FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0204 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 07/24/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:HIGH PRESSURE TWO WAY SOLENOID VALVE, NC, TYPE 5	MC284-0403-0027
	UNITED SPACE ALLIANCE - NSLD	12238-3

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE, HIGH-PRESSURE, 2-WAY, PILOT OPERATED SOLENOID, ENGINE HELIUM SUPPLY ISOLATION, NORMALLY CLOSED (0.5 INCH DIA).

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY WRIGHT COMPONENTS (NOW PERKIN ELMER) BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS:
LV1
LV2
LV3
LV4
LV5
LV6

QUANTITY OF LIKE ITEMS: 6
TWO PER ENGINE HE SUPPLY

FUNCTION:
ISOLATES ENGINE HELIUM SUPPLY FROM REMAINDER OF SYSTEM WHEN IN CLOSED POSITION. ALL VALVES ARE OPEN DURING PRELAUNCH AND LIFT-OFF AND AT MM303 THROUGH LANDING. THE VALVES ARE LOCATED ON PARALLEL REDUNDANT PANELS (A&B) TO ASSURE HELIUM FROM EACH MAIN ENGINE SUPPLY TO ITS PARTICULAR ENGINE INTERFACE.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: VALVE, SOLENOID, NC 2W TYPE 5
ITEM NAME: SSME GHE SUPPLY ISO SOL VLV (LV1-6)

CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
RUPTURE/LEAKAGE OF THE VALVE BODY.

MISSION PHASE:

PL	PRE-LAUNCH
LO	LIFT-OFF
DO	DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:
MATERIAL DEFECT, FATIGUE, DEFECTIVE/DAMAGED SEAL.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) N/A
B) N/A
C) N/A

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
DURING ASCENT, HELIUM SUPPLY TO ONE ENGINE WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT.

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. RUPTURE DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED MAY

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RESULT IN OVERPRESSURIZATION OF THE AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

PRIOR TO T-9 MINUTES, EXCESSIVE HELIUM LEAKAGE WILL BE DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS) AND SCREENED BY LCC REQUIREMENTS.

(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

(C) MISSION:
ON GROUND, POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE VALVE IS A PILOT OPERATED SOLENOID VALVE CONTROLLING THE APPLICATION OF VALVE INLET PRESSURE TO THE POPPET. THE POPPET IS PART OF A RING ASSEMBLY (PISTON) THAT IS SPRING LOADED TO THE CLOSED POSITION. THE VALVE INLET PRESSURE IS ALWAYS EXERTING AN OPENING FORCE ON THE PISTON. WHEN THE SOLENOID IS DEENERGIZED, THE PILOT VALVE DIRECTS THE INLET PRESSURE TO THE CLOSING SIDE OF THE POPPET, UNBALANCING THE FORCE FROM THE INLET SIDE. THIS ALLOWS THE SPRING FORCE PLUS THE PRESSURE-AREA DIFFERENTIAL FORCE TO HOLD THE VALVE CLOSED. WHEN THE SOLENOID IS ENERGIZED, THE PILOT VALVE VENTS THE PRESSURE AT THE CLOSING SIDE OF THE PISTON TO AMBIENT. THIS ALLOWS THE INLET PRESSURE TO OVERCOME THE VALVE SPRING FORCE AND OPEN THE VALVE.

THE PILOT VALVE UTILIZES A 430 CRES BALL AS A CLOSURE DEVICE SEALING AGAINST EITHER OF TWO 17-4PH CRES SEATS. IN THE DEENERGIZED STATE, THE BALL IS HELD AGAINST THE CLOSING SEAT BY A SPRING ACTIVATED PUSHROD. WHEN ENERGIZED, THE SOLENOID FORCE OVERCOMES THE SPRING FORCE AND TRANSLATES THE PUSHROD AND BALL AND HOLDS THE BALL AGAINST THE OPENING SEAT. TOTAL BALL MOVEMENT (STROKE) IS LESS THAN 0.05 INCH.

