

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE**

NUMBER: 03-1-0503 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/09/00

**PART DATA**


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	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
SRU	:GH2 2" ET PRESSURIZATION DISCONNECT (ORB) VACCO INDUSTRIES	MC284-0391-0001
SRU	:GH2 2" ET PRESSURIZATION DISCONNECT (ET) VACCO INDUSTRIES	MC284-0391-0032

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**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

DISCONNECT, ET PRESSURIZATION (GH2), ORBITER &amp; ET HALF (2.0 INCH DIA).

REFERENCE DESIGNATORS: PD5

QUANTITY OF LIKE ITEMS: 1

**FUNCTION:**

PROVIDES THE FLOW PATH BETWEEN THE ET AND THE ORBITER FOR THE GH2 FROM THE MAIN ENGINES TO PRESSURIZE THE ET. ALSO USED FOR HE ANTI-ICING FLOW (PRELAUNCH) AND HE PREPRESSURIZATION PRIOR TO ENGINE START. THE DISCONNECT POPPETS ARE OPEN UNTIL ORBITER/ET SEPARATION, AT WHICH TIME THE DISCONNECT CLOSES TO PREVENT CONTAMINATION OF THE MPS DURING ENTRY. THE DISCONNECT INCORPORATES A PORT USED IN CONJUNCTION WITH THE GH2 PRESSURIZATION LINE VENT VALVE (LV52) TO VENT THE GH2 SYSTEM DURING VACUUM INERTING.

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**SUBSYSTEM NAME: MAIN PROPULSION**

**LRU: GH2 2" ET PRESSURIZATION DISCONNECT (PD5)**

**CRITICALITY OF THIS**

**ITEM NAME: GH2 2" ET PRESSURIZATION DISCONNECT (PD5)**

**FAILURE MODE: 1/1**

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**FAILURE MODE:**

FAILS TO REMAIN OPEN

**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 OF THE POPPET SUPPORT STRUTS. (ORBITER AND ET HALF)

**CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO**

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**REDUNDANCY SCREEN**

A) N/A  
B) N/A  
C) N/A

**PASS/FAIL RATIONALE:**

A)

B)

C)

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**- FAILURE EFFECTS -**

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**(A) SUBSYSTEM:**

CASE 1:

1/1 TIME FRAME - PROPELLANT LOADING, ET PREPRESSURIZATION

DEAD-ENDED 750 PSI ANTI-ICE PURGE OR 2,000 PSIG PREPRESSURIZATION FROM THE GSE WILL RUPTURE THE DISCONNECT (BURST PRESSURE OF THE PRESSURIZATION DISCONNECT ORBITER HALF WITH POPPET FAILED IN THE CLOSED POSITION IS 500 PSIG, AND THE MATED DISCONNECT BURST PRESSURE IS 1200 PSIG) AND/OR THE ASSOCIATED

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PRESSURIZATION SYSTEM. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION. GHE FLOW RATE ANTICIPATED FROM THE GROUND SYSTEM DURING PROPELLANT LOADING AND PREPRESSURIZATION FOR A RUPTURE OF THIS TYPE EXCEEDS 6.0 LB/SEC. A HELIUM FLOW RATE OF 3.5 LB/SEC, IN ADDITION TO THE NORMAL NITROGEN AFT COMPARTMENT PURGE FLOW, WILL CAUSE A DELTA P OF 1 PSID ACROSS THE AFT COMPARTMENT.

GHE LEAKAGE FROM THE ANTI-ICING PURGE FLOW IS DETECTABLE IN THE AFT COMPARTMENT USING HAZARDOUS GAS DETECTION SYSTEM (HGDS). LCC REQUIREMENTS EXIST TO: VERIFY ET LH2 ULLAGE PRESSURE IN THE PREPRESSURIZATION BAND BETWEEN T-75 SECONDS AND T-10 SECONDS; VERIFY PREPRESSURIZATION CYCLE COUNT TO BE NO GREATER THAN MAX LCC ALLOWABLE FROM INITIAL PRESSURIZATION TO T-43 SECONDS.

CASE 2:  
1/1 TIME FRAME - ENGINE OPERATION.

PREVENTS PRESSURIZATION OF ET AND RESULTS IN LOW LH2 ULLAGE PRESSURE. LOSS OF ET LH2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS AND UNCONTAINED SSME SHUTDOWN DUE TO LOW NPSP.

THE FLOW CONTROL VALVES WILL CYCLE TO HIGH FLOW POSITION IN AN ATTEMPT TO MAINTAIN ET ULLAGE PRESSURE. PRESSURE DOWNSTREAM OF THE FLOW CONTROL VALVES WILL EQUALIZE WITH THE UPSTREAM (ENGINE OUTLET) PRESSURE RESULTING IN AFT COMPARTMENT OVERPRESSURIZATION DUE TO RUPTURE OF LINES DOWNSTREAM OF THE FLOW CONTROL VALVES AND ET/ORBITER DISCONNECT.

