

SRB CRITICAL ITEMS LIST

SUBSYSTEM: SEPARATION

ITEM NAME: FWD Booster Separation Motor (BSM)

PART NO.: 10317-0001-805, -806

FM CODE: A03

ITEM CODE: 30-01-06

REVISION: Basic

CRITICALITY CATEGORY: 1

REACTION TIME: Immediate

NO. REQUIRED: 4 per SRB

DATE: March 1, 2002

CRITICAL PHASES: Separation

SUPERCEDES: March 1, 2001

FMEA PAGE NO.: B-21

ANALYST: T. Burke/S. Parvathaneni

CN 044

SHEET 1 OF 9

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 adapter
  - Igniter Case
  - Thread failure
- o Liner
  - Formulation
  - Processing
  - Mechanical properties
  - Debond
- o Cracks or other material defects
  - Case
  - Closure
  - Igniter adapter
  - Igniter case
- o Dimensional Non-Conformances
  - Case
  - Closure
  - Throat insert
  - 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 10SPC-0067.

- o Propellant UTP 19048 per Specification SEO22. (Propellant)

- Formulation is ammonium perchlorate, hydroxyl/terminated polybutadiene, isophorone diisocyanate, di-octyl 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 per SEO727. (Propellant)
  - Constituent requirements and controls for each premix and final mix defined.
  - Temperature and time limits defined.
- o Liner - UTC 0040 Liner per CSD Specification SEO729.
  - Formulation is hydroxyl terminated poly-butadiene, dimethyl diisocyanate, HX-868 bonding agent, carbon black, Ralox 46 antioxidant. 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 fluoroelastomer (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 10317-0001-805. 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 per 10SPC-0084 or 10SPC-0085 (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 systems requirements by CSD QA personnel.
- o All listed KSC related inspections are conducted 100% by USA SRBE or SPC QA personnel.
- o Radiographic Inspection is performed on each loaded case to detect cracks, voids and debonds.

VENDOR RELATED INSPECTIONS

- o 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° 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° 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

o 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 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: BKNO<sub>3</sub>, retainer plate, propellant grain and centering insert.
- Throat Insert
  - o Certifications of material, grain direction and x-ray inspection for cracking are verified.
- o Dimensional Non-conformances Inspections:
  - Throat Insert
    - o Throat I.D. is dimensionally inspected.
  - Case (The following are dimensionally and/or visually inspected)
    - o Wall thickness and 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)
  - Inspection of 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 per OMRSD File V, Vol. I, requirement number B000FL.009.
- o Installation Inspections per 10REQ-0021.
  - Inspection of forward BSM interior prior to aeroheat shield cover installation for damage, contamination, and exposed propellant surface cracks or voids is performed per para. 1.1.2.3. (Contamination/ Foreign Material, Propellant)
  - Aeroheat Shield (AHS) cover seal integrity is tested by verifying no visual leakage for forward BSM AHS per para. 1.1.3. (Contamination/Foreign Material)

D. FAILURE HISTORY:

Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- o Not applicable to this failure mode.



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