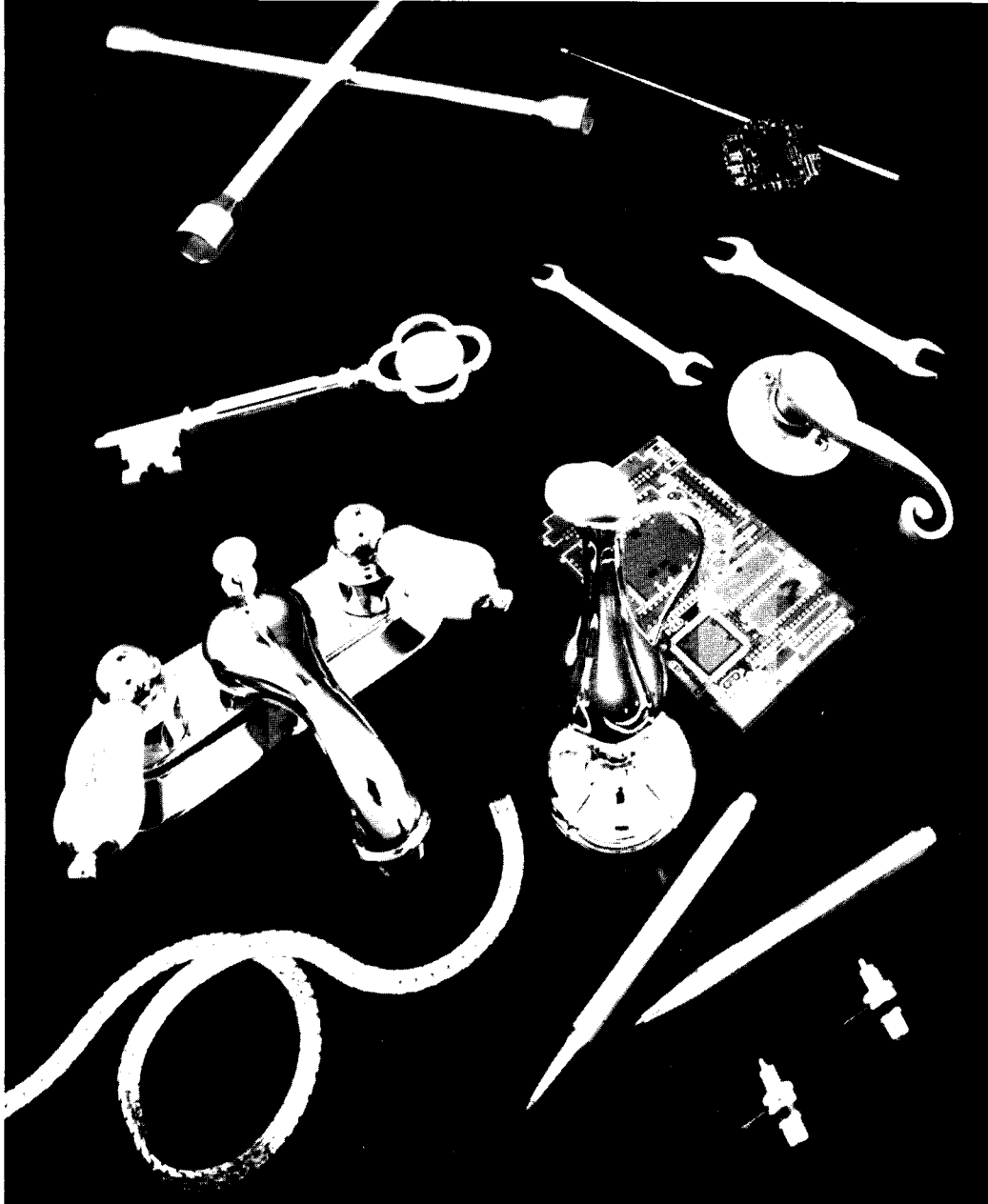


# Understanding SIGNET in the Plating Industry



**GEORGE FISCHER +GF+**

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## Overview

The plating industry has always been an important market for SIGNET products. It is a very large industry that exists in all regions of the country. It encompasses many different types of processes including electroless and electroplating, aluminum anodizing, electronic/circuit board production, powder coating, phosphatizing. These processes find applications in heavy plating of aircraft components, decorative chrome plating, flash gold plating on costume jewelry, nickel plating for prevention of electromagnetic and radio frequency interference, to hard abrasion resistant aluminum anodizing for motor shafts and bearings, and many more.

The industry has been challenged in many areas to help reduce not only its demand of water, but also to discharge less in terms of both water volume and in contaminants including heavy metals

and cyanide. SIGNET products and distributors have provided this cost sensitive market with high quality, corrosion resistant products and a level of service that has established SIGNET as an important part of their total commitment to product quality, water use minimization and waste treatment compliance.

This package will help you to understand the industry itself, and the many different areas where SIGNET products are used. From the front end incoming water monitoring, to process control, to waste treatment, SIGNET products are important tools to achieve the industry's goals. The opportunity for SIGNET products is limited only by the lack of understanding of the many different applications that exist.

## Plating Industry Overview

There are at least 22,286 products finishing manufacturing plants in the U.S. The breakout with regard to type of finishing performed is shown below:

<b>Operation Performed</b>	<b># of Plants</b>
Electroplating .....	7,389
Anodizing .....	1,621
Printed Circuits/Electronics .....	1,295
Painting .....	12,001
Spray Painting .....	7,241
Cleaning and Pickling .....	4,654
Phosphatizing .....	3,168
Polishing/buffing .....	7,938
Tumbling/Vibratory Finishing .....	4,615
Powder Coating .....	<u>2,998</u>
<b>Total .....</b>	<b>22,286</b>

## Geographics

The strongest geographical region of plating plants appears to be in the East North Central states (OH, IN, IL, MI, and WI). See below:

<b>Region</b>	<b># of Plants</b>
New England (ME, NH, VT, MA, RI, CT) .....	2,040
Middle Atlantic (NY, NJ, PA) .....	3,382
South Atlantic (DE, MD, DC, VA, WV, NC, SC, GA, FL) .....	2,199
East North Central (OH, IN, IL, MI, WI) .....	7,296
East South Central (KY, TN, AL, MS) .....	1,071
West North Central (MN, IA, MO, ND, SD, NE, KS) .....	1,579
West South Central (AR, LA, OK, TX) .....	1,238
Mountain (MT, ID, WY, CO, NM, AZ, UT, NV) .....	517
Pacific (AK, WA, OR, CA, HI) .....	2,411
US Territories .....	53
Canada .....	500
<b>Total .....</b>	<b>22,286</b>

## Shows/Associations/Trade Magazines Related to Plating Industry

### Shows

AESF Week  
SURFIN (AESF)  
NEPCON West

The SURFIN Show is the key show for the plating industry. NEPCON West is primarily an electronics show — about 95% is dedicated to the PC market, while the remainder is pure plating.

### Associations

American Electroplaters and Surface Finishers Society (AESF)  
Metal Finishing Supplier's Association

### Primary Trade Magazines

	<b>Circulation</b>
Products Finishing .....	46,462
Plating and Surface Finishing .....	10,000
Metal Finishing .....	9,367
Finisher's Management .....	10,745
Industrial Finishing (paint & coatings) .....	36,650

### Magazine Overview

**Products Finishing:** Circulation: 46,462

Monthly magazine. Goes to owners, engineers and managers in broad range of finishing operations. To subscribe, call (800)950-8020 or (513)231-8020

**Plating and Surface Finishing:** Circulation: 10,000

Bi-monthly magazine. Goes to owners, managers, engineering directors, plant superintendents and foremen in the surface finishing industry. To subscribe, call (407)281-6441

**Metal Finishing:** Circulation: 9,367.

Monthly magazine. Predominantly finishing functions in anodizing and electroplating, degreasing, cleaning, and descaling and bright dipping. To subscribe, call (212)989-5800

**Finisher's Management:** Circulation: 10,745

Monthly. Goes to management-job shops and departments of manufacturing plants engaged in plating, metal finishing of metal and non-metallic products. To subscribe, call (708)699-1700

**Industrial Finishing:** Circulation: 36,650

Serves total coatings market. Targeted to company and production managers, engineers and R&D personnel in paint and coating manufacturing companies as well as finishers. To subscribe, call (708)665-1000

## AESF Branch Directory 1992-93

### Allegheny

Steve Swanson ..... President  
716/763-4114  
Meeting place, day and time vary.

### Allentown-Reading

David P. Honald ..... President  
717/424-8510  
Meeting Place: Varies  
Day of Month: Fourth Thursday  
Meeting Time: 6:30 p.m.

### Baltimore-Washington

Patrick W. Moore ..... President  
301/727-6770  
Meeting Place: Brass Duck Restaurant, Laurel, MD  
Day of Month: Second Tuesday  
Meeting Time: 5:30 p.m.

### Blue Ridge

David Horton ..... President  
919/723-7946  
Meeting Place: Howard Johnson, Greensboro  
Day of Month: Second Thursday  
Meeting Time: 6:30 p.m.

### Boston

Marko B. Duffy, CEF ..... President  
508/881-2404  
Meeting Place: Howard Johnson Motor Lodge,  
Cambridge MA  
Day of Month: Second Thursday  
Meeting Time: 5:30 p.m.

### Bridgeport

Allen Ferguson ..... President  
203/575-9450  
Meeting Place: Rapp's Paradise Inn, Ansonia, CT  
Day of Month: Second Thursday  
Meeting Time: 6 p.m.

### Buffalo

LaVerne Luscom ..... President  
716/856-2368  
Meeting Place: Varies  
Day of Month: Third Monday  
Meeting Time: 6:00 p.m.

### Charlotte-Metrolina

Ron Papesh ..... President  
704/588-1820  
Meeting Place: Slug's University Place Restaurant  
Day of Month: Last Monday  
Meeting Time: 6:30 p.m.

### Chicago

Connie Vrenios ..... President  
312/254-2406  
Meeting Place: Midway Motor Lodge  
Day of Month: Second Thursday  
Meeting Time: 6 p.m.

### Cincinnati

Charles Broerman ..... President  
513/731-3400  
Meeting Place: Golden Lamb Restaurant,  
Lebanon, OH  
Day of Month: Fourth Monday  
Meeting Time: 7 p.m.

### Cleveland

Jim Mayer ..... President  
216/231-5600  
Meeting Place: The Harley Hotel of  
Cleveland South  
Day of Month: Second Thursday  
Meeting Time: 6 p.m.

### Columbus

Stanley B. Moore ..... President  
614/486-6421  
Meeting place, day and time not available.

### Dallas-Ft. Worth

Les Winkler ..... President  
214/669-9418  
Meeting Place: Cafe Italia, Dallas, TX  
Day of Month: Third Thursday  
Meeting Time: 6:30 p.m.

### Dayton

John Stratton ..... President  
513/253-5311  
Meeting Place: The Golden Lamb, Lebanon, OH  
Day of Month: Fourth Monday  
Meeting Time: 6 p.m.

### Denver

Brad David, CEF ..... Contact  
303/534-8161  
Meeting place, day and time not available.

### Detroit

William Krenz ..... President  
313/872-1800  
Meeting Place: Penna's Restaurant, Warren, MI  
Day of Month: First Tuesday  
Meeting Time: 6:30 p.m.

### Erie

Thomas Byerly ..... President  
814/453-7531  
Meeting Place: Varies  
Day of Month: Third Tuesday  
Meeting Time: 6 p.m.

### Garden State

Paul Theusen ..... President  
201/991-4174  
Meeting Place: Ramada Inn, Fairfield, NJ  
Day of Month: Third Friday  
Meeting Time: 7 p.m.

### Grand Rapids

Arthur J. Kowalski, CEF ..... President  
616/455-2081  
Meeting Place: Dub's Restaurant  
Day of Month: Second Thursday  
Meeting Time: 6 p.m.

### Hampton Roads

Douglas E. Kirk, CEF ..... President/Secretary  
804/853-0065  
Meeting place, day and time not available.

### Hartford

John Zaczynski, CEF ..... President  
203/236-6801  
Meeting Place: The Gallery Glastonbury  
Day of Month: Third Tuesday  
Meeting Time: 6 p.m.

