

Fountain Solutions, pH and Conductivity

BACKGROUND

People with only a passing familiarity with the offset printing process have probably heard the phrase, “ink and water,” often in the context of a pressroom problem. When Senefelder discovered the lithographic process in 1798, he found that the secret of keeping ink in the image area of the printing “plate,” or in his day the lithographic stone, was to have a thin film of water in those areas where ink was not wanted. The presence of a very thin film of water in these so-called non-image areas was sufficient to prevent ink from being transferred to the plate from the inking rollers. How we create image and non-image areas is not the purpose of this bulletin. Rather we want to discuss the “water” used in the process, for it is not pure water but a dilute chemical solution that makes the process work as well as it does.

The chemical solution, usually called the dampening or fountain solution, or fount in Europe, historically was a dilute solution containing phosphoric acid and gum arabic. In fact, it was Senefelder who discovered the benefits of the components and to this day very few, if any, superior replacements have been found in spite of all the changes and improvements made in the lithographic process itself.

FOUNTAIN SOLUTION COMPOSITION

Modern fountain solutions generally consist of a concentrated solution of chemicals that are diluted, in the pressroom, to the working concentration. Typically, we might add one to six ounces of concentrate to a gallon of water. The extent of the dilution varies depending on the actual concentration of the chemicals in the concentrated solution.

While we most often encounter acid-based fountain solutions, there are also neutral and alkaline-based solutions used in certain industry segments, specifically the non-heat web offset markets such as newspaper printing. Our discussion here will concentrate on the acid systems.

Table 1 shows the typical acid fountain solution composition. Phosphoric acid has always had a unique role in fountain solution chemistry, but it has also been cited as a possible cause of catalyst poisoning in the afterburners of web offset press ovens. For that reason, alternatives such as citric acid are used.

What keeps the non-image area water receptive is the presence of a chemical known as a desensitizer—gum arabic has proven to be the best over time. It works best in an acidic environment, hence the reason for having the phosphoric, or other acid present.

Buffering agents are materials that help keep the acidity, as measured by the pH of the solution, at a fixed value, regardless of its concentration. We’ll come to this important concept in just a moment.

Corrosion inhibitors are necessary because the dampening solution can be very aggressive toward metal parts on the press and supporting equipment. Likewise, bactericides are necessary in order to prevent unwanted bacterial and algae growth in the dampening system. This is especially critical in solutions that are neutral or alkaline in pH.

The wetting agent is a rather recent addition to the mix. At one time, it was found necessary to add

alcohol, typically isopropyl alcohol (isopropanol), to the diluted solution such that the resultant mix contained anywhere from 5%-25% alcohol. The purpose in doing this was to improve the ability of the solution to “wet out” the dampening rollers and non-image areas of the printing plates. Because of insurance concerns (the alcohol is very flammable), alcohol is rarely used in North America, at least at the high concentrations formerly used. Other chemicals, known as wetting agents, are now used and may be present either in the fountain solution concentrate itself, or added to the diluted solution at press-side. Some wetting agents have been known to create foam problems in the circulation system, hence “defoamers” might also be found in the fountain solution concentrate.

