print review
Volume 3: Fall 2006
For Affiliates of the Printing Industry Center at RIT

Papers for Digital Printing, Part I

Over the past ten years, the market for digitally printed documents has soared. The best runnability and image quality for digital printing is obtained from papers designed specifically for electrophotographic operations. This month's eReview will cover the first portion of a recent Printing Industry Center research monograph entitled *An Investigation into Papers for Digital Printing*, by Mary Anne Evans, Ph.D., and Bernice A. LeMaire (PICRM-2005-06).

With new technological developments in electrophotographic printing, more stringent demands are being placed on paper performance. Expectations of higher run speeds and higher image quality are challenging paper manufacturers to produce papers with the appropriate characteristics at acceptable price points. The trend is toward graphic-intense documents, with near photo-quality color, and therefore digital substrates must be able to handle higher levels of toner from four component colors while maintaining sharp line edge acuity and accurate dot placement.

Intermediate decision makers in the value chain may not have an understanding of paper attributes that differentiate digital papers from those grades designed for traditional technologies. A technical understanding of these issues is essential if print buyers are to appreciate the value offered by digital papers.

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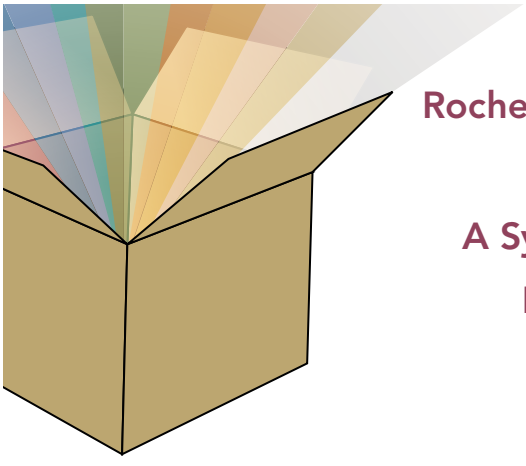
inside

R·I·T Printing Industry Center

Package Printing

An Engineered Approach to Repeatable and Predictable Color



November 14, 2006

Rochester Institute of Technology

A Symposium Presented by the RIT Printing Industry Center

The Printing Industry Center at Rochester Institute of Technology has developed a methodology for achieving consistent, repeatable color package printing, which can enable predictable color between design and production while reducing waste and improving turnaround time and quality.
This breakthrough research will be unveiled at a daylong technical symposium on the RIT campus on Tuesday, Nov. 14. To register, visit http://print.rit.edu/events/symp06_pkg/.

Bob Chung, Gravure Research Professor in RIT's School of Print Media, and researchers from RIT's Printing Applications Laboratory, will showcase the research that identifies the key steps necessary for consistent color in package printing, as well as tools for efficient production. Bob Eller, ExxonMobil Chemical Company's manager of business process and new business will be the keynote speaker. Eller will discuss how ExxonMobil selected RIT to transform package printing from an art to a well-engineered industrial process.

Case studies will also be presented that focus on solutions for implementing new technologies and workflows for successful color package printing across a variety of platforms, including gravure, flexography, and offset lithography.

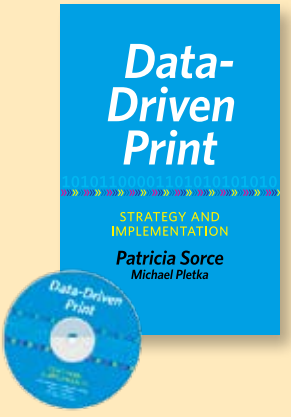
"RIT spent the past three years building smart tools to achieve this methodology," says Chung. "We recognized that using craftsmanship alone to address high impact graphics is time-consuming and costly. The engineered approach we've developed achieves high impact graphics that meets customer's requirements and improves profitability. My colleagues and I are excited to share this methodology with the industry."

Registration/Details

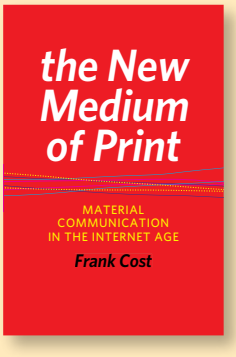
Symposium Fee: $80. The day-long conference runs from 8:30 a.m to 5:30 p.m., with a dinner reception from 5:30 to 7:30 p.m. Meals and materials will be provided throughout the day.

Go to **http://print.rit.edu/events/symp06_pkg/index.php** for registration and more information.

