

use at NASA for years, enabling aircraft to literally float unsupported for highly accurate GVT. These isolators must be placed underneath the aircraft for this to occur. Traditionally, this is achieved by a “critical lift” — a high-risk procedure in which a crane and flexible cord system are used to lift the aircraft. In contrast, the Starr Soft Support isolation system eliminates the need for critical lift by integrating the inflatable isolators into an

aircraft jacking system. The system maintains vertical and horizontal isolating capabilities. The aircraft can be rolled onto the system, jacked up, and then the isolators can be inflated and positioned without any personnel needing to work underneath the aircraft. Also, the system accommodates changes in aircraft configuration, automatically adapting to changes in mass, and it can adjust the height of the isolators in one basic setup.

Dryden personnel used the Starr Soft Support system to successfully perform a GVT on an F-15 being structurally modified by Gulfstream, Dryden’s Gulfstream III used for science research and the crew exploration module and adaptor cone assembly.

*This work was done by Starr Ginn of Dryden Flight Research Center. Further information is contained in a TSP (see page 1). DRC-009-042*

## Anti-Rotation Device Releasable by Insertion of a Tool

*Lyndon B. Johnson Space Center, Houston, Texas*

A drive mechanism enables a socket-type wrench to rotate a shaft and prevents accidental rotation of the shaft when the wrench is not coupled to the shaft. In the original intended application, the shaft would be part of an attachment mechanism on a spacecraft, and the purpose to be served by the drive is to prevent back-driving of the shaft by launch vibrations while enabling an astronaut equipped with the appropriate wrench to actuate the shaft while in orbit. The design could

also be adapted to terrestrial applications in which it is necessary to prevent rotational back-driving. The mechanism includes a gear near the tip of the shaft, and a drive nut that constitutes the tip of the shaft. The gear and drive nut are positioned in a recess in a housing. The recess is sized to receive the wrench socket that mates with the drive nut. Also contained in the housing are four linkages that include pins that are spring-loaded into engagement with the gear to prevent

rotation of the shaft. When the wrench socket is inserted in the recess, it pushes on the linkages in such a manner as to disengage the pins from the gear.

*This work was done by Harry K. Warden and Terro J. Jenkins of The Boeing Co. for Johnson Space Center. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809.*

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## A Magnetically Coupled Cryogenic Pump

**A proof of concept pump is successful.**

*John F. Kennedy Space Center, Florida*

Historically, cryogenic pumps used for propellant loading at Kennedy Space Center (KSC) and other NASA Centers have a bellows mechanical seal and oil bath ball bearings, both of which can be problematic and require high maintenance. Because of the extremely low temperatures, the mechanical seals are made of special materials and design, have wearing surfaces, are subject to improper installation, and commonly are a potential leak path. The ball bearings are non-precision bearings [ABEC-1 (Annular Bearing Engineering Council)] and are lubricated using LOX compatible oil. This oil is compatible with the propellant to prevent explosions, but does not have good lubricating properties. Due to the poor lubricity, it has been a goal of the KSC cryogenics community for the last 15 years to develop a magnetically coupled pump, which would eliminate these two potential issues. A number of projects have been attempted, but none of the pumps was a success.

An off-the-shelf magnetically coupled pump (typically used with corrosive fluids) was procured that has been used for hypergolic service at KSC. The KSC Cryogenics Test Lab (CTL) operated the pump in cryogenic LN<sub>2</sub> “as received” to determine a baseline for modifications required. The pump bushing, bearings, and thrust rings failed, and the pump would not flow liquid (this is a typical failure mode that was experienced in the previous attempts).

Using the knowledge gained over the years designing and building cryogenic pumps, the CTL determined alternative materials that would be suitable for use under the pump design conditions. The CTL procured alternative materials for the bearings (bronze, aluminum bronze, and glass filled PTFE) and machined new bearing bushings, sleeves, and thrust rings. The designed clearances among the bushings, sleeves, thrust rings, case, and case cover were altered once again using experience gained from previous cryogenic

pump rebuilds and designs. The alternative material parts were assembled into the pump, and the pump was successfully operated meeting all expected operating parameters.

Unique pump sub-assembly parts were designed and manufactured by the CTL using specialized materials determined to be superior for cryogenic thermal applications under the pump design conditions. This work is a proof-of-concept/proof-of-operation of the pump only. Other known internal design modifications to the pump should be accomplished for the long-term use of the pump. An upscaled version of this pump, which is under development and testing at the CTL, can be used either for current or future vehicle loading or for vehicle replenishment. Scaling of this pump can be easily accomplished.

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