FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0514 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 08/09/00

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	:GO2 ENGINE I/F ISOLATION CHECK VALVE	ME284-0479-0023
	CIRCLE SEAL	P61-647

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
VALVE, CHECK, GO2 ENGINE ISOLATION (0.625 INCH DIA). (CV18, CV19, CV20)

REFERENCE DESIGNATORS: CV18
CV19
CV20

QUANTITY OF LIKE ITEMS: 3

FUNCTION:
PREVENTS LOSS OF PRESSURANT FROM REMAINING OPERATING ENGINES THROUGH AN ENGINE WHICH HAS BEEN SHUT DOWN.

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SUBSYSTEM NAME: MAIN PROPULSION
LRU: GO2 ENGINE I/F ISOLATION CHECK VALVE **CRITICALITY OF THIS**
ITEM NAME: GO2 ENGINE I/F ISOLATION CHECK VALVE **FAILURE MODE:** 1R2

FAILURE MODE:
FAILS TO CHECK

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF

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

CAUSE:
BINDING, CONTAMINATION, PIECE PART STRUCTURAL FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES
AOA ABORT ONCE AROUND
ATO ABORT TO ORBIT
PAD PAD ABORT
RTLS RETURN TO LAUNCH SITE
TAL TRANS-ATLANTIC LANDING

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

PASS/FAIL RATIONALE:
A)

B)
CHECK VALVE IS STANDBY REDUNDANT TO UNCONTAINED SSME FAILURE. FAILURE IS NOT DETECTABLE BECAUSE NO INSTRUMENTATION EXISTS ON ORBITER AND ENGINE SUPPLIED DATA IS NOT AVAILABLE AFTER ENGINE SHUTDOWN.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

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NO EFFECT. THE CHECK MODE OF THE VALVE IS NOT REQUIRED DURING NOMINAL OPERATIONS.

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

(C) MISSION:
NO EFFECT.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
1R/2 2 SUCCESS PATHS. TIME FRAME - OFF NOMINAL ENGINE SHUTDOWN.
1) ENGINE SHUTDOWN WITH CONTAINED DAMAGE (ASSUMES ENGINE IS DAMAGED ONLY TO THE EXTENT THAT ISOLATION OF THE DAMAGE WILL SAFE THE SYSTEM).
2) CHECK VALVE POPPET FAILS TO CLOSE ON SHUTDOWN ENGINE.

IF AN ENGINE SHUTS DOWN WITH A RUPTURED LINE (ON THE ENGINE), GO2 WILL CONTINUOUSLY DUMP THROUGH THE ENGINE'S RUPTURED LINE INTO THE AFT COMPARTMENT. RESULTS IN FIRE HAZARD, AFT COMPARTMENT OVERPRESSURIZATION, AND DAMAGE DUE TO HOT GAS IMPINGEMENT ON ADJACENT COMPONENTS.

LOSS OF ET LO2 ULLAGE PRESSURE WILL RESULT IN VIOLATION OF TANK MINIMUM STRUCTURAL CAPABILITY REQUIREMENTS. MASS OF LO2 AND VEHICLE ACCELERATION SHOULD BE SUFFICIENT TO MAINTAIN PROPER ENGINE NPSP, DELAYING UNCONTAINED SSME SHUTDOWN DUE TO LOW NPSP UNTIL LATE IN POWERED FLIGHT.

FOR A CONTAINED SSME SHUTDOWN, A FAILED CHECK VALVE WILL HAVE NO EFFECT AS THE ENGINE WILL CONTAIN THE GO2. LO2 TANK ULLAGE PRESSURE WILL NOT BE SIGNIFICANTLY REDUCED AS A RESULT OF THIS FAILURE. THIS WILL PUT SOME PRESSURE IN THE HEAT EXCHANGER LINE AND POGO ACCUMULATOR LINE (ENGINE).

POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE CHECK VALVE IS SPRING LOADED TO THE CLOSED POSITION. UPSTREAM PRESSURE OVERCOMES THE SPRING FORCE TO UNSEAT THE POPPET FOR PRESSURES EXCEEDING 1.0 PSID. IF THE DOWNSTREAM PRESSURE IS GREATER THAN THE UPSTREAM PRESSURE BY MORE THAN 0.2 PSID THE DIFFERENTIAL WILL AID IN SEALING. THE DESIGN OPERATING PRESSURE IS 5500 PSIA. THE CHECK VALVE IS OPEN DURING ENGINE OPERATION. FOR

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AN ENGINE OUT FAILURE, PRESSURE FROM THE OTHER TWO ENGINES (UP TO 5500 PSIA) CLOSES THE FAILED ENGINE'S CHECK VALVE. THE VALVE IS REQUIRED TO CYCLE ONLY ONCE PER FLIGHT.

THE CHECK VALVE CONTAINS A LEAK DETECTION PORT AND A TRANSDUCER PORT.

