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PRINT DATE: 05/11/95

FAILURE MODES EFFECTS ANALYSIS (FMEA) - CRITICAL HARDWARE
NUMBER: 03-1-0431 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 09/23/94

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
LRU	: VALVE, BALL (TYPE 3) EATON CONSOLIDATED CONTROLS	MC284-0395-0053 1440-511

PART DATA

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE, LH2 HIGH POINT BLEED 1.5 INCH. NORMALLY CLOSED, PNEUMATICALLY
ACTUATED OPEN. INCORPORATES RELIEF VALVE.

REFERENCE DESIGNATORS: PV22

QUANTITY OF LIKE ITEMS: 1
ONE

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 AT THE START OF 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.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : MAIN PROPULSION FMEA NO 03-1 -0431 -10 REV: 05/03/8

ASSEMBLY : EATON CONSOL. CNTLS	CRIT. FUNC: 1R
P/N RI : MC284-0395-0053	CRIT. HDW: 2
P/N VENDOR:	VEHICLE 102 103 10
QUANTITY : 1	EFFECTIVITY: X X X
: ONE	PHASE(S): PL LO X OO DO LS

PREPARED BY:	REDUNDANCY SCREEN: A-PASS B-FAIL C-PASS	APPROVED BY (NASA):
DES J E OSLUND	DES <u>HPBafford</u>	SSM <u>[Signature]</u>
REL L H FINEBERG	REL <u>LASCOE</u>	REL <u>[Signature]</u>
QE E M GUTIERREZ	QE <u>[Signature]</u>	QE <u>[Signature]</u>

ITEM:

VALVE, GH2 HIGH PT BLEED 1.5 INCH. NORMALLY CLOSED, PNEUMATICALLY ACTUATED OPEN. INCORPORATES RELIEF VALVE. (FV22)

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 AT THE START OF FAST FILL TO BLEED OFF ANY GH2 ACCUMULATED IN THE FEEDLINE DURING LOADING OPERATIONS. VALVE IS CLOSED APPROXIMATELY TWENTY SECONDS PRIOR TO LIFTOFF. THE VALVE IS MANUALLY OPENED FOR FIRST VACUUM INERT (WIRED TO THE LH2 INBOARD FILL & DRAIN [PV12] COCKPIT SWITCH). 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.

FAILURE MODE:

RELIEF VALVE FAILS TO RESEAT DURING ASCENT.

CAUSE(S):

PIECE PART STRUCTURAL FAILURE, BINDING, CONTAMINATION.

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM :MAIN PROPULSION

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EFFECT(S) ON:

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

(A,B) NO EFFECT FIRST FAILURE. LH2 WILL ENTER THE BLEED LINE AND WILL NOT LEAK OVERBOARD SINCE THE LH2 BLEED DISCONNECT (PD17) WILL BE CLOSED. THE BLEED LINE CAN WITHSTAND ACCELERATION LOADS WITH LH2 PRESENT. LCC REQUIRES VALVE TO BE CLOSED AT T-10 SECONDS (ONE TIME VERIFICATION).

FAILS B SCREEN BECAUSE RELIEF VALVE LEAKAGE IS UNDETECTABLE IN FLIGHT AND THERE IS NO INSTRUMENTATION IN THE BLEED LINE.

PASSES C SCREEN BECAUSE CONTAMINATION CANNOT BE USED AS A COMMON CAUSE FOR THE DISCONNECT (PD17) FAILURE TO CLOSE AND THE HIGH POINT BLEED RELIEF VALVE (PV22) FAILURE TO RESEAT (BLEED LINE PRESSURE WILL NOT INCREASE TO RELIEF VALVE CRACKING PRESSURE WHEN DISCONNECT FAILS TO CLOSE). REFERENCE FMEA/CIL 0432-2.

(C,D) NO EFFECT.

(E) FUNCTIONAL CRITICALITY EFFECTS

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

- 1) HIGH POINT BLEED (PV22) RELIEF VALVE FAILS TO RESEAT.
- 2) LH2 BLEED DISCONNECT (PD17) FAILS TO REMAIN CLOSED.

LH2 WILL DUMP OVERBOARD RESULTING IN LOSS OF PROPELLANT. FIRE/EXPLOSIVE HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CREW/VEHICLE.

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

- 1) HIGH POINT BLEED (PV22) RELIEF VALVE FAILS TO RESEAT.
- 2) LH2 BLEED LINE BETWEEN PV22 AND PD17 RUPTURE/LEAKAGE.

LH2 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

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DISPOSITION & RATIONALE:

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

(A) DESIGN

INTERNAL LEAKAGE CAN OCCUR DUE TO ENTRAPMENT OF CONTAMINANT PARTICLES BETWEEN THE RELIEF VALVE POPPET AND SEAT. HOWEVER, SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN ET SCREEN, A GSE DEBRIS PLATE, AND A GSE FILTER.

THE RELIEF VALVE WILL RELIEVE AND RESEAT IN THE RANGE OF 15 TO 40 PSID WITH A MAXIMUM FLOWRATE OF 1 POUND PER SECOND OF LO2. 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.

(B) TEST

ATP

EXAMINATION OF PRODUCT

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

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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
ACTUATOR: 740 PSIG

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

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

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

ELECTRICAL BONDING - LESS THAN 100 MILLIOHMS

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

OMRSD

V41AYO.140 LH2 PROPELLANT SYSTEM DECAY (EVERY FLT)
V41BFO.090 LH2 HI PT BLEED VALVE (PV22) SEAT LEAK TEST (EVERY FLT)
V41BHO.090 LH2 HI PT BLEED VALVE (PV22) RELIEF VALVE FUNCTIONAL (I10)
V41BUO.161 LH2 FEEDLINE SCREEN INSPECTION (I5)
V41BUO.163 LH2 FEEDLINE SCREEN INSPECTION - VERTICAL (I25)

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(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.

PACKAGING/HANDLING

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

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(D) FAILURE HISTORY

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 PARENT 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 LEAK TEST AT KSC, THE RTLS INBOARD DUMP VALVE LEAKED INTERNALLY (REFERENCE CAR AB5689). LEAKAGE WAS DUE TO CONTAMINATION ON THE RELIEF VALVE POPPET. THE VALVE WAS REPLACED AND SUBSEQUENTLY PASSED THE VEHICLE LEAK CHECK REQUIREMENTS.

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 MAINTENENCE PROCEDURES HAVE BEEN IMPROVED.

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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 AC2229). 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 CARs 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. BORESCOPE 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.