PAPER NEEDS OF XEROGRAPHIC MACHINES (a summary)

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INTRODUCTION

There may be no single set of paper properties that are optimum for all xerographic machines (including the so called 'laser' printers). This article will summarize properties and quality procedures important xerographic papers used in faster machines.

BASIS WEIGHT AND CALIPER

The usual basis weight of xerographic paper is 20 pounds (17" x 22" 500 sheets) or 75 grams/sq. meter. Good manufacturing control should keep weight within 0.5-0.75 pounds of nominal 99% of the time. The choice of a caliper specification depends on other factors such as the type of fuser roll used in the copy machine. With hard roll fusers print quality depends on the paper being sufficiently smooth. With such machines the nominal caliper should be 0.0042" or less. For machines with soft roll fusers the caliper can be greater than 0.0042" to obtain better copy machine performance from paper that is rougher and stiffer. Caliper should be controlled within ±0.00025" of nominal. The control of basis weight and caliper will improve control of other properties such as smoothness and stiffness.

SMOOTHNESS

IBM publications recommend a range of 100-200 Sheffield for the 3827® Page Printer. Xerox papers will vary depending on the grade. Smoothness in the range of 60-250 Sheffield will affect print quality when the print fixing is done with a hard type fuser roll (the roll that touches the print side). Rougher (higher Sheffield) is worse for solid area mottle, toner fix to the paper, and print density. Higher toner concentrations and usage will be needed to help improve mottle and density. With soft fuser rolls we should not have mottled solid areas, good density and fix over the entire 60-250 range, with fix getting somewhat better at higher values.

Smoothness plays an important role in the separation of paper from the photoreceptor (where toner is transferred to the paper). The smoother the paper the more difficult it is to separate because of increased the electrostatic attraction. We should expect rougher papers to perform better, to separate easier from the photoreceptor. Smoothness is also indirectly related to sheet stiffness in that a rougher paper will also be thicker, and therefore stiffer (assuming same basis weight). For this reason rougher paper is also more likely to have fewer jams.

In machines that have hard fuser rolls, we are limited to maintaining the sheet reasonably smooth so that print quality is not compromised too much (includes the Xerox 3600®, 9200®, 9400® and 9700®). On the other hand, a paper targeted for soft roll fuser machines (Xerox 1065®, 1075®, 1090®, 8200®, 9210®, 9500®, 9700-mod 5® and 5090®; Eastman Kodak machines; IBM 3827 Page Printer® are examples) higher Sheffield values can be used to help decrease jam rates.

STIFFNESS

The normal minimum stiffness of 20 pound paper (0.7-0.8 CD Taber) should be sufficient for xerography. On the other hand, with continued use and lack of maintenance copier machine parts may become worn and out of specification. In this situation lower stiffness paper may not be as tolerant and jam more frequently. If paper can be made to a 1.0-1.2 CD Taber stiffness it will have a better chance to perform well.

ELECTRICAL RESISTIVITY

If resistivity is too high the prints may have image distortions because unwanted charges may move the toner to where it is not supposed to be. If resistivity is too low there may be deletions because the charge placed on the paper to transfer toner conducts away too rapidly. A reasonable range for paper surface resistivity is 10^{11} to 10^{12} ohms at 5% moisture. Packaged paper should be protected from moisture increases in high humidity conditions. In the 4-6% moisture a one percent increase in moisture will decrease resistivity about one decade. If resistivity is not in the desired range small amounts of salt(s) can be added to the surface sizing to adjust it. Only small amounts are needed, usually in the order of tenths of one percent. Laboratory surface sizing experiments may be a good way to determine the amount needed.

SHEET TO SHEET COEFFICIENT OF FRICTION

When variation in sheet to sheet friction becomes too high, friction feeders will feed more than one sheet (a multi-feed). A multi-feed can cause a jam or blank copies. Variation in friction between sheets should be less than 0.1. If it is more than that, depending on the machine, multi-feeds will occur. An average sheet to sheet friction between 0.4 and 0.55 should be satisfactory. Friction values higher than 0.6 could cause misfeeds.

One of the frequent causes of multi-feeds is a low friction sheet pair at the interface of two reams loaded in a feeder. The outer sheets of finished reams are often contaminated with friction lowering materials used on the packaging line or from materials (such as waxes) in the wrapper.

SHEET TO FEEDROLL (OR FEEDBELT) FRICTION

Initially, a feedroll or feedbelt material has sufficient friction to accelerate a sheet from a pile of paper. However, if the paper being used has poor bonding of the filler material within its structure, the filler will contaminate the feeder surface and lower its friction against paper. The result is a misfeed and a machine shutdown. The appearance of problems with contamination may take up to several thousand feeds.

The effect of paper contamination can be tested. A single spot a feedbelt or feedroll is pulled across 20-30 inches of paper and the decline in friction is measured. The test has to be carefully controlled by comparing results with a paper that is known to be non-contaminating because of the variability of feeder materials. The degree of degradation that can cause problems will depend on the copy machine.

Bonding sufficient to prevent contamination is usually obtained by a good coverage of surface size. Maintaining filler content at a reasonable level is also desirable. The felt side is almost always more contaminating. In machines with friction-retard feeders (like the Xerox machines mentioned in the section on smoothness) we can have two problems from felt side contamination. If the felt side touches the feedbelt, its contamination will cause misfeeds. If the felt side touches the retard surface, its contamination will lead to multi-feeds because it will no longer be able to hold back the sheets that follow the top one.

