

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0513 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/09/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
SRU	:GO2 2" ET PRESSURIZATION DISCONNECT (ORB) VACCO INDUSTRIES	MC284-0391-0001
SRU	:GO2 2" ET PRESSURIZATION DISCONNECT (ET) VACCO INDUSTRIES	MC284-0391-0032

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

DISCONNECT, ET PRESSURIZATION (GO2), ORBITER & ET HALF (2.0" DIA).

REFERENCE DESIGNATORS: PD4

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

PROVIDES THE FLOW PATH BETWEEN THE ET AND THE ORBITER FOR THE GO2 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 AND LOSS OF REPRESSURIZATION HELIUM.

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: GO2 2" ET PRESSURIZATION DISCONNECT (PD4)

CRITICALITY OF THIS

ITEM NAME: GO2 2" ET PRESSURIZATION DISCONNECT (PD4)

FAILURE MODE: 3/3

FAILURE MODE:

FAILS TO CLOSE/REMAIN CLOSED AT ET/ORBITER SEPARATION.

MISSION PHASE: LO LIFT-OFF

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

CAUSE:

FAILS TO CLOSE - BINDING, PIECE PART STRUCTURAL FAILURE, CONTAMINATION

FAILS TO REMAIN CLOSED - PIECE PART STRUCTURAL FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTLS	RETURN TO LAUNCH SITE
TAL	TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN	A) N/A
	B) N/A
	C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

FAILURE OF THE ET DISCONNECT VALVE TO CLOSE MAY RESULT IN BLOWDOWN OF THE RESIDUAL PROPELLANT IN THE ET THROUGH THE OPEN DISCONNECT. PROPULSIVE VENTING FROM THE DISCONNECT WILL NOT RESULT IN ET/ORBITER RECONTACT.

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FAILURE OF EITHER ORBITER OR ET DISCONNECT TO CLOSE WILL ALLOW GO2 TO LEAK INTO THE DISCONNECT CAVITY AND OVERBOARD. AFTER MECO, VACUUM CONDITIONS AT UMBILICAL AND IN AFT COMPARTMENT ARE INSUFFICIENT TO ALLOW COMBUSTION.

RESULTS IN LOSS OF GHE SUPPLY DURING MANIFOLD REPRESSURIZATION POSSIBLY CAUSING A LOSS OF LO2 MANIFOLD PURGE DURING ENTRY. POSSIBLE HAZARD GAS INGESTION INTO MANIFOLD AND FIRE/EXPLOSION HAZARD. HELIUM REPRESSURIZATION REGULATOR FLOW IS REGULATED BY LO2 MANIFOLD PRESSURE. HOWEVER, DUE TO THE MANIFOLD REPRESS SOURCE BEING A COMMON SUPPLY THE LOSS OF HELIUM THROUGH THE GO2 PRESSURIZATION SYSTEM MAY NOT ALLOW THE LO2 MANIFOLD TO REACH REGULATOR LOCK-UP PRESSURE.

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

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE/PUBLIC.

(D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS C.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
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,

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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 INSURE 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 CLOSE/REMAIN CLOSED AT ET/ORBITER SEPARATION CAN OCCUR DUE TO BINDING OF THE POPPET SHAFT IN THE BUSHING RESULTING FROM MISALIGNMENT CAUSED BY BENDING OF THE STRUT LEGS OR THE POPPET SHAFT. 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.

TO PREVENT BINDING OF THE POPPET SHAFT THE DESIGN PROVIDES AN ALUMINUM-BRONZE BUSHING (SELF LUBRICATING) TO GUIDE THE CHROME PLATED POPPET SHAFT AT EACH END. THE OUTSIDE SURFACE OF THE SHAFT AND THE INSIDE SURFACE OF THE BUSHINGS HAVE A 16 MICRO-INCH FINISH.

FAILURE OF THE POPPET RETURN SPRING MAY PREVENT THE POPPET FROM FULLY CLOSING OR REMAINING CLOSED AFTER SEPARATION. FLOW FORCES ACT TO CLOSE THE POPPET BUT THESE FORCES MAY BE LOW. DEVELOPMENT TESTS WERE CONDUCTED ON THIS DISCONNECT WITH THE SPRING BROKEN IN SEVERAL PLACES AND NO INDICATORS DETECTED ANY PROBLEMS WITH THE POPPETS FAILING TO CLOSE. A REDUCTION IN SPRING FORCE WAS NOTED.

CONTAMINATION IS AVOIDED BY THE FILTRATION OF THE FACILITY SUPPLIED GASSES TO 25 MICRONS ABSOLUTE IN THE GROUND SYSTEM. UPSTREAM OF THE FILTER, THE GSE SYSTEM IS MAINTAINED TO THE 300A CLEANLINESS LEVEL OF KSC SPEC -123. THE ORBITER GO2 SYSTEM IS MAINTAINED AT 800 CLEANLINESS LEVEL.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

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PROOF PRESSURE

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

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100 OPERATIONAL TESTS AT 500° F
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

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PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

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:

DURING PRE-OPERATIONS SET-UP AT KSC, THE POPPET FAILED TO RETURN TO THE SPRING LOADED CLOSED POSITION (REFERENCE CAR AC8008). THE POPPET WAS DAMAGED DUE TO BACKING OUT OF THE POPPET STOP ON THE GSE COVER ASSEMBLY. DRAWINGS HAVE BEEN CHANGED ON THE GSE.

FOLLOWING THE ATP PROOF PRESSURE TEST, THE POPPET DID NOT CLOSE AFTER DISCONNECT HALF SEPARATION (REFERENCE CAR AC8053). FAILURE WAS ATTRIBUTED TO THE DIMENSIONAL DISCREPANCY OF THE ECCENTRIC POPPET BORE ALIGNMENT. THE ASSEMBLY PROCEDURE WAS MODIFIED TO CLEARLY DEPICT THE BUSHING LOCATION AND IDENTIFICATION.

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.

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