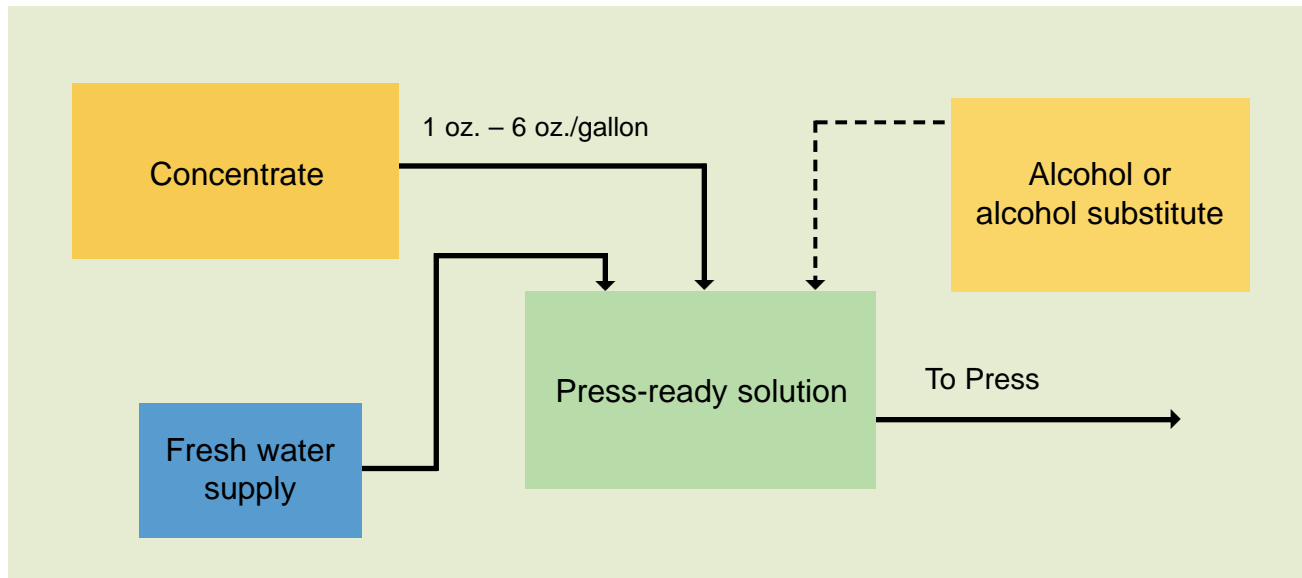
In many pressrooms, all the dilutions and additions generally take place automatically. **Figure 1** depicts the process. The amount of concentrate to use (typically between 1 – 6 ounces/gallon) is determined by the composition of the fountain solution. When alcohol was being used it was always added

separately because so much was required that it could not be “packed into” the fountain solution concentrate. Since there were two additions or steps required, this was called a “Two Step” fountain solution. When alcohol substitutes or replacements were introduced, it was often found that lesser amounts were needed, and it was possible to squeeze it into the concentrate itself. These solutions became known as “One Step” solutions. Everything was in one container, which simplified the mixing equipment, but more of the concentrate was required. One Step or Two, it doesn’t matter. What is important, and is often overlooked, is that the concentration of all the active ingredients must be maintained at the proper level. **“Over-dosing,” particularly with a One Step solution, to correct one problem, will likely create additional problems because the other components will then be present at elevated concentrations.**

We mentioned earlier that the main desensitizing agent, gum arabic, is most effective at maintaining acidic pH values. What is pH? To a chemist, “pH” is the negative logarithm of the hydrogen ion

Table 1. Typical components in an acid fountain solution

| | |
|-----------------------------|---|
| Acid | - the basis for most fountain solutions and one that provides the best environment for the desensitizer (often gum arabic) to work; often phosphoric acid but others, such as citric, are also used |
| Desensitizer | - to keep the non-image area water receptive (gum arabic is still the desensitizer of choice) |
| Buffering agents | - to help stabilize the pH of the solution |
| Corrosion inhibitors | - to prevent corrosion of metal components on the press |
| Bactericides | - to prevent the growth of bacteria and algae in the dampening system |
| Wetting agents | - to help the solution “wet” the non-image area of the plate |
| Defoamers | - to minimize/eliminate foam in the circulating system |

Figure 1. Automatic fountain solution mix

concentration. To the non-chemist, however, it is an indicator of how “acidic” a solution is. **Figure 2** shows how the pH scale works.

Water contains positively charged hydrogen ions (H^+) and negatively charged hydroxyl ions (OH^-). Ions are simply atoms or molecules that are electrically charged. When the $pH = 7$, there is an equal number of each, and we say that the water has a neutral pH. However, if there are more hydrogen ions than hydroxyl ions, $H^+ > OH^-$, then the water is considered acidic (if $OH^- > H^+$, then the water is alkaline). The greater the ratio, the more acidic (or alkaline) the water.