### Indianapolis

James W. Collins ..... President  
812/379-3327  
Meeting Place: Estridge's Charcoal Steakhouse  
Day of Month: Second Monday  
Meeting Time: 6:30 p.m.

### Kansas City

Woody Allen ..... President  
816/887-3456  
Meeting Place: Varies  
Day of Month: Second Monday  
Meeting Time: 5:45 p.m.

### Lancaster

Bradley Ream ..... President  
717/780-4690  
Meeting Place: Varies  
Day of Month: Third Thursday  
Meeting Time: 6 p.m.

### Los Angeles

Francis Jones ..... President  
213/771-8301  
Meeting Place: Quiet Cannon Montebello, CA  
Day of Month: Second Monday  
Meeting Time: 6 p.m.

### Louisville

Ernest McAfee ..... President  
502/241-7505  
Meeting Place: Cliff Hagan's, Lexington, KY  
Day of Month: Second Thursday  
Meeting Time: 7 p.m.

### Memphis-Midsouth

Robert E. Patrick ..... President  
901/767-1338  
Meeting Place: George & David's Restaurant  
Day of Month: Third Friday  
Meeting Time: 6 p.m.

### Merrimack

Joseph Conoby ..... Contact  
508/294-4227  
Meeting Place: Varies  
Day of Month: Third Monday  
Meeting Time: 7 p.m.

### Mid-Tennessee

Dick Waltz ..... President  
615/452-3338  
Meeting place: Ramada Inn Airport  
Day of Month: Second Thursday  
Meeting Time: 6 p.m.

## AESF Branch Directory 1992-93 (Continued)

### Midwest Florida

Donald E. Melton, CEF ..... President  
813/343-7363  
Meeting Place: The Inn of St. Petersburg  
Day of Month: Second Thursday  
Meeting Time: 7 p.m.

### Milwaukee

John Newman, CEF ..... President  
414/449-6917  
Meeting Place: Country Gardens Restaurant  
Day of Month: First Monday  
Meeting Time: 6 p.m.

### Nebraska-Iowa

Mike Wiemann, CEF ..... President  
402/733-3266  
Meeting Place: Stockade Restaurant, Omaha, NE  
Day of Month: Third Thursday, Quarterly  
Meeting Time: 6:00 p.m.

### New York

Gene Packman, CEF ..... President  
717/449-6917  
Meeting Place: Epner Technology, Brooklyn, NY  
Day of Month: First Thursday  
Meeting Time: 6:30 p.m.

### North Alabama

Don Owens ..... Contact  
205/442-2577  
Meeting place, day and time not available

### Oklahoma City

Mark Knight ..... Contact  
405/232-6331  
Meeting place, day and time not available.

### Orange County Metropolitan

Susan Watcher ..... President  
714/632-0200  
Meeting Place: The Revere House, Tustin  
Day of Month: First Thursday  
Meeting Time: 6 p.m.

### Orlando

Dr. James J. Steppan ..... President  
407/423-5941  
Meeting Place: Varies  
Day of Month: Second Tuesday  
Meeting Time: 6:30 p.m.

### Philadelphia

Fred Mueller, CEF ..... President  
215/742-1288  
Meeting Place: Frankford Torsdale C.C.  
Day of Month: Third Tuesday  
Meeting Time: 7 p.m.

### Phoenix

Ann Skanadore, ESC ..... President  
602/258-1554  
Meeting Place: Spaghetti Company  
Day of Month: Second Tuesday  
Meeting Time: 6 p.m.

### Pittsburgh

Thomas E. Baker ..... President  
412/384-5353  
Meeting Place: Tonidale Restaurant  
Day of Month: Third Tuesday  
Meeting Time: 7 p.m.

### Portland

Bradley C. Johnson ..... President  
503/256-2777  
Meeting Place: Varies  
Day of Month: First Thursday after  
Second Wednesday  
Meeting Time: 6 p.m.

### Providence-Attleboro

Robert McIntyre Jr. .... President/Treasurer  
401/941-6676  
Meeting Place: Ramada Inn, Seekonk, MA  
Day of Month: Third Monday  
Meeting Time: 5 p.m.

### Rochester

Patricia Frisch ..... President  
716/223-0227  
Meeting Place: Varies  
Day of Month: First Monday  
Meeting Time: 6 p.m.

### Rockford

Jim Brown ..... President  
815/234-2711  
Meeting Place: Varies  
Day of Month: First Monday  
Meeting Time: 6 p.m.

### Saginaw Valley

Michael W. Miller, CEF ..... President  
313/743-7450  
Meeting Place: Walli's Supper Club, Flint  
Day of Month: Second Wednesday  
Meeting Time: 6:30 p.m.

### St. Louis

Greg Thomas, CEF ..... President  
314/343-0456  
Meeting Place: Radisson Hotel, Clayton, MO  
Day of Month: Second Wednesday  
Meeting Time: 6:30 p.m.

### Salt Lake City

William E. Harrison ..... President  
801/972-5000  
Meeting Place: Red Flame, Bountiful  
Day of Month: Fourth Tuesday  
Meeting Time: 6 p.m.

### San Diego

Charles Forman, CEF ..... Contact  
619/534-2181  
Meeting place, day and time vary.

### Santa Clara Valley

Dr. Thomas M. Tam ..... President  
408/721-3281  
Meeting Place: Holiday Inn, Sunnyvale  
Day of Month: Second Tuesday  
Meeting Time: 6 p.m.

### Seattle-Puget Sound

Robert A. Munzer, CEF ..... President  
206/854-9330  
Meeting Place: Andy's Tuckwilla Station  
Day of Month: Second Wednesday  
Meeting Time: 6:30 p.m.

### South Florida

Dr. Clarence Roy, CEF ..... President  
407/796-6434  
Meeting Place: Marriott, Palm Beach Gardens  
Day of Month: Second Wednesday  
Meeting Time: 6 p.m.

### Springfield

Thomas D. Foley ..... President  
413/568-3716  
Meeting Place: Collegian Court Restaurant,  
Chicopee, MA  
Day of Month: Fourth Tuesday  
Meeting Time: 6 p.m.

### Syracuse

David Kolceski ..... President  
315/446-2264  
Meeting Place: Giovanni's Restaurant  
Day of Month: Third Monday  
Meeting Time: 6 p.m.

### Toledo

Frederick M. Deye ..... President  
313/273-5705  
Meeting Place: Krotzer's Steak House  
Day of Month: Third Tuesday  
Meeting Time: 6:30 p.m.

### Tulsa

Jeff Blanke ..... President  
918/485-9531  
Meeting Place: Angelo's Restaurant  
Day of Month: Third Tuesday  
Meeting Time: 6 p.m.

### Upper Midwest

Greg Dant, CEF ..... President  
612/822-2185  
Meeting Place: Jax Restaurant  
Day of Month: First Monday  
Meeting Time: 5:30 p.m.

### Valley Forge

Robert J. Bieling ..... President  
215/666-8695  
Meeting Place: Johnny Cross's Restaurant  
Day of Month: Second Tuesday  
Meeting Time: 7 p.m.

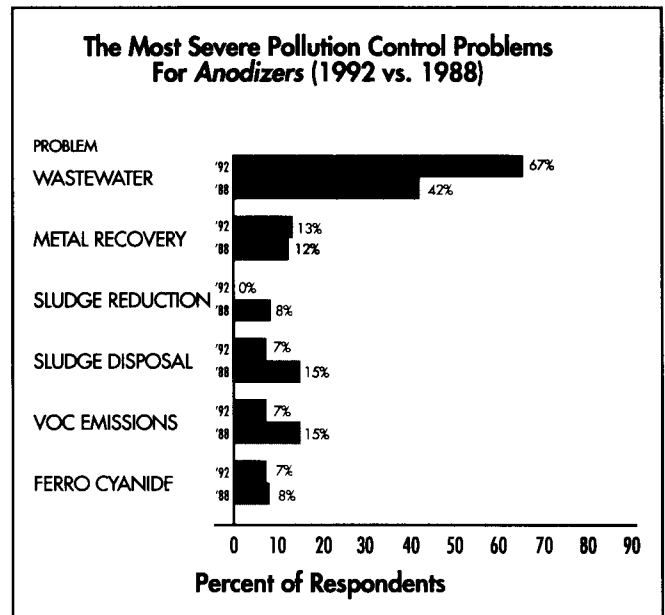
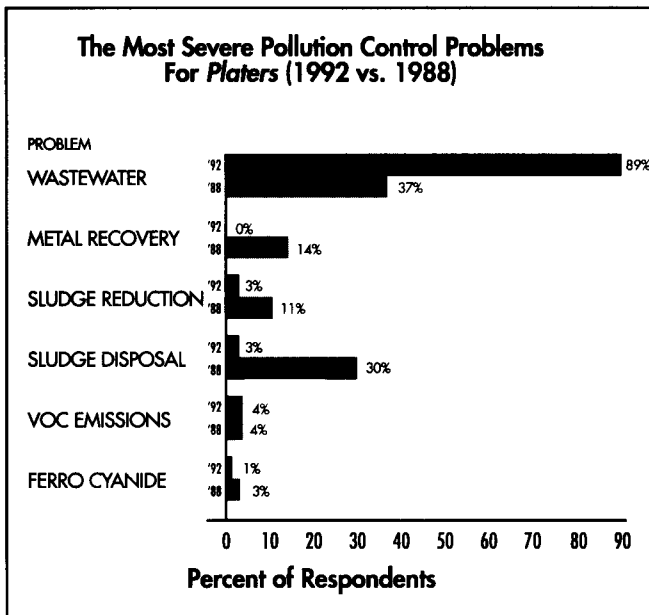
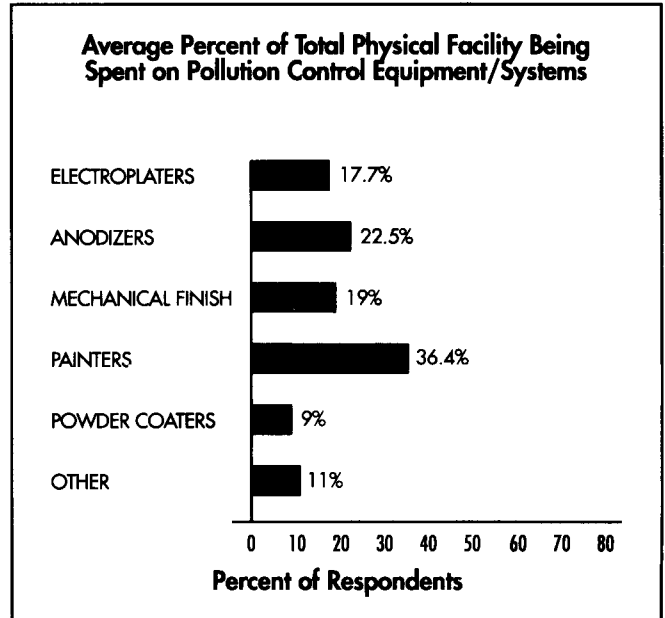
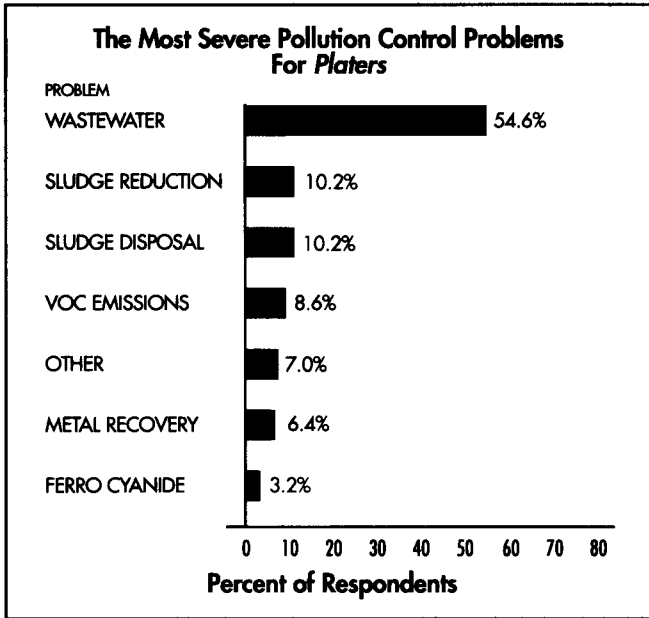
### Waterbury

Susan Labeck ..... President  
203/621-6755  
Meeting Place: Rapp's Paradise Inn  
Day of Month: Second Thursday  
Meeting Time: 5:15 p.m.

