READING: The Solid Rocket Booster

Got Thrust?

The solid rocket boosters, or SRBs, are one of the three main parts of the Shuttle system (SRBs, external tank, and orbiter). These booster rockets are the largest solid fuel motors ever used in space flight, and are also the first designed to be reusable.

Each booster rocket is attached to either side of the external tank (ET) and is 149.16 feet (45.46 meters) tall with a diameter of 12.17 feet (3.7 meters). Each SRB weighs approximately 1,300,000 pounds (589,670 kilograms) at launch with roughly 85 percent being the weight of the solid fuel itself. The solid fuel, or propellant, is a mixture of ammonium perchlorate, aluminum, and iron oxide. When the Shuttle's three main parts are assembled and placed on the mobile launch platform, the entire weight of the ET and the orbiter is held by the two SRBs. Each SRB is bolted to the launch platform by four pyrotechnic bolts; each bolt is 25 inches in length and 3.5 inches in diameter. Each weighs 62 pounds. These bolts are designed to perform the following tasks:

1. support the Shuttle while on the launch platform (including holding it while on its transported three miles to one of the two launching complexes).

2. hold the Shuttle down while the Space Shuttle's three main engines ignite at T-6 seconds in the countdown and power up to 90 percent.

3. pyrotechnically break when the SRBs are ignited at T-0 seconds.

The two SRBs provide 71.4 percent of the main thrust needed to lift the Space Shuttle off the launch pad. Each booster has a thrust of approximately 3,300,000 pounds (14,685 kilonewtons) at launch and help lift the Shuttle to an altitude of about 150,000 feet, or 28 miles (50 kilometers). The SRBs burn for approximately two minutes and are then jettisoned from the Shuttle. During their decent, three parachutes are deployed from the top of each SRB to allow for a safe splashdown in the Atlantic Ocean, roughly 141 miles (260 kilometers) downrange from Kennedy Space Center. Both SRBs are equipped with special floatation devices that allow them to float once they splash down. Flotation is aided by the large air pocket trapped inside when the empty rocket booster crashes down tail first into the water. Two specially designed and equipped NASA boats, the Liberty Star and Freedom Star, are deployed to retrieve both SRBs and return them to the Kennedy Space Center. Once they return to the Space Center, they are disassembled and sent to be reprocessed so they can be used again.

Did You Know?

- These booster rockets are the largest solid fuel motors ever used in space flight, and are also the first designed to be reusable.
- Each SRB weighs approximately 1,300,000 pounds (589,670 kilograms) at launch with roughly 85 percent being the weight of the solid fuel itself.
- The solid fuel, or propellant, is a mixture of ammonium perchlorate, aluminum, and iron oxide.
- The SRBs burn for approximately two minutes and are then jettisoned. During their descent, three main parachutes are deployed from the top of each SRB to allow for a safe splashdown in the Atlantic Ocean.

Rocket Motor

The traditional definition of a ***rocket*** is a vehicle or missile that obtains thrust by the reaction to the ejection of fast moving exhaust gas from within a rocket engine.

A chemical reaction is initiated between the fuel and the oxidizer in the combustion chamber, and the resultant hot gases accelerate out of a nozzle (or nozzles) at the rearward facing end of the rocket. The acceleration of these gases through the engine exerts force (thrust) on the combustion chamber and nozzle, propelling the vehicle (in accordance with Newton's Third Law).

Solid Rocket Boosters

The solid rocket boosters (SRB) operate in parallel with the main engines for the first two minutes of flight to provide the additional thrust needed for the orbiter to escape the gravitational pull of the Earth. At an altitude of approximately 45 km (24 nautical miles), the boosters separate from the orbiter/external tank, descend on parachutes, and land in the Atlantic Ocean. They are recovered by ships, returned to land, and refurbished for reuse. The boosters also assist in guiding the entire vehicle during initial ascent. Thrust of both boosters is equal to 5,300,000 lb.

In addition to the solid rocket motor, the booster contains the structural, thrust vector control, separation, recovery, and electrical and instrumentation subsystems.

The solid rocket motor is the largest solid propellant motor ever developed for space flight and the first built to be used on a manned craft. The huge motor is composed of a segmented motor case loaded with solid propellants, an ignition system, a movable nozzle, and the necessary instrumentation and integration hardware.

The SRBs separate from Columbia about two minutes after the first launch of the Shuttle Program.

Each solid rocket motor contains more than 450,000 kg (1,000,000 lb.) of propellant, which requires an extensive mixing and casting operation at a plant in Utah. The propellant is mixed in 600 gallon bowls located in three different mixer buildings. The propellant is then taken to special casting buildings and poured into the casting segments.

