

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

07/27/00

**PART DATA**

|      | <b>PART NAME</b>                                | <b>PART NUMBER</b>   |
|------|---|----------------------|
|      | <b>VENDOR NAME</b>                              | <b>VENDOR NUMBER</b> |
| ASSY | : FILTER ASSEMBLY (TYPE I)<br>VACCO INDUSTRIES  | MC286-0097-0011      |
| ASSY | : FILTER ASSEMBLY (TYPE II)<br>VACCO INDUSTRIES | MC286-0097-0012      |
| LRU  | : FILTER ELEMENT<br>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)

**FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE****NUMBER: 03-1-1518-01****REVISION#: 1 07/27/00****SUBSYSTEM NAME: MAIN PROPULSION****LRU: FILTER ASSEMBLY, GH2/GHE****ITEM NAME: GH2 FILTER ELEMENT****CRITICALITY OF THIS****FAILURE MODE: 1R2**

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**FAILURE MODE:**

RESTRICTED OR BLOCKED FLOW/CLOGGED

**MISSION PHASE:**

PL PRE-LAUNCH

LO LIFT-OFF

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

**CAUSE:**

CONTAMINATION FROM UPSTREAM COMPONENT. FOR ENGINE LEG FILTERS, CONTAMINATION FROM ET, FEED SYSTEM, OR SSME. FOR PREPRESS SYSTEM FILTER, CONTAMINATION FROM GHE PREPRESSURIZATION SYSTEM, INCLUDING GROUND SUPPORT SYSTEM.

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES**

RTLS RETURN TO LAUNCH SITE

TAL TRANS-ATLANTIC LANDING

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**REDUNDANCY SCREEN**

A) FAIL

B) PASS

C) FAIL

**PASS/FAIL RATIONALE:****A)**

REMOVAL OF FILTER REQUIRES INVASIVE OPERATIONS. VISUAL INSPECTION OF FILTER ELEMENT IS NOT DEPENDABLE VERIFICATION OF UNRESTRICTED FLOW. RESTRICTED FLOW CAN ONLY BE DETECTED AT VENDOR SITE.

**B)**

PRESSURE TRANSDUCER DOWNSTREAM OF EACH FILTER DETECTS RESTRICTED FLOW AS PRESSURE DROP.

**C)**

POSSIBLE CONTAMINATION, ORIGINATING FROM THE EXTERNAL TANK, INTRODUCED INTO ALL PRESSURIZATION FILTERS.

**MASTER MEAS. LIST NUMBERS:**

V41P1160A

V41P1260A

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V41P1360A

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

WITH MC280-0017-1301 FLOW CONTROL VALVES (FCV) INSTALLED, BLOCKAGE OF THE FILTER WOULD RESULT IN THE REMAINING FCV'S ON THE REMAINING TWO GH2 PRESSURIZATION LEGS STROKING TO THE HIGH FLOW POSITION TO ATTEMPT TO COMPENSATE FOR THE REDUCED FLOW AND MAINTAIN LH2 ULLAGE PRESSURE. FLIGHT RULES A5.1.1-14 & A5.1.4-5 COVER LH2 TANK PRESSURIZATION FAILURES. THE GROUND WILL CHECK THE 2" DISCONNECT OUTLET PRESSURE, V41P1490A, TO DETERMINE IF THE FAILURE IS A PRESSURIZATION FLOW RESTRICTION OR AN ULLAGE LEAK. IN THE CASE OF A FLOW RESTRICTION, THE GROUND WILL DIRECT THE CREW TO MANUALLY THROTTLE THE SSME'S IN ORDER TO MAINTAIN THE SSME NET POSITIVE SUCTION PRESSURE (NPSP).

DURING RTLS/TAL ABORTS, ONE OF THE THREE MAIN ENGINES (SSME'S) HAS ALREADY BEEN SHUTDOWN, RESULTING IN LOSS OF ONE FCV PRESSURIZATION LEG. AT NOMINAL POWER LEVEL, A NO FLOW PRESSURIZATION SYSTEM FAILURE ON ONE OF THE TWO REMAINING ENGINES WILL CAUSE THE ET LH2 ULLAGE PRESSURE TO FALL BELOW THE REQUIRED CONTROL BAND (32 - 34 PSIG) DURING MAIN ENGINE OPERATIONS. POSSIBLE VIOLATION OF TANK MINIMUM STRUCTURAL REQUIREMENTS WILL RESULT IN STRUCTURAL FAILURE. ALSO, POSSIBLE LOW NPSP, RESULTING IN UNCONTAINED ENGINE SHUTDOWN.

