

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION FMEA NO 03-1 -0462 -2 REV:05/04/88F

ASSEMBLY :ROCKWELL INTL.		CRIT. FUNC:	1	
P/N RI :VO70-415407		CRIT. HDW:	1	
P/N VENDOR:	VEHICLE	102	103	104
QUANTITY :1	EFFECTIVITY:	X	X	X
:ONE ASSY	PHASE(S):	PL X LO X OO	DO	LS

PREPARED BY:	REDUNDANCY SCREEN:	A-	B-	C-
DES J E OSLUND	APPROVED BY:	APPROVED BY (NASA)		
REL L H FINEBERG	DES <u>H.P. Ballard</u>	SSM <u>[Signature]</u>	REL <u>[Signature]</u>	QE <u>[Signature]</u>
QE E M GUTIERREZ	REL <u>L. S. COE</u>	REL <u>[Signature]</u>	QE <u>[Signature]</u>	
	QE <u>R. Williams</u>			

ITEM:
 LINE ASSEMBLY, LH2 RELIEF VALVE SENSE, 0.38 INCH DIAMETER. CONSISTS OF TUBING SEGMENTS, MECHANICAL FITTINGS, AND BRAZE JOINTS. PARTIALLY FOAM INSULATED.

FUNCTION:
 THE LINE EXTENDS FROM THE PILOT SENSE PORT OF THE LH2 RELIEF VALVE (RV6) TO THE MOUNTING FLANGE FOR THE LH2 RECIRC PUMPS (PP1,2,3), PROVIDING A PATH FOR THE RELIEF VALVE TO SENSE LH2 MANIFOLD PRESSURE.

FAILURE MODE:
 CLOGGED SENSE LINE DURING LOADING, ASCENT, AND POST MECO.

CAUSE(S):
 CONTAMINATION.

EFFECT(S) ON:
 (A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE

(A,B) SENSE LINE CLOGS, ISOLATING THE RELIEF VALVE SENSING CAVITY FROM MANIFOLD PRESSURE. TRAPPING HIGH PRESSURE IN THE SENSE CAVITY COULD CAUSE RELIEF VALVE TO RELIEVE ABOVE SYSTEM PROOF PRESSURE (REFERENCE FMEA/CIL 0436-1). THIS WOULD RESULT IN POSSIBLE LH2 MANIFOLD LINE RUPTURE AND LH2 LEAKAGE INTO AFT COMPARTMENT. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD.

(C,D) POSSIBLE LOSS OF CREW/VEHICLE.

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(E) FUNCTIONAL CRITICALITY EFFECTS:

LR2, 2 SUCCESS PATHS, TIME FRAME - LOADING AND ASCENT.

- 1) RELIEF SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED.
- 2) CLOGGED SENSE LINE RESULTS IN RELIEF VALVE (RV6) LEAKAGE.

SENSE LINE CLOGS, TRAPPING LOW PRESSURE IN SENSE CAVITY. CAUSES RELIEF VALVE TO RELIEVE AT A LOWER PRESSURE SINCE INLET PRESSURE MUST OVERCOME ONLY MAIN POPPET SPRING FORCE AND RESIDUAL PRESSURE IN THE PILOT SECTION.

LH2 WILL DUMP OVERBOARD (640 POUNDS MAXIMUM) RESULTING IN LOSS OF PROPELLANT. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CREW/VEHICLE.

DISPOSITION & RATIONALE:

(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN

THE HYDROGEN SYSTEM IS CLEANED AND MAINTAINED AT A CLEANLINESS LEVEL OF 400. CONTAMINATION IS ALSO MINIMIZED DUE TO THE PRESENCE OF AN ET SCREEN, A GSE DEBRIS PLATE, AND A GSE FILTER.

(B) TEST

ATP

THE LINE ASSEMBLY IS PROOF PRESSURE TESTED TO 66 PSIG AND LEAK CHECKED AT 30 PSIG AFTER INSTALLATION IN THE VEHICLE.

CERTIFICATION

DYNATUBE FITTING TO 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.

