

**A Brief Review  
of the  
History of Sizing and Resizing Practices**

by  
Karen Garlick

Early oriental paper was unsized. Soft, pliant, and absorbent, it was well suited to the calligraphic brushwork of scribes. In the 8th century, in a process very similar to surface coating, the Chinese began to apply gypsum and later an adhesive like substance made from lichen to the surface of their paper. Later in the century they made a size from flour starch which was added to the paper pulp in the tub or to the finished sheet after forming.

In the mid 8th century papermaking was introduced to the Arab world where it gained swift popularity. Arabic papers were sized with starch and afterwards glazed to produce a highly burnished surface that physically resembled the more traditional and familiar parchment. It was also suitable for the inks, pens, and calligraphic styles that had gradually developed for use on the parchment surface. Quite unlike the finished product, the surface of an unsized sheet of Arabic paper was very irregular, reflecting the impressions left by the reeds used to construct the paper mould and the effects of drying with little or no pressing.

An important source of information about the technique of Arabic papermaking is the 11th century treatise The Writing Base of Scribes and the Instruments of Their Intelligence. The author describes the process of sizing that prepared the rough sheet for burnishing. In the two translations of this work, the materials used to make the size are variously described as combinations of wheat starch and wheat flour or equal parts of chalk and starch. These were mixed separately in cold water, poured together into boiling water, and stirred until thickened. This

thick adhesive-like substance was spread by hand over the sheet of paper in several applications to fill in holes and even out surface irregularities. Then the paper was hung up to dry.

A second process that is outlined may be an additional sizing step carried out when a sheet was not yet considered ready for burnishing or it may be just a variation of the first procedure. In this process, rice or gum tragacanth was boiled in water until it was completely dissolved and was then filtered through a clean cloth. The paper was passed through the resulting solution and hung on reeds or laid on a clean cloth to dry.

Shortly after the beginning of the 8th century, Arab forces in North Africa crossed the Straits of Gibraltar and conquered Spain, extending the Arabic empire and introducing Islamic culture into Europe. It is no surprise, then, that the first paper used in early Spanish manuscripts is similar to traditional Arabic paper. Several codices preserved in the Monastery of Santo Domingo of Silos and dating from the 10th century are thought to contain early Spanish made paper. This paper, like its traditional Arabic counterpart, is sized with a thick starch that has been spread over the sheet so that the surface is smooth and even. This method of sizing, and in fact Arabic papermaking practices in general, were continued in Spain into the 14th century.

From the 11th century on, Arabic papers were exported throughout the Byzantine empire and Christian Europe. Through this trade, paper was introduced into Italy. Credit is generally given to Pietro Miliani for establishing the first paper mill in the town of Fabriano in the mid 13th century when he brought together

several small businesses to found the mill, Cartiere Miliani-Fabriano. It was also in the mill at Fabriano, at approximately the same time, that gelatin was first used to size paper. The raw material for gelatin size (and I am going to use the word "gelatin" generically to refer the protein based size derived from animal hides, horns, hooves, and bones) was possibly supplied by the tannery in Fabriano that operated close to the paper mill.

We do not know why gelatin sizing was introduced. Whatever the reason, its use gave the paper a hard, opaque surface that was impervious to contemporary inks and was well suited to quill pens, qualities which may have helped foster the wide use of paper over parchment.

There are no contemporary accounts that describe the sizing process from this period; the earliest European account of sizing did not appear until 1693 in the French book entitled Papyrus sive Ars Conficiendae Papyri written by the Jesuit priest, J. Imberdis, Claromonti.

Modern historians generally assume that while certain changes in gelatin sizing may have occurred over time, the basic method remained essentially the same. To prepare the size, the papermaker repeatedly boiled the raw animal materials in water in a large cauldron set over a fire. Periodically, the solution was skimmed and filtered through cloths. When the gelatin was ready, it was transferred to a tub to cool and clarify. The gelatin was again heated before application so that it would remain at the right consistency throughout the entire procedure. To size the paper, the papermaker picked up as many sheets as he could hold in

one hand or between 2 sticks and immersed them all together into the tub of hot size. (hence the name "tub sizing" given to this procedure.) He used his free hand to fan out the sheets so that the size penetrated each sheet. Following this dipping, the paper was pressed lightly to distribute the size evenly over the surface. The pressing removed excess size which was drained into a container and emptied back into the sizing tub. Apparently, sizing was one of the more difficult jobs for the papermaker, and many sheets were damaged beyond use. For this reason, and probably others as well, the sizing room was known as the "slaughterhouse".

