

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: M4-1BG-LV013-X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC

REVISION : 0 11/19/92 W

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
SRU	:	SOLENOID VALVE, O2 REACTANT EATON CONSOLIDATED CONTROLS	MC284-0429-4102 74405-4102
SRU	:	SOLENOID VALVE, O2 REACTANT EATON CONSOLIDATED CONTROLS	MC284-0429-4103 74405-4103

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
SOLENOID VALVE, O2 REACTANT

REFERENCE DESIGNATORS: 40V45LV013
: 40V45LV023
: 40V45LV024

QUANTITY OF LIKE ITEMS: 3
ONE PER O2 MANIFOLD #1
TWO PER O2 MANIFOLD #2

FUNCTION:
PROVIDES CAPABILITY TO ISOLATE O2 FROM ASSOCIATED FUEL CELL.

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ITEM NAME: SOLENOID VALVE, O2 REACTANT **CRITICALITY OF THIS FAILURE MODE:** 1R2

FAILURE MODE:
 FAILS OPEN OR INTERNAL LEAKAGE

MISSION PHASE:
 PL PRELAUNCH
 LO LIFT-OFF
 OO ON-ORBIT
 DO DE-ORBIT
 LS LANDING SAFING

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
: 103	DISCOVERY
: 104	ATLANTIS
: 105	ENDEAVOUR

CAUSE:
 MECHANICAL SHOCK, VIBRATION, CORROSION, PHYSICAL BINDING/JAMMING, CONTAMINATION, ELECTRICAL OPEN OR SHORT

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN A) PASS
 B) FAIL
 C) PASS

PASS/FAIL RATIONALE:
 A)

B)
 REDUNDANCY SCREEN B - FAILURE MODE IS NOT DETECTABLE DURING FLIGHT SINCE VALVE IS NORMALLY OPEN.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
 NO EFFECT AFTER FIRST FAILURE. VALVE IS NORMALLY OPEN.

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

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(C) MISSION:
SAME AS (A)

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE IF AN ADDITIONAL FAILURE OF EXTERNAL
LEAKAGE OF O2 REACTANT (CIL 04-1A-0101-4) OCCURS IN THE ASSOCIATED
FUEL CELL POWERPLANT.

- DISPOSITION RATIONALE -

(A) DESIGN:

VALVE IS SPRING-LOADED CLOSED. 50 MICRON ABS FILTER AT THE INLET.
VALVE CONTAINS NO SOFT GOODS IN CONTACT WITH THE FLUID. MOVING PARTS
ARE GOLD PLATED TO REDUCE FRICTION. HOUSING IS CONSTRUCTED OF CRES 304
TO PREVENT CORROSION. ALL VALVE COMPONENTS ARE COMPATIBLE WITH WORKING
FLUIDS. VALVE IS MOUNTED WITH BODY AXIS PERPENDICULAR TO VEHICLE
X-AXIS TO MINIMIZE VIBRATION EFFECTS. VALVE IS DESIGNED TO CLOSE WITH A
MINIMUM OF 18 VOLTS (NOMINAL ORBITER BUS VOLTAGE IS 28 VOLTS).

(B) TEST:

QUALIFICATION TEST VERIFIED NORMAL OPERATION DURING SHOCK (20 G) AND
VIBRATION (0.1 G SQ/HZ MAXIMUM RANDOM, +/- 0.25 G PEAK SINGUSOIDAL) AND
THERMAL OPERATING LIFE TEST (TOTAL OF 3000 CYCLES FROM -284 TO +220 DEG
F AT OPERATING PRESSURE).

ACCEPTANCE TEST VERIFIES FUNCTIONAL OPERATION OF MAGNETIC LATCHES, NO
EXCESSIVE INTERNAL OR EXTERNAL LEAKAGE AND THAT PRESSURE DROP IS WITHIN
LIMITS. VALVE IS DIELECTRIC STRENGTH AND INSULATION RESISTANCE TESTED
(10 MEGADHMS) TO 500 VOLTS AND VERIFIED CLEANED TO LEVEL 200A BY
PARTICLE COUNT AND NON-VOLATILE RESIDUE. VALVE IS FURTHER VERIFIED
DURING PANEL MODULAR ASSEMBLY AND SUBSYSTEM CHECKOUT.

OMRSD: VALVE OPERATION AND INTERNAL LEAK TEST VERIFIED EVERY
TURNAROUND.

(C) INSPECTION:

RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATION DOCUMENTS ARE REVIEWED FOR
COMPLIANCE WITH PROGRAM REQUIREMENTS.

CONTAMINATION CONTROL

ALL DETAIL PARTS ARE CLEANED PER ROCKWELL APPROVED SUPPLIER PROCEDURES.
ALL DETAIL PARTS AND SUBASSEMBLIES ARE VISUALLY INSPECTED FOR EVIDENCE
OF CONTAMINATION AT 40X MAGNIFICATION. ALL CRES DETAILS ARE PASSIVATED
TO PREVENT CORROSION. THE VALVE IS VERIFIED CLEANED TO LEVEL 200A.

