

FRAGILE PAPER—OTHER ANGLES, OTHER ALLIES?

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Starting by considering the causes of fragile paper and the methods of manufacturing paper, the idea is raised that, were the production of fragile paper to be detrimental to the environment or to the workers in the paper manufacturing industry, the environmental lobby groups and the Unions could be powerful allies in the fight for archival quality paper. Although little evidence was found to support this proposition, there are signs that the paper manufacturers are changing their methods for economic reasons. (This paper is a slightly revised version of an essay written in 1988 towards an MA (Archives and Records), Monash University.)

The problem of fragile paper

In the age of computers and audio-visual technologies, much of the world's culture is still recorded only on paper. For that culture to survive, the paper must survive. In order for paper to survive, it should be composed, for the most part, of long and stable fibres, be sized with an alkaline-compatible material and be filled with a buffer against acidity, such as calcium carbonate. Paper which does not meet these specifications will last perhaps only fifty years.¹ Paper which does meet the specifications should survive, under reasonable conditions, for perhaps three hundred years. Papers which do not have good ageing properties will lose brightness more quickly, become brittle faster and suffer more from loss of other strength properties.

The problem of fragile paper, then, can be considered as having two aspects: the pH level of the paper and, to a lesser extent, the length of the fibre.

Fragile paper is not a new problem: as early as 1829, Englishman John Murray found a thirteen year old Bible was "crumbling literally into dust".² In 1903 the cause of brittle paper was ascribed, by Winkler, to its acidity; many other workers extended knowledge of the cause.³ Numerous surveys of library holdings demonstrated the enormity of the problem: for example, Schmude⁴ and Williams⁵ cite the Library of Congress, the University of California libraries, the libraries of Yale

The Determinants of the Strength of Paper

WEAKER PAPER

STRONGER PAPER

Long fibres

Absence of Lignin

pH Level

depends on tree species

depends on method of pulp production

depends on materials used to:
size fill

ground-wood

thermo-mechanical

chemi-thermo-mechanical

semi-chemical

chemical

sulphite

sulphate (kraft)

rosin

ASA*

kaolin

calcium carbonate

Increasing pH →

Increasing pH →

Decreasing damage to fibres →

Decreasing amount of lignin →

*ASA = artificial sizing agents

University and Stanford University, the Reference Division of the British Library and France's national library. Other surveys extrapolate findings to predict the quality of materials from particular countries for various periods, with similarly depressing results.⁶

Several processes have been developed for treating brittle paper to increase its strength and therefore its survival; however, taking the cost to treat individual books⁷ and calculating the cost of treating all the paper currently at risk, shows that this is not feasible. Whether or not such actions were feasible, any possible steps should be taken now to achieve the production of stronger paper in order to halt the growth the number of books and documents at risk.

Librarians and archivists around the world have encouraged paper manufacturers to change their production methods. However, a producer of paper has little to gain merely by meeting the requirements of the librarian and archivist. It is the book printer who is the mill's customer for printing paper, and other printers and stationers who are the mill's customers for writing paper. A change in the manufacturing process will not increase sales of paper or books; possibly the reverse, as the self-destructing book may result in a replacement sale, whereas a book printed on archival quality (strong or "permanent") paper may not.

If a change to the production of archival quality paper were to have beneficial effects on the environment and occupational health of workers in the industry, there are powerful lobby groups which might be recruited to the cause of archival quality paper. Government financial incentives and the publication of Standards and other documents are also possible means of achieving the production of archival quality paper. Before considering these possibilities, it is necessary to understand the manufacturing processes that produce paper of archival quality or paper which is susceptible to embrittlement. The diagram summarises the determinants of the strength of paper and the relevant aspects of papermaking.

Making paper

Paper has been used since about AD 105 when it was developed in China. A variety of raw materials have been used to make paper, particular cotton rags. Until a machine was developed in England in 1803, all paper was handmade.⁸ The first paper mill in Australia was established in 1818, only fifteen years later, although it was not until 1939 that pulp was manufactured in this country.⁹

In the nineteenth century, a great increase in demand for paper led to changes in the method of manufacture: one of the major changes was in the method of sizing the paper. Sizing is necessary to make paper less absorbent so that ink does not feather when the paper is used in writing or printing. Illig found that size could be added to the pulp

(machine-sizing), rather than being applied later as a separate process. The separate process of tub-sizing had involved dipping the paper into a bath of glue or gelatine which had the additional advantage of increasing the strength of the paper. However, when aluminium sulphate (alum or papermakers' alum) was added, as it increasingly was from the sixteenth century onwards, to encourage the enmeshing of the fibres and to "set" the gelatine size, this had the contrary effect of decreasing the durability of the product.¹⁰ Illig, in 1807, instead of using gelatine for sizing, used rosin which has no strengthening effect on paper. Rosin requires a solution of alum as a precipitating agent; because of the larger amounts of alum required in this method, paper became increasingly acid.¹¹ (Acid paper is that which has pH of less than 7.0.¹²) Artificial sizing agents (ASA) are now available which are not acid.

