

**SSME FMEA/CIL
REDUNDANCY SCREEN**

Component Group: Joints
 CIL Item: L104A-01
 Part Number: See Table L104A
 Component: Hydraulic System Supply Line Joints
 FMEA Item: L104A
 Failure Mode: Leakage.

Prepared: D. Early
 Approved: T. Nguyen
 Approval Date: 7/25/00
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Phase	Failure / Effect Description	Criticality Hazard Reference
M 4.1	Hydraulic fluid leakage into aft compartment. Loss of hydraulic pressure results in hydraulic lockup. Loss of mission may result when hydraulic lockup occurs during Max Q throttling. Redundancy Screens: SINGLE POINT FAILURE: N/A	1R ME-E1P,S,A,M,C,D, ME-G4M
C 4.2	If failure occurs when MFV is less than 10%, but not closed, channel B SEI will not occur. MFV will remain at lockup position until fail-safe servoswitch is de-energized post-cutoff. Open air fire if on launch pad. Loss of vehicle. Redundancy Screens: SINGLE POINT FAILURE: N/A	1 ME-A1A

**SSME FMEA/CIL
DESIGN**

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Design / Document Reference

FAILURE CAUSE: A: Seal failure.

ALL THE HYDRAULIC JOINTS NOTED IN THE FMEA USE MOLDED IN PLACE ELASTOMER PLATE SEALS. IN THIS DESIGN AN ELASTOMER IS MOLDED AND BONDED INTO GROOVES ON EACH SIDE OF AN 6061-T6 ALLOY PLATE (1). ALL OF THE JOINT BOLT LOADING IS REACTED THROUGH THE PLATE. THIS RESULTS IN GOOD CONTACT BETWEEN THE MATING FLANGES AND THE SEAL PLATE. A PORTION OF THE ELASTOMER HEIGHT IS ABOVE THE SEAL PLATE SURFACE. THE ELASTOMER CONFIGURATION IS DESIGNED TO SUBSTANTIALLY FILL THE SEAL GROOVE, BUT LESS THAN 100% WHEN THE JOINT IS COMPRESSED BY THE BOLT LOADING DURING ASSEMBLY. THIS COMPRESSION IS SUFFICIENT FOR THE ELASTOMER TO CONFORM TO THE MATING FLANGE TOPOGRAPHY AND EFFECT A SEAL AT LOW PRESSURE. WHEN THE SYSTEM PRESSURE IS APPLIED, THE ELASTOMER IS FURTHER COMPRESSED AND THE ELASTOMER-FLANGE CONTACT PRESSURE IS INCREASED SO THE FLUID CANNOT ESCAPE. THIS OPERATIONAL CONCEPT IS SIMILAR TO AN O-RING. ADEQUATE BOLT LOAD IS USED TO KEEP FLANGE DEFLECTION TO A LEVEL WHERE THE ELASTOMER CANNOT BE FORCED OUT BETWEEN THE SEAL PLATE AND THE FLANGES. THE SYNTHETIC ELASTOMER MATERIAL WAS CHOSEN FOR ITS COMPATIBILITY WITH HYDRAULIC FLUID AND FOR ITS RESILIENCE AND RESISTANCE TO COMPRESSION SET (2). THE HYDRAULIC SUPPLY SYSTEM NORMALLY OPERATES IN THE 60 TO 250 DEGREE F. TEMPERATURE RANGE, WHICH IS WITHIN THE TEMPERATURE LIMITS OF THE ELASTOMER. THESE MOLDED IN PLACE SEALS WERE DVS TESTED BY HOT-FIRE TESTING (3).

SEALS REMOVED FROM BROKEN JOINTS ARE EITHER REPLACED OR ARE REINSPECTED AND REUSED. HIGH CYCLE AND LOW CYCLE FATIGUE LIFE OF THE SEALS MEET CEI REQUIREMENTS (4). THE MINIMUM FACTOR OF SAFETY FOR THE SEALS MEET CEI REQUIREMENTS (5). THE SEALS PARENT MATERIALS WERE CLEARED FOR FRACTURE MECHANICS/NDE FLAW GROWTH SINCE THEY ARE NOT FRACTURE CRITICAL PARTS (6). SPECIAL PACKAGING REQUIREMENTS ARE SPECIFIED TO PROTECT THE SEALS DURING SHIPMENT OR STORAGE (7).

