

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0452 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1

11/06/00

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
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.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0452-08

REVISION#: 1 11/06/00

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LRU: LO2 OVERBOARD BLEED VALVE, PV19

ITEM NAME: LO2 OVERBOARD BLEED VALVE, PV19

CRITICALITY OF THIS

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE OF THE VALVE ACTUATOR DURING ASCENT.

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

FATIGUE, MATERIAL DEFECTS, DAMAGED/DEFECTIVE ACTUATOR 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:

LOSS OF APPLICATION OF ACTUATION PRESSURE TO THE LO2 OVERBOARD BLEED VALVE (PV19), CAUSING THE BLEED VALVE TO OPEN. LO2 BLEED DISCONNECT (PD13) IS REDUNDANT TO PREVENT OVERBOARD LO2 FLOW DURING ASCENT. REFER TO FMEA/CIL 03-1-0452-02 (VALVE FAILS TO CLOSE/REMAIN CLOSED) FOR EFFECTS DURING TERMINAL COUNT AND ASCENT.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0452-08**

ACTUATOR IS LOCATED ON HELIUM PNEUMATIC LEG DOWNSTREAM OF CHECK VALVE CV9 (ACCUMULATOR LEG). ACTUATOR IS PRESSURIZED DURING ASCENT TO MAINTAIN BLEED VALVE CLOSED.

(B) INTERFACING SUBSYSTEM(S):

POSSIBLE DEPLETION OF VALVE ACTUATION PRESSURE, CAUSING FAILURE TO CLOSE LO2 PREVALVES AT MECO. RESULTS IN INABILITY TO MAINTAIN INJECTED HELIUM AND LO2 PRESSURE AT THE SSME PUMP, RESULTING IN POSSIBLE PUMP OVERSPEED AND EXPLOSION. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSIVE HAZARD.

AT MECO THE ENGINE NUMBER TWO HELIUM SUPPLY IS SWITCHED INTO THE PNEUMATIC VALVE SYSTEM (VIA LV10) AS A BACKUP, BY SOFTWARE COMMAND, WHICH MAY NOT ACTUATE THE LO2 PREVALVES CLOSED.

(C) MISSION:

POSSIBLE LOSS OF CREW/VEHICLE.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:

FACTORS OF SAFETY: PROOF - 2.0; BURST - 4.0. DURING CERTIFICATION TESTING, ACTUATOR WAS BURST TESTED TO 3400 PSIG. ACTUATOR MAX OPERATING PRESSURE IS 850 PSIG. BOTH THE ACTUATOR BODY AND END CAP ARE MANUFACTURED FROM ALUMINUM ALLOY. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION; FRACTURE /FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

EXTERNAL LEAKAGE FROM THE ACTUATOR END CAP IS PREVENTED BY THE USE OF A CREEVEY-TYPE SEAL (TEFLON COVER OVER A SANDVIK SPRING) AND A KEL-F STATIC SEAL. EXTERNAL LEAKAGE FROM THE ACTUATOR PISTON IS PREVENTED BY USE OF A KEL-F LIP SEAL.

(B) TEST:

ATP

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0452-08**

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

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.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0452-08**

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 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

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0452-08**

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:

ATP

DURING ATP PROOF PRESSURE TEST, EXCESSIVE LEAKAGE PAST THE ACTUATOR SEAL WAS NOTED (REF CAR A9705). TEARDOWN REVEALED A SCRATCH ON THE PISTON SEAL. THE SEAL WAS REPLACED AND ACTUATOR MET LEAKAGE REQUIREMENTS. CORRECTIVE ACTION WAS TO INCORPORATE A MANDATORY INSPECTION POINT OF THE SEALS PRIOR TO INSTALLATION.

QUALIFICATION

DURING QUALIFICATION TEST, ACTUATOR LEAKAGE WAS OBSERVED (REF CAR A9894). X-RAY OF THE ACTUATOR REVEALED A BROKEN RACK/PISTON SPRING. UPON TEARDOWN, A BROKEN STATIC SEAL WAS ALSO FOUND. FAILURE ANALYSIS OF THE SPRING DETERMINED THAT THE SPRING FAILED FROM IMPACT EMBRITTLEMENT. THE ACTUATOR SPRING MATERIAL WAS CHANGED FROM TITANIUM TO ELGILOY AND REDUNDANT ACTUATOR STATIC SEALS WERE ADDED. THE QUAL UNIT WAS REWORKED AND SUCCESSFULLY RETESTED.