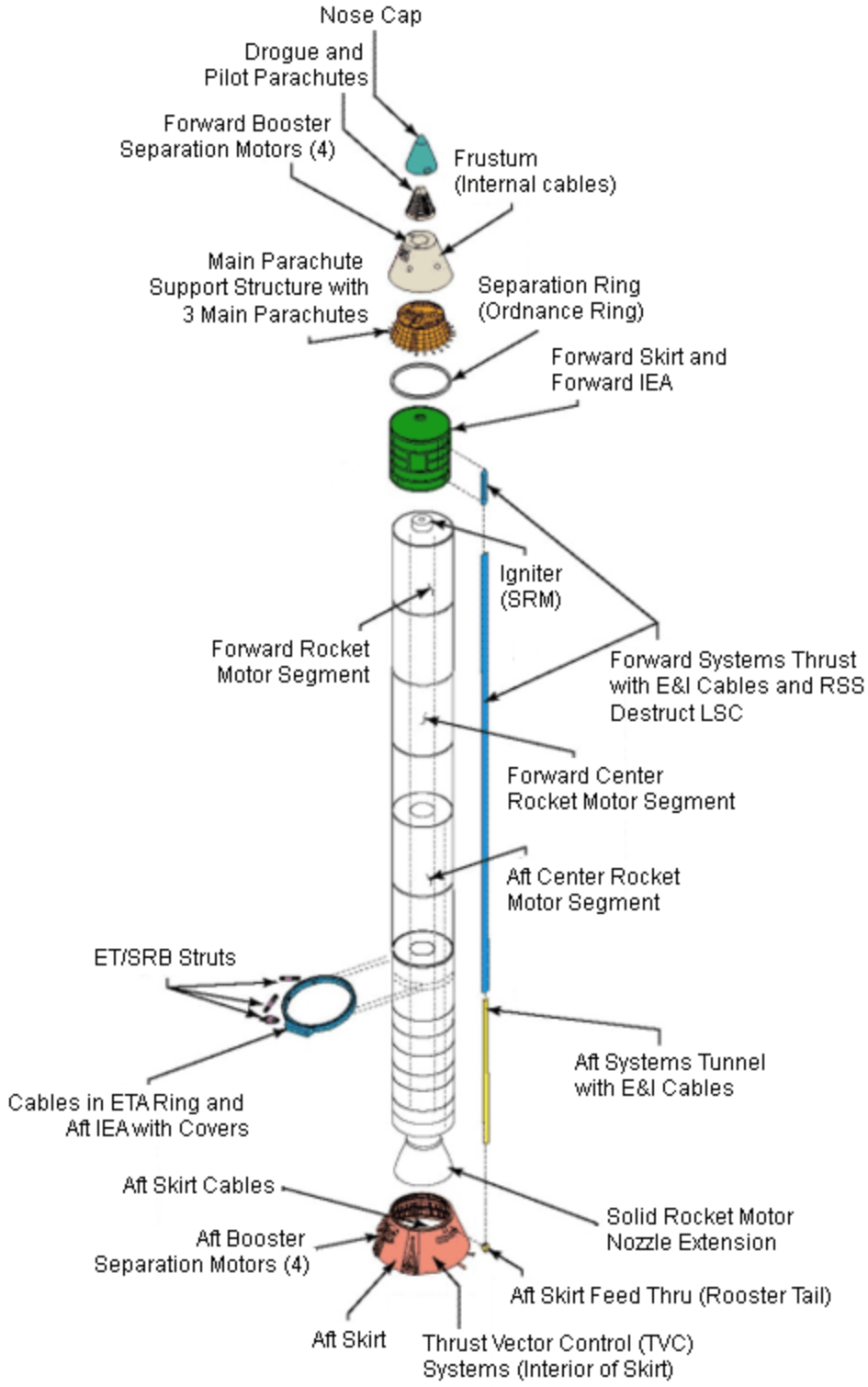
Booster Statistics

Thrust at lift-off
1,202,020 kilograms (2,650,000 pounds)

Propellant Properties
Atomized aluminum powder (fuel: 16%)
Ammonium perchlorate (oxidizer: 69.83%)
Iron oxide powder (catalyst: 0.17%)
Polybutadiene acrylic acid acrylonite (binder: 12%)
Epoxy curing agent (2 %)

Weight
Empty: 87,543 kilograms (193,000 pounds)
Propellant: 502,126 kilograms (1,107,000 pounds)
Gross: 589,670 kilograms (1,300,000 pounds)

Cured propellant looks and feels like a hard rubber typewriter eraser. The combined polymer and its curing agent is a synthetic rubber. Flexibility of the propellant is controlled by the ratio of binder to curing agent and the solid ingredients, namely oxidizer and aluminum. The solid fuel is actually powdered aluminum—a form similar to the foil wraps in your kitchen—mixed with oxygen provided by a chemical called ammonium perchlorate.


Nose Cap
Drogue and Pilot Parachutes
Forward Booster Separation Motors (4)
Frustum (Internal cables)
Main Parachute Support Structure with 3 Main Parachutes
Separation Ring (Ordnance Ring)
Forward Skirt and Forward IEA
Igniter (SRM)
Forward Rocket Motor Segment
Forward Systems Thrust with E&I Cables and RSS Destruct LSC
Forward Center Rocket Motor Segment
Aft Center Rocket Motor Segment
ET/SRB Struts
Aft Systems Tunnel with E&I Cables
Cables in ETA Ring and Aft IEA with Covers
Aft Skirt Cables
Solid Rocket Motor Nozzle Extension
Aft Booster Separation Motors (4)
Aft Skirt Feed Thru (Rooster Tail)
Aft Skirt
Thrust Vector Control (TVC) Systems (Interior of Skirt)