

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

NUMBER: 03-1-0453 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 11/06/00

**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	: VALVE, BALL (TYPE 2) VACCO INDUSTRIES	MC284-0395-0052 1397-501-511

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

VALVE, 2 INCH. LO2 POGO RECIRCULATION (PV20, PV21), NORMALLY OPEN, PNEUMATICALLY ACTUATED CLOSED.

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY VACCO INDUSTRIES (EATON) THE UNITED SPACE ALLIANCE-NSLD IS A CERTIFIED REPAIR DEPOT BUT HAS NOT YET BEEN CERTIFIED AS AN ALTERNATE PRODUCTION AGENCY.

**REFERENCE DESIGNATORS:** PV20  
PV21

**QUANTITY OF LIKE ITEMS:** 2

**FUNCTION:**

TWO PARALLEL VALVES PROVIDE A FLOW PATH FOR GO2 FROM THE ENGINE POGO ACCUMULATOR SYSTEM TO THE LO2 17 INCH DISCONNECT DURING ENGINE OPERATION. VALVES ARE CLOSED DURING LOADING TO PROVIDE A POSITIVE FLOW PATH FROM THE SSME TO THE OVERBOARD BLEED SYSTEM FOR ENGINE CONDITIONING. VALVES OPEN AT T-12.5 SECONDS AND REMAIN OPEN TO THE END OF THE MISSION. THE VALVES INCORPORATE A RELIEF CAPABILITY TO RELIEVE PRESSURE FROM THE POGO LINE INTO THE 17-INCH FEEDLINE.

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**NUMBER: 03-1-0453-04**

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: LO2 POGO RECIRCULATION VALVE, PV21,22**

**CRITICALITY OF THIS**

**ITEM NAME: LO2 POGO RECIRCULATION VALVE, PV21,22**

**FAILURE MODE: 1R2**

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**FAILURE MODE:**

ERRONEOUS INDICATION - VALVE CLOSED, OPEN POSITION INDICATION ON DURING TERMINAL COUNT.

**MISSION PHASE:** PL PRE-LAUNCH  
LO LIFT-OFF

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

**CAUSE:**

PIECE PART STRUCTURAL FAILURE (BINDING AND CONTAMINATION ARE NOT CAUSES FOR THIS FMEA/CIL SINCE IT IS NOT CRITICAL FOR THIS VALVE TO BE FULLY OPEN)

**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)

POSITION SWITCH INDICATOR 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.

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

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LOSS OF REDUNDANCY. LCC WILL BE SATISFIED SINCE BOTH VALVE OPEN INDICATIONS MUST BE ON PRIOR TO LAUNCH. THE PARALLEL VALVE WILL CONTINUE TO PROVIDE A FLOW PATH.

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

SAME AS A.

**(C) MISSION:**

NO EFFECT.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

CASE 1:

3/3. TIME FRAME - SSME START TRANSIENT.

NO EFFECT. LOSS OF POGO RETURN PATH (ERRONEOUS INDICATION: POGO VALVES CLOSED, OPEN POSITION INDICATORS "ON") CAUSING OVERFLOW OF HELIUM PRECHARGE FROM POGO ACCUMULATOR INTO HIGH PRESSURE OXIDIZER TURBOPUMP (HPOT) IS TOLERATED.

CASE 2:

1R2 2 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) LO2 POGO VALVE (PV20 OR PV21) ERRONEOUS INDICATION - VALVE CLOSED/OPEN POSITION INDICATOR ON.
- 2) ERRONEOUS INDICATION OR FAILURE TO REMAIN OPEN ON PARALLEL POGO VALVE (PV20 OR PV21).

LOSS OF POGO RETURN PATH CAUSES EXCESSIVE GO2 VOLUME IN POGO ACCUMULATOR RESULTING IN BUBBLE COLLAPSE AND LOSS OF POGO DAMPING FUNCTION. MAY RESULT IN EXCESSIVE VEHICLE POGO OSCILLATION. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 3:

1R/2 2 SUCCESS PATHS. TIME FRAME - POST MECO ENGINE SHUTDOWN SEQUENCE.

