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PRINT DATE: 04/23/92

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: M4-1BG-LV012-X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC

REVISION : 1 04/23/92

| | PART NAME VENDOR NAME | PART NUMBER VENDOR NUMBER |
|---------|-----------------------------|------------------------------|
| ■ SRU : | SOLENOID VALVE, ECLSS O2 | MC284-0429-4101 |
| ■ | EATON CONSOLIDATED CONTROLS | 74405-4101 |

PART DATA

- EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
SOLENOID VALVE, ECLSS O2
- REFERENCE DESIGNATORS: 40V45LV012
: 40V45LV022
- QUANTITY OF LIKE ITEMS: 2
ONE PER O2 MANIFOLD ASSY
- FUNCTION:
PROVIDES CAPABILITY TO ISOLATE O2 TO ECLSS PRIMARY OR SECONDARY PATH.

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SUBSYSTEM: ELECTRICAL POWER GENERATION - CRYO, GENERIC REVISION# 1 04/23/92 R

ITEM NAME: SOLENOID VALVE, ECLSS OZ CRITICALITY OF THIS FAILURE MODE:1R3

- FAILURE MODE:
FAILS OPEN OR INTERNAL LEAKAGE

MISSION PHASE:

| | |
|----|----------------|
| 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.

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- (B) INTERFACING SUBSYSTEM(S):
SAME AS (A)
- (C) MISSION:
SAME AS (A)
- (D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (A)
- (E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE DUE TO DEPLETION OF O2 REACTANTS (LOSS OF ALL THREE FUEL CELL POWERPLANTS) IF ALL LEAK ISOLATION CAPABILITY IS LOST IN THE EVENT OF EXTERNAL LEAKAGE OF THE ECLSS O2 LINE DOWNSTREAM OF THE ECLSS O2 SOLENOID VALVE.

- 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 SINUSOIDAL) 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, TO INCLUDE INTERNAL LEAK-CHECK, VERIFIED EVERY TURNAROUND.
- (C) INSPECTION:
RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATION DOCUMENTS ARE REVIEWED FOR

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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.

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 MHB 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. ACB705-010 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. ADO901-010 DOWNEY, VALVE PANEL ATP

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UNIDIRECTIONAL SHUTOFF VALVE EXHIBITED EXCESSIVE INTERNAL LEAKAGE DURING DOWNY 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. 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

TWO H2 UNIDIRECTIONAL REACTANT VALVES EXHIBITED EXCESSIVE INTERNAL LEAKAGE AT THE SUPPLIER. BOTH VALVES HAD BEEN REMOVED FROM OV-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 SCREENABLE EVERY TURNAROUND BY A MANIFOLD PRESSURE DECAY TEST (10 PSI/10 MIN REPRESENTING 18 SCCM ALLOWABLE LEAKAGE).

■ (E) OPERATIONAL USE:

NO CREW ACTION AFTER FIRST FAILURE. IF A SUBSEQUENT LEAK OCCURS DOWNSTREAM OF O2 SUPPLY VALVE, THE CREW WOULD ISOLATE THE LEAK TO A SINGLE TANK BY CLOSING THE APPROPRIATE MANIFOLD VALVE AND IF REQUIRED BASED ON TANK PRESSURE, SHUT DOWN THE FUEL CELL POWERPLANT/DEACTIVATE HEATERS.

- APPROVALS -

RELIABILITY ENGINEERING: M. D. WEST
DESIGN ENGINEERING: M. M. SCHEIERN
QUALITY MANAGER: O. J. BUTTNER
NASA RELIABILITY:
NASA SUBSYSTEM MANAGER:
NASA QUALITY ASSURANCE:

M. D. West
M. M. Scheiern
O. J. Buttner
E. Ocher
Approved for in Strickland MCR 11065 04/19/92
Approved L. P. Pinner 6/14/92
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