Another change in papermaking was in the raw material: in the mid-nineteenth century, the supply of cotton rags was no longer able to meet the demand and wood was used instead. For a long time, it was thought that deterioration of paper made from wood fibre was caused by the material itself but Sutermeister showed this to be incorrect by an extended experiment where a paper composed entirely of refined wood fibre retained its colour and strength when other papers of mixed refined wood fibre and rag failed: the paper which survived carried calcium carbonate filling (with a pH of 8.9) whereas the other samples were rosin-sized and clay filled (with pH levels between 3.6 and 4.3).¹³ Thus, the non-acid paper performed better than acid paper irrespective of its basic raw material.

When wood was introduced as a raw material for paper, it needed a machine to turn it into pulp. A machine was developed in 1844¹⁴ to grind de-barked logs on a revolving stone, a method which retains in the pulp all components of the original wood except water-soluble materials which are washed away. This is called mechanical or ground-wood pulp. One of the substances remaining in the pulp is lignin which renders the paper unstable. In making refiner (or refined) groundwood, counter rotating metal discs are used to grind chipped logs. In the newer methods, the lignin and other undesirable materials can be removed to a greater or lesser extent: their removal reduces the yield of pulp from a given volume of wood but increases the quality of the paper.

There are now a variety of techniques available: chemical or wood-free (that is, all non-fibrous material is removed after the wood has been "digested" under heat and pressure), semi-chemical (a compromise between chemical and groundwood methods), thermo-mechanical (where the refining takes place at high temperatures) and chemi-thermo-mechanical (a combination of the three techniques).¹⁵ Semi-chemical pulp retains more lignin than chemical pulp but less than groundwood; chemical pulp has longer fibres than groundwood and no lignin.¹⁶ Although groundwood or semi-chemical pulp can have chemical pulp blended with

it to improve the paper quality,¹⁷ it is still likely that the strength of papers made from groundwood or semi-chemical pulp will be reduced by the shorter wood fibres and lignin remaining in the pulp.

Groundwood is used for newspapers and semi-chemical paper for offset magazines, but other printing and writing papers are made from pulp produced by the chemical process or a variety of it. Currently, therefore, for books and much new archival material, any deterioration will not be caused by short wood fibres. However, much of the earlier library and archival holdings will be of paper made before the development of the chemical process.

There have been other changes outside the paper manufacturing process which have accelerated the deterioration of paper: most forms of air pollution, for example. However, the effects of these external influences would be slower were the paper stock to begin its life in a non-acid condition and with an alkaline reserve or "buffer": that is, with a pH of about 8.5 to 10.0.¹⁸

Environment

In considering paper production from an environmental point of view, there are two main aspects: the environmental effects of production of the raw material and the effects of the manufacturing process itself.

Of the raw material, wood is the greatest in volume and logging has received much attention from the environmental lobbies. To the extent that stronger paper (that is, with longer fibres) is produced by methods with lower yield, a change to stronger paper could be said to be detrimental to the environment; however, there appears to be no difference in yield between acid and non-acid paper so that particular aspect of stronger paper would not increase the amount of logging.

Using calcium carbonate as filler material instead of china clay is merely transferring any detrimental effect to another type of environment: calcium carbonate is derived from limestone and such areas are often the subject of conservationists' lobbying.

In the paper manufacturing process, abundant water is required although mills recycle as much as possible for economic reasons, including the recovery of fibres in suspension that would otherwise be lost.¹⁹ Modern machines are more efficient at recycling water.²⁰ Apart from fibres, the water may contain the dissolved organic compounds and chemicals, and bark remaining from the wood together with fillers and additives, such as dyes, used in the papermaking process. Many of these materials are, or are like, naturally occurring substances and some are biodegradable. As this degradation involves the use of oxygen, however, such materials discharged to rivers and lakes in excessive quantities have a devastating effect.²¹

Chlorine can be used in papermaking for bleaching. The resultant paper can vary in acidity depending on the amount of washing of the pulp. Bleach left in the pulp slightly weakens the paper as bleach is acid; the washing process is alkaline. If the bleach is completely removed by washing, the paper will be neutral.²²

A chemical mill produces more waste materials than a mechanical mill as the chemical method uses less of the pulp to produce paper and more, therefore, becomes waste.²³ However, this volume of waste is the same whether the resultant paper is acid or not, as the pH level depends on processes other than the pulp production.

