

FAILURE MODES EFFECTS ANALYSIS (FMEA) - GIL HARDWARE
NUMBER: M4-1BG-LV011 -X

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

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
SRU : SOLENOID VALVE, O2 MANIFOLD EATON CONSOLIDATED CONTROL	MC284-0429-4110 74410-4110

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

REFERENCE DESIGNATORS: 40V45LV011
40V45LV021

QUANTITY OF LIKE ITEMS: 2
ONE PER O2 MANIFOLD ASSY

FUNCTION:
PROVIDES CAPABILITY TO ISOLATE O2 MANIFOLD #1 FROM MANIFOLD #2.

FAILURE MODES EFFECTS ANALYSIS FMEA - CIL FAILURE MODE
NUMBER: M4-1BG-LY011-01

REVISION#: 2 03/27/96

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC
LRU:
ITEM NAME: SOLENOID VALVE, O2 MANIFOLD
CRITICALITY OF THIS FAILURE MODE: 1R2

FAILURE MODE:
FAILS OPEN OR INTERNAL LEAKAGE

MISSION PHASE: LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT

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? NO

REDUNDANCY SCREEN A) PASS
B) FAIL
C) PASS

PASS/FAIL RATIONALE:

A)

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 TO TWO FUEL CELLS IF A LEAK WERE TO OCCUR DURING LIFTOFF. LOSS OF TWO FCP'S DURING DESCENT LOSES CREW/VEHICLE IF INSUFFICIENT TIME IS AVAILABLE FOR AN ELECTRICAL LOAD RECONFIGURATION RESULTING IN THE INABILITY OF THE SINGLE REMAINING FUEL CELL TO SUPPLY ADEQUATE ELECTRICAL POWER.**

-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 LATCH AND NO EXCESSIVE INTERNAL LEAKAGE. VALVE IS DIELECTRIC STRENGTH AND INSULATION RESISTANCE TESTED (10 MEGAOHMS) TO 500 VOLTS AND VERIFIED CLEANED TO LEVEL

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200A BY PARTICLE COUNT AND NON-VOLATILE RESIDUE. VALVE OPERATION IS FURTHER VERIFIED DURING PANEL MODULAR ASSEMBLY AND SUBSYSTEM CHECKOUT.

OMRSD: VALVE OPERATION VERIFIED IN FLIGHT.

(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.

ASSEMBLY/INSTALLATION

ALL DETAIL PARTS ARE INSPECTED UNDER 40X MAGNIFICATION FOR SURFACE FINISH BURRS AND DAMAGE. THREAD LUBRICATION, TORQUING AND LOCKWIRE ARE 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:

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATA BASE.

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CAR NO. A3634-010 DOWNEY, VALVE PANEL ATP
AN O2 BIDIRECTIONAL MANIFOLD SHUTOFF VALVE EXHIBITED INTERNAL LEAKAGE DURING DOWNEY O2 PANEL ACCEPTANCE TESTING. THE OUT OF SPECIFICATION LEAKAGE WAS ATTRIBUTED TO EXCESS POROSITY OF THE BALL (POPPET) MATERIAL. CORRECTIVE ACTION INCLUDED CORRECTION OF THE BALL'S MANUFACTURING PROCESSES TO ELIMINATE THE EXCESS POROSITY.

CAR NO. A9695-010 SUPPLIER, ATP
AN H2 BIDIRECTIONAL MANIFOLD SHUTOFF VALVE FAILED ITS INSULATION RESISTANCE TEST. AN ANALYSIS DETERMINED THE CAUSE TO BE BURNED LEADWIRES WHICH OCCURRED DURING WELDING OF THE UNIT'S CLOSEOUT PLUG. THE WIRES WERE IN CONTACT WITH THE VALVE'S OUTER COVER DURING THE WELDING PROCESS DUE TO THE LEADWIRES BEING EXCESSIVELY LONG. CORRECTIVE ACTION INCLUDED INCORPORATION OF AN INSPECTION STATION ON THE OPERATION ASSEMBLY SHEETS TO REQUIRE INSPECTION OF THE LEADWIRE LENGTH PRIOR TO INSTALLATION OF THE CONNECTOR.

CAR NO. AC7074-010 DOWNEY, VALVE PANEL ATP
AC7326-010 DOWNEY, VALVE PANEL ATP
AN H2 AND AN O2 BIDIRECTIONAL MANIFOLD SHUTOFF VALVE FAILED TO TRANSFER TO THE CLOSED POSITION DURING DOWNEY PANEL ACCEPTANCE TESTING. INSPECTION REVEALED CORROSION AND FLAKING OF THE GOLD PLATING ON BOTH VALVES' ARMATURES. FAILURE OF THE VALVES TO TRANSFER WAS ATTRIBUTED TO THE PLATING PROBLEM. M&P EVALUATION INDICATED THE PLATING PROBLEM TO BE TYPICAL OF POOR PLATING PREPARATION TECHNIQUES. THE ARMATURE PLATING PROBLEM WAS ISOLATED TO TWO OF THREE PLATING MANUFACTURERS WITH PARTS PLATED BETWEEN 1981 AND 1983. CORRECTIVE ACTION INCLUDED: THE RETURN OF ALL VALVES IDENTIFIED TO HAVE SUSPECT PLATING FOR ARMATURE INSPECTION AND REPLACEMENT AS REQUIRED, AND RETURN OF UNITS ALREADY INSTALLED WITHIN 5 YEARS OF THEIR PLATING DATES. IN ADDITION, IMPROVED CONTROLS OVER PROCESSING AND INSPECTION OF ARMATURES AND VALVES AT THE VALVE MANUFACTURER WERE IMPOSED. SEE MCR 11065 FOR ADDITIONAL DETAIL.