2 GREAT BOOKS on the Printing Industry



"*Data-Driven Print* is an excellent and comprehensive view of the world of personalized communications as they relate to print. Whether you are a marketing executive, senior manager in an advertising agency or a print services provider, this book will arm you with facts and strategies that will help you capitalize on and benefit from this rapidly growing segment of business communications."
— Cary Sherburne, *What They Think*

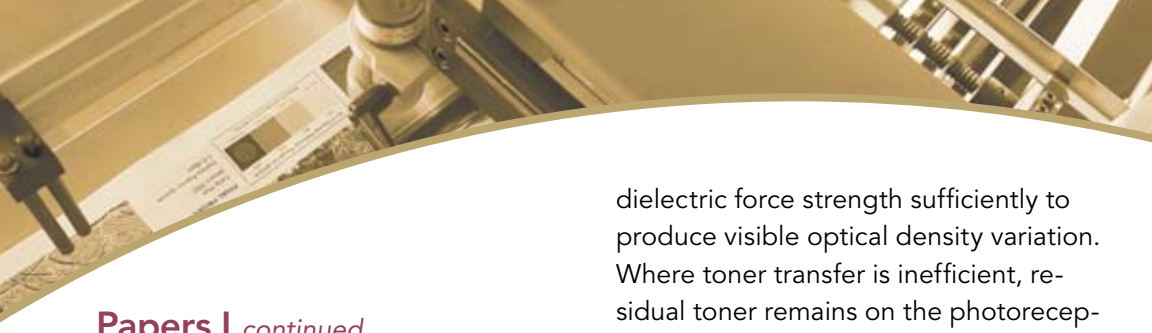


"Rapid technical change requires a different approach to print operations. The most important step to managing the technological future is to do one's homework. A good starting point is Frank Cost's *The New Medium of Print*. . .an action guide that blends print history, business applications, marketing data, and the evolution and application of ideas for today. TechWatchers and present-day printers will all find value within the fast-reading and enjoyable pages of Cost's book."
— Henry Freedman, *Graphic Arts Monthly*

ORDERING INFORMATION

Data-Driven Print: Strategy and Implementation
Printing Industry Center Series: 2
by Patricia Sorce and Michael Pletka. 192 pages, ISBN 1-933360-06-2
$18.00 AVAILABLE AT LULU.COM
Also Available ***Data-Driven Print Teaching Supplements CD,*** $49

The New Medium of Print: Material Communication in the Internet Age
Printing Industry Center Series: 1
by Frank Cost. 272 pages, illustrated, ISBN 1-933360-03-8
$18.00 AVAILABLE AT LULU.COM AND AMAZON.COM



Papers I *continued*

Paper Performance Characteristics Required for Printing

In general, printing papers must perform adequately in three functional areas:

- runnability – sheets or webs of paper running smoothly through the print engine without jamming,
- printability – image quality and overall appearance of the printed sheet, and
- fitness for use – usability, meeting permanence requirements, and the ability to be finished and distributed in the required manner.

Acceptable levels of performance in these areas are required for all types of printing processes.

Additional Paper Requirements for Digital Printing

Digital printing makes greater demands on paper than offset printing. Two steps in the electrophotographic imaging process are critically related to paper properties: toner transfer and fusing.

Inside an electrophotographic printer, the image is written using a laser or other light-based system to a photosensitive drum or belt known as the photoreceptor. Charged toner is attracted to the image areas of the photoreceptor, which are charged differently than the background areas. The dielectric force that drives the toner transfer arises from a charge placed on the paper before it reaches the transfer gap. The strength and uniformity of this force determines the efficiency of toner transfer.

Toner transfer efficiency is related to the distribution and density of fillers within the paper structure, and variations in the thickness of the paper. Moisture variations can also affect the dielectric force strength sufficiently to produce visible optical density variation. Where toner transfer is inefficient, residual toner remains on the photoreceptor and may be transferred to the next image, increasing background speckle or producing "ghosting."

Once on the paper, the toned image must be fused to become permanent, usually by heat and pressure, cold pressure, radiation, or vapor methods. Generally, fusing quality decreases as the surface roughness of the paper increases.

Liquid "inks," consisting of toner particles dispersed in a vehicle, are used in HP Indigo digital printing systems. Vehicle penetration into the paper pores and evaporation leave the toner particles on the substrate surface. The fusing step in this process tends to require lower temperatures and pressures compared with powder toner technologies.

