FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: 04-2-LVII-IM-X

SUBSYSTEM NAME: AUXILIARY POWER UNIT (APU)
REVISION : 3 08/30/91

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
■ LRU :	FUEL TANK ISOLATION VALVE	MC284-0572
■	MOOG	B41429

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
FUEL TANK ISOLATION AND REVERSE PRESSURE RELIEF VALVE ASSEMBLY. TWO NORMALLY CLOSED SOLENOID VALVES MANIFOLDED IN PARALLEL AND SINGLE REVERSE PRESSURE RELIEF VALVE.

■ QUANTITY OF LIKE ITEMS: 3
ONE MANIFOLD SET PER APU SUBSYSTEM.

■ FUNCTION:
(1) TO OPEN AND ALLOW FUEL TO FLOW FOR APU OPERATION. (2) TO PROVIDE FUEL SHUTOFF CAPABILITY IN THE EVENT OF DOWNSTREAM LEAKAGE (INTERNAL OR EXTERNAL). (3) TO PROVIDE REVERSE PRESSURE RELIEF. (4) TO PROVIDE VALVE/FUEL TEMPERATURE DATA TO ACTIVATE ORBITER OVERTEMPERATURE ALARM.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE NUMBER: 04-2-LV11-IM-11

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SUBSYSTEM: AUXILIARY POWER UNIT (APU)
LRU :FUEL TANK ISOLATION VALVE
ITEM NAME: FUEL TANK ISOLATION VALVE

CRITICALITY OF THIS FAILURE MODE:1R3

■ FAILURE MODE:
FAILS CLOSED (FAILS TO OPEN, FAILS TO REMAIN OPEN, OR INCOMPLETE TRANSFER TO THE OPEN POSITION)

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

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

■ CAUSE:
LOSS OF ELECTRIC POWER, FAILURE OF HYBRID DRIVER OR SWITCH, SOLENOID FAILURE, INTERNAL MECHANICAL FAILURE, CONTAMINATION OR CORROSION

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

■ REDUNDANCY SCREEN A) PASS
■ B) FAIL
■ C) PASS

PASS/FAIL RATIONALE:
■ A)

■ B)
ONE FAILED CLOSED VALVE MAY NOT BE DETECTED IN ALL CASES. IF THE SOLENOID IS POWERED, AND NO/LOW FUEL FLOW OCCURS, A TEMPERATURE INCREASE IN THE FAILED VALVE IS DETECTABLE.

■ C)

■ MASTER MEAS. LIST NUMBERS: V46P0X10A
: V46P0X00A
: V46X0X15E
: V46X0X34E
: V46P0X05A

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- FAILURE EFFECTS -

- (A) SUBSYSTEM:
FIRST FAILURE NO EFFECT. EACH APU SUBSYSTEM HAS PARALLEL REDUNDANT VALVES. SECOND PARALLEL VALVE FAILURE RESULTS IN LOSS OF ONE APU.

- (B) INTERFACING SUBSYSTEM(S):
FIRST FAILURE NO EFFECT. SECOND PARALLEL VALVE FAILURE RESULTS IN LOSS OF ONE HYDRAULIC SYSTEM.

- (C) MISSION:
NO EFFECT

- (D) CREW, VEHICLE, AND ELEMENT(S):
FIRST FAILURE - NO EFFECT. SECOND PARALLEL VALVE FAILURE RESULTS IN LOSS OF ONE APU. LOSS OF SECOND APU SUBSYSTEM COULD RESULT IN LOSS OF CREW/VEHICLE.

- (E) FUNCTIONAL CRITICALITY EFFECTS:
LOSS OF BOTH PARALLEL VALVES IN ONE APU SUBSYSTEM AND LOSS OF SECOND APU COULD RESULT IN LOSS OF CREW/VEHICLE.

- DISPOSITION RATIONALE -

- (A) DESIGN:
THE APU PROPELLANT TANK ISOLATION VALVE ASSEMBLY CONSISTS OF TWO INDEPENDENTLY OPERATED SOLENOID VALVES MANIFOLDED IN PARALLEL WITH A SINGLE RELIEF VALVE COMMON TO EACH SOLENOID VALVE. ONE SWITCH IS USED TO OPERATE BOTH PARALLEL VALVES OF EACH APU SYSTEM. SERIES REDUNDANT POWER DRIVERS ARE USED TO PREVENT POWERING VALVES WITH A SINGLE DRIVER FAILURE. A CIRCUIT BREAKER FOR EACH VALVE IS INCORPORATED IN EACH CIRCUIT TO REMOVE POWER FROM EITHER VALVE IF REQUIRED. DISCRETE SIGNAL (V46X0X15E/V46X034E) MEASURED BETWEEN SECOND DRIVER AND EACH VALVE TO CONFIRM ELECTRICAL POWER TO EACH VALVE. A SINGLE GROUND DRIVER IS USED. EACH SOLENOID VALVE INCORPORATES REDUNDANT VALVE/FUEL TEMPERATURE SENSORS TO CONTINUOUSLY MEASURE VALVE TEMPERATURE WHICH IS MONITORED ON FDA. EACH SOLENOID VALVE IS DESIGNED TO REMAIN CLOSED THROUGH A SPRING PRELOAD UNTIL OPENED BY ELECTRICAL ENERGIZATION OF IT'S SOLENOID COIL. EACH VALVE COIL IS A THREE PIECE SEGMENTED DESIGN TO REDUCE POSSIBILITY AND SEVERITY OF SHORTING. THE DESIGN INCORPORATES INCREASED VALVE BODY MASS AND AN UNSTRESSED THICK BARRIER SEPARATING HYDRAZINE FROM THE COIL. EACH VALVE ASSEMBLY IS PROTECTED BY AN INLET FILTER TO PREVENT SYSTEM CONTAMINATES FROM ENTERING THE VALVE SEAT ASSEMBLY. THE COMMON RELIEF VALVE ASSEMBLY IS ALSO