DURING QUALIFICATION TEST AT CRYO TEMPERATURE, THE ACTUATOR SHAFT SEAL LEAKAGE WAS 400 SCIM, MAX ALLOWABLE IS 100 SCIM (REF CAR AC6963). THE CAUSE ATTRIBUTED TO NORMAL INTERNAL WEAR IN COMBINATION WITH MIGRATING LUBRICANT. THE SPECIFICATION FOR MAXIMUM ACTUATOR SHAFT SEAL LEAKAGE WAS REVISED TO 500 SCIM (TYPE II VALVES ONLY), TO BE MEASURED AFTER EXPOSURE TO QUALIFICATION VIBRATION TEST.

DURING CRYOGENIC QUAL TESTING, ACTUATOR PISTON SEAL LEAKAGE OF 130 SCIM WAS NOTED. MAX ALLOWABLE IS 100 SCIM (REFERENCE CAR AB1806). THE LEAKAGE WAS DUE TO METALLIC PARTICLE GENERATION DURING ASSEMBLY FROM IMPROPERLY CLEANED PARTS CAUSING GALLING DURING ASSEMBLY. SUPPLIER ACTUATOR ASSEMBLY PROCEDURE PS-352M WAS CHANGED TO ADD CAUTION AND INSPECTION NOTE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0452-08**

DURING QUALIFICATION TESTING, ACTUATOR PISTON SEAL LEAKAGE OF 200 SCIM WAS DETECTED. MAX ALLOWABLE IS 100 SCIM. LEAKAGE WAS DUE TO METALLIC PARTICLES GENERATED DURING ASSEMBLY WITH AN INADEQUATE ASSEMBLY TOOL. REDESIGNED TOOL ELIMINATED THE PROBLEM (REFERENCE CAR AB0197).

DURING QUALIFICATION TESTING, LEAKAGE AT THE ACTUATOR PISTON SEAL RETAINER INTERFACE WAS 560 SCIM. MAX ALLOWABLE IS 100 SCIM (REFERENCE ARE AB0088). LEAKAGE WAS DUE TO INSUFFICIENT SEAL RETAINER TORQUE OF 70 FT-LBS. ASSEMBLY TORQUE WAS INCREASED TO 95 - 100 FT-LBS WITH REPEAT APPLICATIONS AT 5 MINUTE INTERVALS UNTIL SUB-ASSEMBLY STOPS MOVING. IMPLEMENTED OV-102 AND SUBS.

FIELD

DURING MPTA CHECKOUT, HELIUM WAS LEAKING THROUGH THE VENT PORT OF THE ACTUATOR CAUSING THE VALVE TO FAIL TO REMAIN OPEN (REF CAR A9630). DURING DISASSEMBLY, IT WAS FOUND THAT THE STATIC SEAL WAS PROTRUDING OUTSIDE ITS RETAINER AREA AND THAT THE SEAL RETAINER TORQUE WAS LOW. IT WAS CONCLUDED THAT THE ACTUATOR STATIC SEAL RETAINER TORQUE RELAXES EITHER FROM SEAL MATERIAL COLD FLOW OR RETAINER BACKING OFF. THE VALVE WAS REDESIGNED TO ADD REDUNDANT ACTUATOR SEALS AND LOCKTITE IS APPLIED TO THE RETAINER TO PREVENT TORQUE RELAXATION AND A SERIES OF RETORQUING TO MINIMIZE COLD FLOW. THE VALVE WAS REWORKED AND PASSED SUBSEQUENT LEAKAGE TESTS.

AT PALMDALE ACTUATOR LEAKAGE OCCURRED FROM UNDER THE ENDCAP OF THE ACTUATOR (REFERENCE CAR AD2446). THE ORIGIN OF THE LEAK WAS DUE TO TWO DAMAGED GASKETS P/N 1397-60 AND A SEAL P/N 1397-29-2. THE FAILURE WAS DUE TO A FAILURE TO BACK UP THE END CAP ON THE ACTUATOR WHILE TURNING A LINE FITTING DURING THE INSTALLATION OF THE VALVE. GASKETS AND SEAL REPLACED. NO FURTHER ACTION REQUIRED.

DURING CHECKOUT AT PALMDALE ON OV-099, THE ACTUATOR END CAP LEAKED EXCESSIVELY (REFERENCE CAR AC2152). NEW SEALS AND END CAP WERE INSTALLED ON THE VEHICLE BY THE SUPPLIER AND PASSED SUBSEQUENT LEAK TEST. CAUSE FOR LEAKAGE WAS NOT DETERMINED.

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:

HELIUM BOTTLE PRESSURE IS ON DISPLAY IN COCKPIT. CREW ACTION CAN CLOSE PNEUMATIC ISOLATION VALVES (LV7,8) DURING ASCENT. PRIOR TO MECO, THE ISOLATION VALVES CAN BE REOPENED OR THE LEFT ENGINE LOW PRESSURE GHE CROSSOVER VALVE (LV10) CAN BE OPENED.

- APPROVALS -

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0452-08**

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