

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE****NUMBER: 03-1-0401 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 07/12/00**PART DATA**

<b>PART NAME</b>	<b>PART NUMBER</b>
<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU : LO2 PREVALVE	MC284-0396-0007,-0009
UNITED SPACE ALLIANCE - NSLD	73325000-115,-119

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, PRE, LO2 12 INCH PNEUMATICALLY OPERATED, INCORPORATES REVERSE FLOW RELIEF VALVE

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY FAIRCHILD CONTROLS BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

**REFERENCE DESIGNATORS:** PV1  
PV2  
PV3

**QUANTITY OF LIKE ITEMS:** 3

**FUNCTION:**

VALVE OPEN DURING CHILLDOWN AND LOADING. REQUIRED TO REMAIN OPEN DURING ENGINE OPERATION. REVERSE FLOW RELIEF VALVE AND A VISOR LIFTOFF MECHANISM PROVIDE MEANS OF RELIEVING BOILOFF PRESSURE WITHIN FEEDLINE WITH PREVALVE IN CLOSED POSITION. ELECTRICAL CIRCUITRY LOCKOUT PREVENTS PREVALVE CLOSURE UNTIL THRUST CHAMBER PRESSURE DECAYS TO 30% LEVEL DURING A NORMAL MISSION. CLOSING OF THE PREVALVE BECOMES CRITICAL DURING MAIN ENGINE CUTOFF (MECO). DURING THIS ZERO G CONDITION, HELIUM IS INJECTED INTO SYSTEM VIA SSME POGO ACCUMULATOR TO MAINTAIN REQUIRED LO2 PRESSURE AT THE SSME HPOTP TO PREVENT OVERSPEED. USED AS AN ISOLATION VALVE FOR THE PROPELLANT FEED SYSTEM FOR A SHUTDOWN/FAILED SSME. THE VALVE IS REOPENED FOR PROPELLANT DUMP AND CLOSED FOR REENTRY. DURING MECO, THE 30% MINIMUM CHAMBER PRESSURE REQUIREMENT IS REMOVED FROM THE ENGINE OPERATION PARAMETERS. VALVE INCORPORATES AN ANTI-SLAM MECHANISM TO PREVENT VALVE SLAMMING DAMAGE DURING IMPROPER VALVE OPEN/CLOSE OPERATIONS.

**FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE**

**NUMBER: 03-1-0401-05**

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: LO2 PREVALVE (PV1, PV2, PV3)**

**ITEM NAME: LO2 PREVALVE (PV1, PV2, PV3)**

**CRITICALITY OF THIS**

**FAILURE MODE: 1R3**

**FAILURE MODE:**

FAILS TO OPEN FOR SYSTEM DUMP FOLLOWING SSME SHUTDOWN.

**MISSION PHASE: LO LIFT-OFF**

<b>VEHICLE/PAYLOAD/KIT EFFECTIVITY:</b>	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

**CAUSE:**

PIECE PART STRUCTURAL FAILURE, BINDING, ACTUATOR LEAKAGE, ANTI SLAM VALVE LEAKAGE, ACTUATOR FILTER CLOGGING.

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

**REDUNDANCY SCREEN**

- A) PASS
- B) FAIL
- C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

POSITION SWITCH INDICATION CANNOT BE USED TO PASS THE B SCREEN. PIECE PART STRUCTURAL FAILURE MAY BE UNDETECTABLE BECAUSE POSITION SWITCHES ARE LOCATED IN THE ACTUATOR, NOT AT THE END OF THE VALVE DRIVE MECHANISM. LO2 ENGINE INLET PRESSURE RISE ONLY OCCURS AFTER MULTIPLE RELIEF FAILURES.

