

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0431 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 2 11/07/00**PART DATA**

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: LH2 HIGH POINT BLEED VALVE, BALL VALVE, TYPE III, NC VACCO INDUSTRIES	MC284-0395-0053 1440-511

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, LH2 HIGH POINT BLEED 1.5 INCH. NORMALLY CLOSED, PNEUMATICALLY ACTUATED OPEN. INCORPORATES RELIEF 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: PV22**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

THIS VALVE CONTROLS THE FLOW OF GH2 BLEED FROM THE LH2 17-INCH DISCONNECT (WHICH IS THE HIGH POINT IN THE ENGINE FEED SYSTEM) OVERBOARD THROUGH THE HIGH POINT BLEED DISCONNECT (PD17) INTO THE GROUND VENT SYSTEM. THE VALVE IS ACTUATED OPEN DURING SLOW FILL TO BLEED OFF ANY GH2 ACCUMULATED IN THE FEEDLINE DURING LOADING OPERATIONS. VALVE IS CLOSED APPROXIMATELY TWENTY SIX SECONDS PRIOR TO LIFTOFF. THE VALVE INCORPORATES A RELIEF FEATURE WHICH RELIEVES THE LINE BETWEEN THE HIGH POINT BLEED DISCONNECT AND THE BLEED VALVE BACK INTO THE FEEDLINE. THE BLEED DISCONNECT ACTS AS A REDUNDANT INHIBIT AGAINST OVERBOARD FLOW AFTER LH2 TSM UMBILICAL SEPARATION.

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: LH2 HIGH POINT BLEED VALVE, PV22

ITEM NAME: LH2 HIGH POINT BLEED VALVE, PV22

CRITICALITY OF THIS

FAILURE MODE: 1R3

FAILURE MODE:

LOSS OF POSITION INDICATION - CLOSED 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 SINCE FAILURE INDICATION CANNOT BE READILY DISTINGUISHED FROM EXPECTED OUTPUT DURING LCC PERIOD. THE CLOSED INDICATION IS MANUALLY MONITORED TO BE "OFF" PRIOR TO T-31 SECONDS AND LCC VERIFIES "ON" BETWEEN T-14 AND T-10 SECONDS (ONE TIME CHECK).

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

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

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

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(C) MISSION:

POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

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

FIRST FAILURE - NO EFFECT.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/3 3 SUCCESS PATHS. TIME FRAME – ASCENT.

- 1) HIGH POINT BLEED VALVE (PV22) CLOSED POSITION SWITCH FAILS ON AFTER T-31 SECONDS.
- 2) HIGH POINT BLEED VALVE (PV22) FAILS TO CLOSE/REMAIN CLOSED. VALVE POSITION LCC IS ERRONEOUSLY SATISFIED DUE TO FIRST FAILURE.
- 3) HIGH POINT BLEED DISCONNECT (PD17) FAILS TO CLOSE/REMAIN CLOSED.

LH2 WILL DUMP OVERBOARD RESULTING IN LOSS OF 230 LBM OF PROPELLANT. THIS WILL NOT EFFECT ENGINE INLET CONDITIONS OR CAUSE A LOW LEVEL CUTOFF. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

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

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AMBIENT PROOF:

VALVE BODY - 195 PSIG, VALVE OPEN AND CLOSED
ACTUATOR - 1700 PSIG

VALVE RESPONSE TIMES - AMBIENT AND CRYO (-300 DEG F AND -423 DEG F):

VALVE: 55 PSIG
ACTUATOR: 500 AND 740 PSIG

EXTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F AND -423 DEG F):

VALVE BODY: 130 PSIG
ACTUATOR: 740 PSIG

INTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F AND -423 DEG F):

INLET-TO-OUTLET @ 55 PSIG
ACTUATOR: 740 PSIG

POSITION INDICATION: VERIFICATION OF OPERATION

ELECTRICAL CHARACTERISTICS - CONTACT RESISTANCE; INSULATION RESISTANCE; AND DIELECTRIC STRENGTH.

RELIEF VALVE CRACK AND RESEAT - AMBIENT AND CRYO(-300 DEG F): 15-40 PSID

CERTIFICATION

LIFE -

CRYO - 500 CYCLES AT -400 DEG F
AMBIENT - 1500 CYCLES

RANDOM VIBRATION TESTS - IN ALL THREE AXES

13.3 HOURS IN EACH AXIS WHILE PRESSURIZED TO 105 PSIG AND AT -300 DEG F.

DESIGN SHOCK (ALL THREE AXES) - 18 SHOCKS OF 15G EACH, THREE IN EACH DIRECTION.

THERMAL CYCLE TESTS - PERFORMED THREE TIMES

70 DEG F TO -400 DEG F TO 70 DEG F TO 275 DEG F TO 150 DEG F

VALVE RESPONSE TIMES - AMBIENT AND CRYO (-300 DEG F AND -423 DEG F):

VALVE: 55 PSIG
ACTUATOR: 500 AND 740 PSIG

EXTERNAL LEAKAGE - AMBIENT AND CRYO (-300 DEG F AND -423 DEG F):

VALVE BODY: 130 PSIG
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INLET-TO-OUTLET @ 55 PSIG
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ELECTRICAL BONDING - LESS THAN 100 MILLIOHMS

BURST - BY SIMILARITY TO THE TYPE V VALVE. 800 PSIG VALVE BODY, 3400 PSIG ACTUATOR

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 LEAK CHECKED AT PROOF PRESSURE. ALL WELDS ON THE ELECTRICAL CONNECTOR ARE DYE PENETRANT INSPECTED AND VERIFIED BY INSPECTION.

TESTING

ATP VERIFIED BY INSPECTION.

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PACKAGING/HANDLING

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, AB0813).

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.

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, WHICH WILL REPLACE THE CURRENT VALVES ON ALL VEHICLES.

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.

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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 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
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