

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

ITEM NAME: LO2 POGO RECIRCULATION VALVE, PV21,22

CRITICALITY OF THIS

FAILURE MODE: 1R3

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

REDUNDANCY SCREEN

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

PASS/FAIL RATIONALE:

A)

B)

FAILS B SCREEN AFTER VALVE IS COMMANDED OPEN SINCE INDICATOR FAILURE CANNOT BE DISTINGUISHED FROM EXPECTED OUTPUT. VALVE REMAINS IN THE OPEN POSITION FOR THE REMAINDER OF THE MISSION.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

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

GROUND LCC VERIFIES THAT OPEN POSITION SWITCH OF EACH VALVE INDICATES OFF PRIOR TO APU START (T-5 MINUTES). VALVES ARE COMMANDED OPEN AT T- 12.5

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SECONDS. AT T-9.5 SECONDS, RSLs LCC VERIFIES ONE TIME ONLY THAT BOTH OPEN POSITION SWITCHES INDICATE ON.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

PRIOR TO APU START, FAILURE TO VERIFY OPEN POSITION SWITCH OFF WILL RESULT IN LAUNCH SCRUB.

IF FAILURE OCCURS AFTER APU START, LCC IS SATISFIED AND LAUNCH CONTINUES. SINCE VALVE IS STILL FUNCTIONAL, THERE IS NO FLIGHT EFFECT.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/3 3 SUCCESS PATHS. TIME FRAME - AFTER APU START.

- 1) LO2 POGO VALVE (PV20 OR PV21) OPEN POSITION SWITCH FAILS ON AFTER GROUND LCC VERIFICATION.
- 2) VALVE THEN FAILS TO OPEN OR REMAIN OPEN. OPEN POSITION RSLs LCC FOR THAT VALVE IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE.
- 3) ERRONEOUS INDICATION OR FAILURE TO REMAIN OPEN ON PARALLEL POGO VALVE (PV21 OR PV20).

NO EFFECT DURING ENGINE START TRANSIENT. LOSS OF THE POGO RETURN PATH CAUSING OVERFLOW OF HELIUM PRECHARGE FROM POGO ACCUMULATOR INTO HIGH PRESSURE OXIDIZER TURBOPUMP (HPOT) IS TOLERATED.

DURING ASCENT, 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.

DURING POST MECO ENGINE SHUTDOWN SEQUENCE, HELIUM IS INJECTED INTO POGO ACCUMULATORS TO MAINTAIN NPSP AND PREVENT HIGH PRESSURE OXIDIZER TURBOPUMP (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.

-DISPOSITION RATIONALE-

(A) DESIGN:

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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. RTV IS USED IN THE SCREW HOLES AND BETWEEN THE SWITCH HOUSING AND MOUNTING PLATE TO MINIMIZE SHIFTING DUE TO TEMPERATURE CHANGES. 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.

EACH SWITCH IS SCREENED AT CRYOGENIC TEMPERATURE BEFORE INSTALLATION TO VERIFY PERFORMANCE CHARACTERISTICS. ACTUATING ARM MOVEMENT BETWEEN THE ACTUATED AND DEACTUATED POSITIONS IS VERIFIED TO BE 0.005 INCH MINIMUM.

(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

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

ACTUATOR PRESSURIZED TO 740 AND 600 PSIG

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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.

CONTAMINATION CONTROL

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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:

SEVERAL POSITION INDICATION FAILURES AT MPTA EARLY IN THE PROGRAM WERE ATTRIBUTED TO FASTER VALVE OPERATION IN THE FIELD THAN ORIGINALLY TESTED FOR IN DEVELOPMENT, QUAL, AND ATP. THE FAST OPERATION RESULTED IN SHOCK DAMAGE AFFECTING THE VALVE POSITION INDICATION FUNCTION. CORRECTIVE ACTIONS INCLUDED ADDITION OF AN ACTUATOR ORIFICE/FILTER WHICH PRECLUDED RAPID OPERATION AND REVISION OF THE SPECIFICATION TO ESTABLISH A MINIMUM VALVE ACTUATION TIME AT CRYOGENIC TEMPERATURES (REFERENCE CARS AB0332, AB0794, ABO813).

DURING QUALIFICATION TESTING (VIBRATION IN THE X-AXIS DIRECTION), THE OPEN POSITION SWITCH FAILED TO INDICATE (REFERENCE CAR AB3014). THE SWITCH ACTUATOR WAS FOUND TO BE WORN DUE TO VIBRATION. A REDESIGN WAS AUTHORIZED TO INCORPORATE A CAM OPERATED SWITCH AND A NEW HOUSING.

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DURING QUALIFICATION LIFE CYCLING TEST, THE OPEN INDICATOR SWITCH FAILED TO INDICATE (REFERENCE CAR AB0142). TEARDOWN REVEALED THAT TWO SWITCH WIRES HAD FAILED DUE TO FATIGUE. CORRECTIVE ACTION WAS TO REROUTE THE WIRES AND PROVIDE ADDITIONAL SUPPORT.

TWO POSITION INDICATION FAILURES DURING QUAL AND ATP WERE ATTRIBUTED TO A GRADUAL LOSS OF ADJUSTMENT (REFERENCE CAR AB0160). CORRECTIVE ACTION WAS TO ADD A LOCKWASHER AND USE HIGHER TORQUE ON THE RETAINING SCREW TO MAINTAIN PROPER ADJUSTMENT.

DURING ATP, A CLOSED INDICATION SWITCH FAILED TO OPERATE (REFERENCE CAR AB0097). THE DIAPHRAGM SEAL FOR THE ACTUATING ARM WAS FOUND TO BE DEFORMED, REDUCING THE STROKE. THE VALVE WAS REDESIGNED USING THE APPROVED SWITCH ASSEMBLY ACTUATING MECHANISM DESIGN FOR THE TYPE V VALVE.

DURING STS-3, THE LO2 BLEED VALVE INDICATED "CLOSED" 4.64 SECONDS (SHOULD BE 1.5 SECONDS) AFTER THE CLOSED COMMAND WAS GIVEN (REFERENCE CAR AC3003). NO ANOMALIES WERE DETECTED AND THE MICROSWITCH WAS READJUSTED TO ACTIVATE DURING THE LAST 7 DEGREES OF CAM ROTATION. THE IMPROVED SWITCH ADJUSTMENT TECHNIQUE WAS USED ON THE -0055 BALL VALVES.

DURING QUALIFICATION OF THE -0041 BALL VALVE, THE POSITION SWITCH INDICATION DURING CLOSING AT CRYOGENIC TEMPERATURES WAS ERRATIC (REFERENCE CAR AC3007). NO PHYSICAL ANOMALIES WERE DETECTED. THE ASSEMBLY PROCEDURES WERE REVISED TO ADJUST THE MICROSWITCH TO ACTIVATE DURING THE END OF THE SWITCH ACTUATION CAM TRAVEL. ADDITIONALLY, THE BRACKETS SUPPORTING THE MICROSWITCHES WERE KNURLED ON ONE END AND LUBRICATED WITH DRI-LUBED ON THE OTHER.

DURING ATP AT DOWNEY, VALVE CLOSING TIMES WERE OUT OF TOLERANCE (REFERENCE CAR AC7436). FAILURE ANALYSIS CONCLUDED THAT A LARGER ORIFICE WAS NECESSARY TO OBTAIN FASTER VENTING. THE VENDOR DRAWING WAS REVISED TO INCORPORATE THE LARGER ORIFICE.

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.

- 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

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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