

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0248 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 2 08/10/00

PART DATA

	PART NAME	PART NUMBER
	VENDOR NAME	VENDOR NUMBER
LRU	:LH2 RTLS REPRESS CHECK VALVE CIRCLE SEAL	ME284-0472-0024 P198-180

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, CHECK, RTLS DUMP, 0.75 INCH DIAMETER

REFERENCE DESIGNATORS: CV30

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THIS CHECK VALVE PREVENTS LH2 OR GH2 IN THE FEEDLINE RELIEF LINE FROM ENTERING THE HELIUM PRESSURE LINE AND ITS ASSOCIATED COMPONENTS, AFTER MECO WHEN THE LH2 FEEDLINE RELIEF ISOLATION VALVE (PV8) IS OPENED.

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LRU: LH2 RTLS REPRESS CHECK VALVE (CV30)

ITEM NAME: LH2 RTLS REPRESS CHECK VALVE (CV30)

CRITICALITY OF THIS

FAILURE MODE: 1R2

FAILURE MODE:

FAILS TO CHECK/REMAIN CLOSED, INTERNAL LEAKAGE

MISSION PHASE:

PL PRE-LAUNCH

LO LIFT-OFF

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102 COLUMBIA

103 DISCOVERY

104 ATLANTIS

105 ENDEAVOUR

CAUSE:

BINDING/SEAT DAMAGE/CONTAMINATION/PIECE PART STRUCTURAL FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS

B) FAIL

C) PASS

PASS/FAIL RATIONALE:

A)

B)

FAILS B SCREEN BECAUSE FAILURE CANNOT BE DETECTED WITH EXISTING INSTRUMENTATION.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

NO EFFECT. LOSS OF RTLS REPRESSURIZATION SYSTEM ISOLATION FROM THE LH2 MANIFOLD.

(B) INTERFACING SUBSYSTEM(S):

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SAME AS A.

(C) MISSION:
NO EFFECT.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:

CASE 1:

1R/2 2 SUCCESS PATHS. TIME FRAME - ASCENT (POST MECO).

- 1) CHECK VALVE (CV30) FAILS TO CHECK.
- 2) RUPTURE BETWEEN CV30 AND LV75, INCLUSIVE.

AT MECO, THE LH2 FEEDLINE RELIEF ISOLATION VALVE (PV8) WILL OPEN AND HYDROGEN FROM THE LH2 MANIFOLD WILL LEAK THROUGH THE RUPTURED LINE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION, FIRE/EXPLOSION HAZARD AND LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO EXPOSURE TO CRYOGENICS. POSSIBLE LOSS OF CREW/VEHICLE.

CASE 2:

1R/3 3 SUCCESS PATHS. TIME FRAME - ENGINE OPERATION.

- 1) CHECK VALVE (CV30) FAILS TO CHECK.
- 2) RUPTURE BETWEEN CV30 AND LV75, INCLUSIVE.
- 3) PV8 FAILS TO REMAIN CLOSED.

HYDROGEN FROM THE LH2 MANIFOLD WILL LEAK THROUGH THE RUPTURE INTO THE AFT COMPARTMENT. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION, FIRE/EXPLOSION HAZARD AND LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO EXPOSURE TO CRYOGENICS.

LEAKAGE OF HYDROGEN REDUCES THE NPSP AND THE AMOUNT OF PROPELLANT AVAILABLE FOR ENGINE OPERATION. LOW NPSP MAY CAUSE TURBOPUMP CAVITATION AND UNCONTAINED ENGINE SHUTDOWN. MAY NOT HAVE SUFFICIENT HYDROGEN TO MEET VELOCITY MECO TARGET.

POSSIBLE ABORT DUE TO EARLY ENGINE SHUTDOWN.

POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

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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 POPPET 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.

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 THE 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 CRES 316 FOR THE POPPET 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. THERE IS A 25 MICRON ABSOLUTE FILTER UPSTREAM OF THE CHECK VALVE TO CONTROL CONTAMINATION.

(B) TEST:

ATP

EXAMINATION OF PRODUCT

AMBIENT TESTS

BODY PROOF PRESSURE (1717 PSIG)
CLOSURE DEVICE PROOF PRESSURE (1717 PSIG)
EXTERNAL LEAKAGE (850 PSIG)
INTERNAL LEAKAGE (5, 25, 100, 850 PSIG)
CRACKING AND RESEAT PRESSURE: 3 CYCLES
CRACKING PRESSURE 5 PSID MAX
RESEAT PRESSURE 2 PSID MIN

CYROGENIC TESTS (-300 DEG F)

INTERNAL LEAKAGE (5, 25, 100, 850 PSIG)

CERTIFICATION

FLOW TEST (0.202 LB/SEC GHE)
MAX INLET PRESSURE OF 130 PSIG
PRESSURE DROP (45 PSID MAX)

CHATTER TEST (850 TO 0 PSIG)
RECORD FLOW RATE WHEN CHATTER OCCURS

CRACKING AND RESEAT PRESSURE

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CRYO (-300 DEG F): 3 CYCLES EACH
CRACKING PRESSURE 5 PSID MAX
RESEAT PRESSURE 2 PSID MIN

INTERNAL LEAKAGE
AMBIENT (0 TO 850 PSIG)
CRYO (-300 DEG F, 0 TO 850 PSIG)

EXTERNAL LEAKAGE (AMBIENT, 850 PSIG)

LIFE CYCLE TEST

ONE CYCLE CONSISTS OF PRESSURIZING THE INLET TO 130 PSIA, VENTING THE INLET TO AMBIENT, PRESSURIZING THE OUTLET TO 850 PSIG (AMBIENT) OR 130 PSIG (CRYO), AND VENTING THE OUTLET TO AMBIENT.

AMBIENT
42,000 CYCLES, FOLLOWED BY CRACKING, RESEATING, AND INTERNAL LEAKAGE TESTS

CRYO (-300 DEG F)
18,000 CYCLES, FOLLOWED BY CRYO CRACKING, RESEATING, INTERNAL LEAKAGE TESTS

UPON COMPLETION OF BOTH AMBIENT AND CRYO TESTS PERFORM AMBIENT FLOW, PRESSURE DROP, AND EXTERNAL LEAKAGE TESTS.

VIBRATION (AMBIENT, 2 AXES)
QUALIFIED BY SIMILARITY TO TYPE V CHECK VALVE. TYPE V VALVES ARE CERTIFIED BY THE FOLLOWING TESTS:

TRANSIENT
5 TO 35 HZ AT +/- 0.25 GS PEAK

RANDOM
13.3 HOURS FOR EACH OF 2 AXES

UPON COMPLETION OF VIBRATION TESTS PERFORM CRACK, RESEAT, AND INTERNAL LEAKAGE TEST.

BURST PRESSURE (3400 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

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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

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

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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).

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

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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.

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