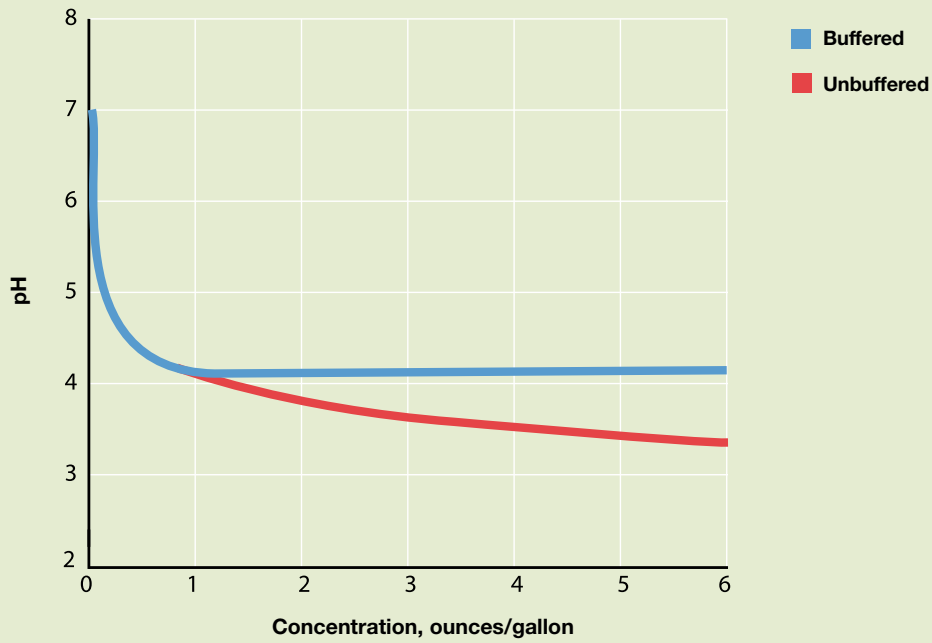
Note that on the pH scale a solution with $pH = 4$ is 10 times more acidic (it has 10x the concentration of hydrogen ions) than a solution with $pH = 5$, and so on, thus the logarithmic function in the pH definition.

Figure 3 shows how the pH of a hypothetical fountain solution would change as its concentration is increased. In the graphic arts, it is customary to refer to the concentration in terms of ounces of concentrate per gallon of diluted solution (ounces/gallon). The region where gum arabic is most effective is around $pH = 4 - 4.5$. By increasing the

Figure 2. Concentration, in moles/liter of hydrogen and hydroxyl ions, and their relationship to pH

| Concentration and pH | | | |
|----------------------|-----|-------------|-----|
| OH^- | 0.1 | 0.000000001 | ~0 |
| pH | | | |
| H^+ | ~0 | 0.000000001 | 0.1 |

Figure 3. Differences between regular and buffered fountain solutions



concentration we not only increase the gum arabic concentration, we also cause the pH to decrease, perhaps to an excessively low level. As the pH becomes too low, we can dissolve carbonate in the paper's coating.

This is where the concept of "buffered" solutions comes into play. By adjusting the chemistry of the solution, it is possible to ensure that the pH of the solution stays fairly constant, regardless of the concentration of the fountain solution concentrate. This effect is also depicted in **Figure 3**. Buffering agents keep the pH constant, in spite of contamination by materials from both the ink and paper that would alter the pH of an unbuffered solution.

Although buffered fountain solutions offered the advantage of a controlled pH, they created a new problem. Historically, a pressman would check the pH of the solution and, by knowing the pH could be

fairly confident that the proper numbers of ounces per gallon of etch (also known as fountain solution concentrate) were present. With buffered solutions, pH was no longer a reliable measure of concentration. To overcome this, an alternative methodology was sought, and in 1976, the use of conductivity measurements was introduced¹.

Conductivity refers to the electrical conductivity (the opposite of electrical resistance) of the solution. Solutions that contain dissolved ions conduct electricity—the more ions the higher the conductivity. These ions come not only from the hydrogen ions, but other materials present in the fountain solution. **Figure 4** depicts the general relationship between etch concentration, pH and electrical conductivity.