### Worcester

Steven Jarjorian, Sr. .... President  
508/799-0557  
Meeting Place: Varies  
Day of Month: Third Tuesday  
Meeting Time: 6:30 p.m.

## Survey of Platers, Anodizers and Metal Finishers



## Process Control

The pH of a plating bath is nearly always a critical measurement. It can affect many qualities of the finished plated surface including color, strength, ductility, thickness, consistency, hardness, etc. In addition, it can affect the efficiency or throwing power of the bath, resulting in less plating thickness per dollar of energy used, or even in uneven plating thicknesses across a part.

In many baths, we are able to measure the pH with an on-line glass electrode technology system. In general, if the bath is in the range of 2 to 12 pH, it should be further analyzed to determine if it is a candidate for on-line control. Very high plating bath temperatures (>180°F) significantly decreases the electrode's life, but this may be acceptable to the end-user, or it may be possible to install the electrode in a low flow, cooled, recirculated loop outside of the tank. Other concerns are the presence of poisoning ions. SIGNET electrodes are designed to reduce the effect of such ions, which include sulfur, cyanide and ammonia, but shorter electrode life should be anticipated in these processes. Finally, one must be careful to avoid hydrofluoric Acid (HF) which will rapidly dissolve the measuring glass membrane, or any bath containing a form of Fluorine, such as Fluoboric Acid, which will exist in equilibrium with the aggressive F-ion.

Process control of the plating tank will usually involve monitoring of the pH, with automatic control of a chemical addition system. The SIGNET 9030 pH controller is the ideal choice for these applications, offering the end user selectable pH resolution of .1 or .01 pH, and optional output control and recording options including on/off relays, proportional pulse to metering pumps, analog proportional to a control valve or to a recorder or computer.

The pH sensors may be installed as submersion sensors to the side of the tank, or in-line in a recirculating filtration system. Flow rates in such systems should be kept at 4 fps or less. For high temperature baths, in-line installation is preferred.

For accurate pH bath control, routine cleaning and calibration is critical. Control tighter than  $\pm .1$  pH is unrealistic, and becomes more difficult as you travel further in pH from neutral 7.0.

Many times the actual pH is too extreme (<1 or >13), that the glass measurement technology of the pH electrode is inadequate, and only a laboratory titration is sufficient for accurate concentration of acid or caustic in the solution. Remember, pH is a logarithmic measurement of hydrogen ion concentration. At the pH extremes, it requires a very large change in hydrogen ion concentration to achieve a small change in the pH measurement. At these extremes, a titration will provide much greater accuracy and resolution for these concentrations. Glass electrodes will instead tend to age very quickly, showing a drift which may erroneously be interpreted as an actual pH change.

A reference table of plating bath pH measurements is given on page 26.

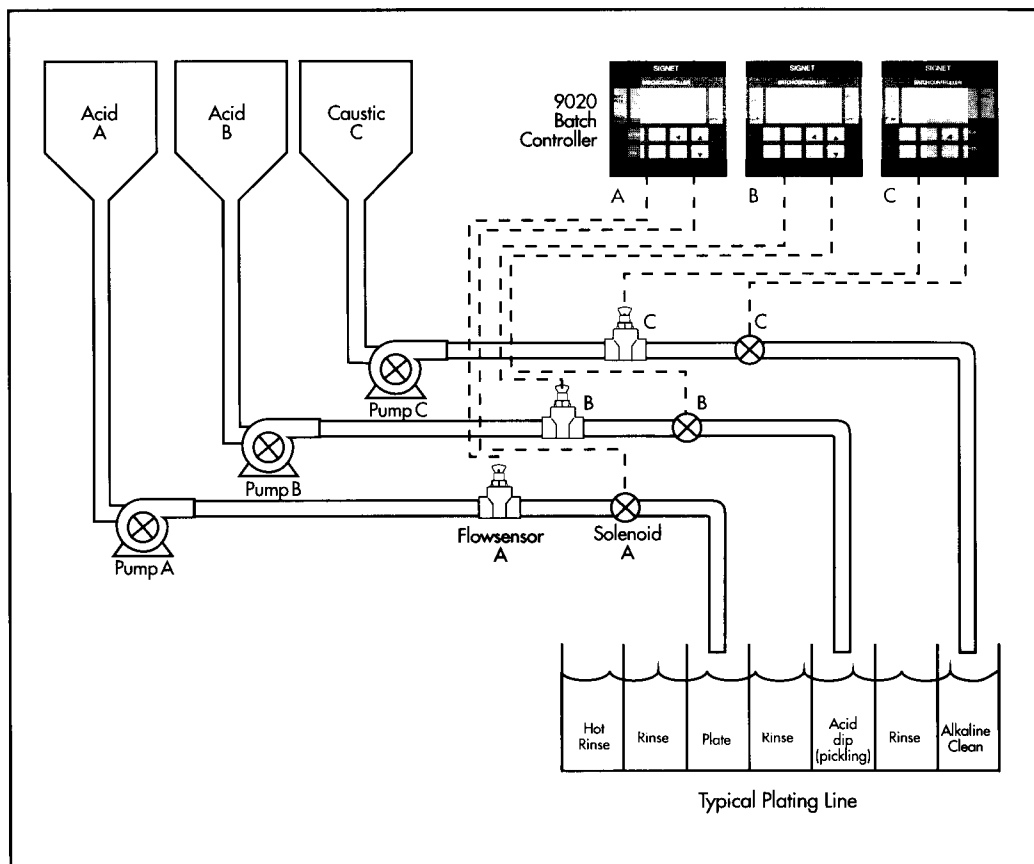
## Bath Chemical Addition

Whenever plating baths operate at pH extremes, the acid, caustic or ammonia concentration is too strong to be analyzed and automatically controlled using an on-line pH system. Instead, the baths are generally sampled once or twice per operating shift, and analyzed in the laboratory via titration for the appropriate concentrations of acid or caustic. When the concentration is found to be low, a calculation is made based on the current concentration in the tank, the volume of the tank, and the strength of the reagent to be added. This calculation results in an "add" that must be made to the tank to bring it back to its nominal operating concentration. For example, the laboratory will report to add 5 gallons of acid, or 7 gallons of caustic etc. to bring each tank back to its nominal operating level.

Once this information is reported to the production area, operators must accu-

rately and safely make these additions in a timely manner so as not to delay production in the process. The SIGNET 9020 batch controller provides a simple, safe, accurate and efficient method for completing these additions. The operator is able to quickly program the determined add, and safely make the addition with a minimum of effort.

Because concentrated chemicals are normally used as the reagents, it is critical to carefully check material compatibilities of sensors and fittings that will be used. In addition, because many additions are made using gravity feed from "day" storage tanks (normally a "day's" production requirement stored separately from the large bulk storage) line size and velocity should be verified. Remember, the SIGNET 2530 low flow sensor works to a minimum fluid velocity of .3 fps and would be the best alternative for most gravity flow systems.



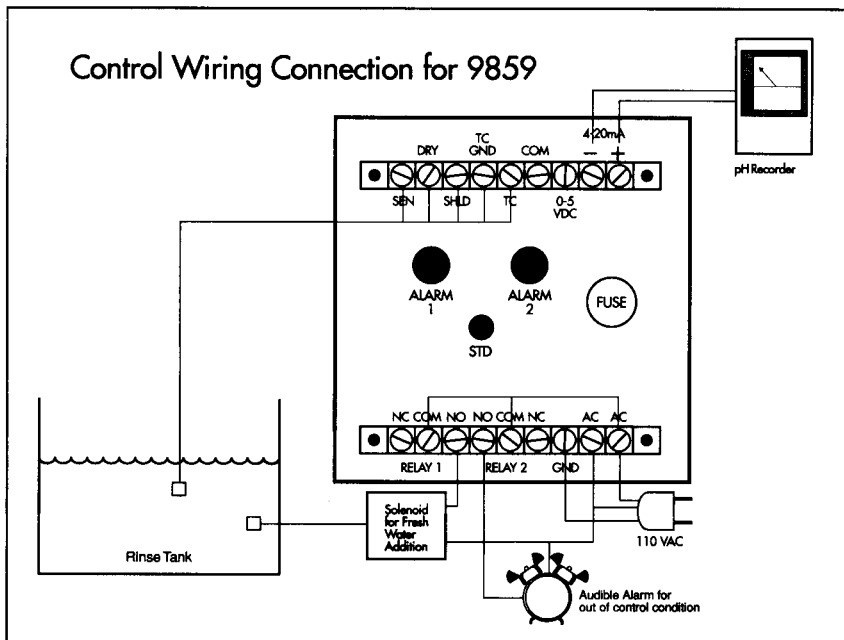
## Rinse Tank Control

Consistent quality of the finished plated part is created by controlling every important feature of every bath in the plating process. Rinse waters between the chemical baths are no exception. They play a critical role in preparing the surface for the next chemical reaction; dirty rinse tanks can result in surface pits, plating voids, peeling surfaces, etc. Their function is to rinse away remaining chemicals from a previous bath, yet remain sufficiently clean so as not to contaminate the bath.

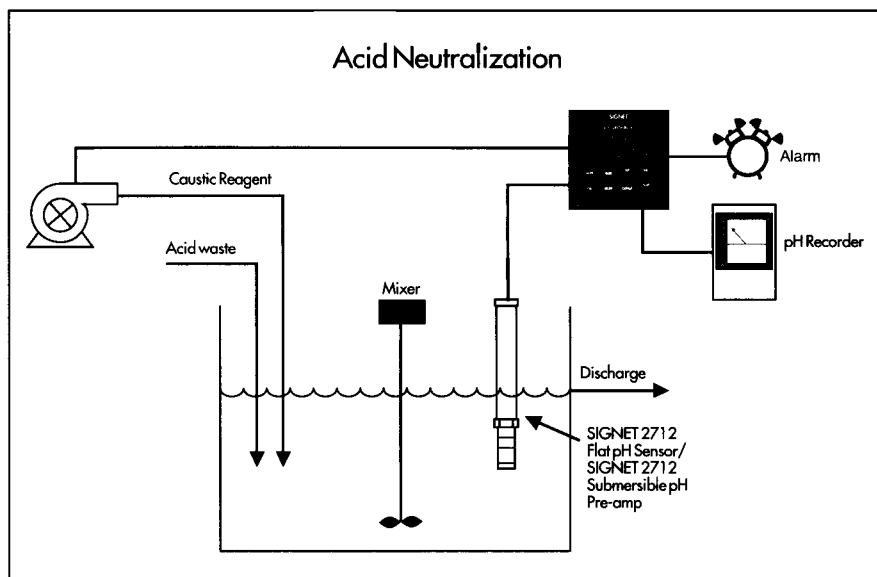
Fortunately, we are able to easily measure the amount of contaminating ions in a rinse tank using conductivity. An economical, reasonably maintenance free and drift free measurement, conductivity enables us to "see" all of the ions in the solution, and if desired, automatically control their concentration to a predetermined level.

Conductivity is a measurement that uses the ions in solution to conduct electricity. The more ions present, the more conductive the solution is, and the higher the conductivity reading. Pure water, with essentially no ions present, would not be conductive (it would be resistive, and measured with resistivity) and would have an associated conductivity value of less than .1 microSieman ( $\mu\text{S}$ ). To automatically control conductivity in the rinse tank, we would add "clean" water whenever a high conductivity condition in the tank occurs. The conductivity level required in the tank and the required cleanliness of the replenishment water varies significantly from one plating process to another, and for each installation. Historical data on a plating process's rinse tank quality versus product plating quality or process yield is often the best information to help determine if improved rinse water quality is necessary.

