FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0509 -X

SUBSYSTEM NAME: MAIN PROPULSION
REVISION: 1 02/22/01

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: GO2 2" PRESSURIZATION LINE ASSEMBLY BOEING	V070-415409

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
THE LINE ASSEMBLY CONSISTS OF GIMBAL JOINTS, LINE FLANGES, TRANSDUCER BOSS, DYNATUBE FITTINGS, TEE, AND TUBE SEGMENTS.

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
PROVIDES THE FLOW PATH FOR ET PRESSURIZATION GO2 FROM THE FLOW CONTROL VALVE MANIFOLD TO THE ET/ORBITER DISCONNECT DURING ENGINE OPERATION. IT ALSO PROVIDES THE FLOW PATH FOR GSE SUPPLIED HELIUM FROM THE PREPRESSURIZATION CHECK VALVE (CV16) FOR PROPELLANT LOADING PRESSURIZATION, ANTI-ICING AND PREPRESSURIZATION PRIOR TO SSME START. THE LINE ASSEMBLY INCLUDES THE LINE TO THE GO2 REPRESSURIZATION ORIFICE (RP1); THE LINE FROM THE REPRESSURIZATION CHECK VALVE (CV10) OUTLET; THE LINE TO THE GO2 DISCONNECT PRESSURE TRANSDUCER PORT; THE DELTA PRESSURE TRANSDUCER LINE; AND THE LINE TO CV16.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0509-01

REVISION#: 1 02/22/01

SUBSYSTEM NAME: MAIN PROPULSION
LRU: GO2 2" PRESSURIZATION LINE ASSEMBLY **CRITICALITY OF THIS**
ITEM NAME: GO2 2" PRESSURIZATION LINE ASSEMBLY **FAILURE MODE:** 1/1

FAILURE MODE:
RUPTURE/LEAKAGE.

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF
DO DE-ORBIT

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

CAUSE:
MATERIAL DEFECT, FATIGUE FAILURE, DAMAGED BRAZE/WELD JOINTS, DAMAGED/DEFECTIVE JOINT SEALS.

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:
GO2 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: 03-1-0509-01

THE FLOW CONTROL VALVES WILL OPEN IN AN ATTEMPT TO MAINTAIN ET ULLAGE PRESSURE (ACTIVE CONFIGURATION ONLY). LOSS OF ET LO2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE LOSS OF ADJACENT CRITICAL COMPONENTS DUE TO IMPINGEMENT OF HIGH PRESSURE GAS. POSSIBLE UNCONTAINED SSME SHUTDOWN DUE TO LOW NPSP LATE IN ENGINE OPERATION.

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 LINE ASSEMBLY CONSISTS OF A 2 INCH DIAMETER LINE ASSEMBLY AND 1 INCH AND 1/4 INCH DIAMETER TUBE SEGMENTS AND FITTINGS.

THE 2.0 INCH LINE ASSEMBLY WAS MANUFACTURED USING TWO FLANGE ASSEMBLIES, 3 TYPE I GIMBAL JOINTS, A TEE, AND 3 STRAIGHT TUBE SEGMENTS. THE GIMBAL JOINTS, MANUFACTURED BY AMETEK STRAZA, WERE DESIGNED TO DEFLECT A MINIMUM OF Ñ13 DEGREES IN ANY PLANE. THE BENDING MOMENT AT MAXIMUM OPERATING TEMPERATURE AND PRESSURE IS DESIGNED TO A MAXIMUM OF 450 INCH POUNDS IN THE PIN AXIS AND 700 INCH POUNDS IN THE OTHER AXES. 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 CLEANLINESS LEVEL 400A. THE GIMBAL JOINT WAS FABRICATED USING AN INCONEL 718 THREE PLY BELLOWS, AN INCONEL 718 GIMBAL RING, TWO INCONEL 718 GIMBAL FORKS, FOUR INCONEL 718 PINS, TWO INCONEL 718 LINERS AND ONE 321 CRES RETAINER. THE GIMBAL JOINT IS ASSEMBLED USING FUSION WELDING. EACH 21-6-9 CRES FLANGE HAS A LEAK TEST PORT FOR MEASURING THE FLANGE/SEAL LEAKAGE. THE FLANGE AT THE DISCONNECT END HAS A PORT FOR DFI INSTRUMENTATION (NOW PLUGGED) AND ANOTHER

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0509-01

PORT WHICH CONNECTS TO A PRESSURE TRANSDUCER, GO2 REPRESS CHECK VALVE (CV10), AND THE DELTA P TRANSDUCER.

