

SRB CRITICAL ITEMS LIST

SUBSYSTEM: SEPARATION

ITEM NAME: Aft Booster Separation Motor (BSM)

PART NO.: 10317-0002-805, -806

FM CODE: A03

ITEM CODE: 30-02-06

REVISION: Basic

CRITICALITY CATEGORY: 1

REACTION TIME: Immediate

NO. REQUIRED: 4 Aft

DATE: March 1, 2002

CRITICAL PHASES: Separation

SUPERCEDES: March 1, 2001

FMEA PAGE NO.: B-35

ANALYST: T. Burke/S. Parvathaneni

CN 044

SHEET 1 OF 7

APPROVED: S. Parvathaneni

FAILURE MODE AND CAUSES: Rupture or burnthrough of motor caused by:

- o Propellant
 - Voids
 - Cracks
 - Formulation
 - Processing
 - Mechanical properties
- o Mechanical/Material properties
 - Case
 - Closure
 - Igniter Case
 - Igniter adapter
 - Throat Insert
 - Thread failure
- o Liner
 - Formulation
 - Processing
 - Mechanical properties
 - Debond
- o Cracks or other material defects
 - Case
 - Closure
 - Igniter case
 - Igniter adapter
- o Dimensional Non-Conformances
 - Throat insert
 - Case
 - Closure
 - O-rings
- o Improper Assembly
 - Defective or damaged o-rings
 - Defective or damaged sealing surfaces
 - Contamination/foreign material

FAILURE EFFECT SUMMARY: Loss of mission, vehicle and crew due to damage resulting from motor debris which impacts the Orbiter/ET.

RATIONALE FOR RETENTION:

A. DESIGN

Design Specification is USA SRBE specification 10SPC-0067

- o Propellant UTP 19048 per specification SE022. (Propellant)
 - Formulation is ammonium perchlorate, hydroxyl/terminated poly-butadiene, isophorone diisocyanate, dioctyl adipate, aluminum, ferric oxide, PRO-TECH, and HX-752 bonding agent. Each constituent is procured and accepted to CSD specification.
- o Propellant - Processing of propellant, liner and loaded motor case. (Propellant)
 - Constituent requirements and controls for each premix and final mix defined.
 - Temperature and time limits defined.
- o Liner - UTL-0040 liner per CSD specification SEO729
 - Formulation is hydroxyl terminated poly-butadiene, dimeryl diisocyanate, HX-868 bonding agent, carbon black, Ralox 46 anti-oxidant. Each constituent is procured and accepted to CSD specification.
- o Mechanical/Material Properties
 - Case and closure are 7075-T73 aluminum per 10SPC-0084 and 10SPC-0085 respectively.
 - Igniter parts are stainless steel 303, 304 or 304L condition A per QQ-S-763 or QQ-S-764.
- o O-rings are sized per AS568 / AS3582(alt.). Material is fluorocarbon (Viton) per MIL-R-83248, Type 1, Class 1.
- o Contamination/Foreign Material
 - Security bag with lead seal installed over exit cone following final assembly inspection.
- o Assembly - Interfaces subject to the internal chamber pressure (MEOP of 2220 psig) of the rocket motor have redundant O-rings. Exit cone to aft closure interface is on the low pressure side of the nozzle throat and does not require O-ring seals. (Improper Assembly)
- o Qualification of design documented in CSD 5180-79-109 (All Failure Causes)
 - Motor performance verified by 14 motor tests.
- o Design demonstration tests (Improper assembly)
 - CSD 5596-87-2 BSM O-ring Referee Tests No O-ring Configuration Test Report. Three motors tested with no O-ring or missing O-rings sustained no damage or decrease in performance. Leakage was insignificant and clearly showed rupture and burnthrough due to missing O-rings is not a likely failure.
 - CSD 5596-87-3-BSM O-ring Referee Test No RTV Test Report. Four motors tested with RTV removed from the faying surfaces at the closure/case and igniter/case interface. The primary O-rings in these motors showed a more uniform or consistent ablation characteristic than motors fired with RTV installed.
 - CSD 5596-87-5 BSM O-ring Referee Tests Test Report - This report presents the results of two BSM motors tested with primary O-rings cut and no RTV. The results show that no damage was sustained by the hardware and only insignificant trace leakage occurred through the cut on the igniter primary O-rings. No heat effects or ablation were evident.

