# A One-Step Process for Metal Pretreatment

*Organic phosphating positioned as environmentally sound, user-friendly and inexpensive alternative to current systems.*

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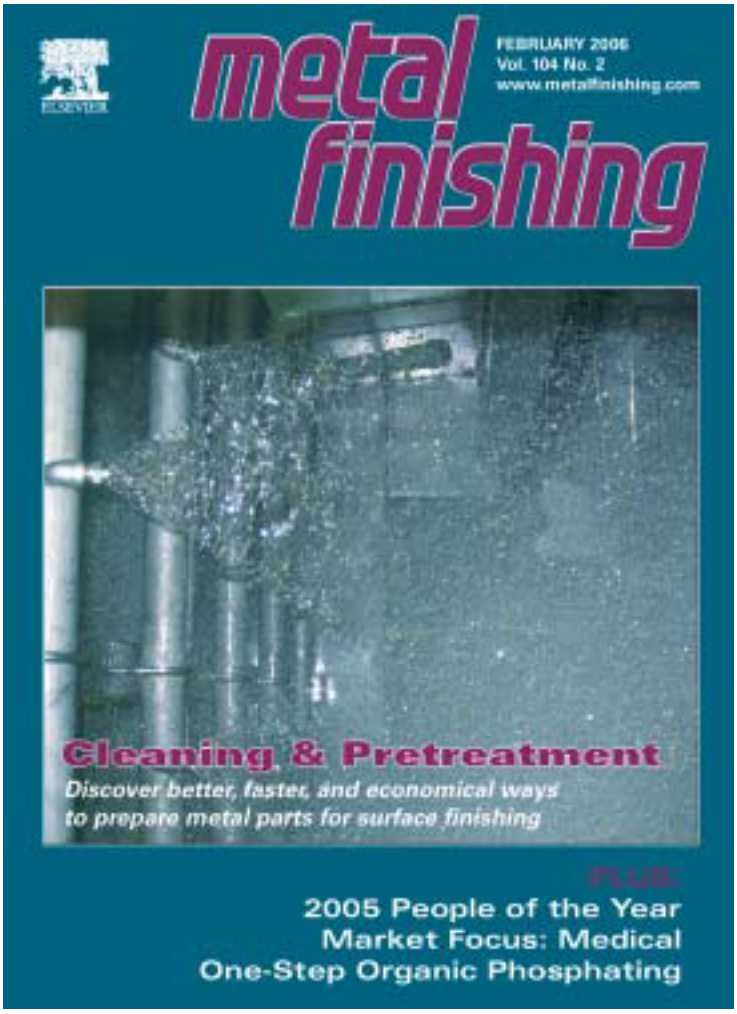
How does a company introduce and sell a completely ìdifferentî kind of process or product?

In the metal pretreatment field, ìeverybody knowsî that heat, water, high-pressure impingement, and at least two and generally five or more treatment stages (more for application of a sealant), are needed to get parts clean and ready for painting. So how does a company successfully counter that it has an equally effective, simpler, smaller, and less expensive process?

When ìeverybody knowsî that sludge, oil dumping, and waste water treatment are necessary evils of pretreatment, how does the company convince prospective customers that an environmentally sound process that does not create any of these problems is now available? Those were just some of the questions faced by Carpenter Chemicals, the NAFTA distributor of the One-Step Organic Phosphating line of metal pretreatment products, when it introduced the process in 2000. The short answer has been, ìkeep at it.î The longer answer follows.




The One-Step Organic Phosphating technology has been in use in Europe for more than 25 years, and boasts between 400 and 500 users. Quite a few of these users can trace their relationship with the product back to the introduction of the product line in the 1980s. The popularity of the product continues to grow in Europe, and has established itself in the North American market. Users can be found from Quebec to Texas, and from Puerto Rico to the Upper Midwest. Despite stringent regulations, San Diego County, Calif. has just weighed in with its approval of this unique pretreatment process.

The manufacturer, PaiKor srl of Milan, Italy, is ISO-9001/2000 certified and a member of the United Nations Environment Programme (UNEP), an organization whose members manufacture environmentally sound products.

Interest in the process has taken another significant upturn in the past year or so, for two main reasons: a growing number of customers who can and do attest to the process; and the cost savings realized from a truly ambient-temperature process that eliminates the ever-rising expense of natural gas.

## AN INNOVATIVE TECHNOLOGY

How does the One-Step Organic Phosphating process work, and how does it differ from conventional pretreatment? Its chemistry is uniqueñvery different from conventional systems. To fully appreciate the process, it should be analyzed from a completely fresh perspective. ìForget everything you know about phosphatingî is a good way to start.

## CONVENTIONAL PRETREATMENT

Conventional pretreatment is a multi-stage process.