In considering the environmental effects of producing pulp and paper, it should be noted that, in Victoria, the Melbourne and Metropolitan Board of Works' requirements²⁴ for waste disposal are the same whatever process is employed, and therefore the effects are the same whether the paper produced is strong or brittle. If manufacturing brittle paper could be shown to produce a more toxic waste, therefore, the effect would be on the economics of the manufacturing company rather than on the environment: the company would have to spend more on environmental protection to achieve the standards set by the Board of Works before disposing of the waste or pay the fines involved. However, the literature does not suggest any difference in the toxicity of waste, whether the sizing and filling methods produce acid or non-acid paper.

As the papermaking process requires large amounts of power, a method that uses less power will have a beneficial effect on the environment. This is considered later, together with other aspects of the economics of paper production.

Regarding air pollution from paper production, the major problem is that of sulphur dioxide. Among the chemical pulp production methods, that which produces the most sulphur dioxide is the sulphite process, although much can be recovered.²⁵ The sulphite process, however, produces a paper of lesser strength than the sulphate (or "kraft" meaning strong) process. Unfortunately, sulphate discharges cause corrosion of concrete structures in the sewage system.²⁶

Overall, because of Victoria's strict pollution control measures, it would seem that there is little to choose, environmentally, between the production of paper that is of archival quality or that is fragile.

Occupational health

Allied to the question of whether the production of archival quality paper is more harmful to the environment than the production of fragile paper is the question of whether it is more harmful to the workforce of the industry.

Potential hazards to the workers in the pulp and paper industry can occur at several points: pulp production, paper production and the sizing and filling stage. During pulp production a major risk occurs in the bleaching process and handling the chemicals. Chlorine, used for bleaching the pulp, is a hazardous substance but, at most stages, workers are not exposed to it as pulp production is a closed process; however, there is always a risk of leakage. During the washing process, there is a risk of exposure to workers during sampling and maintenance operations.²⁷ The bleach plant is common to all pulp methods so the risks are no different, whatever the strength of the paper made from it.²⁸

The main hazard during the paper production stage is formaldehyde which can be used as an anti-mould additive.²⁹ Formaldehyde is not a determinant of acidity and is rarely used in Australia.

During the sizing and filling stage, the hazard is from paper dust resulting from the materials used (such as kaolin, calcium carbonate, titanium dioxide, clay or starches).³⁰ Such dusts are considered non-proliferative dusts. That is, they do not permanently alter the structure of the lung or form scar tissue; any tissue reaction to these dusts is potentially reversible. On the other hand, silica quartz and asbestos, for instance, are proliferative dusts, and these can cause permanent damage. One risk of permanent injury to paper industry workers therefore depends on the amount, if any, of contamination by proliferative dusts used in the particular process;³¹ these, however, do not seem to be determinants of strong paper.

Many of the other risks to workers in paper manufacturing are common to whatever method is used: accidents from machinery, steam or electrical equipment, and the effects of noise or of shift work. Heat and humidity can be present in some work areas and these workers are somewhat more prone to bronchitis and other respiratory ailments, and rheumatism.³²

The medical literature does not always differentiate between the various papermaking techniques in describing occupational health studies. However, Hunter states that kaolins produced a very mild reticulin reaction in the lungs³³ but calcium carbonate is harmless.³⁴ Thus the acid filling process could be slightly hazardous compared to the non-acid process.

There have been a number of studies of the health of workers in the pulp and paper industry. In a British Columbia pulp and paper mill, Chan-Yeung *et al* found that workers exposed to gases and chemicals did not have more respiratory symptoms than did other workers. The authors of this study report that their findings are similar to another study and differ from two others, and suggest this may be because the general levels of gases in the air of the region they studied were lower than the current threshold limits. However, workers exposed to wood dust had a slight but significant lowering of pulmonary function when compared to a control group; this was not the case for workers exposed to paper dust.³⁵ Because

the sizing and filling methods used are not mentioned in the report, it is not known whether this harmless paper dust is from acid or non-acid paper.

Schlueter *et al* report that two workers in a pulp mill suffered a hypersensitivity pneumonitis³⁶ but the men worked sorting logs and so probably have no relevance to this enquiry.

