

MARS EXPLORER ROVERS

Dicronite® provided vacuum stable lubrication for space exploration



BACKGROUND

Two twin robots – Spirit and Opportunity – were launched in 2004 as NASA's Mars Explorer Rovers (MER). These robots were equipped with a five degree-of-freedom, 1-meter-long robotic arm known as the Instrument Deployment Device (IDD). Instruments used for exploring the Martian surface are mounted to the IDD's end effector. To protect the IDD, a mechanism was needed to prevent damage during launch, travel, landing, and release of the IDD when required on the planetary surface.

DESIGN

The design consisted of two dual-use caging mechanisms that are very small in size. The protective devices relied upon pins engaging bushings, where the pin ends were radiused to mimic spherical bearings. The mechanisms were intended to serve as launch restraints as well as provide a way to re-stow features during the rover's excursions.

Initially, no lubrication was specified; a wet lubrication could hinder latch release due to its low viscosity at the -120°C operating temperature. However, upon assembly, the sliding friction of the pins through the bushings was assessed to be too high. Without the proper function and protection of the IDD, the mission's objective to successfully

collect samples on Mars was at risk. To combat this friction, a lubrication was deemed necessary. The lubricant would need to withstand extreme temperatures (-120°C to $+110^{\circ}\text{C}$ Survival / -120°C to $+45^{\circ}\text{C}$ operational) as well as provide the lubricity necessary to ensure proper function of the protective caging mechanisms.

RESULTS

Dicronite® dry lubrication met the required temperature ranges, with a functional temperature range of -188°C to $+538^{\circ}\text{C}$ and did not affect mechanical tolerances due to its 0.5-micron thickness. Dicronite®'s lubricating properties relieved contact stress in the radiused ball end of the pins, and became the selected lubrication for all sliding and rotating surfaces.

The IDDs along with the mounted instruments remained intact on both rovers throughout the journey and were able to successfully operate on the Martian surface. History was made as these two explorers were able to collect an abundance of data that characterized the modern climate of the Red Planet. Dicronite®'s successful lubrication on the Mars Rover Mission has also earned itself a seat on various other spacecraft.

