

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0435 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 1 02/22/01

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : FLAME ARRESTOR, LH2 BOEING	V070-415430-006

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

FLAME ARRESTOR, LH2, 1.8 INCH DIAMETER.

REFERENCE DESIGNATORS: FL1

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

THE FLAME ARRESTOR IS LOCATED AT THE LH2 VENT LINE OUTLET BETWEEN THE BASE OF THE VERTICAL STABILIZER AND THE LEFT OMS POD. THE DEVICE PREVENTS EXTERNAL FLAME (FROM RELIEF SYSTEM) FROM PROPAGATING BACK INTO THE LH2 VENT SYSTEM.

FOR NOMINAL, ATO, AOA, AND TAL MISSIONS, GH2 VENTING OCCURS AFTER MECO WHEN THE MANIFOLD RELIEF SHUTOFF VALVE (PV8) OPENS. AFTER COMPLETION OF PROPELLANT DUMP AND VACUUM INERTING NO ADDITIONAL VENTING IS EXPECTED FOR NOMINAL, AOA, AND ATO MISSIONS. FOR RTLS AND TAL MISSIONS, GH2 VENTING OF LH2 RESIDUALS IS EXPECTED POST LANDING.

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LRU: LH2 FLAME ARRESTOR

ITEM NAME: LH2 FLAME ARRESTOR

CRITICALITY OF THIS

FAILURE MODE: 1R3

FAILURE MODE:

FAILS TO ARREST FLAME.

MISSION PHASE: LS LANDING/SAFING

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

CAUSE:

PIECE PART STRUCTURAL FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? YES

RTLS	RETURN TO LAUNCH SITE
TAL	TRANS-ATLANTIC LANDING

REDUNDANCY SCREEN

- A) FAIL
- B) N/A
- C) PASS

PASS/FAIL RATIONALE:

A)
VERIFICATION OF QUENCHING FUNCTION REQUIRES INVASIVE TEST

B)
FLAME ARRESTOR IS STANDBY REDUNDANT TO LH2 SYSTEM RELIEF OR LEAKAGE.

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

THIS FAILURE MAY ALLOW PROPAGATION OF EXTERNAL FLAME BACK INTO THE LH2 VENT SYSTEM RESULTING IN LH2 SYSTEM RUPTURE. POSSIBLE LOSS OF CRITICAL ADJACENT COMPONENTS DUE TO CRYOGENIC EXPOSURE. POSSIBLE AFT COMPARTMENT OVERPRESSURIZATION AND FIRE/EXPLOSION HAZARD.

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NOTE: LH2 RESIDUALS WILL ONLY BE PRESENT DURING ENTRY/LANDING FOR RTLS AND TAL MISSIONS.

(B) INTERFACING SUBSYSTEM(S):

SAME AS A.

(C) MISSION:

NO EFFECT FOR NOMINAL MISSION. POSSIBLE LOSS OF CREW/VEHICLE DURING RTLS/TAL ABORTS.

(D) CREW, VEHICLE, AND ELEMENT(S):

SAME AS A.

(E) FUNCTIONAL CRITICALITY EFFECTS:

1R/3 3 SUCCESS PATHS. TIME FRAME - LOADING, ASCENT

- 1) MANIFOLD RELIEF SHUTOFF VALVE INTERNAL LEAKAGE/FAILS TO REMAIN CLOSED.
- 2) MANIFOLD RELIEF VALVE INTERNAL LEAKAGE.
- 3) FLAME ARRESTOR FAILS TO ARREST FLAME

RESULTS IN PROPOGATION OF FLAME INTERIOR OF LH2 MANIFOLD. FIRE/EXPLOSION HAZARD, POSSIBLE LOSS OF CREW/VEHICLE.

-DISPOSITION RATIONALE-

(A) DESIGN:

VENTING IN THE ATMOSPHERE FROM THE LH2 FEEDLINE RELIEF MAY RESULT IN COMBUSTION. THE FLAME ARRESTER PREVENTS THE RESULTING FLAME FROM PROPAGATING BACK INTO THE ORBITER LH2 PLUMBING. THE ARRESTER CONSISTS OF FOUR PARTS: A HOUSING THAT CONTAINS TWO DISCS THAT ARE SEPARATED BY A SPACER. EACH DISC HAS A 1.750 INCH O.D., IS 0.500 INCHES THICK, AND CONTAINS APPROXIMATELY SIX THOUSAND 0.017 INCH DIAMETER HOLES THROUGH THE THICKNESS. IF FLAME ATTEMPTS TO PASS THROUGH THE DISC, ITS TEMPERATURE IS REDUCED BELOW THE THRESHOLD OF FLAMMABILITY AND IS QUENCHED. THE SECOND DISC IS REDUNDANT.

BECAUSE ALL RESIDUAL HYDROGEN IS VENTED DURING PROPELLANT DUMP AND VACUUM INERTING, THERE IS NO VENTING DURING REENTRY FOR NORMAL, AOA, AND ATO MISSIONS. IN THE EVENT OF TAL OR RTLS ABORTS THE DUMP SEQUENCE IS NECESSARILY SHORTENED, AND SOME RESIDUAL LH2 MAY REMAIN (LESS THAN THREE POUNDS). THIS RESIDUAL WOULD BE VENTED AFTER LANDING.

