FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 03-1-0767 -X

SUBSYSTEM NAME: MAIN PROPULSION

REVISION: 0 07/12/88

PART DATA

	PART NAME / **VENDOR NAME**	**PART NUMBER** / **VENDOR NUMBER**
LRU	: HEAT SHIELD AZTEC	V070-410364-001
LRU	:HEAT SHIELD AZTEC	ME264-0009

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
HEAT SHIELD MATCHED SET, EMISSIVITY COATED

REFERENCE DESIGNATORS:

QUANTITY OF LIKE ITEMS: 3
ONE MATCHED SET PER ENGINE

FUNCTION:
THE HEAT SHIELD PROVIDES CLOSEOUT OF THE SSME PENETRATION OPENING THROUGH THE BASE HEAT SHIELD OF THE AFT FUSELAGE WHICH PREVENTS EXCESSIVE LEAKAGE OUT OF AND INTO THE AFT FUSELAGE. DURING ASCENT AND ENTRY, THE SHIELD PROTECTS SSME POWER HEAD AND AFT FUSELAGE HARDWARE FROM HOT GAS IMPINGMENT AND RADIANT HEAT.

FAILURE MODES EFFECTS ANALYSIS FMEA -- CIL FAILURE MODE

NUMBER: 03-1-0767-01

REVISION#: 1 02/21/01

SUBSYSTEM NAME: MAIN PROPULSION
LRU: SSME MOUNTED HEAT SHIELD
ITEM NAME: SSME MOUNTED HEAT SHIELD

CRITICALITY OF THIS FAILURE MODE: 1/1

FAILURE MODE:
FAILURE TO PROTECT SSME POWERHEAD AND AFT FUSELAGE FROM HOT GASSES AND RADIANT HEAT.

MISSION PHASE:
PL PRE-LAUNCH
LO LIFT-OFF
DO DE-ORBIT

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

CAUSE:
PIECE PART STRUCTURAL FAILURE

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

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

PASS/FAIL RATIONALE:
A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:
STRUCTURAL FAILURE OF THE HEAT SHIELD WOULD CAUSE LOSS OF HEAT PROTECTION TO THE SSME POWERHEAD AND THE AFT COMPARTMENT.

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DURING ASCENT, PRESENCE OF HOT EXHAUST GASES AROUND CRYOGENIC COMPONENTS WILL AFFECT THERMAL CHARACTERISTICS OF THE FLUID WITHIN. POSSIBLE GASIFICATION OF FEEDLINE PROPELLANT CAUSING POSSIBLE TURBOPUMP CAVITATION RESULTING UNCONTAINED SSME DAMAGE. POSSIBLE LOSS OF CRITICAL FUNCTIONS DUE TO EXPOSURE TO HOT GASES. POSSIBLE RUPTURE OF SSME AND/OR MPS LINES. FIRE/EXPLOSION HAZARD.

DURING ENTRY, PRESENCE OF HOT ENTRY GASES MAY RESULT IN POSSIBLE LOSS OF ADJACENT CRITICAL FUNCTIONS.

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

(C) MISSION:
POSSIBLE LOSS OF CREW/VEHICLE.

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

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE HEAT SHIELD MATCHED SET CONSISTS OF 2 HONEYCOMB PARTIAL SEGMENTS (OUTER COVER AND CORE: INCONEL 625), 2 SHEAR PLATES (RENE 41 NICKEL ALLOY), AND DOUBLER PLATES (INCONEL 718) WHICH WHEN BOLTED TOGETHER FORM A SPHERICAL DISC ASSEMBLY. THE HONEYCOMB PARTIAL SEGMENTS ARE FASTENED TO THE SHEAR PLATES WITH MECHANICAL FASTENERS AND DOUBLER PLATES. THE DOUBLER PLATES ARE LOCATED ON THE OUTSIDE OF THE HEAT SHIELD SET. THE HEAT SHIELD IS ATTACHED TO THE SSME SKIRT USING THE DOUBLER PLATES. THE OUTSIDE DIAMETER INTERFACES WITH A SEAL ATTACHED TO THE DOME HEAT SHIELD.

