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DEVELOPMENT OF ATLAS: A LIQUID ROCKET ENGINE CRYOGENIC FEED SYSTEM

Abstract

Student-designed engines and rocket teams have continued to advance and develop to create more powerful and complex cryogenic liquid rocket engines. The increased requirements and complexity of advanced rocket engines requires the development of test infrastructure to validate the engine research. USC Liquid Propulsion Laboratory (LPL) presents the adaptation of their existing GOx/Kerosene test stand (HYDRA) to develop a LOx/Kerosene test stand (ATLAS) with increased testing capability and performance while maintaining a futureproof, robust design. The resulting ATLAS design is capable of safely testing cryogenic propellant engines greater than 10kN of thrust and 20 kg/s mass flow rate. An iterative design cycle was implemented to determine and size components on the ATLAS test stand that would successfully meet testing requirements. The first step of this process was to identify and realize the main design constraints of HYDRA, and pinpointing the components that can be refurbished, or would need further development. A test stand MEOP of 1500 psi was determined after estimating all system pressure losses. After establishing the new requirements, it was determined that HYDRA's GOx lines and components for the fuel and pressurant side were refurbishable. Other fuel and oxidizer lines and components were sized to meet new requirements. LPL incorporated cost saving methods where applicable and conducted trade studies to reduce the overall cost of this project and minimize component lead time. Commercial off the shelf (COTS) components were utilized where applicable due to their quick lead times. Retrofitting techniques were used on COTS components such as hand ball valves to enable them to be used safely in cryogenic environments. COTS medical oxygen tanks were modified with an inlet at the bottom to use as fuel and oxidizer propellant tanks. Engineering controls were implemented to ensure safe high-pressure and cryogenic operations based on a failure modes and effects analysis (FMEA) investigation. To ensure test stand operator safety, a single-key lockout system was implemented, and the test stand was designed such that all operations from the start of propellant loading could be done remotely. Maximum projected cryogenic boil-off rates were used to size relief devices and vent paths to allow for adequate venting. The system also has redundant vent and relief paths to prevent boiling liquid expanding vapor explosion (BLEVE) from occurring in cryogenic lines, components, and the tank. Additional redundancy was incorporated by supplying independent auxiliary power sources to valves.