

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0520 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 0 02/22/01

PART DATA

| | PART NAME | PART NUMBER |
|-----|--|----------------------|
| | VENDOR NAME | VENDOR NUMBER |
| LRU | : GH2 ET PRESSURIZATION MANIFOLD ASSEMBLY BOEING | V070-415413 |

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

MANIFOLD ASSEMBLY, GH2 PRESSURIZATION. THE MANIFOLD ASSEMBLY CONSISTS OF TEST PORT BOSS, TUBE SEGMENTS, AND A MANIFOLD.

REFERENCE DESIGNATORS:**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

PROVIDES A FLOW PATH FOR GH2 FROM THE THREE FLOW CONTROL VALVES TO THE TWO INCH GH2 PRESSURIZATION LINE INTERFACE FOR ET ULLAGE PRESSURIZATION DURING ENGINE OPERATION. ALSO PROVIDES THE FLOW PATH FOR HELIUM FROM THE GSE FOR PROPELLANT LOADING PRESSURIZATION, ANTI-ICING PURGE, AND ET PRESSURIZATION. MANIFOLD ASSEMBLY INCLUDES A MANIFOLD, FOUR ONE INCH DIAMETER LINES, BOSS FOR THE TEST POINT COUPLING (PD16), AND CONNECTING UNIONS.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0520-01

REVISION#: 1 02/22/01

SUBSYSTEM NAME: MAIN PROPULSION

LRU: GH2 ET PRESSURIZATION MANIFOLD ASSEMBLY

CRITICALITY OF THIS

ITEM NAME: GH2 ET PRESSURIZATION MANIFOLD ASSEMBLY

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE.

MISSION PHASE:

PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

MATERIAL DEFECT, FATIGUE FAILURE, DAMAGED BRAZE JOINTS.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

GH2 AND/OR GHE LEAKAGE INTO THE AFT COMPARTMENT. POSSIBLE OVERPRESSURIZATION OF THE AFT COMPARTMENT AND FIRE/EXPLOSION HAZARD. GHE LEAKAGE FROM ANTI-ICING PURGE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0520-01**

GH2 FLOW CONTROL VALVES WILL OPEN IN AN ATTEMPT TO MAINTAIN ULLAGE PRESSURE. LOSS OF ET LH2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE UNCONTAINED SSME SHUTDOWN DUE TO LOW LH2 NPSP.

ALSO RESULTS IN POSSIBLE LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

ON GROUND, VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

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

POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:

NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE GH2 MANIFOLD IS DESIGNED TO PROVIDE THE MAXIMUM FLOW CAPACITY FROM 3 FULLY OPENED FLOW CONTROL VALVES AND TO PROVIDE A FLOW PATH FOR HELIUM FROM THE GSE FOR PROPELLANT LOADING PRESSURIZATION, ANTI-ICING PURGE, AND ET PRE PRESSURIZATION.

THE DESIGN CONSISTS OF A RIGID MANIFOLD MACHINED FROM FORGED 21-6-9 CRES. THE MANIFOLD HAS 4 TUBE ATTACH INTERFACES FOR CONNECTING THE 1 INCH DIAMETER BY 0.028 INCH WALL THICKNESS TUBE SEGMENTS (21-6-9 CRES) FROM EACH FLOW CONTROL VALVE AND THE ET HELIUM PRE PRESSURIZATION CHECK VALVE (CV17). THE TUBE SEGMENT CONNECTING TO THE PRE PRESSURIZATION CHECK VALVE CONTAINS A TEE (21-6-9 CRES 1 INCH DIAMETER BY 0.028 INCH WALL THICKNESS) FOR INSERTION OF THE TEST POINT COUPLING (PD16).

THE TUBE SEGMENTS ARE CONNECTED TO THE MANIFOLD ATTACH INTERFACES BY INDUCTION BRAZING USING 21-6-9 CRES UNIONS AND BRAZE ALLOY PREFORMS (81.5AU, 16.5CU, 2NI). THE ROCKWELL INTERNATIONAL BRAZE ALLOY WAS SELECTED DUE TO ITS LOWER BRAZING TEMPERATURE REQUIREMENT THAN THE INDUSTRY STANDARD, AIDING IN THE PREVENTION OF EXCESSIVE GRAIN GROWTH AND REDUCING EROSION OF TUBE ENDS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0520-01**

FACTORS OF SAFETY ON THE FINAL ASSEMBLY ARE 2.0 PROOF AND 4.0 BURST. STRUCTURAL ANALYSIS OF THE MANIFOLD ASSEMBLY INDICATED POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF ENGINE OPERATION.

(B) TEST:
ATP

THE TEE FITTING IS PROOF PRESSURE TESTED TO 1900 PSIG AND LEAK CHECKED AT 950 PSIG PRIOR TO INSTALLATION INTO THE VEHICLE. THE MANIFOLD IS PROOF PRESSURE TESTED AT 970 PSIG AND LEAK CHECKED AT 650 PSIG PRIOR TO INSTALLATION INTO THE VEHICLE.

THE MANIFOLD ASSEMBLY IS PROOF PRESSURE TESTED TO 950 PSIG AND LEAK CHECKED AT 550 PSIG AFTER INSTALLATION INTO THE VEHICLE.

CERTIFICATION

CERTIFICATION OF THE TUBING INSTALLATION WAS ACCOMPLISHED BY ROCKWELL INTERNATIONAL PER THE "ORBITER TUBING VERIFICATION PLAN SD75-SH-205".