CAR NO. AD0900-010 DOWNEY, VALVE PANEL ATP
AN O2 BIDIRECTIONAL MANIFOLD SHUTOFF VALVE FAILED TO TRANSFER CLOSED AT THE REQUIRED INPUT VOLTAGE (18 VOLTS) DURING DOWNEY PANEL ACCEPTANCE TESTING. ONCE THE VALVE CLOSED AT A HIGHER THAN NORMAL INPUT VOLTAGE (23.2 VOLTS), THE VALVE OPERATED SATISFACTORILY WITH FURTHER CYCLING. INSPECTION WITHIN THE VALVE FAILED TO REVEAL ANY DISCREPANCIES. THE PROBLEM WAS CLOSED WITH THE FOLLOWING RATIONALE: THIS IS THE FIRST REPORTED INSTANCE OF A BIDIRECTIONAL VALVE FAILING TO CLOSE WHOSE CAUSE COULD NOT BE IDENTIFIED. THERE HAVE BEEN TWO OTHER BIDIRECTIONAL VALVE FAILURES WHICH FAILED TO CLOSE BUT THE CAUSES WERE ATTRIBUTED TO FLAKING OF THE ARMATURE'S GOLD PLATING. THE PLATING ON THE FAILED VALVE'S ARMATURE APPEARED SATISFACTORY. IN ADDITION, THE VEHICLE'S INPUT VOLTAGE IS ROUGHLY 28 VDC WHICH IS MORE THAN ADEQUATE TO CLOSE THE SUSPECT VALVE. BIDIRECTIONAL SHUT OFF VALVES ARE USED ON THE O2 & H2 MANIFOLDS WHICH ARE LEFT OPEN THROUGHOUT A FLIGHT AND WOULD NOT BE CLOSED UNLESS REQUIRED DUE TO A SYSTEM FAILURE. THESE VALVES ARE ALSO USED FOR THE O2 & H2 GAS SUPPLY VALVES WHICH ARE VERIFIED TO BE CLOSED PRIOR TO LAUNCH.

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CAR NO. AD3199-010 SUPPLIER, RECEIVING INSPECTION
 AD3437-010 SUPPLIER, RECEIVING INSPECTION
 AD0925-010 KSC, OV-102, GROUND CHECK

TWO H2 BIDIRECTIONAL T-O SHUTOFF VALVES EXHIBITED EXCESSIVE INTERNAL LEAKAGE AT THE SUPPLIER. ONE VALVE HAD BEEN REMOVED FROM OV-104 AND ONE HAD BEEN REMOVED FROM OV-103 FOR INSPECTION OF THE GOLD PLATING ON THE VALVES' ARMATURES. THE CAUSE OF LEAKAGE WAS IDENTIFIED IN BOTH CASES TO BE A RESULT OF RADIAL CRACKS ON THE VALVE SEATS. CRACKS WERE FOUND AT BOTH THE UPPER AND LOWER WELDS. AN H2 BIDIRECTIONAL MANIFOLD SHUTOFF VALVE EXHIBITED INTERNAL LEAKAGE DURING OV-102 SYSTEM CHECKOUT. LEAKAGE WAS VERIFIED AT ITS SUPPLIER AND INSPECTION REVEALED AN INDENTATION ON THE VALVE'S SEAT SEALING SURFACE. A LEAK CHECK OF THE SEAT ALSO REVEALED A CIRCUMFERENTIAL CRACK ALONG THE SEAT WELD. ANALYSIS IDENTIFIED RADIAL CRACKS AT THE BOTTOM WELD SIMILAR TO THE VALVES REPORTED ON CARS AD3199-010 AND AD3437-010. SUCH LEAKAGES ARE OMRSD SCREENABLE EVERY TURNAROUND BY A MANIFOLD PRESSURE DECAY TEST (10 PSI/10 MIN REPRESENTING 18 SCCM ALLOWABLE LEAKAGE). CORRECTIVE ACTION IS UNDER INVESTIGATION.

(E) OPERATIONAL USE:

NO CREW ACTION AFTER FAILURE, FIRST FAILURE IS UNDETECTABLE.

 - APPROVALS -

PAE MANAGER : D. F. MIKULA
 PRODUCT ASSURANCE ENGR : L. X. DANG
 DESIGN ENGINEERING : G. AVILA
 NASA SSMA :
 NASA SUBSYSTEM MANAGER :

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