

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

NUMBER: 03-1-0259 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 08/10/00

**PART DATA**

	<b>PART NAME</b>	<b>PART NUMBER</b>
	<b>VENDOR NAME</b>	<b>VENDOR NUMBER</b>
LRU	:SSME GHE SUPPLY INTERCONNECT "IN"	ME284-0472-0002, -0012
	CHECK VALVE	
	CIRCLE SEAL	P69-180

**EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:**

INTERCONNECT "IN" CHECK VALVE, 0.375 INCH DIAMETER.

**REFERENCE DESIGNATORS:** CV27  
CV38  
CV43

**QUANTITY OF LIKE ITEMS:** 3  
ONE PER ENGINE HE SUPPLY

**FUNCTION:**

THE FUNCTION OF THE CHECK VALVE (CV27,38,43) IS TO PREVENT REVERSE FLOW INTO THE PNEUMATIC SYSTEM. THE CHECK VALVES ARE LOCATED DOWNSTREAM OF THE SOLENOID VALVES (LV59,61,63) WHICH ALLOW HELIUM TRANSFER INTO A PARTICULAR ENGINE SUPPLY SYSTEM FROM EITHER THE PNEUMATIC ACTUATION SUPPLY OR ANOTHER ENGINE SUPPLY SYSTEM.

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**LRU: SSME GHE SUPPLY I/C "IN" CHECK VALVE**

**ITEM NAME: SSME GHE SUPPLY I/C "IN" CHECK VALVE**

**CRITICALITY OF THIS**

**FAILURE MODE: 1R2**

**FAILURE MODE:**

FAILS TO CHECK/INTERNAL LEAKAGE

**MISSION PHASE:**

LO LIFT-OFF  
DO DE-ORBIT

**VEHICLE/PAYLOAD/KIT EFFECTIVITY:**

102 COLUMBIA  
103 DISCOVERY  
104 ATLANTIS  
105 ENDEAVOUR

**CAUSE:**

PIECE PART STRUCTURAL FAILURE, BINDING, CONTAMINATION, SEAT DAMAGE

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

**REDUNDANCY SCREEN**

A) PASS  
B) N/A  
C) PASS

**PASS/FAIL RATIONALE:**

A)

B)

CHECK VALVE IS STANDBY REDUNDANT TO HELIUM SYSTEM LEAK UPSTREAM OF CHECK VALVE. FAILURE IS NOT DETECTABLE BECAUSE THIS FAILURE CANNOT BE DETECTED WITH EXISTING INSTRUMENTATION.

C)

**- FAILURE EFFECTS -**

**(A) SUBSYSTEM:**

NO EFFECT. LOSS OF PROTECTION TO PREVENT GHE LEAKAGE IN CASE OF AN UPSTREAM LEAK.

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**(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 - ASCENT, DEORBIT.

- 1) CHECK VALVE (CV27,38,43) FAILS TO CHECK.
- 2) SYSTEM LEAKAGE UPSTREAM OF THE CHECK VALVE (CV27, CV38, AND CV43)

RESULTS IN LOSS OF HELIUM FROM ONE MAIN ENGINE HELIUM SUPPLY. POSSIBLE OVERPRESSURIZATION OF THE AFT COMPARTMENT. INTERRUPTION OF FLOW TO HIGH PRESSURE OXIDIZER TURBOPUMP INTERMEDIATE SEAL MAY RESULT IN UNCONTAINED ENGINE FAILURE PRIOR TO SAFE REDLINE SHUTDOWN. EXCESSIVE ENGINE HELIUM TANK AND/OR REGULATOR PRESSURE DECAY WILL BE INDICATED BY SM ALERT OR CAUTION AND WARNING.

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. FAILURE DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED MAY RESULT IN AFT COMPARTMENT OVERPRESSURIZATION. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC. SOFTWARE CAUTION & WARNING AND SM ALERT IS NOT PROVIDED IN OPS 3. HARDWARE C&W IS NOT ENABLED DURING THIS TIME FRAME.

