FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: 03-1-0251-X

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SUBSYSTEM NAME: MAIN PROPULSION
REVISION : 1 04/05/90

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU :	VALVE, RELIEF, 850 PSI EATON CONSOLIDATED CONTROLS	MC284-0398-0005 76130

PART DATA

- EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
  850 PSI RELIEF, PNEUMATIC HELIUM SUPPLY, 0.75 INCH DIAMETER.
- REFERENCE DESIGNATORS: RV4
- QUANTITY OF LIKE ITEMS: 1
  ONE
- FUNCTION:

  PROVIDES A MEANS OF RELIEVING AN OVERPRESSURE CONDITION RESULTING FROM AN UPSTREAM REGULATOR FAILING TO REGULATE. ONE RELIEF VALVE IS PROVIDED FOR THE PNEUMATIC HELIUM SUPPLY SYSTEM.

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REVISION# 1 04/05/90

SUBSYSTEM: MAIN PROPULSION
LRU :VALVE, RELIEF, 850 PSI
ITEM NAME: VALVE, RELIEF, 850 PSI

CRITICALITY OF THIS FAILURE MODE: 1/1

■ FAILURE MODE:
RUPTURE/LEAKAGE.

MISSION PHASE:
LO LIFT-OFF
DO DE-ORBIT

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

■ CAUSE:
MATERIAL DEFECT, FATIGUE.

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

■ REDUNDANCY SCREEN A) N/A
■ B) N/A
■ C) N/A

PASS/FAIL RATIONALE:
■ A)

■ B)

■ C)

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
DURING ASCENT, THE PNEUMATIC HELIUM SUPPLY WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT.

WHEN THE CROSSOVER VALVE (LV10) OPENS AT MECO, THE PNEUMATIC HELIUM DISTRIBUTION SYSTEM WILL BE FED FROM THE LEFT ENGINE HELIUM SUPPLY. WHEN THE INTERCONNECT "OUT" VALVES OPEN AT MECO PLUS 20 SECONDS, THE ENGINE HELIUM SUPPLIES WILL LEAK THROUGH THE FAILED LINE.

STORED HELIUM PRESSURE IN THE ACCUMULATOR LEG SHOULD BE ADEQUATE TO

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OPERATE THE LO2 PREVALVES AT MECO. LOSS OF HELIUM MAY PREVENT OPERATION OF VALVES FOR MPS DUMP.

PURGE OF AFT COMPARTMENT AND LH2/LO2 SYSTEMS WOULD DEPEND SOLELY ON THE LEFT ENGINE HELIUM SYSTEM RESIDUALS, RESULTING IN INADEQUATE ABORT PURGE, INCOMPLETE PROPELLANT DUMP, AND INGESTION OF CONTAMINATION.

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. RUPTURE DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED MAY RESULT IN OVERPRESSURIZATION OF AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

PRIOR TO T-9 MINUTES, EXCESSIVE HELIUM LEAKAGE WILL BE DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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

■ (C) MISSION:
ON GROUND, POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

■ (D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

■ (E) FUNCTIONAL CRITICALITY EFFECTS:

- DISPOSITION RATIONALE -

■ (A) DESIGN:
THE RELIEF VALVE IS PILOT OPERATED AND PRESSURE ACTUATED. AS THE SENSE LINE PRESSURE EXCEEDS 790 PSIG THE INLET PRESSURE FORCE ON THE POPPET SEAT PISTON BECOMES GREATER THAN THE RESEATING FORCE OF THE BELLEVILLE SPRINGS. THE UNBALANCED FORCE CAUSES THE POPPET SEAT PISTON TO MOVE. THE PILOT SPRING CAUSES THE POPPET TO MOVE WITH THE SEAT PISTON UNTIL THE PILOT POPPET CONTACTS ITS UPPER SEAT. THE POPPET SEAT PISTON CONTINUES TO MOVE CAUSING SEPARATION BETWEEN THE POPPET SEAT PISTON AND THE PILOT POPPET.

