

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : MAIN PROPULSION FMEA NO 03-1 -0452 -2 REV:05/04/88

ASSEMBLY : EATON CONSOL. CNTL	CRIT. FUNC: 1
P/N RI : MC284-0395-0055	CRIT. HDW: 1
P/N VENDOR:	VEHICLE 102 103 104
QUANTITY : 1	EFFECTIVITY: X X X
: ONE	PHASE(S): PL X LO X OO DO LS
:	

PREPARED BY:	REDUNDANCY SCREEN:	A-	B-	C-
DES J E OSLUND	APPROVED BY:	APPROVED BY (NAME):		
REL L H FINEBERG	DES <u>H. P. Balford</u>	SSM <u>Chell...</u>		
QE E M GUTIERREZ	REL <u>L. A. SCOPE</u>	REL <u>...</u>		
	QE <u>C. Hallinan</u>	QE <u>...</u>		

ITEM

LO2 OVERBOARD BLEED VALVE (PV19), 1.5 INCH DIAMETER, NORMALLY OPEN, PNEUMATICALLY ACTUATED CLOSED. RELIEVES TO INBOARD SIDE OF VALVE.

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 NOT REQUIRED CLOSED BY LCC. FOR NOMINAL, ATO, AND AOA MISSIONS THE VALVE IS OPENED AT COMPLETION OF DUMP. FOR RTLS ABORTS THE VALVE IS OPENED AT 3800 FEET/SECOND. FOR TAL ABORTS THE VALVE REMAINS CLOSED UNTIL POWER IS REMOVED FROM VEHICLE (POST LANDING). THE VALVE INCORPORATES TWO REDUNDANT CLOSED POSITION INDICATORS AND A SINGLE OPEN INDICATOR.

FAILURE MODE

FAILS TO CLOSE DURING TERMINAL COUNT.

FAILS TO REMAIN CLOSED (INCLUDES BUILT-IN RELIEF VALVE) DURING TERMINAL COUNT.

CAUSE(S)

FAILS TO CLOSE - PIECE PART STRUCTURAL FAILURE, BINDING, CONTAMINATION, ACTUATOR LEAKAGE, ACTUATOR FILTER CLOGGING.

FAILS TO REMAIN CLOSED - PIECE PART STRUCTURAL FAILURE, ACTUATOR LEAKAGE

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

EFFECT(S) ON:

(A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE

(A,B) FAILURE OF VALVE TO CLOSE/REMAIN CLOSED WILL RESULT IN CONTINUED BLEED FLOW RESULTING IN LOSS OF LO2 OVERBOARD WITH FAILURE OF BLEED DISCONNECT (PD13) TO CLOSE. BLEED DISCONNECT IS NOT CERTIFIED FOR CLOSURE UNDER FLOW CONDITIONS AND CANNOT BE CONSIDERED A REDUNDANT INHIBIT AGAINST OVERBOARD FLOW. POSSIBLE RUPTURE OF DISCONNECT HOUSING AND/OR DOWNSTREAM BLEED SYSTEM DUE TO WATER HAMMER. RESULTS IN LOSS OF APPROXIMATELY 3000 LBS OF PROPELLANT (TWO PHASE FLOW FROM POGO SYSTEM) WHICH IS INSUFFICIENT TO CAUSE PREMATURE SSME SHUTDOWN.

POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSIVE HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE. NO LCC EXISTS FOR VERIFICATION OF VALVE POSITION PRIOR TO T-0.

ALSO RESULTS IN LOSS OF HELIUM SUPPLY DURING MANIFOLD REPRESSURIZATION CAUSING LOSS OF AFT COMPARTMENT PURGE (RTLS AND TAL ABORT CRITICAL).

(C) VALVE IS CYCLED DURING LAUNCH COUNTDOWN TO VERIFY PROPER OPERATION. FAILURE WOULD RESULT IN LAUNCH SCRUB.

(D) FOR FAILURE OCCURRENCE DURING TERMINAL COUNT, POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE I: 1R/2, 2 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) BLEED VALVE (PV19) FAILS TO REMAIN CLOSED.
- 2) BLEED DISCONNECT (PD13) FAILS TO CLOSE/REMAIN CLOSED.

RESULTS IN LOSS OF APPROXIMATELY 3000 LBS. (TWO PHASE FLOW FROM POGO SYSTEM) OF PROPELLANT OVERBOARD WHICH IS INSUFFICIENT TO CAUSE PREMATURE SSME SHUTDOWN. POSSIBLE FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CREW/VEHICLE.

