

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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LRU: LO2 POGO RECIRCULATION VALVE, PV21,22

CRITICALITY OF THIS

ITEM NAME: LO2 POGO RECIRCULATION VALVE, PV21,22

FAILURE MODE: 1/1

FAILURE MODE:

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

MISSION PHASE:

PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

FATIGUE FAILURE, MATERIAL DEFECT, DAMAGED OR DEFECTIVE INTERNAL SEALS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LO2 LEAKAGE INTO THE AFT COMPARTMENT. GN2 PURGE OF THE AFT COMPARTMENT MAY LOWER THE GO2 CONCENTRATION, BUT THE FIRE/EXPLOSION HAZARD IS STILL PRESENT. LEAKAGE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). POSSIBLE OVERPRESSURIZATION OF THE AFT COMPARTMENT AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS DUE TO CRYO EXPOSURE.

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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.

-DISPOSITION RATIONALE-

(A) DESIGN:

VALVE OPERATING PRESSURE IS 400 PSIG. FACTORS OF SAFETY: PROOF - 1.5; BURST - 2.0. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATIONS; FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE. THE VALVE BODY IS CONSTRUCTED OF A356 MACHINED ALUMINUM.

SHAFT LEAKAGE IS CONTROLLED BY DUAL DYNAMIC SEALS; ONE MYLAR AND THE OTHER TEFLON (SPRING LOADED AGAINST THE PINION SHAFT). LEAKAGE PAST THE LOWER SHAFT TRUNION IS CONTROLLED BY A CREEVEY SEAL (TEFLON JACKET OVER A CRES SPRING), BACKED UP BY A TEFLON STATIC SEAL.

(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

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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.

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

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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 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.

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HANDLING/PACKAGING

HANDLING, PACKAGING, STORAGE, AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

ATP

DURING ATP, SHAFT SEAL LEAKAGE WAS 12 SCIM, MAX ALLOWABLE IS 2 SCIM (REFERENCE CAR AC6593). THE SHAFT SEAL WAS REMOVED AND REPLACED AND PASSED SUBSEQUENT LEAKAGE TESTS. FAILURE IS ATP SCREENABLE.

DURING ATP WITH VALVE PRESSURIZED AT 130 PSIG, THE EXTERNAL LEAKAGE WAS 41.6 SCIM, MAX ALLOWABLE 5 SCIM (REF CAR A4821). DURING DISASSEMBLY, IT WAS FOUND THAT BOTH THE PRIMARY AND SECONDARY SHAFT SEALS WERE OFF CENTER FROM THEIR INSTALLATION POSITIONS. IN ADDITION, THE SHAFT END THAT ENGAGES THE BALL HAD SPLINES WITH SHARP EDGES WHICH RESULTED IN SCRATCHES ON THE PRIMARY SHAFT SEAL WHEN THE SEAL PASSED OVER THE SPLINES. THE VALVE WAS REWORKED AND PASSED ATP. SHAFT DRAWINGS HAVE BEEN REVISED TO REMOVE SHARP EDGES ON THE SPLINES AND USE OF PROPER TOOLING TO OBTAIN THE CORRECT ALIGNMENT OF THE SEALS WAS IMPLEMENTED.

DURING ATP, EXTERNAL LEAKAGE OF THE SHAFT SEAL AT CRYO TEMPERATURE WAS 6.3 SCIM, MAXIMUM ALLOWABLE OF 5 SCIM (REF CAR A7202). THE SEAL WAS REPLACED AND VALVE MET LEAKAGE REQUIREMENTS AT CRYO TEMPS.

DURING ATP, THE EXTERNAL LEAKAGE AT CRYO TEMPS WAS AT 22 SCIM, MAX ALLOWABLE 2 SCIM (REF CAR A5438). INSPECTION OF THE VALVE REVEALED A CRACK IN THE TRUNION BEARING SEAL. THE SEAL WAS REPLACED AND THE VALVE PASSED SUBSEQUENT LEAKAGE TESTS.

DURING ATP, THE EXTERNAL LEAKAGE AT CRYO TEMPERATURE WAS 2.87 SCIM, MAX ALLOWABLE 2 SCIM (REF CAR A9706). DISASSEMBLY OF THE VALVE REVEALED THAT THE TRUNION BEARING SEALING SURFACE WAS DAMAGED DURING ASSEMBLY. THE VALVE WAS REWORKED AND MET LEAKAGE REQUIREMENTS AT CRYO TEMPERATURES.

DURING ATP, THE SHAFT SEAL LEAKAGE WAS 25 SCIM, MAX ALLOWABLE 10 SCIMS (REF CAR A9674). THE VALVE WAS DISASSEMBLED AND SCRATCHES WERE FOUND ON THE SHAFT SEAL. NEW SEALS WERE INSTALLED AND THE VALVE PASSED ATP.

QUALIFICATION

DURING QUALIFICATION TESTING AT CRYO TEMPERATURE, SHAFT SEAL LEAKAGE WAS 13 SCIM, MAX ALLOWABLE 10 SCIM (REF CAR AB0141). DISASSEMBLY FOUND SMALL SLIVERS OF TEFLON MATERIAL ON THE SEALING SURFACE. IT WAS DETERMINED THAT THE CONTAMINATION WAS GENERATED WITHIN THE VALVE DURING QUAL TEST. CORRECTIVE ACTION RESULTED IN RELAXATION OF QUALIFICATION LEAKAGE REQUIREMENTS TO ALLOW 20 SCIM. VALVE WAS REASSEMBLED AND PASSED LEAKAGE TESTS.

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DURING QUALIFICATION TEST, LEAKAGE OF THE SHAFT SEAL AT CRYO TEMPERATURE, THE SHAFT SEAL LEAKAGE WAS 27 SCIM, MAX ALLOWABLE IS 20 SCIM (REF CAR AC6963). THE CAUSE ATTRIBUTED TO NORMAL INTERNAL WEAR IN COMBINATION WITH MIGRATING LUBRICANT. THE SPECIFICATION FOR MAXIMUM SHAFT SEAL LEAKAGE WAS REVISED TO 30 SCIM (TYPE II VALVES ONLY), TO BE MEASURED AFTER EXPOSURE TO QUALIFICATION VIBRATION TEST.

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
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