POSSIBLE LOSS OF CREW/VEHICLE.

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**-DISPOSITION RATIONALE-**

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**(A) DESIGN:**

THE CHECK VALVE IS A POPPET TYPE, SPRING LOADED AND PRESSURE ASSISTED TO THE CLOSED POSITION. THE POPPET AND SPRING ARE CONTAINED IN A THREADED HOUSING AND END CAP. THE SEAL IS A SELF-CENTERING TEFLON O- RING. THE VALVE BODY PROVIDES A GUIDE FOR THE POPPET TRAVEL. THE VALVE BODY IS DESIGNED TO A FACTOR OF SAFETY OF 2.0 PROOF AND 4.0 BURST.

FAILURE OF THE CHECK VALVE TO REMAIN CLOSED WOULD REQUIRE STRUCTURAL FAILURE OF THE POPPET AND POPPET SPRING. THE REVERSE PRESSURE, HOWEVER, WILL RESIST ANY TENDENCY FOR THE POPPET TO UNSEAT.

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FAILURE OF THE VALVE TO CHECK/INTERNAL LEAKAGE WOULD REQUIRE PIECE PART STRUCTURAL FAILURE OF THE POPPET AND/OR THE TEFLON O-RING. THE POPPET IS MADE OF 316 CRES AND HAS A DESIGN FACTOR OF SAFETY OF 2.0 PROOF AND 4.0 BURST. IF TEFLON O-RING DISINTEGRATES, PIECES MAY PREVENT POPPET FROM CHECKING. THE MOVING PARTS HAVE LITTLE TENDENCY TO GALL DUE TO THE LIGHT SIDE LOADS RESULTING FROM THE SYMMETRICAL GEOMETRY. THE USE OF 316 CRES AGAINST INCONEL 718 FOR THE END PIECE ALSO REDUCES THE GALLING TENDENCY.

INTERNAL LEAKAGE MAY BE CAUSED BY CONTAMINATION ON THE SEAL/SEAT INTERFACE AND IN THE GUIDED SECTION OF THE POPPET.

FAILURE TO CLOSE/INTERNAL LEAKAGE DUE TO CONTAMINATION IS AVOIDED BY THE FILTRATION OF THE FACILITY SUPPLIED GASSES TO 25 MICRONS ABSOLUTE IN THE GROUND SYSTEM.

**(B) TEST:**

ATP

EXAMINATION OF PRODUCT  
AMBIENT TEMPERATURE TESTS  
BODY PROOF PRESSURE (9090 PSIG)  
CLOSURE DEVICE PROOF PRESSURE (9090 PSIG)  
EXTERNAL LEAKAGE (4500 PSIG)  
INTERNAL LEAKAGE (5, 50, 300, 4500 PSIG)

LOW TEMPERATURE TESTS (-160 DEG F)  
CRACKING AND RESEAT PRESSURE: 3 CYCLES  
CRACKING PRESSURE 5 PSID MAX  
RESEAT PRESSURE 2 PSID MIN  
INTERNAL LEAKAGE (5, 50, 300, 4500 PSIG)

CERTIFICATION

FLOW TEST (0.05 LB/SEC HE)  
MAX INLET PRESSURE 4200 PSIG  
PRESSURE DROP (10 PSID MAX)

CHATTER TEST (4200 TO 0 PSIG)  
RECORD FLOW RATE WHEN CHATTER OCCURS

CRACKING AND RESEAT PRESSURE  
AMBIENT AND LOW TEMPERATURE (-160 DEG F): 3 CYCLES EACH  
CRACKING PRESSURE 5 PSID MAX  
RESEAT PRESSURE 2 PSID MIN

INTERNAL LEAKAGE  
AMBIENT (0 TO 4500 PSIG)  
LOW TEMPERATURE (-160 DEG F, 0 TO 4500 PSIG)

LIFE CYCLE TEST

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ONE CYCLE CONSISTS OF INLET PRESSURE OF 4200 PSIG FOLLOWED BY CHECKING PRESSURE OF 4500 PSIG