THE TEE IS MANUFACTURED FROM 21-6-9 CRES 2 INCH DIAMETER BY 0.035 INCH WALL THICKNESS (TWO PORTS) AND 1 INCH DIAMETER BY 0.028 INCH WALL THICKNESS (ONE PORT). THE THREE STRAIGHT TUBES ARE MANUFACTURED FROM 21-6-9 CRES 2 INCH DIAMETER BY 0.035 INCH WALL THICKNESS. THEY ARE CONNECTED TO THE GIMBAL JOINTS BY BUTT WELDING USING INCONEL 718 WELD WIRE. THE TUBES ARE CONNECTED TO THE FLANGE AND TEE BY WELDING PER SPECIFICATION MAO107-313.

THE 1 INCH (0.028 INCH WALL THICKNESS, 21-6-9 CRES) AND 1/4 INCH (0.020 INCH WALL THICKNESS, 304L CRES) TUBE SEGMENTS AND FITTINGS ARE CONNECTED TOGETHER BY INDUCTION BRAZING USING A CRES UNION AND A BRAZE ALLOY PREFORM (81.5 AU, 16.5 CU, 2 NI). THE ROCKWELL INTERNATIONAL BRAZE ALLOY WAS SELECTED BECAUSE OF ITS LOWER BRAZING TEMPERATURE REQUIREMENT THAN THE INDUSTRY STANDARD, AIDING IN THE PREVENTION OF EXCESSIVE GRAIN GROWTH AND REDUCING EROSION OF TUBE ENDS.

THE DYNATUBE MECHANICAL FITTINGS ARE MADE OF INCONEL 718. THE COMPONENTS ARE CONNECTED TO THE DYNATUBE FITTING USING A UNION MADE OF INCONEL 718 AND METALLIC BOSS SEALS (TYPE III) FABRICATED FROM A286 CORROSION RESISTANT STEEL THAT IS COATED WITH K-6 NICKEL-LEAD. ALL INCONEL TUBE ENDS ARE NICKEL PLATED.

(B) TEST:
ATP

THE 2 INCH LINE ASSEMBLY WAS PROOFED TO 975 PSIG AND LEAK CHECKED AT 650 PSIG PRIOR TO INSTALLATION INTO THE VEHICLE. THE LINE ASSEMBLY (2 INCH, 1 INCH, AND 1/4 INCH) WAS PROOF PRESSURE TESTED AT 950 PSIG AND LEAK TESTED AT 550 PSIG AFTER INSTALLATION INTO THE VEHICLE.

CERTIFICATION

GIMBAL JOINT (6 UNITS)

VIBRATION
- 43 MINUTES IN EACH OF TWO AXES
- PRESSURIZED TO 650 PSIG AT +600ºF (TWO UNITS)
- PRESSURIZED TO 275 PSIG AT -297ºF (TWO UNITS)
- AMBIENT PRESSURE AND TEMPERATURE (TWO UNITS)
- LEAK TEST

PRESSURE IMPULSE TEST (TWO UNITS)
- 500 CYCLES
- PRESSURE: 28 TO 650 PSIG
- TEMPERATURE: 600 DEG F
- RADIAL 13 DEG POSITION

LIFE CYCLE
- 200 CYCLES AT +/- 11.7 DEGREES ROTATION
- 2000 CYCLES AT +/- 9.36 DEGREES ROTATION

650 PSIG AND +600 DEG F (TWO UNITS)
400 PSIG AND -300 DEG F (TWO UNITS)

BURST TEST
2808 PSIG (THREE UNITS)
1664 PSIG (ONE UNIT)

1 INCH AND 1/4 INCH TUBE SEGMENTS AND FITTINGS

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

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.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0509-01

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 AND WELDING ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
RADIOGRAPHIC INSPECTION AND DYE PENETRANT INSPECTION OF INDUCTION BRAZED AND WELDED JOINTS ARE VERIFIED.

TESTING
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
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:
NO CREW ACTION CAN BE TAKEN.

- APPROVALS -

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0509-01

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