- 1) LO2 POGO VALVE (PV20 OR PV21) ERRONEOUS INDICATION - VALVE CLOSED/OPEN POSITION INDICATOR ON.
- 2) ERRONEOUS INDICATION OR FAILURE TO REMAIN OPEN ON PARALLEL POGO VALVE (PV20 OR PV21).

DURING ZERO-G SHUTDOWN SEQUENCE, HELIUM IS INJECTED INTO POGO ACCUMULATORS TO MAINTAIN NPSP AND PREVENT HPOT OVERSPEED. LOSS OF POGO RETURN PATH CAUSES GHE OVERFLOW FROM ACCUMULATORS AND INGESTION INTO THE HPOT RESULTING IN PUMP OVERSPEED AND POSSIBLE UNCONTAINED ENGINE DAMAGE. POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

FOR ERRONEOUS INDICATION (VALVE REMAINING CLOSED, AFTER HAVING BEEN COMMANDED OPEN, AND THE OPEN POSITION SWITCH INDICATING ON) WOULD NECESSITATE STRUCTURAL FAILURE OF THE PINION SHAFT (INCONEL 718), OR OF THE PINION SHAFT/BALL SQUARE DRIVE CONNECTION, OR OF THE VALVE BALL (7075-T351, HEAT TREATED AND HARD ANODIZED). STRUCTURAL ANALYSIS, PERFORMED BY THE VALVE MANUFACTURER, INDICATES A POSITIVE FACTOR OF SAFETY FOR THE VALVE POWER TRAIN FOR ACTUATION PRESSURES UP TO 850 PSIG. THE VALVE WAS CYCLED 2000 TIMES (1500 CYCLES AT AMBIENT TEMPERATURE AND 500 CYCLES AT CRYOGENIC TEMPERATURE) DURING CERTIFICATION TESTING WITHOUT FAILURE OF THE VALVE POWER TRAIN. FACTORS OF SAFETY: PROOF - 1.5 BODY, 2.0 ACTUATOR; BURST - 2.0 BODY, 4.0 ACTUATOR.

**(B) TEST:**

ATP

EXAMINATION OF PRODUCT

AMBIENT PROOF

VALVE BODY - 600 PSIG VALVE OPEN; 157 PSIG VALVE CLOSED.  
ACTUATOR - 1700 PSIG.

VALVE RESPONSE TIMES

AMBIENT AND CRYO (-300 DEG F) VALVE PRESSURIZED TO 105 PSIG  
ACTUATOR PRESSURIZED TO 740 AND 600 PSIG

EXTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F)

VALVE BODY @ 220 PSIG  
SHAFT SEAL @ 220 PSIG  
ACTUATOR @ 740 PSIG

RELIEF FUNCTION (INLET-TO-OUTLET)

CRACK/RESEAT CRYO (-300 DEG F, 15-40 PSID)

INTERNAL LEAKAGE

OUTLET-TO-INLET @ 105 PSIG

POSITION INDICATION: VERIFICATION OF OPERATION

ELECTRICAL CHARACTERISTICS: INSULATION RESISTANCE, DIELECTRIC STRENGTH AND RESISTANCE.

CERTIFICATION

VALVE RESPONSE TIMES

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AMBIENT AND CRYO (-300 DEG F) - VALVE PRESSURIZED TO 105 PSIG  
ACTUATOR PRESSURIZED TO 740 AND 600 PSIG

EXTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F)  
VALVE BODY @ 220 PSIG  
SHAFT SEAL @ 220 PSIG  
ACTUATOR @ 740 PSIG

LIFE

CRYO (500 CYCLES @ -300 DEG F FOLLOWED BY CRYO LEAKAGE TESTS)

AMBIENT (1500 CYCLES. AFTER EACH 500 CYCLES PERFORM AMBIENT LEAKAGE  
TESTS AND AMBIENT CRACK/RESEAT TESTS).

