

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0724 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 02/20/01

PART DATA

| | PART NAME | PART NUMBER |
|-----|-------------------------------------|--------------------------|
| | VENDOR NAME | VENDOR NUMBER |
| LRU | :TRANSDUCER, LH2 TEMPERATURE RDF | ME449-0013-0018 21035 |

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

TRANSDUCER, LH2 17 INCH FEEDLINE MANIFOLD DISCONNECT TEMPERATURE (V41T1428A).

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

MEASURES TEMPERATURE OF LH2 IN THE FEEDLINE MANIFOLD NEAR THE 17-INCH DISCONNECT. THIS TRANSDUCER IS USED TO DETECT THE TEMPERATURE OF LH2 AND WILL INDICATE THE PRESENCE OF GH2 DUE TO EXCESSIVE HEAT LEAK INTO THE FEED SYSTEM, INADEQUATE RECIRCULATION FLOW, OR THE HIGH POINT BLEED VALVE AND/OR THE T-0 DISCONNECT NOT OPEN.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: TRANSDUCER, LH2 TEMPERATURE
ITEM NAME: TRANSDUCER, LH2 TEMPERATURE

CRITICALITY OF THIS FAILURE MODE: 1R2

FAILURE MODE:
ERRONEOUS INDICATION (FAILS WITHIN LCC LIMITS)

MISSION PHASE: PL PRE-LAUNCH

| | | |
|---|-----|-----------|
| VEHICLE/PAYLOAD/KIT EFFECTIVITY: | 102 | COLUMBIA |
| | 103 | DISCOVERY |
| | 104 | ATLANTIS |
| | 105 | ENDEAVOUR |

CAUSE:
PIECE PART STRUCTURAL FAILURE, CONTAMINATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

- A) PASS
- B) FAIL
- C) PASS

PASS/FAIL RATIONALE:

A)
FAILURE WITHIN LCC LIMITS WOULD BE DETECTABLE AT AMBIENT CONDITIONS.

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

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
LOSS OF ABILITY TO DETECT LH2 TEMPERATURE VIOLATION DURING PRELAUNCH.

(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

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(C) MISSION:

NO EFFECT. VIOLATION OF LCC WILL RESULT IN LAUNCH SCRUB.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

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

- 1) LH2 MANIFOLD TEMPERATURE TRANSDUCER (V41T1428A) -ERRONEOUS INDICATION WITHIN LCC LIMITS.
- 2) LH2 MANIFOLD TEMPERATURE OUT OF LCC LIMITS (HIGH).

POSSIBLE GAS FORMATION IN LH2 MANIFOLD RESULTING IN GAS INGESTION INTO SSMES AT ENGINE START. RESULTS IN POSSIBLE UNCONTAINED ENGINE DAMAGE DUE TO PUMP CAVITATION. HAZARDS ASSOCIATED WITH FIRE/EXPLOSION. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE TRANSDUCER IS HERMETICALLY SEALED AND IS DESIGNED AND CONSTRUCTED TO WITHSTAND THE STATIC AND DYNAMIC LOADS IMPOSED BY OPERATIONAL SERVICE AND ALL OTHER HANDLING ASPECTS. THE PROBE IS CYLINDRICAL CONSISTING OF THE ONE PIECE HEX NUT AND THREADED SECTION WHICH IS TUNGSTEN-INERT GAS (TIG) WELDED TO AN EXTENDED MANDREL. THE PLATINUM SENSING WIRE IS COILED AROUND THE MANDREL. IT IS INSULATED FROM THE MANDREL BY PLASMA DEPOSITED ALUMINUM OXIDE (AL₂O₃). THE SENSING WIRE AND MANDREL IS CONTAINED WITHIN AN OUTER STAINLESS STEEL SHEATH THAT IS TIG WELDED TO THE THREADED PART AND ALSO AT THE TIP OF THE MANDREL. THE STRUCTURE IS ALL STAINLESS STEEL. THE PROBE IS DESIGNED AND CONSTRUCTED TO WITHSTAND 3,000 PSIA WITHOUT ANY STRUCTURAL FAILURE.

(B) TEST:

ATP

EXAMINATION OF PRODUCT

LEAKAGE TEST

LEAK TESTING PRECLUDES LEAKAGE GREATER THAN 1X10⁻⁶ SCC/SEC.

INSULATION RESISTANCE TEST

USING 100 VOLTS DC AND AN ELECTRIFICATION TIME OF 2 MINUTES BEFORE MEASUREMENT THE RESISTANCE SHALL BE LESS THAN 50 MEGOHMS WHEN

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MEASURED BETWEEN INSULATED TERMINALS AND BETWEEN THE TERMINAL AND THE CASE.

CALIBRATION

CALIBRATED AT 5 POINTS (-450, -410, -320, +32, AND +212 DEG F)

CERTIFICATION

CALIBRATION

CALIBRATED AT 5 POINTS (-450, -410, -320, +32, AND +212 DEG F)

THERMAL SHOCK

10 CYCLES FROM +75 TO -320 DEG F

RANDOM VIBRATION AND LOW TEMPERATURE TEST:

13.3 HOURS OF RANDOM VIBRATION AT -320 DEG F IN EACH OF THE 2 AXES.

BURST PRESSURE TESTING

NO LEAKAGE SHALL OCCUR WHEN SUBJECTED TO 3000 PSI.

