HANDLING PER DOCUMENTED INSTRUCTIONS IS VERIFIED BY INSPECTION TO PRECLUDE DAMAGE, SHOCK, AND CONTAMINATION DURING COMPONENT HANDLING, TRANSPORTING, AND PACKAGING.

**(D) FAILURE HISTORY:**

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

**(E) OPERATIONAL USE:**

FLIGHT RULES DOCUMENT PROPER ACTIONS TO BE TAKEN IN THE EVENT THAT AN LH2 ULLAGE LOSS OCCURS AND THE GH2 PRESSURIZATION SYSTEM PRESSURE MEASUREMENT IS FUNCTIONING CORRECTLY.

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**- APPROVALS -**

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S&R ENGINEERING	: L. DANG	:/S/ L. DANG
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	:/S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: HERB WOLFSON	:/S/ HERB WOLFSON
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
INSTRUMENTATION	: BILL MCKEE	:/S/ BILL MCKEE
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MIKE SNYDER	:/S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	:/S/ ERICH BASS