Jäppinen found that Finnish pulp and paper workers suffered an excess mortality from diseases of the circulatory system but this applied to workers in both sulphate and sulphite processes (the sizing and filling methods are not described).³⁷ Deprez *et al* compared workers in four groundwood and seven kraft (sulphate) mills and found that the kraft mill workers had increased morbidity from respiratory diseases but this also applied to all other causes of morbidity.³⁸

Unions responsible for paper workers in Great Britain and the United States of America do not appear to have had any long-standing concerns about the occupational health of their members.³⁹ However, this may not indicate that there have been no risks for workers; unions until very recently have tended to campaign for more money as recompense for potential hazards rather than attempt to have the hazards removed or reduced.

Overall there appears to be little occupational health benefit from a change to the production of archival quality paper.

As an aside, a medical group is lobbying for medical literature to be produced on archival quality paper, demonstrating that some doctors are aware of the problem of brittle paper as far as it relates to themselves.⁴⁰

Government Financial Incentives

Through a range of financial incentives, the Australian Government is able to influence imports, the manufacturing processes of local producers and consumption. While publishers could receive incentives for selecting archival quality paper for book production, it would be more effective to concentrate on incentives for the producers of the paper itself.

The main forms of assistance open to the government are tariffs, bounties, by-laws, preferential trading agreements and closer economic relations agreements.⁴¹ Tariffs are duties levied, usually on imports; bounties are premiums paid, usually for local production. By-law imports are duty free. These three incentives could be relevant in promoting the production or importation of archival quality paper. Preferential trading agreements and closer economic relations agreements would only be relevant were any of the countries exporting paper to Australia to produce only archival quality paper.

The pulp, paper and paperboard sector of the industry receives govern-

ment assistance in the form of tariffs and bounties. For the period 1977–78 to 1982–83 this assistance, mainly in the form of tariffs, fluctuated between 8 and 10 per cent,⁴² although this is lower than the 1974–75 level at 14 per cent.⁴³ Tariffs have the effect of increasing the price of imports competing with the local product. Although this enables local producers to increase their own prices while remaining competitive, the assistance does not have any directional effect on local producers; if, instead, a bounty were to be paid for production of archival quality paper in preference to other paper, this might encourage changes in production processes while still assisting local paper mills to compete, in price, with imports.

Until 1987 bounties were paid for the production of certain types of paper and similar imports were allowed free entry under policy by-laws but this assistance does not appear to have depended on the strength of the paper concerned.⁴⁴

Another avenue for government financial influence could be in bounties or tariffs on the various chemicals used in papermaking. Chemicals can account for 10 per cent of total production costs⁴⁵ and therefore changes in the actual cost of the chemicals used in the production of archival quality paper could be very influential to paper manufacturers.

Papermaking machines have a long working life. One Melbourne machine commissioned in 1866 was still producing paper one hundred years later.⁴⁶ Machines can also be modified during their lives: another Melbourne machine, designed to run at 600 feet per minute was modified to work at a speed approaching 1,500 feet per minute⁴⁷ and other modifications can lead to improvements in the quality of the paper produced.⁴⁸ The enormous cost of new papermaking machines (between \$80 and \$100 million) precludes their replacement on other than sound economic considerations. However, to change from acid sizing to non-acid sizing does not require replacement of machines, only of some minor parts at a comparatively small cost (usually equivalent to less than 10 per cent of a new machine), together with a thorough clean and replacement of all the water used.⁴⁹

It would be possible for a government to offer financial incentives, in the form of tariffs waived or bounties paid, for the import or local production of archival quality paper and of the replacement parts needed for the change to non-acid sizing.

Standards

Another front on which the problems of brittle paper may be tackled is that of Standards for papermaking. In the USA there are standards for permanent paper.⁵⁰ The ANSI Standard is based on earlier work by the National Historical Publications and Records Commission (1981), the Library of Congress (around 1977) and the Barrow Research

Laboratory (1975).⁵¹ The ASTM Standard D3290-81 is the latest edition of a Standard first published in 1974.

