General Magnaplate Corp.

WHITE PAPER

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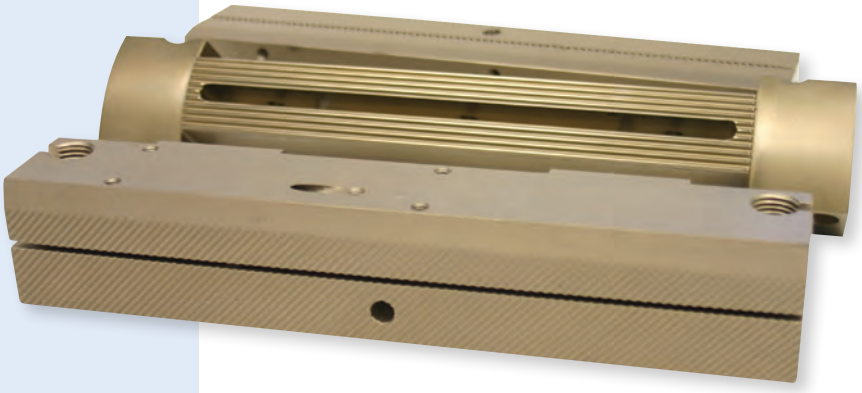
New Breed of Release Coatings Withstand Extreme Temperatures, Increase Production Rates

By Corey Wesnitzer, General Magnaplate Corporation

Faster throughput with reduced downtime is the mantra of today's manufacturing environment. With the escalating need for speed, unprecedented demands are being placed on equipment and machine parts. Across a wide range of industries — from packaging and food processing to aerospace and rubber molding — specialized coatings are playing an important role in protecting machine components and increasing uptime.

However, despite several decades of advances in materials science and coating formulations, engineers are still searching for release coatings able to withstand temperatures above 500° F and finding that traditional polymer coatings are not up to the task. To meet the demands of high-temperature conditions, a new family of coatings from General Magnaplate Corporation has just been introduced. The Magnaplate 10K™ Series is now available for use in applications reaching temperatures as high as 1,000° F.



Seal jaws treated with Magnaplate 10K Series coatings enable quick release at temperatures up to 1,000° F.

Synergistic coatings 101

Before exploring the unique properties of the 10K Series, a few words about surface-enhancement coatings may prove helpful. The basic idea behind engineered coatings is to enhance the surfaces of metals and other substrates, imparting performance attributes such as corrosion resistance, hardness, and dry lubrication. Initially used in space applications, synergistic coatings from General Magnaplate now transform plentiful and inexpensive, common metal parts into chemical-resistant, super-hard, dry-lubricated products that last longer, perform better, and are more cost effective than components made of expensive and rare metals.

Coatings are applied to substrates in a multi-step system that begins with specialized cleaning processes. Next, the substrate's surface is enhanced by applying a base coating using conversion, deposition, thermal spray, or a mix of these techniques, depending on the specific coating

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formulation. The process then continues with a controlled infusion of various engineered polymers or other dry-lubricating particles or metals. For example, on some metals, a hard layer of nickel alloy is deposited on the surface. The micro pores are enlarged, and polymer particles are then infused into the surface layer.

A second-stage treatment ensures thorough integration into the top layer.

The major advantage of Magnaplate coatings versus other types, is that the particles in the Magnaplate coatings become an integral part of the substrate. Particles are mechanically bonded and the resulting new surface layer cannot chip, flake, peel, or rub off. Because these coatings create metal surfaces that offer superior performance to both the original base metal and the coatings themselves, these surface enhancements are said to be synergistic. Further, because the engineered surfaces either duplicate or surpass the performance characteristics traditionally provided by metals such as chromium, cobalt, cadmium, manganese and other materials, use of these expensive, scarce, or environmentally hazardous materials can be reduced.

When selecting an engineered surface treatment, it is important to consult with the coating provider early in the design process so that the most appropriate formula may be matched to the intended application. Several families of Magnaplate coating systems are available, each developed to protect a certain metal or group of metals or to solve a specific problem.