Characteristics of Efficient Digital Papers

In order to produce high quality images and good on-press runnability, electrophotographic papers are required to have certain characteristics that offset papers do not necessarily share. These are briefly outlined below.

Moisture levels. Of all digital paper properties, the moisture level and moisture history are arguably the most critical, and are often the only rigid paper specifications provided by a press manufacturer. The moisture level of most digital papers generally varies from 4 to just below 5 percent of the paper's overall weight. Paper that is too dry may result in static discharge within the print engine, resulting in paper jams. Too much moisture causes print defects, curl, and again, jamming. Moisture history is also a factor: paper "remembers" moisture and temperature exposures, and may not fully recover from an inappropriate environmental exposure.

Runnability. Out-of-plane deformation (such as curl or cockle) is a problem that is exacerbated at the higher toner levels and fuser temperatures used in full-color digital printing. Like incorrect moisture levels, out-of-plane deformation will also reduce a paper's runnability. Compared with many offset press requirements, sheet properties for digital printing must be more stringently controlled in terms of stiffness, moisture level, edge quality, and dimensional integrity in order to meet the jam-free requirements of complex high-speed paper paths.

Capiler (Thickness). Managing caliper in digital printing is critical because the magnitude of the electrostatic force which pulls toner towards the sheet surface in the toner transfer step depends on how much material is beneath the surface. Sheet thickness variation, or z-direction non-uniformity, has been shown to be a significant factor in the variation of surface charge density.

Grain direction. In digital presses, feeding sheets with the grain in the wrong direction can cause paper jams if the stiffness in not in the functional range.

Formation. The performance of paper in digital printing has been shown to be very closely related to formation, or the distribution of mass density. Ink penetration depends on the right size, depth, shape and distribution of voids and pores in the surface.

Surface properties. Fluctuations in paper surface composition can result in variations in surface resistivity, and hence toner density, degrading the print quality of graphic images. The distribution of fillers within the body of the paper both laterally and perpendicularly to the surface will affect the charge density at the surface, influencing toner transfer.

Toner adhesion. Dry toners used in digital printing generally penetrate much less into the surface than offset inks, even though there is a molten phase in which some liquid polymer or resin is able to penetrate pores and voids. Thus there is a higher concentration of colorant on the surface than with similar offset inking levels. Coated papers retain more toner on the surfaces, but do still rely on some pore penetration for effective adhesion.

Surface strength. In the toner fusing stage, paper surface strength must be adequate to prevent delamination of coatings, or fiber-picking with uncoated papers. Either fuser oil or surface control agents on the toner particles themselves may be used to enable release from fuser rolls.

Smoothness. Very smooth surfaces cause high levels of light reflection from the paper surface, or gloss. In areas with differential toner coverage, or if fusing is non-uniform, differential gloss across solid tones can be distracting. Also, gloss stock can blister if the underlying moisture is heated in the fusing step and the steam has nowhere to go. Therefore environmental conditioning and low, uniform moisture levels are particularly important with high-gloss digital papers.

Dimensional stability. In a digital press, papers are subjected to heat, pressure and a variety of other forces, most of which are imposed in the fusing cycle. High temperatures can cause expansion, contraction, curl, cockle, and in some cases accelerated creep. Digital papers must be able to maintain adequate dimensional stability in toner fusing cycles

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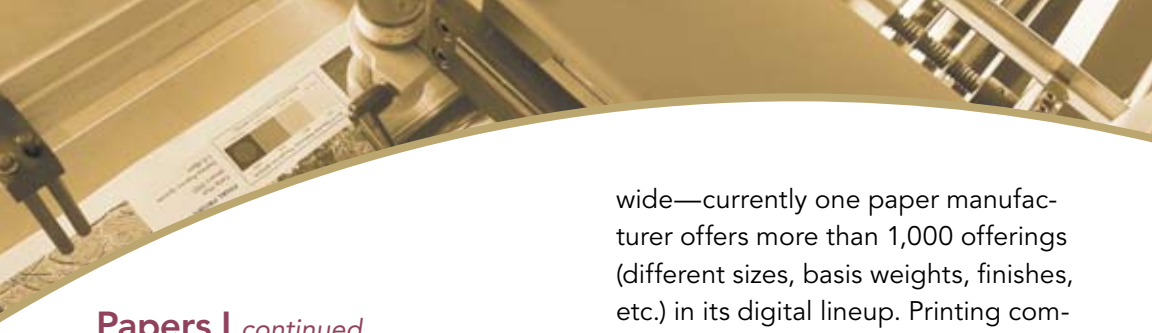

Papers I *continued*

up to 400 degrees F to enable the accurate registration of images on both sides of the paper.