PRESSURE MAINTAINING THE MAIN POPPET SEATED IS VENTED THROUGH THE UNSEATED PILOT POPPET INTO THE AFT FUSELAGE. A DIFFERENTIAL PRESSURE ACROSS THE MAIN POPPET IS CREATED FORCING THE MAIN POPPET TO UNSEAT. THIS RELIEVES INLET PRESSURES FROM 850 PSIG (MAXIMUM) DOWN TO 785 PSIG (MINIMUM RESEAT) INTO THE AFT FUSELAGE AT A RATE OF 1.0 LB/SEC (MINIMUM AT 850 PSIG).

AS THE SENSE LINE PRESSURE DECREASES, THE PRESSURE FORCE ON THE POPPET

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SEAT PISTON BECOMES LESS THAN THE RESEATING FORCE CAUSED BY THE BELLEVILLE SPRINGS. THIS UNBALANCED FORCE CAUSES THE POPPET SEAT PISTON TO MOVE INTO CONTACT WITH THE PILOT POPPET'S LOWER SEAT CAUSING THE PILOT POPPET TO LEAVE ITS UPPER SEAT. THIS ALLOWS INLET PRESSURE TO AUGMENT THE MAIN POPPET RETURN SPRING FORCE CLOSING THE VALVE. ONCE SEATED, THE POPPET IS HELD CLOSED BY THE DIFFERENTIAL PRESSURE ACROSS THE MAIN POPPET AND BY THE MAIN POPPET RETURN SPRING FORCE. THE PILOT VENT CLOSES BY SPRING FORCE TO SEAL AGAINST CRYO PUMPING.

THE RELIEF VALVE ALSO INCORPORATES A FAST SENSING POPPET TO CONTROL THE RATE AT WHICH UPSTREAM PRESSURE IS SENSED. THIS FAST SENSING POPPET IS CONNECTED TO THE MAIN PRESSURIZATION LINE BY A 0.25 INCH (OUTER DIAMETER) TUBE. UNDER STEADY STATE CONDITIONS, INLET PRESSURE IS SENSED THROUGH ORIFICES IN BOTH THE INLET PORT AND THE FAST SENSING POPPET. INSTANTANEOUS PRESSURE RISES THAT EXCEED 775 PSIG UNSEAT THE FAST SENSING POPPET EXPOSING FOUR ADDITIONAL LARGER ORIFICES IN THE POPPET. THIS INCREASES THE RATE OF RELIEF VALVE RESPONSE. WHEN THE PRESSURE DECREASES TO A PREDETERMINED DIFFERENTIAL ACROSS THE FAST SENSING POPPET, SPRING FORCE RESEATS THE POPPET, THUS DAMPENING VALVE RESPONSE.

THE VALVE BODY CONSISTS OF THREE ALUMINUM ALLOY 6061-T651 PARTS: THE HOUSING, THE END CAP, AND THE SEAT RETAINER. THE POTENTIAL LEAK PATHS ARE THE HOUSING/END CAP INTERFACE AND THE HOUSING/SEAT RETAINER INTERFACE. THE HOUSING/END CAP AND THE HOUSING/SEAT RETAINER INTERFACES ARE SEALED USING RAYCO TYPE SEALS. THE SEALS USE CRES 302 SPRINGS WITH TEFLON (TFE) JACKETS. THE SEAL GLANDS ARE MACHINED INTO THE HOUSING WITH AN 8 MICROINCH SURFACE FINISH. THE END CAP IS THREADED INTO THE HOUSING AND TORQUED TO 630 IN-LB BEFORE BEING LOCK WIRED TO THE HOUSING. THE RETAINER IS ATTACHED TO THE HOUSING USING SIX 19-32 CRES A286 SOCKET HEAD CAP SCREWS WITH A MINIMUM ULTIMATE TENSILE STRENGTH OF 160 KSI (NAS 1351). THESE CAP SCREWS ARE TORQUED TO 45 IN-LB BEFORE BEING LOCK WIRED TO EACH OTHER. FLAT AND LOCK WASHERS ARE USED WITH THE SCREWS.