As can be seen, the change in conductivity with etch concentration is linear, thus making it an ideal tool for checking the concentration of etch. **The pH of the**

Figure 4. Typical changes in pH and conductivity for an acid etch

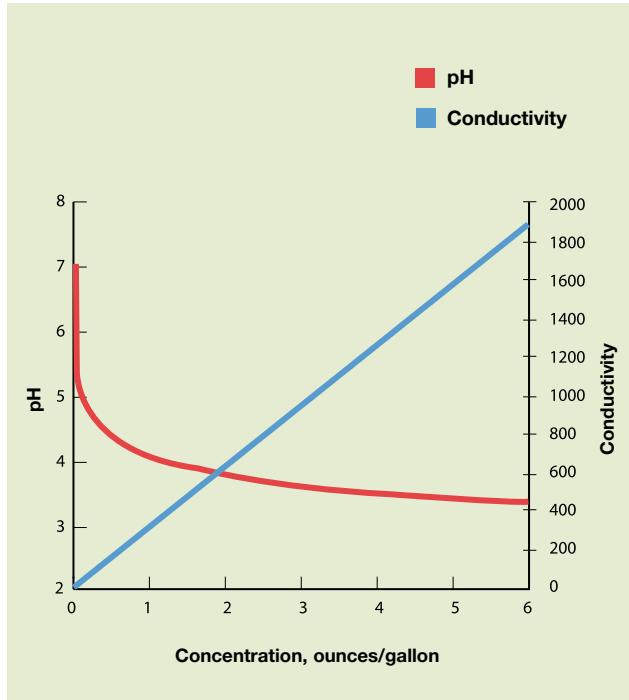
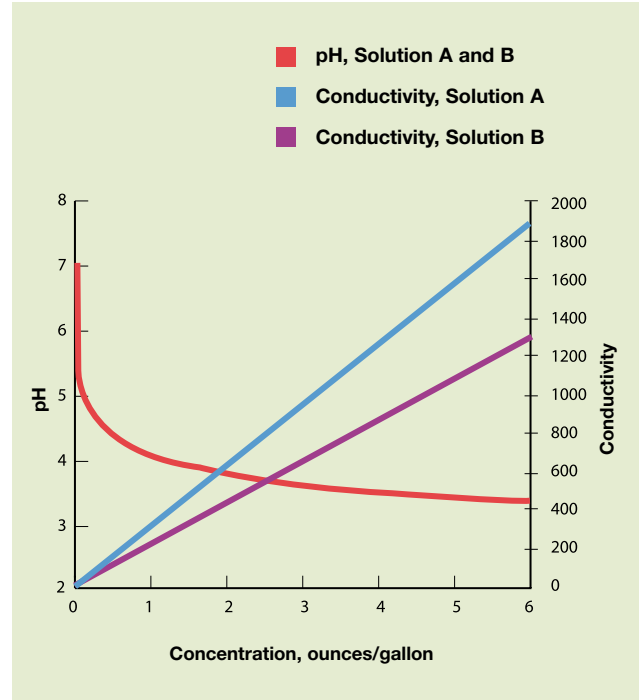


Figure 5. Typical changes in pH/ conductivity with concentration, two different solutions



solution is still important, however, and needs to be checked as well.

Fountain solution manufacturers have many materials at their disposal when it comes to formulating their products. Each of these components may contribute to the overall electrical conductivity of the solution in its own way, thus it is important to remember that the conductivity of the solution is only important insofar as it relates to the concentration of the etch. There is no "magic" value for conductivity as there is

for pH. As shown in **Figure 5**, it is quite possible to formulate two fountain solutions having similar pH-concentration characteristics but different conductivity-concentration curves.

Understanding how all the pieces fit together will make clear why both the pH and the conductivity of the fountain solution are important.

¹ Bates, J. B., and Blom, B. E., "Accurately monitoring concentration of alkaline fountain solutions," Newspaper Production, 5(7), 20-25 (1976).

Frequently Asked Questions

1. Is it true they still use alcohol (isopropyl alcohol) at fairly high levels in European pressrooms?

The answer is “yes” but this is changing. Environmental, health and safety regulations forced North American pressrooms to find alternatives to alcohol many years ago. Europe has been slow in adopting these changes primarily because the use of alcohol in the fountain solution was extremely helpful, and the regulatory climate did not discourage its use. Again, this is changing.

2. I've been told to make sure the conductivity of my etch stays between 1500 – 2000. Is this correct?

No. As explained earlier, there is no magic value for the conductivity reading. Different etches, being used at their proper levels, can give different conductivity readings. The conductivity reading is only to be used to ensure that the proper concentration of etch is present. In order to do this, you need to have a calibration curve, showing the conductivity versus concentration, prepared for each etch and dilution water combination. The pH is still important, however.

