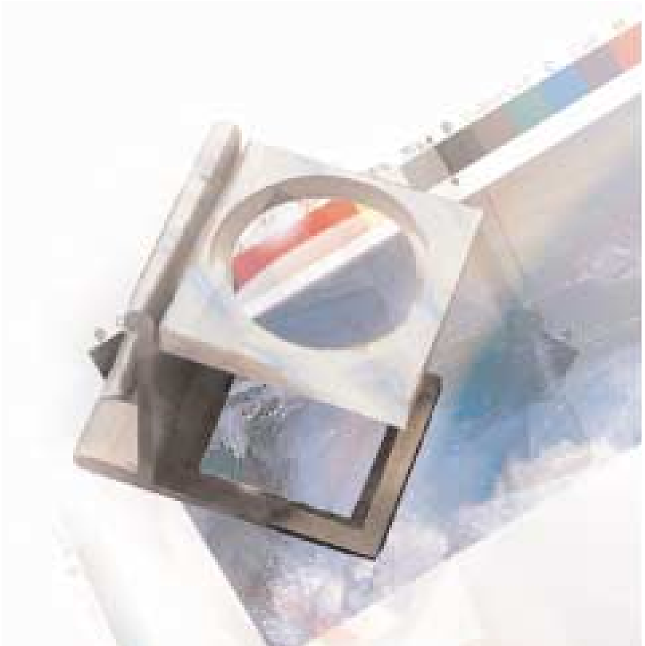

FUJI HUNT PHOTOGRAPHIC CHEMICALS, INC.

HEADQUARTERS

40 Boroline Road
Allendale, NJ 07401
Tel: 201.995.2200
Fax: 201.995.2299
www.fujihuntusa.com

MANUFACTURING FACILITY

50 Industrial Loop North
Orange Park, FL 32073
Tel: 904.264.3500
Fax: 904.278.9697
www.anchorlith.com

FUJI HUNT
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WATER, PH AND CONDUCTIVITY FOR PRINTERS

FUJI HUNT
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INTRODUCTION

Our technical staff recognizes the need to provide helpful information for pressmen and pressroom managers.

Water chemistry is an important variable in the lithographic process. By developing an improved understanding of fountain chemistry, you will be better able to control the printing process, select the optimum products for your application and diagnose problems that you encounter.

We hope you find this guide to be interesting and instructive.

If you have any questions or comments, please feel free to call or contact us.

Technical Staff
Fuji Hunt Photographic Chemicals, Inc.
50 Industrial Loop North
Orange Park, Florida 32073
800.354.2300 or 904.264.3500
www.fujihuntusa.com | www.anchorlith.com

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This is a primer for printers; it is not taken from a college chemistry book nor is it intended for chemists. There are some over-simplifications and generalizations, but that makes it easier for you to understand and use "Water Chemistry."

While the lithographic process consumes fairly large quantities of water, most printers do not think of it as a raw material. You should! Lithography is both chemical and physical, and the type of water you are using will affect the printing process.

Water is water—yes or no? The answer is yes, but what is dissolved in your water is quite variable and very important. If you look at what has happened to the water from the time it was "pure" rain (distilled) to "tap," you can get some idea about what it may contain. Was it run off from agricultural fields, snow that melted into a reservoir, or perhaps it percolated through limestone to become deep well or spring water? Each of these histories will impart a definite character to the water.

pH

pH is a number that describes the number of acid ions (hydrogen ions) present in water. Pure water has a pH of 7.0. This means that the water contains $1x10^{-7}$ moles of hydrogen ions per liter. You can see that working with the pH is much easier than using the concentration numbers. As the pH decreases by one unit, the acid ions increase by a factor of ten. pH 4 is mildly acid, while pH 2 and below is strongly acid. pHs greater than 7 are referred to as alkaline solutions.

TERMS OF WATER CHEMISTRY

HARDNESS

Total Hardness of water is the sum of the dissolved metal ions. Metals are primarily introduced from dissolving rock. Common metals would be magnesium, sodium, calcium, and iron. The level of each of the metals depends on what types of minerals have dissolved into the water. Geographical location is an indicator of what type of water to expect. Calcium is of special concern, because it can cause problems like toning, short plate life, or roller glazing.

