

SRB CRITICAL ITEMS LIST

SUBSYSTEM: SEPARATION

ITEM NAME: FWD Booster Separation Motor (BSM)

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

FM CODE: A04

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, 1995

FMEA PAGE NO.: B-23

ANALYST: T. Burke/S. Parvathaneni

SHEET 1 OF 8

APPROVED: S. Parvathaneni

CN 044

FAILURE MODE AND CAUSES: Debris ejection caused by:

- o Aft insulator
 - Mechanical material properties
 - Processing
 - Debond
- o Contamination/foreign material
- o Propellant break up
- o Mechanical/material properties
 - Closure failure
 - Exit cone failure
 - Igniter case failure
 - Throat insert failure
 - Thread Failure
- o Improper installation of the aeroheating shield (also see FMEA 30-01-08)
- o Crack or other material defects
 - Case
 - Closure
 - Exit cone
 - Igniter adapter
 - Throat insert
- o Improper nozzle assembly
- o Dimension Non-conformances
 - Case
 - Closure
 - Exit Cone
 - Throat Insert
 - O-rings

FAILURE EFFECT SUMMARY: Debris generation results in loss of mission, vehicle and crew.

RATIONALE FOR RETENTION:

A. DESIGN

Design Specification is USA SRBE 10SPC-0067.

- o Propellant UTP 19048 per specification SE022. (Propellant)
 - Formulation is ammonium perchlorate, hydroxyl/terminated polybutadiene, 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 and loaded motor case per SEO727. (Propellant)
 - Constituent requirements and controls for each premix and final mix defined.
 - Temperature and time limits defined.
- o Mechanical/Material Properties
 - Case and closure 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.
 - The nozzle assembly consists of an aluminum closure, a carbon steel exit cone finished with a nondebris forming ceramic (Sermetel), on the external surfaces, a heat resisting ablative, butadiene acrylonitrile rubber insulator and a graphite throat. The throat and the insulator are bonded to the closure and are held in position at separation by the motor internal pressure.
- o Foreign Material (Contamination/Foreign Material)
 - Security bag with lead seal installed over exitcone following final assembly inspection.
- o Aeroheat Shield Installation - The aeroheat shield is shipped separately from the BSM and is installed at KSC in accordance with drawing 10125-0008 (Forward BSM Installation, Frustum SRB).
- o Qualification of design documented in CSD 5180-79-109 (All Failure Causes)
 - Motor performance verified by 14 motor tests.
 - BSM exhaust particle size and distribution determined from exhaust samples from 5 test motors.
- o Delta Qualification Tests
 - CSD 5596-88-3 delta qualification test for booster separation motor configurations 10317-0001-803 and 10317-0002-803. 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 on each lot
- 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 Processing of propellant and loaded motor case. (Propellant)

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)
 - Thrust/Pressure vs time data analyzed for conformance to performance requirements.

- o Mechanical/Material Properties
 - Each case/closure hydrotested as a serialized unit.
 - Each igniter case hydrotested.
 - Each case/closure heat treat lot.
 - 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
 - Leak Test
 - o For each motor the case to closure and igniter to case sealing surface O-rings are seated and the joints are tested under low pressure with no leakage allowed.

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.

VENDOR RELATED INSPECTIONS

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^o
 - 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 Contamination/Foreign Material:

- A one hundred percent Inspection is performed on interior of motor just prior to installing of the nozzle assembly and taping weather seal on nozzle.
- Installation of security bag and lead seal verified.

o Mechanical/Material Properties- Case & 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 Hydro- test.

- Exit Cone

- o Physical and chemical material properties are verified.
- o Magnetic Particle Inspection is verified.

- Nozzle Assembly

- o Proper mixing of adhesive ingredients is verified.
- o Nondestructive evaluation of each insulator to aft closure bond by ultrasound and tap test is made to verify acceptance criteria for voids and debonds. CN 044
- o Insulator edge visually inspected for debonds from Aft Closure

- Throat Insert:

- o Certification of material, grain direction and x-ray inspection for cracking.
- o All throat inserts are subjected to an alcohol wipe inspection for external cracks.

- Igniter Assembly:

- o Material Certifications on the Igniter Adapter and Igniter Case are verified.
- o Penetrant Inspection on Igniter Case and Igniter 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.

- 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 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
 - Exit Cone
 - o Threads at closure end 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 BOOOFL.005.
 - Visual inspections of the BSM grain for damage, sags or cracks per OMRSD File V, Vol. I, requirement number BOOOFL.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. (Propellant, Contamination/Foreign Material)
 - Proper installation of the aeroheat shield is verified per para. 1.1.3. (Improper installation of Aeroheating Shield)
 - Aeroheat shield seal integrity is tested by verifying no visual leakage for forward BSM aeroheat shields per para. 1.1.3. (Improper installation of Aeroheating Shield)

- Installation of aeroheat shield attach screws lockwire is verified per para. 1.1.3 (Improper installation of Aeroheating Shield)

D. FAILURE HISTORY:

Failure Histories may be obtained from the PRACA database.

E. OPERATIONAL USE

- o Not applicable to this failure mode.