In some situations, an end user may desire his conductivity measurement to be in units of parts per million (ppm) of total dissolved solids (TDS), instead of microSiemens or its equivalent, micromhos. There is a direct relationship between these, which in most areas of the country is:  $\text{ppm} \times 2 = \text{microSiemens}$ . In other words,  $100 \text{ ppm TDS} = 200 \text{ microSiemens} = 200 \text{ micromhos}$ . This relationship can be easily compensated for in the dial selection and specified calibration range of the SIGNET 9859 Conductivity Analyzer. In our example, the instrument would be fitted with a 0-100 dial, but calibrated electronically for a 0-200  $\mu\text{S}$  range.



## Acid Neutralization



Acid neutralization is the simplest form of waste treatment found in plating or finishing operations. Although usually combined with a metal hydroxide precipitation process, in some instances waste streams without metals may be separated and neutralized separately. This strategy can reduce capacity needs for separation (clarifier), settling and pressing and therefore reduce a waste treatment system capital expense.

Acid neutralization consists of addition of a caustic, usually sodium hydroxide, into a tank to neutralize acid wastes. In many cases, the incoming waste stream may also contain caustic streams such as alkaline cleaners, etc., which will also assist in the acid neutralization. This process is best handled in a tank with good mixing. On/off, proportional control, or a combination of the two can be used with SIGNET controllers. On/off is recommended for large adjustments, but may result in excess reagent being used and the set point being overshoot. Proportional control requires a more expensive delivery system, such as a metering pump or proportional valve, but can prevent set point overshoot and save on reagent costs.

To determine the size of the delivery system, it is necessary to perform a

titration analysis on the waste stream. Two streams of the same pH value being neutralized to a pH of 7.0 may have significantly different amounts of reagent required to neutralize them. Without this information, it is impossible to determine the size of the delivery system. In any single neutralization tank, no more than 3 pH units of adjustments should be made.

Retention time in the tank is also important. A minimum of 10 minutes is recommended for most installations. Good mixing is also essential, otherwise stratification of pH within the tank is possible. Impeller mixers are preferred over air sparging or recirculation systems.

Recommended placement of the pH probe is near the outlet of the tank, but below the lowest solution level so that the probe remains in solution at all times. In many situations, extended electrode life may be achieved by protecting the electrode from the high velocity of the mixer by placing a half-pipe baffle in front of the pH sensor. Do not hide the electrode inside a pipe as it is essential that the electrode sees the well mixed sample immediately. Reagent addition should also be far from the electrode, generally near the point of the waste stream inlet.

## Metal Precipitation

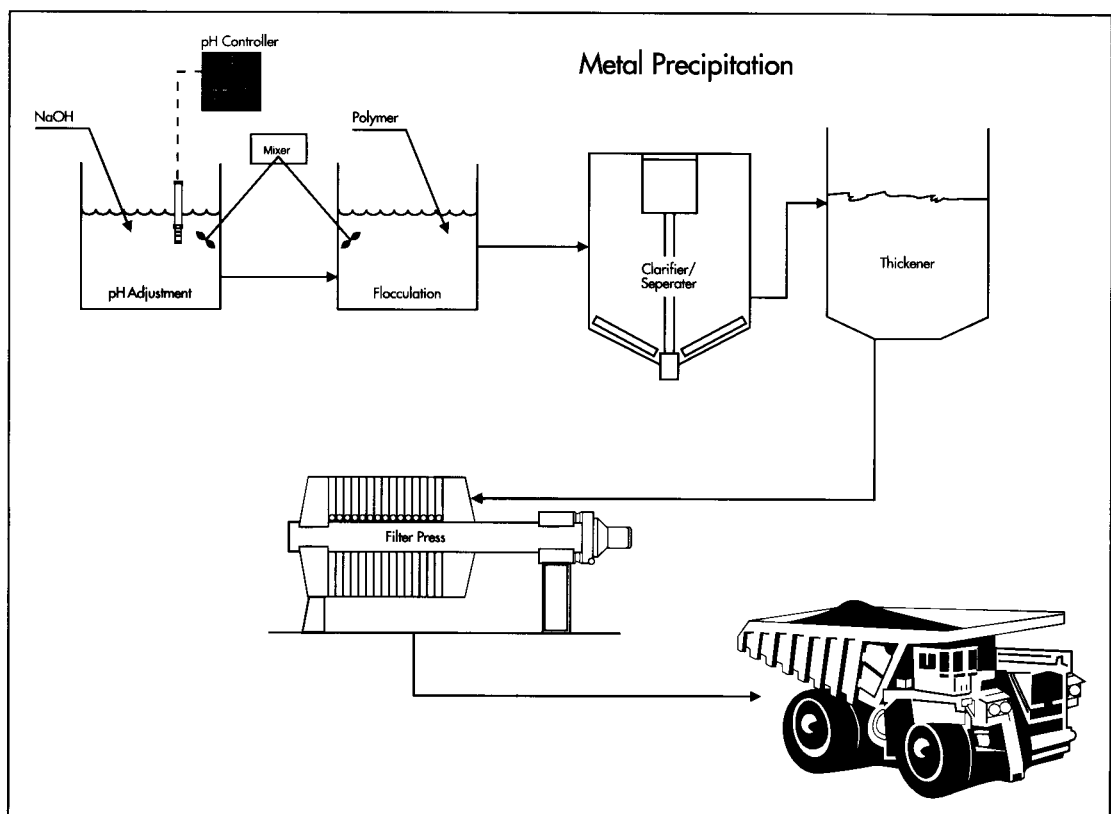
Metal precipitation is a process similar to acid neutralization, however the pH setpoint selected is designed to provide maximum precipitation of one or metals in the solution as metal hydroxides. Polymer addition assists in rapid settling of the metal hydroxides, and may be added as a function of flow rate. Following the metal precipitation step, the hydroxides are separated in a clarifier, then concentrated in a thickening tank, and finally pressed to remove as much water as possible. The pressed sludge can then be transported in its minimum volume to an appropriate landfill sight. In some states the effluent of the process may be further pH adjusted in a final treatment step to a more neutral pH before discharge to the sewer.

Each metal has its own optimum pH for maximum hydroxide precipitation, leaving the minimum amount in solution to be discharged. In many plating shops a compromise pH is used to achieve an optimum condition between

two or more metals in solution. In most situations, the pH set point will be between 9.0 and 10.5. In addition, the polymer used to accelerate precipitation can also affect the amount of metal left in solution. Trial and error with different pH set points and polymers is usually recommended for optimum system performance.

As restrictions on some metals become tighter, it may become necessary to treat each metal at its own optimum pH set point, in individual systems. This strategy is rare at this time but as restrictions on the discharge becomes tighter, it may become a necessary consideration.

Similar to acid neutralization, either on/off, proportional or a combination of the two may be used for pH adjustment. Other recommendations for maximum pH adjustment, mixing and probe placement also hold true for metal precipitation.



## Cyanide Oxidation

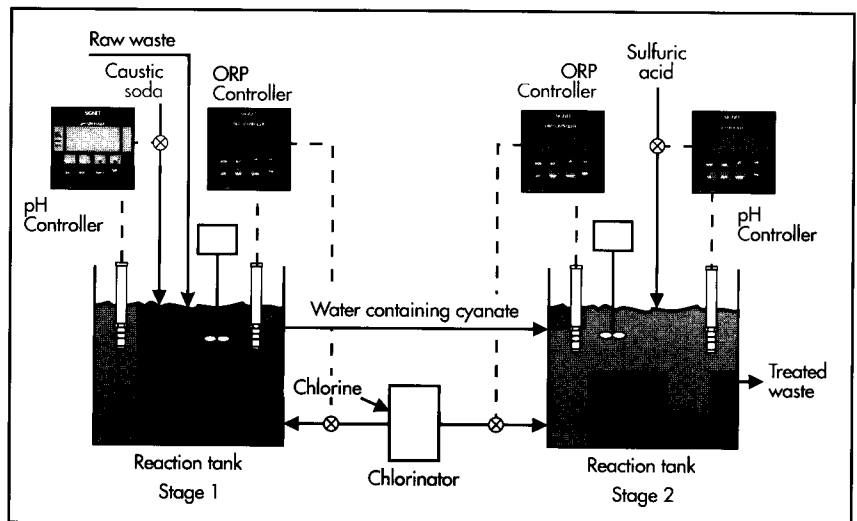
Cyanide is an important complexing agent for many plating processes including copper, brass, gold and zinc. Other metal finishing operations which also may require cyanide waste treatment include: conversion coatings, chemical milling, barrel finishing, burnishing, heat treating and electrochemical machining. Cyanide is an extremely toxic chemical however, and alternative solutions for these plating baths are continuously researched to develop non-cyanide chemistries with equal or better plated properties and ease of bath control. It is likely that in the next ten to twenty years cyanide will no longer be necessary for use in the plating industry, but at this time it remains an important process and must be carefully handled through waste treatment to properly destroy it before discharging to the sewer.

Cyanide Oxidation is normally carried out in two stages. The first stage converts cyanide to a less toxic cyanate. The second stage then converts the cyanate to carbonate and nitrogen gas. In some areas, second stage treatment may not be required, however, the national trend is to require two stage treatment.

In the first stage, both pH and ORP control are essential. First the pH is adjusted with Sodium Hydroxide to the range of 11.0 to 11.5. In this range, the cyanide is rapidly converted to cyanate without the risk of releasing the extremely toxic cyanogen chloride gas. Once the pH is in range, ORP control for oxidizer addition is started. Common oxidizers include chlorine gas, or sodium hypochlorite, both very hazardous chemicals. Experienced operators only should handle these materials with proper safety equipment. For most installations, an ORP set point of +325 mV is adequate. If destruction rate is not adequate, the ORP set point may be

raised, but +400 mV is generally considered the maximum. Lowering the pH will produce a higher ORP, however the rate may still be inadequate. Each installation must determine the optimum pH and ORP set points based on their loading rate and detention time. A proper system should be able to achieve oxidation to a level of less than .1 ppm.

In the second stage, again both pH and ORP control are used. The pH is lowered with sulfuric acid to a set point around 8.5 (but never lower than 8.0), while ORP controls the addition of the oxidizer. As in the first stage, this may be either chlorine gas or sodium hypochlorite, although chlorine is preferred because it is less alkaline than the hypochlorite while you are attempting to lower the overall pH. The ORP set point in this stage is generally around +600 mV, but may be as high as +800 mV if a faster reaction rate is required. Again, rate required is determined by the loading of the system and the detention time. Modern systems are often designed with as much as a four hour detention time.



## Chrome Reduction

In the plating of chrome, or chromium, traditional processes use chromium in the hexavalent state. In this form, the chromium is 1000 times more toxic than trivalent chromium, and has more strictly controlled discharge limits. In addition, the hexavalent form of the chrome does not form a hydroxide precipitate which can then be settled and filtered out. The chrome reduction process is used as a pretreatment for the standard metal hydroxide precipitation process.

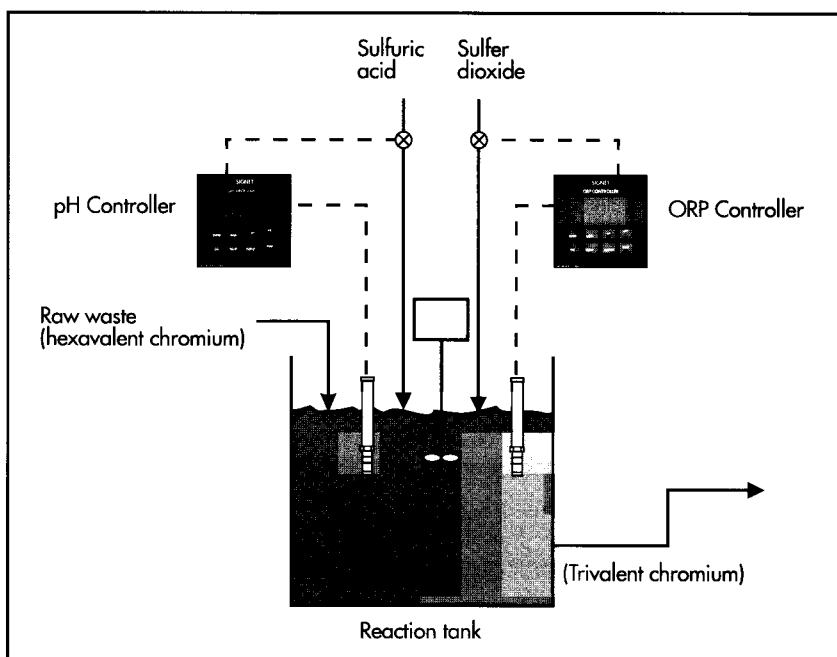
In the chromium reduction process, hexavalent, or +6 charged chromium ion is reduced to trivalent, or +3 charged ion state. The reduction is completed in a single stage operation where the pH is first lowered to approximately 2.5, followed by addition of a reducing agent such as sulfur dioxide, sodium sulfite, or sodium metabisulfite. ORP is used to control the reducing chemistry and reaction.