AN EMISSIVITY COATING (PROPRIETARY POWDERED METALLIC COATING) IS APPLIED TO THE OUTSIDE OF THE HEAT SHIELD SET.

STRUCTURAL FAILURE OF THE HEAT SHIELD WOULD CAUSE LOSS OF HEAT PROTECTION TO THE SSME POWERHEAD AND THE AFT COMPARTMENT. STRUCTURAL ANALYSIS INDICATES POSITIVE MARGINS OF SAFETY FOR ALL CONDITIONS OF OPERATIONS. THE STRUCTURAL ANALYSIS WAS VERIFIED BY EXTENSIVE CERTIFICATION TESTING.

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(B) TEST:
ATP

EXAMINATION OF PRODUCT

CERTIFICATION

CHECKOUT

POSITIVE SEAL PRESSURE TEST
ZERO THRUST POSITION
PRESSURE: 0.5, 1.0, 1.5, 2.0, 2.65 PSID (GN2)

NEGATIVE SEAL PRESSURE TEST
ZERO THRUST POSITION
PRESSURE: 0.5, 1.0, 1.35 PSIG (GN2)

THERMAL TEST
DURATION: 1520 SECONDS
TEMPERATURE: 1740 TO 2000 DEG F
FULL THRUST POSITION

GIMBAL TEST
ITCH AND YAW ANGLE PROFILE VERSUS TIME

FLIGHT CERTIFICATION

PREFLIGHT GIMBALING
EXPOSED TO SERIES OF GIMBALING PATTERNS FROM ZERO THRUST POSITION.

THRUST MOVEMENT (3 CYCLES)
ZERO THRUST POSITION TO FULL THRUST POSITION
2 INCH MOVEMENT

THERMAL TEST

PHASE 1
3 CYCLES: 2.65 PSID (POSITIVE PRESSURE)
1 CYCLE: 1.35 PSID (NEGATIVE PRESSURE)
TEMPERATURE: 38 TO 1600 DEG F
DURATION: 120 SECONDS PER CYCLE

PHASE 2
4 CYCLES
TEMPERATURE: 38 TO 1600 DEG F
GIMBALING PER SET PROFILE
DURATION: 540 SECONDS PER CYCLE

PHASE 3
1 CYCLE

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TEMPERATURE: 1740 TO 2000 DEG F
DURATION: 1540 SECONDS

LEAKAGE TEST
PRESSURE: 0.5, 1.0, 1.5, 2.0, 2.65 PSID (GN2)

MISSION

BOUNCE BACK TEST
FULL THRUST POSITION TO 1/2 INCH BEYOND ZERO THRUST POSITION
HOLD FOR 10 SECONDS
RETURN TO ZERO THRUST POSITION.

ULTIMATE PRESSURE
1 CYCLE: 3.71 PSID (POSITIVE PRESSURE)
1 CYCLE: 1.89 PSID (NEGATIVE PRESSURE)

VIBROACOUSTIC TEST
68 MINUTES FOR 100 MISSIONS

OMRSD
ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:
RECEIVING INSPECTION
INCOMING MATERIALS ARE VERIFIED FOR MATERIAL AND PROCESS CERTIFICATIONS.

CONTAMINATION CONTROL
HEAT SHIELD MATCHED SET IS VISUALLY INSPECTED TO ENSURE THE PARTS ARE FREE OF VISIBLE PARTICULATE OR NON PARTICULATE. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
SURFACE FINISH TO 250 RMS ON CROWNS AND RIDGES ON SPHERICAL SURFACE AND ON FLAT OR CONICAL SURFACES IS VERIFIED. OUTER SURFACE OF SHIELD SET COATED WITH HIGH EMITTANCE WEAR RESISTANT COATING IS VERIFIED PER DRAWING SPECIFICATIONS. MANDATORY INSPECTION POINTS ARE INCLUDED IN MANUFACTURING PROCESS.

CRITICAL PROCESSES
FUSED WELDS AND ELECTRO-CHEMICAL ETCH ARE VERIFIED BY INSPECTION. HEAT TREATMENT IS CHECKED AND VERIFIED.