The ANSI Standard has been taken by a sub-committee (ISO/TC 46, Documentation) of the International Organization for Standardization as the basis for an International Standard. Because this has not been published, the Standards Association of Australia formed a committee (MS/48) to develop an Australian Standard for archival quality paper, again based on the ANSI Standard. The draft of the first part of the Australian Standard for the permanence of uncoated paper went for public review on 1 June 1988: Part 1 (DR 88100) covers chemical and fibre requirements. The test method included in Part 1 is based on the ASTM Standard. The Committee, under the chairmanship of Dr. Jan Lyall of the Australian National Library, intends to specify requirements for the durability of archival quality paper in separate parts of the Standard for each application (for example, encyclopaedias, bond paper, photocopier paper, and so on) to suit the amount of use and handling each type of paper would be given over a one-hundred year period.⁵²

Having established a Standard, however, papermakers must then be encouraged to meet the criteria. An existing Australian Standard specifies that paper used in the printing of medical record forms "shall be calcium carbonate loaded and free of mechanical pulp" and with a pH of at least 7.⁵³ A firm which produces medical record stationery for many hospitals in Australia reports that paper manufacturers do not provide such technical information for their products so it is difficult even for a firm striving to meet the criteria set out in this Standard to know whether it is selecting appropriate paper.⁵⁴ However, it is likely that, once an Australian Standard is established, manufacturers will endeavour to meet it.⁵⁵

The paper industry in Australia has been the subject of various reviews but only in the most recent, that of the Industries Assistance Commission, was any mention found (during this research) of the archival aspect of paper. The Commission reported that submissions had been received pointing out the need to establish Standards and seeking relief from import duties on archival paper. It stated that the existence of Standards against which to assess papers would probably increase the likelihood of such concession being granted.⁵⁶ Clearly it is important for the relevant librarian and archivist organisations to make submissions to such reviews.

Establishing Standards assists those paper manufacturers that wish to market archival quality paper and, the very least, may help to alert other paper manufacturers that a problem exists; standards are worth the effort involved in their preparation.

Economics

Exploration of these other possible areas of influence did not reveal many available to librarian and archivist organisations wanting to

encourage the production of archival quality paper. However, the current situation in Australia was found to be much better than expected.

The three major paper producers contacted in this research are all making changes to their manufacturing practices. Australian Paper Manufacturers Ltd's output of photocopying, computer and white paper is now all alkaline-sized⁵⁷ and all papers developed at the Fairfield Mill "have an archival rating in excess of 600 years".⁵⁸ Associated Pulp and Paper Mills (APPM) is producing some archival paper from its Shoalhaven Mill, having installed an alkaline-sizing process;⁵⁹ however, APPM's parent company, North Broken Hill Holdings Limited, also mines clay⁶⁰ so a total change away from clay filling may be less attractive for this company. Smorgon Consolidated Industries, which produces cardboard, has conducted trials of new chemicals for sizing board under neutral conditions instead of the acid system of rosin and alum. The trials were successful and Smorgon has now adopted neutral sizing for all container linerboards;⁶¹ this change will mean that, once old stocks are exhausted, boxes made from Smorgon board would automatically be non-acid.

The forces behind these changes and potential changes appear to be economic. For example, APPM notes that its change to alkaline-sizing is to improve efficiency as well as quality.⁶² The experience of overseas manufacturers appears to confirm the favourable economics of stronger paper.

There are a variety of areas where savings can be made. APPM found that calcium carbonate was more economical than clay. In the manufacture of the paper, as the pulp passes along on the wire, the filler tends to drain out and be lost; calcium carbonate, however, is retained more efficiently than clay filler with resultant savings to the paper manufacturer. If a non-acid paper is being produced, alum is not needed with further savings to the paper manufacturer.⁶³

Acid systems suffer significantly more from corrosion than alkaline systems, resulting in higher maintenance costs.⁶⁴ Other economic aspects of non-acid paper manufacture reported overseas are lower water consumption and lower energy use because the paper dries more quickly and at lower heat.⁶⁵ In Scotland, Gestetner Papers Ltd reported a 32 per cent reduction in energy, a reduction in the number of drying cylinders needed because the higher retention of filler leads to easier drying, and a reduction in oil, water and steam required. Gestetner did not need any additional capital investment or special equipment in order to change to the production of stronger paper.⁶⁶

Summary

This research failed to identify substantial reasons why the environmental lobby groups and the union movement might take an interest in the change to archival quality paper production. Such paper requires

less energy so the environmental effects of energy production are thereby reduced but, apart from this, Victorian regulations strictly control pollution so that the process used makes no effective difference to the environment. Only one authority, Hunter, indicated that the occupational health risks were lower from alkaline fillers; however, no actual studies of this proposition were found.

Within the present government financial incentives, it appears that there are ways of encouraging production of paper of archival quality.

It was found that work has started on the development of a range of Australian Standards for papermaking.

The important point that emerged during this research, however, is that three major producers are changing their manufacturing methods to produce archival quality paper and board. While the objectives of this research were not achieved, the situation appears to be improving for economic reasons.

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