THE VALVE IS DESIGNED AND VERIFIED TO PRESSURE FACTORS OF SAFETY OF 1.5 PROOF AND 4.0 BURST. THE 304L CRES VALVE BODY AND THE ARMCO NITRONIC 40 CONNECTION TUBES ARE MACHINED PARTS. BOTH THE BODY AND THE TUBES ARE PASSIVATED

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FOLLOWING MACHINING. THE TUBES ARE ELECTRON BEAM WELDED TO THE BODY. THE WELDS ARE RADIOGRAPHIC AND DYE PENETRANT INSPECTED.

EXTERNAL LEAKAGE IS PREVENTED BY ISOLATING THE HIGH PRESSURE AND VENTED SECTION OF THE VALVE FROM ONE ANOTHER BY USE OF SILVER PLATED, INCONEL "V" SEALS.

THE VENT PORT CHECK VALVE WAS REDESIGNED TO PREVENT THE POPPET FROM BEING EJECTED DUE TO SHEARING OF THE RETAINING NUT THREAD. A PIN WAS ADDED TO THE CHECK VALVE HOUSING, WHICH RETAINS THE POPPET WITHIN THE CHECK VALVE HOUSING. A NEW ALUMINUM NUT, WHICH PROVIDE A MINIMUM ENGAGEMENT OF THREE THREADS, WAS UTILIZED TO INCREASE RELIABILITY.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

AMBIENT TEMPERATURE TESTS
PROOF PRESSURE (6750 PSIG)
EXTERNAL LEAKAGE (4500 PSIG)
INTERNAL LEAKAGE (4500 PSID, ENERGIZED AND DEENERGIZED)
CHECK VALVE LEAKAGE (15 PSID)
ELECTRICAL CHARACTERISTICS
VALVE RESPONSE TIMES (4500 PSIG)

REDUCED TEMPERATURE TESTS (-160 DEG F)
INTERNAL LEAKAGE (4500 PSID, ENERGIZED AND DEENERGIZED)
ELECTRICAL CHARACTERISTICS
VALVE RESPONSE TIMES (4500 PSIG)

ELECTRICAL TESTS
ELECTRICAL BONDING
DIELECTRIC WITHSTANDING VOLTAGE
INSULATION RESISTANCE

SOLENOID SUBASSEMBLY TESTS
ELECTRICAL CHARACTERISTICS
ENCLOSURE LEAKAGE (1 ATMOSPHERE DIFFERENTIAL)

CERTIFICATION

VIBRATION

TRANSIENT: 5 TO 35 HZ

RANDOM (AMBIENT HELIUM):
INLET PRESSURE: 4500 PSIG
2.2 HRS ENERGIZED IN EACH OF 2 AXES
FLOWING 100 SCIMS

2.2 HRS DEENERGIZED IN EACH OF 2 AXES
OUTLET PORT LEAKAGE MONITORED

ELECTRICAL CHARACTERISTICS, VALVE RESPONSE, AND INTERNAL LEAKAGE TESTS AFTER EACH AXIS.

LIFE CYCLE TESTING (10,000 CYCLES)
(ALL TESTING WITH UNITS IN VACUUM ENVIRONMENT)

5000 CYCLES:
INLET PRESSURE: 4500 PSIG
TEMPERATURE: +130 DEG F SURROUNDING ENVIRONMENT

5000 CYCLES:
INLET PRESSURE: 4500 PSIG
TEMPERATURE: -160 DEG F SURROUNDING ENVIRONMENT

ELECTRICAL CHARACTERISTICS, VALVE RESPONSE, AND INTERNAL LEAKAGE TESTS AFTER EACH 2500 CYCLES

FLOW TESTS

DIFFERENTIAL PRESSURE TEST
INLET PRESSURE: 950 PSIG
FLOW RATES: 0.14 TO 0.25 LBS/SEC
PRESSURE DROP NOT TO EXCEED 50 PSID

HIGH FLOW CLOSURE TEST
12 CYCLES:
INLET PRESSURE: 4500 PSIG
FLOW RATE: 1 LBS/SEC
CYCLE VALVE CLOSED AND VERIFY CLOSURE BY LEAKAGE TEST

BURST TEST (18,000 PSIG)

PARTLY CERTIFIED BY SIMILARITY TO MC284-0403-0001

SHOCK:
BENCH HANDLING
DESIGN
SALT FOG
CONTINUOUS CURRENT TEST
THERMAL VACUUM AND ENDURANCE TEST

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

(C) INSPECTION:
RECEIVING INSPECTION

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RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESSES CERTIFICATION. BODY HOUSING BAR STOCK IS ULTRASONICALLY INSPECTED.