3. What happens if the pH of the fountain solution is too low?

In the case of sheetfed printing inks that undergo a chemical reaction as they dry, an excessively low pH (< 3.5) can interfere with the chemical reaction and prevent ink drying.

Below pH = 4, calcium carbonate, used in many of our paper coatings, can dissolve. The problem is aggravated as the pH gets lower and can be worsened by certain fountain solution components.

4. If calcium carbonate were dissolved into the fountain solution, would the pH begin to rise?

Yes, if the fountain solution were not “buffered.” On the other hand, if the fountain solution were buffered, the calcium carbonate contamination would not increase the pH of the solution unless the absorption capacity of the buffer were reached. As discussed earlier, the buffering agent serves to keep the pH fairly constant in the presence of contaminants.

5. I haven't heard that there are any problems in Europe, where they have been running high carbonate coating for many years. Why is this?

European fountain solutions tend to run around pH = 5, as opposed to North American fountain solutions which run closer to, and sometimes below, pH = 4. Why the difference? Most often cited is the use of alcohol in European pressrooms, but this explanation is not universally agreed upon. For example, hard water is often found in Europe and even recommended by some authorities. The same concentration of etch in hard water will have a higher pH than in deionized water.

Frequently Asked Questions (continued)

6. You mentioned there were other fountain solutions that were not acidic. Can you tell me more about them?

In the late 1960s, early 1970s, it was discovered that alkaline fountain solutions, similar in chemical composition to detergents, worked well in non-heat web operations, primarily newspapers. They were much more cost-effective than conventional acidic solutions and had the added benefit that the printing plates did not need to be wiped with a gum arabic solution during press shutdowns. They were used much like their acid counterparts. Evolutions in their formulation also allowed them to be sold in dry form. The user could add the dry form to a predetermined amount of water and in "super concentrate" form, dilute 10 gallons to make 55 gallons of the standard concentrate. These latter versions afforded appreciable freight savings to the user.

pH neutral solutions also appeared and enjoyed limited success in the newspaper production industry. The popularity of neutral solutions grew so that today they are extensively used in newspaper production whereas alkaline solution usage has diminished. However, there appears to be renewed interest in alkaline solutions because of their resistance to bacteria growth compared to their neutral counterparts.

7. Does it matter what the pH and conductivity of the water is that I'm using to make my press-ready fountain solution?

Yes and no. Conductivity readings are pretty much additive. For example, suppose a particular fountain solution, mixed at the ratio of one ounce per gallon with deionized water, which has a conductivity of zero, gives a reading of 2,000. If the same dilution had taken place with water that itself had a conductivity reading of 500, then this solution would read 2,500 on our meter. Thus, when making a calibration curve (conductivity versus ounces/gallon), be sure to read the conductivity of the diluting water.

Water quality, and potentially conductivity readings, can change during the course of the year, depending on local water supply systems. Be sure to check the conductivity/pH of the water periodically to ensure that the calibration curve remains accurate.

The pH of the diluting water is usually not too important. If it is between pH = 6 to 8, then the chemistry of the fountain solution tends to overwhelm and dominate the properties of the solution. However, it is good practice to measure the pH and conductivity of the solution when preparing the calibration curve, just in case.

Frequently Asked Questions (continued)

8. Should I be using tap water or treated water to mix my fountain solution?

Not surprisingly, it depends. The water chemistry of most urban water systems is sufficiently stable that it can be used “as is.” Other areas of the country experience fluctuations, sometimes daily, often seasonally, in water quality, and this could upset the chemistry of the fountain solution and perhaps the ink-water balance on press.

Keep in mind that these variations in water chemistry can also have an impact on plate processing.

9. If I need to treat my water, what method should I use? A softener, a deionizer, or a reverse osmosis unit?

A softener removes the hardness minerals, calcium and magnesium, from the water and replaces them with common salt. This is considered only a partial solution to water problems and is not generally recommended or found in the majority of press/plate rooms.

Deionizers and reverse osmosis units remove all minerals, but the reverse osmosis (RO) units have the advantage of removing some organic contaminants as well. Maintenance of RO units is generally simpler although their initial cost is often higher than deionizers. RO appears to be the method of choice in most plate/press rooms.

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