News From MCDONNELL DOUGLAS CORPORATION

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MCDONNELL DOUGLAS S-IVB ROCKET FOR NASA'S SATURN LAUNCH VEHICLE

Background Information

The powerful S-IVB rocket, produced by the McDonnell Douglas Astronautics Company, a division of McDonnell Douglas Corporation, is the top stage of both the Saturn IB and Saturn V launch vehicles.

S-IVB, 58 feet 7 inches in length and 21 feet 8 inches in diameter, is powered by a single Rocketdyne J-2 engine burning liquid hydrogen and liquid oxygen propellants and generating 225,000 pounds of thrust.

McDonnell Douglas was selected by the National Aeronautics and Space Administrations's (NASA) Marshall Space Flight Center, Huntsville, Alabama, to develop and produce the S-IVB, utilizing experience and techniques from its earlier Saturn S-IV program in designing the S-IVB systems, tooling and test equipment.

The S-IVB serves as second stage of NASA's two-stage Saturn IB, which is capable of delivering over 18 tons to earth orbit. Initially the Saturn IB was assigned the mission of launching manned Apollo spacecraft into orbit about the earth in order to check out and test the Apollo system in preparation for flights to the moon.

Launch vehicle for the manned lunar missions is the more powerful three-stage Saturn V. As third stage of

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the Saturn V, the S-IVB provides the final thrust to insert the Apollo spacecraft and its astronaut crew into earth orbit and then restarts and boosts the spacecraft from its parking orbit into a trans-lunar trajectory.

Saturn V is capable of placing over 125 tons into orbit around the earth and sending more than 45 tons to the vicinity of the moon.

Newest assignment for the S-IVB is as an orbital manned space workshop in NASA's Apollo Applications Program. Designated the Saturn I Workshop, the modified S-IVB will provide shelter and working space for three astronauts inside its empty 21.7-foot-diameter, 10,000-cubic foot hydrogen tank. The hydrogen fuel is depleted when the S-IVB fires to achieve earth orbit.

The Saturn I Workshop will be launched as part of a Saturn IB for rendezvous in orbit with a subsequently launched manned Apollo spacecraft. The astronauts will transfer from the Apollo to the Workshop through an airlock being built by McDonnell Douglas Astronautics in St. Louis, Missouri. During the initial workshop mission, the flight crew will live inside the stage for up to 28 days while conducting space flight experiments.

The initial S-IVB development contract was signed with NASA in August 1962, and the first S-IVB flight stage was turned over to NASA on August 31, 1965 -- just three years later.

Earlier, McDonnell Douglas had delivered two ground-test stages and had completed an extensive series of test

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firings of the J-2 engine, with prototype hardware and systems, on a non-flight "battleship" stage built of heavy stainless steel in the configuration of an actual flight stage.

The full-duration acceptance test firing of the first S-IVB flight stage marked the first time that a fully automatic system was used to perform the complete checkout, propellant loading and static firing of a space vehicle.

The automatic checkout system, utilizing a general purpose computer, was developed by Douglas for the S-IVB. It performs all the complex operations of the final factory checkout on the vehicle, conducting the item-by-item countdown before testing and controlling the propellant loading and the actual firing. It then is used again in the post-firing checkout.

Similar systems installed at the Kennedy Space Center by NASA provide for automated checkout of the complete Saturn IB and Saturn V vehicles.

Basic configuration of the S-IVB is cylindrical, with an insulated common bulkhead forming a structural thermal barrier, separating the forward liquid hydrogen tank from the liquid oxygen tank. The common bulkhead design, consisting of two aluminum domes, with fiber glass honeycomb bonded to each to form a rigid "sandwich," was developed by McDonnell Douglas for the Saturn S-IV program.

Interior of the aluminum alloy tanks is milled in a "waffllelike" pattern. Insulation is installed along the interior of the liquid hydrogen tank to prevent excessive

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loss of this super-cold (boiling point about -423 degrees Fahrenheit) liquid from "boil-off."

During powered flight of the S-IVB, pitch and yaw control is accomplished by gimbaling the main engine, and roll control is maintained through the firing of the 150-pound-thrust attitude control engines of the auxiliary propulsion system (APS).

When the S-IVB is coasting in orbit, the APS engines are fired by the flight computer to provide pitch, yaw and roll stabilization.

Propellant capacity for orbital operations is over 230,000 pounds -- 64,000 gallons of liquid hydrogen and 20,000 gallons of liquid oxygen.

Significant milestones in the S-IVB program began with the highly successful first flight of the rocket on February 26, 1966, as second stage of NASA's first Saturn IB, which launched an unmanned Apollo spacecraft on a 5000-mile suborbital test.

First launch of the S-IVB as third stage of the giant Saturn V was on November 9, 1967. This successful launch marked the debut of the Saturn V and the first restart of the S-IVB propulsion system in space.

Initial manned launch for a Saturn vehicle and for the S-IVB stage occurred on October 11, 1968, when a Saturn IB lofted Apollo 7 and its crew of three astronauts into earth orbit. As its contribution to the highly successful mission, the S-IVB fired for about $7\frac{1}{2}$ minutes to insert the spacecraft into its orbital path.

An even more demanding assignment for the S-IVB was the historic Apollo 8 mission which carried three astronauts on man's first lunar flight. Performing flawlessly, the S-IVB third stage fired for about two minutes during the launch on December 21, 1968, inserting Apollo 8 into earth orbit.

After a two-orbit coasting period, the S-IVB restarted and burned for more than five minutes, propelling Apollo 8 to a speed of 24,610 m.p.h. toward its rendezvous with the moon. After 10 orbits of the moon, Apollo 8 returned to earth on December 27, 1968. The depleted S-IVB ultimately went into solar orbit. The launch was the first manned mission for the Saturn V.

Another historic Saturn/Apollo mission was Apollo 10, which carried three astronauts on a 500,000-mile voyage to the moon and back. Launched by a Saturn V on May 18, 1969, the Apollo 10 returned eight days later, splashing down in the south Pacific May 26, 1969.

The Apollo 10 circled the moon 31 times at an altitude of about 69 miles. During this period the Lunar Module (LM) was separated from the command and service modules and two astronauts descended in it to within 9.4 miles of the moon's surface. Purpose of Apollo 10 flight was to demonstrate all the steps required for an actual lunar landing with the exception of touchdown and to scout possible lunar landing sites.

The S-IVB stage of the Saturn V functioned successfully during Apollo 10, igniting to push itself, the LM and the

command and service modules into earth orbit and then restarting to propel the Apollo and LM on their way to the moon.

Major components and subassemblies of the S-IVB are fabricated at McDonnell Douglas Astronautics in Santa Monica and Huntington Beach, California. Final assembly and checkout of the vehicle are performed at the company's Space Systems Center in Huntington Beach, and ground test firings are conducted at its Sacramento Test Center near Sacramento, California.

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