For example, the widely used Nedox® family is a nickel-alloy-based coating that protects most metals, including aluminum, against wear, corrosion, sticking, and galling. Within the Nedox family are many varieties that employ various polymers, dry lubricants and other materials to achieve different properties, such as enhanced hardness, superior mold release, or excellent release at high temperatures. Similarly, the Tufram® family of coatings for aluminum and aluminum alloys also features a range of specialized formulations depending on the intended use. The ability to customize product families by adding specialized polymers holds true across all Magnaplate coating families.

10K Coatings at a Glance

- Withstand temperatures to 1,000° F
- Low surface energy, highly water-repellant
- Provide anti-stick, easy-clean surfaces
- No fluoropolymers, no PFOAs
- Will not degrade at high temperatures
- FDA compliant to Title 21 CFR175.300
- Protects Nedox-treated substrate from oxidation at high temperatures

From left, 10K1 coated disc, 10K3 coated disc, electroless nickel-plated disc. Samples treated with 10K1 and 10K3 coatings resist oxidation at temperatures of 1,000° F, while the electroless nickel-plated sample exhibits oxidation and discoloration.

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Magnaplate 10K™ Series of high-temperature coatings

Prior to the introduction of the 10K Series, coatings from major manufacturers featured mold release temperatures to roughly 450° F. However, end users from across a range of industries were consistently requesting release coatings that could handle temperatures up to 1,000° F. The 10K Series was developed in response to these needs and offers three formulations:

10K1 — Solvent-based formula, withstands temperatures to 1,000° F

10K2 — Water-based formula (no VOCs), withstands temperatures to 1,000° F

10K3 — Solvent-based formula, withstands temperatures to 850° F, best release

Each coating formulation features low surface energy and is therefore highly water-repellant, or hydrophobic. 10K coatings also feature a low coefficient of friction (COF), retain their properties at high temperatures, provide easy mold and die release at high temperatures, and are FDA compliant to Title 21 CFR175.300. The 10K family may be applied on its own as a high-temperature coating, or used in conjunction with any of General Magnaplate's coating families, such as Nedox, Tufram, Plasmadize®, and many others.

Typical applications for 10K coatings are found across a variety of industries including packaging, food processing, aerospace, power generation, plastics, and rubber molding, essentially anywhere a quick-release coating is required in a high-temperature environment.

Typical Applications for 10K High-Temperature Coatings

Food processing: Griddles, grills, oven components

Packaging: Seal jaws, platens, dies

Aerospace: Composite tooling, autoclaves

Power generation: Turbines, fans

Plastics: Heat-staking tools, blades, extrusions

Rubber molding: Mandrels, molds, runners

Molds and dies: Quick-release of molded products

Composites: Permanent surface treatment for tooling faces; eliminates use of spray-release products

Selection as easy as one, two, three

With regard to the three coating formulations, 10K1 is the base formula, featuring the best temperature resistance of the 10K family in a solvent-based formula. However, for applications that must meet stringent environmental standards, 10K2 offers a water-based formula with no volatile organic compounds (VOCs). The 10K2 formula also features low surface energy, low COF, and high water repellency, although these values are not quite to the same levels as the solvent-based 10K1 and 10K3 formulas.

For applications requiring the lowest COF values and highest release qualities, the 10K3 formula is the most suitable choice, although temperature resistance is limited to 850° F versus 1,000° F for both the 10K1 and 10K2. In a nutshell, the end use will dictate which formula is most suitable.

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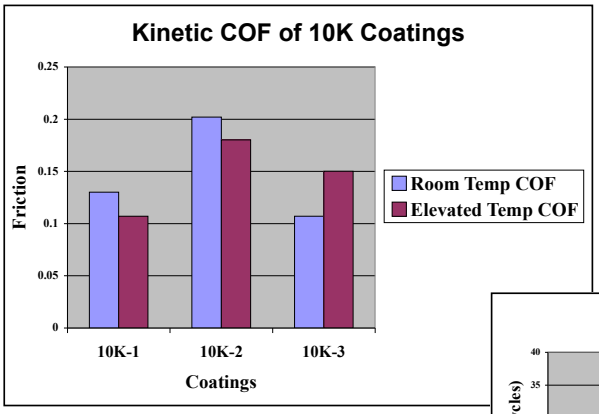

