

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0428 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 02/22/01

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : LINE ASSEMBLY BOEING	V070-415309

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LINE ASSEMBLY, LO2 BLEED AND POGO SUPPRESSION. 2.0, 1.5, 1.0 INCH DIAMETERS. CONSISTS OF TUBING SEGMENTS, FLANGE FITTINGS, BRAZE AND WELDED JOINTS, AND GIMBAL SECTIONS.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THE LINE ROUTES LO2 BLEED FLOW OVERBOARD FROM THE SSME'S TO THE T-0 UMBILICAL FOR PRECONDITIONING OF THE SSME'S FOR ENGINE START. THE FLOW CONTINUES UNTIL CLOSURE OF THE ENGINE BLEED VALVES AT ENGINE START. WHEN THE OVERBOARD BLEED VALVE (PV19) IS CLOSED AT T-9.5 SECONDS, THE ENGINE BLEED FLOW IS ROUTED THROUGH THE MPS POGO ACCUMULATOR VALVES (PV20, PV21) TO THE LO2 FEED SYSTEM. THE LINE ASSEMBLY EXTENDS FROM EACH INDIVIDUAL SSME LO2 BLEED INTERFACE TO A COMMON MANIFOLD (1.0 INCH DIA), FROM THE COMMON MANIFOLD TO THE POGO VALVES (PV20, PV21) (2.0 INCH DIA), FROM THE POGO VALVES TO THE ORBITER/ET 17-INCH DISCONNECT (PD1) (2.0 INCH DIA). IT ALSO INCLUDES A LINE (1.5 INCH DIA) FROM THE COMMON MANIFOLD TO THE LO2 OVERBOARD BLEED VALVE (PV19) AND FROM THE LO2 OVERBOARD BLEED VALVE TO THE LO2 OVERBOARD BLEED DISCONNECT (PD13) (1.5 INCH DIA).

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ITEM NAME: LO2 BLEED/POGO LINE ASSEMBLY

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/EXTERNAL LEAKAGE DURING LOADING, ASCENT, AND DUMP/INERT.

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

FATIGUE FAILURE, MATERIAL DEFECT, IMPROPER BRAZE OR WELDS,
DAMAGED/DEFECTIVE JOINT SEAL

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:

LOSS OF POGO RECIRCULATION AND BLEED CAPABILITY. LO2 LEAKAGE INTO AFT COMPARTMENT, RESULTING IN HAZARDS ASSOCIATED WITH LEAKAGE OF CRYOGENIC PROPELLANTS. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE HAZARD. LEAKAGE IN THE AFT COMPARTMENT DETECTABLE DURING LOADING USING

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HAZARDOUS GAS DETECTION SYSTEM (HGDS). POSSIBLE DEPLETION OF LO2 RESULTING IN PREMATURE ENGINE SHUTDOWN.

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

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT
1) OVERBOARD BLEED VALVE (PV19) FAILS TO REMAIN CLOSED.
2) RUPTURE/LEAKAGE OF LINE BETWEEN BLEED VALVE AND DISCONNECT (PD13)

LO2 LEAKAGE INTO THE AFT COMPARTMENT. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE HAZARD. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE LINE SEGMENTS FROM THE ENGINE INTERFACES TO THE MANIFOLD ARE MANUFACTURED USING 21-6-9 CRES TUBE SEGMENTS 1 INCH O.D. WITH .020 INCH WALL THICKNESS. THE TEE'S ARE MACHINED FROM 21-6-9 CRES MATERIAL. THE TUBE SEGMENTS, CHECK VALVE, TEE'S, AND MANIFOLD ARE CONNECTED TOGETHER BY INDUCTION BRAZING USING 21-6-9 CRES UNIONS AND BRAZE ALLOY PREFORMS (81.5 AU, 16.5 CU, 2 NI). 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.

THE LINE SEGMENT FROM THE MANIFOLD TO THE LO2 BLEED DISCONNECT IS MANUFACTURED USING 21-6-9 CRES TUBE SEGMENTS 1.5 INCH O.D., .035 INCH WALL THICKNESS. THE VALVE AND DISCONNECTS ARE INSTALLED USING FLANGE JOINTS. THE FLANGES ARE MACHINED FROM 21-6-9 CRES AND 304L CRES AND ARE WELDED TO THE TUBE SEGMENTS. THREE GIMBAL JOINTS WERE BUTT WELDED TO THE FLANGE AND TUBE SEGMENTS USING INCONEL 718 WELDING WIRE.

THE LINE SEGMENT FROM THE MANIFOLD TO THE ET DISCONNECT IS MANUFACTURED USING 21-6-9 CRES TUBE SEGMENTS 2 INCH O.D., .035 WALL THICKNESS. THE VALVES ARE INSTALLED USING FLANGE JOINTS MACHINED FROM 21-6-9 CRES. THE TUBE

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SEGMENTS, TEE'S AND FLANGE ARE WELDED TOGETHER. THE GIMBAL LINE ASSEMBLY IS MANUFACTURED FROM 21-6-9 CRES TUBE SEGMENTS (2 INCH O.D., .035 INCH WALL THICKNESS), GIMBAL JOINTS FABRICATED FROM INCONEL 718, AND FLANGES MACHINED FROM 21-6-9 CRES MATERIAL. THREE GIMBAL JOINTS WERE BUTT WELDED TO THE FLANGE AND TUBE SEGMENTS USING INCONEL 718 WELDING WIRE.