ALKALINITY

Total Alkalinity—think of the alkalinity of water as the ability to neutralize the acid in the fountain solution. Your working pH is determined largely by the buffer system the chemist has picked and the alkalinity of the water, NOT by the concentration (ounces per gallon) of etch you are using. Often alkalinity and hardness are thought of together because "hard" water is also usually alkaline.

Here is the reason. As water slowly filters down through common limestone rock, the calcium and magnesium carbonate ($MgCO^3$ and $CaCO^3$) minerals dissolve into the water. The magnesium (Mg^{++}) and calcium (Ca^{++}) ions then make up the hardness, while the carbonate ($CO^{3=}$) is the alkalinity.

CONDUCTIVITY

Conductivity is the ability of a water solution to conduct electricity. It is a measure of how much (not what) material is dissolved in water. Conductivity alone is not adequate to characterize the water. More will be said about this topic later.

You will be interested to understand the effects that these various dissolved chemicals may have on the printing process.

ALKALINITY ALTERS pH

First, and most noticeable, is the effect alkalinity has on the working pH. As the alkalinity increases, the pH of your working solution will rise. To compensate for alkaline water, you will need to use a more acidic fountain solution. You may be wondering why not simply use more or less "etch?" Most modern fountain solutions are "buffered" and using more will not generally change the pH very drastically. Even if you can obtain the pH you want, there will be undesirable side effects caused by over or under use.

A survey indicated that most heatset processes operate best at pH 3.6 to 3.8 (in the fresh solution). Starting with the pH slightly on the low side will tend to compensate for the effects of contamination from paper, ink, plate cleaners, etc. This range offers good chemical cleaning of the non-image while not causing any plate deterioration.

Sheetfed printers generally prefer to run at pHs near 4.0. This will desensitize and prevent any retardation of the drying reaction due to excessive acid content in the printed ink. This "oxidative" drying is very similar to that of oil-based paints, and if the pH (acid content) of the printed ink is below 3.6, there may be some increase in the drying time.

IMPACT OF METALS

Consider now the impact of the metals that cause hardness—most commonly magnesium, iron, and calcium.

The magnesium is no problem and is even an occasional fountain solution ingredient.

Iron can be a real problem, causing corrosion in the background of the plates. The citric acid buffer system frequently used today will tie up some iron and should prevent problems. If your water is very high in iron, you may want to consider water treatment.

Calcium is the common "hardness" metal that can plague the lithographic chemical process. The positively charged calcium ions (Ca^{++}) will react with negative ions from the fountain solution like phosphate ($PO^{4=}$) or citrate and, in effect, rob the working solution of ingredients. Calcium also reacts with other materials to form what are called insoluble "calcium soaps." These compounds can be deposited onto plates, rollers or blankets causing glazing, toning in non-image areas, plate blinding and numerous other problems. The fountain solution chemist should include ingredients that tend to prevent these calcium symptoms when he designs products for hard water.

Alkaline coated papers and certain red pigments can be an additional source of calcium, making the situation worse. If you will be running alkaline paper frequently or having magenta problems, consult your suppliers.

Water treatment has become a topic of interest to many printers these days. Considerable confusion exists about when it is needed and what the various systems are capable of.

WHEN TO TREAT YOUR WATER

Several situations make good candidates for treatment:

- The water company uses a number of sources for their water (e.g., wells and a reservoir) that have significantly different conductivity, alkalinity, or hardness.
- The water has large seasonal variations.
- The conductivity is greater than 500 mmhos.
- The water is very hard (more than 15 grains per gallon alkalinity or hardness).
- The conductivity varies by more than 200 mmhos daily.

TREATMENT SYSTEMS

Softening is an ion-exchange process that trades sodium (from salt) for the hardness metals. There is no change of alkalinity or conductivity, but softening will prevent "calcium symptoms." Because softening does not control alkalinity or conductivity, your process is still subject to variations from the water. These appear as changes in the pH and conductivity of the press-ready solution. It is the least expensive system, but is not very popular today.