Figure 1

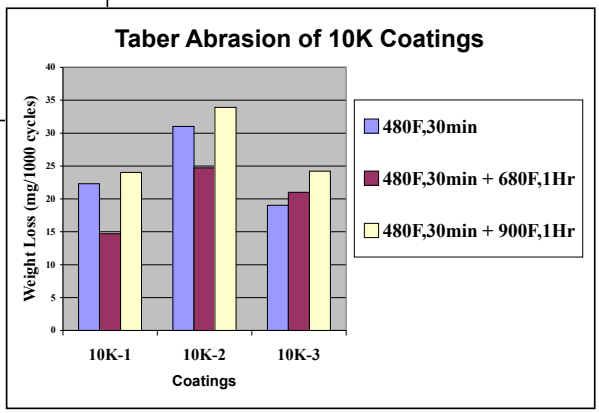

Figure 2

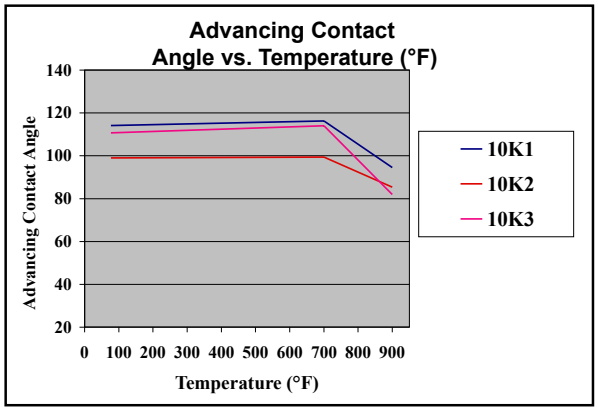

Figure 3

Testing details and data

Part of developing a new coating family involves rigorous testing according to international standards. For the 10K Series of high-temperature coatings, tests were conducted to collect data regarding coefficient of friction values, abrasion resistance, and contact angle measurements.

With regard to COF values, testing was performed in accordance with ASTM D1894 to determine both kinetic and static coefficient of friction values for the 10K family. Results determined that each member of the 10K Series features excellent coefficient of friction values, well beyond the capabilities of standard polymer coatings. The 10K3 sample achieved the lowest COF values for both static and kinetic friction, therefore providing the best release/non-stick qualities of the 10K family *(see Figure 1).* For example, the Nedox 10K3 sample achieved a static COF value of 0.113 compared to 0.242 for the water-based Nedox 10K2 sample, evaluated at room temperature.

To determine abrasion resistance, 10K coatings were tested using Taber Abrasion with a CS10 wheel using a 1,000 g load, in accordance with ASTM D4060. Weight loss was recorded after 1,000, 5,000, and 10,000 cycles. Samples run after being subjected to 680° F for one hour demonstrated excellent weight loss characteristics. Slight increases in weight loss totals were evident on the 900° F samples. Solvent-based samples

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(10K1 and 10K3) held up better than the water-based 10K2 sample, though all of the 10K samples featured excellent abrasion resistance through a wide range of operating temperatures *(see Figure 2, page 4).*

Contact angle measurements were used to determine the amount of surface energy present on each 10K sample. The greater the angle, the lower the surface energy — which corresponds to greater release and therefore easier cleaning of coated surfaces. All three 10K coatings offer excellent contact angle measurements over a wide temperature range, compared to standard polymer coatings that decompose at elevated temperatures. For example, the Nedox 10K1 sample achieved a contact angle of 116.18°, versus 113.99° for the Nedox 10K3 sample and 99.35° for the Nedox 10K2 sample *(see Figure 3, page 4).* Results indicate that at very high temperatures, the 10K polymeric coatings retain water-repellant properties and also prevent the Nedox base coat from getting oxidized.

For best results, it is vitally important to discuss application requirements with your coating provider early in the design stage. Experts in material science and coating formulations will then be able to recommend the best combination of base formulas, polymer additives, topcoats, and coating processes to meet specific requirements.

To contact technical representatives at General Magnaplate Corporation, call (800) 852-3301, e-mail info@magnaplate.com, or visit www.magnaplate.com.