SUBSYSTEM: SEPARATION

ITEM NAME: Fwd Booster Separation Motor (BSM)

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

FM CODE: A06

ITEM CODE: 30-01-06

REVISION: Basic

CRITICALITY CATEGORY: 1R

REACTION TIME: Immediate

NO. REQUIRED: 4 Forward

DATE: March 1, 2002

CRITICAL PHASES: Separation

SUPERCEDES: March 31, 2000

CN 044

FMEA PAGE NO.: B-19A

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SHEET 1 OF 6

APPROVED: S. Parvathaneni

FAILURE MODE AND CAUSES: Fails to ignite, delayed ignition, or low thrust (two BSMs) caused by:

- o Propellant
  - formulation
  - processing
- o Low temperature
- o Moisture or contamination in igniter, main grain or BKNO3

FAILURE EFFECT SUMMARY: Loss of separation thrust results in the loss of mission, vehicle and crew. One success path remains after the first failure. Operation is not affected until failure of two out of four BSMs.

REDUNDANCY SCREENS AND MEASUREMENTS:

1. N/A
2. N/A
3. Pass

RATIONALE FOR RETENTION:

A. DESIGN

Design Specification is USA SRBE 10SPC-0067.

- o Propellant UTP 19048 per Specification SE0622. (Propellant)
  - Formulation is ammonium perchlorate, hydroxyl/terminated poly-butadiene, 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 and loaded motor case per SEO727. (Propellant, Moisture)

- Constituent requirements and controls for each premix and final mix defined.
- Temperature and time limits defined
- Allowable moisture content at each premix operation defined. (Mois- ture)

o Igniter

- Propellant and processing same as main grain above. (Propellant)
- Pyrotechnic Booster Charge is BKNO3 per USA SRBE 10SPC-0136. The BKNO3 velostat bags are purged with nitrogen to displace moisture, then the loaded bags are heat sealed.(Propellant Explosives, Moisture, Low Temperature)

o Shipping and Storage (Moisture or Contamination)

- Security bag with lead seal installed over exit cone following final assembly acceptance inspection.
- Each motor packed in a drum for long term shipping and storage. Each drum includes desiccant and externally visible humidity indicator.

o Qualification of design documented in CSD 5180-79-109. (All Failure Causes)

- Motor performance verified by 14 motor tests.
- Moisture - Six FWD and two Aft motors exposed to two hour rain cycle at rate of four inches per hour.
- Seven motors thermally conditioned at +30^{o}F for 24 hours prior to tests.

o Delta Qualification Tests

- CSD 5597-93-2 delta qualification tests for BSM configuration 10317-0001-805. Delta qualification on two units subjected to environmental and functional tests.

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 (lot) 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.

C. INSPECTION

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^{o} 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 (weight percent)
- 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 Igniter Moisture/Contamination

- BKN03 velostat bag is processed in a nitrogen box and purged with nitrogen until it reaches a specified relative humidity is verified.

- Propellant and processing is same as main grain above.

- BKNO3 bag welds are vacuum tested and verified.

o Igniter (All Failure Causes)

- Internal Components - The proper position and the presence of the following internal components are verified by examination of X-rays: $BKNO_3$, retainer plate, propellant grain, and centering insert.

o Main grain moisture and contamination

- A 100% 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.

KSC RELATED INSPECTIONS

o Receiving inspection. (Contamination/Foreign Material)

- Inspect each BSM received for evidence of damage, corrosion or moisture per OMRSD File V, Vol. I, requirement number B000FL.005.

- Visual inspections of the BSM grain for damage, sags, cracks or moisture per OMRSD File V, Vol. I, requirement number B000FL.009.

o FWD BSM 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, Moisture/Contamination)

- Aeroheat Shield (AHS) cover seal integrity is tested by verifying no visual leakage for forward BSM AHS per para. 1.1.3. (Contamination)

o Launch commit criteria precludes launch when air temperature is below design constraint.

D. FAILURE HISTORY:

o Failure histories may be obtained from the PRACA database.

E. OPERATIONAL USE

o Not applicable to this failure mode.