

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER: 03-1-0629 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1 07/26/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	: REGULATOR, PURGE VACCO INDUSTRIES	MC284-0399-0004 76500-0004

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

LH2 HELIUM MANIFOLD REPRESSURIZATION REGULATOR, 20 PSIG (0.5 INCH DIAMETER INLET, .075 INCH DIAMETER OUTLET, 0.25 INCH DIAMETER SENSE PORT).

REFERENCE DESIGNATORS: PR6**QUANTITY OF LIKE ITEMS:** 1**FUNCTION:**

REGULATES THE HELIUM SUPPLY PRESSURE FROM 750 PSI DOWN TO A LOWER PRESSURE TO PURGE THE MPS FOLLOWING ENGINE SHUTDOWN AND TO PROVIDE SYSTEM REPRESSURIZATION DURING REENTRY. SENSES LH2 MANIFOLD PRESSURE TO CONTROL PURGE FLOW. REGULATOR OPENS AT MANIFOLD PRESSURES BELOW 17 PSI AND CLOSES AT PRESSURES ABOVE 30 PSI.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0629-01

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: 20 PSIG REGULATOR

CRITICALITY OF THIS

ITEM NAME: LH2 MANIFOLD REPRESS REGULATOR (PR6)

FAILURE MODE: 3/3

FAILURE MODE:

FAILS CLOSED/LOW OUTLET PRESSURE DURING MANIFOLD REPRESSURIZATION.

MISSION PHASE: LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:	102	COLUMBIA
	103	DISCOVERY
	104	ATLANTIS
	105	ENDEAVOUR

CAUSE:

PIECE PART STRUCTURAL FAILURE, BINDING.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTLS	RETURN TO LAUNCH SITE
TAL	TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN	A) N/A
	B) N/A
	C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

LH2 MANIFOLD REPRESSURIZATION SYSTEM FUNCTION CONSIDERED NON MANDATORY FOR NOMINAL, AOA, AND ATO MISSIONS. NOMINAL POST DUMP RESIDUALS (APPROXIMATELY THREE LBM) ARE SUFFICIENT TO CAUSE PROPELLANT SYSTEM RUPTURE IN CASE OF RELIEF SYSTEM FAILURE, REGARDLESS OF REPRESS SYSTEM OPERATION.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0629-01**

DURING RTLS AND TAL ABORT ENTRIES, FAILURE RESULTS IN LOSS OF THE LH2 MANIFOLD REPRESS (MANDATORY TO PRECLUDE FLAMMABLE CONCENTRATIONS IN THE LH2 PROPELLANT SYSTEM) CAUSING POSSIBLE FIRE/EXPLOSION HAZARD IN THE LH2 PROPELLANT SYSTEM.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

POSSIBLE LOSS OF CREW/VEHICLE DURING RTLS AND TAL ABORTS.

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

SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:

NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:

THE 20 PSI HELIUM REGULATOR IS A PILOT OPERATED PRESSURE CONTROL VALVE THAT REGULATES 750 PSI HELIUM TO 17-30 PSIG IN THE O2 AND H2 PROPELLANT FEED MANIFOLDS.

WHEN THE MANIFOLD PRESSURE FALLS BELOW 17 PSIG THE SENSOR DIAPHRAGM COLLAPSES, PUSHING THE PILOT VALVE OPEN. THIS ACTION RELIEVES PRESSURE BEHIND THE MAIN POPPET THUS OPENING THE VALVE. WHEN THE SENSE PRESSURE REACHES 17-30 PSIG, THE DIAPHRAGM EXPANDS CLOSING THE PILOT POPPET AND THUS CLOSING THE MAIN POPPET. THE REGULATOR ALSO CONTAINS AN INTERNAL RELIEF VALVE THAT RELIEVES THE OUTLET PRESSURE THROUGH THE SENSE PORT AT PRESSURES BETWEEN 160 AND 200 PSID.

