

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**NUMBER:03-1-1518 -X****SUBSYSTEM NAME:** MAIN PROPULSION**REVISION:** 1

07/27/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
ASSY	: FILTER ASSEMBLY (TYPE I) VACCO INDUSTRIES	MC286-0097-0011
ASSY	: FILTER ASSEMBLY (TYPE II) VACCO INDUSTRIES	MC286-0097-0012
LRU	: FILTER ELEMENT VACCO INDUSTRIES	MC286-0097-0015

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

FILTER ELEMENT, GH2 PREPRESS/PRESSURIZATION SYSTEM, COMMON TO BOTH THE 5/8" DIA, TYPE I FILTER ASSEMBLY (MC286-0097-0011) USED ON THE 3 ENGINE LEGS AND THE 1" DIA, TYPE II FILTER ASSEMBLY (MC286-0097-0012) USED ON THE GROUND SUPPLIED GHE PREPRESS LINE.

NOTE: ALTHOUGH THE FILTER HOUSINGS AND ELEMENTS ARE USUALLY PROCURED AS SEPARATE PART NUMBERS, THEY CAN BE PROCURED AS A FILTER ASSEMBLY.

REFERENCE DESIGNATORS: FL10 (PREPRESS)
FL11 (ENGINE 1)
FL12 (ENGINE 2)
FL13 (ENGINE 3)

QUANTITY OF LIKE ITEMS: 4
ONE FILTER ON EACH OF THREE ENGINE LEGS, AND ONE ON THE PREPRESS SYSTEM

FUNCTION:

THE FILTER TRAPS CONTAMINATION THAT MAY BE PRESENT IN EITHER THE HELIUM PREPRESS SYSTEM FROM THE GROUND SUPPORT EQUIPMENT SUPPLY OR IN THE GH2 PRESSURIZATION SYSTEM ORIGINATING FROM THE LH2 FEED SYSTEM, THE SSME'S, OR THE EXTERNAL TANK.

REFERENCE DOCUMENTS: VS70-415007 (MAIN PROPULSION SYS SCHEMATIC)
NSTS-12820 (SPACE SHUTTLE OP FLIGHT RULES)

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: FILTER ASSEMBLY, GH2/GHE

ITEM NAME: GH2 FILTER ELEMENT

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

FAILURE TO FILTER SYSTEM CONTAMINATION

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

PIECE PART STRUCTURAL FAILURE, DAMAGE TO ELEMENT/DISCS

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTLS RETURN TO LAUNCH SITE

TAL TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN

A) FAIL

B) FAIL

C) PASS

PASS/FAIL RATIONALE:

A)

REMOVAL OF FILTER REQUIRES INVASIVE OPERATIONS. VISUAL INSPECTION OF FILTER ELEMENT IS NOT DEPENDABLE VERIFICATION OF PROPER FILTER FUNCTION.

CONTAMINATED FLOW CAN ONLY BE DETECTED AT VENDOR SITE.

B)

FAILURE TO FILTER MAY NOT RESULT IN LOWER PRESSURE DROP DURING OPERATION.

C)

MASTER MEAS. LIST NUMBERS:

V41P1160A

V41P1260A

V41P1360A

- FAILURE EFFECTS -

(A) SUBSYSTEM:

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FAILURE OF THE FILTER TO PREVENT CONTAMINATION MIGRATING TO THE GH2 FLOW CONTROL VALVES CAN RESULT IN GALLING OF THE FCV AND FAILURE OF THE VALVES TO CYCLE TO EITHER HIGH OR LOW FLOW POSITION. THE REMAINING TWO FCV'S WILL CONTROL ULLAGE PRESSURE WITHIN THE CONTROL BAND.

FOR RTLS AND TAL ABORT, AN ENGINE OUT RESULTS IN THE LOSS OF ONE FCV PRESSURIZATION LEG. A SUBSEQUENT FCV FAILING HIGH ON EITHER OF THE REMAINING OPERATING ENGINE SYSTEMS RESULTS IN VENTING OF GH2 AT LOW ALTITUDE. POSSIBLE VIOLATION OF TANK MAXIMUM STRUCTURAL CAPABILITY REQUIREMENTS. POSSIBLE FIRE/EXPLOSION HAZARD EXTERNAL TO THE VEHICLE.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

SAME AS A.

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

SAME AS A.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R2 2 SUCCESS PATHS. TIME FRAME ASCENT.