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ASSEMBLY/INSTALLATION

ALL DETAIL PARTS ARE INSPECTED UNDER 40X MAGNIFICATION FOR SURFACE FINISH BURRS AND DAMAGE. THREAD LUBRICATION, TORQUING AND LOCKWIRE IS VERIFIED BY QC. DOCUMENTATION IS REVIEWED TO VERIFY RECORDING OF SHIM AND GAP DIMENSIONS USED TO OBTAIN AND MEASURE ARMATURE STROKE.

CRITICAL PROCESSES

THE GOLD PLATING PROCESS IS WITNESSED AND THE PLATED ARMATURE IS VISUALLY INSPECTED UNDER MAGNIFICATION FOR PLATING DEFECTS. LEAD WIRE TO CONNECTOR SOLDERING IS VERIFIED IN ACCORDANCE WITH NHB 5300.4 (3A). VALVE SEAT WELDS ARE LEAK CHECKED UNDER FULL PROOF PRESSURE AND VISUALLY INSPECTED UNDER 20X MAGNIFICATION. ELECTRON BEAM WELD PROCESS IS VERIFIED BY SECTIONING A SAMPLE VALVE SEAT TO DETERMINE WELD INTEGRITY (20X MAGNIFICATION INSPECTION).

TESTING

ALL SPRINGS ARE LOAD TESTED AT DETAIL LEVEL AND ARE LOT TRACEABLE. COIL ASSEMBLY IS TESTED AT SUBASSEMBLY LEVEL FOR INSULATION RESISTANCE, DIELECTRIC STRENGTH AND POLARITY. OPERATING VOLTAGES AND LATCH FORCES ARE CALIBRATED AND VERIFIED BY INSPECTION DURING FINAL ACCEPTANCE OF THE MAGNETIC LATCH. INTERNAL LEAKAGE IS VERIFIED LESS THAN 18 SCCM DURING VALVE ACCEPTANCE TESTING.

HANDLING/PACKAGING

HANDLING, PACKAGING, STORAGE AND SHIPPING PROVISIONS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

CAR NO. AC8705-010 DOWNEY, VALVE PANEL ATP UNIDIRECTIONAL SHUTOFF VALVE EXHIBITED EXCESSIVE INTERNAL LEAKAGE DURING DOWNEY O2 PANEL ACCEPTANCE TESTING. LEAKAGE THROUGH O2 REACTANT VALVE FELL WITHIN SPECIFICATION FOLLOWING VALVE CYCLING AND BACKFLUSHING AT THE SUPPLIER. INSPECTION WITHIN REVEALED NO DISCREPANCIES. THE ANOMALY WAS SUSPECTED TO HAVE BEEN CAUSED BY A CONTAMINANT WHICH CLEARED ITSELF. NO CORRECTIVE ACTION WAS IMPOSED SINCE NO EVIDENCE TO SUPPORT THE CAUSE OF LEAKAGE WAS FOUND.

CAR NO. AD0901-010 DOWNEY, VALVE PANEL ATP UNIDIRECTIONAL SHUTOFF VALVE EXHIBITED EXCESSIVE INTERNAL LEAKAGE DURING DOWNEY O2 PANEL ACCEPTANCE TESTING. O2 REACTANT VALVE LEAKAGE WAS VERIFIED AT THE SUPPLIER, ALTHOUGH IT VARIED WITH VALVE CYCLES. THE EXCESS VALVE LEAKAGE WAS ATTRIBUTED TO THE BALL (POPPET) WHICH HAD OUT OF SPECIFICATION SURFACE FLAWS. ONE OF THESE FLAWS, WHICH WAS IN THE FORM OF A CAVITY IS SUSPECTED TO HAVE STRADDLED THE SEAT'S SEALING SURFACE WHICH IN TURN CREATED THE LEAK PATH. THE CHANGE IN LEAK RATE CAN BE ATTRIBUTED TO THE FACT THAT THE POPPET IS FREE TO ROTATE AND COULD SHIFT DURING VALVE ACTUATION. THE PROBLEM WAS CLOSED WITH THE FOLLOWING RATIONALE: ALL PRSD SOLENOID VALVES ARE NORMALLY OPEN WITH THE EXCEPTION OF THE GAS SUPPLY VALVES.

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THE MANIFOLD, ECLSS GAS SUPPLY, AND THE REACTANT VALVES WOULD ONLY BE CLOSED IN THE EVENT OF A PRIOR SYSTEM FAILURE REQUIRING ISOLATION. THE GAS SUPPLY VALVES ARE CLOSED AND LEAK CHECKED PRIOR TO LIFTOFF. ALSO, TO REDUCE THE PROBABILITY OF THIS PROBLEM RECURRING ON FUTURE HARDWARE, THE BALL INSPECTION CRITERIA HAS BEEN MADE MORE STRINGENT. LEAK CHECKS FOLLOWING POPPET/SEAT ASSEMBLY AND PRE-ACCEPTANCE TESTING HAVE BEEN IMPLEMENTED.