**(B) INTERFACING SUBSYSTEM(S):**  
SAME AS A.

**(C) MISSION:**  
POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION. POSSIBLE ABORT DUE TO EARLY ENGINE SHUTDOWN.

**(D) CREW, VEHICLE, AND ELEMENT(S):**  
POSSIBLE LOSS OF CREW/VEHICLE.

**(E) FUNCTIONAL CRITICALITY EFFECTS:**  
NONE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

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THE DISCONNECT CONSISTS OF A TANK HALF AND AN ORBITER HALF. THE DISCONNECT IS A MECHANICAL DEVICE, EACH HALF CONTAINING A POPPET ASSEMBLY WHICH IS SPRING LOADED TO THE CLOSED POSITION. EACH POPPET IS ACTUATED TO THE OPEN POSITION DURING THE MATING OF THE ET AND ORBITER UMBILICALS. THE ORBITER HALF IS MOUNTED TO A BELLEVILLE WASHER ARRANGEMENT WHICH PROVIDES THE CLAMPING FORCE TO MAINTAIN INTERFACE SEAL REQUIREMENTS TO PREVENT LEAKAGE.

THE CLOSURE SEAL (301 CRES, FULL HARD), POPPET (316 CRES INVESTMENT CAST), POPPET RETURN SPRING (302 CRES CONDITION B), BUSHINGS (ALUMINUM BRONZE), AND BODY (316 CRES INVESTMENT CAST) ARE IDENTICAL FOR EACH HALF. THE TWO HALVES DIFFER ONLY IN THEIR CAP SECTIONS. THE ORBITER CAP SECTION CONTAINS THE WASHER TYPE INTERFACE SEAL (301 CRES, FULL HARD) RETAINED AGAINST THE CAP SECTION BY A RETAINER (304 CRES, CONDITION A) WHICH SCREWS ON THE CAP SECTION AND IS TORQUED TO 275 FOOT-POUNDS. LEAKAGE PAST THE RETAINER AND SEAL IS PREVENTED BY A SOFT COPPER GASKET. THE ET CAP SECTION INCORPORATES A GUIDE SECTION AT THE INTERFACE, TO PROPERLY ALIGN AND MAINTAIN THE ORBITER SECTION, AND A SEAT SURFACE COATED WITH TEFLON. EACH OF THE CAP SECTIONS IS MATED TO ITS RESPECTIVE BODY USING A SOFT COPPER GASKET AND 18 INCONEL 718 SCREWS TORQUED TO 30 INCH-POUNDS MAXIMUM. THE COPPER GASKET IS UTILIZED TO PREVENT EXTERNAL LEAKAGE AT HIGH TEMPERATURES.

EACH POPPET IS GUIDED BY TWO LINEAR BUSHINGS. THESE BUSHINGS ARE INSTALLED IN AND SUPPORTED BY A PAIR OF RADIAL STRUTS. EACH RADIAL STRUT CONSISTS OF TWO SUPPORTING LEGS WHICH ARE 120° APART. THE STRUTS ARE AN INTEGRAL PART OF THE BODY AND CAP SECTION AND ARE ALIGNED DURING ASSEMBLY OF THE CAP SECTION TO THE BODY TO MINIMIZE THERMAL STRESSES AND PREVENT COCKING BETWEEN THE POPPET SHAFT AND BUSHING. INDEX MARKS ARE LOCATED ON EACH FLANGE TO INSURE PROPER CLOCKING OF THE ET AND ORBITER HALVES.

DURING MATING OF THE ET/ORBITER UMBILICALS A VISUAL INSPECTION (USING A BOROSCOPE) OF THE INTERFACE IS PERFORMED TO ENSURE PROPER POPPET STEM MATING. IMPROPER ALIGNMENT WILL CAUSE BENDING OF THE POPPET STEMS AND PREVENT POPPETS FROM FULLY OPENING, FULLY CLOSING ON SEPARATION, AND MAY CAUSE INTERFACE LEAKAGE.

FAILURE OF THE POPPET TO REMAIN OPEN CAN ONLY OCCUR DUE TO STRUCTURAL FAILURE OF THE UPPER POPPET STEM OR BOTH LEGS OF THE STRUT. BOTH FLIGHT AND STRUCTURAL ANALYSIS INDICATE THE EXISTENCE OF MINOR SIDE LOADS BETWEEN THE POPPET SHAFT AND THE BUSHING AND MAJOR AXIAL LOADS ON THE MATED POPPET STEMS DUE TO FLOW AND SPRING FORCES. FRACTURE ANALYSIS INDICATES THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES THE ORBITER LIFE OF 100 MISSIONS. THE 316 CRES MATERIAL USED FOR THE POPPET AND STRUTS IS IN AN ANNEALED STATE AND IS NOT SUSCEPTIBLE TO FRACTURE.