STRUCTURAL FAILURE OF THE BELLOWS, THE RELIEF SPRING, THE DIAPHRAGM SPRING, OR THE SPRING RETAINERS IN THE SENSOR DIAPHRAGM AREA COULD CAUSE THIS FAILURE MODE. A FAILURE OF THIS TYPE WOULD REDUCE THE FORCE OF THE SHAFT ON THE PILOT POPPET, THUS PREVENTING THE PILOT POPPET FROM OPENING OR OPENING FULLY. TO DESIGN AGAINST THIS TYPE OF FAILURE, THE SPRING IS MADE FROM NI-SPAN-C AND THE RETAINERS ARE OF 6061 ALUMINUM. THE SPRING SEATING AREA IS SIZED TO PREVENT THE SPRING FROM SLIPPING OFF THE RETAINER. THE REGULATOR COULD ALSO FAIL CLOSED/LOW OUTPUT BY A FATIGUE FAILURE OF THE PILOT FLEXURE. THIS COULD PREVENT THE PILOT FROM SEATING PROPERLY. THE FLEXURE IS MADE FROM 347 CRES.

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0629-01**

FOR THE REGULATOR TO FAIL OUTPUT LOW OR CLOSED DUE TO BINDING, EITHER THE MAIN POPPET RINGS OR BEARINGS WOULD HAVE TO BE GALLED OR DAMAGED DUE TO EXCESSIVE WEAR, WHICH WOULD CAUSE EXCESSIVE FRICTION AND RESTRICT THE POPPET MOVEMENT. TO PREVENT THIS FAILURE OCCURRENCE, THE RINGS ARE MADE FROM TFE TEFLON, AND THE BEARINGS ARE MADE FROM VESPEL. THE RINGS AND BEARINGS SLIDE AGAINST 6061 ALUMINUM.

**(B) TEST:
ATP**

AMBIENT TEMPERATURE TESTS

PROOF PRESSURE (1700 PSIG INLET, 580 PSIG OUTLET AND SENSE)

INTERNAL LEAKAGE

INLET TO OUTLET (850 AND 500 PSIG INLET, 30 PSIG SENSE)

INLET TO SENSE (850 AND 500 PSIG INLET)

SENSE TO INLET (180 PSIG SENSE)

EXTERNAL LEAKAGE (850 PSIG INLET, 285 PSIG OUTLET AND SENSE)

FUNCTIONAL

REGULATION (500 TO 850 PSIG INLET PRESSURE AND 17 TO 30 PSIG SENSE PRESSURE)

TRANSIENT RESPONSE (SLAM START WITH 500 AND 850 PSIG INLET AND 17 TO 30 PSIG SENSE)

ELECTRICAL BONDING

LOW TEMPERATURE TESTS (-140 DEG F MAX FLUID TEMPERATURE AND BODY TEMPERATURE -100 DEG F MAX)

INTERNAL LEAKAGE

INLET TO OUTLET (850 AND 500 PSIG INLET, 30 PSIG SENSE)

INLET TO SENSE (850 AND 500 PSIG INLET)

SENSE TO INLET (180 PSIG SENSE)

FUNCTIONAL TEST

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0629-01**

REGULATION (500 TO 850 PSIG INLET PRESSURE AND 17 TO 30 PSIG SENSE PRESSURE)

TRANSIENT RESPONSE (SLAM START WITH 500 AND 850 PSIG INLET AND 17 TO 30 PSIG SENSE)

CERTIFICATION

TWO UNITS CERTIFIED

VIBRATION AND SHOCK TESTING

RANDOM VIBRATION - 13.3 HOURS IN EACH OF TWO AXES (REGULATOR CENTERLINE AXIS AND MOUNTING HOLE CENTERLINE) [TWO UNITS]
ONE UNIT PRESSURIZED TO 190 PSIG (ALL PORTS)
ONE UNIT PRESSURIZED TO 34 PSIG (ALL PORTS)

TRANSIENT VIBRATION - 5 TO +/- 35 HZ AT +/- 0.25 G IN EACH OF TWO AXES WITH THE INLET AND OUTLET PORTS PLUGGED. [TWO UNITS]
ONE UNIT WITH SENSE PORT PRESSURIZED TO 190 PSIG
ONE UNIT WITH SENSE PORT PRESSURIZED TO 34 PSIG

DESIGN SHOCK - PER MIL-STD-810 IN EACH OF 2 AXES. [TWO UNITS]

PERFORM AMBIENT INTERNAL AND EXTERNAL LEAKAGE AND FUNCTIONAL TESTS (SEE ATP ABOVE) AFTER VIBRATION AND SHOCK TESTING IN EACH AXIS.