**(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 SCENARIO IS AS FOLLOWS:

- 1) ONE ENGINE LEG GH2 PRESSURIZATION SYSTEM FILTER CLOGS.
- 2) EITHER OF REMAINING TWO ENGINE LEG GH2 PRESSURIZATION SYSTEMS FAILS TO PROVIDE SUFFICIENT GH2 FLOW (COULD BE ANOTHER CLOGGED ENGINE LEG FILTER, FCV FAILURE TO OPEN TO HIGH FLOW RATE, LOSS OF GH2 PRESSURANT FROM SSME'S, ETC.).

THIS SCENARIO RESULTS IN INSUFFICIENT PRESSURIZATION GASES TO MAINTAIN LH2 ULLAGE PRESSURE IN THE REQUIRED FLIGHT CONTROL BAND (32-34 PSIA). THIS COULD CAUSE VIOLATION OF TANK STRUCTURAL CAPABILITY (RESULTING IN STRUCTURAL FAILURE

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OF LH2 TANK) AND LOW NPSP (RESULTING IN UNCONTAINED SSME SHUTDOWN). EITHER EVENT RESULTS IN LOSS OF CREW/VEHICLE.

CRITICALITY 3/3 FOR A FAILURE IN THE GROUND GHE PREPRESSURIZATION SYSTEM FILTER. THE INABILITY TO PRESSURIZE THE LH2 TANK TO PREPRESSURIZATION LEVELS WOULD BE DETECTED ON THE GROUND, RESULTING IN LAUNCH SCRUB.

**DESIGN CRITICALITY (PRIOR TO DOWNGRADE, DESCRIBED IN (F)):** 1/1

**(F) RATIONALE FOR CRITICALITY DOWNGRADE:**

SAME AS A.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE FILTER HAS A FILTRATION RATING OF  $14\pm 3$  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  $14\pm 3$  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

EXAMINATION OF PRODUCT

BUBBLE POINT TEST EQUIVALENT TO 17 MICRON ABSOLUTE FILTRATION RATING.

BOIL POINT TEST EQUIVALENT TO 14 MICRON NOMINAL FILTRATION RATING.

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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 GH<sub>2</sub>)
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  
DISASSEMBLE/REASSEMBLE FILTER 20 TIMES  
LEAK CHECK AND BUBBLE POINT TEST
10. GH<sub>2</sub> FLOW TEST (1.1 LBS/SEC GH<sub>2</sub> @ 3050±50 PSIG, 50°±50°F)  
CLEAN PRESSURE DROP (160 PSID)

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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.

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 A GH2 PRESSURIZATION FILTER BECOMES CLOGGED, RESTRICTING FLOW THROUGH  
ONE OF THE THREE ENGINE LEG FLOW PATHS, GH2 PRESSURIZATION WILL BE  
ACCOMPLISHED VIA THE REMAINING TWO ENGINE LEGS. THE FCV'S (MC280-0017-1301) ON  
THESE TWO ENGINE LEGS WILL AUTOMATICALLY STROKE TO INCREASE GH2 FLOW,  
COMPENSATING FOR THE DIMINISHED FLOW/NO FLOW CONDITION OF THE CLOGGED  
ENGINE FLOW PATH. IF THIS AUTOMATIC CORRECTING ACTION DOES NOT OCCUR, THE  
RESULTING LOW LH2 ULLAGE PRESSURE CONDITION WILL TRIGGER A SYSTEMS  
MANAGEMENT (SM) ALERT. THE FLIGHT CREW WILL OPEN ALL THREE GH2 FCV'S VIA

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COCKPIT SWITCH S53 ON PANEL R2. IF THE LOW LH2 ULLAGE PRESSURE CONDITION RESULTS IN NET POSITIVE SUCTION PRESSURE (NPSP) BELOW PRE-FLIGHT ACCEPTED LEVELS (PER FLIGHT RULES), THE CREW WILL THROTTLE DOWN THE MAIN ENGINES TO LOWER THE MINIMUM ALLOWABLE NPSP, TO PREVENT LH2 TURBOPUMP CAVITATION.

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**- APPROVALS -**

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| 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          |