THE DESIGN CONSISTS OF FIVE PARTS: A TUBE END (INCONEL 718, PASSIVATED, NICKEL PLATED, AND EVERLUBE 812), A BODY (INCONEL 718, PASSIVATED), A SPRING GUIDE (INCONEL 718, PASSIVATED, AND EVERLUBE 812), A SPRING (INCONEL X), AND A POPPET (BERYLLIUM COPPER ALLOY 172).

THE ONLY PART THAT COULD BIND IS THE POPPET. THE POPPET IS COMPLETELY GUIDED WITHIN THE BODY WHEN THE POPPET IS IN THE CLOSED POSITION. IT SLIDES SMOOTHLY WITHIN A MACHINED BORE (8 MICROINCH) IN THE BODY. THE BODY IS INCONEL 718 (HEAT TREATED). THE POPPET IS BERYLLIUM COPPER ALLOY 172. ANALYSES PERFORMED BY THE SUPPLIER INDICATE POSITIVE CLEARANCE BETWEEN THE POPPET AND THE BORE FOR ALL CONDITIONS OF VALVE OPERATION.

SYSTEM CONTAMINATION IS MINIMIZED DUE TO THE PRESENCE OF AN ET SCREEN, A PREVALVE SCREEN, A GSE DEBRIS PLATE, AN SSME ANTI-FLOOD VALVE SCREEN (CHANGED OUT EVERY FLIGHT), AND A GSE FILTER. CONTAMINANT PARTICLES CAN BE EMBEDDED INTO THE SOFT BERYLLIUM COPPER ALLOY POPPET TO A CERTAIN EXTENT WITHOUT BINDING. HIGH OPERATING PRESSURE ENSURES ADEQUATE OPENING PRESSURE.

STRUCTURAL FAILURE OF THE POPPET WOULD RESULT IN A FAILURE TO CLOSE. STRUCTURAL FAILURE OF THE SPRINGS WOULD HAVE LITTLE EFFECT. FORWARD PRESSURE WOULD OPEN THE POPPET TO ALLOW GASEOUS OXYGEN TO PASS THROUGH THE VALVE AND REVERSE PRESSURE/FLOW WOULD CLOSE THE POPPET.

STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF VALVE OPERATION. FRACTURE/FATIGUE ANALYSES SHOW THAT ALL CRITICAL PARTS ARE SATISFACTORY FOR FOUR TIMES EXPECTED LIFE.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

PROOF PRESSURE (11,960 PSIA)

CLOSURE PROOF PRESSURE (2000 PSIA)

REVERSE FLOW LEAKAGE (0 TO 600 PSIA, AT AMBIENT AND +530 DEG F)

EXTERNAL LEAKAGE (5500 PSIA, AMBIENT)

CRACK AND RESEAT PRESSURE (BODY TEMPERATURE -150 DEG F, 3 CYCLES)
CRACK PRESSURE 1 PSID MAXIMUM
RESEAT PRESSURE 0.2 PSID MINIMUM

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CERTIFICATION

PERFORMANCE TEST
REVERSE PRESSURE LEAKAGE, CRACK PRESSURE, AND RESEAT PRESSURE TESTS (AMBIENT TEMPERATURE, AIR)

HIGH TEMPERATURE FLOW AND CHATTER TEST
2.75 LB/SEC MIN, GO2 AT 260 DEG F, 3000 PSIA INLET
0.30 LB/SEC MIN, GO2 AT 530 DEG F, 3200 PSIA INLET
RECORD FLOW RATE AT WHICH CHATTER IS DETECTED
REPEAT PERFORMANCE TEST

HIGH PRESSURE EXPOSURE TEST (4 CYCLES)
10 MINUTES FLOW AT 1.0 LB/SEC MIN, GO2 AT +530 DEG F, 4800 PSIA INLET
REPEAT PERFORMANCE TEST AFTER TEST COMPLETION

ENDURANCE FLOW TEST (5 CYCLES EACH)

10 MINUTES FLOW AT 1.13 LBS/SEC MIN, GO2 AT +390 DEG F, 3600 PSIA INLET

10 MINUTES FLOW AT 2.6 LBS/SEC MIN, GO2 AT +390 DEG F, 3600 PSIA INLET

REPEAT PERFORMANCE TEST AFTER TEST COMPLETION

HIGH TEMPERATURE EXPOSURE TEST (4 CYCLES)

10 MINUTES FLOW AT 1.0 LBS/SEC MIN, GO2 AT +710 DEG F, 1500 PSIA INLET

REDUCE INLET PRESSURE TO 0 PSIG AND OUTLET PRESSURE TO 600 PSIG

REPEAT PERFORMANCE TEST AFTER TEST COMPLETION

VIBRATION

RANDOM (AMBIENT TEMPERATURE)