CONTAMINATION CONTROL
CLEANLINESS LEVEL IS VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
ALL DETAIL PARTS AND ASSEMBLIES ARE EXAMINED FOR BURRS, DAMAGE AND CORROSION (AT 10X MAGNIFICATION) AND INSPECTED FOR CORRECT DIMENSIONS PRIOR TO ASSEMBLY. CRITICAL SURFACE FINISHES ARE INSPECTED USING A COMPARATOR AT 10X MAGNIFICATION. OTHER SURFACE FINISHES ARE INSPECTED AND VERIFIED WITH A PROFILOMETER. TORQUES ARE VERIFIED TO BE IN ACCORDANCE WITH DRAWING REQUIREMENTS. BELLOWS ASSEMBLY IS PROOF PRESSURE TESTED AND LEAK CHECKED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESS
THE FOLLOWING ARE VERIFIED BY INSPECTION:

WELDING
HEAT TREATMENT
PARTS PASSIVATION
POTTING OF SOLDER CUPS
ELECTRICAL WIRE STRIPPING
DRY FILM LUBRICATION
CHROME PLATING

NONDESTRUCTIVE EVALUATION
ALL WELDS ARE VISUALLY EXAMINED AND VERIFIED BY X-RAY OR DYE PENETRANT INSPECTIONS. THE SOLENOID ASSEMBLY IS SUBJECTED TO LEAKAGE VERIFICATION USING RADIOACTIVE TRACER TECHNIQUES. SOME VALVE BODIES WERE SUBJECTED TO 10X MAGNIFICATION INSPECTION ONLY. OTHER VALVE BODIES WERE SUBJECTED TO EDDY CURRENT INSPECTION, IN ADDITION TO 10X MAGNIFICATION. REFURBISHED VALVE BODIES ARE SUBJECTED TO 40X MAGNIFICATION INSPECTION.

TESTING
ATP VERIFIED BY INSPECTION.

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

(D) FAILURE HISTORY:
DURING QUALIFICATION, THE "V" SEAL WAS NOT SEALING PROPERLY (REFERENCE CAR A9476). THE THICKNESS OF SILVER PLATE WAS INCREASED TO 0.003 EFFECTIVE NEXT PRODUCTION ORDERS AND REPAIR.

DURING ATP, THE UNIT WAS FOUND TO BE LEAKING ACROSS A DAMAGED "V" SEAL (REFERENCE CAR AC5633). THE SEAL WAS REPLACED AND PERSONNEL WERE

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CAUTIONED TO USE UTMOST CARE DURING VALVE ASSEMBLY. INSPECTION PERSONNEL WERE INSTRUCTED TO PERFORM A COMPLETE PRETEST PRIOR TO ACCEPTANCE TESTING.

AT DOWNEY, THE "V" SEAL WAS MISSING (REFERENCE CAR AC7257). THIS WAS SCREENED DURING PANEL LEAK CHECK. THE ASSEMBLY PROCEDURE WAS CHANGED TO VERIFY "V" SEAL INSTALLATION.

AT DOWNEY TWO VALVES WERE FOUND WITH SAFETY WIRE MISSING FROM THE SOLENOID MOUNTING SCREWS (REFERENCE CARS AC6776, AC6777). SUPPLIER ADDED MANDATORY INSPECTION BUY-OFF TO ASCERTAIN THAT SAFETY WIRE IS INSTALLED.

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:
LOADING/PRELAUNCH:
PRIOR TO T-9 MINUTES GHE LEAKAGE IS SCREENED PER LCC. AFTER T-9 MINUTES THE LCC REQUIREMENT IS REMOVED DUE TO CYCLING OF MPS PNEUMATIC VALVES, HOWEVER, EXCESSIVE GHE LEAKAGE IN THE AFT COMPARTMENT IS DETECTABLE BY HGDS AND THE COUNT CAN BE TERMINATED BY GROUND CALL

ASCENT:
NO CREW ACTION CAN BE TAKEN.

- APPROVALS -

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