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PROTECTED FROM SYSTEM CONTAMINATES BY INLET AND OUTLET FILTERS. BACKPRESSURE RELIEF IS BETWEEN 75 AND 250 PSID. THE POPPET/SEAT OF EACH SOLENOID VALVE AND RELIEF VALVE IS A NON SLIDING FIT DESIGN (S-SPRING) USED TO REDUCE MISALIGNMENT AND FRICTION.

EXTERNAL LEAK PATH OF THE VALVE ASSEMBLY HAS BEEN MINIMIZED BY LOW STRESS HERMETIC SEAL DESIGN. VALVE TO SYSTEM INTERFACE IS A MECHANICAL DYNA-TUBE SEAL DESIGN WITH A LOCK WIRE FEATURE TO ASSURE INTERFACE TORQUE.

■ (8) TEST:
VALVE IS PROOF PRESSURE TESTED AT 1,110 PSIG GN2 IN ATP. MAXIMUM EXTERNAL LEAKAGE IS 1 x 10-4 SCC/SEC AT 750 PSIG HELIUM. MAXIMUM INTERNAL LEAKAGE IS 36 SCCH AT 410 PSIG HELIUM.
OMRSD: TOXIC VAPOR CHECKS AND POST-FLIGHT SYSTEM INSPECTION PERFORMED DURING EACH GROUND TURNAROUND AS WELL AS VERIFICATION THAT EACH OF THE TWO PARALLEL VALVES OPENS AND CLOSES ON COMMAND. RELIEF VALVE CRACK AND VALVE RESEAT IS VERIFIED IN-FLIGHT EVERY FLIGHT.

■ (C) INSPECTION:
RECEIVING INSPECTION
MATERIAL AND PROCESSES CERTIFICATIONS ARE VERIFIED.

CONTAMINATION CONTROL
CLEANLINESS TO LEVEL 100 IS VERIFIED BY INSPECTION. CORROSION PROTECTION REQUIREMENTS ARE VERIFIED BY TEST.

ASSEMBLY/INSTALLATION
MANUFACTURING, ASSEMBLY, AND INSTALLATION REQUIREMENTS ARE VERIFIED BY INSPECTION. CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. BURR AND WELD SPLATTER INSPECTION AT 20X MAGNIFICATION IS VERIFIED. SOLENIOD IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
WELDS INSPECTED AT 20X TO 30X MAGNIFICATION FOR SURFACE CRACKS, WELD BEAD GEOMETRY, VOIDS OR PORES. WELD VERIFICATION SAMPLE IS INSPECTED SIMILARLY AND RETAINED IN FILES FOR TRACEABILITY.

CRITICAL PROCESSES
WELDING PER SPECIFICATION REQUIREMENTS IS VERIFIED BY INSPECTION.

TESTING
TEST EQUIPMENT AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. ATP (INCLUDING INSULATION RESISTANCE AND DIELECTRIC STRENGTH) IS WITNESSED AND VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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HANDLING, PACKAGING, STORAGE AND SHIPPING PROCEDURES ARE VERIFIED.

- (D) FAILURE HISTORY:
  NO FAILURES

- (E) OPERATIONAL USE:
  LOSS OF BOTH PARALLEL ISOLATION VALVES WILL RESULT IN LOSS OF A SINGLE APU/HYDRAULIC SYSTEM AND MAY RESULT IN CREW RUNNING THE REMAINING APU'S AT HIGH SPEED WITH THE SAFETY CIRCUITS INHIBITED, DEPENDING ON MISSION PHASE.

- APPROVALS -

RELIABILITY ENGINEERING	D. R. ATAPATTU	:
DESIGN ENGINEERING	T. FARKAS	:
QUALITY ENGINEERING	M. SAVALA	: 10/11/91
NASA RELIABILITY		:
NASA SUBSYSTEM MANAGER		: 1-24-92
NASA QUALITY ASSURANCE		: 12/1/91