SPACE SHUTTLE

Solid Rocket Motors
Morton Thiokol Inc

Block II SRM Conceptual Design Studies Final Report

Preliminary Development and Verification Plan
Volume I, Book 2

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MORTON THIOKOL, INC.

Wasatch Operations

Space Division

P.O. Box 524, Brigham City, Utah 84302 (801) 863-3511

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4.5.3.4.3 Joint Environment Simulation and Transient Pressure Tests

The vertical launch environment effects on the Block II case joints will be evaluated with fully instrumented JES tests. These tests will provide verification data for seal gap changes and effectiveness of the Block II case sealing system (see Internal Insulation Section). These tests will be supplemented with Transient Pressure Test Articles which add the external loads to the full scale test components during the simulated ignition pressure transient.

4.5.3.4.4 Static Test

Case behavior during motor operation will be determined during three development motor static tests.

4.5.3.5 Acceptance Tests

Each new and refurbished case segment will be proof tested at a pressure in excess of MEOP to assure flaw detection that could compromise the successful completion of six additional mission cycles. The proof test factor has been calculated as 1.08 with the MAR-T250 material data.

Detailed raw material acceptance data requirements will be developed for the MAR-T250 material specification. The heat treatment process will be validated from excess material coupon testing from each case component.

4.5.3.6 Qualification Tests

With the development hydroburst test and structural test confirmed with advanced modeling and characterization, the case strength certification will be achieved. The joint response to transient pressure and repetitive loading will be defined over the range of operating conditions with the joint environmental simulation test which allows detailed deflection measurements for analytical correlation. Four full scale static tests will provide the final qualification of the motor components.

4.6 Propellant

DL-H396 propellant has been selected as the propellant for the Block II SRM. It offers potential for a significant performance gain in the "heads-up" mode. It is a modified Peacekeeper Stage I propellant.

DL-H396 propellant contains a R-45HT/HTPB polymer, aziridine bonding agent, IPDI (isocyanate curing agent), aluminum, and ammonium perchlorate. Iron oxide is used as a burn rate catalyst. The formulation, mechanical, and theoretical ballistic properties are presented in Table IX. The physical, mechanical, and ballistic properties of DL-H396 will meet or exceed the Block II SRM design requirements.

The SRM Block II propellant grain design (Figure 8) is essentially the same as the current SRM grain design. It consists of a forward segment with an 11-point star that transitions into a cylindrical perforated (CP) configuration in the cylindrical portion of the segment, two identically configured center segments that are tapered CP configurations, and an aft segment with a dual taper CP configuration. The aft face of the forward segment, both ends of the center segments, and the forward face of the aft segment are inhibited to achieve the required thrust-time profile.

4.6.1 Propellant Development and Tailoring

DL-H396 propellant will be designed, developed and qualified to meet all the requirements for the Block II SRM CEI specification, CPW1-1900. The propellant tailoring program will optimize processing properties, tailor burn rate, and characterize mechanical properties. Process optimization will consist of varying ground-to-unground oxidizer ratio to achieve the lowest end-of-mix viscosity, optimum rheology, pot-life and castability. Burn rate will be tailored with Fe_2O_3 catalyst. Mechanical properties will be characterized to define the curative-to-polymer ratio for maximum stress and strain at maximum stress.

The initial effort will encompass a grain analysis and grain stress analysis in conjunction with a propellant tailoring program. This will verify the compatibility of the propellant ballistic and physical properties and the SRM grain design. Repeatable ballistic and physical properties from mix-to-mix and motor-to-motor will be ensured through the use of raw material acceptance testing, propellant standardization procedures, and in-process inspection and acceptance testing. A theoretical combustion stability analysis will be conducted on the selected propellant and grain design. These data, coupled with the test data obtained from T-burner tests, will establish the overall SRM combustion stability. The T-burner (A tubular burner) is a test motor that either oscillates spontaneously or is made to oscillate through pulsing. Measurements of the logarithmic growth rate of the oscillations and/or the logarithmic decay rate for various propellant configurations yield data which provide a measure of the propellant stability characteristics.

TABLE IX: TYPICAL PROPELLANT DESIGN DATA

Formulation	Weight/Percent
R-45HT/HTPB Polymer	11.02
HX-752 Bonding Agent	0.15
Iron Oxide	0.2
Aluminum	19.00
Ammonium Perchlorate	68.92
IPDI Curing Agent	0.71

Mechanical Properties (JANNAF Uniaxial)	Temperature 77 Deg F
Initial Modulus (psi)	578
Strain at Max Stress (%)	45
Stress (psi)	142

Ballistic Properties (P_C = 715 psia, 60 deg F)	Chamber	Nozzle	Exit
Flame Temperature (deg K)	3522	3337	2327
Molecular Weight (lb/lb-mole)	29.29	29.54	30.53
Specific Heat Ratio	1.129	1.129	0.998
Blowing Coefficient (corrosivity index)	0.0935	0.0901	0.0809
Characteristic Velocity (fps)			5,173
Solid Density, Theoretical ($lb/in.^3$)			0.06508

Burn Rate Data at 1000 psia,	
60 Deg F	0.454 inch/sec
Burn Rate Exponent, n	0.38
Effective Nozzle Specific Heat Ratio	1.13
Vacuum Theoretical Specific Impulses	280.4 lb-sec/lb
Expansion Ratio	7.72:1
Absolute Viscosity of Chamber Gas	$1.63X10^{-7}$ lbF-sec/in-ft