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

PROOF PRESSURE

PRESSURIZED TO TWO TIMES OPERATING PRESSURE AND HELD FOR 5 MINUTES.

EXTERNAL LEAKAGE

LEAK CHECKED AT 1-1/2 TIMES OPERATING PRESSURE. MAXIMUM ALLOWABLE LEAK RATE IS 1×10^{-6} SCCS.

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BURST TEST

EXCEEDED 4 TIMES OPERATING PRESSURE.

IMPULSE FATIGUE

200,000 CYCLES AT A CYCLIC RATE OF 70 +/- 5 CYCLES PER MINUTE FROM ZERO PSIG TO OPERATING PRESSURE TO ZERO PSIG.

FLEXURE FATIGUE

SPECIMENS WERE FILLED WITH HYDRAULIC FLUID AND PRESSURIZED TO OPERATING PRESSURE. THE SPECIMENS WERE THEN TESTED TO 10 MILLION CYCLES OF FLEXURE.

VIBRATION

7 TEST SPECIMENS WERE SUBJECTED TO 45 MINUTES OF RANDOM VIBRATION AT 0.4 G2/HZ, 30 MINUTES AT 0.7 G2/HZ AND 10 MINUTES AT 0.2 G2/HZ AT AMBIENT PRESSURE AND TEMPERATURE CONDITIONS.

OMRSD

V41BEO.030 RV6 LH2 MANIFOLD RELIEF VALVE INTERNAL LEAK (I5)
V41BHO.120 RV6 LH2 MANIFOLD RELIEF VALVE FUNCTIONAL (PRIOR TO FIRST REFLIGHT OF EACH VEHICLE)
V41BUO.161 LH2 FEEDLINE SCREEN INSPECTION (I5)
V41BUO.163 LH2 FEEDLINE SCREEN INSPECTION - VERTICAL (I25)
V41BZO.190 RV5,6 SENSE LINE FLOW PATH (I5)

(C) INSPECTION

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

CLEANLINESS TO LEVEL 400 IS VERIFIED BY INSPECTION. 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. LUBRICATION OF THREADED FLUID FITTING COUPLINGS, WHEN REQUIRED, IS VERIFIED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES

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

NONDESTRUCTIVE EVALUATION

RADIOGRAPHIC INSPECTION OF INDUCTION BRAZED JOINTS IS VERIFIED BY INSPECTION. PENETRANT INSPECTION OF DETAIL PARTS IS VERIFIED.

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FMEA NO 03-1 -0462 -2

REV:05/04/88

TESTING

ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT VERIFIED BY INSPECTION.

D) FAILURE HISTORY

GENERAL SYSTEM CONTAMINATION

THIS FAILURE MODE HAS NOT OCCURRED ON THIS COMPONENT DUE TO CONTAMINATION. HOWEVER, GENERAL MPS SYSTEM CONTAMINATION HAS OCCURRED WHICH MAY LODGE ANYWHERE IN THE SYSTEM CAUSING THIS FAILURE MODE (REFERENCE THE FOLLOWING PARAGRAPHS).

CONTAMINATION FAILURES HAVE OCCURRED AT ALL PHASES OF MANUFACTURING AND PARTS REPLACEMENT. IN ALL CASES, STRICT ADHERENCE TO CLEANLINESS CONTROL PROCEDURES IS THE PRIMARY METHOD OF CONTAMINATION PREVENTION.

NUMEROUS LARGE PARTICLES OF BLACK RUBBER MATERIAL WERE FOUND DURING A POST FLIGHT EXAMINATION OF THE LH2 17 INCH DISCONNECT OF OV099 (FLIGHT 7, REFERENCE CAR AC9800). THE LO2 AND LH2 SYSTEMS OF ALL VEHICLES WERE EXAMINED. NO RUBBER WAS FOUND IN ANY OTHER VEHICLES. AFTER EXTENSIVE INVESTIGATION THE ORIGIN WAS NOT DETERMINED.

