PART V. SOLID ROCKET BOOSTER/REUSABLE SOLID ROCKET MOTOR

Introduction

The twin solid rocket boosters (SRBs), designed as the primary propulsion element of the STS, provided the Space Shuttle with 80 percent of the liftoff thrust during the first two minutes of launch. They burned more than 2,200,000 pounds of propellant and produced 36 million horsepower.[1487] Each SRB booster was comprised of both motor and non-motor segments. The motor segments, referred to as the solid rocket motor (SRM), and later renamed "reusable solid rocket motor" (RSRM), contained the fuel to power the SRBs.[1488] The SRMs/RSRMs were the largest and only human-rated solid-propellant rocket motors ever flown, and the first designed for recovery and reuse. The major non-motor segments included the nose cap, frustum, and forward and aft skirts. These structural components contained the electronics to guide the SRBs during liftoff, ascent, and ET/SRB separation, and housed the parachutes, which slowed the descent of the reusable boosters into the Atlantic Ocean after their jettison from the spacecraft.

Historically, SRM/RSRM development followed a path separate from the non-motor SRB components. Throughout the SSP, Thiokol, of Promontory, Utah, was the sole fabricator and prime contractor for the SRM/RSRM.[1489] Thiokol supplied NASA with the propellant-loaded forward motor case segment, with the igniter/safe and arm (S&A) device installed; the two propellant-loaded center motor case segments; the propellant-loaded aft motor case segment, with the nozzle installed; the case stiffener rings; and the aft exit cone assembly with the severance system installed. Over 400 suppliers, located in thirty-seven states and Canada, provided metal components, seals, insulation, fabrics, paints, and adhesives. In addition, six companies supplied the major ingredients that comprised the RSRM propellant. These included American Pacific (AMPAC) in Cedar Rapids, Utah (ammonium perchlorate); Dow Chemical in Freeport, Texas (epoxy resin); Alcoa in Rockdale, Texas (aluminum powder); Toyal America in Naperville, Illinois (spherical aluminum powder); American Synthetic Rubber Company (ASRC) in Louisville, Kentucky (polybutadiene-acrylic acid-acrylonitrile terpolymer [PBAN]); and Elementis Pigments in Easton, Pennsylvania (iron oxide). For the final flight motors, Mitsubishi Argentine ingot replaced the aluminum powder provided by Alcoa, and the ammonium perchlorate was provided by HCL-Olin in Becancour, Quebec, Canada, and Niagara Falls, New York.

[1487] ATK, "RSRM Overview" (presentation materials, MSFC, Huntsville, AL, April 8, 2010), 5.

[1488] Following the *Challenger* accident, the SRMs were redesigned. Effective November 1, 1987, the new motor configuration became known as the Redesigned SRM (RSRM). By 1995, they were renamed Reusable SRM (still RSRM).

[1489] The Thiokol Chemical Company, founded in 1929, experienced several mergers and splits, resulting in a series of name changes, including Morton Thiokol Incorporated (1982), Thiokol Inc. (1989), Cordant Technologies (1998), AIC (Alcoa Industrial Components) Group (2000), Alliant Techsystems (ATK) Inc. (2001), ATK-Thiokol, and ATK Launch Systems Group (2006). The company will be referred to as "Thiokol" throughout this document.

The major non-motor SRB components originally were designed in-house by MSFC engineers, and SRB hardware was the responsibility of MSFC during the development phase.[1490] MSFC designed the structural components and a number of the subsystems, then contracted to have them fabricated. Beginning with the seventh SSP mission, STS-7, United Space Boosters, Inc. (USBI) of Sunnyvale, California, a wholly-owned subsidiary of United Technology Corporation, replaced MSFC as the prime contractor for the SRB until 1999, when USBI became part of USA.[1491] At KSC, USA was the prime contractor for the fabrication, assembly, and refurbishment of primary SRB non-motor segments and associated hardware. One set of flight-ready SRBs contained approximately 5,000 refurbished parts.[1492] The major suppliers for the SRB program were located in twelve states across the U.S. These providers included the following: McDonnell Douglas Corporation, California (aft skirt, forward skirt, frustum, and ET attach ring); Hamilton Sunstrand, Illinois (APU); ATK-Thiokol Propulsion, Utah and Chemical Systems Division, California (booster separation motor); Moog-Servoactuator, New York (fuel isolation valve); Aerojet General Corporation, Washington (gas generator); Parker Abex, Michigan (hydraulic pump); L3 S&N, New Jersey (integrated electronic assembly); L3 Cincinnati Electronic, Ohio (command receiver/decoder); Honeywell Inc. Space Systems, Arizona (modulator/demodulator); Oceaneering Space & Thermal, Texas and Hi-temp Insulation, California (thermal curtain); BST Systems, Connecticut (batteries); LaBarge, Inc., Missouri (cables); and Goodrich UPCO, Arizona and California, and Pacific Scientific, Arizona (ordnance).

Historical Overview

Early Booster Concept Studies

A number of different booster concepts were under consideration by NASA and the aerospace industry when President Nixon gave the go-ahead to proceed with the development of the STS. The alternative configurations included a recoverable, reusable unmanned booster; a manned, reusable, flyback booster; and an expendable booster (See Part I. Historical Context).

Concurrent with the Phase B Space Shuttle definition studies, on September 28, 1970, MSFC chose McDonnell Douglas to study an expendable second stage for a reusable shuttle booster. Shortly after, the contract was modified for a period of one year to allow for testing the structural components of its proposed shuttle booster. In mid-1971, Phase B shuttle definition contracts with North American Rockwell-General Dynamics and McDonnell Douglas-Martin Marietta, and study contracts with Grumman-Boeing and Lockheed were extended to consider the phased approach to shuttle design and the use of existing liquid or solid propulsion boosters as interim

[1490] Dunar and Waring, *Power to Explore*, 308.
[1491] T.A. Heppenheimer, *Development of the Space Shuttle 1972-1981*, 174.
[1492] United Technologies Corporation, "Solid Rocket Booster Fact Sheet," n.d., MSFC History Office, Huntsville.