AMBIENT  
4000 CYCLES FOLLOWED BY CRACKING, RESEATING, AND LEAKAGE TESTS

LOW TEMPERATURE (-160 DEG F)  
1000 CYCLES FOLLOWED BY CRACKING, RESEATING, INTERNAL LEAKAGE, FLOW, PRESSURE DROP, AND EXTERNAL LEAK TESTS

EXTERNAL LEAKAGE TEST (1 SCCH MAXIMUM AT 4500 PSIG)

VIBRATION AND SHOCK (AMBIENT TEMPERATURE AND PRESSURE)  
BY SIMILARITY TO VALVE TYPES III, IVR, AND V (RI DASH NUMBERS -0003, - 0005, AND -0014 RESPECTIVELY). THESE UNITS WERE TESTED IN EACH OF TWO AXIS 48 MINUTES FOR RANDOM VIBRATIONS AND SUBJECTED TO A SWEEP CYCLE TO COVER SHOCK REQUIREMENTS.

BURST PRESSURE (18,000 PSIG)

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. RECEIVING INSPECTION VERIFIES CERTIFICATION OF SPRING HEAT TREATMENT AND PERFORMS LOAD TEST OF SPRINGS.

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

ASSEMBLY/INSTALLATION  
DIMENSIONS AND SURFACE FINISHES ARE VERIFIED BY INSPECTION. REQUIRED TORQUES ARE VERIFIED PRIOR TO WELDING. INSPECTION POINTS ARE ESTABLISHED TO VERIFY ASSEMBLY PROCESS. WELDS ARE VISUALLY VERIFIED BY 10X MAGNIFICATION.

CRITICAL PROCESSES  
ALL WELDING, ELECTROPOLISHING AND PARTS PASSIVATION ARE VERIFIED BY INSPECTION. DRY FILM LUBRICANT COATED THREADS ARE VERIFIED PER DRAWING REQUIREMENT.

NONDESTRUCTIVE EVALUATION  
HELIUM LEAKAGE DETECTION IS PERFORMED.

TESTING  
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

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PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

**(D) FAILURE HISTORY:**

SEVERAL INTERNAL LEAKAGES HAVE OCCURRED BECAUSE OF SELF-GENERATED METALLIC PARTICLES DUE TO POPPET OSCILLATION/CHATTER. CAUSE WAS INSUFFICIENT FLOW DURING PNEUMATIC PANEL GAS PURGE CLEANLINESS VERIFICATION. CORRECTIVE ACTION WAS TO REVISE THE CHECKOUT PROCEDURE BY INCREASING THE FLOW RATES AND USING A STEP INPUT FLOW RATE TO PRECLUDE VALVE CHATTER (REFERENCE CARS AC0538 AND AC3559 AT DOWNEY AND AC7147 AT KSC).

SEVERAL INTERNAL LEAKAGES HAVE OCCURRED DUE TO CONTAMINATION FROM EXTERNAL SOURCES SUCH AS TEST EQUIPMENT, BRAZING PARTICLES, PREFORMS, A TEFLON WASHER FROM SOME GSE AND METALLIC CHIPS FROM COMPONENT REPLACEMENT. (REFERENCE CAR'S AC0725, AB0561, AB0576, AB1326, AB0371 AT THE SUPPLIER; AB1451, AB4910, AB1452 AT NSTL; AC4347 AT DOWNEY; AD2169, AC2172, AC2864 AT PALMDALE; AC8572, AC9108, AC9781, AD3880, AD0495, AC1154 AT KSC.) METHODS HAVE BEEN IMPROVED TO MINIMIZE PARTICLE GENERATION WHEN DEBRAZING/REPLACING COMPONENTS. PERSONNEL HAVE BEEN INSTRUCTED IN THE LATEST TECHNIQUES TO MINIMIZE GENERATION OF CONTAMINANTS.