C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

ONE FEEDLINE WILL NOT BE COMPLETELY DUMPED. MAJOR PORTION OF LO2 WILL DUMP THRU THE OTHER ENGINES. LO2 TRAPPED BETWEEN THE PREVALVE AND THE MAIN OXIDIZER VALVE WILL RELIEVE VIA THE PREVALVE RELIEF SYSTEM (VISOR LIFTOFF AND

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0401-05**

BODY BYPASS RELIEF VALVE) INTO THE MANIFOLD AND/OR OVERBOARD VIA THE SSME HPOT PUMP SEAL LEAKAGE.

**(B) INTERFACING SUBSYSTEM(S):**

SAME AS A.

**(C) MISSION:**

NO EFFECT. LO2 RESIDUALS MAY BE PRESENT.

**(D) CREW, VEHICLE, AND ELEMENT(S):**

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

CASE 1:

1R/3 5 SUCCESS PATHS. TIME FRAME - LO2 DUMP/VACUUM INERT.

- 1) DUMP SWITCH FAILS "STOP" PREVENTING OPENING OF ALL THREE LO2 PREVALVES.
- 2,3) BOTH LO2 POGO VALVES (PV20 & PV21) FAIL CLOSED.
- 4) EITHER OUTBOARD OR INBOARD FILL & DRAIN VALVES FAIL TO OPEN/REMAIN OPEN (PV9 OR PV10).
- 5) LO2 MANIFOLD RELIEF SYSTEM FAILS TO RELIEVE.

RESULTS IN RUPTURE OF THE 17" FEEDLINE DUE TO EXPANDING LO2 RESIDUALS AFTER LO2 DUMP. POSSIBLE AFT COMPARTMENT OVERPRESSURE AND FIRE/EXPLOSIVE HAZARD. LOSS OF ADJACENT CRITICAL COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2:

1R/3 6 SUCCESS PATHS. TIME FRAME - LO2 DUMP.

- 1) LO2 PREVALVE FAILS TO OPEN.
- 2) SSME MAIN OXIDIZER VALVE FAILS TO OPEN
- 3) PREVALVE VISOR RELIEF FAILS TO RELIEVE.
- 4) PREVALVE BUILT IN RELIEF VALVE FAILS TO RELIEVE.
- 5) HPOT PUMP SEAL CLOGS.
- 6) SSME RECIRCULATION ISOLATION VALVE (RIV) FAILS TO OPEN.

RESULTS IN RUPTURE OF THE 12" LO2 ENGINE FEEDLINE DUE TO EXPANDING LO2 RESIDUALS AFTER DUMP. POSSIBLE AFT COMPARTMENT OVERPRESSURE AND FIRE/EXPLOSIVE HAZARD. POSSIBLE LOSS OF ADJACENT CRITICAL COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0401-05**

**(A) DESIGN:**

DESIGNED FOR FACTORS OF SAFETY OF 1.3 PROOF AND 1.5 BURST FOR THE VALVE BODY, 1.5 PROOF AND 2.0 BURST FOR THE ACTUATOR. STRUCTURAL FAILURE IS AVOIDED BY MANUFACTURING THE POWERTRAIN OF A286 CRES, 21-6-9 CRES OR COPPER-BERYLLIUM COMPONENTS. BINDING IS GUARDED AGAINST BY THE USE OF ROLLER BEARINGS THROUGHOUT.

THE ACTUATOR DRIVES THE VALVE VIA A LINEAR RACK AND PINION GEAR (BOTH OF COPPER-BERYLLIUM), AND THE RACK IS POWERED BY HELIUM-DRIVEN DUAL PISTONS. LEAKAGE ACROSS THE PISTONS IS PRECLUDED BY TWO SEALS OF THE TEFLON JACKETED, RACO TYPE (THE METALLIC "V" SPRING IS OF 301 CRES). THIS TYPE OF SEAL IS USED TO PREVENT EXTERNAL LEAKAGE AT ALL ACTUATOR JOINTS.