**An in-line flowcoat installation in operation, making casings for test bombs. The one-step phosphating system has Mil. Spec. approval.**

Even those that claim to be single-stage must be rinsed once or twice for good performance, so they are, in reality, a two- or three-stage process in terms of the number of tanks needed and their space and water requirements. Using water, with various chemicals added at different stages, conventional pretreatment accomplishes only one task at each stage. A typical five-stage pretreatment consists of a hot alkaline cleaning stage, a rinse, an iron phosphating stage, another rinse, a seal rinse, and then an optional de-ionized water rinse.

In order to work properly in the heated stage(s), the water must be heated, generally to 140∞F or greater Water-based chemistry basically needs heat to work effectively.

The heating bills for these operations are now very significant, and many companies using conventional heated pretreatment systems have not really weighed the ongoing expense of heating their water tanks and keeping them at temperature. A typical burner may be rated at 1,500,000 BTU and operating at 75% efficiency (a conservative assumption).

Assuming it operates one eight-hour shift per day and that natural gas prices are $1.20 per therm, that burner is costing about $35,000 per year in natural gas costs alone. A 2,500,000-BTU burner will cost about $58,000 per year under those same conditions, and if it operates two shifts the costs will top $115,000. An evaporator, if there is one, will only add to those costs. Water clarifiers and evaporators also add to the fuel costs.

The fossil fuels burned also generate NOx and large amounts of carbon dioxide.

Conventional pretreatment systems use large quantities of water, which must generally be treated or neutralized. In addition, waste oils must be skimmed, contained, and treated or burned as hazardous waste, and sludge is created and must be treated and deposited in landfills. Finally, unless a sealant has been applied (which necessitates more tanks), parts that have been treated using conventional pretreatment systems must be painted immediately or be subject to flash rust.

## ONE-STEP ORGANIC PHOSPHATING

The One-Step process, on the other hand, accomplishes the cleaning, etching, phospating, and sealing in a single bath in just one minute of treatment time. The One-Step process uses no water and is not rinsed. It never requires heating and operates at ambient temperatures ranging from 60∞F up to typical plant conditions found during the summer months in the southern part of the U.S.

The process creates no waste, either liquid or solid. Since no water is used in the treatment and parts are not rinsed, by definition nothing is sent into the water stream. No sludge is created, so nothing goes to a landfill except the filtered fines that came in on the parts. In a particularly ingenious twist, the oil is chemically captured and used in the process as a plasticizer in the seal, and, therefore, never needs to be dumped.

Because of the polymer seal that is created, parts that have been treated can sit on a shelf for weeks before painting without the fear of flash rusting. The process can treat virtually all metals, and can treat multiple metals in the same bath at the same time.

How does this all work? At first it may sound somewhat hard to believe, but installations are operating throughout North America that attest to its efficacy.

## ELEMENTS OF THE PROCESS

First, the solvents are carefully chosen to accomplish several things.

- Their solubility parameters and hydrogen bonding values are designed to be compatible with most of the oils normally found on the metals to be treated, permitting the solvents to remove the oils from the metal surface and take these oils into solution in the bath.
- The solvents are also effective at washing the fines (dust, dirt, metal fines) off the parts with a minimal agitation (in a spray plant, for instance, pressure is three to five psi rather than the 15 to 20 psi required in a conventional plant).
- Finally, the solvents are designed to be environmentally friendly. They contain no hazardous air pollutants, ozone-depleting elements, halogenated compounds, carcinogenic or mutagenic compounds, or other ingredients that require special regulatory reporting. The solvents biodegrade to $CO_2$ and water only (and the $CO_2$ emitted is less than 1/10th the amount created by burners used to heat conventional water tanks). And they are very low-evaporating, so they meet VOC regulatory emission requirements. For example, Ecophor B700 has a vapor pressure well

below one mm of mercury, and a high boiling point, so a spray plant using and treating 50,000 square feet per year would emit only 170 pounds of VOCs in that year. A similar plant using Ecophor A447 would emit only 1,200 pounds per year.

Second, the phosphating: The mixture contains a small amount of phosphoric acid, which is consumed in the process, to etch the metal surface and create a phosphate out of the substrate metal. When applied to steel, this creates an iron phosphate, and on galvanized products it produces zinc phosphate. Since there is no water, no phosphate materials are released to the waste stream.

Third, the seal:

- The bath contains a small amount of a polymer that also serves several functions. Most importantly, this polymer is designed to absorb up to four times its weight in oils. The oils that are dissolved in the bath from the parts are transferred to the polymer, and the bath never accumulates oils. The upper limit for this system is approximately four times the amount of oils found on cold rolled steel (three to four gm/100 square feet), so the process is effective for most any application except where very oily parts, such as tubing with heavy amounts of oil inside, are involved.
- In addition to absorbing and using what would otherwise be waste oils, the polymer makes a very thin (one micron) continuous seal on top of the inorganic phosphate. This seal blocks out water vapor and air. As a result, the pretreated parts do not flash rust for weeks if kept indoors (in fact, one prospect called to report that it had seen no flash rust on pretreated, but unpainted parts, that it had kept in storage for three years).