THE FLANGE DESIGN SPECIFIES THE REQUIREMENTS FOR SURFACE FLATNESS, SURFACE FINISH, AND THE SEALING SURFACE AREA ON THE FLANGE. THIS ENSURES THAT THE SEAL MATING AREA IS CLOSELY INSPECTED TO VERIFY IT IS FREE OF DEFECTS WHICH WOULD CAUSE LEAKAGE. TYPICAL FLANGES WERE USED DURING DVS ENGINE TESTING WHICH CONFIRMED DESIGN REQUIREMENTS USED ON THE ENGINE FLANGES (3). LEAK CHECKS DURING ENGINE BUILD AND AT INTERVALS DURING ENGINE SERVICE HAVE SHOWN THAT THE FLANGES PERFORM SATISFACTORILY AND MAINTAIN JOINT INTEGRITY.

(1) RS008843, RS008851; (2) RSS-8582; (3) RSS-101-67A; (4) RL00532, CP320R0003B; (5) RSS-8546; (6) NASA TASK 117; (7) STO116GA0002

FAILURE CAUSE: B: Loss of bolt preload.

JOINT BOLTING IS AN INTEGRAL PART OF STATIC SEAL JOINTS. THE BOLTING IS DESIGNED TO TAKE INTO CONSIDERATION BOTH THE PRESSURE SEPARATING LOAD AND ALL EXTERNAL LOADS THAT ACT ON THE JOINT. BOLTS ARE SPACED CLOSELY TOGETHER TO MINIMIZE FLANGE DEFLECTION. HIGH STRENGTH BOLTS ARE USED TO PROVIDE THE NECESSARY CLAMPING LOAD WHILE KEEPING THE TOTAL JOINT WEIGHT TO A MINIMUM. THE BOLT MATERIALS ON FLUID SYSTEMS ARE A-286 AND INCONEL 718, WHICH ARE USED FOR THEIR STRENGTH, ELASTIC MODULUS, AND COMPATIBILITY WITH ENGINE ENVIRONMENT (1) TEMPERATURES. THE BOLTS ARE NORMALLY COATED WITH DRY-FILM LUBRICANTS OR PLATED TO REDUCE THE TORQUE REQUIRED FOR TIGHTENING AND TO REDUCE THE LOAD RANGE VARIATIONS DUE TO FRICTION. THE FASTENERS ARE INSTALLED INTO THREADED HOLES AND ARE LOCKWIRED TO PREVENT BOLT BACKOFF. FASTENER INSTALLATION IS CONTROLLED AT ENGINE ASSEMBLY TO ENSURE THAT THE INSTALLATION HAS THE PROPER BOLT LOADING AND NO DAMAGE OCCURS TO EITHER THE FASTENERS OR FLANGES. ON TORQUED INSTALLATIONS THE TORQUE IS APPLIED IN THREE EQUAL STEPS WITH TORQUE AT EACH STEP APPLIED IN A CROSS TORQUEING PROCEDURE (2). REUSE OF FASTENERS REQUIRES RELUBRICATION AND REINSPECTION FOR GALLING, THREAD DAMAGE, OR WRENCHING ELEMENT DISTORTION. THE MATERIALS USED FOR THE WASHERS IN THE JOINT BOLTING ARE SELECTED FOR THEIR COMPRESSIVE YIELD STRENGTH TO PREVENT YIELDING UNDER JOINT OPERATING PRESSURES (1). LEAK CHECKS DURING ENGINE BUILD AND AT INTERVALS DURING ENGINE SERVICE HAVE SHOWN THAT JOINT INTEGRITY IS SATISFACTORILY MAINTAINED BY THE BOLTING DESIGNS.

