

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0436 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 2 07/27/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: VALVE, RELIEF UNITED SPACE ALLIANCE - NSLD	MC284-0501-0002 5760074-101

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, RELIEF, 1 INCH, LH2 FEEDLINE MANIFOLD RELIEF.

REFERENCE DESIGNATORS: RV6**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

RELIEVES PRESSURE BUILDUP FROM LH2 MANIFOLD. THE VALVE INLET IS ISOLATED FROM THE FEED SYSTEM UNTIL MECO BY THE UPSTREAM FEEDLINE RELIEF SHUTOFF VALVE (PV8). THE RELIEF VALVE INCORPORATES A SENSE PORT WHICH SENSES THE LH2 MANIFOLD PRESSURE VIA A SENSE LINE. THE CRACKING AND RESEAT PRESSURES ARE BETWEEN 40 & 55 PSIG.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0436-02

REVISION#: 1 07/27/00

SUBSYSTEM NAME: MAIN PROPULSION

LRU: VALVE, RELIEF

CRITICALITY OF THIS

ITEM NAME: LH2 FEEDLINE MANIFOLD RELIEF VALVE (RV6)

FAILURE MODE: 1R2

FAILURE MODE:

FAILS TO REMAIN CLOSED/INTERNAL LEAKAGE THROUGH MAIN POPPET

MISSION PHASE:

PL PRE-LAUNCH
LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA
103 DISCOVERY
104 ATLANTIS
105 ENDEAVOUR

CAUSE:

PIECE PART STRUCTURAL FAILURE, BINDING, CONTAMINATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTLS RETURN TO LAUNCH SITE
TAL TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN

A) PASS
B) N/A
C) PASS

PASS/FAIL RATIONALE:

A)

B)

RELIEF VALVE IS STANDBY REDUNDANT TO MANIFOLD RELIEF SHUTOFF VALVE LEAKAGE.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

PRIOR TO MECO, LOSS OF REDUNDANCY AGAINST LH2 OVERBOARD LEAKAGE. RELIEF VALVE ISOLATED BY RELIEF SHUTOFF VALVE (PV8) UNTIL MECO.

POST MECO, WILL RESULT IN THE LOSS OF GHE SUPPLY DURING MANIFOLD REPRESSURIZATION AND LOSS OF AFT COMPARTMENT PURGE.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02**

ON RTLS OR TAL ABORTS LEAKAGE OF LH2 RESIDUALS IS A FIRE/EXPLOSION HAZARD EXTERNAL TO THE VEHICLE. POSSIBLE LOSS OF CREW/VEHICLE.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

LOSS OF GHE SUPPLY HAS NO EFFECT (RESULTS IN POSSIBLE SYSTEM CONTAMINATION DURING REENTRY).

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

1R/2 2 SUCCESS PATHS. TIME FRAME - PRELAUNCH.

- 1) RELIEF VALVE (RV6) FAILS TO REMAIN CLOSED.
- 2) SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED/LEAKS.

LH2 WILL DUMP OVERBOARD RESULTING IN PROPELLANT LEAKAGE ON TO THE PAD SURFACE. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE AND ON THE PAD. FIRE AND/OR LEAKAGE MAY BE DETECTABLE USING TV CAMERAS AND FIRE DETECTOR SENSORS. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2:

1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT (PRE MECO).

- 1) RELIEF VALVE (RV6) FAILS TO REMAIN CLOSED.
- 2) SHUTOFF VALVE (PV8) FAILS TO REMAIN CLOSED/LEAKS.

LH2 WILL DUMP OVERBOARD (640 POUNDS MAXIMUM) RESULTING IN LOSS OF PROPELLANT. FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE RELIEF VALVE CONSISTS OF TWO SECTIONS: A PRESSURE ACTUATED MAIN POPPET SECTION AND A PILOT SECTION WHICH SENSES MANIFOLD PRESSURE BY MEANS OF A SENSING LINE.

THE PILOT SECTION CONTROLS THE OPENING AND CLOSING OF THE MAIN POPPET BY ALLOWING THE MANIFOLD PRESSURE TO ENTER OR EXIT A CONTROL CHAMBER. WHEN

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02

THE MANIFOLD PRESSURE REACHES A PREDETERMINED PILOT SETTING, THE PILOT VENTS THE CHAMBER PRESSURE OVERBOARD ALLOWING THE PRESSURE DIFFERENTIAL ACROSS THE MAIN POPPET TO PUSH THE MAIN POPPET OPEN. ONCE THE MANIFOLD PRESSURE DROPS BELOW THE PILOT CONTROL SETTING, THE PILOT POPPET CLOSES, THE MANIFOLD PRESSURE ENTERS THE CONTROL CHAMBER, AND THE MAIN POPPET CLOSES.