DURING PNEUMATIC PANEL TESTING AT DOWNEY, A CHECK VALVE WAS FOUND TO HAVE AN ALUMINUM SPRING GUIDE INSTALLED INSTEAD OF CRES (REFERENCE CAR AC1355). ALL CHECK VALVES WERE X-RAYED AND NO OTHER DISCREPANT PARTS WERE FOUND ON ANY VEHICLES OR IN STOCK. MANUFACTURING PLANNING DOCUMENTS HAVE BEEN REVISED TO INSURE INSTALLATION OF CORRECT DETAIL PARTS.

TWO UNITS FAILED OPEN AT KSC DURING VEHICLE CHECKOUT (REFERENCE OPEN CAR AD4079). FAILURE ANALYSIS OF ONE UNIT DISCLOSED THAT THE POPPET HAD BEEN DRIVEN INTO THE SPRING GUIDE AND JAMMED IN THE OPEN POSITION. TEARDOWN OF THE SECOND CHECK VALVE DID NOT INDICATE THE SAME CONDITION; HOWEVER, A SIMILAR FAILURE MECHANISM IS SUSPECTED. THE PROBLEM OCCURRED DUE TO A LARGE FLOW DEMAND (OR LARGE PRESSURE GRADIENT ACROSS THE CHECK VALVE). THE -0002 DESIGN IS SUCH THAT THE SMALL POPPET O.D. CAN BECOME JAMMED WITHIN THE SPRING GUIDE I.D. WHEN SUBJECTED TO A LARGE DIFFERENTIAL PRESSURE, RATHER THAN RESTING AGAINST THE SPRING GUIDE. THE INTERCONNECT "IN" CHECK VALVES (CV27, CV38, AND CV43) WERE THE ONLY CHECK VALVES BEING OPERATED WITH LARGE DIFFERENTIAL PRESSURES (INTERCONNECT "OUT" CHECK VALVES WERE PROTECTED BY AN OMRSD CONSTRAINT AND ENGINE REG OUT CHECK VALVE DIFFERENTIAL PRESSURE IS LIMITED TO 750 PSI). THE OMRSD HAS BEEN REVISED TO PRECLUDE OPERATION OF THE INTERCONNECT "IN" SYSTEM WITH EXCESSIVE DIFFERENTIAL PRESSURE ACROSS THE CHECK VALVES. A REDESIGN INCORPORATING A SIGNIFICANTLY LENGTHENED POPPET WHICH LIMITS ITS COCKING ABILITY (WHICH PRECLUDES THIS FAILURE FROM OCCURRING HAS BEEN INCORPORATED INTO THE -0012 DESIGN CHECK VALVE.

**GENERAL SYSTEM CONTAMINATION**

THIS FAILURE MODE HAS OCCURRED ON THIS COMPONENT DUE TO CONTAMINATION. ADDITIONALLY, GENERAL MPS SYSTEM CONTAMINATION HAS OCCURRED WHICH MAY LODGE ANYWHERE IN THE SYSTEM CAUSING THIS FAILURE MODE (REFERENCE THE FOLLOWING PARAGRAPHS).

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CONTAMINATION FAILURES HAVE OCCURRED AT ALL PHASES OF MANUFACTURING AND PARTS REPLACEMENT. IN ALL CASES, STRICT ADHERENCE TO CLEANLINESS CONTROL PROCEDURES IS THE PRIMARY METHOD OF CONTAMINATION PREVENTION.

NUMEROUS LARGE PARTICLES OF BLACK RUBBER MATERIAL WERE FOUND DURING A POST FLIGHT EXAMINATION OF THE LH2 17 INCH DISCONNECT OF OV099 (FLIGHT 7, REFERENCE CAR AC9800). THE LO2 AND LH2 SYSTEMS OF ALL VEHICLES WERE EXAMINED. NO RUBBER WAS FOUND IN ANY OTHER VEHICLES. AFTER EXTENSIVE INVESTIGATION THE ORIGIN WAS NOT DETERMINED.

