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FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: M4-1BG-TX030-X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC

REVISION: 1 11/12/91

	PART NAME VENDOR NAME	PART NUMBER VENDOR NUMBER
▣ LRU	HYDROGEN TANK SUBASSEMBLY	MC282-0063-0200
▣	BEECH	15548-1000
▣ LRU	TANK SUBASSEMBLIES, H2	MC282-0112-0200
▣	BALL AEROSPACE	163196-500

PART DATA

▣ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
TANK ASSEMBLIES, H2

▣ REFERENCE DESIGNATORS:

- : 40V45TK030
- : 40V45TK040
- : 40V45TK500
- : 40V45TK568
- : 40V45TK650
- : 40V45TK860
- : 40V45TK870
- : 40V45TK880
- : 40V45TK890

▣ QUANTITY OF LIKE ITEMS: 3-9
MISSION DEPENDENT

▣ FUNCTION:
PROVIDES STORAGE OF CRYOGENIC HYDROGEN FOR FUEL CELL OPERATION.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE

NUMBER: M4-1BG-TK030-02

SUBSYSTEM: ELECTRICAL POWER GENERATION - CRYO, GENERIC REVISION# 1 11/12/91 R
LRU :HYDROGEN TANK SUBASSEMBLY
ITEM NAME: TANK SUBASSEMBLIES, H2

CRITICALITY OF THIS FAILURE MODE:1R2

- FAILURE MODE:
LOSS OF ANNULUS VACUUM

MISSION PHASE:

PL PRELAUNCH
 LO LIFT-OFF
 DO DE-ORBIT
 LS LANDING SAFING

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

- CAUSE:
LEAKAGE OF OUTER SHELL, VIBRATION, CORROSION, MISHANDLING

- CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

- REDUNDANCY SCREEN A) PASS
- B) FAIL
- C) PASS

PASS/FAIL RATIONALE:

- A)
- B)
REDUNDANCY SCREEN B - FAILURE MODE IS NOT DETECTABLE IN FLIGHT SINCE VEHICLE IS IN A VACUUM ENVIRONMENT ON ORBIT.
- C)

- FAILURE EFFECTS -

- (A) SUBSYSTEM:
LOSS OF VACUUM WOULD RESULT IN INCREASED HEAT LEAKAGE TO THE H2 TANK AND RESULTANT LOSS OF H2 THROUGH THE RELIEF VALVE EXCEPT FOR ON ORBIT OPERATIONS.

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- (B) INTERFACING SUBSYSTEM(S):
POSSIBLE REDUCTION OF H2 CONSUMABLES AVAILABLE FOR FUEL CELL POWERPLANT OPERATION.
- (C) MISSION:
NO EFFECT.
- (D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (C)
- (E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE DUE TO TANK RUPTURE (CIL-04-1-TK030-01)
IF AN ADDITIONAL FAILURE RESULTS IN LOSS OF OVERBOARD RELIEF CAPABILITY.

- DISPOSITION RATIONALE -

- (A) DESIGN:
PRESSURE VESSEL (INCONEL 718) AND OUTER SHELL (ALUMINUM 2219) ARE ALL WELDED CONSTRUCTION. VACUUM DESIGN LIFE 5 YEARS MINIMUM. OUTER SHELL COATED WITH KOROPON FOR CORROSION PROTECTION. VAC-ION PUMP ENABLES GROUND VERIFICATION AND MAINTENANCE OF VACUUM. SHIPPING CONTAINER PREVENTS HANDLING DAMAGE.
- (B) TEST:
QUALIFICATION TEST INCLUDE: MECHANICAL SHOCK (20 G), SINUSOIDAL VIBRATION (+/- 0.25 G PEAK), RANDOM VIBRATION (0.008 G SQ/HZ MAXIMUM FOR 48 MINUTES), ACCELERATION (+/- 5 G FOR 5 MINUTES PER AXIS). VIBRATION MET 100 MISSION EQUIVALENT WITH TANK FULL AND 25 MISSION EQUIVALENT WITH TANK OFFLOADED.

ACCEPTANCE TESTS INCLUDE: VAC-ION PUMP TEST VERIFIES ANNULUS VACUUM INTEGRITY. MINIMUM DQ/DM HEAT LEAK TEST AT 110 DEG F ALSO VERIFIES ANNULUS VACUUM INTEGRITY.
- (C) OMRSD: TANK ASSEMBLY IS STRUCTURALLY INSPECTED DURING EVERY ORBITER MAINTENANCE DOWN PERIOD (OMDP). VAC-ION PUMP IS POWERED UP EVERY TURNAROUND AND EVERY 6 MONTHS DURING TANK STORAGE.
- (C) INSPECTION:
RECEIVING INSPECTION
ALLOY COMPOSITION AND HEAT TREAT CERTIFICATION VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CLEANLINESS LEVEL OF 200A IS MAINTAINED.