RUPTURE OF THE INCONEL 718 BELLOWS (1 PLY) WOULD CAUSE EXTERNAL LEAKAGE. THE BELLOWS ACTS AS A LEAK BARRIER BETWEEN THE POPPET SEAT PISTON AND THE ATMOSPHERE. ALL BELLOWS ARE ACCEPTANCE TESTED BY THE SUPPLIER BEFORE BEING ASSEMBLED INTO THE RELIEF VALVE. BELLOWS ACCEPTANCE TESTS INCLUDE 200 MECHANICAL CYCLES AT -160 THROUGH 275 DEG F WHILE PRESSURIZED TO 850 PSIG EXTERNAL PRESSURE; PROOF PRESSURE TESTS TO 1700 PSIG; AND LEAKAGE TEST AT 1035 PSIG EXTERNAL PRESSURE.

RUPTURE OF THE 6061-T651 ALUMINUM MAIN POPPET WOULD CAUSE EXTERNAL LEAKAGE. THE VALVE HAS BEEN PROOF PRESSURE TESTED DURING ATP TO 1750 PSIG WITHOUT DAMAGE OR DISTORTION. IT HAS ALSO BEEN BURST PRESSURE TESTED TO 3400 PSIG DURING CERTIFICATION WITHOUT RUPTURE.

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THE FACTORS OF SAFETY ARE 2.0 PROOF AND 4.0 BURST. STRUCTURAL ANALYSES INDICATE POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION. FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

■ (8) TEST:
ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE (1,750 PSIG)

INTERNAL LEAKAGE (GHe)
AMBIENT TEMPERATURE
INLET PRESSURES: 100, 500, 750, AND 785 PSIG

FUNCTIONAL TESTS

PILOT CRACK AND RESEAT
AMBIENT TEMPERATURE
CRACK 790 PSIG, RESEAT 785 PSIG
LOW TEMPERATURE (BODY: -75 DEG F OR COLDER)
INLET PRESSURES: 100, 500, 750, AND 785 PSIG
CRACK 790 PSIG, RESEAT 785 PSIG

SLAM START TESTS
(ORIFICE INSTALLED IN INLET LINE TO LIMIT FLOW TO 1.0 LB/SEC)
AMBIENT BODY TEMPERATURE (HELIUM AT 220 DEG F)
PRESSURE UPSTREAM OF THE ORIFICE:
4500 PSIG, FOLLOWED BY FULL FLOW, BLOW DOWN, AND RESEAT
2500 PSIG, FOLLOWED BY BLOWDOWN, AND RESEAT
PRESSURE DOWNSTREAM OF THE ORIFICE:
NO GREATER THAN 850 PSIG

ELECTRICAL BONDING

CERTIFICATION

VIBRATION

TRANSIENT VIBRATION:

5 TO 35 HZ, +/- 0.25 g, IN EACH OF THREE AXES

RANDOM VIBRATION:

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60 MINUTES IN EACH OF THREE AXES

DURING THE LAST 5 MINUTES OF TESTING IN EACH AXIS CRACK AND RESEAT PRESSURE TESTS ARE PERFORMED.

PERFORM LEAK AND FUNCTIONAL TESTS AFTER EACH AXIS

DESIGN SHOCK
PER MIL-STD-810 IN EACH OF THREE AXES
PERFORM LEAK AND FUNCTIONAL TESTS AFTER EACH AXIS

SAND AND DUST
PER MIL-STD-810

THERMAL CYCLE (3 CYCLES, NO FLOW)
+70 DEG F TO -150 DEG F TO +250 DEG F TO +70 DEG F
INLET PRESSURE: 750 PSIG
PERFORM LEAK AND FUNCTIONAL TESTS