CASE II: 1R/2, 2 SUCCESS PATHS. TIME FRAME - ASCENT.

- 1) BLEED VALVE (PV19) FAILS TO REMAIN CLOSED.
- 2) LO2 BLEED LINE BETWEEN PV19 AND PD13 RUPTURE/LEAKAGE.

LO2 WILL LEAK INTO THE AFT FUSELAGE CAUSING POSSIBLE AFT COMPARTMENT OVERPRESS AND FIRE/EXPLOSION HAZARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYO EXPOSURE. POSSIBLE LOSS OF CREW/VEHICLE.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

DISPOSITION & RATIONALE:

(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN

VALVE

THE VALVE ACTUATOR IS SPRING LOADED TO THE OPEN POSITION AND IS DESIGNED TO CLOSE WITH THE APPLICATION OF 500 TO 800 PSIG OF HELIUM PRESSURE TO THE VALVE ACTUATOR. THE ACTUATOR PISTON DRIVES A SPRING LOADED RACK WHICH DRIVES A PINION GEAR, THE SHAFT OF WHICH ROTATES THE VALVE BALL (CLOSURE). THE PISTON IS OF 304 CRES AND THE RACK AND PINION ARE OF INCONEL 718. THE PINION GEAR/SHAFT IS MACHINED FROM A SINGLE PIECE OF STOCK.

THE ACTUATOR AND VALVE BEARINGS ARE OF EITHER VESPEL OR FLUOROGOLD AND ARE DESIGNED SO THAT THEY WILL TURN WITHIN THEIR HOUSING IN THE EVENT OF SHAFT/BEARING SEIZURE/BINDING. TO PREVENT BINDING IN THE ACTUATOR, THE RACK IS GUIDED ON EACH END BY A FLUOROGOLD GUIDE RING. THE CHROME PLATED PISTON SLIDES THROUGH RETAINERS TREATED WITH A DRY FILM LUBRICANT.

THE ACTUATOR PISTON SEAL DESIGN USES A KEL-F STATIC SEAL AGAINST THE MOVING, CHROME-PLATED PISTON. THE SEAL IS LOADED WITH A COPPER-BERYLLIUM SPRING AND THE ACTUATOR PRESSURE FURTHER ASSISTS IN MINIMIZING LEAKAGE ACROSS THE PISTON. EXTERNAL LEAKAGE FROM THE ACTUATOR IS PREVENTED BY THE USE OF A CREEVEY-TYPE SEAL (TEFLON COVER OVER A SANDVIK SPRING) AND A KEL F STATIC SEAL.

TO CONTROL CONTAMINATION, A 10 MICRON FILTER IS DESIGNED INTO THE ACTUATOR PRESSURIZATION PORT.

PROPELLANT SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN E SCREEN, PREVALVE SCREENS, A GSE DEBRIS PLATE, A GSE FILTER, AND MAINTAINING A CLEANLINESS LEVEL OF 800A.

THE VALVE WAS CYCLED 2000 TIMES (1500 CYCLES AT AMBIENT TEMPERATURE AND 500 AT CRYOGENIC TEMPERATURE) DURING CERTIFICATION TESTING WITHOUT EVER FAILING TO CLOSE OR REMAIN CLOSED. FACTORS OF SAFETY: PROOF - 1.5 BODY, 2.0 ACTUATOR; BURST - 2.0 BODY, 4.0 ACTUATOR.

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.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

SYSTEM

IF THE LO2 BLEED VALVE FAILS TO CLOSE BEFORE T-0 THE LO2 BLEED DISCONNECT WOULD BE CLOSING WITH AN OXYGEN FLOW OF 4.1 POUNDS/SECOND. THIRTY-TWO PERCENT OF THIS FLOW WILL BE VAPOR. THE LO2 BLEED DISCONNECT IS NOT CERTIFIED FOR CLOSURE UNDER FLOW. HOWEVER, THE CLOSURE IS AT A ONE "G" ACCELERATION RATE (T-0 UMBILICAL SEPARATION RATE), WHICH LIMITS THE IMPACT ENERGY ON THE VESPEL SEAL TO A LEVEL WHICH IS BELOW THE LO2/VESPEL IGNITION LEVEL (NOT PREVIOUSLY TESTED WITH THESE CONDITIONS). THE WATER HAMMER EFFECT GENERATED DURING THIS CLOSURE HAS BEEN CALCULATED TO BE APPROXIMATELY 60 PSIG. SYSTEM PROOF PRESSURE LEVEL IS 286 PSIG.

(B) TEST

ATP

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.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

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.