THE ANTI-SLAM VALVES USE A286 CRES POPPETS SPRING LOADED TO KEL-F SEATS. WITH THE ANTI-SLAM PORT VENTED, ACTUATION PRESSURE ASSISTS THE SPRING IN SEALING THE POPPET TO THE SEAT. BINDING IS CONSIDERED UNLIKELY BECAUSE ALL SLIDING SURFACES ARE COATED WITH A DRY FILM LUBRICANT WHICH HAS HAD EXTENSIVE UTILIZATION WITHOUT PROBLEMS.

THE VALVE IS DESIGNED FOR 5000 LIFE CYCLES AND WAS TESTED THROUGH 5260 CYCLES (OVER 100 MISSIONS) UNDER BOTH CRYOGENIC AND AMBIENT TEMPERATURE CONDITIONS AND AT BOTH NORMAL AND ACCELERATED (SLAM) CYCLE TIMES. THE VALVE, DURING THIS LIFE CYCLE TESTING, NEVER FAILED TO OPEN. FILTERS ARE PROVIDED ON ALL PNEUMATIC PORTS TO PREVENT CONTAMINATION.

**(B) TEST:**

ATP

ACTUATOR -

AMBIENT PROOF (1275 PSIG)

CRYO PROOF OF ACTUATOR FLANGE AND SHAFT SEALS (358 PSID)

POSITION INDICATION

ELECTRICAL CHARACTERISTICS

AMBIENT AND CRYO RESPONSE TIME (NORMAL AND SLAM) AT 400 AND 740 PSIG  
ACTUATION PRESSURE

AMBIENT AND CRYO LEAKAGE (FROM PORT TO PORT)

AMBIENT AND CRYO SHAFT SEAL LEAKAGE (PRIMARY AND SECONDARY) WITH 220 PSID  
ACROSS SEAL

AMBIENT AND CRYO EXTERNAL LEAKAGE.

RELIEF VALVE ASSEMBLY -

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0401-05**

AMBIENT PROOF (299 PSIG)

AMBIENT AND CRYO CRACK AND RESEAT (15-50 PSID).

PREVALVE ASSEMBLY -

POSITION INDICATION

ELECTRICAL CHARACTERISTICS

VALVE HOUSING AND VISOR AMBIENT PROOF (299 PSIG)

VALVE HOUSING AND VISOR CRYO PROOF (358 PSID)

ACTUATOR AMBIENT PROOF (1275 PSIG)

AMBIENT AND CRYO EXTERNAL LEAKAGE (WITH VALVE BODY AT 220 PSIG AND ACTUATOR AT 740 PSIG)

AMBIENT AND CRYO RESPONSE TIME AT 400 AND 740 PSIG ACTUATION PRESSURE

AMBIENT AND CRYO ACTUATOR LEAKAGE FROM PORT TO PORT

AMBIENT AND CRYO VALVE SHAFT SEAL (PRIMARY AND SECONDARY) LEAKAGE WITH 220 PSID ACROSS THE SEAL

AMBIENT AND CRYO VISOR LEAKAGE (INLET-TO-OUTLET WITH 200 PSID OUTLET-TO-INLET WITH 5 PSID AMBIENT AND 15 PSID CRYO)

AMBIENT RELIEF VALVE CRACK (6.7 TO 50 PSID) AND RESEAT (5 TO 50 PSID) WITH ACTUATOR CLOSE PRESSURE ON

CRYO RELIEF VALVE CRACK AND RESEAT (15 TO 50 PSID) WITH ACTUATOR CLOSE PRESSURE ON

AMBIENT VISOR LIFT-OFF (15 PSID MAX) WITH ACTUATOR VENTED

CERTIFICATION

STRUCTURAL LOAD AT CRYO TEMPS (-300 DEG F) (AXIAL, SHEAR, TORSION, BENDING)

LIFE CYCLING (3050 AMBIENT CYCLES, 2050 CRYO CYCLES. ACTUATOR RECEIVED ADDITIONAL 300 AMBIENT AND 200 CRYO SLAM CYCLES); RELIEF VALVE LIFE (500 CYCLES AMBIENT, 500 CYCLES CRYO); ANTI-SLAM VALVE LIFE (2700 CYCLES AMBIENT, 1800 CYCLES CRYO)