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NONDESTRUCTIVE EVALUATION

WELDMENTS VERIFIED BY A SPECIAL LEVEL PENETRANT INSPECTION. ULTRASONIC AND RADIOGRAPHIC INSPECTION BY QUALIFIED/CERTIFIED NDT PERSONNEL.

CRITICAL PROCESSES

WELDING IS CONTROLLED AND VERIFIED BY MANUFACTURING OPERATING PROCEDURE, CERTIFICATION OF OPERATORS, VISUAL INSPECTION, THERMOGRAPHY, AND X-RAY. PROCESS CONTROL COUPON, AFTER FORMING AND BEFORE WELDING, IS ANALYZED FOR COMPOSITION, GRAIN STRUCTURE AND TENSILE STRENGTH. HEAT TREATMENT AND KOROPON COATING APPLICATION IS VERIFIED BY INSPECTION.

TESTING

TANK ANNULUS IS EVACUATED AT ELEVATED TEMPERATURE FOR 21 DAYS; THE ANNULUS VACUUM LEVEL IS VERIFIED BY TANK ION PUMP INSTRUMENTATION AT THE VENDOR AND PERIODICALLY DURING STORAGE. MATERIALS ARE VERIFIED COUPON TESTED FOR LOAD STRENGTH. VESSELS ARE PRESSURE-TESTED AND LEAK TESTED AND VERIFIED BY INSPECTION.

PACKAGING/HANDLING

INSPECTION VERIFIES PARTS ARE PACKAGED AND PROTECTED PER REQUIREMENTS INCLUDING HANDLING REQUIREMENT FOR FRACTURE-CRITICAL HARDWARE.

(D) FAILURE HISTORY:

CAR NO. A83696-010 SUPPLIER, QUALIFICATION

DURING RANDOM VIBRATION OF AN H2 QUALIFICATION TANK ASSEMBLY, TANK PRESSURE COULD NOT BE MAINTAINED BELOW A SPECIFIED LEVEL. DURING DETANK, GAS WAS DISCOVERED ESCAPING IN THE CONVERTER/VAC-ION PUMP AREA. REMOVAL OF THE CONVERTER REVEALED THE PUMP HIGH VOLTAGE ROD-TO-INSULATOR END CAP HAD FRACTURED. ANALYSIS INDICATED THAT THE VAC-ION END CAP WAS OVERSTRESSED DURING VIBRATION TESTING AS A RESULT OF BEING SUBJECTED TO EXCESSIVE VIBRATION LEVELS IMPOSED BY THE TEST FIXTURE.

CORRECTIVE ACTION INCLUDED A MODIFICATION OF THE VIBRATION TEST FIXTURE TO PROVIDE A MORE REALISTIC VIBRATION TEST.

CAR NO. A87017-010 SUPPLIER, ATP

DURING END ITEM ACCEPTANCE TESTING OF AN H2 TANK ASSEMBLY, AN INCREASE IN TANK ANNULUS PRESSURE WAS NOTED. AFTER AN EXTENSIVE INVESTIGATION AND A VERIFICATION OF THE REBUILT TANK ASSEMBLY, THE MOST PROBABLE CAUSE FOR THE FAILURE WAS DETERMINED TO BE A SMALL CRACK/POROSITY IN THE HEATER COLD LEAD SHEATH.

ATTEMPTS TO DEVISE BETTER PROBE SCREENING TESTS WERE UNSUCCESSFUL; THE END ITEM ACCEPTANCE TEST PROVED TO BE THE MOST PRACTICAL AND RELIABLE SCREENING TEST.

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- (E) OPERATIONAL USE:
FOR FAILURE IN ATMOSPHERIC FLIGHT, CREW WILL BE ALERTED AND WILL DEACTIVATE ASSOCIATED TANK HEATERS.

- APPROVALS -

RELIABILITY ENGINEERING:	M. D. WEST	:	<u>M. D. West</u> ✓ Ocho
DESIGN ENGINEERING	: M. M. SCHEIERN	:	<u>M. M. Scheiern</u>
QUALITY MANAGER	: O. J. BUTTNER	:	<u>O. J. Buttner</u>
NASA RELIABILITY	:	:	<u>[Signature]</u>
NASA SUBSYSTEM MANAGER	:	:	<u>[Signature]</u> 4/1/92
NASA QUALITY ASSURANCE	:	:	<u>[Signature]</u> HTF