General Magnaplate Corp.

CASE STUDY

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Dry Lubricant Coating Plays A Hand In Man Reaching For Mars

By Corey Wesnitzer, General Magnaplate Corp.

Following the recent successful landings of the 'Opportunity' and 'Spirit' Rovers on Mars, NASA has become more open about its investigations into a potential manned lunar mission and a manned planetary expedition on MARS itself. In fact, NASA recently set up a new exploration office at its headquarters.

Scientists and researchers involved in the study, realizing that a hostile environment will confront long-distance space travelers, have noted the requirement of highly specialized technologies and systems, e.g., durable type suits for protection against events such as the severe dust storms experienced on MARS. In response to the growing likelihood of manned planetary expeditions, ILC Dover of Dover, Delaware, has developed a new generation of spacesuit called the 'I-Suit'.

Since project Apollo, ILC has been the designer and producer of the space suits for NASA (sub-contracted by Hamilton Sundstrand), and the Company has leveraged its expertise in material fabrication to manufacture most of the blimps we see floating above sporting events, and even the inflatable 'balloons' that were responsible for the safe landing of both Mars Rovers. A total of 400 humans have been sent to explore space in ILC Dover suits since the mid-1960s and the next manned mission (slated for April 2005) is Expedition-9, a trip to the International Space Station.

Space suits are largely modular in design and manufacturing them is a two-part process. ILC Dover is responsible for developing and manufacturing the arms, gloves, legs, torso, waist etc and the liquid cooling ventilation garment (LCVG) that removes most of the body heat from the suit. The suits are then sent to Johnson Space Center so that the life-support system can be added to enable astronauts to undertake extravehicular activities, such as mending broken parts on satellites and space station assembly. Different suits are developed for intravehicular and extravehicular activities because they are required to perform under very different scenarios.

The total cost of one extravehicular activity (EVA) suit can be in the region of $10M; so ensuring the right design and maximum operational life are critical issues for NASA. In anticipation of these manned missions to the moon and possibly Mars, ILC Dover has spent the last few years developing its new I-Suit, which continues to be evaluated by current and former astronauts for independent feedback.

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According to David Graziosi, Engineering Manager for the Shuttle Spacesuit Assembly at ILC Dover, spacesuit comfort is important for astronauts because extravehicular activity may take as long as 8 hours, but the most important aspect of the EVA suit is its ability to enable astronauts to undertake the difficult tasks that are required in space walks.

"Each EVA suit needs to be able to withstand pressures of 4.3 PSI and temperatures anywhere from -250°F to 250°F, " reports Graziosi. "The suit is designed to permit low torque body movements for operating spacecraft controls and devices required for space exploration or traversing the lunar surface."

"In zero gravity conditions, the differential pressures impose stress or tension on the suit and the 'soft' material becomes very rigid and difficult to bend in, except in those areas where specially designed joints are provided to accommodate normal body flexure. Without these specially developed joints for the space suit, it would be virtually impossible for the astronaut to carry out critical extravehicular work."

One area of particular concern regarding EVA is the glove. Its quite possible that an astronaut will have to handle an object as big as a large SUV and despite the absence of weight in space, once a large object gathers momentum it is very difficult to stop. Therefore, the glove not only needs to be able to deal with the harsh environment of outer space, it needs to be able to withstand some challenging structural forces.

Graziosi continues, "The gloves need to provide the astronaut with dexterity and they have to enable the astronaut to grab a mass as large as 4000 lbs. The gloves are manufactured from an intricate system of fabric, webbing and hardware rings that provide this combination of strength and flexibility."

Given their importance to the functionality of the glove, gimbal rings have been an area of focus for ILC Dover over the past few years. The most recent version of the EVA glove, the Phase VI glove, utilizes stainless steel gimbals that are coated with a dry lubricant to ensure maximum wrist flexing. This lubricant, however, was only a temporary solution because it only lasted for a short period of time and had to be re-applied.

"This short cycle was an issue for NASA because they wanted the longest possible cycles and in an ideal world did not want to have to ever maintain the gimbal rings during the lifespan of the glove. Each glove is designed for over 200 hours of man-

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pressurized use and the lubricant had to be reapplied for every 40 hours of use. This meant the gimbal being removed from the glove, because the astronaut does not want to risk poking a hole in the glove with a syringe, and then applying the coating. In space, this was a tremendous hassle."

Graziosi's design team had encountered a similar problem with shoulder brackets and the solution in this case was sending the parts to General Magnaplate, New Jersey for coating. General Magnaplate provides a range of surface enhancement coatings, many of which were used in NASA's space program. In fact, every NASA vehicle sent into space has used parts coated by General Magnaplate, including the recent Mars Rovers.

"Magnaplate has a strong track record in space so we approached them about coating the glove ring gimbals," reports Graziosi. "The solution was to coat the parts with Nedox-SF2, a coating which not only provided the required permanent lubricity but also gave us confidence that it would last without being affected by the harsh conditions."

Magnaplate's Nedox® coatings are created by the controlled infusion of various polymers within a proprietary nickel alloy plating. Subsequent controlled treatment cycles assure thorough infusion of the surface with polymer material and concurrently increase the hardness of the matrix. Suitable for use on most metals, Nedox® creates a harder-than-steel surface and provides permanent lubricity, a very low coefficient of friction, and protects against wear, corrosion and chemical attack.

Edmund Aversenti, COO of General Magnaplate Corporation, claims that Nedox (NASA material # 20386) provides a better wear resistance than hard chrome plate.

Nedox Friction Chart

Material Vs	Material	COF Static	KOF Kinetic
Steel	Aluminum	0.47	0.38
Steel	NEDOX SF-2	0.3	0.26
NEDOX SF-2	NEDOX SF-2	0.18	0.12
Teflon SF-2	NEDOX	0.1	0.09

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Says Aversenti, "Nedox provides a hardness of up to Rc68 and it is superior in corrosion resistance to chromium or standard electrolytic coatings. In fact, the coating has actually been used to coat outside parts of the International Space Station. A 0.001" coating of Nedox shows little or no corrosion after 14 months of continuous exposure to atmosphere and salt water, and no effect after 90 days immersion in pH3.0 -9.5 solutions."

Before the gloves even make it to space they are tested for 100s of hours in training for one eight-hour space walk. Graziosi continues, "Much of the training is conducted in a pool full of chlorinated water and the salt build-up on the metals parts is considerable. After physical testing, the gimbal rings were examined and test showed that they were not only clean, but also required no maintenance at all. In addition, the low coefficient of friction provided by Nedox meant low torque and gave the astronauts added flexibility."

"The new glove design means that astronauts do not have to lubricate their own glove joints and we have adopted the Nedox coatings in other metal areas of the suit. Since the development of the new I-Suit we have upgraded the suit brackets from stainless steel to titanium, but this was not an issue for General Magnaplate. They gave us the option of coating the new titanium rings in either Nedox or Magnagold - an enhanced PVD titanium nitride coating for high strength alloys."

ILC Dover is now eagerly awaiting the results of its independent testing of the I-Suits. Meanwhile, David Graziosi and his team hope that we will all get to see an iteration of the new I-Suit design being used on Mars in our lifetime.