Controlling the pH in the range of 2.0 to 2.5 keeps the chrome reduction reaction at its optimum rate. The

reaction rate slows significantly as the pH rises to 3.0, and becomes very slow at a pH of 4.0. Operation at the lower pH setting can also help to correct for insufficient detention time in the reaction tank. An absolute minimum detention time of 15 minutes is required for most chrome reduction processes. Lowering the pH further has not been shown to improve the reaction chemistry further, and may lead to hazardous sulfur dioxide gas being released to the atmosphere.

ORP is used to control the addition of the reducing agent. A set point of -300 mV is generally adequate for most installations at pH 2.0. Because all processes vary, each operation must determine their optimum set point. Decreasing the ORP set point (increasing in negative value) will increase the amount of reducing agent in solution, and should increase the rate of reaction. An ORP set point of -400 mV is generally accepted as the maximum. Raising the ORP set point (moving towards 0 or into the positive ORP range) will slow the reaction, but also result in less reagent used and a subsequent cost savings.

The combined set points for pH and ORP determine the rate of the reduction reaction. The rate required for any operation depends on the amount of hexavalent chrome needing to be reduced, and the detention time available in the tank. The optimum set points to achieve both complete destruction (.1 ppm residual) and minimum reagent usage must be determined by the end user.



## Effluent Flow Monitoring

Industries are charged for their water usage. In addition, a treatment charge is often levied for the amount of waste discharged. This is generally a price per gallon based on their incoming water, or possibly less a small amount for their employees personal needs. If the company can accurately document their total waste volume, significant cost savings to the company may be realized

Waste discharge permits limit the amount of gallons to be discharged, the average daily maximum level of a pollutant in ppm (mg/l) that can be discharged, and the total amount of the pollutant that can be discharged in pounds per day. This means that although the waste treatment process may be in control for ppm of metal in the effluent, if the flow volume increases significantly, the plant may still be out of compliance for total metal discharged.

Finally, documentation of the waste flow can also help to determine when a process change may have occurred that is generating additional waste. For example, a stuck water solenoid on a rinse tank can result in tens of thousands of additional gallons of water being used. Data from a waste stream flow totalization system can help to identify when such problems occur.

The Signet 2550 Magmeter provides an ideal measurement technology for an effluent waste stream. The neutralized solution is generally high in conductivity, and there is no rotor to be interfered with. A low spot in the piping system can insure a full pipe at all times. A flow rate and totalizing system along with our N.I.S.T. traceable Flow sensor can provide valuable data for the waste treatment system engineers.

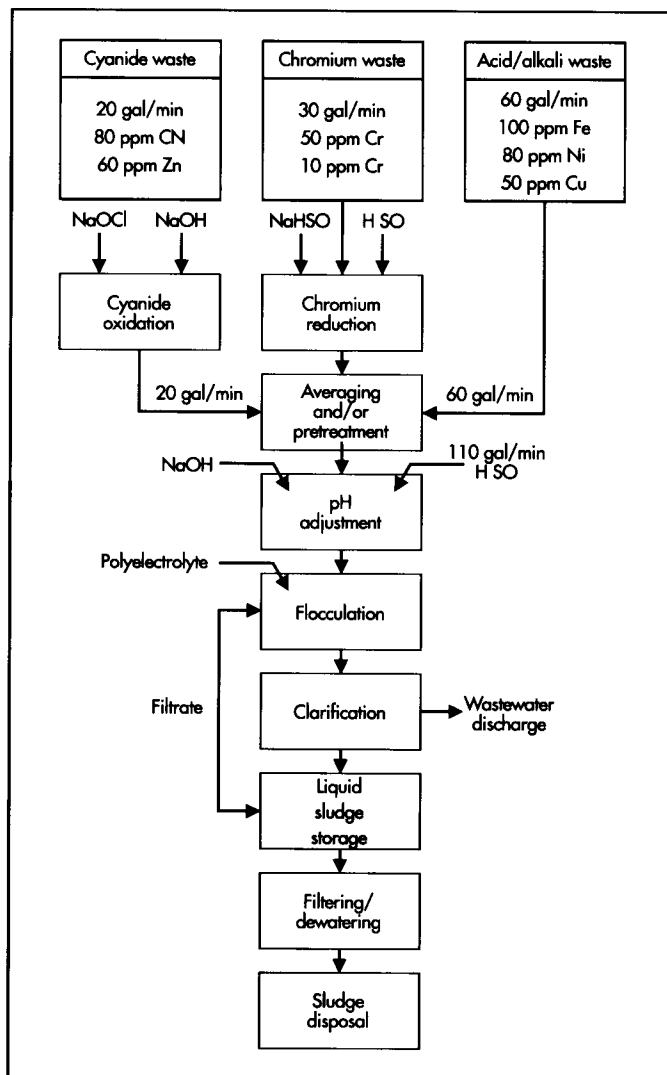
## Complete Waste Treatment System Overview

Cyanide destruction and chrome reduction are pretreatment processes to a standard waste treatment system. It is essential to isolate any waste streams containing these components and pretreat them individually. Once treated, they can then join the other acid and alkaline wastes (many being metal bearing) in a central waste collection area. The collection area helps to average acid and alkaline waste streams, provides immediate dilution of concentrated streams, and helps compensate for fluctuations in the waste stream flow rate.

From the collection area, the waste stream is pumped to the pH adjustment tank. Here the pH is adjusted based on optimum precipitation of the metals in the stream. Next is the clarifier or

separator. This generally uses inclined plates to help capture the metal hydroxide "sludge" in an established sludge "blanket" with fairly rapid flowthru. Clean liquid discharges from the top of the clarifier, while the sludge is pumped on a periodic basis from the bottom of the unit.

The sludge is normally pumped to a storage or "thickening" tank where it is given more time to settle into a "thicker" (less water content) concentration. Finally, it is pumped to a filter/dewatering press which concentrates it further into a "dry" cake that can be more economically transported to an appropriate landfill or other facility (reclamation, incineration, etc.). Excess water from the thickening tank and filter press are generally returned to the flocculation tank, or sometimes to the central collection area. Proximity of these tanks and ease of access (whether gravity flow will transfer the liquid or whether a pump is needed) will generally decide this.



## Water Monitoring

### Water Use Efficiency

Getting maximum use out of a minimum volume of water is important for many reasons. There are certainly many costs associated with water from its initial use cost, to many others associated with it as a "waste". Energy, raw materials, time, waste treatment equipment costs and space requirements all increase as a company's waste treatment needs expand. Most systems that reduce water consumption and waste treatment discharge volume, generally pay for themselves in reasonable amounts of time. Recycling water, reclamation, minimization and zero discharge are all strategies that are investigated to help reduce water consumption.

Recycling water is a very old idea, but one that is usually not implemented to its

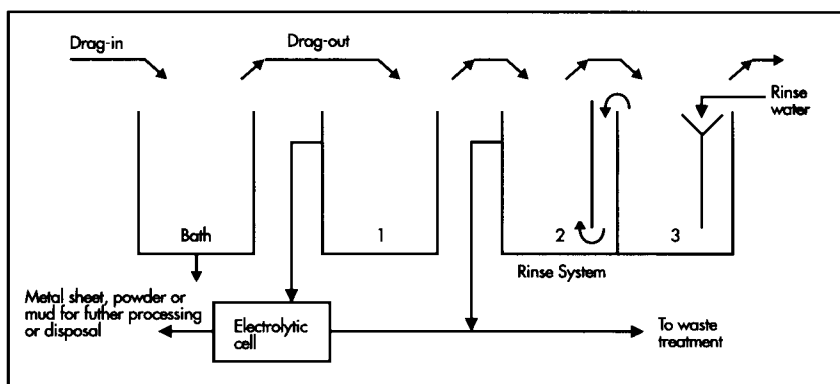
fullest capability in most plating facilities. Countercurrent rinses are generally the most significant method of recycling water, double counterflow rinsing in place of single station rinses can save as much as 90% of water consumption in the plating line. Conductivity control to initiate the fresh water feed to the "clean" tank also helps contribute significant water savings.

Reclamation, or recovery is a more expensive strategy, which generally is feasible only for the most precious metals such as gold and silver. Electrolytic recovery is a method that plates the metal out of the solution and onto a cathode surface. It can be used on rinse tanks (dilute) or strong, spent solutions, but is generally much more efficient using the concentrated solutions. In many systems, the recovered metal is simply stripped away from the cathode sheets.

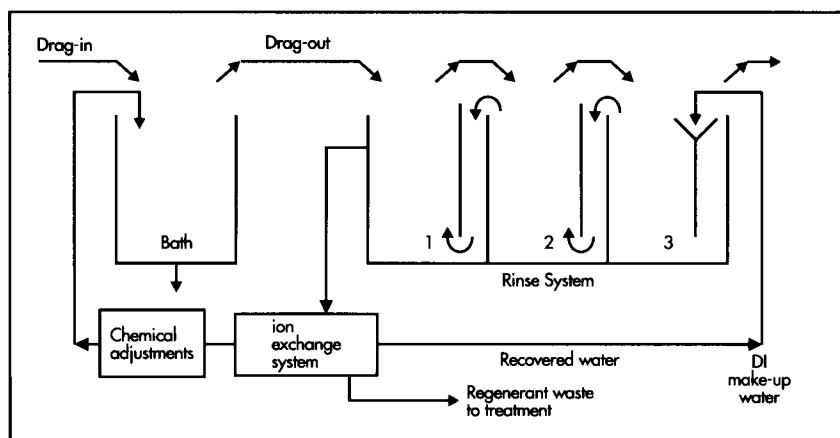
Ion exchange is an excellent method for recycle/minimization strategy which continues to improve each year as resin technology advances. In ion exchange, positive or negatively charged resin beads are packed in a column and attract the metal ions onto their active surface. The clean water can then be returned to the rinse tanks instead of fresh water feed. After about 50% of the bed capacity is used, the metals must then be extracted using an acid solution. This acid solution is heavy with metals and must then be treated in the traditional, waste treatment system.

Other, less common strategies continue to be evaluated and improved. Reverse osmosis, electrodialysis and evaporative recovery are all technologies that will become more important as companies strive to reduce their water consumption. One important note is that electroplating companies that can achieve discharge volumes of less than 10,000 gallons per day can significantly ease their effluent limits by reclassifying into the lower volume category.

To effectively initiate, monitor and control a sincere water use minimization strategy, it is critical to know where the water is being used, how much is being used for each part of the process, and eventually, what the true requirements of the process are for both water volume and water quality. Monitoring flow rates at different process stations can help the engineer or operator to balance the flows between stations as necessary. Total water usage in an area can help to establish product quality. Conductivity in the plant feed water, and as a control point in the rinse tanks will also provide valuable information that will ultimately result in water savings, and more consistent product



Electrolytic metal recovery.



Ion exchange (metals recycle).

quality. SIGNET systems offer low cost per measuring point to provide this information. Stand alone analog or digital instrumentation, or current output from transmitters to data acquisition devices can economically provide accurate data needed to effectively monitor and control the total water consumption within the plant.