THERMAL CYCLE TEST - WITH INLET AT 750 PSIG AND THE REGULATOR FLOWING, CYCLE +70 F TO -140 F TO +250 F TO -140 F TO +250 F TO -140 F TO +250 F TO -140 F TO 70 F. UPON COMPLETION, PERFORM AMBIENT INTERNAL AND EXTERNAL LEAKAGE AND FUNCTIONAL TESTS (SEE ATP ABOVE). [ONE UNIT]

LIFE CYCLE TESTS

1500 TRANSIENT CYCLES
INCREASE INLET PRESSURE FROM 0 TO 850 PSIG IN 8 MS MAXIMUM
PERFORM AMBIENT INTERNAL AND EXTERNAL LEAKAGE TESTS AFTER EACH 500 CYCLES.

50 CYCLES
DECAY THE INLET PRESSURE FROM 850 PSIG TO 30 PSIG WITH THE OUTLET PLUGGED.

MAX FLOW TEST
700 PSIG INLET PRESSURE, MAX FLOW RATE OF 0.32 LB/SEC GHE, MEDIA TEMPERATURE 80 DEG F

UPON COMPLETION OF ALL CYCLING, PERFORM AMBIENT AND LOW TEMPERATURE INTERNAL AND EXTERNAL LEAKAGE, AND LOW TEMPERATURE FUNCTIONAL TESTS.

BURST TEST - 3400 PSIG (INLET), 1140 PSIG (OUTLET AND SENSE) ONE UNIT

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0629-01**

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

INCOMING MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL

ALL PARTS ARE CLEANED PRIOR TO ASSEMBLY AND ARE MAINTAINED TO CLEANLINESS LEVEL 100A.

ASSEMBLY/INSTALLATION

PARTS ARE VISUALLY INSPECTED. PRIOR TO ASSEMBLY, TESTS ARE PERFORMED TO PRECLUDE FAILURES OF THE MAIN POPPET STATIC SEAL, BELLOWS ASSEMBLY AND BELLEVILLE SPRINGS. TORQUE IS VERIFIED PER APPLICABLE REQUIREMENTS. ALL MANDATORY INSPECTION POINTS ARE INCLUDED TO ENSURE THAT CORRECT MANUFACTURING PROCEDURES ARE FOLLOWED. SEALS ARE VISUALLY EXAMINED PRIOR TO INSTALLATION FOR DAMAGE.

CRITICAL PROCESSES

TIG WELDED PARTS ARE WITNESSED BY INSPECTION. ALL SOLDERING IS PERFORMED BY CERTIFIED PERSONNEL AND IS VERIFIED BY INSPECTION. SEALS ARE VISUALLY EXAMINED PRIOR TO INSTALLATION FOR DAMAGE. ALL CRES DETAILS ARE PASSIVATED TO PRECLUDE CORROSION.

NONDESTRUCTIVE EVALUATION

HELIUM LEAK DETECTION IS VERIFIED BY INSPECTION. WELDING SAMPLES ARE EXAMINED AND VERIFIED BY INSPECTION.

TESTING

ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

DURING ATP AMBIENT FUNCTIONAL TEST, THE OUTLET PRESSURE WAS LOW, 15.7 PSIG, WHEN THE INLET PRESSURE WAS DECREASED FROM 850 - 500 PSIG (REFERENCE CAR A7423). FAILURE WAS ATTRIBUTED TO THE LACK OF HEAT TREATMENT ON THE BELLOWS. THE SUPPLIER CONTRACT WAS CANCELED AND DELIVERED HARDWARE WILL BE USED FOR MPTA ONLY. FLIGHT HARDWARE OF A COMPLETELY DIFFERENT DESIGN WAS BOUGHT FROM A DIFFERENT SUPPLIER (CONSOLIDATED CONTROLS).

DURING ATP OF THE FIRST CONSOLIDATED CONTROLS UNIT, THE OUTLET PRESSURE WAS MEASURED LOW, 16.2 PSIG (REFERENCE CAR A9929). PRESSURE SHOULD BE BETWEEN 17 - 30 PSIG. THE PRESSURE USED TO FORM THE SENSING DIAPHRAGM DURING

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0629-01**

MANUFACTURE WAS INSUFFICIENT TO FULLY FORM THE DETAIL PART. MANUFACTURING PROCESS WAS CHANGED TO FORM THE DIAPHRAGM AT A HIGHER PRESSURE.

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:
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	: CHARLES EBERHART	:/S/ CHARLES EBERHART
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	: BILL PRINCE	:/S/ BILL PRINCE