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 -9 REV:05/03/88F

ASSEMBLY :EATON CONSOL. CNTLS
P/N RI :MC284-0395-0053
P/N VENDOR:
QUANTITY :1
:ONE
:

CRIT. FUNC: 1
CRIT. HDW: 1

VEHICLE EFFECTIVITY:	102	103	104
	X	X	X

PHASE(S): PL X LO X OO DO LS

REDUNDANCY SCREEN: A- B- C-

PREPARED BY:		APPROVED BY:		APPROVED BY (NASA)	
DES	J E OSLUND	DES	H P Safford	SSM	
REL	L H FINEBERG	REL	L H Coe for R A	REL	
QE	E M GUTIERREZ	QE	B. Williams	QE	

ITEM:
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FAILURE MODE:
ERRONEOUS INDICATION.
VALVE OPEN, CLOSED POSITION INDICATION ON DURING TERMINAL COUNT.

CAUSE(S):
PIECE-PART STRUCTURAL FAILURE OF THE VALVE, BINDING, CONTAMINATION.

SUBSYSTEM :MAIN PROPULSION FMEA NO 03-1 -0431 -9 REV:05/03/88

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

(A,B) LCC REQUIREMENT FOR HIGH POINT BLEED VALVE TO BE VERIFIED CLOSED AT T-10 SECONDS WOULD BE SATISFIED. POSITION INDICATOR HAS SUFFICIENT DEADBAND TO ALLOW A CLOSED INDICATION WHEN THE VALVE IS NOT FULLY CLOSED. FAILURE WILL RESULT IN CONTINUED BLEED FLOW DURING T-0 UMBILICAL SEPARATION. BLEED DISCONNECT (PD17) IS NOT CERTIFIED FOR CLOSURE UNDER FLOW CONDITIONS AND CANNOT BE CONSIDERED AS A REDUNDANCY AGAINST OVERBOARD LEAKAGE. POSSIBLE RUPTURE OF DISCONNECT HOUSING AND/OR DOWNSTREAM BLEED SYSTEM DUE TO WATER HAMMER.

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

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

(C,D) POSSIBLE LOSS OF CREW/VEHICLE.

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

(A) DESIGN
THE VALVE ACTUATOR IS SPRING LOADED TO THE CLOSED POSITION. THE ACTUATOR PISTON DRIVES A SPRING LOADED RACK WHICH, IN TURN, DRIVES A PINION GEAR, THE SHAFT OF WHICH ROTATES THE VALVE BALL (CLOSURE). THE SPRING IS MANUFACTURED FROM 0.177 INCH DIAMETER ELGILOY WIRE AND HAS A SPRING RATE OF 96 POUNDS PER INCH. IN THE INSTALLED POSITION, WITH THE ACTUATOR VENTED, THE SPRING EXERTS A FORCE OF 275 POUNDS. IF THE SPRING SHOULD BREAK WITH THE VALVE CLOSED, THE INTERNAL FRICTION OF THE ACTUATOR AND VALVE WOULD PREVENT THE VALVE FROM LEAVING THE CLOSED POSITION.

PRESSURE LOADS ON THE VALVE BALL, FROM EITHER DIRECTION, ARE EVENLY DISTRIBUTED AND WOULD NOT TEND TO OPEN THE VALVE. THE RACK AND PINION ARE OF INCONEL 718 AND THE PINION GEAR/SHAFT IS MACHINED FROM A SINGLE PIECE OF STOCK. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATIONS; FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

VALVE CLOSE POSITION INDICATES PRIOR TO FULL TRAVEL OF VALVE BALL. VALVE BINDING (THAT OCCURS DURING FINAL CLOSURE MOTION) OR INTERNAL SYSTEM CONTAMINATION PREVENTING BALL MOVEMENT WILL RESULT IN AN ERRONEOUS INDICATION. SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN ET SCREEN, A GSE DEBRIS PLATE, AND A GSE FILTER.

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.

FACTORS OF SAFETY FOR INTERNAL PRESSURE: PROOF - 1.5 BODY, 2.0 ACTUATOR; BURST - 2.0 BODY, 4.0 ACTUATOR.

(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

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 CYLE 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
V41AY0.140 LH2 PROPELLANT SYSTEM DECAY (EVERY FLIGHT)
V41BF0.090 LH2 HI POINT BLEED VALVE (PV22) SEAT LEAK TEST (EVERY FLIGHT)
V41BH0.090 LH2 HI POINT BLEED VALVE (PV22) RELIEF VALVE FUNCTIONAL (I10)
V41BU0.161 LH2 FEEDLINE SCREEN INSPECTION (I5)
V41BU0.163 LH2 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 VERIFED 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 VERIFED 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.

(D) FAILURE HISTORY

THERE HAVE BEEN NO ACCEPTANCE TEST, QUALIFICATION TEST, FIELD OR FLIGHT FAILURES ASSOCIATED WITH THIS FAILURE MODE.

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 MAINTENENCE PROCEDURES HAVE BEEN IMPROVED.

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 MAINTENENCE 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.