FOR A FAILURE IN AN ENGINE LEG GH2 PRESSURIZATION SYSTEM FILTER WITH FCV'S MC280-0017-1301 INSTALLED. THE 2-FAILURE SCENARIOS ARE AS FOLLOWS:

CASE 1

HIGH FLOW FAILURE:

- 1) ONE ENGINE LEG GH2 PRESSURIZATION SYSTEM FILTER FAILS TO PREVENT CONTAMINATION FLOW TO GH2 FLOW CONTROL VALVE. RESULTS IN FAILURE OF FCV TO CYCLE TO LOW FLOW.
- 2) ONE OF THE FOLLOWING FAILURES ON A PARALLEL GH2 PRESSURIZATION LEG CAUSING A SECOND FCV TO OPEN/REMAIN OPEN:
 - A SECOND HDC FAILS TO CONDUCT
 - ET ULLAGE PRESSURE TRANSDUCER FAILURE
 - LOSS OF A SIGNAL CONDITIONER
 - FCV FAILS IN THE HIGH FLOW POSITION
 - CONTACT-TO-CONTACT SHORT IN THE LH2 ULLAGE PRESSURE TOGGLE SWITCH INHIBIT CIRCUIT TO THE FCV CLOSE COMMAND HYBRID DRIVER

RESULTS IN EXCESSIVE GH2 ULLAGE PRESSURE CAUSING ET VENT VALVE TO RELIEVE EXCESS PRESSURE. POTENTIAL FIRE/EXPLOSION HAZARD EXTERIOR TO THE VEHICLE. POSSIBLE VIOLATION OF THE ET MAXIMUM STRUCTURAL CAPABILITY REQUIREMENTS.

CASE 2:

LOW FLOW FAILURE:

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- 1) ONE ENGINE LEG GH2 PRESSURIZATION SYSTEM FILTER FAILS TO PREVENT CONTAMINATION FLOW TO GH2 FLOW CONTROL VALVE. RESULTS IN FAILURE OF FCV TO CYCLE TO HIGH FLOW.
- 2) EITHER OF THE REMAINING TWO FCV'S FAILING TO STROKE TO HIGH FLOW POSITION OR LOSS OF GH2 PRESSURANT FROM EITHER OF THE REMAINING TWO ENGINES.

RESULTS IN INSUFFICIENT PRESSURIZATION GAS TO MAINTAIN LH2 ULLAGE PRESSURE IN THE REQUIRED FLIGHT CONTROL BAND (32 -34 PSIA). POSSIBLE VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS.

POSSIBLE LOSS OF CREW/VEHICLE.

DESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)):

(F) RATIONALE FOR CRITICALITY DOWNGRADE:

-DISPOSITION RATIONALE-

(A) DESIGN:

THE FILTER HAS A FILTRATION RATING OF 14 ± 3 MICRONS (17 MICRON ABSOLUTE). IT USES A STAINLESS STEEL ETCHED DISC FILTER ELEMENT. THE .002 INCH THICK FILTER ELEMENT DISCS HAVE SHALLOW RADIAL GROOVES ETCHED IN THEM TO A DEPTH OF 14 ± 3 MICRONS. WHEN THE DISCS ARE STACKED TOGETHER, THE GROOVES FORM RECTANGULAR PASSAGES THAT ALLOW FLOW TO PASS THROUGH BUT RESTRICT THE SIZE OF PARTICLES THAT CAN PASS THROUGH. THE 6 INCH FILTER ELEMENT CONTAINS APPROXIMATELY 3000 OF THESE DISCS.

THE FILTER ELEMENT IS DESIGNED TO BE 100% CLEANABLE THROUGH BACKFLUSHING WHICH MUST BE ACCOMPLISHED WITH THE ELEMENT REMOVED FROM THE HOUSING. THE FILTER HOUSING IS FLANGED. THE LOWER HALF OF THE HOUSING MAY BE REMOVED FOR REMOVAL OF THE FILTER ELEMENT WITHOUT REMOVAL OF THE COMPLETE HOUSING FROM THE SYSTEM. THE FILTER ELEMENT IS DESIGNED TO ACCEPT 15 GRAMS OF STANDARD ALUMINUM CONTAMINANT WITH AN INCREASE IN PRESSURE DROP OF LESS THAN 50 PSID. THIS IS PROJECTED TO BE EQUIVALENT TO AT LEAST 5 MISSIONS OF SERVICE. BOTH THE TYPE I AND TYPE II FILTERS HAVE A FACTOR OF SAFETY OF 1.1 AND 1.5 FOR PROOF AND BURST PRESSURE RESPECTIVELY.

THE TYPE I FILTER USED IN THE ENGINE LEGS OF THE PRESSURIZATION SYSTEM HAS PROVISIONS FOR A TRIM ORIFICE TO BE INTERNALLY INSTALLED IN ITS INLET LINE. THE ORIFICE CAN BE USED TO MAKE SMALL ADJUSTMENTS TO PRESSURIZATION SYSTEM FLOWRATE BY ADJUSTING FLOW CONTROL VALVE INLET PRESSURE.

(B) TEST:

ATP

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EXAMINATION OF PRODUCT

BUBBLE POINT TEST EQUIVALENT TO 17 MICRON ABSOLUTE FILTRATION RATING.

BOIL POINT TEST EQUIVALENT TO 14 MICRON NOMINAL FILTRATION RATING.