With the ascendancy of papermaking in Italy, in the 14th century, gelatin sizing became widely accepted. But, even during the late 13th and early 14th centuries, other materials were used as well.

For example Italian paper in a late 13th century Spanish Chancellery Register is sized with a thick starch that appears to have been crudely applied with a brush. Italian papermakers are also known to have sized with a resinous substance, made primarily of rosin, to which alum was added.

Much of the paper in incunabulae (books printed prior to 1501) contained little or no size. This is because early printing inks were thicker in composition than the writing inks and did not require a paper with much, if any, size to create a good, clean type impression.

One of the major problems encountered with gelatin size was that it deteriorated quickly, especially when the weather was hot. In a practice that began in the 16th century and was widely used by

the mid 17th century, papermakers added potassium aluminum sulphate (alum) to the size to control the growth of mold and bacteria. Prominent paper historian, Henk Voorn states that in hot weather sometimes as much as 20% alum was added to the sizing tub. Two other reasons given for the use of alum are that it stabilized the viscosity of the size at various concentrations and temperatures and increased the ability of a gelatin sized sheet to resist ink penetration.

Most of the time, alum was added directly to the sizing tub. Occasionally, it was added separately to the sized sheet itself. In 1678 the English diarist, John Evelyn, visited a paper mill in Blyfleete, Surrey and noted that after the paper was formed, it was "ply<ed> and dry<ed> on strings, as they dry linnen in the Laundry, then dip<ped>... in allum water". Similarly, a German process called for running the finished sheet through an alum solution.

Like their modern counterparts, early papermakers were concerned that the finished sheet be properly sized and suited for its intended use. The tests were not, of course, as sophisticated as those used by the industry today...but they were clever. Imberdis, In the late 17th century treatise referred to previously, suggests two methods for testing the degree of sizing of writing paper. Crumple a piece of paper, he says. If it sounds like the rattle of parchment, then the paper is adequately sized. Or, alternately, run your tongue over the paper. If saliva penetrates through the sheet, then you know that there is not enough size to prevent the ink from feathering.

More information is available on 18th century sizing materials and practices than exists on previous centuries.

One interesting late 18th century document, the Official Instructions for Paper Factories issued by the government in Barcelona, mentions the use of parchment clippings to make size. An English document from this same period specifies the use of clean parchment or vellum shavings. One of the few technical articles intended for the papermaker is found in Joseph de La Lande's work Description of Arts and Crafts in which size made from fish is mentioned. It has also been stated, although not proven, that the Dutch used a fish size for their best papers. And, toward the end of the century, in Germany, an early casein sizing was produced from cheese.

Preventing the size from putrefying in the tub remained a constant struggle. Contemporary descriptions of papermaking in Germany, western France, and Spain refer to the addition of zinc sulfate (known as white vitriol) as well as alum to the size to retard spoilage. One English account reports that the papermakers "prepare a fine cloth, on which they strew a due proportion of white vitriol and rock alum finely powdered, and strain the size through it into a large tub".

Until the 19th century, sizing was most commonly applied to the surface of a finished paper in a separate hand operation. However, in the late 17th and 18th centuries, some papermakers did experiment with adding a sizing agent to the paper pulp. But these experiments, like those related to the search for new pulp materials, were not always recorded, nor were they described

in such a way that they could be applied directly to the needs of the industry.

John Evelyn's diary, cited earlier, refers to a late 17th century practice in Blyfleet in which the papermakers "Put some gumm in the water in which they macerate the raggs into a pap".