Deionizing removes all ions and produces very pure water. This approach is perfectly suitable for lithography, however the logistics are often prohibitive. Systems may be either the returnable tanks or a self-regenerating unit at your plant. The ease of the returnable tanks makes them a cost-effective answer for smaller sheetfed printers. The capacity of one returnable tank is somewhere around 1,000 gallons depending on the water—at a cost of perhaps $100.

WATER TREATMENT

TREATMENT SYSTEMS —*continued*

The self-regenerating units recharge themselves at regular intervals similar to a water softener, but require concentrated acid and caustic soda. Their complexity effectively prohibits use at all but the largest of plants.

Reverse Osmosis is a simple mechanical process that "squeezes" water through a membrane. The undesired mineral content is wasted to the drain with a portion of the water used. RO systems consist of a high-pressure pump, a membrane unit, and a storage tank. These units can be sized anywhere from a home unit (100 gallons per day) to large units that will produce hundreds of gallons per hour. Simplicity, reliability, small physical size, and low cost make these attractive to any printer requiring water treatment.

BENEFITS—REAL OR IMAGINED

Generally there are no "miracle" benefits like a 50% reduction in the use of fountain concentrate, instant alcohol elimination, or greatly improved print quality from using RO or DI water.

However, there are two very real benefits. The first is process consistency. The water becomes one more item that you control and you monitor. It does not change. The second is elimination of the undesirable side effects of the hardness metals. Water can become one more controlled variable that leads to optimum print quality and consistency.

Thus far, the chemical parameters of water and the three types of water treatment systems have been covered.

SUMMARY OF WATER DATA

CLASSIFICATION OF TAP WATER

Water Type	Conductivity mmhos	Alkalinity grains/gal.	Hardness grains/gal.
Soft	0 - 200	0 - 6	0 - 6
Medium	200 - 400	7 - 11	7 - 11
Hard	400 - 550	12 - 15	12 - 15
Very Hard	> 550	> 15	> 15

These are only generalizations and, to be accurate, you should obtain a water analysis. This will ensure the optimum complement of water and other fountain chemistry.

CHARACTERISTICS OF TREATED WATER

Each treatment system will modify the raw water in a specific way. The following table shows what changes to expect:

System	Conductivity % reduction	Alkalinity % removal	Hardness % removal
Softening	No Change	No Change	95%
Deionizing	100%	100%	100%
RO	90 - 95%	90 - 95%	90 - 95%

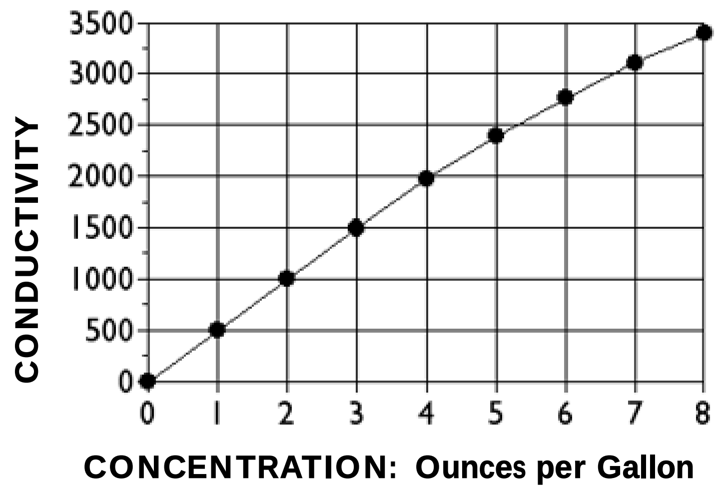
This concludes the discussion of the chemistry of incoming water. For additional information, consult your water company, fountain solution supplier, or local technical library. The next topic is how to use this information to tell what is happening on press.

The relationship of conductivity, pH, and printing is not generally well understood. Conductivity is the newer and preferable method of monitoring fountain solution performance. pH, however, is still an important factor in sensitivity, plate life, ink drying, etc., and should be checked regularly.