## Copper Plating Industry

Copper plating has many applications in many different industries. Its high electrical conductivity makes it excellent for printed circuit boards and other types of electronic hardware. It can be plated on plastics, and being relatively inert to other plating solutions, is an excellent undercoat for other deposits. It is the only metal that is plated directly over zinc die castings. It is inexpensive, with a relatively stable supply, has good plating efficiency, and a well understood waste treatment. As a waste product, it is less environmentally hazardous than other metals. In volume, it is second only to Nickel.

Copper is used as a topcoat on steel wire to produce a high strength electrical conductor. Other applications include rotogravure cylinders, electroforms, and decorative items.

There are basically three different types of copper plating baths. These are: Acid Copper (sulfate and fluoborate), Alkaline (cyanide or non-cyanide), and Pyrophosphate Copper.

Alkaline cyanide copper plating is the original copper plating solution. It has a low efficiency, and generally is used to deposit a thin copper layer over an active metal surface such as zinc or steel. It is able to deposit a very uniform thickness compared to other plating solutions. The pH of these solutions is 11.0 or greater, and may be controlled with an on-line pH control system. The trend of the industry is converting to newer non-cyanide baths requiring less waste treatment processes.

The non-cyanide baths operate generally at a lower pH (around 9.0) and will likely replace all cyanide baths for the thin "strike" coatings. The alkaline baths (both cyanide and non-cyanide) are generally used only to deposit a thin complete layer of copper, which then may be followed by a faster acid copper or nickel plate.

Acid copper is a low cost plating solution, with non-critical bath control, simple effluent control, and has a high plating efficiency. The solution itself is very corrosive and material compatibility must be carefully monitored. The pH range of the bath is very low (generally less than 1 pH), and therefore is not normally controlled in the plating bath itself. Acid concentration of the bath is generally determined by laboratory titration.

Finally, Pyrophosphate copper produces a copper surface of very consistent ductility, which is regularly specified by Federal Agencies. The main application of the pyrophosphate copper bath is the plating of printed circuit boards, although acid copper is becoming more popular. It is mildly alkaline with a pH in the range of 8-9 which can be controlled with on-line process control. Its waste treatment is generally simple, although the phosphate content may be a concern in some areas.

## Electroless Nickel

Electroless Nickel deposits Nickel on to an active surface without the use of electricity. A reducing agent such as sodium hypophosphite is used to drive the reaction to reduce nickel from its ionic state to its metallic state. Because it is not an electrical process, it can be plated on many different surfaces, including plastics, mild and stainless steel, aluminum, graphite, ceramics, copper and zinc die castings. It has the ability to produce a uniform coating on complex, irregular surfaces.

Electroless Nickel surfaces offer excellent corrosion resistance, and therefore is specified on many parts to protect them from corrosive environments. It is especially suited for fighting corrosion in alkaline environments. Many industrial products such as pumps, valves, piping and heat exchangers routinely have nickel plated surfaces for applications in chemical process, petrochemical, food and automotive industries.

Another important property of the Electroless Nickel surface is its hardness. This offers exception protection against wear and abrasion for applications such as aircraft compressor components. It also offers good lubricity, making it an excellent choice for low friction requirements on components in gyro, shock absorbers and lock components in the automotive industry, as well as some nuts and bolts.

Other characteristics include ease of solderability providing applications in the electronics industry for soldering non-metal components to electronic hardware. Finally, Electroless Nickel offers protection from both Electromagnetic and radio frequency interference (EMI/RFI), especially when used over electroless copper. This has been recognized by both engineers and the Federal Communications Commission as a very effective way to shield against EMI/RFI radiation.

There are many different types of Electroless Nickel baths which may range from a pH of 4 up to a pH of 11 depending on the characteristics and plating thickness desired. Many of these baths may be controlled for pH using on-line control. Waste treatment of the Nickel baths and Nickel rinses is generally a simple hydroxide precipitation followed by filter press removal.

## Brass Plating

Brass is the most widely used alloy in the metal plating industry. A combination of Copper and Zinc, The finish is primarily decorative for use on furniture hardware and other household goods, however brass plating may also provide functional advantages such as improved adhesion on wire to rubber for steel belted radials.

Yellow brass alloys generally consist of 65 to 80 percent copper. Alloys above 80 percent are redder in color. A very bright brass finish is usually accomplished by first plating bright nickel, followed by a thin brass flash plate. Bronze may also be used as an undercoat. Thicker brass deposits are used whenever the surface is to be buffed, burnished, satin finished or antiqued.

Brass plating is similar to copper plating, with the primary solution being a cyanide based alkaline solution. Non-cyanide baths and pyrophosphate baths have also been widely investigated but have yet to be perfected. The pH of the cyanide bath runs normally between 9.8 and 10.2, and may be controlled with an on-line pH control system. Below 9.8, zinc solubility may be affected, and an attack of steel anode baskets and unlined steel tanks may occur. Above 10.5, the plating color may be affected.

As in other cyanide plating chemistry, waste treatment for brass plating will include both a cyanide destruct process, followed by metal hydroxide precipitation of the metals. Both the residual copper and zinc concentrations must be considered in this process.

## Chromium Plating

Chromium plating is used extensively for plumbing fixtures and fittings, automotive components, and other decorative uses. The familiar, bright chrome finish has typically been produced out of the more toxic form of chromium, the hexavalent or +6 ionic state of the chrome. Plating from the less toxic, trivalent or +3 ionic state of the chrome has traditionally created a darker finish, yet provided for more simple waste treatment processes. The industry is now beginning to be successful at achieving the bright finish from the trivalent chromium plating process.

The hexavalent plating bath is based on a chromic acid and sulfate solution. These baths are also the most difficult to operate, and require rigorous controls on all bath parameters. These solutions generally have pH values less than 1.0 and can not be effectively controlled with an on-line pH control system.

The trivalent plating system, although not yet widely accepted, offers easier bath control, and has a pH in the range of 3.5 to 3.9. This solution can be controlled using on-line pH control.

Waste treatment for the chromium baths and subsequent rinse tanks depends on whether the chrome is present in the hexavalent or trivalent state. If hexavalent chrome is present, the chrome must first be reduced to the trivalent state in a separate process. Trivalent chrome is treated much easier using the traditional metal hydroxide precipitation method.

## Gold Plating

There are over 200 different gold and gold alloy baths used to produce everything from a light gold flash to a heavier deposit, from a soft gold to a very hard gold, and many with a wide variety of colors that change each year with the fashion world.

Because of the significant expense of gold, the plating process is subject to economics more than other plating processes. The goal is to use the smallest amount possible for the thickness desired, and to plate as quickly as possible to minimize the capital and material investment.

Applications for gold plating consist of the thin gold flash, 2-4  $\mu$ " over bright Nickel usually used for costume jewelry, a heavy gold deposit used on jewelry labeled as "Gold Electroplate", and many different types of specialty gold platings such as plating on stainless steel (Hypoallergenic), antique finish, and roman gold. In addition, for the electronic industry, there is soft pure gold used for easy solderability, and a hard, bright gold used on printed circuit board tabs, edge connectors, and relay contacts.

There are three basic bath types used to produce these many different gold finishes. Cyanide based chemistries remain popular for the thin, gold flash applications. The pH of these baths may range from 7 to 12, and may be controlled with an on-line pH control system. Waste treatment usually consists of a sophisticated gold recovery system, followed by a cyanide treatment system.

Sulfite baths are also used for gold flash applications instead of cyanide. The pH of these baths will generally be lower than the cyanide baths, and offer the advantage of no cyanide to be separately treated.

Acid gold baths are used primarily for the heavy gold deposits. These require very tight control, and a .25 change in pH or a 3 degree change in temperature can affect the color of the finish produced. The pH of these baths range from 4.0 to 4.8, however on-line pH control has generally not been successful. Treatment of these baths generally consists of gold recovery, followed by acid neutralization.

Variations of the Acid gold baths are generally used in the electronics industry. Very pure gold solutions are used for the soft gold applications for solderability, while small additions of cobalt or nickel will significantly increase the hardness for PC tabs or edge connectors. A new trend in printed circuit production is to gold plate the entire circuit with a soft, pure gold so that components can be soldered onto the surface of the board (surface mount).

## Tin-Lead Plating

Tin-Lead alloy plating is the simplest of all alloy plating systems. Variations of the percentage of both the tin and the lead can significantly change its characteristics, and the applications it is used for. Deposits of 5-12 percent tin are used on bearings. Alloys of 10 to 60 percent are deposited on wire and strip for corrosion protection and preserving solderability. In circuit board production, an alloy of 60-65 percent tin is used as a metal etch resist. For contact surfaces, an alloy of 88 to 98 percent tin is used.

Although Tin-Lead alloys can be plated from several types of solution, the fluoborate solution is most universally used. The pH of these solutions is very low (.5 pH or less) which cannot be controlled using on-line pH control. In addition to problems with strong acid concentration and electrode drift, the solution also contains hydrofluoric acid which will immediately attack and destroy the glass pH electrode. Waste Treatment of these processes should be isolated from other wastes to prevent attack of the pH neutralization measuring system.

Recent developments have been made with a non-fluoborate solution using a base of organic sulfonic acid. Its advantages are that it is less corrosive and has an easier to treat effluent. Some also report that the alloy composition deposited is more uniform. Although not widely in use at this time, the solution does appear promising.

## Zinc Plating

Zinc deposits are used extensively on a variety of nuts, bolts, fasteners and other small parts to achieve corrosion resistance and a bright, attractive finish. It is also common to follow zinc plating with a trivalent chrome plate.

Similar to many of the other metal plating chemistries discussed earlier, Zinc may be plated out of several different chemistries: the highly alkaline (pH > 14) cyanide, the alkaline non-cyanide (pH > 14), an acid Zinc, and a chloride Zinc process. The two most common today are the alkaline non-cyanide and the chloride Zinc.

Zinc was one of the first plating chemistries to convert from a cyanide base to a non-cyanide one. The chemistry remains highly caustic, and on-line pH control of the bath is difficult.

The chloride zinc process is a modification of the acid zinc chemistry, which operates at a less corrosive, higher pH level, and is generally more forgiving. Several variations of the chemistry exist, some based on sodium chloride, while others are based on potassium chloride. The pH of the bath ranges from 4.8 to 5.8, and can be controlled with on-line pH control. The pH of the solution will increase during plating. If the pH is allowed to go too high, the deposit will become dull and brittle. In addition, a sudden formation of turbidity in the tank as a result of zinc salts precipitating will be noticed. Addition of hydrochloric acid is generally used to keep the pH in control.

## Aluminum Anodizing

Anodizing is a process unique to aluminum where the aluminum surface is electrochemically converted to a thick oxide coating. In comparison to the naturally forming oxide which forms on aluminum, the anodized surface is significantly thicker, and harder, with hardness rivaling that of diamond. In addition, abrasion resistance and corrosion resistance are also significantly improved. Finally, the aluminum oxide surface also serves as an electrical insulator which is important for many electrical components.

There are many different chemical solutions which can be used for commercial anodizing. Some of these are: Chromic Acid, Oxalic Acid, Phosphoric Acid, Boric Acid, Sulfuric Acid, Sulfuric/Oxalic Acid, or Organic Acids. The chemistry used will affect the coating thickness, the color, the level of corrosion resistance, and the finished hardness of the oxide. The concentration of acid in any of the baths is generally quite strong, with pH values of less than 1. On-line pH control of these baths has not been successful. Waste treatment consists of metal hydroxide precipitation.

Pretreatment prior to anodizing is very important for a quality anodized surface. This pretreatment generally consists of several cleaning steps to remove organic compounds, machine oil, surface soils, plant dust, etc. prior to anodizing. An alkaline cleaner is common for normal soil; a vapor degreaser prior to the alkaline cleaner may be required if significant amounts of oil exist. Conductivity control of the alkaline cleaner will control the concentration of the cleaner at a nominal value. Rinse tanks following the alkaline clean should be controlled for conductivity to limit the amount of cleaner dragged into the rinse tanks with the plating racks.

