Executive Summary

The U.S. Department of Energy contracted with Air Products and Chemicals, Inc. to design a bench-scale bubble column reactor unit for Fischer-Tropsch slurry catalyst operations. The resulting process design includes the reaction, wax withdrawal, and product fractionation sections of a bench scale Fischer-Tropsch reactor. This design satisfies the requirements of Task 4 of the Department of Energy contract DE-AC22-80PC30021, "Catalyst and Reactor Development for a Liquid Phase Fischer-Tropsch Process."

The design of the bench-scale Fischer-Tropsch reactor (BFTR) is based upon reaction rates and product yields measured with the slurry-phase catalysts that Air Products developed and evaluated in Task 2 of this contract and on results of a cold-flow hydrodynamic study of the bubble-column reactor that was conducted under Task 3 of the contract.

The BFTR is sized to operate in the churn-turbulent flow regime, in which commercial-scale reactors will operate. Task 3 results indicate that this flow regime can be achieved with an effective reactor diameter of 5 inches, that is, an annular reactor having a flow area equal to that of a 5-inch cylinder. To achieve 40-50% conversion of the synthesis gas in a single pass at a superficial gas velocity of 0.3 ft/sec requires an expanded slurry height of 30 feet. The catalysts will yield up to 85 pounds per day of distillate and 25-65 pounds per day of wax. The BFTR will also be capable of operating with more active catalysts, converting up to 90% of the synthesis gas and producing up to 230 pounds per day of distillate. The BFTR has been designed for location at an Air Products gas processing plant at LaPorte, Texas in order to minimize synthesis gas and capital equipment costs.

The BFTR includes equipment for mixing batches of catalyst/molten wax slurry, withdrawing wax from the reactor with catalyst removal by an unproven filtration or gravity sedimentation system, sampling the slurry, condensing and separating the distillate liquids from product gases, and measuring all product flow rates. A packed distillation column, equivalent to four

theoretical stages, improves the split between wax and distillate. The synthesis gas metering train and certain other subsystems are currently available at the LaPorte site and are not included in the cost of the BFTR facility.

The estimated cost to construct the BFTR is $550,000 in 4th Quarter 1982 dollars, which includes $188,300 in equipment costs, $290,000 in labor costs and a 15% contingency of $71,700. This cost estimate should be accurate to within 20%. Operating cost is estimated at $914,000 annually for 200 days per year of operation.