

SSME FM CIL
INSPECTION AND TEST

Component Group: Ducts and Lines
 CIL Item: K501-01
 Part Number: RES1004
 Component: Helium Supply Hose
 FMEA Item: K501
 Failure Mode: Fails to contain helium.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 7/25/00
 Change #: 1
 Directive #: CCBD ME3-01-5638

Page: 1 of 1

| Failure Causes | Significant Characteristics | Inspection(s) / Test(s) | Document Reference |
|----------------|-----------------------------|--|---|
| A, B | FLEX LINE, HELIUM SUPPLY | | RES1004 |
| | MATERIAL INTEGRITY | MATERIAL INTEGRITY IS VERIFIED PER SPECIFICATION REQUIREMENTS. | RC1313 |
| | WELD INTEGRITY | ALL WELDS ARE INSPECTED TO DRAWING AND SPECIFICATION REQUIREMENTS PER WELD CLASS. INSPECTIONS INCLUDE: VISUAL, DIMENSIONAL, PENETRANT, RADIOGRAPHIC, ULTRASONIC, AND FILLER MATERIAL, AS APPLICABLE. | RL10011 RA0607-094 RA0115-116 RA0115-006 RA1115-001 RA0115-127 |
| | HEAT TREAT | LINE HEAT TREAT IS VERIFIED PER SPECIFICATION REQUIREMENTS. | RA1611-002 |
| | ASSEMBLY INTEGRITY | THE LOT COMPARISON TEST IS PERFORMED PER SPECIFICATION REQUIREMENTS INCLUDING: - PROOF PRESSURE. - BENDING MOMENT. - FLEXUAL ENDURANCE. - VACUUM LEAK. - SECTIONING. | RC1313 RC1313 RC1313 RC1313 RC1313 |
| | ACCEPTANCE TESTING | A BALL CHECK IS PERFORMED ON EACH LINE PER SPECIFICATION REQUIREMENTS. LINE IS PROOF PRESSURE TESTED PER SPECIFICATION REQUIREMENTS. LINE IS MASS SPECTROMETER LEAK TESTED PER SPECIFICATION REQUIREMENTS. | RC1313 RC1313 RC1313 |
| | FLIGHT FLOW TESTING | THE EXTERNAL SURFACE IS VISUALLY INSPECTED PRIOR TO EACH LAUNCH. (LAST TEST) | OMRSD V41BU0.030 |

Failure History: Comprehensive failure history data is maintained in the Problem Reporting database (PRAMS/PRACA)
 Reference: NASA letter SA21/88/308 and Rocketdyne letter 88RC09761.

Operational Use: Not Applicable.

SSME FMEA/CIL
DESIGN

Component Group: Ducts and Lines
CIL Item: K501-01
Part Number: RES1004
Component: Helium Supply Hose
FMEA Item: K501
Failure Mode: Fails to contain helium.

Prepared: D. Early
Approved: T. Nguyen
Approval Date: 7/25/00
Change #: 1
Directive #: CCBD ME3-01-5638

Page: 1 of 1

Design / Document Reference

FAILURE CAUSE: A: Parent material failure or weld failure.
B: Damaged/defective bellows assembly.