At the beginning of the 19th century, Moritz Illig, a watchmaker by training, began to work in his father's paper mill in Erbach, Frankfort. There, he developed the first practical method of adding size to the vat, by using rosin. In 1805, he advertised for subscribers to support the private publication of his discovery and by 1807 had received enough financial backing to issue his monograph, An Introduction into the Art of Sizing Paper in the Vat, Securely, Simply, and Cheaply: A Contribution to the Art of Papermaking. In this monograph he described "sizing in the mass" or as we call it "engine sizing" or "internal sizing".

Initially, papermakers showed little interest in this new method, partly because they resisted the modification of familiar sizing practices and partly because the papermaking machine was not yet established enough to make the need for an internal size compelling. However, unaware of Illig's work, scientists and some other papermakers were conducting similar research at about the same time.

In 1806, the French Society of Encouragement offered 3000 francs to anyone who developed a practical method of engine sizing. They withdrew the prize when no suitable methods were submitted. One year later, the Magazine of All New Inventions, Discoveries,



and Improvements, reported that Karl Gottlob Otto, a German papermaker at Obersclema, showed paper sized in a new way that "does not use pieces of hide and other animal material". In France, between 1820 and 1830, papermakers and scientists experimented with combinations of wax and alum, rosin and alum, and rosin and starch, among others...all in an effort to find a workable method.

As improvements in the papermaking machine transformed it into a piece of practical industrial equipment, engine sizing was recognized as the only economically feasible method of sizing, and gradually, rosin was adopted as its agent. Joseph Krah, a German papermaker, introduced rosin sizing to the United States in 1830. One year later, the papermaker Louis Piette published his Treatise on the Fabrication of Paper which includes his experience with rosin sizing. Finally, in the decade between 1840 and 1850, rosin sizing became well known and widely used.

Papermakers made the first rosin size themselves, using a method related to soap making. The rosin was cooked with 20-25% sodium carbonate (soda), in a reaction known as saponification, until it became a soapy emulsion. After the emulsion settled, the excess alkaline liquors were skimmed off the top and discarded. Some papermakers let the size sit for a month after saponification in the belief that this improved its quality. Because this form of rosin is water soluble, it was added directly to the stock in the beater. The rosin dissolved quickly and was able to react with the alum as soon as it was added. The addition of alum was necessary to precipitate the rosin on to the paper fibers and to allow the conversion of the precipitate to a stable aluminum-

rosinate film. In the late 19th century, aluminum sulfate (or papermaker's alum) was developed in the United States and substituted for the more costly potassium aluminum sulfate.

Also, at this time, new theories about the mechanism of rosin sizing were advanced. This led to the addition of less sodium carbonate during cooking and the use of sizes with a higher percentage of free rosin. Because free rosin cannot react with alum when it is added to the paper stock, this change made it necessary to develop emulsifying systems so that the uniform dispersion required for sizing could be produced. Prepared rosin size began to displace mill-made size at the beginning of the 20th century and was in wide use by 1910.

From this time on, there is a proliferation of new sizing agents, supplementary treatments related to sizing, and modifications in the paper machine to permit more efficient sizing - and the history of sizing becomes tremendously complex.

So, at this point, I would like to turn to a brief look at resizing practices before Walter takes us into the present.

As early as the classical period, custodians and collectors expressed their concern for the condition and survival of artistic and historic collections. Most of the existing writings and later writings that pertain specifically to paper based materials contain brief, general comments about the proper housing and handling of collections materials. References to treatment are few, brief, and only allude to techniques that could be or had been used to correct particular problems.

In the 18th century, several sources provide some specific, though incomplete, information about treatment. Unfortunately, these documents rarely refer to resizing beyond a passing remark.

In 1731, the English House of Commons issued a report on the efforts made to restore the Cotton Library after a disastrous fire damaged many of its priceless paper and vellum manuscripts. The first part of the report discusses the proposed treatments, including those for "the paper books that are stained, <which should> be immediately unbound, and put into the softest and clearest cold Water, in which Alum has been dissolved, in order to strengthen and fortify them; afterwards to be hung upon Lines till dry and then bound again". The second part of the report describes the techniques used in several of the treatments, but provides no other details of the step related to resizing.