LIFE CYCLE (2000 CYCLES, 850 PSIG TO RESEAT)
CRACK AND RESEAT AND SLAM START TESTS AFTER EACH 400 CYCLES
PERFORM LOW TEMPERATURE LEAK AND FUNCTIONAL TESTS

BURST TEST (3400 PSIG)

GROUND TURNAROUND TEST
V41AZ0.100 MPS PNEUMATIC LOW PRESSURE DECAY TEST (EVERY FLIGHT)
V41AZ0.150 FLIGHT PRESSURIZATION ISOLATION TEST (PERFORM GROUND TURNAROUND TEST IF VALID VERIFICATION IS UNOBTAINABLE IN FLIGHT)
V41AZ0.190 HELIUM SYSTEM BRAZE/WELD JOINT LEAK CHECK (EVERY TENTH FLIGHT)
V41BC0.100 HIGH PRESSURE 2-WAY SOLENOID VALVE LEAK TEST (EVERY SIXTH FLIGHT)
V41BG0.010 PR1-4, 7-9 PNEUMATIC SSME REGULATOR LOCKUP TEST (EVERY FLIGHT)
V41BU0.010 ORBITER MPS COMPONENT INSPECTIONS (EVERY FLIGHT)

(C) INSPECTION:
RECEIVING INSPECTION
RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION. PART PROTECTION COATING AND PLATING REQUIREMENTS ARE VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CLEANLINESS TO LEVEL 100A IS VERIFIED BY INSPECTION.

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ASSEMBLY/INSTALLATION
ALL CRITICAL DIMENSIONS ARE VERIFIED BY INSPECTION. TORQUE PER DRAWING REQUIREMENT IS VERIFIED BY INSPECTION. SURFACE FINISHES AND SURFACES REQUIRING CORROSION PROTECTION ARE VERIFIED BY INSPECTION. ALL SEALING SURFACES AND SEALS ARE VISUALLY EXAMINED BEFORE INSTALLATION USING 10X MAGNIFICATION. DRY FILM LUBRICANT AND ELECTROCHEMICAL ETCH MARKING IS VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE INSPECTION PROCEDURE.

CRITICAL PROCESSES
WELDING, HEAT TREATMENT, PARTS PASSIVATION, AND ANODIZING ARE VERIFIED.

NONDESTRUCTIVE EVALUATION
HELIUM LEAK TEST IS VERIFIED BY INSPECTION.

TESTING
ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPPING IS VERIFIED BY INSPECTION.

■ (D) FAILURE HISTORY:
THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

■ (E) OPERATIONAL USE:
PNEUMATIC ACTUATION HELIUM BOTTLE PRESSURE IS ON A DEDICATED DISPLAY IN COCKPIT. CREW ACTION IS TO FOLLOW NORMAL LEAK ISOLATION PROCEDURE. PRIOR TO MECO, ISOLATION VALVES (LV7, LV8) WILL BE REOPENED AND THE LEFT ENGINE HELIUM CROSSOVER VALVE (LV10) WILL BE OPENED.

EFFECTIVE FOR OI-8D SOFTWARE, CR 69397B "MPS PNEUMATIC SYSTEM FDA AND DISPLAY - BFS" ADDS PNEUMATIC TANK, REGULATOR, AND ACCUMULATOR PRESSURE TO THE S/M ALERT FDA SYSTEM AND ADDS THE 3 PRESSURE MEASUREMENTS TO THE BFS SYSTEM SUMMARY DISPLAY. THIS ALLOWS THE FLIGHT CREW TO RESPOND TO A PNEUMATIC HELIUM SYSTEM LEAK INDEPENDENT OF GROUND CONTROL.

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- APPROVALS -

RELIABILITY ENGINEERING	K. ANVARI	5/22/90
DESIGN ENGINEERING	H. P. BAFFORD	4-16-90
QUALITY ENGINEERING	O. J. BUTTNER	5/19/90
NASA RELIABILITY		10/18/90
NASA SUBSYSTEM MANAGER		5/18/90
NASA QUALITY ASSURANCE		7/24/90