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
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

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

CMRSD

V41AYO.010 LO2 PROPELLANT VALVE SHAFT SEAL AND EXT. LEAK TEST (I5)
V41AYO.130 LO2 PROPELLANT SYSTEM DECAY CHECK (EVERY FLT)
V41AYO.221 HELIUM SIGNATURE LEAK CHECK (EVERY FLT)
V41AZO.131 PROPELLANT VALVE ACTUATOR LEAK TEST (I5)
V41BFO.070 PV19 LO2 OVERBOARD BLEED VALVE SEAT LEAK CHECK (EVERY FLT)
V41BIO.170 LO2 OVERBOARD BLEED VALVE RESPONSE (EVERY FLT)
V41BIO.230 INFLIGHT VALVE RESPONSE (POST FLIGHT DATA ANALYSIS)
V41BUO.160 LO2 FEEDLINE SCREEN INSPECTION (I5)
V41BUO.162 LO2 FEEDLINE SCREEN INSPECTION - VERTICAL (I25)

(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.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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

(D) FAILURE HISTORY

INTERNAL LEAKAGE:

MINOR INTERNAL LEAKAGES HAVE OCCURRED AT THE SUPPLIER DURING ATP. CORRECTIVE ACTIONS WERE DESIGN CHANGES TO THE BALL SEAL AND RETAINER. DISCREPANT PARTS WERE REPLACED, MANUFACTURING ASSEMBLY PROCEDURES WERE CHANGED, AND ALLOWABLE ACTUATOR AND SHAFT SEAL LEAKAGE RATE REQUIREMENTS WERE RELAXED (REFERENCE CARs AC5714, AC6963, AB3341).

INTERNAL LEAKAGE DURING ATP WAS CAUSED BY BURRS AT THE SEALING CONTACT AREA OF THE BALL SEAL (REFERENCE CAR AB9088). SUPPLIER INITIATED A DEBURRING OPERATION UNDER 30X MAGNIFICATION. CORRECTIVE ACTION IS EFFECTIVE FOR TYPE I THRU TYPE V VALVES.

INTERNAL LEAKAGE DURING ATP WAS DETERMINED TO BE CAUSED BY INSUFFICIENT SEALING PRESSURE BETWEEN THE BALL SEAL AND THE BALL (REFERENCE CAR AC5985). THE SEAL RETAINER WAS FOUND TO BE DIMENSIONALLY DISCREPANT, CAUSING THE LACK OF SEALING PRESSURE. ALL EXISTING SEAL RETAINERS (P/N 80692) HAVE BEEN INSPECTED AND REWORKED TO THE CORRECT ANGLE OF 26 DEGREES.

DURING ATP AT ROCKWELL-DOWNEY, THE TYPE IV BALL VALVE EXHIBITED EXCESSIVE OUTLET-TO-INLET LEAKAGE AT LH2 TEMPERATURES (REFERENCE CAR AD1422). THE LEAKAGE WAS DUE TO HIGH POROSITY OF THE VALVE BODY (A356 ALUMINUM) AT THE BALL SEAL BODY CONTACT AREA. CORRECTIVE ACTION WAS TO IMPLEMENT A HOT ISOSTATIC PRESSING (HIP) PROCESS WHICH REDUCES THE POROSITY OF THE PAREN METAL. THE PROBLEM IS ATP SCREENABLE DURING THE HYDROGEN ATP. OV103 AND OV104 BALL VALVES (LH2 ATPped BUT NOT HIPped) HAVE EXHIBITED NO LEAKAGE. THE OV102 VALVES WERE NOT ACCEPTANCE TESTED WITH LH2. THE OV102 LH2 VALVES ARE SCHEDULED FOR REMOVAL AND REWORK FOR OTHER DESIGN CHANGES.

DURING ATP, THE INLET TO OUTLET LEAKAGE AT CRYO TEMPERATURES EXCEEDED THE LEAKAGE REQUIREMENT (REFERENCE CAR A6441). DURING DISASSEMBLY, IT WAS NOTED THAT THE TORQUE ON THE BALL SEAL ASSEMBLY RETAINER WAS LOW. THE RETAINER WAS RETORQUED AND THE VALVE WAS RETESTED AT CRYO TEMPERATURES AND LEAKAGE REQUIREMENTS WERE MET. ASSEMBLY PROCEDURES WERE CHANGED TO INCORPORATE AN INSPECTION POINT TO VERIFY PROPER RETAINER TORQUE.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

DURING ATP CRYO TESTS, LEAKAGE PAST THE BALL SEAL WAS NOT WITHIN THE LEAKAGE REQUIREMENTS (REF CAR A5402). DIS-ASSEMBLY OF THE VALVE SHOWED NO OBVIOUS LEAK PATHS. THE ATP WAS REVISED TO ESTABLISH A ONE HOUR COLD SOAK STABILIZATION TIME PRIOR TO FUNCTIONAL TESTING. ALSO, THE PROCEDURES WERE ESTABLISHED TO OBTAIN CORRECT SEAL LOADING DURING ASSEMBLY. THE VALVE HAS BEEN REDESIGNED AND THIS SEAL CONFIGURATION IS NO LONGER IN USE.

