SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Systems I (1)

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AEROJET HIGH-PERFORMANCE BIPROPELLANT APOGEE ENGINES

Abstract

Aerojet originally developed the 445-Newton Model R-4D in the early 1960s for the Reaction Control Systems for the Apollo Service Module and the Lunar Excursion Module. Between 1966 and 1975, over 450 Model R-4Ds were delivered for the Apollo missions to the moon and performed flawlessly. In the early 1980s, the R-4D was re-engineered to incorporate the emerging materials of silicide coated columbium. This resulted in an upgraded Model R-4D-11 with a nominal thrust of 490-Newtons which became the apogee engine of choice by the GEO Comsat producers of the time: Ford Aerospace, Hughes Aircraft Company, and British Aerospace. In 1992, the Model R 4D was qualified for GE Astro for the Mars Observer mission; and in 1997, two Model R 4Ds were delivered for the Cassini mission to Saturn having completed (according to NASA) the world's most demanding bipropellant liquid rocket engine qualification program. Subsequent to the successful qualification, NASA's Jet Propulsion Laboratory described the Model R-4D as a "bullet-proof" engine. The Model R-4D-11 is also used on the ESA Automated Transfer Vehicle (ATV), the NASDA H-II Transfer Vehicle (HTV), and the NASA Orion crew exploration vehicle. In the late 1990s, the R-4D-11 was upgraded to the Model R-4D-15 HiPAT^{TM} rocket engine. The primary design modification was the incorporation of a chemical vapor deposited (CVD) iridium lined rhenium combustion chamber capable of operating at 1750C to 1875C. The nominal ISP performance of the Model R-4D-15 engine is 322 seconds. A "dual mode" version (Model R-4D-15DM), was qualified in 2003, with nominal specific impulse performance of approximately 328 seconds. In October 2009, the 50th HiPAT^{TM} engine was successfully flown. Aerojet will complete delivery of the 100th production HiPAT^{TM} engine in 2010. Most recently, Aerojet successfully completed development of the AMBR 625-Newton apogee engine, an upgraded version of the R-4D-15DM Dual-Mode HiPAT^{TM}. The nominal ISP performance of the AMBR engine is 333 sec. Aerojet has incorporated an improved injector, higher chamber pressure, and improved nozzle to accomplish these performance improvements. Additionally AMBR incorporates an improved chamber fabrication process to reduce the cost of the engine. All development testing is complete and the engine is ready to enter flight qualification testing. To date, over 700 Model R-4D engines have been delivered for flight. Excluding Apollo, Model R-4D rocket engines have successfully completed seven (7) qualification programs. The Model R-4D series of engines has demonstrated 100% mission success.