CURL

Two important aspects of curl are as packaged curl and output curl (produced by the fuser). As packaged curl can be adjusted by drying and decurling. Curl should be slightly away from the first printed side. Curl toward the printed side is likely to increase feeding and stripping jams significantly. Curl produced in the fuser is the result of an interaction of the heating in the fuser with the paper's structure and moisture content. The structural properties that affect curl include wire vs. felt side (W/F) moisture expansivity (and the differential internal strain it produces within the sheet) and average internal strain (how much a sheet shrinks by wetting and redrying without

constraining shrinkage). The most important driver of W/F moisture expansivity is W/F fiber orientation. W/F moisture diffusivity (the rate at which moisture can diffuse from the surface) is another potentially important property, but methods of measurement and interpretation need to be developed.

Moisture is probably the most important variable because it defines whether curl is toward the print or away from it. At low moistures (4-5%) curl is toward the print. At higher moistures (5.7 and higher depending on the paper and copy machine) curl is away from the print. The amount of curl at low or high moisture will depend on things like W/F moisture expansivity and average internal strain. More fibers oriented on the wire side will tend to increase toward print curl at low moisture for wire side printing. It will also tend to decrease the moisture content at which curl moves away from the printed side.

When there is more internal strain, curl will be higher toward the print at low moisture and higher away from the print at high moisture. Internal strain can be decreased by reducing web tensions and dryer felt tensions. This strategy is limited by any cockling and print deletions that are produced.

The curl axis (whether machine or cross direction) will depend on how W/F fiber orienta-tion affects moisture expansivity. When the wire side has more fibers oriented in the MD than on the felt side, curl is to the wire side, MD axis (of the curl cylinder) will be more likely. If curl is to the felt side, CD axis curl is more prevalent. When adjusting fiber orientation to change curl, the sheet should remain slightly wire side oriented so that you do not get CD axis curl printed wire side first. This kind of curl could cause stacking problems in the duplex tray. For most papers, printing wire side first is probably best because printing felt side first could result in away from print curl at lower moisture content.

MOISTURE

Moisture content is of prime importance in keeping curl toward the first pass printed side. JCP 0-60 targets moisture at 4.7%. IBM literature suggests moisture be kept within the range 3.4-5.5%. By controlling to a nominal 4.5% we should be able to produce paper that performs well as long as it meets other requirements set out for curl and resistivity.

SHEET FLATNESS

Sheet flatness is important for preventing print deletions (sometimes called voids). If parts of the sheet are out of plane, the air gap prevents transfer of toner to the sheet. Deletions are not seen on machines that have bias roll transfer because the pressure on the sheet to flattens it (Xerox 8200®, 9200®, 9400®, 9500®, 9700®). Machines which may have deletions from unflat paper include IBM, Kodak, and Xerox 1065®, 1075®, 1090®, and 5090® (note: machine upgrades have been made to reduce or eliminate deletions). Machines that use low voltage transfer systems are also less likely to have deletions.

Sheet flatness can be caused by uneven drying. An important thing to remember that unflat paper may be found in only some of the reams of a carton, because unflat areas may occur in only parts of the deckle width. Sometimes deletions only show up when the second side is printed. Second pass deletions observed evenly distributed across the deckle width is another aspect of the problem. These can be reduced by tightening draws and drier felt tensions and reducing paper moisture.

MILLWORK

It is probably self-evident that paper needs to be free of padding (edge welds), foldovers and other finishing defects. The edge cut quality is important in preventing padding and reducing the amount of paper dust. The wrapper should be of the polyethylene laminate type. Pallets should

be wrapped with a plastic wrap to prevent changes in moisture content. Paper should be free of flat flaky material such as starch that may have dried on heated drying surfaces. These can attach to the photoreceptor electrostatically and print out black spots on the copy. Flakes can be detected by shaking stacks of paper above a sheet of plastic.

POROSITY

The IBM guideline for porosity is 10 sec./100 ml. Gurley minimum. Xerox has a similar specification. Along with the absence of edge welds, a Gurley above the minimum is needed to prevent multi-feeds and jams in machines with vacuum pickup feeders (such as the 3600I®). In addition there is some indication that paper which is too porous may deplete oil applied to fuser rolls cause and adhering and jamming.

COMPOSITION

Paper for xerography should be made free of talc, calcined clay, surface sizing containing synthetic materials, and photoreceptor poisons such as ammonium and nitrate com-pounds. Some IBM publications have recommended a maximum of 18% ash content.

MACHINE TESTING

Machine testing is an important part of xerographic paper quality assessment. Jamming problems from friction, stiffness, curl, smoothness and resistivity can be uncovered. Print quality can be checked for things like mottle, fix, and toner disturbances (unwanted toner movement on copy). Several thousand sheets should be run to determine long term effects of friction degradation of feeding surfaces. JCP 0-60 requires that there be less than one jam/5000 to meet specifications.

SUMMARY

This article has briefly reviewed the paper property needs of medium and high speed xerographic machines, which includes the so called ‘laser’ printers. These printers have the same machine parts as their copier counterparts. The only difference is that the image is placed on the photoreceptor by lasers. It is remotely possible that stripping from the photoreceptor could be different, however, no differences have been reported.

Several manufacturers have made 24 pound grades for ‘laser’ printers that are very smooth. Very smooth paper would be needed for high quality prints for machines using hard roll fusers that are used in some low speed printers. The need for smooth paper with sufficient stiffness seems to be met by the move to 24 pound paper. However, feeders in these machines should be carefully evaluated to be sure they are able to handle higher stiffness papers.

For ‘laser’ printers based on medium and high speed copiers and duplicators that are manufactured by Xerox, IBM and Kodak, the paper requirements should be essentially the same as those for the base machines themselves. Enhancements in brightness and opacity would be a marketing need.