CAR NO. AD3438-010 SUPPLIER, RECEIVING INSPECTION
 AD3439-010 SUPPLIER, RECEIVING INSPECTION
 AD3199-010 SUPPLIER, LEAK TESTING
 KB0571-010 KSC, GROUND TEST

THE MANIFOLD ISOLATION VALVES HAVE A DESIGN SIMILAR TO THE REACTANT VALVES. DURING GROUND TURNAROUND TEST AT KSC, THE H2 MANIFOLD NO. 1 HAD A DECAY RATE OF 124 PSI/10 MINUTES. MAXIMUM ALLOWABLE IS 100 PSI/10 MINUTES. THE H2 VALVE WAS SENT TO EATON CONSOLIDATED CONTROLS (ECC) WHERE THE LEAKAGE WAS DETERMINED TO BE 328 SCCM AT 305 PSIG ON THE INLET AND SHOULD BE LESS THAN 18 SCCM HE. INVESTIGATION REVEALED CRACKS IN THE SEAT ASSEMBLY. ECC REPLACED THE SEAT AND HOUSING. THE VALVE PASSED ATP AND IT WAS RETURNED TO NSLD.

INITIAL DETECTION OF THE FAILURE WAS DONE AT THE VENDOR AFTER VALVES HAD BEEN REMOVED FROM OV-103 AND OV-104 FOR ARMATURE INSPECTION. TURNAROUND PROCEDURES IN EFFECT AT THE TIME DID NOT INCLUDE VALVE PANEL LEAKAGE TEST EXCEPT AS A CONTINGENCY SO IT WAS NOT POSSIBLE TO DETERMINE IF THE VALVES FAILED AFTER FIRST EXPOSURE TO HYDROGEN. LEAKAGE TEST OF THE REACTANT VALVES IS NOW MANDATORY DURING TURNAROUND AND WAS IMPOSED PRIOR TO RESUMPTION OF FLIGHT (PRE-STS-26). NO FURTHER FAILURES HAVE OCCURRED AFTER STS-28.

ALL FAILED VALVES WERE BUILT DURING THE PERIOD FROM OCTOBER, 1980 TO FEBRUARY 1984 WHEN ECC RESUMED MANUFACTURING AFTER A TWO-YEAR HIATUS UNTIL CHANGES WERE MADE TO THE MANUFACTURING SEQUENCE PRIOR TO WELD OF THE SEAT ASSEMBLY; I.E., IMMERSION OF THE SEAT IN LN2 PRIOR TO INSERTION INTO HOUSING ASSEMBLY VERSUS PRESSURE FIT. ALL H2 VALVES MANUFACTURED DURING THAT PERIOD HAVE BEEN REMOVED AND REPAIRED EXCEPT FOR THREE VALVES (TWO IN OV-102, ONE IN OV-104). THESE THREE VALVES HAVE PASSED THE SCREENING TESTS IN EVERY TURNAROUND. THE PROBLEM WAS CLOSED WITH THE FOLLOWING RATIONALE:
 BASED ON THE ACCUMULATED TURNAROUND DATA AND FLIGHT HISTORY, ALL FLIGHT VALVES HAVE ACCEPTABLE LEAKAGE. SYSTEM LEAK CHECKS AND GROUND SERVICING PRIOR TO FLIGHT WOULD SCREEN ANY VALVES EXHIBITING OUT OF SPECIFICATION LEAKAGE. NO EFFECT AFTER FIRST FAILURE. REACTANT VALVES ARE NEEDED ONLY AFTER A FAILURE THAT RESULTS IN CRYO LEAKAGE REQUIRING ISOLATION OF THE LEAK.

(E) OPERATIONAL USE:

NO CREW ACTION AFTER REACTANT VALVE FAILURE (UNDETECTABLE). IF THE SECOND FAILURE IS LEAKAGE OF A FUEL CELL THEN THE MANIFOLD VALVES CAN

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BE CLOSED TO ATTEMPT TO ISOLATE THE LEAK. THE ASSOCIATED FUEL CELL
MAY BE SHUT DOWN AND REMOVED FROM THE BUS.

- APPROVALS -

P&E MANAGER	:	T. J. EAVENSON	:	<i>V.L. Rayter for 11/19/92</i>
PRODUCT ASSURANCE ENGR	:	T. K. KIMURA	:	<i>T.K. Kimura 11/19/92</i>
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NASA RELIABILITY	:		:	<i>Mark T. Strickland 1/14/93</i>
NASA SUBSYSTEM MANAGER	:		:	<i>Donald S. ... 1-20-93</i>
NASA QUALITY ASSURANCE	:		:	<i>Jeff Malha ...</i>