NONDESTRUCTIVE EVALUATION
SHIELD WELDED AREAS ARE RADIOGRAPHICALLY INSPECTED FOR POSSIBLE CORE/FACE SHEET SEPARATION OR OTHER DEFECTS.

TESTING
ATP, INCLUDING BENDING BEAM TEST, IS VERIFIED BY INSPECTION.

HANDLING/PACKAGING

HANDLING, PACKAGING, STORAGE, AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:
DURING QUALIFICATION TESTING OF THE ENGINE HEAT SHIELD AND SEAL ASSEMBLY IN DOWNEY, THE SEAL WAS MELTED AT ITS CONTACT SURFACE WITH THE HEAT SHIELD AFTER THERMAL TESTS WITH SIMULATED ENGINE GIMBALLING (REFERENCE CAR AB8170). THE SEAL DAMAGE RESULTED FROM TEST CONDITIONS THAT DO NOT OCCUR DURING A NORMAL MISSION. NO DEGRADATION WAS OBSERVED ON OV-102 ENGINE HEAT SHIELD SEALS AFTER FOUR FLIGHTS. THE OMRSD WAS REVISED TO INCORPORATE AN INSPECTION OF THE ENGINE HEAT SHIELD SEAL WHENEVER AN ENGINE IS GIMBALLED 6 DEGREES OR MORE, OR IF A DOME HEAT SHIELD IS REMOVED FROM THE ORBITER (OMRSD V41BUO.010-K MPS COMPONENT VISUAL INSPECTION).

AFTER QUALIFICATION THERMAL CYCLING TESTS OF THE ENGINE HEAT SHIELD WITH SIMULATED GIMBALLING OF THE ENGINE, INDENTATIONS WERE NOTED IN THE OUTER SPHERICAL SURFACE OF THE HEAT SHIELD (REFERENCE CAR AB8111). INDENTATIONS WERE CAUSED BY FRICTIONAL CONTACT OF SEAL SPACERS, ENGINE GIMBALLING AND HEAT SHIELD TEMPERATURES. INSPECTION REQUIREMENTS WERE ESTABLISHED TO EXAMINE THE CONVEX SURFACE OF THE HEAT SHIELDS FOR DAMAGE AND/OR SURFACE DEFORMATIONS AFTER EACH FLIGHT (OMRSD V41BUO.010-K MPS COMPONENT VISUAL INSPECTION).

AFTER COMPLETION OF STS-2 CERTIFICATION TESTS OF THE ENGINE HEAT SHIELD/SEAL TEST ARTICLE, FOUR OF THE 48 SPRING CAN ASSEMBLIES BECAME OVEREXTENDED AND DISENGAGED (REFERENCE CAR AC0151). THIS WAS CAUSED BY OFFSETTING OF THE ENGINE CENTERLINE, ADDITIONAL FORWARD DISPLACEMENT OF THE HEAT SHIELD AND WORST CASE GIMBALLING. THOSE CONDITIONS WILL NOT EXIST ON THE VEHICLE DURING A NORMAL FLIGHT. THE SPRING CAN ASSEMBLY WAS REDESIGNED WITH ADDITIONAL STROKE.

CRACKS WERE FOUND IN FOUR OF SIX SEAL SUPPORT RINGS REMOVED FROM OV- 102 ENGINE DOME HEAT SHIELDS AT KSC (REFERENCE CAR AB7217). INVESTIGATION REVEALED THAT THE CRACKS INITIATED FROM THE EDGES OF THE HOLES IN THE SLOTS OF THE INNER FLANGE (SIX SLOTS PER RING). CRACKS WERE CAUSED BY FATIGUE, INITIATED BY BENDING LOADS DURING INSTALLATION. OTHER ANOMALIES INCLUDE LACK OF DEBURRING AT HOLE EDGES, SCRIBE MARKS, AND HIGH HARDNESS OF THE RING. THE SEAL SUPPORT RING WAS REDESIGNED TO ELIMINATE THE SLOTS IN BOTH THE INNER AND OUTER FLANGES. THE OUTER FLANGE EDGES WERE SCALLOPED TO INCREASE RING FLEXIBILITY.

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