VIBRATION

TRANSIENT VIBRATION - (5 TO 35 HZ) PRIOR TO EACH AXIS OF RANDOM VIBRATION  
TEST.

RANDOM VIBRATION - (13.3 HOURS IN EACH OF THREE AXES WHILE PRESSURIZED  
TO 105 PSIG AND AT -300 DEG F.

PRIOR TO EACH AXIS TEST, PERFORM CRYO VALVE RESPONSE TIMES TEST.  
FOLLOWING EACH AXIS TEST, PERFORM CRYO VALVE RESPONSE TIMES  
TEST, CRYO LEAKAGE TESTS, AND CRYO CRACK/RESEAT TESTS. AFTER  
TEST UNIT HAS WARMED, PERFORM ELECTRICAL CHARACTERISTICS TESTS,  
AMBIENT VALVE RESPONSE TIMES TEST, AMBIENT LEAKAGE TESTS, AND  
AMBIENT CRACK/RESEAT TESTS).

THERMAL CYCLE TEST (+70 DEG F TO -300 DEG F, TO +70 DEG F, TO +275 DEG F, TO +150  
DEG F, TO AMBIENT)

ELECTRICAL CHARACTERISTICS TESTS AND ELECTRICAL BONDING TEST

DESIGN SHOCK - BY SIMILARITY TO THE TYPE I AND III VALVES

BURST TEST

VALVE BODY @ 800 PSIG  
ACTUATOR @ 3400 PSIG

OMRSD

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:**

RECEIVING INSPECTION

RAW MATERIAL VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.  
TEST REPORTS REQUIRED ON CAST MATERIAL. COMPLETION OF HOT ISOSTATIC  
PRESSING (HIP) PROCESS IS VERIFIED. CAST HOUSING (ROUGH MACHINED) IS INSPECTED  
FOR POROSITY.

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CONTAMINATION CONTROL

CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. THE INTERNAL WETTED SURFACES ARE CLEANED TO LEVEL 400A VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL DETAIL PARTS ARE INSPECTED FOR CRITICAL DIMENSIONS, SURFACE FINISH, BURRS, DAMAGE, AND CORROSION. CRITICAL POPPET AND SLEEVE SURFACES ARE LAPPED AND INSPECTED WITH 40X MAGNIFICATION. TORQUES ARE VERIFIED TO BE IN ACCORDANCE WITH DRAWING REQUIREMENTS. PRIOR TO INSTALLATION, SEALS ARE VISUALLY EXAMINED WITH 10X MAGNIFICATION FOR DAMAGE AND CLEANLINESS. ALL SPRINGS ARE LOT TRACEABLE AND LOAD TESTED AT THE PIECE PART LEVEL. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES

HEAT TREATMENT OF THE VALVE BALL AFTER MACHINING IS VERIFIED. PART PASSIVATION AND HARD ANODIZING ARE VERIFIED. CERTIFICATION OF WELDING, POTTING, AND SOLDERING IS VERIFIED. PAINTING (ON BODY), ELECTRICAL BONDING, AND DRY FILM LUBRICANT ARE VERIFIED BY INSPECTION. ALL CASTINGS ARE SUBJECTED TO A HIP PROCESS.

NONDESTRUCTIVE EVALUATION

PRIOR TO FINAL MACHINING, THE HOUSING IS X-RAYED, ETCH AND DYE PENETRANT INSPECTED, AND PRESSURE LEAK CHECKED. ALL WELDS ON THE ELECTRICAL CONNECTOR ARE DYE PENETRANT INSPECTED AND VERIFIED BY INSPECTION.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING, PACKAGING, STORAGE, AND SHIPPING REQUIREMENTS ARE 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:**

NO CREW ACTION CAN BE TAKEN.

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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	: EARL HIRAKAWA	: /S/ EARL HIRAKAWA
MPS SUBSYSTEM MGR.	: TIM REITH	: /S/ TIM REITH
MOD	: BILL LANE	: /S/ BILL LANE
USA SAM	: MIKE SNYDER	: /S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	: /S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	: /S/ BILL PRINCE