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 -5 REV:04/21/88F

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 LO X OO	DO	LS	

REDUNDANCY SCREEN: A- B- C-

PREPARED BY:		APPROVED BY:		APPROVED BY (NASA):	
DES	J E OSLUND	DES	H P Bafford	SSM	
REL	L H FINEBERG	REL		REL	
QE	E M GUTIERREZ	QE		QE	

ITEM:
VALVE, GH2 HIGH PT BLEED 1.5 INCH. NORMALLY CLOSED, PNEUMATICALLY ACTUATED OPEN. INCORPORATES RELIEF VALVE. (PV22)

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
FAILS TO RELIEVE DURING ASCENT.

CAUSE(S):
BINDING.

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

(A,B) AFTER BLEED VALVE CLOSURE BLEED LINE IS DRAINED BY GRAVITY. SOME FLUID WILL REMAIN AT LIFTOFF. PRESSURE BUILDUP OF TRAPPED PROPELLANT IN THE LINE BETWEEN PV22 AND PD17 MAY RESULT IN RUPTURE OF THE HIGH POINT BLEED VALVE (PV22), BLEED LINE, OR BLEED DISCONNECT (PD17).

CASE I: RUPTURE OF THE HIGH POINT BLEED VALVE.

CAUSES 230 POUNDS OF LH2 LEAKAGE IN THE AFT COMPARTMENT FROM THE FEED MANIFOLD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. FIRE/EXPLOSION HAZARD IN THE AFT COMPARTMENT. THIS WILL NOT EFFECT ENGINE INLET CONDITIONS OR CAUSE LOW LEVEL CUTOFF.

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

CASE II: RUPTURE OF THE BLEED LINE AND/OR DISCONNECT.

CAUSES LIMITED (PROPELLANT TRAPPED BETWEEN PV22 AND PD17) LH2 LEAKAGE INTO THE AFT COMPARTMENT OR OVERBOARD. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE FIRE/EXPLOSION HAZARD BOTH INTERIOR AND EXTERIOR TO THE VEHICLE.

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

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

(A) DESIGN

THE RELIEF VALVE WILL RELIEVE AND RESEAT IN THE RANGE OF 15 TO 40 PSID WITH A MAXIMUM FLOWRATE OF 1 POUND PER SECOND. IF BLEED LINE PRESSURE INCREASES ABOVE 40 PSID, SOME FLOW PAST THE BALL SEAL WILL OCCUR.

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

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
V41BH0.090 LH2 HI PT BLEED VALVE RELIEF VALVE FUNCTIONAL (I10)

(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

DURING ATP AT THE SUPPLIER, RELIEF VALVE FAILED TO RELIEVE UP TO 55 PSIG. ISOLATED FAILURE COULD NOT BE REPEATED. CAUSE NOT DETERMINED. TEST CONFIGURATION OR OPERATOR ERROR ARE SUSPECTED (REFERENCE CAR AC7729).

AT KSC, THE RELIEF VALVE DID NOT CRACK AT 49 PSIG (MAX ALLOWABLE 40 PSIG). VALVE WAS RETURNED TO THE SUPPLIER AND FAILURE WAS VERIFIED AT AMBIENT CONDITIONS BUT PASSED AT CRYO TEMPERATURES. FAILURE WAS DETERMINED TO BE DUE TO THE RELIEF VALVE POPPET BINDING ON A MACHINED RIDGE. CORRECTIVE ACTION WAS TO REMACHINE AND LAP THE AFFECTED SURFACES AT THE SUPPLIER. ALSO, THE ASSEMBLY PROCEDURE WAS CHANGED TO ASSURE PROPER PREPARATION OF THE RELIEF VALVE SEAT (REFERENCE CARs AC8603).

(E) OPERATIONAL USE
NO CREW ACTION CAN BE TAKEN.