Similarly, the itemized bills of the 18th century bookbinder and restorer Roger Payne provide an unusual level of detail about his materials and techniques, but only a cursory reference to resizing. For example, two of the costs itemized in the bill for the restoration of an early edition of Petrarch read:

1) <With regard> To washing there was a great deal of writing ink and bad stains, it required several washings to make the paper of the Book quite safe.....9.

2) <With regard> To sise-ing <done> very carefully and strong.....7.6."

In the 19th century, the literature begins to reflect the slow movement away from the empirical approach to treatment that had characterized the earlier craftsman/restorers approach.

However, with a few exceptions, resizing practices are given little attention.

One exception is John Hannett's book Bibliopegia, Or The Art of Bookbinding in All its Branches, written in the first half of the 19th century. In a section entitled "On Giving Consistence to Bad Paper", Hannett recommended the so-called German method to give paper "an additional firmness" and "a better color". His recipe specifies: Boil 1 oz of isinglass (a very pure fish gelatin) in a quart of water, add 1/4 pound of alum, and finally strain the mixture.

In the mid 19th century, the French bibliophile Alfred Bonnardot published his Essay on the Restoration of Old Prints and Rare Books. This book was the first comprehensive attempt to merge practical experience with scientific knowledge and was the greatest contribution to paper restoration to date. Bonnardot believed that resizing would often restore old paper that had become soft. Like Hannett, he recommended that paper be resized with isinglass after washing. He gives the following directions for preparing and using the size. Dissolve 1/2 oz. of isinglass in a pint of water. Heat the mixture to about 125 degrees Farenheit, then transfer the size to a shallow pan. Immerse the paper in the heated size for a few seconds only. And, finally, dry the paper between sheets of blotting paper.

As a whole, 20th century literature does not provide much more information about resizing procedures than 19th century literature does. There is little discussion about the criteria to apply in determining the need for resizing. The reasons most often

advanced for resizing seem to be the paper's limp handle, "wooly" surface texture, or lack of strength. Usually no attempt is made to establish relationships or differences among cited criteria, and no objective testing is cited or recommended to verify established assumptions.

There are two important exceptions to these observations. The first is William J. Barrow's 1955 monograph Manuscripts and Documents: Their Deterioration and Restoration. In this document, Barrow suggests that librarians and archivists are proponents of resizing for 2 reasons. First, they believe that original sizing completely breaks down over time leaving a sheet "unsized", so to speak. Second, since librarians and archivists know that a small amount of size will strengthen an unsized sheet, they believe that, by extension, resizing will strengthen an older paper. Barrow disagrees with the assumption that original sizing breaks down completely unless mold or some other unusual conditions are present. His position is based on research conducted at the National Bureau of Standards in the 1940's. This research showed that test papers from the 17th and 18th century contained about 3-6% gelatin, suggesting that the original sizing had not deteriorated. Modern ink applied to the surface of these papers did not feather, further supporting his theory about the retention of the original size. He concludes, and I think a little tongue in cheek, "It would be of interest if those who advocate this practice of resizing old papers offered data showing approximately how much physical strength was added by this procedure."

The second 20th century source that is of interest for the issues it raises about resizing criteria is a 1971 talk on the paper conservation treatments used in Florence that Peter Waters gave at the Conservation Center at New York University. Like Barrow, Waters questions the assumption that resizing increases the strength of paper and proposes instead that resizing is related more to increasing the resistance of paper to handling. Further, he advances the idea that the essential functional differences between book leaves and flat paper should determine the resizing agent used and the percent working solution prepared. More specifically, he points out that oversizing book leaves can inhibit the proper opening of a book after it is bound, can interfere with the utility of a book, and can lead to structural failure of the binding. Therefore, he recommends that before resizing, careful consideration be given to such factors as the weight, thickness, and format of the paper to ensure that a functioning binding structure is produced.

For a view of current resizing practices in conservation today, I would like to turn the podium over to Walter.

Karen Garlick can be contacted at the Library of Congress, Paper Conservation, (202) 287-5634.