CONDUCTIVITY AND pH ON PRESS

CONDUCTIVITY

Conductivity is the ability of a solution to conduct electricity. Small electrically-charged particles called ions can carry an electric current through water solutions. These ions primarily come from the acids and salts in the fountain solution. As more fountain concentrate is added to the water, the number of ions goes up and so does the conductivity.



Notice how the curve is nearly straight until the concentration gets high. This near linear relationship allows you to easily match a conductivity to a specific concentration. **No guessing involved**.

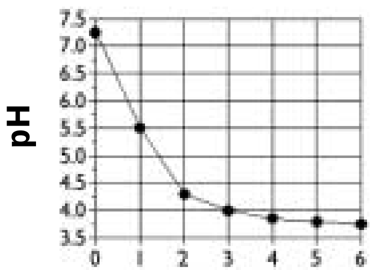
Most modern solutions will run well at conductivities between 1000 and 2500 mmhos above the conductivity of the water. These numbers represent the lower and upper concentrations of salts and acids that generally work best.

pH

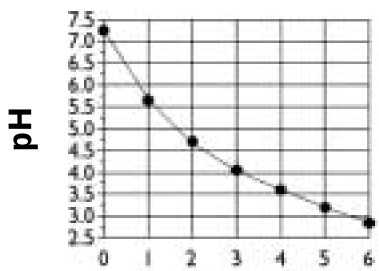
pH has already been defined as a convenient way of expressing the number of hydrogen (acid) ions in a solution. The pH 4.0 range was found to be near optimum when using gum arabic and aluminum plates. This mild acid solution gently etches the plate and activates the gum molecules for maximum adhesion to the plate background. Keeping the pH near 4.0 will also prevent any chemical problems with ink drying.

pH BUFFERS

Buffered solutions resist changes in pH from the effects of varying alkalinity of water, ounces per gallon used, or contaminants. Look at the next two graphs. On the left, a buffered solution; on the right, an older design which was poorly buffered.



Ounces per gal.
BUFFERED



Ounces per gal.
NON-BUFFERED

Notice that the buffered curve flattens out near pH 4.0 and then changes only slowly. On the right, notice that the pH is not very stable as more concentrate is added—the pH just keeps going down.

BENEFITS OF BUFFERED SOLUTIONS

Simply stated, buffered solutions are better because they tend to stabilize pH in the working solution in spite of changing conditions. There are a number of important reasons to provide a constant pH.

1. Moderate changes in the amount of fountain concentrate used will not produce radical changes in pH.
2. These solutions tend to resist the effects of acid or alkaline contamination from paper, ink, plate cleaners, etc.
3. They require less attention from the pressman to maintain a good printing pH.
4. A constant pH, at the desired level, will maintain optimum desensitizing.

The material thus far has only been preparation for the important topic—What does all this really have to do with printing?

CONDUCTIVITY AS A QC TOOL

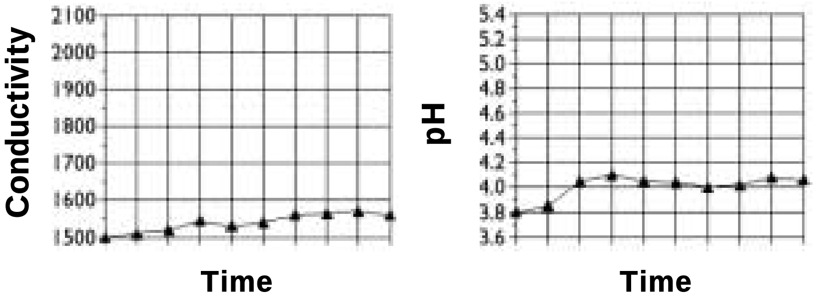
Conductivity is your QC tool to tell how much etch is being run. This is important to monitor because automatic blenders do foul up and press helpers do make mistakes from time to time. Run too weak—poor plate restarts or scum are likely. Run too strong—you'll have ink emulsification, blinding/stripping, or poor print quality.

