

**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.

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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: 1R2**

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**FAILURE MODE:**

LOSS OF POSITION INDICATION - OPEN POSITION INDICATION FAILS ON (LCC DECEPTION).

**MISSION PHASE:**

PL PRE-LAUNCH

LO LIFT-OFF

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

**CAUSE:**

POSITION SWITCH PIECE PART FAILURE

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

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**REDUNDANCY SCREEN**

A) PASS

B) FAIL

C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

FAILS B SCREEN SINCE FAILURE INDICATION CANNOT BE READILY DISTINGUISHED FROM EXPECTED OUTPUT.

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

NO EFFECT. CAPABILITY OF VALVE TO CONTROL FLUID FLOW IS NOT AFFECTED.

LCC VERIFIES THAT OPEN POSITION SWITCH IS ON AT T-31 SECONDS.

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

SAME AS A.

**(C) MISSION:**

NO EFFECT - FIRST FAILURE.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

1R/2 2 SUCCESS PATHS. TIME FRAME - ENGINE OPERATION.

- 1) LO2 PREVALVE OPEN POSITION SWITCH FAILS ON PRIOR TO T-31 SECONDS.
- 2) STRUCTURAL FAILURE OF PREVALVE POWER TRAIN.

VALVE POSITION LCC IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE. STRUCTURAL FAILURE ALLOWS VISOR TO SHIFT, NEGATING DETENT FUNCTION. AT SSME START, INCREASED PROPELLANT FLOW CAUSES ABRUPT VISOR CLOSURE.

ONE ENGINE WOULD SHUTDOWN. POSSIBLE LO2 PUMP CAVITATION AND OVERSPEED, RESULTING IN UNCONTAINED ENGINE DAMAGE. POSSIBLE FEEDLINE/MANIFOLD RUPTURE DUE TO WATER HAMMER EFFECT (LINE PRESSURE IS IN EXCESS 600 PSI). RESULTS IN EARLY LO2 DEPLETION, AFT COMPT OVERPRESS, AND POSSIBLE LOSS OF CRITICAL COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE VALVE VISOR FRACTURE AND INGESTION INTO ENGINE (ENGINE INLET SCREENS WOULD NOT CONTAIN PARTS OF THIS SIZE). FIRE/EXPLOSIVE HAZARD, POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

TWO VALVE POSITION INDICATION MICROSWITCHES ARE PROVIDED TO MONITOR VALVE OPEN AND CLOSED POSITIONS. THE HERMETICALLY SEALED, CAM OPERATED MECHANICAL MICROSWITCHES ARE MOUNTED AND SECURED TO PLATES WITH TWO SCREWS. TWO SEPARATE TRIP LEVERS ON THE PLATES RIDE ON A CAM CONNECTED TO THE VALVE CLOSURE DEVICE SHAFT. THESE TRIP LEVERS ACTUATE THE MICROSWITCH EXTERNAL SPRING ARMS WHICH IN TURN ACTUATE THE SWITCH INTERNAL ELECTRICALLY CONDUCTING METALLIC SPRINGS WITH ELECTRICAL CONTACTS. THESE SPRINGS ARE ATTACHED TO TERMINAL POSTS WHICH ARE EXTERNALLY SOLDERED TO LEAD WIRES. THE EXTERNAL SWITCH SPRING ARMS MOVE A MINIMUM OF 0.0015 INCH BETWEEN THE ACTUATED AND DEACTUATED POSITIONS.

EACH SWITCH IS SCREENED AT CRYOGENIC TEMPERATURE BEFORE INSTALLATION TO VERIFY PERFORMANCE CHARACTERISTICS. NEWLY MANUFACTURED SWITCHES ARE SUBJECTED TO A PARTICLE IMPACT NOISE DETECTION TEST (PIND). PIND TESTED SWITCHES WILL BE IMPLEMENTED ON AN ATTRITION BASIS.

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**(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 - 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).

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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 100A.

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 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 MPTA STATIC FIRING #1, THE ENGINE 2 LH2 PREVALVE CLOSED SWITCH INDICATED ON WHEN THE VALVE WAS OPEN (REFERENCE CAR AB0317). THE SWITCH WAS FOUND TO BE SENSITIVE TO CERTAIN CRYOGENIC TEMPERATURES. INSULATION WAS REMOVED FROM THE ACTUATOR TO PROVIDE A WARMER ENVIRONMENT FOR THE SWITCHES. THE INSULATION CHANGE WAS EFFECTIVE ON OV-102 AND SUBS.

LH2 PREVALVE CLOSED SWITCH INDICATIONS HAVE BEEN LOST MULTIPLE TIMES AFTER THE VALVE WAS CLOSED AT MECO. FAILURE INVESTIGATION ATTRIBUTED THE LOSS OF THE CLOSED INDICATION TO PREVALVE VISOR RELIEF OF DOWNSTREAM PRESSURE INTO THE MANIFOLD. AS THE VISOR LIFTS OFF ITS SEAT, THE MAIN SHAFT ROTATES, AND DEPENDING ON TOLERANCES, MAY DEACTUATE THE CLOSED SWITCH. THIS IS NOT CONSIDERED A FAILURE CONDITION.

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DURING STS-51B (OV-099), THE LO2 PREVALVE OPEN SWITCH DID NOT INDICATE ON DURING THE MPS DUMP ALTHOUGH THE CLOSED INDICATION WAS OFF (REFERENCE CAR 24F016). THE MALFUNCTION WAS AN ISOLATED CASE AND COULD NOT BE REPRODUCED AT THE SUPPLIER. A NEW SWITCH WAS INSTALLED AND SUBSEQUENTLY PASSED ATP.

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: N/A

GROUND: GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING 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