ALL THE GIMBAL JOINTS WERE DESIGNED AND MANUFACTURED BY AMETEK STRAZA. THE GIMBAL JOINT WAS DESIGNED TO DEFLECT A MINIMUM OF PLUS AND MINUS 13 DEGREES IN ANY PLANE. THE GIMBAL ASSEMBLY CONSISTS OF TWO OPPOSITE FORMED FORKS LOCATED 90-DEGREES TO EACH OTHER AND LINKED TOGETHER WITH ENTRAPPED PINS THROUGH A GIMBAL RING. THE BELLOWS WERE DESIGNED TO PRECLUDE FLOW INDUCED VIBRATION BY USING TWO INCONEL 718 FLOW LINERS. THE GIMBAL JOINT WAS DESIGNED TO PRECLUDE GENERATION OF PARTICLES IN EXCESS OF 400A PER MA0110-301. THE GIMBAL JOINT WAS FABRICATED FROM INCONEL 718 MATERIAL AND IS ASSEMBLED USING FUSION WELDING.

STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF LINE OPERATIONS.

(B) TEST:

ATP

LINE ASSEMBLY

THE MANIFOLD ASSEMBLIES AND THE TWO LINE ASSEMBLIES WITH GIMBAL JOINTS ARE PROOF PRESSURE TESTED TO 600 PSIG AND EXTERNAL LEAK CHECKED AT 400 PSIG PRIOR TO INSTALLATION IN THE VEHICLE.

AFTER INSTALLATION THE SYSTEM IS PROOF PRESSURE TESTED TO 286 PSIG AND LEAK CHECKED AT 100 PSIG.

GIMBAL JOINT ASSEMBLY

EXAMINATION OF PRODUCT
DIMENSIONAL VERIFICATION

PROOF AT 2 TIMES MAXIMUM OPERATING PRESSURE

EXTERNAL LEAKAGE AT 200 PSIG GHE

ANGULATION

- +/- 13 DEGREES IN EACH PLANE (4 TESTS; BENDING MOMENT IS MEASURED);
- 1 TEST IN EACH OF THE 2 PIN AXES;
- 1 TEST 45 DEGREES FROM EACH OF THE 2 PIN AXES.

REPEAT EXTERNAL LEAKAGE TEST AT 200 PSIG GHE

CERTIFICATION

GIMBAL JOINT ASSEMBLY

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QUALIFICATION TESTS WERE PERFORMED ON FOUR 2 INCH AND TWO 1.5 INCH GIMBAL JOINTS.

VIBRATION (6 GIMBAL JOINTS) VIBRATED ALONG AXES OF BELLOWS AND NORMAL TO THE BELLOWS AXES

2 INCH GIMBALS (2 UNITS): +600 DEG F, 650 PSIG
SINUSOIDAL TEST FROM 5 TO 35 HZ, +/- 0.25 G'S PEAK
RANDOM VIBRATION MAINTAINED FOR 13 HOURS AND 18 MINUTES

2 INCH GIMBALS (2 UNITS): CRYO (-300 DEG F), 275 PSIG
SINUSOIDAL TEST FROM 5 TO 35 HZ, +/- 0.25 G'S PEAK
RANDOM VIBRATION MAINTAINED FOR 13 HOURS AND 18 MINUTES

1.5 INCH GIMBALS (2 UNITS): AMBIENT PRESSURE & TEMPERATURE
SINUSOIDAL TEST FROM 5 TO 35 HZ, +/- 0.25 G'S PEAK
RANDOM VIBRATION MAINTAINED FOR 48 MINUTES

NO LEAKAGE OR BINDING NOTED AFTER COMPLETION OF VIBRATION TESTS

PRESSURE IMPULSE (2 UNITS)
500 CYCLES, 28 PSIG TO 650 PSIG WITH NO LEAKAGE OR BINDING

LIFE CYCLE FLEXURE TEST (4 UNITS)
200 CYCLES AT PLUS AND MINUS 11.7 DEGREES
2000 CYCLES AT PLUS AND MINUS 9.36 DEGREES
NO LEAKAGE OR WEAR NOTED

BURST TEST (3 UNITS)
2 INCH GIMBAL (2 UNITS) - PRESSURIZED TO 2850 PSIG ROOM AMBIENT TEMPERATURE FOR 5 MINUTES
1.5 INCH GIMBAL (1 UNIT) - PRESSURIZED TO 1664 PSIG AT ROOM AMBIENT TEMPERATURE FOR 5 MINUTES

LEAKAGE - 200 PSIG GHE, 1X10-5 SCC/SEC.

