

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: M4-1BG-LVD33-X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC

REVISION: 1 11/12/91

		PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■	SRU :	SOLENOID VALVE, H2 REACTANT	MC284-0429-4200
■		EATON CONSOLIDATED CONTROLS	74405-4200
■	SRU :	SOLENOID VALVE, H2 REACTANT	MC284-0429-4201
■		EATON CONSOLIDATED CONTROLS	74405-4201

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
SOLENOID VALVE, H2 REACTANT

■ REFERENCE DESIGNATORS: 40V45LV033
: 40V45LV043
: 40V45LV044

■ QUANTITY OF LIKE ITEMS: 3
ONE PER H2 MANIFOLD #1
TWO PER H2 MANIFOLD #2

■ FUNCTION:
PROVIDES CAPABILITY TO ISOLATE H2 FROM ASSOCIATED FUEL CELL.

PAGE: 2

PRINT DATE: 04/01/92

103

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M4-1BG-LV033-01

SUBSYSTEM: ELECTRICAL POWER GENERATION - CRYO, GENERIC REVISION# 1 11/12/91 R

ITEM NAME: SOLENOID VALVE, H2 REACTANT CRITICALITY OF THIS FAILURE MODE:1R2

- FAILURE MODE:
FAILS OPEN OR INTERNAL LEAKAGE

MISSION PHASE:

LG LIFT-OFF
CO CE-CRSIT
LS LANDING SAFING

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

- CAUSE:
MECHANICAL SHOCK, VIBRATION, CORROSION, PHYSICAL BINDING/JAMMING, CON-
TAMINATION, ELECTRICAL OPEN OR SHORT

- CRITICALITY 1/1 DURING INTACT ABORT ONLY?

- 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)

PAGE: 3

PRINT DATE: 04/01/92

104

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M4-1BG-LV033-01

- (C) MISSION:
SAME AS (A)
- (D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (A)
- (E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE IF EXTERNAL LEAKAGE OF H2 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 AT 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 SINUSOIDAL) AND
THERMAL OPERATING LIFE TEST (TOTAL OF 3000 CYCLES FROM -410 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 MEGAOHMS) TO 500 VOLTS AND VERIFIED CLEANED TO LEVEL 200 BY
PARTICLE COUNT. VALVE IS FURTHER VERIFIED DURING PANEL MODULAR
ASSEMBLY AND SUBSYSTEM CHECKOUT.

CMRSD: VALVE OPERATION AND INTERNAL LEAK CHECK 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

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M4-1BG-LV033-01

OF CONTAMINATION AT 40X MAGNIFICATION. ALL CRES DETAILS ARE PASSIVATED TO PREVENT CORROSION. THE VALVE IS VERIFIED CLEANED TO LEVEL 200.

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 SCOM 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. A00901-010 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

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M4-18G-LV033-01

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. 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. A03438-010 SUPPLIER, RECEIVING INSPECTION
A03439-010 SUPPLIER, RECEIVING INSPECTION
TWO H2 UNIDIRECTIONAL REACTANT VALVES EXHIBITED EXCESSIVE INTERNAL LEAKAGE AT THE SUPPLIER. BOTH VALVES HAD BEEN REMOVED FROM DV-104 FOR INSPECTION OF THE GOLD PLATING ON THE VALVE'S ARMATURES PER MCR 11065. THE CAUSE OF LEAKAGE WAS IDENTIFIED IN BOTH CASES TO BE A RESULT OF RADIAL CRACKS ON THE VALVE SEATS. SUCH LEAKAGES ARE OMRSD SCREEENABLE EVERY TURNAROUND BY A MANIFOLD PRESSURE DECAY TEST (10 PSI/10 MIN REPRESENTING 18 SCCM ALLOWABLE LEAKAGE).

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

- APPROVALS -

RELIABILITY ENGINEERING: M. D. WEST : *M. D. West*
DESIGN ENGINEERING : M. M. SCHEIERN : *M. M. Scheiern*
QUALITY MANAGER : O. J. BUTTNER : *O. J. Buttner*
NASA RELIABILITY : : *[Signature]*
NASA SUBSYSTEM MANAGER : : *[Signature]*
NASA QUALITY ASSURANCE : : *[Signature]*