In Search of Closed Processes In the Swedish Surface Finishing Industry

By Osten Ekengren, Staffan Filipsson, Jonas Tolf and Lars Clarin

New guidelines for the Swedish metal finishing industry have been implemented to encourage finishers to develop closed processes within the next 10 years.

In laboratory and pilot experiments with separators and membrane filtration, researchers have extended the life of pretreatment solutions by more than five times.

The following excerpts from a presentation at AESF Week 1993 show that surface finishers in Sweden are searching for effective methods to reach "zero discharge" while continuing to produce high quality products

Effluent Limitations to Municipal Purification Plants

Parameter mg/L	Sweden	Denmark	Finland	Norway*	PARCOM**
Al	2			10	
Fe	2			5	
Zn	2	3-5	2	3	0.5
Pb	1	2-3	0.5	0.5	0.5
Cu	1	2-3	0.5	1	0.5
Tot-Cr	1	2-3	0.5	1	0.5
$Cr6^+$	0.1			0.05	0.1
Ni	1	2-3	0.5	5	0.5
Ag	1	1-2	0.1	0.1	0.1
Sn	1	2-5	2	5	2.0
Cd	0.1	0.5-2	0.01	0.1	
Free-CN	0.1				0.2
Tot-CN	1	0.2-0.5	0.5	0.5	
Suspended Solids	10				

*Guiding values 1974; new values under preparation
**Paris Convention for the Prevention of Marine Pollution (PARCOM)

Environmental interests in Sweden have been focused on the metal finishing industry mainly because of the discharge of metals and cyanides. The problem has often been solved by "end-of-pipe" treatment. Chemical precipitation has significantly reduced the discharge of metals to the aqueous phase, but the cost of this treatment is accelerating. Chemical precipitation also produces sludge that must be disposed by landfill or by some chemical treatment method-possibly with concomitant recovery of metals.

These processes have environmental, technical and economical problems associated with them, and it is becoming more difficult to meet lower and lower guidelines—for example, those established by the Paris Convention for the Prevention of Marine Pollution (PARCOM, refer to Table).

Most industries try to avoid producing waste effluents and hydroxide sludge. The only practical way of doing this is to recycle both the rinsewater and the chemicals in each sub-process, which can be done by a "kidney" procedure. This is not feasible, however, as long as there is little or no knowledge of the impurities and how they inhibit the process.

Another approach is the substitution of harmless chemicals for toxic process chemicals.

Guiding Values in Sweden

Sweden is cooperating in international agreements to reduce the discharge of metals to the sea by 50 percent between 1985 and 1995. This will create more environmental restrictions for the surface finishing industry. (The current guidelines or effluents discharged to municipal treatment plants are presented in the Table.)

Swedish EPA Guidlines

Solvents -In 1991 the Swedish Government suggested a plan to reduce the use of chlorinated degreaser. According to the plan, trichloroethylene and methylene chloride could not be marketed or sold after January 1, 1993; and cannot be commercially used after January 1,1996.

1,1,1 -trichloroethane cannot be used, imported or produced after January 1, 1995. The commercial use of carbon tetrachloride was eliminated on January 1, 1993.

The use of other solvents will be reduced primarily through substitution with solvent-free or low solvent products, or through purification.

Dust—The discharge of dust will be reduced by the use of textile suppression filters. The guiding value is about 5-10 mg/m^3.

Metals in effluents-For some metals, the guiding value is a reduction to what is practical and theoretically possible to reach with conventional precipitation. The

remaining measurements are: Alternative precipitation chemicals, additional treatment, or more closed processes. The goal is to reach closed processes in 10 years.

Metal sludge-The aim is to avoid producing metal sludge through use of closed processes. It is still relatively inexpensive to place metal sludge in landfills in Sweden.

Organic substances—There has been an increased interest in the toxic, stable and/or bioaccumulable organic substances from the surface finishing industry. The Swedish EPA is studying the presence of these substances in effluents from surface finishing.

Recirculation Treatment Of Decreasing Baths

Degreasing is an unwanted but necessary treatment used to remove organic and inorganic matter from metal surfaces before additional surface treatment can be done. A common and efficient method is decreasing by chlorinated solvents. The use of such solvents has been criticized because of their negative impact on the environment.

The industry is changing its decreasing processes to meet new environmental requirements. The most common substitutes for chlorinated solvents are water based decreasing processes—mainly alkaline decreasing.

Changing the decreasing process from solvents to water results in moving the environmental problems from air to water. The surface finishing industry has a lengthy experience with the treatment of aqueous effluents containing metals, *i.e.,* by chemical precipitation. Treating the solutions from spent decreasing baths in chemical precipitation units, however, has resulted in a liquor problem. Even though small amounts of spent bath are mixed with the main effluent streams, disturbances in metal precipitation can be noted because of the content of completing agents in the decreasing baths.

The effect on metal precipitation when adding spent decreasing bath liquor has been evaluated at the Swedish Environmental Research Institute (IVL) laboratories. The tests showed an increasing metal concentration in the treated water after a relatively small addition of decreasing bath liquor.

Apart from decreasing chemicals, impurities (such as oil, grease, metals and additives used in previous steps), continuously accumulate in the decreasing bath during operation. Because it is not practical to mix metal-containing wastewaters with decreasing bath liquors and environmental impurities, the use of separate treatment techniques for spent decreasing bath liquor is necessary.

Techniques for separate treatment are, for example, membrane filtration and evaporation, or combinations of both. Ultrafiltration (UF) has been used for treatment of spent cutting oils for years. UF membranes retain oil and particles, but do not retain free metal ions and a large amount of the cleaning compounds, such as the completing agents that cause disturbances in the metal precipitation. The treated water (permeate) from the ultrafiltration can be polished by reverse osmosis filtration (RO) to improve the treatment.

RO Filtration

RO filtration was originally developed to desalinate drinking water and has been useful for treating industrial wastewater. It produces permeate of high quality that can be used as a rinsewater. Tests show that the treatability of UF-permeate by RO-filtration varies and the technique should be tested for each application.

Evaporation is being used as a final treatment of spent decreasing bath liquors. Evaporators can be constructed to be insensitive to the water being treated. When solutions containing Surfactants are evaporated, problems with foaming arise. Anti-foaming agents have to be added to avoid problems. A drawback to evaporation is that compounds more volatile than water will be transported to the condensation unit initially, and mixed with the treated water. A final polish of the condensate is often necessary to achieve a good result. Tests with RO-filtration of evaporation condensate have shown both good treatability and separation qualities.

Even though good results can be athieved with the right technology for effluent treatment, end-of-pipe solutions are only of interest at the end of a degreasing bath's lifetime. A prolonged life for the solution is very important to limit the volumes that have to be finally treated. A long-lasting solution is economical and better for the environment.

The lifetime of a solution can often be prolonged by recycling it through a separator to remove impurities. When recycling a bath, it is important to determine the level of impurities that can be accepted without risking the production quality. In general, batch-treatment is preferred for small baths, while larger baths are normally recycled continuously.

When emulsified oil is a limiting factor for the lifetime of a solution, membrane filtration has proven to be a possible recycling technique. Membrane filtration can be carried out in batch treatments or in continuous processes.

Research Will Continue

Guidelines for the Swedish metal finishing industry have established a goal of producing closed processes within the next 10 years. Laboratory and pilot experiments with separators and membrane filtration have proven that the life of pretreatment baths can be extended by more than five times.

Continuing experiments are underway to try to find ways of effectively treating plating solutions so that the chemicals and metals can be reused for long durations without sacrificing quality. The occupational health effects of recycling process chemicals and rinsewater are also being examined.

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