THE FOLLOWING COMPONENTS MAY CAUSE A FAILURE TO RESEAT/REMAIN CLOSED OR LEAKAGE DUE TO STRUCTURAL FAILURE: MAIN POPPET PUSH ROD, MAIN POPPET SEAT, MAIN POPPET SEAL ASSEMBLY, MACHINED SPRING, STOP SPRING, STOP, PUSH ROD, PILOT POPPET SPRING, PILOT POPPET, PILOT SEAT, PILOT SEAT RETAINER, MAIN BELLOWS, MAIN SEAL, MAIN SEAT, PILOT SEAT ASSEMBLY SEAL, AND PILOT SEAT ASSEMBLY SEAL SPRING.

THE MAIN SEAL IS RULON-A, LAPPED TO A TWO MICROINCH SURFACE FINISH, AND COMPLETELY RETAINED BETWEEN THE MAIN POPPET SEAL RETAINER AND THE MAIN POPPET CAP.

THE MAIN SEAT IS CRES (PH 13-8 MO) PASSIVATED. THE SEALING SURFACE IS LAPPED TO A FOUR MICROINCH SURFACE FINISH.

THE MAIN POPPET PUSH ROD IS CONSTRUCTED OF PASSIVATED INCONEL 718.

THE MACHINED SPRING CONTROLS THE CRACKING PRESSURE. IT IS OF INCONEL 718, HEAT TREATED AND PASSIVATED.

THE STOP SPRING PRELOADS THE PILOT STOP. IT IS A BELLEVILLE SPRING OF HEAT TREATED INCONEL 718.

THE STOP PRELOADS THE INSIDE DIAMETER OF THE STOP SPRING. THE STOP IS CRES PH 15-5, HEAT TREATED AND PASSIVATED.

THE PUSH ROD PRELOADS THE PILOT POPPET SPRING. THE PUSH ROD IS A286 CRES, HEAT TREATED AND PASSIVATED.

THE PILOT POPPET SPRING IS THE RETURN SPRING FOR THE PILOT POPPET. THE SPRING IS OF ELGILOY 54-71A AND HEAT TREATED.

THE PILOT POPPET IS THE FLOW CONTROL DEVICE FOR THE PILOT VALVE, IT IS CRES PH 13-8 MO, HEAT TREATED AND PASSIVATED.

THE PILOT SEAT IS TEFLON (TFE).

THE PILOT SEAT RETAINER RETAINS THE PILOT SEAT IN THE PILOT SEAT ASSEMBLY. IT IS OF 6051-T651 ALUMINUM ALLOY. THE PILOT SEAT RETAINER IS TORQUED, STRESS RELIEVED, AND RETORQUED.

THE PILOT BELLOWS (2 PLY) AND MAIN BELLOWS (3 PLY) ARE SIMILAR IN CONSTRUCTION AND OF THE SAME MATERIAL. BOTH BELLOWS ASSEMBLIES CONSIST OF 3 PARTS; THE FLANGE, A BELLOWS, AND A CAP; ALL OF INCONEL 625 AND PASSIVATED. THE SEAMS OF THE BELLOWS ARE FUSION WELDED (FULL PENETRATION). THE FLANGE AND CAP ARE FUSION WELDED TO THE BELLOWS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02**

EACH BELLOWS ASSEMBLY IS TESTED FOR PROOF PRESSURE AND LEAKAGE BEFORE BEING ASSEMBLED INTO A RELIEF VALVE. THE MAIN BELLOWS ASSEMBLY IS THEN ELECTRON BEAM WELDED TO THE MIDDLE HOUSING ASSEMBLY. THE WELD IS DYE PENETRANT INSPECTED, PROOF PRESSURE TESTED, AND LEAK TESTED.

THE MAIN SEAL IS RULON-A, LAPPED TO A TWO MICRO INCH SURFACE FINISH, AND COMPLETELY RETAINED BETWEEN THE MAIN POPPET SEAL RETAINER AND THE MAIN POPPET CAP.

THE MAIN SEAT IS CRES (PH 13-8 MO) PASSIVATED. THE SEALING SURFACE IS LAPPED TO A FOUR MICRO INCH SURFACE FINISH.