- o Delta Qualification Tests
 - Booster separation motor configurations 10317-0001-803 and 10317-0002-803 were qualified as documented in CSD 5596-88-3 delta qualification test report. Delta qualification on two units subjected to thermal cycling, vibration tests, and motor static test.
 - CSD 5597-93-2 delta qualification tests for BSM configuration 10317-0002-805. Delta qualification on two units subjected to environmental and functional tests.
- o Case and closure forging qualification tests performed on all first production heat treat lots from new supplier or for a process change. (Mechanical/Material Properties)
 - 14/12 point electrical conductivity test for each forging.
 - Chemical analysis
 - Grain flow determination on one forging
 - Cross sectional hardness tests on one forging
 - Tensile tests and fracture toughness tests on two forgings

B. TESTING

- o All listed vendor related tests are witnessed or monitored by vendor (or sub-tier vendor) QA personnel. When no designated QA organization exists at a vendor, tests are witnessed/monitored by CSD QA personnel or test records are evaluated for compliance with specification requirements by CSD QA personnel.
- o All listed KSC related tests are witnessed or monitored by USA SRBE or SPC QA personnel.
- o Propellant batch acceptance test.(Propellant)
 - Examination of material certification
 - Examination of process weight records
 - Physical properties determination
 - Examination of workmanship
 - Final propellant mixture to meet following requirements:
 - Burn rate verified by liquid strand burn rate tests.
 - Properties:
 - Percent IPDI at 60 minutes after addition
 - Viscosity @ 140 degrees F and 60 minutes after addition (kpoise @ 5000 dynes/cm)
 - True strain @ max corrected stress
 - Maximum corrected stress
- o Liner Batch (Lot) Acceptance Tests. (Liner)
 - Examination of material certification
 - Examination of formulation
 - Bond in tension tests
 - Peel strength tests
 - Examination of workmanship
- o Processing of propellant, liner, and loaded motor case. (Propellant, Liner).

Propellant Formulation and Mixing Verifications

- The HX-752 concentration in premix A
- Premix A water content
- Premix C parameters:
 - Percent iron oxide
 - Percent aluminum plus iron oxide
 - Percent ammonium perchlorate
- o Propellant ballistic properties are verified by static test of flight configuration motor.(Propellant, Liner)
 - Thrust/Pressure vs time data analyzed for conformance to performance requirements.
- o Mechanical/Material Properties/Improper Assembly
 - Each case/closure hydrotested as serialized unit -Each igniter case hydrotested
 - Each igniter adapter hydrotested
 - For each motor the case to closure and igniter to case sealing surface O-rings are seated and the joints are leak tested under low pressure with no leakage allowed.
 - Each case/closure heat treat lot tested as follows.
 - o Chemical analysis on each lot
 - o Surface hardness test on each forging
 - o 6/8 point electrical conductivity test on each forging
 - o Tensile and fracture toughness test on two forgings

C. INSPECTIONS:

- o All listed vendor related inspections are conducted 100% by vendor (or sub-tier vendor) QA personnel. Where no designated QA organization exists at a vendor, inspections are witnessed/monitored by CSD QA personnel or inspection records are evaluated for compliance with quality system requirements by CSD QA personnel.
- o All listed KSC related inspections are conducted 100% by USA SRBE or SPC QA personnel.
 - Radiographic Inspection is performed on each loaded case to detect cracks , voids and debonds.