THREE THERMAL CYCLES (70 DEG F TO -300 DEG F TO +200 DEG F TO 70 DEG F)

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0401-05**

TRANSIENT SINUSOIDAL VIBRATION (AT 200 PSIG AND -250 DEG F); RANDOM VIBRATION (13.3 HRS IN EACH OF THREE AXES WITH VALVE OPEN AND AT 200 PSIG/LESS THAN -250 DEG F. OPEN PRESSURE WAS REMOVED DURING A PORTION OF THE TEST; SUBSEQUENTLY REPEATED TO CERTIFY THE ANTI-SLAM ACTUATOR)

DESIGN SHOCK (18 SHOCKS OF 15G EACH - THREE IN EACH DIRECTION OF THREE AXES, ALL WITH VALVE OPEN AND ACTUATOR VENTED; REPEATED TO CERTIFY THE ANTI-SLAM ACTUATOR)

AMBIENT AND CRYO FUNCTIONAL, INTERNAL AND EXTERNAL LEAKAGE PERFORMANCE

BURST (413 PSIG VALVE BODY, 1700 PSIG ACTUATOR)

SPECIAL ANTI SLAM LEAKAGE TEST-

BOTH OPEN AND CLOSE ANTI SLAM VALVES TESTED

VALVE FAILED TO CLOSE IN REQUIRED TIME WHEN:  
ANTI SLAM POPPET OPEN 0.0085 INCHES  
EQUIVALENT TO A PARTICLE SIZE OF 216 MICRONS  
RESULTED IN 61 SCFM GHE LEAK (10,472 SCIMS)

THIS REPRESENTS 86% OF MAXIMUM FLOW CAPABILITY OF SYSTEM

OMRSD  
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**  
RECEIVING INSPECTION  
RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL  
VALVE IS CLEANED TO LEVEL 800A AND THE ACTUATOR IS CLEANED TO 400A.

ASSEMBLY/INSTALLATION  
ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. LOG OF CLEAN ROOM AND TOOL CALIBRATION ARE VERIFIED BY INSPECTION. MICROSCOPIC EXAMINATION OF ALL DETAIL PARTS ARE MADE PRIOR TO ASSEMBLY. TORQUE REQUIREMENTS VERIFIED BY INSPECTION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURES.

CRITICAL PROCESSES  
CRITICAL DIMENSIONS AND SURFACE FINISHES EXAMINED FROM 3X TO 7X MAGNIFICATION FOR MATERIAL DEFECTS.

NONDESTRUCTIVE EVALUATION  
FLOW LINER WELD VISUALLY EXAMINED. THE VALVE BODY, PRIOR TO FINAL MACHINING, IS SUBJECTED TO DYE PENETRANT INSPECTION. REQUIREMENTS FOR DETAIL PARTS

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE  
NUMBER: 03-1-0401-05**

PENETRANT INSPECTION ARE BASED UPON CONFIGURATION, MATERIAL, AND MANUFACTURING PROCESSES.

TESTING  
ACCEPTANCE TEST VERIFIED BY INSPECTION.

HANDLING/PACKAGING  
PACKAGING FOR CLEANLINESS VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

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

**(E) OPERATIONAL USE:**

NOMINAL AUTO VACUUM INERTING OPERATIONS ARE PERFORMED AFTER COMPLETION OF THE SOFTWARE CONTROLLED PROPELLANT DUMP. SUBSEQUENT VACUUM INERTINGS WILL BE PERFORMED IF REQUIRED.

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**- APPROVALS -**

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S&R ENGINEERING	: W.P. MUSTY	: /S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	: /S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: STUART KOBATA	: /S/ STUART KOBATA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: JEFFREY L. MUSLER	: /S/ JEFFREY L. MUSLER
USA SAM	: MICHAEL SNYDER	: /S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: WILLIAM PRINCE	: /S/ WILLIAM PRINCE