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RECEIVING INSPECTION PERFORMS VISUAL AND DIMENSIONAL EXAMINATION OF ALL INCOMING PARTS. CERTIFICATION RECORDS/TEST REPORTS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES.

CONTAMINATION CONTROL

CLEANLINESS LEVEL 400 IS MAINTAINED AND VERIFIED IN ACCORDANCE WITH APPLICABLE REQUIREMENT.

ASSEMBLY/INSTALLATION

MANDATORY INSPECTION POINTS ARE INCLUDED IN MANUFACTURING PROCESS. TOOL CALIBRATION IS VERIFIED TO THE REQUIREMENT. PARTS ARE INSPECTED VISUALLY, DIMENSIONALLY, AND INCREMENTALLY IN ACCORDANCE WITH SPECIFICATION.

CRITICAL PROCESSES

DRY FILM LUBRICANT APPLIED TO THREADS IS VERIFIED PER DRAWING SPECIFICATION. TIG WELDING IS VERIFIED BY INSPECTION AND LEAK CHECK.

NONDESTRUCTIVE EVALUATION

HELIUM LEAK TEST IS VERIFIED BY INSPECTION. RADIOGRAPHIC INSPECTION IS CONDUCTED TO VERIFY THE EXISTENCE OF STRAIN RELIEF ON THE WINDING ELEMENT AND TO DETECT METALLIC CONTAMINATION IN THE HOUSING WHERE THE CONNECTOR IS WELDED.

TESTING

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ATP AND PROOF PRESSURE TESTS ARE OBSERVED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING AND PROTECTION ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS. SPECIAL HANDLING PER DOCUMENTED INSTRUCTIONS IS VERIFIED TO PRECLUDE DAMAGE, SHOCK, AND CONTAMINATION DURING COMPONENT HANDLING/TRANSPORTING/PACKAGING BETWEEN WORK STATIONS.

(D) FAILURE HISTORY:

DURING QUALIFICATION VIBRATION TEST AN OPEN CIRCUIT WAS NOTED. EXAMINATION LOCATED THE OPEN CIRCUIT AT THE POINT WHERE THE ELEMENT WIRES EXIT SMALL CERAMIC TUBES INTO THE TRANSITION AREA. BOTH ELEMENT WIRES SHEARED FOR TWO REASONS: FIRST, THE TRANSITION WIRING (SWAGED CABLE ASSEMBLY) WAS HEAVIER AND MOVED AT A DIFFERENT RATE THAN THE .0007 INCH DIAMETER ELEMENT WIRES. SECOND, THE ALUMINUM OXIDE PACKING MATERIAL (POWDER) ALLOWED SOME SHIFTING OR WIRE MOVEMENT. CORRECTIVE ACTION WAS TO REPLACE THE SWAGED CABLE ASSEMBLY WITH FIBERGLASS INSULATED .015 DIAMETER PLATINUM WIRE AND CHANGE THE PACKING POWDER FROM 180 GRIT TO A COMBINATION OF 180 AND 300 GRIT. THE 300 GRIT WILL ELIMINATE VOIDS BETWEEN THE LARGER 180 GRIT AND ENSURE TIGHTER PACKING. NOTE: THE QUAL UNIT WAS REWORKED WITH .012 INCH DIAMETER TRANSITION WIRE INSTEAD OF THE REQUIRED .015 (BECAUSE OF IMMEDIATE AVAILABILITY) AND SUBSEQUENTLY PASSED. PRODUCTION UNITS WILL USE THE .015 WIRE. THIS ACTION IS ACCEPTABLE BECAUSE THE .012 WIRE WOULD BE THE WORST CASE CONDITION (REFERENCE CAR AB9628).

DURING QUALIFICATION VIBRATION TEST, AN OPEN CIRCUIT WAS NOTED. FAILURE ANALYSIS REVEALED AN OPEN CIRCUIT BETWEEN THE ELEMENT AND TRANSITION WIRING ON THE ELEMENT SIDE OF THE RIBBON CONNECTION, RESULTING FROM LACK OF STRESS RELIEF LOOP (REFERENCE CAR 9807). THIS IS A WORKMANSHIP ERROR. ASSEMBLY DRAWINGS CLEARLY STIPULATE THE REQUIREMENT FOR A STRESS RELIEF LOOP. AS A RESULT OF THIS FAILURE THE VENDOR HAS ADDED A MANDATORY INSPECTION POINT TO THE TRAVEL CARD TO INSURE PRESENCE OF A STRESS RELIEF LOOP.