**(B) TEST:**  
ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE

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920 PSIG MATED  
500 PSIG ORBITER HALF  
56 PSIG ET HALF

INTERNAL LEAKAGE (ACROSS CLOSURE, DEMATED), BOTH HALVES  
20 PSIG GHE (15 SCIM MAX)  
40 PSIG GHE (100 SCIM MAX)

EXTERNAL LEAKAGE, MATED  
600 PSIG GHE (100 SCIM MAX)

OPERATIONAL TEST (3 CYCLES)  
PRESSURIZE BOTH HALVES TO 5 PSIG  
MATE  
RAISE PRESSURE TO 37 PSIG  
DEMATE  
RECORD ENGAGE (120 LB MAX) AND DISENGAGE (50 LB MAX) FORCES

ROSAN INSERT TORQUE VERIFICATION

CERTIFICATION

COMPONENT

HIGH TEMPERATURE LEAKAGE (500°F)  
MATED WITH 600 PSIG GHE (183 SCIM MAX AT INTERFACE)  
DEMATED, ACROSS CLOSURE (EACH HALF)  
20 PSIG GHE (18 SCIM MAX)  
40 PSIG GHE (201 SCIM MAX)

VIBRATION

RANDOM: 48 MINUTES IN EACH OF TWO AXES AT 600 PSIG, 500°F FOLLOWED  
BY ATP OPERATIONAL AND LEAKAGE TESTS AT BOTH 500°F AND  
AMBIENT

THERMAL CYCLE (100 CYCLES)

MATE  
REDUCE BODY TEMPERATURE TO -100°F  
FLOW 8 LB/SEC GO2 AT 600 PSIG AND 500°F (26 PSID MAX PRESSURE DROP)  
THROUGH UNIT UNTIL BODY TEMPERATURE IS STABILIZED (700  
SECONDS MAX)  
REDUCE PRESSURE TO 37 PSIG  
DEMATE  
AFTER EACH 25 CYCLES PERFORM HIGH TEMPERATURE LEAKAGE TEST  
AND OPERATIONAL, INTERNAL LEAKAGE, AND EXTERNAL LEAKAGE  
TESTS

LIFE CYCLE

380 OPERATIONAL TESTS AT AMBIENT  
100 OPERATIONAL TESTS AT 500°F

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AFTER EACH 25 CYCLES PERFORM INTERNAL AND EXTERNAL LEAKAGE TESTS

BURST (MATED): 1,200 PSIG

SYSTEM

UMBILICAL SEPARATION TEST

THE DISCONNECT WAS INSTALLED IN THE UMBILICAL ASSEMBLY DURING THE SEPARATION TEST PROGRAM. THE UMBILICAL ASSEMBLY WAS SUBJECTED TO RANDOM VIBRATION TESTS (4.4 HOURS PER AXIS). THE DISCONNECT WAS ALSO SUBJECTED TO UMBILICAL RETRACT TESTS AT BOTH NOMINAL CONDITIONS AND SIMULATED HYDRAULIC RETRACT ACTUATOR FAILURES.

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

**(C) INSPECTION:  
COMPONENT**

RECEIVING INSPECTION

INCOMING COMPONENTS ARE VERIFIED BY INSPECTION FOR MATERIALS AND PROCESSES CERTIFICATION.

CONTAMINATION CONTROL

THE DISCONNECT INTERNAL SURFACES ARE MAINTAINED TO LEVEL 400A PER REQUIREMENT. CORROSION PROTECTION IS IMPLEMENTED AND VERIFIED. PROTECTIVE CAPS ARE PROVIDED TO PREVENT CONTAMINATION AND PROTECT SEALING SURFACES.

ASSEMBLY/INSTALLATION

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

CRITICAL PROCESSES

HEAT TREATMENT AND PART PASSIVATION ARE VERIFIED BY INSPECTION. APPLICATION OF DRY FILM LUBRICANT IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION

THE BODY CASTING IS X-RAYED AND PRESSURE TESTED. THE BODY CASTING IS PENETRANT INSPECTED AFTER PRELIMINARY MACHINING.

TESTING

ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

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UMBILICAL ASSEMBLY

HEAT TREATED AND DRY FILM LUBE COATED BELLEVILLE SPRINGS ARE VISUALLY INSPECTED AND LOAD TESTED PRIOR TO ASSEMBLY. CORRECT INSTALLATION OF THE BELLEVILLE WASHERS IS A MANDATORY INSPECTION POINT. THE SHIMS, WHICH ARE REQUIRED TO SET THE HEIGHT OF THE 2 INCH DISCONNECT MATING SURFACE ABOVE THE 17 INCH DISCONNECT MATING SURFACE AS EXTERNAL FORCE IS APPLIED TO THE 2 INCH DISCONNECT, ARE DIMENSIONALLY INSPECTED. THE SHIMS, WHICH ARE REQUIRED TO SET THE PRELOAD IN THE UNMATED CONDITION, ARE DIMENSIONALLY INSPECTED.

**(D) FAILURE HISTORY:**

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.

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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	: MIKE FISCHER	:/S/ MIKE FISCHER
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIME 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