

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**

NUMBER: 03-1-0401 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 07/12/00

**PART DATA**

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
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.

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**NUMBER: 03-1-0401-09**

**REVISION#: 1 07/12/00**

**SUBSYSTEM NAME: MAIN PROPULSION**

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

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

**CRITICALITY OF THIS**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

RUPTURE/LEAKAGE OF THE VALVE BODY DURING LOADING, ASCENT AND DUMP/INERT.

**MISSION PHASE:**

PL PRE-LAUNCH

LO LIFT-OFF

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

**CAUSE:**

FATIGUE, MATERIAL DEFECTS, DAMAGED/DEFECTIVE VALVE JOINT SEALS.

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

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**REDUNDANCY SCREEN**

A) N/A

B) N/A

C) N/A

**PASS/FAIL RATIONALE:**

A)

B)

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

HAZARDS ASSOCIATED WITH LEAKAGE OF CRYOGENIC PROPELLANTS. LOSS OF CRITICAL FUNCTIONS DUE TO ADJACENT COMPONENT EXPOSURE TO CRYOGENICS. POSSIBLE AFT FUSELAGE OVERPRESS AND FIRE HAZARD. LEAKAGE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

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

**(C) MISSION:**  
ON GROUND, VIOLATION OF HGDS LCC WILL RESULT IN LAUNCH SCRUB.

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

**(E) FUNCTIONAL CRITICALITY EFFECTS:**  
NONE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**  
FACTORS OF SAFETY ARE: PROOF=1.3; BURST=1.5. 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. SUBSEQUENTLY THE VALVE WAS BURST PRESSURE TESTED TO 413 PSIG WITHOUT RUPTURE OR DEFORMATION. STRUCTURAL ANALYSIS, PERFORMED BY THE VALVE SUPPLIER, INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION, AND FRACTURE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES THE ORBITER LIFE OF 100 MISSIONS. SIX EXTERNAL LEAK PATHS EXIST, FIVE STATIC AND ONE DYNAMIC. THE FIVE STATIC JOINTS ARE AT THE INTERFACES BETWEEN EACH DETENT ASSEMBLY AND THE HOUSING, BETWEEN THE RELIEF VALVE ASSEMBLY AND THE HOUSING, BETWEEN THE VALVE HOUSING AND THE ACTUATOR, AND BETWEEN THE LOWER SHAFT SUPPORT AND THE HOUSING. EACH JOINT IS SEALED USING TEFLON JACKETED METALLIC RACO TYPE SEALS (THE METALLIC "V" SPRING IS OF 301 CRES). THE DYNAMIC JOINT IS ON THE VALVE TO ACTUATOR SHAFT AND LEAKAGE VENTS OUT OF THE VALVE ACTUATOR VENT CHECK VALVE. THERE ARE DUAL DYNAMIC SHAFT SEALS AND THE SEALS ARE OF A SPRING LOADED, PRESSURE ASSISTED DESIGN. THE SEAL MATERIAL IS A GLASS-FILLED TEFLON AND THE SPRING MATERIAL IS 301 CRES.

**(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.

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RELIEF VALVE ASSEMBLY - 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)

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)

**GROUND TURNAROUND TEST**

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.

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**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 DIMENSIONS AND SURFACE FINISHES ARE EXAMINED FROM 3X TO 7X MAGNIFICATION FOR MATERIAL DEFECTS.

**CRITICAL PROCESSES**

HEAT TREATMENT AND DRY FILM LUBE APPLICATION ARE VERIFIED BY INSPECTION.

**NONDESTRUCTIVE EVALUATION**

FLOW LINER WELD VISUALLY EXAMINED. THE VALVE BODY, PRIOR TO FINAL MACHINING, IS SUBJECTED TO DYE PENETRANT INSPECTION. REQUIREMENTS FOR DETAIL PARTS PENETRANT INSPECTION ARE BASED UPON CONFIGURATION, MATERIAL, AND MANUFACTURING PROCESSES.

**TESTING**

ACCEPTANCE TEST PROCEDURES VERIFIED BY INSPECTION.

**HANDLING/PACKAGING**

PACKAGING FOR CLEANLINESS VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

DURING SYSTEM CHECKOUT EXTERNAL LEAKAGE OCCURRED AT THE VALVE OUTLET LINE FLANGE (CAR AC6311). THE PREVALVE, SEALS AND SCREEN WERE REMOVED AND REPLACED WITH NO DEFINITE CAUSE ESTABLISHED. DURING ATP, LEAKAGE OCCURRED FROM THE RELIEF VALVE MOUNTING FLANGE (REF CAR A7455 AND AB8473). THE LEAKAGE WAS CAUSED BY MINOR SCRATCHES ON THE SEALING SURFACES. SCRATCHES WERE POLISHED OUT AND ASSEMBLY/INSPECTION PERSONNEL WERE CAUTIONED. NO OPERATIONAL SHAFT SEAL LEAKAGE HAS OCCURRED IN THE FIELD. MINOR SHAFT SEAL LEAKAGE WAS EXPERIENCED DURING ATP (CAR AD0574, A519, AND A6849) CORRECTED BY RUNNING-IN THE PRIMARY AND SECONDARY SEALS.

SIGNIFICANT LH2 LEAKAGE DURING STS-35 PROPELLANT LOADING WAS DETECTED DUE TO PINCHED DETENT COVER SEALS. SEAL INSTALLATION PROCEDURES HAVE BEEN MODIFIED, INCLUDING PRE-COINING OF THE SEALS, COVER GAP CHECKS, AND AN ENHANCED TORQUE SEQUENCE.

RELIEF VALVE COVER PLATE THICKNESS HAS BEEN INCREASED TO PRECLUDE FLEXURE WHICH CAN LEAD TO LEAKAGE.

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:**

FLIGHT: NO CREW ACTION CAN BE TAKEN.

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GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE OXYGEN SYSTEM.

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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