FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE
NUMBER: M4-1BG-RV030-X

SUBSYSTEM NAME: ELECTRICAL POWER GENERATION - CRYO, GENERIC
REVISION : 1 11/12/91

	PART NAME / VENDOR NAME	PART NUMBER / VENDOR NUMBER
■ SRU :	RELIEF VALVE, H2 TANK	MC264-0440-0402
■	PARKER HANNIFIN	5750002-102

PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
RELIEF VALVE, H2 TANK

■ REFERENCE DESIGNATORS: 40V45RV030
: 40V45RV040
: 40V45RV500
: 40V45RV560
: 40V45RV660
: 40V45RV862
: 40V45RV872
: 40V45RV882
: 40V45RV892

■ QUANTITY OF LIKE ITEMS: 1
ONE PER TANK

■ FUNCTION:
PROVIDES OVERPRESSURIZATION PROTECTION FOR H2 TANKS.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M4-18G-RV030-02

REVISION#.. 1 11/12/91 R

SUBSYSTEM: ELECTRICAL POWER GENERATION - CRYO, GENERIC

ITEM NAME: RELIEF VALVE, H2 TANK

CRITICALITY OF THIS FAILURE MODE:1R2

■ FAILURE MODE:
FAILS CLOSED

MISSION PHASE:
PL PRELAUNCH
LO LIFT-OFF
OO ON-ORBIT
DO DE-ORBIT
LS LANDING SAFING

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

■ CAUSE:
CORROSION, VIBRATION, PHYSICAL BINDING/JAMMING

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:
■ A)

■ B)
REDUNDANCY SCREEN B - N/A SINCE RELIEF VALVE IS CONSIDERED STANDBY REDUNDANT.

■ C)

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
NO EFFECT AFTER FIRST FAILURE.

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

■ (C) MISSION:
SAME AS (A)

■ (D) CREW, VEHICLE, AND ELEMENT(S):
SAME AS (A)

■ (E) FUNCTIONAL CRITICALITY EFFECTS:
POSSIBLE LOSS OF CREW/VEHICLE DUE TO TANK RUPTURE IF AN ADDITIONAL FAILURE RESULTS IN TANK OVERPRESSURIZATION.

- DISPOSITION RATIONALE -

■ (A) DESIGN:
15 MICRON FILTER INCORPORATED IN INLET OF RELIEF VALVE. CRYO PLUMBING CLEANED TO LEVEL 200 BY PARTICULATE COUNT. ALL COMPONENTS ARE COMPATIBLE WITH WORKING FLUIDS. VALVE IS MOUNTED WITH BODY AXIS PERPENDICULAR TO VEHICLE X-AXIS TO MINIMIZE VIBRATION EFFECTS. BUILT IN THERMAL COMPENSATION BY THE USE OF BELLEVILLE SPRINGS. VALVE IS CONSTRUCTED OF CRES METALS, CARBON COMPOSITION (VESPEL), AND 6061-T651 ALUMINUM WHICH IS NOT IN CONTACT WITH THE WORKING FLUID.

■ (B) TEST:
QUALIFICATION TESTS INCLUDED; MECHANICAL SHOCK (20 G), SINUSOIDAL VIBRATION (+/- 0.25 G PEAK), RANDOM VIBRATION (0.05 G SQ/HZ MAXIMUM FOR 48 MINUTES), OPERATING CYCLES (1500 AT AMBIENT AND 1400 AT LH2 TEMP), AND THERMALLY CYCLED 5 TIMES (START INITIALLY AT +220 DEG F AND FLOW UNTIL INLET TEMP DROPS TO -380 DEG F).

ACCEPTANCE INCLUDES FUNCTIONAL TEST WITH THERMAL CYCLES (AMBIENT TO +220 DEG F TO AMBIENT TO -300 DEG F TO AMBIENT). VALVE IS FURTHER FUNCTIONALLY VERIFIED DURING PANEL MODULAR ASSEMBLY AND SUBSYSTEM CHECKOUT.

OMRSD: RELIEF VALVE CRACK AND RESEAT TEST PERFORMED DURING EVERY ORBITER MAINTENANCE DOWN PERIOD (OMDP) OR IF VALVE OPERATED DURING THE PREVIOUS FLIGHT OR TURNAROUND.