METAL SHAVINGS HAVE BEEN DISCOVERED IN LINES AND COMPONENTS, WHICH WAS MOST LIKELY GENERATED WHEN THEY WERE CUT OUT AND/OR REPLACED (REFERENCE CARs AC9868, A9654, AC2210, AB1706; DR AD2226). METHODS ARE BEING REVISED TO MINIMIZE PARTICLE GENERATION WHEN INSTALLING/REPLACING COMPONENTS, LINES, AND FITTINGS REQUIRING WELDED OR BRAZED JOINTS (PRODUCT QUALITY IMPROVEMENT COUNCIL). PERSONNEL HAVE BEEN CAUTIONED. ROCKWELL PROBLEM ACTION CENTER WILL CONTINUE TO MONITOR BRAZING/WELDING REWORK CONTAMINATION. PROCEDURES ARE BEING REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENENCE PROCEDURES HAVE BEEN IMPROVED.

A PIECE OF A BRAZING PREFORM LODGED IN A 2-WAY SOLENOID VALVE ON OV-099 AT PALMDALE CAUSING A LEAKAGE FAILURE (REFERENCE CARs AC2111, AB2538). STEEL AND ALUMINUM PARTICLES CAUSED EXCESSIVE LEAKAGE ON THE 850 PSIG HELIUM RELIEF VALVE (REF CAR AC2229). FOR BOTH FAILURES CORRECTIVE ACTION WAS TO ADD SPECIAL PURGE PORTS TO THE MPS HELIUM PANEL ASSEMBLIES TO IMPROVE THE QUALITY OF FINAL CLOSEOUT BRAZES.

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SEVERAL FOREIGN MATERIALS WERE INTRODUCED INTO THE MPS SYSTEM DURING MANUFACTURE AND PARTS REPLACEMENT. EXAMPLES ARE: GLASS CLOTH IN LINE TO PREVENT TRAVEL OF CHIPS DOWN LINE; POLYSTYRENE OBJECT TO HOLD VALVE POPPET OPEN WHILE PURGING; COTTON SWAB MATERIAL AND GLASS BEADS FROM CLEANING OPERATION; MISCELLANEOUS PLASTIC; FOAM; AND TAPE (REFERENCE CARS AB4751, AC2217, AC6768, AC9868, MPS3A0005, AC7912, AB0530). MATERIALS WERE REMOVED AND PERSONNEL WERE CAUTIONED. A HIGH FLOW DELTA P TEST AT PALMDALE WAS ADDED TO VERIFY THAT LINES WERE NOT PLUGGED. CRIT BLASTING (GLASS BEADS AND SAND USED TO CLEAN A LINE) IS NO LONGER PERFORMED. PROCEDURES ARE BEING REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

ONE PIECE OF WIRE WAS FOUND IN THE INTERNAL RELIEF VALVE OF THE LO2 PREVALVE ON OV103 (REFERENCE CAR AC9101). THE SOURCE OF THE CONTAMINATION WAS NEVER FOUND, BUT IT WAS BELIEVED TO BE FROM THE ET.. OTHER CONTAMINATION HAS BEEN FOUND ON THE FEEDLINE SCREENS, SUCH AS AN UNIDENTIFIED ROUND OBJECT AND VARIOUS METALLIC PARTICLES (REFERENCE CARS AB0529 AND AB0530). SOURCE OF CONTAMINATION WAS UNDETERMINED. BORESCOPE EXAMINATIONS ARE CONDUCTED ON ALL FEEDLINE SCREENS EVERY FIFTH FLIGHT TO VERIFY CLEANLINESS. CONTAMINATION WAS REMOVED WHEN POSSIBLE.

(E) OPERATIONAL USE

FLIGHT: LH2 MANIFOLD PRESSURE IS ON CAUTION AND WARNING.
POST MECO/PRE DUMP: START MPS PROPELLANT DUMP AS SOON AS POSSIBLE.
POST DUMP: OPEN THE LH2 FILL/DRAIN VALVES.

GROUND: OMI S1004 SEQUENCE TITLED "EMERGENCY PROCEDURE FOR MAJOR LEAK OR FIRE IN THE ORBITER AFT FUSELAGE" CONTAINS SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN SYSTEM.