METAL SHAVINGS HAVE BEEN DISCOVERED IN LINES AND COMPONENTS, WHICH WAS MOST LIKELY GENERATED WHEN THEY WERE CUT OUT AND/OR REPLACED (REFERENCE CARS AC9868, A9654, AC2210, AB1706; DR AD2226). METHODS HAVE BEEN REVISED TO MINIMIZE PARTICLE GENERATION WHEN INSTALLING/REPLACING COMPONENTS, LINES, AND FITTINGS REQUIRING WELDED OR BRAZED JOINTS (PRODUCT QUALITY IMPROVEMENT COUNCIL). PERSONNEL HAVE BEEN CAUTIONED. ROCKWELL PROBLEM ACTION CENTER WILL CONTINUE TO MONITOR BRAZING/WELDING REWORK CONTAMINATION. PROCEDURES ARE BEING REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

A PIECE OF A BRAZING PREFORM LODGED IN A 2-WAY SOLENOID VALVE ON OV-099 AT PALMDALE CAUSING A LEAKAGE FAILURE (REFERENCE CARS AC2111, AB2538). STEEL AND ALUMINUM PARTICLES CAUSED EXCESSIVE LEAKAGE ON THE 850 PSIG HELIUM RELIEF VALVE (REF CAR AC2229). FOR BOTH FAILURES CORRECTIVE ACTION WAS TO ADD SPECIAL PURGE PORTS TO THE MPS HELIUM PANEL ASSEMBLIES TO IMPROVE THE QUALITY OF FINAL CLOSEOUT BRAZES.

SEVERAL FOREIGN MATERIALS WERE INTRODUCED INTO THE MPS SYSTEM DURING MANUFACTURE AND PARTS REPLACEMENT. EXAMPLES ARE: GLASS CLOTH IN LINE TO PREVENT TRAVEL OF CHIPS DOWN LINE; POLYSTYRENE OBJECT TO HOLD VALVE POPPET OPEN WHILE PURGING; COTTON SWAB MATERIAL AND GLASS BEADS FROM CLEANING OPERATION; MISCELLANEOUS PLASTIC; FOAM; AND TAPE (REFERENCE CARS AB4751, AC2217, AC6768, AC9868, MPS3A0005, AC7912, AB0530). MATERIALS WERE REMOVED AND PERSONNEL WERE CAUTIONED. A HIGH FLOW DELTA P TEST AT PALMDALE WAS ADDED TO VERIFY THAT LINES WERE NOT PLUGGED. GRIT BLASTING (GLASS BEADS AND SAND USED TO CLEAN A LINE) IS NO LONGER PERFORMED. PROCEDURES HAVE BEEN REVISED TO IMPROVE CLEANLINESS MAINTENANCE DURING COMPONENT BUILD UP AND REWORK (REFERENCE MCR 12512). SUPPLIER DOCUMENTS/PROCEDURES HAVE BEEN REVIEWED AND CLEANLINESS MAINTENANCE PROCEDURES HAVE BEEN IMPROVED.

ONE PIECE OF WIRE WAS FOUND IN THE INTERNAL RELIEF VALVE OF THE LO2 PREVALVE ON OV103 (REFERENCE CAR AC9101). THE SOURCE OF THE CONTAMINATION WAS NEVER FOUND, BUT IT WAS BELIEVED TO BE FROM THE ET. OTHER CONTAMINATION HAS BEEN FOUND ON THE FEEDLINE SCREENS, SUCH AS AN UNIDENTIFIED ROUND OBJECT AND VARIOUS METALLIC PARTICLES (REFERENCE CARS AB0529 AND AB0530). SOURCE OF CONTAMINATION WAS UNDETERMINED. BORESCOPE EXAMINATIONS ARE CONDUCTED ON ALL FEEDLINE SCREENS EVERY FIFTH FLIGHT TO VERIFY CLEANLINESS. CONTAMINATION WAS REMOVED WHEN POSSIBLE.

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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/ 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