

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE****NUMBER: 03-1-0452 -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 5) VACCO INDUSTRIES	MC284-0395-0055 1442-511

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

LO2 OVERBOARD BLEED VALVE (PV19), 1.5 INCH DIAMETER, NORMALLY OPEN, PNEUMATICALLY ACTUATED CLOSED. RELIEVES TO INBOARD SIDE OF VALVE.

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:** PV19**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

CONTROLS OVERBOARD BLEED FLOW (DURING LOADING) THROUGH LO2 BLEED DISCONNECT (PD13) TO MAINTAIN PROPER CRYOGENIC START CONDITIONS FOR LO2 ENGINE FEED. VALVE IS REDUNDANT TO THE LO2 BLEED DISCONNECT TO PREVENT OVERBOARD LOSS OF LO2 DURING ASCENT. PROVIDES RELIEF FEATURE FOR LO2 TRAPPED BETWEEN BLEED VALVE (PV19) AND LO2 BLEED DISCONNECT (PD13). THE VALVE IS CLOSED APPROXIMATELY 9 SECONDS BEFORE LIFTOFF AND IS REQUIRED CLOSED BY LCC. FOR NOMINAL, ATO, AND AOA MISSIONS THE VALVE IS OPENED AT COMPLETION OF DUMP. FOR RTLS/TAL ABORTS THE VALVE REMAINS CLOSED UNTIL THE END OF THE 650 SECOND BLOWDOWN PURGE. THE VALVE INCORPORATES TWO REDUNDANT CLOSED POSITION INDICATORS AND A SINGLE OPEN INDICATOR.

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: LO2 OVERBOARD BLEED VALVE, PV19**

**ITEM NAME: LO2 OVERBOARD BLEED VALVE, PV19**

**CRITICALITY OF THIS**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

FAILS TO RELIEVE DURING ASCENT.

**MISSION PHASE: LO LIFT-OFF**

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

**CAUSE:**

BINDING

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

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<b>REDUNDANCY SCREEN</b>	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:**

AFTER BLEED VALVE CLOSURE, THE BLEED LINE IS DRAINED BY GRAVITY. SOME FLUID WILL REMAIN AT LIFTOFF. PRESSURE BUILDUP OF TRAPPED PROPELLANT IN THE LINE BETWEEN PV19 AND PD13 MAY RESULT IN RUPTURE OF THE LO2 OVERBOARD BLEED VALVE (PV19), BLEED LINE, AND/OR LO2 BLEED DISCONNECT (PD13).

CASE 1: RUPTURE OF THE LO2 OVERBOARD BLEED VALVE

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CAUSES 3000 POUNDS (TWO PHASE FLOW FROM POGO SYSTEM) OF LO2 LEAKAGE IN THE AFT COMPARTMENT FROM THE FEED MANIFOLD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSION HAZARD IN THE AFT COMPARTMENT. THIS AMOUNT OF LEAKAGE WILL NOT AFFECT ENGINE INLET CONDITIONS. OVERBOARD LEAKAGE MAY BE SUFFICIENT TO CAUSE PREMATURE SSME SHUTDOWN.

ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING ENTRY MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE.

CASE 2: RUPTURE OF THE BLEED LINE AND/OR DISCONNECT.

CAUSES LIMITED (PROPELLANT TRAPPED BETWEEN PV19 AND PD13) LO2 LEAKAGE INTO THE AFT COMPARTMENT OR OVERBOARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE FIRE/EXPLOSION HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE.

ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING ENTRY MANIFOLD REPRESSURIZATION FOR ALL MISSIONS EXCEPT TAL (VALVE MAINTAINED CLOSED DURING TAL ABORTS) CAUSING LOSS OF AFT COMPARTMENT PURGE.

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

SAME AS A.

**(C) MISSION:**

POSSIBLE LOSS OF CREW/VEHICLE.

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

SAME AS C.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**

NONE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE RELIEF VALVE WILL RELIEVE AND RESEAT IN THE RANGE OF 15 TO 40 PSID WITH A MAXIMUM FLOWRATE OF 1 POUND PER SECOND OF LO2. IF BLEED LINE PRESSURE INCREASES ABOVE 40 PSID, SOME FLOW PAST THE BALL SEAL WILL OCCUR.

THE RELIEF VALVE'S SIMPLE DESIGN EMPLOYS A SPHERICAL KEL-F POPPET ATTACHED TO A 6061-T651 PISTON WHICH IS LOADED BY AN ELGILOY SPRING, HOLDING THE POPPET ONTO ITS SEAT. THE PISTON IS GUIDED BY A 6061-T651 CAP AND, TO PREVENT BINDING,

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THE TOLERANCES BETWEEN PISTON AND CAP ARE CLOSELY CONTROLLED (0.002 TO 0.009 ON THE DIAMETER). ADDITIONALLY, THE PISTON IS HARD ANODIZED.

**(B) TEST:**

ATP

EXAMINATION OF PRODUCT

AMBIENT PROOF

VALVE BODY - 600 PSIG VALVE OPEN; 600 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 500 PSIG

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

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

RELIEF FUNCTION (OUTLET-TO-INLET)

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

INTERNAL LEAKAGE

INLET-TO-OUTLET @ 220 PSIG

POSITION INDICATION: VERIFICATION OF OPERATION

ELECTRICAL CHARACTERISTICS: INSULATION RESISTANCE, DIELECTRIC STRENGTH AND RESISTANCE.

CERTIFICATION

VALVE RESPONSE TIMES

AMBIENT AND CRYO (-300 DEG F) - VALVE PRESSURIZED TO 105 PSIG  
ACTUATOR PRESSURIZED TO 740 AND 500 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

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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) BY SIMILARITY TO TYPE II VALVES (LO2 POGO VALVE).

ELECTRICAL CHARACTERISTICS TESTS AND ELECTRICAL BONDING TEST

DESIGN SHOCK - BY SIMILARITY TO THE TYPE I (RECIRC AND TOPPING VALVES) AND III VALVES (INBOARD RTLS DUMP AND HI POINT BLEED VALVE).

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.

CONTAMINATION CONTROL

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

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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 LEAK CHECKED AT PROOF PRESSURE. 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:**

DURING ATP AT THE SUPPLIER, RELIEF VALVE FAILED TO RELIEVE UP TO 55 PSIG. ISOLATED FAILURE COULD NOT BE REPEATED. CAUSE NOT DETERMINED. TEST CONFIGURATION OR OPERATOR ERROR ARE SUSPECTED (REFERENCE CAR AC7729).

AT KSC, THE RELIEF VALVE DID NOT CRACK AT 49 PSIG (MAX ALLOWABLE 40 PSIG). VALVE WAS RETURNED TO THE SUPPLIER AND FAILURE WAS VERIFIED AT AMBIENT CONDITIONS BUT PASSED AT CRYO TEMPERATURES. FAILURE WAS DETERMINED TO BE DUE TO THE RELIEF VALVE POPPET BINDING ON A MACHINED RIDGE. CORRECTIVE ACTION WAS TO REMACHINE AND LAP THE AFFECTED SURFACES AT THE SUPPLIER. ALSO, THE ASSEMBLY PROCEDURE WAS CHANGED TO ASSURE PROPER PREPARATION OF THE RELIEF VALVE SEAT (REFERENCE CARS AC8603).

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:**

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	: 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	: ERICH BASS	: /S/ ERICH BASS