Fourth, the combination of these elements:

- Due to both the unique chemistry and the physical bonds created in the process, adhesion is excellent. Since the phosphate is created out of the substrate metal rather than being washed onto it, there is a chemical and physical bond between the metal and the phosphate.

  The polymer is a polyphosphate, so it makes a chemical as well as a physical bond to the underlying inorganic phosphate. Finally, the polymer forms a chemical and physical bond with the polymeric topcoats.
- Another reason for the excellent adhesion can be found in the oils discussed earlier. When the oils are incorporated into the polymer, they are used in the same way as a plasticizer is used in PVC to lend flexibility to the polymer.

  This allows the treated metal to be bent without cracking the polymer, and strongly resists chipping. The One-Step Organic Phosphating process works very well on highly polished surfaces and on stainless steel, as Rockwell Automation found, because the seal provides the adhesion surface for the topcoat.
- Salt spray results on steel are at least equal to conventional pretreatment. On galvanized or galvanile, the process creates a zinc phosphate, and in addition, it does not wash off the galvanic coating. Results are excellent on aluminum as well. Because of the bath stability, the One-Step process yields consistently good results.
- The bath is very stable compared to a conventional bath, and is never changed out, only supplemented as the chemicals are used in the process. The stability is due to the fact that the components of the bath are used up in proportion. The solvents evaporate off in the drying oven in very small quantities and leave the one-micron seal in place. The phosphoric acid is used in the etching and creation of the inorganic phosphate.

  The oils from the metal surface are absorbed and incorporated chemically into the seal. And the fines that come in on the parts are filtered out and removed.
- The result is that there are no daily bath checks required. The customer sends in a sample every two months, which is analyzed at no charge, and the customer is sent a report on the bath status with any recommendations regarding, for example, filtration or the need to balance the bath with makeup chemicals, such as a little extra solvent.

**An in-line flowcoat tunnel used to pretreat lighting fixtures for the hospitality industry. The tunnel is 41 feet long, with a line speed of four feet per minute. Polyethylene curtains at the entry and between zones control air flow.**

## COSTS OF THE PROCESS

The process is cost effective for most operations. The basic limitation occurs where production levels are so high that the cost of the chemicals outweighs the many cost savings in capital and operational costs. That upper number has been raised very rapidly over the

**A small, self-contained dip unit for treating motor armatures. On the left is the dip tank in which parts are treated and dripped off. Then the parts are blown off (middle section) and staged for powder coating.**

past several years, chiefly because of the inordinate rise in the price of natural gas used to heat water tanks in the conventional pretreatment systems. Natural gas prices are now seven times what they were six years ago, and they continue to rise. At this time, the breakeven point between conventional and One-Step pretreatment is in the vicinity of 60,000 square feet of metal treated per day, although it could be higher depending on the efficiency of the conventional system to which the One-Step process is compared.

One interesting example of the results of the cost savings is Sentry Safe in Rochester, N.Y. When the company performed its analysis prior to installing the One-Step system, it found that the savings in energy, waste management, regulatory compliance, operating, and maintenance costs, in addition to the small footprint of the installation and lower costs of overall installation and operation, were so significant that it was able (along with other factors) to justify bringing production back to Rochester from China.

The supplier has developed an Excel spreadsheet for comparing the costs of conventional and the One-Step process.

## NEW APPLICATIONS FOR ONE-STEP ORGANIC PHOSPHATING

Some of the newer applications for which the One-Step process is now in use include:

- A manufacturer of lighting for the hospitality industry, for whom adhesion has improved tremendously as a result of using the One-Step process;
- a New England manufacturer of wind chimes. Their business has grown over the years from out-sourcing their pretreatment and coating to the point where it has brought the entire manufacturing process in-house. The One-Step process provided an easy and economical way for the firm to achieve this;
- a manufacturer of electric motor armatures, comprised of many layers of sheet steel disks mounted on a stainless steel shaft. Their challenge was to remove the oil from the small gaps between steel plies so that the armature could subsequently be painted. The excellent wetting and absorption properties of the One-Step process cleaned out these narrow gaps, removed the oil, and provided excellent topcoat adhesion;
- a military ordnance manufacturer. There are now two military applications, each with a military specification approval under TT-C-490;
- Senty Group, a well-known producer of fireproof safes that brought production back from China partly based on the cost savings of the the One-Step process process;
- a manufacturer of rolling carts for compressed gas cylinders;
- an aluminum shutter manufacturer;
- and several job shops.

## CONCLUSION

The One-Step Organic Phosphating supplier expects 2006 to be a very good year. New installations were put in at a record rate in 2005, and prospects are becoming customers because of existing users that speak well of the product and their experience with it. Advertising, mailings, and attendance at trade shows over a the last few years have educated an increasing number of metal finishers about the products and the process.

In addition, the capital and operating costs of conventional systems have continued to increaseñespecially natural gas, but also water and water treatment, other environmental compliance costs, electrical energy, and labor and maintenance.

ìKeep at itî is a very workable philosophy after all.

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