FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER:03-1-0237 -X

SUBSYSTEM NAME: MAIN PROPUPLSION

REVISION: 3 11/08/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:TANK, 4.7 CUBIC FT.	MC282-0082-0010
	BRUNSWICK	BLD999020-1
LRU	:TANK, 4.7 CUBIC FT.	MC282-0082-0210
	ARDE	D4554

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
TANK (TK4), HELIUM, 4.7 CUBIC FEET, PNEUMATIC VALVE SUPPLY, 4500 PSIA. LOCATED IN AFT COMPARTMENT.

REFERENCE DESIGNATORS: TK4

QUANTITY OF LIKE ITEMS: 1

FUNCTION:
THE TANK STORES THE HELIUM SUPPLY REQUIRED FOR LO2 PROPELLANT DUMP, MPS MANIFOLD REPRESSURIZATION, AFT COMPARTMENT PURGE, AND ACTUATION OF THE FOLLOWING MPS PNEUMATIC VALVES:

POGO ACCUMULATOR RECIRCULATION VALVES (PV20,21)
LH2 RECIRCULATION PUMP VALVES (PV14,15,16)
LH2 TOPPING VALVE (PV13)
LO2 FILL AND DRAIN VALVES (I/B PV10 & O/B PV9)
LH2 FILL AND DRAIN VALVES (I/B PV12 & O/B PV11)

LO2 PREVALVES (PV1,2,3)
LH2 PREVALVES (PV4,5,6)
LO2/LH2 17 INCH ET/ORBITER DISCONNECT VALVES AND LATCH ASSY (PD1,2)
LH2 4 INCH RECIRCULATION DISCONNECT VALVE (PD3)
LH2 RTLS DUMP VALVES (PV17,18)
LH2 HIGH POINT BLEED VALVE (PV22)
LO2 BLEED SHUTOFF VALVE (PV19)
LO2/LH2 RELIEF ISOLATION VALVES (PV7,8)

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LRU: TANK, 4.7 CUBIC FT.
ITEM NAME: TANK, 4.7 CUBIC FT.

CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
RUPTURE/LEAKAGE.

MISSION PHASE:

PL	PRE-LAUNCH
LO	LIFT-OFF
OO	ON-ORBIT
DO	DE-ORBIT
LS	LANDING/SAFING

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:
MATERIAL DEFECT, FATIGUE

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, THE PNEUMATIC HELIUM SUPPLY WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT.

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WHEN THE CROSSOVER VALVE (LV10) OPENS AT MECO, THE PNEUMATIC HELIUM DISTRIBUTION SYSTEM WILL BE FED FROM THE LEFT ENGINE HELIUM SUPPLY. WHEN THE E2 INTERCONNECT “IN” VALVE AND THE E1 AND E3 INTERCONNECT “OUT” VALVES OPEN AT MECO PLUS 20 SECONDS, THE ENGINE 1 & 3 HELIUM SUPPLIES WILL LEAK THROUGH THE FAILED LINE.

STORED HELIUM PRESSURE IN THE ACCUMULATOR LEG AND SUPPLEMENTAL HELIUM FROM LV10 SHOULD BE ADEQUATE TO OPERATE THE LO2 PREVALVES AT MECO.

PURGE OF AFT COMPARTMENT AND LH2/LO2 SYSTEMS WOULD DEPEND SOLELY ON THE LEFT ENGINE HELIUM SYSTEM RESIDUALS, RESULTING IN INADEQUATE ABORT PURGE, INCOMPLETE PROPELLANT DUMP, AND INGESTION OF CONTAMINATION.

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

EXCESSIVE HELIUM LEAKAGE WILL BE DETECTABLE ON GROUND USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

(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:
TYPE I TANK (BRUNSWICK)
HE TANK LINER CONSISTS OF TWO FORGED HEMISPHERES FABRICATED FROM TITANIUM 6AL-4V ALLOY (0.05 INCH MINIMUM THICKNESS, 130 KSI ULTIMATE STRENGTH). THE TWO HEMISPHERES ARE WELDED TOGETHER. THE LINER IS WOUND WITH EPOXY-IMPREGNATED KEVLAR-49 FIBER (500 KSI TENSILE STRENGTH). FILAMENT WOUND CONSTRUCTION PRECLUDES FRAGMENTATION DAMAGE. THE DESIGN MEETS FRACTURE

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NUMBER: 03-1-0237-02

ANALYSIS REQUIREMENTS FOR 400 MISSIONS. FACTORS OF SAFETY ARE 1.33 PROOF AND 1.5 BURST.

TYPE III TANK (ARDE)
HE TANK LINER CONSISTS OF TWO FORGED HEMISPHERES AND TWO END-SECTIONS FABRICATED FROM TYPE III CRYOFORMED 301 STAINLESS STEEL. THE TWO HEMISPHERES AND THE TWO SECTIONS ARE WELDED TOGETHER. THE LINER IS WOUND WITH GRAPHITE (MINIMUM 730,000 PSI TENSILE STRENGTH). FILAMENT WOUND CONSTRUCTION PRECLUDES FRAGMENTATION DAMAGE. THE DESIGN MEETS FRACTURE ANALYSIS REQUIREMENTS FOR 100 MISSIONS (FATIGUE TESTED FOR 400 MISSION). FACTORS OF SAFETY ARE 1.1 PROOF AND 1.5 BURST.