It is also the tool to tell what is happening with your fountain chemistry. An "in-control" process will show small fluctuations in conductivity and pH as the working solution picks up minor amounts of contaminants. Fresh solution is keeping these values close to their starting points.

The opposite "out-of-control" fountain solution shows large changes in pH and conductivity as the contamination overwhelms the fountain solution. When this happens, the only choice is to eventually dump the tanks and start over with fresh solution.

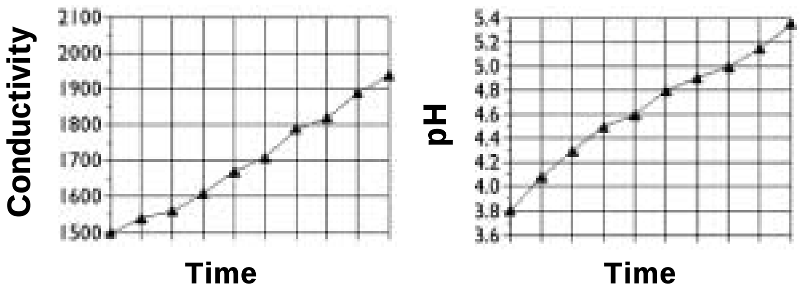
MONITORING

The following graphs show monitoring pH and conductivity as a function of time.



"IN-CONTROL" SITUATION

Notice that the pH and conductivity rise slightly after a few hours and then level off to a fairly constant value. This is very normal and represents minor contamination.



"OUT-OF-CONTROL" SITUATION

These two graphs represent a drastic contamination situation. The conductivity, and probably pH, keeps on rising rapidly. Thus, the level of contamination is increasing faster than fresh solution is being added.

CONTAMINATION

If there are problems with sensitivity or poor print quality and you have detected a bad contamination situation, the only immediate option is to dump the tanks. This is a temporary measure and you must investigate and eliminate the source as quickly as possible. By all means, contact paper, ink, and fountain solution suppliers and be prepared to discuss the following information:

1. Water data, pH, and conductivity of fresh solution.
2. Data showing how the working solution is changing.
3. If you have individual circulators, which units are a problem.
4. Printing symptoms, if any.
5. Use of fountain additives—what, how much, and how often.
6. If a particular stock is a problem, the pH of that paper. Use a paper pH pen to determine.
7. Use of plate cleaners—which ones and how often used.

pH EFFECTS

The pH of your fountain solution will affect the printing process in a number of ways:

1. Acids (pH range of 3.6 to 4.5) will gently etch the plate surface and keep it water-loving (hydrophilic). They act like mild detergents and prevent ink or oily soil from building up.

2. Too hot a pH (less than 3.5) will over etch the plate surface and can actually cause ink sensitivity.

INTERPRETATION OF RESULTS

pH EFFECTS *—continued*

3. Low pH will retard oxidative drying (not heat-setting) of inks (both sheetfed and web). This does not generally occur until below pH 3.5. The ovens on heatset presses remove the emulsified water and allow running a lower pH on webs than on sheetfed.

4. If the pH drifts to the high side (4.5 to 5.5) you may notice some loss of desensitizing. The etching has become too weak, so consider switching to the next lower pH range fountain solution.

SUMMARY

You have learned the nomenclature of water chemistry and the effects of alkalinity and hardness, grouped water by types, which water treatment systems are available, and what they will do for you. Also covered were the valuable tools available for establishing process control of the fountain and interpreting the results.

This has been a lot of information to digest; however, the whole process is really not that complicated:

- Test and continue to monitor your incoming water.
- Work with your fountain solution supplier to get a good match of water and etch.
- Carefully make up one gallon of press-ready solution at the concentration you plan to run, say 3 to 4 ounces per gallon, and record the mixed solution conductivity and pH. You can then compare your "control" data to on-press conditions.
- Minimize the use of fountain additives that can throw your process out of control. Correctly formulated, modern products will run without additional help.
- Establish a regular monitoring program for your fountain chemistry. This will tell you exactly what is happening on press, and you will be prepared to discuss press chemistry with your fountain solution, ink, or plate suppliers in the event of trouble.