FAILING TO ARREST FLAME DUE TO PIECE PART STRUCTURAL FAILURE IS VERY UNLIKELY. THE HOUSING IS MACHINED FROM A SINGLE INCONEL 718 BAR, THE DISCS ARE 304 CRES, AND THE SPACER IS INCONEL X-750. EITHER OF THE TWO DISCS WILL QUENCH FLAME.

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(B) TEST:

ATP

DISC
FLOW TEST (19 PSIA IN AND 4 PSID MAXIMUM):
 AMBIENT: 0.28 LB/SEC GN2

ASSEMBLY
 AMBIENT PROOF (300 PSIG)
 LEAK TEST (150 PSIG)

VERIFICATION

IGNITION TESTING

NINETY-THREE IGNITION TESTS SUCCESSFULLY CHARACTERIZED THE PERFORMANCE OF THE FLAME ARRESTER DESIGN DURING NORMAL AND ADVERSE CONDITIONS. FACTORS MONITORED DURING TESTING WERE PRESSURE DROP, FLAME ARRESTING CAPABILITIES, PLUME CHARACTERISTICS, AND GAS TEMPERATURE EFFECTS ON THE ARRESTER.

VARIED PARAMETERS:

GH2 FLOW (FROM .005 TO .022 LB/SEC)
GH2/AIR FLOW-AIR/FUEL RATIO OF 40 (.005,.010,.020 LB/SEC GH2)
GAS TEMPERATURE (-200 DEG F, AMBIENT, +200 DEG F)
IGNITION ON (BEFORE AND AFTER FLOW INITIATION).
WIND -
 NONE
 200 KNOTS @ 45 DEG TO FACE
 200 KNOTS NORMAL TO THE ARRESTER FACE)

ICING TESTS

NASA/JSC CONDUCTED A SERIES OF TESTS TO DETERMINE IF THE ARRESTER COULD BE CLOGGED BY ICE DUE TO THE ORBITER LANDING IN RAIN. BOILOFF GAS FROM A LH2 DEWAR WAS VENTED THROUGH THE ARRESTER (MOUNTED WITH ITS CENTERLINE VERTICAL). AFTER THE ARRESTER WAS THOROUGHLY CHILLED, WATER WAS SPRAYED (THROUGH A MISTING NOZZLE) ONTO THE EXPOSED SURFACE OF THE OUTER DISC, AND THE SURFACE FROZE OVER.

TEST RESULTS WERE:

- FLOW STOPPED DUE TO THE ICING. DUE TO LACK OF CRYO FLOW, THE TEMPERATURE OF THE ARRESTER INCREASED TO THE MELTING TEMPERATURE OF THE ICE.
- MAXIMUM UPSTREAM PRESSURE INCREASE DUE TO THE STOPPED FLOW WAS APPROXIMATELY 60 PSID.
- UNDER THESE CONDITIONS, A PORTION OF THE ICE BLEW OFF, FLOW WAS REESTABLISHED, AND THE AREA ADJACENT TO THE FLOW RECHILLED.

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AFTER A FEW SECONDS, THE REMAINDER OF THE ICE BLEW OFF. IT WAS THEORIZED THAT THE REESTABLISHED FLOW CREATED A TEMPERATURE GRADIENT WITHIN THE ICE CAUSING IT TO FRACTURE.

OMRSD
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION
RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESS CERTIFICATION.

CONTAMINATION CONTROL
CONTAMINATION CONTROL PROCESS AND CORROSION PROTECTION PROVISIONS ARE VERIFIED. CLEANLINESS TO LEVEL 400 IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
DETAIL PARTS ARE FABRICATED TO DRAWING SPECIFICATIONS AND VERIFIED BY INSPECTION. CORROSION PROTECTION AND SEALING SURFACES PROTECTION ARE VERIFIED. AT THE DETAIL LEVEL, THE DISCS ARE TESTED FOR FLOW, PRESSURE DROP, AND CLEANLINESS REQUIREMENTS. DIMENSIONS AND TOLERANCES ARE VERIFIED.

CRITICAL PROCESSES
HEAT TREATMENT, WELDING, AND BRAZING ARE VERIFIED. PARTS PASSIVATION AND ELECTROPOLISHING ARE VERIFIED BY INSPECTION. ELECTRICAL BONDING AND TEST (SYSTEM INSTALLATION) PER MAO113-306 CLASS L TYPE I IS VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
RADIOGRAPHIC INSPECTION OF INDUCTION BRAZES IS VERIFIED BY INSPECTION. PENETRANT INSPECTION IS VERIFIED.

TESTING
ATP IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING
PACKAGING FOR SHIPMENT IS VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

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 -

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	: LEE DURHAM	:/S/ LEE DURHAM
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MIKE SNYDER	:/S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	:/S/ ERICH BASS