(1) RSS-8582; (2) RA0101-002

SSME FMEA/CIL INSPECTION AND TEST

Component Group: Joints
CIL Item: L104A-01
Part Number: See Table L104A
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Failure Causes	Significant Characteristics	Inspection(s) / Test(s)	Document Reference
A	SEAL, MOLDED IN PLACE-PLATE		RS008843 RS008851
	MATERIAL INTEGRITY	MATERIAL INTEGRITY IS VERIFIED PER DRAWING REQUIREMENTS.	RS008843 RS008851
		MATERIAL HARDNESS INSPECTION VERIFIES PROPER HEAT TREAT.	RS008843 RS008851
	ELASTOMER INTEGRITY	THE ELASTOMER SEAL IS VERIFIED TO BE FREE OF FLASH, VOIDS, NICKS, DEFECTS, OR OTHER IRREGULARITIES WHICH WOULD IMPAIR SEALING.	RS008843 RS008851
	SURFACE FINISH	THE METALLIC SEALING SURFACES ARE INSPECTED PER DRAWING REQUIREMENTS.	RS008843 RS008851
B	BOLT BOLT		RD111-4011 RD111-4105
	BOLT PRELOAD	BOLT FINAL TORQUES ARE VERIFIED PER DRAWING REQUIREMENTS. PROPER LOCK WIRING OF BOLTS IS VERIFIED.	SEE TABLE L104A-CIL SEE TABLE L104A-CIL
	BOLT LUBRICATION	BOLT DRY-FILM LUBRICATION IS VERIFIED PER DRAWING REQUIREMENTS.	RD111-4011 RD111-4105
ALL CAUSES	LEAK TESTS	HYDRAULIC SYSTEM JOINTS ARE LEAK TESTED PRIOR TO GREEN RUN.	RL00050-04
		HYDRAULIC SYSTEM JOINTS ARE LEAK TESTED AFTER GREEN RUN.	RL00050-04
		EXTERNAL LEAK CHECK IS PERFORMED TO REVALIDATE THE SUBSYSTEM, WHENEVER JOINTS ARE DISTURBED.	OMRSD V41GEN.575
		DURING EXTERNAL INSPECTION, THE HYDRAULIC SYSTEM IS VISUALLY INSPECTED FOR LEAKAGE.	OMRSD V41BU0.030
		DURING AFT CLOSEOUT INSPECTION, ANY EVIDENCE OF PREVIOUS HYDRAULIC LEAKAGE REQUIRES FURTHER DISPOSITION. (LAST TEST)	OMRSD V41BU0.070

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: FAILURE MODE CAN BE DETECTED IN REALTIME BY THE FLIGHT CONTROL TEAM WHO WILL EVALUATE EFFECTS UPON VEHICLE PERFORMANCE AND ABORT CAPABILITY. BASED ON THIS EVALUATION THE APPROPRIATE ABORT MODE OR SYSTEM CONFIGURATION WILL BE SELECTED. FAILURE DETECTION CUES AND ASSOCIATED SSME PERFORMANCE DATA HAVE BEEN COORDINATED BETWEEN THE ENGINEERING AND FLIGHT OPERATIONS ORGANIZATIONS WITH THE RESPONSES DOCUMENTED IN MISSION FLIGHT RULES.

**SSME EA/CIL
CIL SYSTEM JOINTS**

Component Group: Joints
Item Name: Hydraulic System Supply Line Joints
Item Number: L104A

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Joint	Location	Seal Part Number	Seal Part Number Description	Torque or Stretch	Locking Feature	Assembly Drawing
H1	HYDRAULIC INLET QUICK DISCONNECT RE2201-01/MC621-0024 TO INTERFACE	N/A		N/A	N/A	N/A
H1.1	QUICK DISCONNECT RE2201-01/MC621-0024 TO HYDRAULIC SUPPLY HOSE RES1001	N/A		TORQUE	LOCKWIRE	RS007003
H2	HYDRAULIC SUPPLY HOSE RES1001 TO HYDRAULIC FILTER RES1008-3003	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H3	HYDRAULIC FILTER RES1008-3003 TO MFVA HYDRAULIC SUPPLY MANIFOLD RS007120	RS008851	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H3.1	MFVA HYDRAULIC SUPPLY MANIFOLD RS007120 TO MFV HYDRAULIC SUPPLY PRESSURE TRANSDUCER RES7007	RS008851	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H3.2	MFVA HYDRAULIC SUPPLY MANIFOLD RS007120 TO MOVA HYDRAULIC SUPPLY MANIFOLD RS007119	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H4	MOVA RES1008-5XXX TO MOVA HYDRAULIC SUPPLY LINE RS007212	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H5	MFVA RES1008-8XXX TO MFVA HYDRAULIC SUPPLY MANIFOLD RS007120	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H6	OPOVA RES1008-6XXX TO MOVA HYDRAULIC SUPPLY MANIFOLD RS007119	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H7	FPOVA RES1008-6XXX TO MFVA HYDRAULIC SUPPLY MANIFOLD RS007120	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H8	CCVA RES1008-7XXX TO MOVA HYDRAULIC SUPPLY MANIFOLD RS007119	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	LOCKWIRE	RS007005
H18	MOVA HYDRAULIC SUPPLY LINE RS007212 TO MOVA HYDRAULIC SUPPLY MANIFOLD RS007119	RS008843	SEAL PLATE - SYNTHETIC ELASTOMER SEAL RINGS IN 6061-T6 ALLOY PLATE.	TORQUE	N/A	RS007005

* Unnumbered Component Joint