NASA SBIR 2008 Phase I Solicitation

X7.02 Cryogenic Fluid Transfer and Handling

Lead Center: KSC

Participating Center(s): GRC, GSFC, JSC

Cryogenic fluid transfer and handling for spacecraft propulsion systems, launch facility ground processing, and Lunar surface systems are critical to the advancement of NASAâ€™s exploration goals. Technology development in cryogenic fluid transfer and handling directly supports the Lunar Lander, Ground Operations, Ares, and Lunar Surface Systems programs. Specifically, for Earth-based applications, propellant conditioning and cryogenic densification technologies are required. Propellant conditioning systems are needed to help control the state of the propellant that is loaded into the flight tank at the launch pad. Other technologies are primarily for active control of cryogenic propellants for densification or subcooling on the launch pad as well as liquefaction on the lunar surface.

Component technologies for cryogenic fluid transfer include regulators, valves, umbilicals, quick disconnects, pumps, distribution line insulation materials and techniques, and thermal standoffs for LH_2, LO_2, LCH_4 and cold GHe (~90K). Cryogenic components using advanced actuation technologies such as piezoelectric ceramics which demonstrates reduced heat flux into the cryogenic fluids as compared to conventional electromechanical actuators is highly desirable. Operating ranges for these components should include but are not limited to normal boiling point (NBP) LH_2 and NBP LO_2 components rated for 50 - 100 psia, NBP LO_2 and below NBP LCH_4 components rated for 100 - 400 psia, and cold GHe (~90K) components rated for 400 to 4,500 psia. The technical focus for these components are for reduced thermal mass, minimal heat leak, minimal leakage, and minimal power consumption. Analytical tools for the design and/or analysis of cryogenic fluid transfer components are also needed. These tools should focus on providing analytical capabilities, which directly correspond to cryogenic fluid component design or thermal analysis.

Advanced transfer systems capable of delivering high quality of liquid over a wide flow range between 100 GPM and 1000 GPM are sought. Liquid oxygen pumps that minimize fluid heating while allowing for a range of flowrates are also needed. Propellant subcooling or densification systems for LOX, LH_2 and LCH_4 are required, to provide for extended storage duration on orbit prior to boil off. These systems should be sized to accommodate the Altair propulsion system. Densification systems should offer reliability and efficiency benefits over past systems. Anti-stratification concepts to ensure homogeneous fluid conditions in the flight tank are needed, and better transfer line insulation to minimize heat leak are required. Connections and recirculation systems to maintain propellant state in the flight tank are also desired.

On the lunar surface, oxygen may be produced via an in situ resource utilization reactor. Efficient liquefaction of this oxygen will depend on integration of the liquefier with the gas production stream. Open cycle liquefaction systems must interface with the high-pressure electrolysis systems at the output of the reactor. Compact, low temperature radiators capable of rejecting 50-100W of heat at 140K to deep space are needed for passive cooling prior to the final liquefaction steps. High efficiency, low mass recuperative heat exchangers are needed for effective heat transfer between gas streams. Innovative heat rejection systems designed for the lunar thermal environment are needed. Heat pumps to increase the high temperature heat rejection point of the cycle can also be proposed.

Next, hydrogen cooling and/or liquefaction are required for lunar surface applications involving regenerative fuel cell systems. Efficient 20K cryocooler technology is needed. Reliquefaction systems should be capable of meeting hydrogen flowrates around 1 gram/second. Open cycle hydrogen cooling systems with low temperature isentropic expansion from 3000 psi to the desired storage pressure are needed. Heat switch technology to control energy flow during the lunar day/night cycle will also be considered.