10 HOURS FOR EACH OF 2 AXES (12 TO 15 PSIG INLET, AIR AT AMBIENT)

REPEAT PERFORMANCE TEST AFTER COMPLETION OF EACH AXIS OF VIBRATION

RANDOM (+530 DEG F)

2.66 HOURS FOR EACH OF 2 AXES (12 TO 15 PSIG INLET, GO2 AT +250 DEG F)

REPEAT PERFORMANCE TEST AFTER COMPLETION OF EACH AXIS OF VIBRATION

RANDOM (+710 DEG F)

0.66 HOURS FOR EACH OF 2 AXES (12 TO 15 PSIG INLET, GO2 AT +250 DEG F)

REPEAT PERFORMANCE TEST AFTER COMPLETION OF EACH AXIS OF VIBRATION

TRANSIENT SHOCK TEST

ALONG X AND Y AXIS, SINUSOIDAL SWEEP, 5 TO 35 HZ, +/-0.25 G

REPEAT PERFORMANCE TEST AFTER TEST COMPLETION

LIFE CYCLE TEST (1800 CYCLES)

ONE CYCLE CONSISTS OF: FLOW AT 60 SCFM (CLEAN DRY AIR), THEN REDUCE FLOW AND INLET PRESSURE TO ZERO WHILE INCREASING OUTLET PRESSURE TO 600 PSID.

REPEAT PERFORMANCE TEST AFTER EVERY 50 CYCLES

BURST TEST (24,000 PSIG, AMBIENT TEMPERATURE)

CLOSURE BURST TEST (2631 PSIG, AMBIENT TEMPERATURE)

GROUND TURNAROUND TEST
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
ALL RAW MATERIALS ARE VERIFIED FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL
ALL PARTS ARE MAINTAINED TO CLEANLINESS LEVEL 100A.

ASSEMBLY/INSTALLATION
DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. DETAIL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINANTS BY PRODUCTION PROCEDURES DURING MANUFACTURING AND TESTING. POPPET-TO-BODY CLEARANCE AND SEALING SURFACES ARE CHECKED AND VERIFIED. SURFACES AND WELD ARE INSPECTED UNDER 10X MAGNIFICATION. MANDATORY INSPECTION POINTS ARE ESTABLISHED TO VERIFY ASSEMBLY PROCESS.

CRITICAL PROCESSES
THE WELD IS VERIFIED PER DRAWING SPECIFICATIONS. ELECTRO-NICKEL PLATED TUBE SURFACE IS VERIFIED PER DRAWING SPECIFICATIONS. HEAT TREATMENT AND PARTS PASSIVATION ARE VERIFIED BY INSPECTION. DRY FILM LUBRICANT APPLIED TO THREADS ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
HELIUM LEAKAGE DETECTION IS PERFORMED PER REQUIREMENT.

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TESTING
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
SEVERAL CHECK VALVES HAVE EXPERIENCED INTERNAL LEAKAGE FROM CONTAMINATION CAUSED BY EXTERNAL SOURCES SUCH AS MPTA SYSTEM (CAR'S: MPTA - AB0921, AB5454, AB3876; PALMDALE - AB2455). METHODS HAVE BEEN DEVELOPED TO MINIMIZE PARTICLE GENERATION WHEN DEBRAZING/REPLACING COMPONENTS AND PERSONNEL HAVE BEEN INSTRUCTED IN THESE LATEST TECHNIQUES.

TWO FAILURES WERE ATTRIBUTED TO SELF GENERATED CONTAMINATION (CAR'S AB6049 AND AB9711). THE CAUSE WAS INCOMPATIBLE MATING MATERIALS BETWEEN THE 300 SERIES CRES POPPET AND INCONEL 718 BODY. THE DESIGN WAS REVISED TO INCORPORATE A BERYLLIUM COPPER POPPET.

POST STS-3 ON OV-102, CV18 EXPERIENCED EXCESSIVE INTERNAL LEAKAGE (REFERENCE CAR AC3082). A SIMILAR FAILURE OCCURRED ON CV19 FROM OV-102 (REFERENCE CAR AC6473). CONTAMINATION HAD BEEN TRAPPED BETWEEN THE POPPET GUIDE AND HOUSING GUIDE BORE CAUSING BINDING. THE POPPET GUIDE BORE FINISH WAS CHANGED FROM A 32 MICRO FINISH TO A 16 MICRO FINISH WHICH ELIMINATES THE POSSIBLE GENERATION OF ANY PARTICLES BY THE SLIDING CONTACT OF THE POPPET GUIDE AND HOUSING GUIDE BORE. THE SUPPLIER'S MANUFACTURING PROCESS PROCEDURE HAS BEEN CHANGED ON THE HOUSING DRAWING REQUIRING THE HOUSING TO BE DESCALED AFTER HEAT TREATMENT. OV-102 VALVES HAVE BEEN CHANGED TO THE NEW -0023 CONFIGURATION.

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	: MICHAEL FISCHER	:/S/ MICHAEL 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