TO PRECLUDE RUPTURE THE PRESSURE VESSELS ARE DESIGNED TO ASSURE THAT UNDER NORMAL OPERATING CONDITIONS, ANY FAILURE RESULTING FROM METAL FATIGUE OR ANY OTHER DEFECTS WILL RESULT IN A LEAK BEFORE BURST FAILURE MODE. LEAK BEFORE BURST FAILURE MODE WAS DEMONSTRATED ON ONE BRUNSWICK TANK DURING TESTING.

(B) TEST:
ATP

- LINER
  - EXAMINATION OF PRODUCT
  - CRYOSTRETCH VERIFICATION (TYPE III TANK ONLY): POST CRYOSTRETCH LINER VOLUME VERIFICATION AND LINER STRETCH DIMENSION VERIFICATION
  - HEAT TREAT VERIFICATION COUPON TENSILE TEST
  - WELD EVALUATION DIMENSIONALLY AND RADIOGRAPHICALLY INSPECTED
  - PROOF PRESSURES: TYPE I TANK = 1057 PSIG; TYPE III TANK = 1185 PSIG.
  - EXTERNAL LEAKAGE INTERNAL PRESSURES:
    - TYPE I TANK = 953 PSIG (MAXIMUM LEAKAGE: $1X10^{-7}$SCC/SEC OF HELIUM)
    - TYPE III TANK = 1070 PSIG (MAXIMUM LEAKAGE. $1X10^{-6}$ SCC/SEC OF HELIUM)
  - FLUORESCENT PENETRANT INSPECTION FOR SURFACE FLAWS

- TANK
  - EXAMINATION OF PRODUCT
  - LEAKAGE TEST INTERNAL PRESSURE:
    4500 PSIG MAXIMUM LEAKAGE (TYPE I TANK = $1X10^{-7}$ SCC/SECOND OF HELIUM, TYPE III TANK = $1X10^{-6}$ SCC/SECOND OF HELIUM)
  - RADIOGRAPHIC INSPECTION INTERNAL PRESSURE:
    - TYPE I TANK = 685 PSIG
    - TYPE III TANK = 2610 PSIG.

CERTIFICATION

- PRESSURE CYCLE TEST 1000 CYCLES PRESSURE RANGE: 0 TO 4500 PSIG
  PRESSURANT: WATER AT AMBIENT TEMPERATURE
- EXTERNAL LEAKAGE INTERNAL PRESSURE:
  4500 PSIG MAXIMUM LEAKAGE (TYPE I TANK = $1X10^{-7}$ SCC/SECOND OF HELIUM, TYPE III TANK = $1X10^{-6}$ SCC/SECOND OF HELIUM)

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- CREEP TEST (TYPE III TANK ONLY): 90 DAYS INTERNAL PRESSURE: 4500 PSIG (HELIUM) AMBIENT TEMPERATURE
- RANDOM VIBRATION 60 MINUTE IN EACH OF 2 AXES INTERNAL PRESSURE: 4500 PSIG
- RADIOGRAPHIC INSPECTION
- BURST/RUPTURE TEST PRESSURIZED UNTIL RUPTURE OCCURS

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT TESTING IS PERFORMED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
MATERIALS AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. QUALITY TESTING PERFORMED ON FORGING IS VERIFIED BY INSPECTION. TYPE I TANK: MICRO-EXAMINATION AND CHEM-ETCH INSPECTION FOR ALPHA SEGREGRATION IS VERIFIED BY INSPECTION

CONTAMINATION CONTROL
CLEANLINESS OF INTERNAL SURFACES TO LEVEL 100A IS VERIFIED BY INSPECTION. CORROSION PROTECTION PROVISIONS ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
PART PROTECTION, MANUFACTURING PROCESSES, FINISHES, ASSEMBLY AND INSTALLATION PER SHOP TRAVELER ARE VERIFIED BY INSPECTION. PRESSURIZATION CYCLE HISTORY LOG AND SCHEDULES OF VESSELS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES
WELDING, KEVLAR WRAPPING (TYPE I TANK) OR GRAPHITE WRAPPING (TYPE III TANK), EPOXY CURE PROCESS AND HEAT TREATMENT ARE VERIFIED BY INSPECTION. MECHANICAL PROPERTIES AND CHEMICAL ANALYSIS ARE VERIFIED BY INSPECTION AFTER FINAL HEAT TREATMENT.

NONDESTRUCTIVE EVALUATION
FLUORESCENT PENETRANT INSPECTION (SPECIAL LEVEL NDE) OF LINERS AND GIRTH WELDS, AND RADIOGRAPHIC INSPECTION OF GIRTH WELDS (BOTH BEFORE AND AFTER PROOF SIZING) ARE USED TO SCREEN POTENTIALLY DETRIMENTAL PARENT MATERIAL OR WELD DEFECTS. PROOF SIZING OF THE PRESSURE VESSEL ABOVE THE YIELD STRESS FOR THE LINER AIDS IN SCREENING FLAWS.

TESTING
ATP IS WITNESSED AND VERIFIED BY INSPECTION. PRESSURIZATION CYCLE HISTORY LOG AND SCHEDULE ARE VERIFIED BY INSPECTION.

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

(D) FAILURE HISTORY:

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NUMBER: 03-1-0237-02

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	: EARL HIRAKAWA	:/S/ EARL HIRAKAWA
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: BILL LANE	:/S/ BILL LANE
USA SAM	: MIKE SNYDER	:/S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	:/S/ ERICH BASS