TUBING

CERTIFICATION OF THE TUBING WAS ACCOMPLISHED BY ROCKWELL INTERNATIONAL PER THE ORBITER TUBING VERIFICATION PLAN SD75-SH-205. THE 21-6-9 CRES TUBING WAS PREVIOUSLY QUALIFIED FOR THE DC-10, L1011 AND 747 AIRCRAFT. THE INDUCTION BRAZING OF 21-6-9 CRES TUBING WITH ROCKWELL INTERNATIONAL BRAZE UNION AND BRAZE ALLOY WAS CERTIFIED BY SUBJECTING A REPRESENTATIVE SAMPLE OF TUBE SEGMENTS TO PROOF PRESSURE, IMPULSE FATIGUE, FLEXURE FATIGUE, RANDOM VIBRATION, AND BURST TESTS.

THE 21-6-9 CRES WELD JOINTS ARE SIMILAR TO THE 304L WELD JOINTS. THE SLEEVE-TYPE BUTT WELDING TECHNIQUE DEVELOPED ON THE APOLLO IS CONSIDERED QUALIFIED BY SIMILARITY TO APOLLO. TUBING USED ON APOLLO WAS NOT EVALUATED FOR FLEXURAL

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FATIGUE AND RANDOM VIBRATION REQUIRED BY FOR THE ORBITER LONG-LIFE. TEST SPECIMENS WERE SUBJECTED TO IMPULSE FATIGUE, FLEXURE FATIGUE, RANDOM VIBRATION, AND BURST TESTS.

TUBE SEGMENTS WERE SUBJECTED TO THE FOLLOWING:

PROOF PRESSURE -	PRESSURIZED TO TWO TIMES MAX OPERATING AND HELD FOR 5 MINUTES.
EXTERNAL LEAKAGE -	PRESSURIZED TO MAXIMUM OPERATING PRESSURE.
IMPULSE FATIGUE -	200,000 CYCLES, BENDING STRESS 20,000 PSI: PRESSURE 1000 PSIG (2 UNITS), 1500 PSIG (1 UNIT), 2000 PSIG (1 UNIT) AND 3000 PSIG (2 UNITS)
FLEXURE FATIGUE -	PRESSURIZE TO OPERATING PRESSURE, 10,000,000 CYCLES
RANDOM VIBRATION -	(7 UNITS) WERE SUBJECTED TO VIBRATION AT AMBIENT PRESSURE AND TEMPERATURE CONDITIONS
BURST TESTS -	2 TIMES MAX OPERATING PRESSURE

VERIFICATION

QUALIFICATION TESTING OF A COMPLETED GIMBAL LINE ASSEMBLY WAS NOT PERFORMED, BUT THE GIMBAL LINE ASSEMBLIES WERE VERIFIED BY ANALYSIS. FOR OV103/OV104 REFER TO REPORT STS85-0254 (STRUCTURAL ANALYSIS FOR 6.0 LOADS, DATED APRIL 1988), VOLUME 10 (THRUST STRUCTURE, MPS, AND SECONDARY STRUCTURE). FOR OV102 REFER TO REPORT SD77-SH-0178 (DESIGN STRESS ANALYSIS OV102, DATED JULY 1988), VOLUME 10; AND REPORT SOD80- 0173 (OV102 STRESS ANALYSIS AND 5.4 LOADS ASSESSMENT, DATED JULY 1980), VOLUME 10. ..

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIALS AND PROCESSES CERTIFICATION.

CONTAMINATION CONTROL

CLEANLINESS LEVEL VERIFIED TO 800A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

PARTS ARE INSPECTED VISUALLY AND DIMENSIONALLY DURING FABRICATION. FABRICATION OF FLANGES AND TUBES IS VERIFIED TO MEET DRAWING AND SPECIFICATION REQUIREMENTS. PROTECTION OF SEALING SURFACES IS VERIFIED.

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DIMENSIONS AND SURFACE FINISHES ARE VERIFIED TO MEET SPECIFICATION REQUIREMENTS. INSTALLATION PER SPECIFICATION REQUIREMENTS IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES

DRY LUBRICANT APPLIED TO THREADS OF PLUGS IS VERIFIED BY INSPECTION. WELDING IS VERIFIED BY INSPECTION. TUBE BRAZING AND ELECTROPOLISHING OF TUBE ENDS ARE VERIFIED TO MEET DRAWING AND SPECIFICATION REQUIREMENTS. HEAT TREATMENT AND PASSIVATION ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

RADIOGRAPHIC AND DYE PENETRANT INSPECTION OF GIMBAL TO TUBE/FLANGE WELDS ARE VERIFIED BY INSPECTION. RADIOGRAPHIC INSPECTION OF TUBE WELDS AND BRAZES IS VERIFIED BY INSPECTION. PENETRANT INSPECTION OF DETAIL PARTS IS VERIFIED. HELIUM LEAKAGE DETECTION IS CONDUCTED TO MEET SPECIFICATION REQUIREMENTS.

TESTING

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

HANDLING/PACKAGING

HANDLING COVERS ARE PROVIDED TO PREVENT DAMAGE DURING STORAGE/INSTALLATION/SHIPPING. PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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:

FLIGHT: NO CREW ACTION CAN BE TAKEN.

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN SYSTEM.

- 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