THE PILOT SEAT ASSEMBLY SEAL PREVENTS INTERNAL LEAKAGE FROM THE PILOT CAVITY BETWEEN THE PILOT SEAT ASSEMBLY AND THE HOUSING. THE "V" SEAL IS A TEFLON JACKETED INCONEL 718 SPRING.

THE PILOT SEAT ASSEMBLY SEAL SPRING PRELOADS THE PILOT SEAT ASSEMBLY AGAINST THE PILOT SEAT ASSEMBLY SEAL. IT IS A BELLEVILLE SPRING OF 302 CRES AND PASSIVATED.

TWO COMPONENTS MAY CAUSE A FAILURE TO RESEAT DUE TO BINDING: THE MAIN POPPET ACTUATING ROD AND THE PILOT SPRING-SEAT. THE MAIN POPPET ACTUATING ROD TRANSFERS FORCE FROM THE MAIN BELLOWS TO THE MAIN POPPET. THE SPRING-SEAT PULLS THE PILOT POPPET COMPLETELY OPEN (WHICH DUMPS PILOT PRESSURE TO ALLOW FULL FLOW THROUGH THE VALVE) BY EQUALIZING THE PRESSURE WITHIN THE MAIN BELLOWS WITH THAT OF THE FEEDLINE, AS SENSED BY THE PILOT BELLOWS. FAILURE OF THE SPRING SEAT TO RETURN WILL PREVENT THE PILOT POPPET FROM SEATING CAUSING FAILURE OF THE MAIN POPPET TO RESEAT.

THE MAIN POPPET ACTUATING ROD PASSES THROUGH A HOLE IN THE THERMAL ISOLATOR. THE THERMAL ISOLATOR IS VESPEL SP-21. THE HOLE IS OVER SEVEN DIAMETERS IN LENGTH, PRECLUDING COCKING. THE ROD IS INCONEL 718 AND PASSIVATED. THE CENTER SECTION IS SMALLER IN DIAMETER THAN THE ENDS TO REDUCE CONTACT AREA, PRECLUDING BINDING DUE TO CONTAMINANT PARTICLES TRAPPED BETWEEN THE ROD AND ISOLATOR. THE CONTACT SURFACE HAS A 16 MICRO INCH FINISH WHICH MATES SMOOTHLY WITH THE THERMAL ISOLATOR.

THE SEAT-SPRING SLIDES SMOOTHLY AND FREELY WITHIN THE BORE OF THE RETAINER. THE RETAINER IS CRES (PH 13-8 MO), HEAT TREATED AND PASSIVATED. ITS BORE IS APPROXIMATELY ONE DIAMETER IN LENGTH AND HAS A 16 MICRO INCH SURFACE FINISH. THE SPRING-SEAT IS 304 CRES AND PASSIVATED. THE UPPER AND LOWER CIRCUMFERENTIAL CONTACT SURFACES ARE POLISHED TO A 16 MICRO INCH FINISH.

SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN ET SCREEN, A GSE DEBRIS PLATE, AND A GSE FILTER.

STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATIONS.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02**

(B) TEST:

ATP

VISUAL INSPECTION

STROKE VERIFICATION OF MAIN POPPET (0.225 +/- 0.002 INCH)

AMBIENT TEST

PROOF PRESS: VALVE BODY, 110 PSIG INLET & SENSE PORT, 300 PSIG OUTLET

INTERNAL LEAKAGE:

1 TO 35 PSIG GHE AT INLET AND SENSE PORT

10 SCIM MAX AT OUTLET PORT

EXTERNAL LEAKAGE: 55 PSIG GHE; 5 SCIM MAX

CRACK/RESEAT: 40 TO 55 PSIG

REVERSE FLOW LEAKAGE:

10 PSID GHE OUTLET TO INLET

MAIN SEAT LEAKAGE 50 SCIM MAX

PILOT REVERSE LEAKAGE 1700 SCIM MAX.

CRYOGENIC TEST (GHE AT -300 DEG F):

CRACK/RESEAT: 40 TO 55 PSIG, VALVE BODY AMBIENT

EXTERNAL LEAKAGE: 55 PSIG, 10 SCIM MAX, VALVE BODY -100 DEG F

INTERNAL LEAKAGE: 35 PSIG, 10 SCIM MAX, VALVE BODY -100 DEG F

CERTIFICATION

LIFE TEST

CRYO - 4500 CYCLES OPEN AND CLOSED USING LN2, VALVE CHECKED FOR INTERNAL LEAKAGE AFTER EACH 500 CYCLES, VALVE CHECKED FOR CRYO INTERNAL LEAKAGE AFTER EACH 1500 CYCLES.