Following the pretreatment, and rinse, two steps known as "deoxidation" and

"etch" help to prepare the aluminum surface for a uniform anodic coating. The deoxidation generally is an acid solution which removes any oxide films present. Etching is generally done in a 5% sodium hydroxide solution. Finally, a "desmutt" operation may be used prior to anodizing to remove aluminum alloy metallic constituents. Finally, the aluminum can be anodized. Control of each of these tanks is best completed by laboratory titration of the acids and aluminum concentration.

In some cases, dyeing may follow anodizing. Various water-soluble, organic dye solutions may be used, and on-line pH control of these baths is recommended for optimum performance.

Finally, sealing of the oxide must be completed or the corrosion resistance of the surface will be diminished. Sealing may be done using boiling deionized water, nickel acetate (for dyed coatings), or dichromate for improved corrosion resistance. On-line pH control in the sealing process is recommended for efficient sealing.

## Electroplating Process pH Ranges

Process	pH
Anodizing .....	1
Anodizing Ni seal .....	5
Brass, Bronze .....	9-11
Cadmium .....	12+
Chromium hexavalent .....	1
Copper acid .....	1
Copper cyanide .....	11-13
Copper electroless .....	14
Copper fabricate .....	1
Copper pyrophosphate .....	8-9
Gold acid (Cyanide) .....	3
Gold Cyanide .....	7-12
Lead fluoborate .....	1
Nickel bright .....	3-5
Nickel semibright .....	2-5
Nickel chloride .....	2
Nickel electroless .....	4-11
Nickel sulfamate .....	3-5
Nickel Watts .....	4
Nickel-Iron .....	3.5-4
Palladium .....	9.5
Rhodium acid .....	1
Silver cyanide .....	12
Tin acid .....	0.5
Tin alkaline .....	12
Tin-lead (solder) .....	0.5
Tin-nickel .....	2.5
Zinc acid chloride .....	3-5
Zinc alkaline .....	14
Zinc cyanide .....	14

TABLE—**Electroplating Guidelines**

Limitations for Planters Discharging More Than 10,000 Gallons Per Day To Publicly Owned Treatment Works (POTEs)

<b>Pollutant</b>	<b>Daily Maximum (mg/liter)</b>	<b>Monthly Average*</b>
Cyanide <sup>1</sup>	1.9	1.0
Copper	4.5	2.7
Nickel	4.1	2.6
Chromium <sup>1</sup>	7.0	4.0
Zinc	4.2	2.6
Lead	0.6	0.4
Cadmium	1.2	0.7
Gold	1.2	0.7
Silver	1.2	0.7
Total Metals*	10.5	6.8

\*Copper, nickel, zinc, total chromium.

TABLE—**Concentrations in Effluent: “Metal Finishing” Guidelines**

<b>Pollutant</b>	<b>Daily Maximum</b>	<b>Concentration (mg/liter)</b>	<b>Monthly Average*</b>
TSS**	60		31
Cadmium	0.69		0.26
Cadmium, new source	0.11		0.07
Chromium, total	2.77		1.71
Copper	3.38		2.07
Lead	0.69		0.43
Nickel	3.98		2.38
Zinc	2.61		1.48
Silver	0.43		0.24
Oil and grease	52		26
Total toxic organics	2.13		—
Cyanide, total	1.2		0.65
Cyanide, amenable	0.86		0.32

\*Based upon 10 days sampling.

\*\*Total suspended solids

## Troubleshooting Waste Treatment . . .

TABLE—Pollution-Control System Troubleshooting

PROBLEM	POSSIBLE CAUSE
Erratic or incorrect pH control	<ul style="list-style-type: none"> <li>• pH meter needs calibration.</li> <li>• Malfunctioning pH control meter or probe.</li> <li>• Probe needs cleaning.</li> <li>• Malfunctioning acid or alkali feed.</li> <li>• Depleted supply of acid or alkali waste.</li> <li>• Flow rate greater than system design can accommodate</li> <li>• Intrusion of more acid or alkali than system can accommodate (see malfunction of segregation system—problem and cause).</li> <li>• Inadequate mixing.</li> <li>• Large surges in waste feed.</li> <li>• Rapid or too slow feeding of reacting chemicals.</li> </ul>
Incomplete cyanide destruct	<ul style="list-style-type: none"> <li>• Improper pH control (see above).</li> <li>• Malfunctioning ORP control or probe.</li> <li>• Probe needs cleaning.</li> <li>• Depleted chlorine supply (hypochlorite).</li> <li>• Intrusion of waste that inhibits cyanide destruct (nickel strips, nickel solutions, alkaline descalers, chromates, iron-containing pickles and pickle rinses).</li> <li>• Inadequate mixing.</li> <li>• Intrusion of more cyanide than the system can accommodate.</li> <li>• Over chlorination will lead to an excess of soluble iron cyanides in the final discharge.</li> <li>• Large surges in waste feed.</li> <li>• Rapid or too slow feeding of reacting chemicals.</li> </ul>
Incomplete chromium reduction	<ul style="list-style-type: none"> <li>• Improper pH control (see above).</li> <li>• Malfunctioning ORP control or probe.</li> <li>• Probe needs cleaning.</li> <li>• Depleted supply of reducing chemicals.</li> <li>• Intrusion of waste that inhibits chromium reduction (cyanide, stannate tin, electroless nickel). See malfunctioning of segregation system—problems and possible causes.</li> <li>• Intrusion of more concentrated hexavalent chromium waste than the system can accommodate.</li> <li>• Inadequate mixing.</li> <li>• Large surges in waste food.</li> <li>• Rapid or too slow feeding of reacting chemicals.</li> </ul>
Malfunction of segregation systems (a contaminant present where it should not be)	<ul style="list-style-type: none"> <li>• A leak in a process tank.</li> <li>• Leaking cooling or heating coil.</li> <li>• Leaking pump seal.</li> <li>• Spills—accidental, deliberate, dumps, filter clean out.</li> <li>• Improperly planned process changes.</li> </ul>
Incomplete clarification (high-solids in clarifier overflow)	<ul style="list-style-type: none"> <li>• Improper pH control.</li> <li>• Improper cyanide destruct.</li> <li>• Improper chromium destruction.</li> <li>• Hydraulic overloading.</li> <li>• Improper amount or type of flocculating agent: may fail to assist settling, excess will often cause floating or upset, may interfere with dewatering system.</li> <li>• Clarifier overloaded (filled) with accumulated solids.</li> <li>• Over-chlorinating in cyanide destruct.</li> <li>• Interference from cleaner (rinse).</li> <li>• Improper premixing of flocculant.</li> <li>• Improper adding of flocculant.</li> <li>• Overaged flocculant.</li> <li>• The wrong flocculant.</li> </ul>

## pH Sensor Concerns

The plating industry environment is typically a difficult one for pH electrodes. High temperatures, high concentrations of acids and caustics, and the presence of poisoning ions are all factors which will prematurely age a pH electrode. The SIGNET double junction construction is designed to help reduce these effects. Following recommended installation guidelines, and implementing a good maintenance program can help to provide optimum pH system performance.

The two most critical conditions to insure during installation is (1) that the electrode be installed in a near vertical position ( $\pm 30^\circ$ ) to prevent air entrapment in the glass measuring surface, and (2) that the electrode remains in solution at all times. Always verify that the tank or pipe that the electrode is installed in is not drained below the electrode's position. In piping systems, a low spot can be plumbed to prevent complete drainage.

Avoiding high temperatures and pH extremes is also recommended whenever possible. High temperatures can sometimes be avoided by relocating the sensor in a low flow, cooled recirculating loop around a hot plating tank. pH extremes that occur in batch neutralization tanks can be avoided by leaving some volume of neutralized solution in the tank before concentrated bath dumps are made. This will help to buffer the concentrated dump and prevent the electrode from seeing the concentrated solution.

Velocity past an electrode should be less than 4 fps for bulb style of electrode, or 5 fps with flat style, if the velocity is helping prevent electrode coating. In a tank the electrodes can be protected by installing a half-pipe baffle in front of the electrode. Be careful not to completely block the electrode from seeing rapid changes that may occur in the tank (a sensor in

a pipe with drilled holes is not recommended!)

There are several poisoning ions that may be found in the plating environment. These include: cyanide, ammonia, chlorine and sulfur. In these environments, one must realize that the electrode life will be less than in a "clean" application, however the double junction construction of the SIGNET pH electrodes will greatly extend the electrode's life compared to a conventional single junction design.

## Flow Sensor Materials

<b>MK515-P</b>	<b>Rotor-X Flowsensor:</b>	<b>MK515-V</b>	<b>Rotor-X Flowsensor:</b>
<b>Description</b>	<b>Materials</b>	<b>Description</b>	<b>Materials</b>
Sensor body	Glass Filled Polypropylene	Sensor body	PVDF
Rotor	PVDF	Rotor	PVDF
Axle	Titanium	Axle	Hastelloy C
"O" Ring	Viton®	"O" Ring	Viton®

<b>MK515-t</b>	<b>Rotor-X Flowsensor:</b>
<b>Description</b>	<b>Materials</b>
Sensor body	PVDF
Rotor	PVDF
Axle	PVDF
"O" Ring	Viton®

### MK515 Optional Parts:

<b>Part Number</b>	<b>Description</b>	<b>Notes</b>
M1538-4	Rotor, Tefzel®	Option for chemical compatibility.
P51546	Rotor, Tefzel®	Minimizes rotor & axle wear in non-lubricating liquids.
M1546-3	Axle, Tantalum	Option for chemical compatibility.
M1546-4	Axle, Stainless Steel	Option for chemical compatibility.
P51545	Axle, Alumina Ceramic	Option for chemical compatibility. Abrasion resistant. Caution: brittle during handling.
1224-0021	"O" Ring, EPR	Option for chemical compatibility.
1220-0021	"O" Ring, Kalroz®	Option for chemical compatibility.

### 3-2530.103-P Rotor-X Low Flowsensor:

<b>Description</b>	<b>Materials</b>
Sensor body	Polypropylene
Rotor	PVDF
Axle	Alumina Ceramic
Bearings	Alumina Ceramic
"O" Ring	Viton®

### 3-2530.103-V Rotor-X Low Flowsensor:

<b>Description</b>	<b>Materials</b>
Sensor body	PVDF
Rotor	PVDF
Axle	Alumina Ceramic
Bearings	Alumina Ceramic
"O" Ring	Viton®

### 3-2550 Magmeter:

<b>Description</b>	<b>Material</b>
Sensor body	Stainless Steel
Noise Piece	Teflon®
Electrodes	Stainless Steel

### 3-2530 Optional Parts:

<b>Part Number</b>	<b>Description</b>	<b>Notes</b>
1224-0021	"O" Ring, EPR	Option for chemical compatibility.
1220-0021	"O" Ring, Kalroz®	Option for chemical compatibility.