SSME-2 LH2 INLET TEMPERATURE INDICATED OFF SCALE HIGH AT ABOUT T+4 MINUTES DURING STS 51-J (OV-104). SUBSEQUENT TESTING BY THE SUPPLIER INDICATED AN OPEN CIRCUIT. TEARDOWN REVEALED THAT THE OPEN CIRCUIT WAS CAUSED BY A CHIP WHICH HAD BROKEN LOOSE FROM THE ALUMINUM OXIDE COATING OVER THE MANDREL HOLDING THE PLATINUM SENSE-WIRE ELEMENT. A POSSIBLE CAUSE WAS INADVERTENT CONTAMINATION DURING THE BUILD CYCLE. THESE UNITS ARE X-RAYED AFTER ASSEMBLY, BUT THE X-RAY WILL NOT SHOW THE CHIPPING DEFECT. MANUFACTURING X-RAYS WERE REVIEWED TO CHECK FOR VOIDS IN THE ALUMINUM OXIDE PACKING POWDER. NO SIMILAR FAILURE (CHIP) HAS BEEN EXPERIENCED BEFORE BY THE SUPPLIER. AS A PRECAUTION A NOTE WAS ADDED TO THE BUILD DRAWING TO AVOID TOUCHING ALUMINUM OXIDE COATING OF MANDREL WITH BARE FINGERS (REFERENCE CAR 28F007).

TEMPERATURE TRANSDUCER S/N 112 FAILED OFF SCALE HIGH DURING STS-4 MAIN ENGINE OPERATION, THEN RETURNED TO NORMAL AFTER MECO. THIS TRANSDUCER IS LOCATED AT A HIGH VIBRATION POINT AS EVIDENCE BY PREVIOUS MPTA FAILURE (REF CAR AB5722). THE TRANSDUCER WAS REMOVED AND SENT TO THE SUPPLIER FOR FAILURE VERIFICATION AND EVENTUAL SCRAP. THIS TRANSDUCER, AND OTHERS THAT ARE ALSO

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LOCATED AT HIGH VIBRATION POINTS, WILL BE REPLACED ON AN ATTRITION BASIS WITH THE -0021 WHICH IS A REDESIGN VERSION FOR HIGHER VIBRATION ENVIRONMENTS (REF MCR 7289).

DURING MPTA STATIC FIRING NUMBER 9-01, THE TRANSDUCER S/N 115 READ 1.5 DEG F TO LOW (REF CAR AB6862). AFTER THE FIRING, THE TRANSDUCER WAS RE CALIBRATED AT MPTA. THE RE CALIBRATION DATA WAS COMPARED TO THE ORIGINAL CALIBRATION DATA AND IT WAS FOUND TO BE OUT OF TOLERANCE BY 0.3 DEG F, WHICH DID NOT VERIFY THE ORIGINAL OUT OF TOLERANCE READING OF 1.5 DEG F. THE UNIT WAS THEN RETURNED TO THE SUPPLIER WHERE THE ANOMALY COULD NOT BE DUPLICATED. THE VALUE OBTAINED DURING THE SUPPLIER RE CALIBRATION COMPARED CLOSELY WITH THE SUPPLIERS ORIGINAL CALIBRATION DATA. IT WAS CONCLUDED THAT THE MOST PROBABLE CAUSE OF FAILURE WAS DUE TO A BAD CONTACT IN THE WIRE GOING TO THE DEDICATED SIGNAL CONDITIONER (D.SC.). A DIRTY OR BAD CONTACT CAN RESULT IN ADDITIONAL WIRE RESISTANCE THAT WILL ALTER THE SIGNAL GOING TO THE D.SC.. THIS WAS THE FIRST OCCURRENCE OF THIS TYPE AND IS CONSIDERED AN ISOLATED CASE.

DURING MPTA STATIC FIRING, 4 TEMPERATURE SENSORS DISPLACED FULL SCALE OUTPUT (-425 DEG F) (REF CAR AB5722). THESE SENSORS WERE: ME449-0013-0017, S/N 105; ME449-0013-0018, S/N 104; 105; AND 113. TEARDOWN ANALYSIS BY THE SUPPLIER REVEALED THAT ALL UNITS EXHIBITED AN OPEN CIRCUIT, RESULTING FROM A BREAK IN THE LEAD OR ELEMENT WIRE. THE CAUSE OF ELEMENT FAILURE IS ATTRIBUTED TO HIGH VIBRATION LEVELS ENCOUNTERED DURING MPTA STATIC FIRINGS. THE VIBRATION LEVELS SEEN DURING THE FIRING EXCEED QUAL TEST LEVELS IN BOTH FREQUENCY AND MAGNITUDE. MCR7289 AUTHORIZED DESIGN OF THE TRANSDUCER USING A LARGER ELEMENT WIRE TO WITHSTAND A HIGHER VIBRATION ENVIRONMENT.

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

(E) OPERATIONAL USE:

NO CREW ACTION CAN BE TAKEN.

HIGH POINT BLEED TEMPERATURE MAY ACT AS A INDICATOR OF LH2 PROPELLANT QUALITY.

- APPROVALS -

| | | |
|---------------------|------------------------|---------------------------|
| S&R ENGINEERING | : W. P. MUSTY | :/S/ W. P. MUSTY |
| 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 |

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NASA SR&QA

: ERICH BASS

:/S/ ERICH BASS