■ (C) INSPECTION:
RECEIVING INSPECTION
TEST REPORTS AND MATERIALS CERTIFICATIONS ARE MAINTAINED CERTIFYING MATERIALS AND PHYSICAL PROPERTIES.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
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CONTAMINATION CONTROL
CLEANLINESS PER SPECIFICATION TO LEVEL 200A IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
ALL PARTS ARE PROTECTED FROM DAMAGE AND CONTAMINATION. DIMENSIONAL AND SURFACE FINISH ARE VERIFIED. ALL SURFACES REQUIRING CORROSION PROTECTION ARE CERTIFIED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESSES
PASSIVATION AND APPLICATION OF BRAYCOTE LUBE IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
ALL INTERNAL WELDS ARE VERIFIED BY THE FOLLOWING INSPECTIONS: 4X VISUAL, DIMENSIONAL, DYE PENETRANT, AND RADIOGRAPHIC EXAMINATION.

TESTING
PROOF PRESSURE TESTING DURING ATP VERIFIES STRUCTURAL INTEGRITY OF THE VALVE AND IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
CAR NO. A7286-010 DOWNEY, RELIEF PANEL ATP
AN H2 TANK RELIEF VALVE FAILED TO CRACK WITHIN SPECIFICATION DURING THE LOW TEMPERATURE TEST OF THE ACCEPTANCE TEST. THE ANALYSIS DETERMINED THE FAILURE TO BE CAUSED BY THE TEST SETUP, NOT THE VALVE. THE UNIT FAILED DUE TO EXCESS MOISTURE WITHIN THE TEST SETUP WHICH CAUSED ICING AND BLOCKAGE OF THE PILOT SECTION OF THE VALVE.

CORRECTIVE ACTION INCLUDED REVISING THE TEST SETUP AND TEST PROCEDURES TO ELIMINATE EXCESS MOISTURE WITHIN THE SYSTEM.

CAR NO. AD3231-010 DOWNEY, MISSION SIMULATION PALLET ATP
AN H2 RELIEF VALVE EXHIBITED OUT OF SPECIFICATION LEAKAGE UPON RESEAT DURING DOWNEY MISSION SIMULATION PALLET PANEL ACCEPTANCE TESTING. FAILURE OF THE VALVE TO RESEAT WAS DUE TO THE PUSHROD ACTUATING THE MAIN RELIEF VALVE POPPET BOUND WITHIN THE UPPER HOUSING BORE. PUSH ROD BINDING IS SUSPECTED TO HAVE BEEN CAUSED BY A CONTAMINANT. THIS GAMAGED THE BUSHING/PUSHROD BORE SLIDING SURFACES TO THE POINT WHERE THE MAIN SPRING COULD NOT OVERCOME THE INCREASED FRICTIONAL FORCES. THE SOURCE OF CONTAMINANT COULD NOT BE DETERMINED.
THE PROBLEM WAS CLOSED WITH THE FOLLOWING RATIONALE: THE RELIEF VALVE PERFORMED ITS PRIMARY FUNCTION WHICH IS CRACKING AT 302 PSIG AND STAYED OPEN TO PREVENT A SYSTEM OVERPRESSURIZATION CONDITION. ANALYSIS HAS INDICATED A LOAD OF 500 POUNDS ON THE PUSHROD ASSEMBLY DURING NORMAL

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FLOW CONDITIONS ACTING AGAINST A 26 POUND LOAD WHICH IS COMPRISED OF; THE SPRING LOAD, BUSHING FRICTION, AND THE INLET PRESSURE. THIS IS THE FIRST REPORTED FAILURE OF AN H2 RELIEF VALVE FAILING RESEAT DUE TO A STUCK POPPET PUSH ROD. SINCE ALL RELIEF VALVES ARE VERIFIED TO BE CLOSED PRIOR TO LAUNCH, A PRIOR NON RELATED SYSTEM FAILURE WOULD BE REQUIRED BEFORE THE RELIEF VALVE WOULD BE NEEDED TO RELIEVE. ALSO, TO REDUCE THE PROBABILITY OF THIS PROBLEM FROM RECURRING ON FUTURE HARDWARE ALL RELATED PARTS HAVE BEEN REMOVED FROM STOCK FOR INSPECTION OF OUT OF SPECIFICATION CONDITIONS. A REQUIREMENT WAS ADDED TO INSPECT THE BUSHINGS AT 10X MAGNIFICATION AND THE 8 MICRON SURFACE FINISH OF THE ASSEMBLY PUSHROD BORE ARE NOW VERIFIED WITH A BORESCOPE.

(E) OPERATIONAL USE:
CREW WILL RESPOND TO TANK OVERPRESSURE ANNUNCIATION BY DEACTIVATING AFFECTED TANK HEATERS.

- APPROVALS -

RELIABILITY ENGINEERING	M. D. WEST	M D West
DESIGN ENGINEERING	M. M. SCHEIERN	
QUALITY MANAGER	O. J. BUTTNER	
NASA RELIABILITY		
NASA SUBSYSTEM MANAGER		
NASA QUALITY ASSURANCE		4/9/92