FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0602 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 07/26/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: REGULATOR, PURGE, 20 PSI VACCO INDUSTRIES	MC284-0399-0004 76500-0004

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
REGULATOR, HELIUM, LO2 MANIFOLD REPRESSURIZATION 20 PSIG (0.5 INCH DIA INLET, 0.75 INCH DIA OUTLET, 0.25 INCH DIA SENSE PORT).

REFERENCE DESIGNATORS: PR5

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
REGULATES THE HELIUM SUPPLY PRESSURE FROM 750 PSI DOWN TO A LOWER PRESSURE TO PURGE THE MPS LO2 FEED AND PRESSURIZATION SYSTEMS FOLLOWING ENGINE SHUTDOWN AND TO PROVIDE FOR SYSTEM REPRESSURIZATION DURING ENTRY. SENSES LO2 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: 03-1-0602-04

REVISION#: 1 07/26/00

SUBSYSTEM NAME: MAIN PROPULSION
LRU: REGULATOR, PURGE, 20 PSI
ITEM NAME: LO2 MANIFOLD 20 PSIG REPRESS REG (PR5)

CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
RUPTURE/LEAKAGE

MISSION PHASE:

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

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:
FATIGUE, MATERIAL DEFECT

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 PRELAUNCH AND ASCENT, RUPTURE OF THE SENSE PORTION OF THE REGULATOR RESULTS IN LO2 FROM THE MANIFOLD (VIA THE REGULATOR SENSE LINE) LEAKING INTO THE AFT FUSELAGE. POSSIBLE LOSS OF CRITICAL FUNCTIONS DUE TO COMPONENT EXPOSURE TO CRYOGENICS. POSSIBLE AFT FUSELAGE FIRE/EXPLOSION HAZARD.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE NUMBER: 03-1-0602-04

LEAKAGE DETECTABLE ON GROUND DOWN TO T-31 SECONDS USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. RUPTURE OF THE REGULATOR DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED AND MANIFOLD REPRESS VALVES (LV40,41) HAVE BEEN COMMANDED OPEN MAY RESULT IN OVERPRESSURIZATION OF AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

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

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

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
CASE 1
1R/2 2 SUCCESS PATHS. TIME FRAME - PRELAUNCH, ASCENT
1) REGULATOR RUPTURES.
2) CHECK VALVE (CV12) FAILS TO CHECK/LEAKS INTERNALLY OR CHECK VALVE (CV10) FAILS TO CHECK/LEAKS INTERNALLY.

LO2 FROM THE FEEDLINE MANIFOLD (THROUGH CV12) OR GO2 FROM THE PRESSURIZATION LINE (THROUGH CV10) WILL ENTER THE AFT COMPARTMENT. POSSIBLE LOSS OF CRITICAL FUNCTIONS DUE TO COMPONENT EXPOSURE TO CRYOGENICS. POSSIBLE FIRE/EXPLOSION HAZARD.

LEAKAGE DETECTABLE ON GROUND PRIOR TO T-31 SECONDS USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2
1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT
1) REGULATOR RUPTURES.
2) COCKPIT TOGGLE SWITCH (PANEL R4 SWITCH S1) FAILS, RESULTING IN OPENING OF REPRESS ISOLATION VALVES (LV40 AND 41).

POSSIBLE OVERPRESSURIZATION OF THE AFT COMPARTMENT. RESULTS IN LOSS OF HELIUM FROM THE PNEUMATIC HELIUM SUPPLY.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0602-04

PRIOR TO T-9 MINUTES, EXCESSIVE HELIUM LEAKAGE WILL BE DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). AFTER LIFTOFF, EXCESSIVE HELIUM TANK AND/OR REGULATOR PRESSURE DECAY WILL NOT BE INDICATED BY SM ALERT OR CAUTION AND WARNING.

POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

POSSIBLE LOSS OF CREW/VEHICLE.

-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 ON THE CLOSING SIDE OF THE MAIN POPPET AND ALLOWS INLET PRESSURE TO OPEN THE MAIN POPPET. WHEN THE SENSE PRESSURE REACHES 17- 30 PSIG, THE DIAPHRAGM EXPANDS CLOSING THE PILOT POPPET. THIS ALLOWS INLET PRESSURE TO THE CLOSING SIDE OF THE POPPET 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.

THE REGULATOR HOUSING IS DESIGNED TO WITHSTAND 3400 PSIG ON THE INLET SIDE AND 1140 PSIG ON THE OUTLET AND SENSE PORTS WITHOUT RUPTURE. THIS YIELDS A BURST SAFETY FACTOR OF 4.0. THE HOUSING MATERIAL IS 6061-T651 ALUMINUM. THE MANIFOLD IS MANUFACTURED FROM 21-6-9 CRES. THE HOUSING/MANIFOLD INTERFACE IS SEALED TO A LEAKAGE ALLOWABLE OF 3 SCIM BY USE OF SPRING LOADED RACO SEALS. THE HOUSING ASSEMBLY IS DESIGNED AGAINST FATIGUE FAILURES WITH THE SUPPLIER PERFORMING A 100 MISSION LIFE CYCLE PRESSURE TEST (1552 TOTAL CYCLES) DURING CERTIFICATION.

(B) TEST:
ATP

AMBIENT TEMPERATURE TESTS

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0602-04

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

  - 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]

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.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0602-04

CRITICAL PROCESSES
TIG WELDED PARTS ARE WITNESSED BY INSPECTION. ALL CRES DETAILS ARE PASSIVATED TO PRECLUDE CORROSION. ANODIZE IS VERIFIED BY INSPECTION.

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 THE EXTERNAL LEAKAGE EXCEEDED REQUIREMENTS (CAR'S A8573, A8597). IT WAS CONCLUDED THAT THE DESIGN CANNOT CONSISTENTLY MEET ONE SCIM REQUIREMENT AT TEMPERATURES COLDER THAN -100°F. THE SPECIFICATION REQUIREMENT WAS RELAXED TO ALLOW THREE SCIMS EXTERNAL LEAKAGE AT TEMPERATURES COLDER THAN -100°F.

DURING ATP EXTERNAL LEAKAGE EXCEEDED REQUIREMENTS (CAR A9962). THE ANODIZING PROCESS ETCHED THE SEALING SURFACE CAUSING IRREGULARITIES SUFFICIENT TO ALLOW LEAKAGE PAST THE SEAL. THE DRAWING WAS CHANGED TO SPECIFY BRUSH ALODINE TO THE SEAL AREA. THE CHANGE IS EFFECTIVE FOR ALL PRODUCTION PARTS.

DURING DISASSEMBLY OF THE PISTON ASSEMBLY AFTER QUALIFICATION TESTING IT WAS DISCOVERED THAT THE ROSAN INSERTS WERE INSTALLED WITH WET ZINC CHROMATE PRIMER. THIS PRIMER IS INCOMPATIBLE WITH LIQUID OXYGEN. ALL REGULATORS WERE RECYCLED TO REMOVE THE ZINC CHROMATE PRIMER. THE DRAWINGS WERE CHANGED TO INSTALL THE ROSAN INSERTS DRY.

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

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL FAILURE MODE
NUMBER: 03-1-0602-04

MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MICHAEL SNYDER	:/S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	:/S/ BILL PRINCE