THE 21-6-9 CRES TUBING WAS CERTIFIED FOR THE DC10, L1011, AND 747 AIRCRAFT. THE 304L CRES TUBING WAS CERTIFIED FOR THE APOLLO PROPULSION SYSTEMS, THE F5E, A-9, C130A, 707, 727, AND 737 AIRCRAFT. THE TUBING WAS QUALIFIED BY SIMILARITY AND BY ANALYSIS FOR ORBITER USAGE EXCEPT FOR FLEXURE FATIGUE AND RANDOM VIBRATION FOR THE LONG-LIFE ORBITER REQUIREMENTS. DATA FROM THE MISSION DUTY CYCLES CONDUCTED ON MPTA WERE ALSO USED TO CERTIFY TUBING INSTALLATIONS.

CRES TUBING WITH DYNATUBE FITTINGS AND SEALS WAS SUBJECTED TO THE FOLLOWING QUALIFICATION TESTS:

PROOF PRESSURE
TWO TIMES OPERATING PRESSURE

EXTERNAL LEAKAGE
1.5 TIMES OPERATING PRESSURE
1X10⁻⁶ SCCS MAX

IMPULSE FATIGUE (200,000 CYCLES)

FLEXURE FATIGUE (10 MILLION FLEXURE CYCLES)

VIBRATION (7 UNITS)
45 MINUTES AT 0.4 G²/HZ
30 MINUTES AT 0.7 G²/HZ
10 MINUTES AT 0.2 G²/HZ

BURST TEST
FOUR TIMES OPERATING PRESSURE

VERIFICATION

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0520-01**

QUALIFICATION TESTING OF A COMPLETED GH2 MANIFOLD ASSEMBLY WAS NOT PERFORMED, BUT THE MANIFOLD ASSEMBLY WAS VERIFIED BY ANALYSIS. FOR OV103 REFER TO REPORT STS85-0254 (STRUCTURAL ANALYSIS FOR 6.0 LOADS, DATED APRIL 1988), VOLUME 10 (THRUST STRUCTURE, MPS, AND SECONDARY STRUCTURE). THE GH2 MANIFOLD DESIGN FOR OV102 AND OV104 IS IDENTICAL TO OV103.

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

ALL DETAIL HARDWARE IS VERIFIED INDIVIDUALLY, BY INSPECTION, AT DETAIL LEVEL ON MANUFACTURING ORDERS, WITH ALL PROCESSES INCORPORATED. RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

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

ASSEMBLY/INSTALLATION

PARTS PROTECTION FROM DAMAGE AND CONTAMINATION IS VERIFIED. COMPONENTS ARE INSPECTED VISUALLY, DIMENSIONALLY, AND INCREMENTALLY DURING FABRICATION. AXIAL ALIGNMENT OF DYNATUBE FITTINGS AND TUBING IS VERIFIED. TORQUES AND SEALING SURFACES ARE VERIFIED BY INSPECTION. LUBRICATION OF ALL THREADED FLUID FITTING COUPLINGS IS VERIFIED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURES.

CRITICAL PROCESSES

ELECTRICAL BONDING, HEAT TREATMENT, AND PARTS PASSIVATION ARE VERIFIED BY INSPECTION. INDUCTION BRAZING IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

RADIOGRAPHIC INSPECTION OF INDUCTION BRAZED JOINTS IS VERIFIED.

TESTING

ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

DURING TURNAROUND MAINTENANCE ON OV-099 AT KSC, THE INLET LINE TO VALVE LV58 WAS OFFSET FROM THE CENTERLINE OF THE ATTACHMENT CLAMPS (REFERENCE CAR AC9224). ATTACHMENT OF THE CLAMPS COULD HAVE ONLY BEEN ACHIEVED THROUGH PRELOADING THE BRAZED JOINT; PRELOADED BRAZE JOINTS ARE UNDER ADDITIONAL STRESS WHICH WILL CONTRIBUTE TO FAILURE. A BRACKET WAS ADDED TO THE AUXILIARY SUPPORT TO RELIEVE THE PRELOAD TO THE LH2 INLET LINE. A SPACER AT THE FLOW CONTROL VALVE INLET LINE WAS ADDED BY KSC PR TO RELIEVE THE OFFSET AT THE

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0520-01**

INLET TEE VO70-415448. OV-102, OV-103, OV-104, AND THE MPTA WERE INSPECTED AND REWORKED; RECORDS INDICATED NO EVIDENCE OF PRELOAD.

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:

LH2 ULLAGE PRESSURE IS ON SYSTEMS MANAGEMENT (SM) ALERT. CREW WILL OPEN THE LH2 FLOW CONTROL VALVES (VIA COCKPIT SWITCH S53 ON PANEL R2) FOR A LOW LH2 ULLAGE PRESSURE CONDITION.

IF THE LH2 NPSP DROPS BELOW THE PRE-FLIGHT ACCEPTED LEVELS (PER FLIGHT RULES), THE CREW WILL MANUALLY THROTTLE THE ENGINES TO KEEP THE NPSP HIGH ENOUGH TO PREVENT LH2 TURBOPUMP CAVITATION.

- 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 | : LEE DURHAM | :/S/ LEE DURHAM |
| MPS SUBSYSTEM MGR. | : TIM REITH | :/S/ TIM REITH |
| 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 |