DURING ATP, THE INLET-TO-OUTLET LEAKAGE (125 AND 162 SCIM - MAX ALLOWABLE 100 SCIM) EXCEEDED THE REQUIREMENT ON TWO VALVES (REF CAR A9672). DUE TO MPTA TEST SCHEDULE DEMANDS, BOTH VALVES WERE WAIVED AND APPROVED FOR MPTA TESTING. NO FAILURE ANALYSIS WAS PERFORMED ON EITHER VALVE.

DURING ATP, THE INLET-TO-OUTLET LEAKAGE (820 SCIM - MAX ALLOWABLE 400 SCIM) EXCEEDED THE REQUIREMENT (REF CAR A8502). ALSO, THE RELIEF VALVE FLOW REQUIREMENTS WERE NOT MET. DUE TO MPTA TEST SCHEDULE DEMANDS, THE VALVE WAS WAIVED AND APPROVED FOR MPTA TESTING. NO FAILURE ANALYSIS WAS PERFORMED.

DURING ATP, EXCESSIVE INLET-TO-OUTLET LEAKAGE ON TWO VALVES OCCURRED AT CRYO TEMPERATURES (REF CARs AC6753 AND AC5201). THE VALVES WERE DISASSEMBLED AND THE BALL SEAL REVEALED HAIRLINE CRACKS AT SEVERAL POINTS ON THE INNER DIAMETER. TESTING INDICATED THAT THE CRACKS WERE CAUSED BY THE GEOMETRY OF THE BALL SEAL. THE BALL SEAL WAS REDESIGNED TO INCORPORATE A LARGER INNER DIAMETER; THE VALVE PASSED SUBSEQUENT LEAKAGE TESTS. THIS DESIGN CHANGE WAS INCORPORATED ON ALL FIVE BALL VALVE CONFIGURATIONS.

DURING LEAK TEST AT KSC, THE RTLS INBOARD DUMP VALVE LEAKED INTERNALLY (REFERENCE CAR A85689). LEAKAGE WAS DUE TO CONTAMINATION ON THE RELIEF VALVE POPPET. THE VALVE WAS REPLACED AND SUBSEQUENTLY PASSED THE VEHICLE LEAK CHECK REQUIREMENTS.

FAILS TO REMAIN CLOSED:

THERE HAVE BEEN NO FAILURES OF THE VALVE TO REMAIN CLOSED.

THE FOLLOWING ACTUATOR LEAKAGE FAILURES HAVE OCCURRED WHICH MAY CAUSE FAILURE OF THE VALVE TO REMAIN CLOSED:

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.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

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.

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 WHILE THE VALVE WAS IN THE OPEN POSITION. 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.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

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.

FAILS TO CLOSE:

A FAILURE OF THE VALVE TO CLOSE OCCURRED DURING QUALIFICATION TESTING (REFERENCE CAR AC1189). THE CAUSE WAS INTERFERENCE DUE TO THE OVERSIZED DIAMETER OF THE PISTON GUIDE RING GROOVE. THE DESIGN WAS CHANGED (THE GROOVE DIAMETER WAS REDUCED) TO ELIMINATE THE PROBLEM.

A FAILURE AT NSTL OF A VALVE TO ACTUATE WAS CAUSED BY BINDING OF THE ALUMINUM BRONZE BUSHING TO THE SHAFT. AN MCR AUTHORIZED DRAWING CHANGES TO TEFLON COAT AND POLISH THE SHAFT (REFERENCE CAR A7950).

GENERAL SYSTEM CONTAMINATION

THIS FAILURE MODE HAS NOT OCCURRED ON THIS COMPONENT DUE TO CONTAMINATION. HOWEVER, GENERAL MPS SYSTEM CONTAMINATION HAS OCCURRED WHICH MAY LODGE ANYWHERE IN THE SYSTEM CAUSING THIS FAILURE MODE (REFERENCE THE FOLLOWING PARAGRAPHS).