Propellant Constituents Inspections**Hydroxyl Terminated Poly-Butadiene**

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Hydroxyl value
 - Water
 - Iron
 - Peroxide
 - Antioxidant
 - Viscosity @30° C
 - Insolubles
- Infrared spectra analysis performed to identify material

Isophorone Diisocyanate

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - NCO equivalent weight
 - Dimer
 - Density @20^o C
 - Hydrolyzable chloride
 - Water
- Infrared spectra analysis performed to identify material

Di-octyl Adipate

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Ester content
 - Specific gravity at 25^o C
 - Acidity, as acetic acid

Stabilizer

- Melting point is verified by test and data evaluation

Bonding Agent

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Imine equivalent weight
 - Hydrolyzable chloride
 - Moisture
- Infrared spectra analysis performed to identify material

Aluminum

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Free aluminum metal
 - Volatiles
 - Ether Extractables
 - Particle size distribution

Ferric Oxide

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Ferric oxide, assay
 - Loss on ignition
 - Water content
 - pH, water suspension
 - Particle size distribution

Ammonium Perchlorate (Standard)

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Ammonium perchlorate assay
 - Tricalcium Phosphate
 - Total water
 - pH of water solution
 - Sulfated ash
 - Particle size

Ammonium Perchlorate (90 micron)

- Chemical/physical properties of the following constituents are verified by test and data evaluation.
 - Ammonium perchlorate assay
 - Tricalcium Phosphate
 - Total water
 - pH of water solution
 - Sulfated ash
 - Particle size

Liner Inspections

- Raw material certifications verified.
- Infrared spectral analysis performed on the following constituents:
 - Hydroxyl Terminated Poly-Butadiene
 - Bonding Agent
 - Antioxidant
- Liner thicknesses measured.
- o Contamination/Foreign Material:
 - A one hundred percent inspection is performed on interior of motor using just prior to installation of the nozzle assembly and taping weather seal on nozzle.
 - Installation of security bag and lead seal verified.
- o Mechanical/Material Properties
 - Case and aft closure
 - o Material certifications and material test data for case and aft closure are verified.
 - o Penetrant inspection on case and aft closure, following hydrotest
 - Igniter Assembly
 - o Material Certification on the Igniter Adapter and Igniter Case are verified.
 - o Penetrant Inspection on Igniter Case and Adapter following hydrotest.
 - o Internal Components - The proper position and the presence of the following internal components are verified by examination of X-rays: BKNO₃, retainer plate, propellant grain and centering insert.
 - Throat Inserts
 - o Certifications of material, grain direction and x-ray inspection for cracking are verified.

- o Dimensional Non-conformances
 - Throat Insert
 - o Throat I.D. is dimensionally inspected.
 - Case (The following are dimensionally and/or visually inspected)
 - o Wall thickness or out of round
 - o Dome thickness
 - o Primary o-ring mating surface
 - o Secondary o-ring mating surface
 - Closure (The following are dimensionally inspected)
 - o Primary o-ring gland diameter
 - o Secondary o-ring gland diameter
 - o Primary o-ring gland width
 - o Secondary o-ring gland width
 - O-rings
 - o I.D. and width of closure to case o-rings are dimensionally inspected.

KSC RELATED INSPECTIONS

- o Receiving inspection. (Contamination/Foreign Material)
 - Inspect each BSM received for evidence of damage or corrosion per OMRSD File V, Vol. I, requirement number B000FL.005
 - Visual inspections of the BSM grain for damage, sags or cracks are performed per OMRSD File V, Vol. I, requirement number B000FL.009.
- o Installation Inspections per 10REQ-0021.
 - Inspection of aft BSM interior prior to aft heat seal cover installation for damage, contamination and exposed propellant surface, cracks, or void is performed per para. 2.1.2.1. (Contamination/Foreign Material, Propellant)

D. FAILURE HISTORY:

Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- o Not applicable to this failure mode.