

SHUTTLE CRITICAL ITEMS LIST - ORBITER

SUBSYSTEM : ORBITAL MANEUVER FMEA NO 03-3 -1001 -1 REV:12/03/

ASSEMBLY : PRESSURIZATION SUBSYSTEM CRIT. FUNC:  
P/N RI : MC282-0082-0001 (TYPE II) CRIT. HDW:  
P/N VENDOR: VEHICLE 102 103 104  
QUANTITY : 2 EFFECTIVITY: X X X  
: ONE PER POD PHASE(S): PL X LO X OO X DO X LS  
:

REDUNDANCY SCREEN: A- B- C-  
PREPARED BY: APPROVED BY: APPROVED BY (NASA):  
DES D W CARLSON DES *[Signature]* SSM *[Signature]*  
REL C M AKERS REL *[Signature]* REL *[Signature]*  
QE W J SMITH QE *[Signature]* QE *[Signature]*

ITEM:  
TANK HELIUM STORAGE, FILAMENT WOUND.

FUNCTION:  
STORES HELIUM AT A MAX WORKING PRESSURE OF 4800 PSI AND PROVIDES PRESSURIZING GAS FOR THE PROPELLANT TANKS TO EXPEL FUEL AND OXIDIZER DURING OMS ENGINE FIRING. TANKS ARE LOCATED IN THE OMS PODS. HELIUM TANK CONSISTS OF DOUBLE MELT TITANIUM LINER WITH DUPONT KEVLAR 49 FIBER AND EPOXY RESIN BONDING OVERWRAP. O.D. IS 40.094 IN., VOLUME IS 30, CU. IN.

FAILURE MODE:  
STRUCTURAL FAILURE/RUPTURE, EXTERNAL LEAK.

CAUSE(S):  
FITTING/BOSS SEAL LEAK, MATERIAL/WELD DEFECT, FATIGUE CRACK GROWTH, STRUCTURAL RUPTURE (STATIC FATIGUE), LINER DEFECT, FAULTY FABRICATION, EPOXY CYCLE NOT ADEQUATE, EXTERNAL PROPELLANT VAPOR EXPOSURE, TEST OR HANDLING DAMAGE, INADEQUATE MOUNTING, SHOCK, VIBRATION. LOSS OF MOISTURE PROTECTIVE COATING ALLOWING MOISTURE TO ENTER EPOXY OVERWRAP WITH SUBSEQUENT FREEZING CAUSING DAMAGE TO OVERWRAP.

EFFECT(S) ON:  
(A) SUBSYSTEM (B) INTERFACES (C) MISSION (D) CREW/VEHICLE

(A) LOSS OF SUBSYSTEM PRESSURIZATION IN ONE POD.

(B) LOSS OF INTERFACE FUNCTION - OMS ENGINE PROPELLANT FEED CAPABILITY AFT RCS PROPELLANT FEED FROM OMS; POD OR VEHICLE DAMAGE, LOSS OF THERMAL PROTECTIVE SYSTEM.

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(C) LOSS OF ENTRY CAPABILITY. LOSS OF PROPELLANT FEED IF ULLAGE INADEQUATE.

(D) POTENTIAL LOSS OF CREW/VEHICLE. LOSS OF HELIUM OVERBOARD MAY RESULT IN INABILITY TO UTILIZE PROPELLANT FOR DEORBIT. SUDDEN LOSS OF HELIUM MAY RESULT IN POD STRUCTURE OR TPS DAMAGE. POTENTIAL STRUCTURAL DAMAGE TO PROPELLANT TANK AND POD DURING LANDING DUE TO EXCESSIVE PROPELLANT WEIGHT.

DISPOSITION & RATIONALE:

(A) DESIGN (B) TEST (C) INSPECTION (D) FAILURE HISTORY (E) OPERATIONAL USE

(A) DESIGN

FILAMENT WOUND TANKS ARE DESIGNED TO LIMIT FAILURE PROPAGATION DUE TO SHRAPNEL IN EVENT OF A LINER FAILURE. KEVLAR 49 FIBER HAS A TENSILE STRENGTH OF 500 KSI ALLOWING LIGHT WEIGHT WITH GREAT STRENGTH. DESIGN LIMITS STRESS IN THE OVERWRAP TO PRECLUDE STRESS RUPTURE FAILURES. INCREASED STRAIN CAPABILITY PROVIDED BY THE COMPRESSIVE LOAD ON AN UNPRESSURIZED LINER. THE FACTOR OF SAFETY (BURST) IS 1.5 X WORKING PRESSURE.