THE LINE ASSEMBLY (1) AND BELLWS ARE MANUFACTURED UTILIZING INCONEL 718. INCONEL 600 WAS USED FOR THE WIRE BRAID ON THE FLEXIBLE HOSE MEMBERS. INCONEL 718 WAS SELECTED FOR ITS STRENGTH, RESISTANCE TO STRESS CORROSION, CORROSION RESISTANCE, HIGH/LOW CYCLE FATIGUE CHARACTERISTICS, AND WELDABILITY (2). MATERIALS ARE HEAT TREATED TO DEVELOP FULL MATERIAL STRENGTH AND HARDNESS. THE BRAID MATERIAL WAS SELECTED FOR ITS STRENGTH AND CORROSION RESISTANCE (2). FLANGE SECTIONS INCORPORATE RADIUS JOINTS TO REDUCE STRESS CONCENTRATIONS. OFFSET LIMIT REQUIREMENTS ARE ESTABLISHED TO REDUCE STRESS CONCENTRATIONS AND IMPROVE WELD GEOMETRY. TUBING STOCK IS DRAWN TO MAINTAIN SURFACE REGULARITY. THE MAXIMUM BEND MOMENT DURING PRESSURIZATION IS SPECIFIED FOR PROPER DUCT LOADING. BRAID IS MULTI-LAYERED INTERWOVEN WIRE FOR TENSILE REINFORCEMENT TO THE PRESSURE CARRYING BELLWS. EXTERNAL RINGS ARE USED TO IMPROVE WELD QUALITY AND SUPPORT THE WIRE BRAID AT THE SPOOL-TO-BRAID INTERFACE. INSTALLATION IS CONTROLLED FOR ANGULARITY AND OFFSET PER SPECIFICATION REQUIREMENTS (3). MINIMUM FACTORS OF SAFETY MEET CEI REQUIREMENTS (4). HIGH AND LOW CYCLE FATIGUE LIFE MEET CEI REQUIREMENTS (5). THE FLEXIBLE LINE HAS SUCCESSFULLY COMPLETED THE BENDING MOMENT, FLEXURAL ENDURANCE, ULTIMATE PRESSURE, SECTIONING, PROOF PRESSURE, FLOW RESONANCE, AND VIBRATION DVS TESTING (6). ANALYSIS/TESTING SHOWED NO POTENTIAL BELLOW EXCITATION OF RESONANCE DUE TO FLOW INDUCED VIBRATION (6) (7). THE LINE ASSEMBLY PARENT MATERIAL WAS CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH, SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (8). TABLE K501 LISTS ALL THE FMEA/CIL WELDS AND IDENTIFIES THOSE WELDS IN WHICH THE CRITICAL INITIAL FLAW SIZE IS NOT DETECTABLE, AND THOSE WELDS IN WHICH THE ROOT SIDE IS NOT ACCESSIBLE FOR INSPECTION. THESE WELDS HAVE BEEN ASSESSED AS ACCEPTABLE FOR FLIGHT BY RISK ASSESSMENT (9).

(1) RES1004; (2) RSS-8575, RSS-8582; (3) I.L. 0126-8066; (4) RSS-8546, CP320R0003B; (5) RL00532, CP320R0003B; (6) RSS-511-9, RSS-511-31, RSS-511-45, RSS-511-47, RSS-511-44, RSS-511-48; (7) NASA TASK 086; (8) NASA TASK 117; (9) RSS-8756

**SSME IEA/CIL
REDUNDANCY SCREEN**

Component Group: Ducts and Lines
 CIL Item: K501-01
 Part Number: RES1004
 Component: Helium Supply Hose
 FMEA Item: K501
 Failure Mode: Fails to contain helium.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 7/25/00
 Change #: 1
 Directive #: CCBD ME3-01-5638

Page: 1 of 1

| Phase | Failure / Effect Description | Criticality Hazard Reference |
|-----------|---|---------------------------------|
| P 4.1 | Helium leakage into aft compartment. Pneumatics fail to maintain MFV actuator in closed position resulting in internal hydrogen leakage. Results in fire; open air detonation and overpressure condition. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A | 1 ME-A1P, ME-G3P,A |
| SM 4.1 | Helium leakage into aft compartment. Loss of HPOTP intermediate seal purge results in loss of intermediate seal pressure barrier and allows mixing of LOX and hot-gas. Overpressurization of aft compartment. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A | 1 ME-C1S,M |
| C 4.1 | Helium leakage into aft compartment. HPOTP intermediate seal post shutdown purge and both preburners shutdown purges not accomplished. Pogo post-charge inactivated resulting in oxidizer pump overspeed. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A | 1 ME-C1A,C, ME-G3P,A |

SSME FMEA/CIL
WELD JOINTS

Component Group: Ducts and Lines
 CIL Item: K501
 Part Number: RES1004
 Component: Helium Supply Hose
 FMEA Item: K501

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 7/25/00
 Change #: 1
 Directive #: CCBD ME3-01-5638
 Page: 1 of 1

| Component | Basic Part Number | Weld Number | Weld Type | Class | Root Side Not Access | Critical Initial Flaw Size Not Detectable | | Comments |
|-----------|-------------------|-------------|-----------|-------|----------------------------|---|-----|----------|
| | | | | | | HCF | LCF | |
| LINE | RES1004 | 1,2,7,8 | GTAW | I | X | | | |
| LINE | RES1004 | 3,6,9,12 | GTAW | II | X | | | |
| LINE | RES1004 | 13-17 | GTAW | I | X | | | |
| LINE | RES1004 | 4,5,10,11 | GTAW | II | X | | | |