CONTAMINATION FAILURES HAVE OCCURRED AT ALL PHASES OF MANUFACTURING AND PARTS REPLACEMENT. IN ALL CASES, STRICT ADHERENCE TO CLEANLINESS CONTROL PROCEDURES IS THE PRIMARY METHOD OF CONTAMINATION PREVENTION.

NUMEROUS LARGE PARTICLES OF BLACK RUBBER MATERIAL WERE FOUND DURING A POST FLIGHT EXAMINATION OF THE LH2 17 INCH DISCONNECT OF OV099 (FLIGHT 7, REFERENCE CAR AC9800). THE LO2 AND LH2 SYSTEMS OF ALL VEHICLES WERE EXAMINED. NO RUBBER WAS FOUND IN ANY OTHER VEHICLES. AFTER EXTENSIVE INVESTIGATION THE ORIGIN WAS NOT DETERMINED.

METAL SHAVINGS HAVE BEEN DISCOVERED IN LINES AND COMPONENTS, WHICH WAS MOST LIKELY GENERATED WHEN THEY WERE CUT OUT AND/OR REPLACED (REFERENCE CARs AC9868, A9654, AC2210, AB1706; DR AD2226). METHODS ARE BEING REVISED TO MINIMIZE PARTICLE GENERATION WHEN INSTALLING/REPLACING COMPONENTS, LINES, AND FITTINGS REQUIRING WELDED OR BRAZED JOINTS (PRODUCT QUALITY IMPROVEMENT COUNCIL). PERSONNEL HAVE BEEN CAUTIONED. ROCKWELL PROBLEM ACTION CENTER WILL CONTINUE TO MONITOR BRAZING/WELDING REWORK CONTAMINATION. PROCEDURES ARE BEING REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : MAIN PROPULSION

FMEA NO 03-1 -0452 -2

REV:05/04/88

A PIECE OF A BRAZING PREFORM LODGED IN A 2-WAY SOLENOID VALVE ON OV-099 AT PALMDALE CAUSING A LEAKAGE FAILURE (REFERENCE CARs AC2111, AB2538). STEEL AND ALUMINUM PARTICLES CAUSED EXCESSIVE LEAKAGE ON THE 850 PSIG HELIUM RELIEF VALVE (REF CAR AC2239). FOR BOTH FAILURES CORRECTIVE ACTION WAS TO ADD SPECIAL PURGE PORTS TO THE MPS HELIUM PANEL ASSEMBLIES TO IMPROVE THE QUALITY OF FINAL CLOSEOUT BRAZES.

SEVERAL FOREIGN MATERIALS WERE INTRODUCED INTO THE MPS SYSTEM DURING MANUFACTURE AND PARTS REPLACEMENT. EXAMPLES ARE: GLASS CLOTH IN LINE TO PREVENT TRAVEL OF CHIPS DOWN LINE; POLYSTYRENE OBJECT TO HOLD VALVE POPPET OPEN WHILE PURGING; COTTON SWAB MATERIAL AND GLASS BEADS FROM CLEANING OPERATION; MISCELLANEOUS PLASTIC; FOAM; AND TAPE (REFERENCE CAR AB4751, AC2217, AC6768, AC9868, MPS3A0005, AC7912, AB0530). MATERIALS WERE REMOVED AND PERSONNEL WERE CAUTIONED. A HIGH FLOW DELTA P TEST AT PALMDALE WAS ADDED TO VERIFY THAT LINES WERE NOT PLUGGED. GRIT BLASTING (GLASS BEADS AND SAND USED TO CLEAN A LINE) IS NO LONGER PERFORMED. PROCEDURES ARE BEING REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

ONE PIECE OF WIRE WAS FOUND IN THE INTERNAL RELIEF VALVE OF THE LO2 PREVALVE ON OV103 (REFERENCE CAR AC9101). THE SOURCE OF THE CONTAMINATION WAS NEVER FOUND, BUT IT WAS BELIEVED TO BE FROM THE ET. OTHER CONTAMINATION HAS BEEN FOUND ON THE FEEDLINE SCREENS, SUCH AS AN UNIDENTIFIED ROUND OBJECT AND VARIOUS METALLIC PARTICLES (REFERENCE CARs AB0529 AND AB0530). SOURCE OF CONTAMINATION WAS UNDETERMINED. BORESCOP EXAMINATIONS ARE CONDUCTED ON ALL FEEDLINE SCREENS EVERY FIFTH FLIGHT TO VERIFY CLEANLINESS. CONTAMINATION WAS REMOVED WHEN POSSIBLE.

(E) OPERATIONAL USE
NO ACTION CAN BE TAKEN.