AMBIENT - 500 CYCLES, VALVE INTERNAL LEAK CHECK EACH 50 CYCLES.

CRYO STEADY STATE FLOW TEST

SENSES PORT PRESS AT 65 PSIG GHE AT -412 DEG F

FLOW RATE OF 272 GPM LH2 AT 23 PSID

CRYO RESPONSE TEST

1.5 SEC TO INDICATE STEADY FLOW AFTER CRACKING WITH LH2

CRYO FUNCTIONAL TEST USING LH2

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02**

CRACKED AT 51 PSIG; RESEAT AT 44 PSIG

RANDOM VIBRATION 13.3 HOURS IN EACH OF THE THREE AXES

FIRST 4 HOUR AND 26 MINUTE PERIOD
ENVIRONMENT: AMBIENT
SENSE PORT: 35 PSIG GHE AT -425 DEG F
MAIN INLET: AMBIENT

SECOND 4 HOUR AND 26 MINUTE PERIOD
ENVIRONMENT: AMBIENT TO +100 TO -100 TO AMBIENT
SENSE PORT: 35 PSIG GHE AT -425 DEG F
MAIN INLET: 35 PSIG GHE AT -425 DEG F

THIRD 4 HOUR AND 26 MINUTE PERIOD
ENVIRONMENT: AMBIENT
SENSE PORT: 35 PSIG GHE AT -425 DEG F
MAIN INLET: 35 PSIG LN2

CRACK/RESEAT AND INTERNAL LEAKAGE PERFORMED AT COMPLETION OF EACH
AXIS OF VIBRATION.

BENCH HANDLING AND DESIGN SHOCK PER MIL-STD-810
FOLLOWED BY AMBIENT CRACK/RESEAT AND INTERNAL LEAKAGE TESTS.

THERMAL CYCLE TEST (3 CYCLES)

VALVE AT 70 DEG F; SHOCKED WITH -300 DEG F FLUID FOR 20 MINUTES MIN;
VALVE ALLOWED TO WARM UP TO 70 DEG F; VALVE HEATED TO 275 DEG F
FOR 15 MINUTES. DURING THE 15 MINUTES THE VALVE WAS TESTED FOR
AMBIENT CRACK/RESEAT PRESSURE.

ELECTRICAL BONDING

BURST TEST
220 PSIG ON SENSE AND INLET PORTS, 600 PSIG ON OUTLET PORT

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS
CERTIFICATION. PART PROTECTION COATING AND PLATING REQUIREMENTS ARE VERIFIED
BY INSPECTION.

CONTAMINATION CONTROL

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02**

CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. CLEANLINESS TO LEVEL 400A (PROCUREMENT SPECIFICATION REQUIREMENT IS 400) VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL CRITICAL DIMENSIONS ARE VERIFIED BY INSPECTION. LOG OF CLEAN ROOM AND TOOL CALIBRATION IS VERIFIED BY INSPECTION. TORQUE PER DRAWING REQUIREMENTS AND SURFACE FINISH ARE VERIFIED BY INSPECTION. SURFACES REQUIRING CORROSION PROTECTION ARE VERIFIED BY INSPECTION. ALL SEALING SURFACES AND SEALS ARE VISUALLY EXAMINED BEFORE INSTALLATION USING 10X MAGNIFICATION. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE MANUFACTURING PROCEDURE.

CRITICAL PROCESSES

HEAT TREATMENT, WELDING, PARTS PASSIVATION, AND ANODIZING ARE VERIFIED. DRY FILM LUBRICANT APPLICATIONS ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

ALL WELDS ARE VISUALLY EXAMINED AND VERIFIED BY DYE PENETRANT. IN ADDITION, BELLOWS WELDS (EXCLUDING END FITTING WELDS) ARE X-RAYED.

TESTING

ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPPING IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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:

FLIGHT
NO CREW ACTION IS REQUIRED.

GROUND

GROUND OPERATIONS SAFING PROCEDURES CONTAIN SAFING SEQUENCE OF EVENTS FOR MAJOR LEAKS IN THE HYDROGEN SYSTEM.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0436-02**

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	: CHARLES EBERHART	:/S/ CHARLES EBERHART
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MICHAEL SNYDER	:/S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	:/S/ ERICH BASS