

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0453 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 11/06/00**PART DATA**

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
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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FAILS TO RELIEVE DURING PROPELLANT LOADING, TANKING TEST, FRF.

MISSION PHASE: PL PRE-LAUNCH

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

CAUSE:

BINDING

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

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

PASS/FAIL RATIONALE:**A)**

FAILS A SCREEN BECAUSE POGO VALVES ARE INSTALLED IN THE SYSTEM IN A PARALLEL CONFIGURATION AND THEIR RELIEF FUNCTION CANNOT BE INDIVIDUALLY VERIFIED.

B)

FAILS B SCREEN BECAUSE POGO VALVES ARE INSTALLED IN THE SYSTEM IN A PARALLEL CONFIGURATION AND THEIR RELIEF FUNCTION CANNOT BE INDIVIDUALLY VERIFIED. B SCREEN IS CONSIDERED APPLICABLE FROM THE START OF PROPELLANT LOADING.

C)**- FAILURE EFFECTS -****(A) SUBSYSTEM:**

LOSS OF REDUNDANCY FOR SINGLE VALVE FAILURE. RELIEF CAPABILITY CAN BE ACCOMPLISHED BY REMAINING VALVE. POGO VALVES ARE CLOSED DURING LOADING AND OPENED AT ENGINE START. POGO VALVES ARE CLOSED WITHIN 30 SECONDS OF ENGINE SHUTDOWN FOLLOWING AN FRF/PAD ABORT. LO2 OVERBOARD BLEED VALVE IS

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OPEN FOR BLEED OPERATIONS DURING LOADING AND CLOSED PRIOR TO ENGINE START. THE BLEED VALVE IS OPENED WITHIN 2 MINUTES FOLLOWING AN ENGINE SHUTDOWN FOR FRF/PAD ABORT.

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

(C) MISSION:
NO EFFECT.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/3, 3 SUCCESS PATHS. TIME FRAME: PROPELLANT LOADING, TANKING, FRF.
1,2) LO2 POGO VALVES (PV20,21) FAIL TO RELIEVE.
3) LO2 OVERBOARD BLEED VALVE (PV19) FAILS TO OPEN/REMAIN OPEN.

PRESSURE BUILDUP IN THE LINE BETWEEN PV20/21 AND PV19 RESULTS IN RUPTURE OF THE MPS ORBITER POGO/BLEED SYSTEM. POSSIBLE OVERPRESSURIZATION OF AFT COMPARTMENT AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

THE LO2 BLEED CHECK VALVES (CV31,33,35) HAVE REVERSE FLOW CAPABILITY (4 SCFM PER CHECK VALVE) TO THE SSME HPOT SEAL OVERBOARD VENT, BUT IS NOT CONSIDERED SUFFICIENT TO PROVIDE A REDUNDANT PATH TO RELIEVE PRESSURE BUILDUP.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE RELIEF VALVE WILL RELIEVE AND RESEAT IN THE RANGE OF 15 TO 40 PSID WITH A MAXIMUM FLOWRATE OF 0.5 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, 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:

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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

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.

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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.

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 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

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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:

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:

FLIGHT: NO CREW ACTION CAN BE TAKEN.

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

- APPROVALS -

S&R ENGINEERING : W.P. MUSTY : /S/ W. P. MUSTY
S&R ENGINEERING ITM : P. A. STENGER-NGUYEN : /S/ P. A. STENGER-NGUYEN

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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