Aggressive Media				Chemical Resistance										
Medium	Formula	Concentration	Temperature C°	PVC	PP	PVDF (SYGEEF®)	IIR EPDM	FPM	316 SS	Hastelloy C	Titanium	Alumina Ceramic	Tefzel	
Ammonium hydroxide	NH <sub>4</sub> OH	aqueous, cold saturated	20	+	+	0	+	+	+	0	+	+	+	
			40	+	+	0	+	+	+	+	+	+	+	
			60	0	+	—	+	+	+	+	+	+	+	+
			80				+	+	+	+	+	+	+	+
			100				0	0	0	0	0	0	0	0
120														
Boric acid	N <sub>3</sub> BO <sub>3</sub>	aqueous, all	20	+	+	+	+	+	0	+	+	+	+	
			40	+	+	+	+	+	+	+	+	+	+	
			60	0	+	+	+	+	+	+	+	+	+	
			80		+	+	+	+	+	+	+	+	+	+
			100		+	+	+	+	+	+	+	+	+	+
120														
Caustic soda solution	NaOH	up to 10% aqueous	20	+	+	0	+	0	+	0	+	—	+	
			40	+	+	0	+	0	+	+	+	—	+	
			60	0	+	0	+	0	+	+	+	—	+	
			80		+	—	+	+	+	+	+	—	+	
			100		+	—	—	+	+	+	+	—	+	
		120												
		up to 40% aqueous	20	+	+	0	+	0	+	0	0	+	—	+
			40	+	+	0	+	—	+	—	0	+	—	+
			60	0	+	0	+	—	+	—	0	+	—	+
			80		+	—	+	—	+	—	0	+	—	+
			100		+	—	—	+	—	—	0	+	—	+
		120												
		50% aqueous	20	+	+	0	+	—	+	—	0	0	—	+
			40	+	+	0	+	—	+	—	0	0	—	+
			60	+	+	0	+	—	0	—	0	0	—	+
80			+	—	+	—	0	—	0	0	—	+		
100			+	—	—	+	—	—	0	0	—	+		
120														
Chlorine	Cl <sub>2</sub>	moist, 97% gaseous	20	0	—	+	0	+	0	0	0	+	0	
			40			+	+	+	+	+	+	+	0	
			60			+	+	+	+	+	+	+	0	
			80			+	+	+	+	+	+	+	0	
			100			0	+	+	+	+	+	+	0	
		120												
		anhydrous, technically pure	20	0	—	+	0	+	0	+	0	+	+	0
			40			+	+	+	+	+	+	+	+	0
			60			+	+	+	+	+	+	+	+	0
			80			+	+	+	+	+	+	+	+	0
			100			0	+	+	+	+	+	+	+	0
		120												
		liquid, technically pure	20	—	—	+	—	0	—	0	0	+	+	0
			40			+	+	+	+	+	+	+	+	0
			60			+	+	+	+	+	+	+	+	0
80				+	+	+	+	+	+	+	+	0		
100				+	+	+	+	+	+	+	+	0		
120														
Chromic Acid	CrO <sub>3</sub> +H <sub>2</sub> O	up to 50% aqueous	20	+	0	+	0	+	+	+	+	+	+	
			40	+	—	+	0	+	+	+	+	+	+	
			60	0		+	0	+	+	+	+	+	+	
			80			+	+	+	+	+	+	+	+	
			100			+	+	+	+	+	+	+	+	
		120			0	+	+	+	+	+	+	+	+	
		all, aqueous	20	+	0	+	0	+	+	+	+	+	+	+
			40			+	+	+	+	+	+	+	+	+
			60			+	+	+	+	+	+	+	+	+
			80			+	+	+	+	+	+	+	+	+
100				0	+	+	+	+	+	+	+	+		
120														
Chromic acid + sulfuric acid + water	CrO <sub>3</sub> H <sub>2</sub> SO <sub>4</sub> H <sub>2</sub> O	50 g 15 g 35 g	20	+	—	+	0	+	+	+	+	+	+	
			40	+		+	0	+	+	+	+	+	+	
			60	0		+	0	+	+	+	+	+	+	
			80			+	+	+	+	+	+	+	+	
			100			0	+	+	+	+	+	+	+	
			120											

Aggressive Media				Chemical Resistance										
Medium	Formula	Concentration	Temperature C°	PVC	PP	PVDF (SYGFF®)	IIR EPDM	FPM	316 SS	Hastelloy C	Titanium	Alumina Ceramic	Tefzel	
Copper salts		all, aqueous	20	+	+	+	+	+	0	+	+	+	+	
			40	+	0	+	+	+	+	+	+	+	+	
			60	0	—	+	+	+	+	+	+	+	+	
			80			+	+	+	+	+	+	+	+	+
			100			+	+	+	+	+	+	+	+	+
120					+				0	+	+	+		
Formic acid		technically pure	20	+	+	+	+	—	0	+	0	+	+	
			40	0	—	+	+	—	+	+	+	+	+	
			60	—	—	+	+	0	+	+	+	+	+	
			80			+	+				+	+	+	+
			100			+	+							+
120					+							+		
Hydrochloric acid	HCl	5% aqueous	20	+	+	+	+	+	0	0	0	0	+	
			40	+	+	+	+	+	+	+	+	+	+	
			60	0	+	+	+	+	+	+	+	+	+	
			80		0	+	+	+	+	+	+	+	+	+
			100			+	+	+	+	+	+	+	+	+
		120			+	+	+	+	+	+	+	+	+	
		10% aqueous	20	+	+	+	+	+	+	0	0	0	0	+
			40	+	+	+	+	+	+	+	+	+	+	+
			60	0	0	+	+	+	+	+	+	+	+	+
			80		0	+	+	+	+	+	+	+	+	+
			100			+	+	+	+	+	+	+	+	+
		120			+	+	+	+	+	+	+	+	+	
		up to 30% aqueous	20	+	+	+	+	+	+	0	0	0	—	+
			40	+	0	+	+	+	+	0	0	0	—	+
			60	0	0	+	+	+	+	0	0	0	—	+
80			—	+	+	+	+	0	0	0	—	+		
100				+	+	+	+	0	0	0	—	+		
120					+							+		
36% aqueous	20	+	+	+	+	+	+	0	0	0	—	+		
	40	+	0	+	+	+	+	0	0	0	—	+		
	60	0	—	+	+	+	+	—	—	—	—	+		
	80			+	+	+	+	—	—	—	—	+		
	100			+	+	+	+	—	—	—	—	+		
120					+							+		
Hydrofluoric acid	HF	up to 40% aqueous	20	+	+	+	—	+	—	+	+	—	+	
			40	0	+	+	—	+	+	—	+	—	+	
			60	0	+	+	—	0	+	—	+	—	+	
			80			+	—	+	+	—	+	—	+	
			100			+	—	+	+	—	+	—	+	
		120					+						+	
		50% aqueous	20	+	+	+	—	+	—	—	0	—	—	+
			40		+	+	—	+	—	—	0	—	—	+
			60		+	+	—	+	—	—	0	—	—	+
			80			+	—	+	—	—	0	—	—	+
			100			+	—	+	—	—	0	—	—	+
		120					+						+	
		70% aqueous	20	+	+	+	—	+	—	—	0	—	—	+
			40		+	+	—	+	—	—	0	—	—	+
			60			+	—	+	—	—	0	—	—	+
80				+	—	+	—	—	0	—	—	+		
100				+	—	+	—	—	0	—	—	+		
120					+						+			
Mixed acids (sulfuric, nitric, water)	H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> H <sub>2</sub> O	48% 49% 3%	20	+	—	+	0	—						
			40	0	—	+	0	—						
			60			+	0	—						
			80			+	0	—						
			100			+	0	—						
	120					+	0	—						
	H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> H <sub>2</sub> O	50% 50% 0%	20	0	—	+	0	—						
			40			+	0	—						
			60			+	0	—						
			80			+	0	—						
100					+	0	—							
120					+	0	—							

Aggressive Media				Chemical Resistance										
Medium	Formula	Concentration	Temperature C°	PVC	PP	PVDF (SYGEE®)	IIR EPDM	FPM	316 SS	Hastelloy C	Titanium	Alumina Ceramic	Tefzel	
Mixed acids (con't) (sulfuric, nitric, water)	H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> H <sub>2</sub> O	10% 87% 3%	20	0	—	0	—	—						
			40											
			60											
			80											
			100											
	H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> H <sub>2</sub> O	50% 31% 19%	20	+	—	+	0	+						
			40											
			60											
			80											
			100											
	H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> H <sub>2</sub> O	50% 33% 17%	20	+	—	+	0	+						
			40	0										
60														
80														
100														
H <sub>2</sub> SO <sub>4</sub> HNO <sub>3</sub> H <sub>2</sub> O	10% 20% 70%	20	+	—	+	+	+							
		40	+		+	+	+							
		60			+	+	+							
		80			+	+	+							
		100			+	+	+							
Mixed acids (nitric hydrofluoric, sulfuric)	15% pure HNO <sub>3</sub> 5% pure HF 18% pure H <sub>2</sub> SO <sub>4</sub>	3 parts 1 part 2 parts	20	0	—	+	+	+						
			40			+	0	0						
			60			+								
			80			+								
			100											
Mixed acids (sulfuric, phosphoric, water)	H <sub>2</sub> SO <sub>4</sub> H <sub>3</sub> PO <sub>4</sub> H <sub>2</sub> O	30% 60% 10%	20	+	+	+	+	+						
			40	+	0	+	+	+						
			60			+	+	+						
			80			+	+	+						
			100											
Nickel salts		cold saturated, aqueous	20	+	+	+	+	+	0	0	+	+	+	
			40	+	+	+	+	+						
			60	0	+	+	+	+						
			80			+	+	+						
			100			+	+	+						
Nitric acid	HNO <sub>3</sub>	6.3%, aqueous	20	+	+	+	+	+	0	+	+	+		
			40	+		+	+	+						
			60	+	0	+	0	0						
			80			+	+	+						
			100			+								
		up to 40%, aqueous	20	+	0	+	+	+	+	+	+	+	+	
			40	+	—	+	+	+	+	+	+	+	+	
			60	0		+	0	0	+	+	+	+	+	
			80			+	+	+						
			100			+								
		65%, aqueous	20	0	—	+	—	+	+	+	+	+	+	+
			40	0		+		+	+	+	+	+	+	+
			60			+		+	+	+	+	+	+	+
			80			+		+	+	+	+	+	+	+
			100			+		+						
100%, aqueous	20		—	—	—	—	—	—	+	+	+	+		
	40								+	+	+	+		
	60								+	+	+	+		
	80								+	+	+	+		
	100								+	+	+	+		

Aggressive Media				Chemical Resistance											
Medium	Formula	Concentration	Temperature C°	PVC	PP	PVDF (SYGEP®)	IIR EPDM	FPM	316 SS	Hastelloy C	Titanium	Alumina Ceramic	Tefzel		
Oxalic acid	COOH   COOH	cold saturated, aqueous	20	+	+	+	0	+	—	—	—	+	+		
			40	+	+	+	0	+	—	—	—	+	+		
			60	+	+	0	—	—	—	—	—	—	+	+	
			80											+	+
			100											+	+
120												+	+		
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	up to 30%, aqueous	20	+	+	+	+	+	+	+	0	+	+		
			40	+	+	+	+	+	+	+	+	+	+		
			60	0	+	+	+	+	+	+	+	+	+		
			80		+	+	+	+	+	+	+	+	+	+	
			100					0	+	+	+	+	+	+	
		120											+	+	
		50%, aqueous	20	+	+	+	+	+	+	+	+	+	0	+	+
			40	+	+	+	+	+	+	+	+	+	+	+	+
			60	+	+	+	+	+	+	+	+	+	+	+	+
			80					0	+	+	+	+	+	+	+
			100							0	+	+	+	+	+
		120												+	+
		85%, aqueous	20	+	+	+	+	+	+	+	+	+	0	+	+
			40	+	+	+	+	+	+	+	+	+	+	+	+
			60	+	+	+	+	+	+	+	+	+	+	+	+
80							0	+	+	+	+	+	+		
100								0	+	+	+	+	+		
120												+	+		
Sodium sulphite	Na <sub>2</sub> SO <sub>3</sub>	cold saturated, aqueous	20	+	+	+	+	+	+	0	+	+	+		
			40	+	+	+	+	+	+	+	+	+	+		
			60	0	+	+	+	+	+	+	+	+	+		
			80											+	+
			100											+	+
120												+	+		
Sulfuric acid	H <sub>2</sub> SO <sub>4</sub>	up to 40%, aqueous	20	+	+	+	+	+	—	—	—	+	+		
			40	+	+	+	+	+	—	—	—	—	+	+	
			60	0	+	+	+	+	—	—	—	—	+	+	
			80											+	+
			100											+	+
		120												+	+
		up to 60%, aqueous	20	+	+	+	+	+	+	+	—	—	—	+	+
			40	+	+	+	+	+	+	+	—	—	—	+	+
			60	+	+	+	+	+	+	+	—	—	—	+	+
			80											+	+
			100											+	+
		120												+	+
		up to 80%, aqueous	20	+	+	+	+	+	+	+	—	—	—	+	+
			40	+	+	+	+	+	+	+	—	—	—	+	+
			60	+	0	+	+	+	+	+	—	—	—	+	+
80												+	+		
100												+	+		
120												+	+		
90%, aqueous	20	+	0	+	+	+	+	+	—	—	—	+	+		
	40	+							—	—	—	+	+		
	60											+	+		
	80											+	+		
	100											+	+		
120												+	+		