(B) TEST

QUALIFICATION TEST

1000 PRESSURE CYCLES WERE PERFORMED DURING QUAL WHICH IS MORE THAN FOUR TIMES ANTICIPATED OPERATING LIFE. A 90-DAY CREEP TEST UNDER PRESSURE WAS ALSO PERFORMED AFTER WHICH THE TANK WAS EXAMINED TO VERIFY NO PERMANENT DEFORMATION OR FLAW GROWTH. DESIGN OF THE TANK TO PRECLUDE STRESS RUPTURE IS VERIFIED BY JSC TEST PROGRAM MAINTAINING A FACTOR OF 4 OVER ACTUAL USE TIME. RANDOM VIBRATION AT ANTICIPATED MISSION LEVELS WAS PERFORMED DURING QUAL. TEST. POD ACOUSTIC TEST FOR 100 MISSION EQUIVALENT WITH 4 X FACTOR ON TANK AND MOUNTING STRUCTURE.

ACCEPTANCE TEST

PROOF PRESSURE (1.10 X WORKING PRESSURE) AND LEAKAGE TESTS ARE PERFORMED DURING ATP.

GROUND TURNAROUND

LEAKAGE TESTS ARE MONITORED AFTER INSTALLATION INTO THE SYSTEM AND AS PART OF THE CHECKOUT PROCEDURE PRIOR TO FLIGHT.

V43CFO.020 PERFORMS HELIUM SERVICING TO FLIGHT LOAD EVERY FLIGHT.

V43CEO.030 PERFORMS SUBSYSTEM INSPECTION EVERY FIFTH FLIGHT.

V43CEO.080 PERFORMS HELIUM SYSTEM SAMPLING EVERY FIFTH FLIGHT.

V43CBO.210 PERFORMS FIRST FLIGHT EXTERNAL LEAKAGE CHECKS.

V43CBO.220 PERFORMS PRESSURE DECAY CHECKS OF HIGH PRESSURE HELIUM SYSTEM FOR EACH FLIGHT.

THE HELIUM TANK PRESSURE AND TEMPERATURE ARE MONITORED EACH FLIGHT FOR LEAKAGE AND THE HELIUM USAGE EACH FLIGHT IS MONITORED FOR DETECTION OF ABNORMAL CONSUMPTION RATE.

A PERIODIC INSPECTION IS CONDUCTED FOR ALL POD COMPONENTS TO CHECK FOR EVIDENCE OF DEGRADATION AND/OR EXPOSURE TO PROPELLANT VAPORS. PRESSURE CYCLES ACCUMULATED ARE RECORDED.

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(C) INSPECTION

RECEIVING INSPECTION

MATERIALS AND PROCESS CERTIFICATIONS ARE VERIFIED BY INSPECTION. MICRO EXAMINATION AND CHEM ETCH INSPECTION FOR ALPHA SEGREGATION IS VERIFIED BY INSPECTION.

CONTAMINATION CONTROL

CLEANLINESS OF INTERNAL SURFACES TO LEVEL 100A IS VERIFIED BY INSPECTION. DRYNESS IS VERIFIED BY INSPECTION. CORROSION PROTECTION PROVISION ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

INSPECTION VERIFIES PARTS PROTECTION, MANUFACTURING PROCESSES, FINISHES, ASSEMBLY AND INSTALLATION PER SHOP TRAVELER.

NONDESTRUCTIVE EVALUATION

INSPECTION VERIFIES NDE PENETRANT INSPECTION OF LINER. X-RAY INSPECTION OF VESSEL IS VERIFIED BY INSPECTION. NDE (PENETRANT LEVEL 7) IS PERFORMED BEFORE AND AFTER WELDING. THE USE OF SPECIAL LEVEL FLUORESCENT PENETRANT INSPECTION OF MACHINED LINERS AND GIRTH WELDS, AND RADIOGRAPHIC INSPECTION OF GIRTH WELDS (BOTH BEFORE AND AFTER PROOF SIZING) ARE USED TO SCREEN POTENTIALLY DETRIMENTAL PARENT MATERIAL WELD DEFECTS. PROOF SIZING OF THE PRESSURE VESSEL ABOVE THE YIELD STRESS FOR THE LINER AIDS IN SCREENING FLAWS.