PROOF PRESSURE TEST (4950 PSIG, TYPE I; 1045 PSIG, TYPE II)

LEAKAGE (0 TO 4500 PSIG, TYPE I; 0 TO 950 PSIG, TYPE II)

CLEANLINESS LEVEL 100 (PER MA0110-301)

CERTIFICATION (TYPE I QUAL UNIT)

1. PROOF TEST (4950 PSIG)
FAILURE OF PRIMARY SEAL SIMULATED, SECONDARY SEAL FULLY PRESSURIZED.
2. FLOW TEST (1.5 LBS/SEC GHE @ 3050±50 PSIG, 50°±50° F)
CLEAN PRESSURE DROP (160 PSID)
CONTAMINATED PRESSURE DROP (50 PSI INCREASE IN ΔP OVER CLEAN VALUE WITH 15 GRAMS OF STANDARD ALUMINUM CONTAMINANT, 0 TO 1000 MICRONS IN SIZE, WITH TEST SEQUENCE REPEATED TWICE)
3. ELEMENT REUSE DEMONSTRATION
RECLEAN FILTER ELEMENT
BUBBLE POINT TEST ELEMENT - EQUIVALENT TO 17 MICRON ABSOLUTE FILTRATION RATING
BOIL POINT TEST ELEMENT - EQUIVALENT TO 14 MICRON NOMINAL FILTRATION RATING
REASSEMBLE FILTER
LEAK CHECK (2 SCCM OF GHE @ 4500 PSIG)
4. RANDOM VIBRATION (PRESSURIZED TO 4500 PSIG)
52 MINUTES IN Y-AXIS, 20 TO 2000 HZ, 10.5 GRMS (ASCENT ENVIRONMENT)
52 MINUTES IN X AND Z AXES, 20 TO 2000 HZ, 5.7 GRMS (ASCENT ENVIRONMENT)
3.3 MINUTES IN X AND Z AXES, 20 TO 2000 HZ, 10.5 GRMS (MAIN ENGINE IGNITION ENVIRONMENT)
5. THERMAL CYCLES (400 CYCLES, +80°F TO -300°F)
6. HYDROGEN COMPATIBILITY (13.5 HRS, 4500 PSIG GH₂)
7. PRESSURE CYCLES (400 CYCLES, AMBIENT, 10 PSIG TO 4500 PSIG)
8. ELEMENT PRESSURE
PLUG ELEMENT WITH A SLURRY OF AC COARSE DUST
PRESSURIZE TO 1000 PSID IN EACH DIRECTION INDEPENDENTLY
CLEAN ELEMENT AND PERFORM BUBBLE POINT TEST
9. LRU DEMONSTRATION

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DISASSEMBLE/REASSEMBLE FILTER 20 TIMES
LEAK CHECK AND BUBBLE POINT TEST

10. GH₂ FLOW TEST (1.1 LBS/SEC GH₂ @ 3050±50 PSIG, 50°±50°F)
CLEAN PRESSURE DROP (160 PSID)
11. BURST TEST (6750 PSIG)

OMRSD

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION:

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

CONTAMINATION CONTROL:

FILTER INTERNAL SURFACES ARE MAINTAINED TO LEVEL 100 (PER MA0110-301).
CORROSION PROTECTION IS IMPLEMENTED AND VERIFIED.

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ASSEMBLY/INSTALLATION:

CRITICAL DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. MANUFACTURING PROCESSES AND INSTALLATION AND ASSEMBLY OPERATIONS ARE VERIFIED BY INSPECTION. TORQUE FORCES APPLIED TO PARTS ARE VERIFIED BY INSPECTION.

CRITICAL PROCESSES:

INLET AND OUTLET TUBE WELDS ARE INSPECTED PER SPECIFICATION REQUIREMENTS.

NONDESTRUCTIVE EVALUATION:

DYE PENETRANT INSPECTION OF HOUSING AND SUMP AFTER MACHINING AND CHEMICAL ETCHING AND X-RAY OF INLET/OUTLET TUBE WELDS WITNESSED BY INSPECTION.

TESTING:

TESTING IS WITNESSED TO VERIFY COMPLIANCE WITH REQUIREMENTS OF ATP.

HANDLING/PACKAGING:

WORKMANSHIP IS INSPECTED. FINAL ASSEMBLY, HANDLING, AND PACKAGING ARE VERIFIED TO MEET REQUIREMENTS OF PROCEDURE.

(D) FAILURE HISTORY:

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

IF THE LH2 NPSP DROPS BELOW THE PRE-FLIGHT ACCEPTED LEVELS (PER FLIGHT RULES), THE CREW WILL MANUALLY THROTTLE THE ENGINES TO KEEP THE NPSP HIGH ENOUGH TO PREVENT LH2 TURBOPUMP CAVITATION.

- 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	: MICHAEL SNYDER	:/S/ MICHAEL SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: BILL PRINCE	:/S/ BILL PRINCE