CRITICAL PROCESSES

WELDING, KEVLAR WRAPPING, EPOXY CURE PROCESS AND HEAT TREATMENT ARE VERIFIED BY INSPECTION.

TESTING

MECHANICAL PROPERTIES AND CHEMICAL ANALYSIS FOR O2, N2 AND H2 CONTENT OF HEMISPHERE AFTER FINAL HEAT TREAT IS VERIFIED BY INSPECTION. TESTING OF FORGINGS AND WELD SCHEDULES ARE VERIFIED BY INSPECTION. PRESSURIZATION CYCLE HISTORY LOG AND SCHEDULE ARE VERIFIED BY INSPECTION. ACCEPTANCE TEST IS VERIFIED BY INSPECTION. DURING FIELD USAGE THE FLUID (GASEOUS HELIUM) IS VERIFIED TO CONFORM TO SPECIFICATION REQUIREMENTS. THE FLUID IS SAMPLED AFTER LOADING TO VERIFY THAT MOISTURE LEVELS ARE WITHIN SPECIFICATION REQUIREMENTS. PERIODIC INSPECTION OF THE INSTALLED TANK IS PERFORMED TO VERIFY NO VISUAL EVIDENCE OF DAMAGE DUE TO PROPELLANT VAPOUR EXPOSURE OR OTHER CAUSATIVE AGENTS.

HANDLING/PACKAGING

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

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**(D) FAILURE HISTORY**

CAR AB8282 AND A9902 RECORD FAILURES (CRACK INDICATION) OF THE OMS GHE PRESSURE TANK DURING PROOF SIZING OPERATIONS EARLY IN THE PROGRAM. NO OTHER FAILURE OF THE OMS TANKS HAVE OCCURRED. THE NUMBER OF LINER THICKNESS MEASUREMENTS FOR THE MEMBRANE WERE INCREASED. ADDITIONALLY THE LINERS ARE MACHINED ON THE HIGH SIDE OF THE TOLERANCE BAND. FLAW SCREENING, PROOF PRESSURE AND SUBSEQUENT X-RAY IDENTIFY POTENTIAL DEFECTS THAT COULD PROPAGATE DURING THE 1000 CYCLE USEFUL LIFE. CAR AC0968 FOR THE ARPCS AND CAR AB8397 FOR THE MPS RECORD SIMILAR FAILURE INDICATIONS. THE VESSEL WITH THE LARGEST CRACK WAS PRESSURE CYCLED TO FAILURE TO VERIFY REJECTION CRITERIA. FAILURE OCCURRED AFTER 479 CYCLES DUE TO CRACK PROPAGATION BY FATIGUE. THE TEST VERIFIED THAT CRACKS IN THE TANKS BELOW THE LEVEL OF X-RAY DETECTION WILL NOT PROPAGATE TO FAILURE WITHIN THE USEFUL LIFE OF THE TANK.

CAR'S A8669 AND A7806 RECORD THAT TWO ARPCS GN2 TANKS LEAKED DURING AND AFTER VIBRATION. INVESTIGATION SHOWED THAT FIXTURE LOADING CONDITIONS DURING VIBRATION TESTING CAUSED EXTREMELY SEVERE STRESS TO THE TANK MOUNTING STRUTS. EXAMINATION OF THE FAILED TANKS SUPPORTED THIS CONCLUSION. CERTIFICATION WAS ACHIEVED WITH ONE FULLY CERTIFIED TANK AND BY SIMILARITY TO OTHER CERTIFIED FILAMENT OVERWRAPPED VESSELS.

**(E) OPERATIONAL USE**

NO ACTION POSSIBLE IF PRESSURE RELEASE CAUSES POD STRUCTURE OR TPS DAMAGE. OPERATE TWO ENGINES FROM PRESSURANT IN FAILED POD TO INCREASE ULLAGE VOLUME AND MAXIMIZE BLOWDOWN. ULLAGE BLOWDOWN IS ADEQUATE FOR DEORBIT AFTER OMS-2 FOR TYPICAL MISSIONS (APPROX.60% ULLAGE IS REQUIRED FOR MAX BLOWDOWN. THE TYPICAL DEORBIT BURN REQUIRES LESS THAN 30% PROPELLANT).