Charging characteristics. Digital papers must be able to take and hold a charge in order to effect a clean and efficient image transfer. The characteristics that relate to efficient toner transfer include the paper's intrinsic conductivity (the product of the charge density and mobility) and also the charge injection and charge lifetimes. The paper must be able to allow charge transfer to exactly the right extent, followed by a limited decay, all the while holding the charge for long enough for the transfer step to take place.

Appearance properties. Early digital printers suffered from significant inconsistency of color and image density during print runs, and a common practice was to operate in several shorter runs to allow "recovery" to a normalized state. The stability requirements of papers for color rendering ability and brightness are tighter with the newer digital technologies. Opacity is another important consideration. Although toners do not penetrate as deeply as offset and inkjet inks into the structure of the paper, highly toned areas can lead to show-through in two-sided printing. This is more of a challenge to color printing in which toner levels in some systems may approach 400%.

Pricing Trends and Paper Availability

The cost of digital papers remains high compared to offset papers, and this is a challenge for sales personnel selling both categories to a print provider. The range of digital papers is already wide—currently one paper manufacturer offers more than 1,000 offerings (different sizes, basis weights, finishes, etc.) in its digital lineup. Printing complex jobs using multiple stocks in one pass through a digital production press is a key advantage of digital printing. With one-pass document printing and finishing, the concept of "productivity" extends beyond press run speeds to the idea of finished pieces per unit time. This integrated capability is driving the need for wider and matched substrate ranges which can run concurrently in a print job.

Conclusion

The chemical composition, spatial distribution of components, and thickness uniformity of papers used in digital printing are more critical than those of papers for other printing processes. Thus the design and production of high quality digital papers requires more thought than just, for example, turning up the dryer on an offset formulation to reduce moisture levels, or tightening specification latitudes. In many cases the economic viability of a print job depends on the quality of the substrate; poor runnability and low image quality can differentiate between profit and loss in an industry with tight profit margins. The demands on paper manufacturers and the need for open research into digital papers have never been greater.

To read about this research in detail, download the monograph from: http://print.rit.edu/pubs/picrm200506.pdf

Papers for Digital Printing, Part II

"Papers for Digital Printing, Part I" explained that the chemical composition, spatial distribution of components, and thickness uniformity are more critical of papers used in digital printing than those used in other printing processes. Part II summarizes the remainder of the Printing Industry Center research monograph *An Investigation into Papers for Digital Printing,* by Mary Anne Evans, Ph.D., and Bernice A. LeMaire.

The objective of this research study was to identify constraints and potential solutions for the improved performance and quality of digital papers. A total of 103 U.S. and Canadian printing companies that offer digital printing services responded to a telephone survey that was designed to:

- identify the paper grades commonly used for the market segment of production digital printing,
- identify the number of brands used and the nature of printing companies' relationships to suppliers,
- determine the factors that affect brand purchase decisions,
- discover the relative importance of different paper properties and characteristics,
- assess the deficiencies in currently-available paper grades, and
- determine what improvements are required by digital printers, and what limitations are currently imposed by press design.

Respondents were also asked for their perceptions of the change in paper costs to the printer over the years 2002–2004, and to what extent, if any, changes in paper costs affected the prices charged to print buyers.

Demographics

The survey sample was dominated by smaller companies, with 68% of participants generating 2004 revenues of less than $3M. The job categories predicted to generate the greatest revenues were marketing and promotional materials, direct mail, and transactional and business communications. There was some ambiguity in the definition of "digital printing" among the participants, based on the press brands and technologies reported by the respondents. Evidently some computer-to-plate and direct-to-press technologies were regarded as "digital" by certain respondents.

Most participants in the survey were commercial printers with some digital equipment. When asked to specify the year of entry into digital production, about 15% of the respondents reported purchasing their first digital presses in 1995. This may correspond to the market introduction of the Indigo and Xeikon digital color presses. There was another significant boom in 2002, when 12% purchased their first digital presses, closely followed by a decrease in 2003 when only 6% entered the market. Eighty-five percent of the respondents used only digital sheetfed presses, and only 5% had only digital web capabilities, indicating that the survey sample did not capture the web-fed high-speed transactional segment that is currently responsible for a significant portion of digital production volume.

Paper Grades for Digital Printing

There was a wide range of substrates used within the research sample for digital printing, but based on two separate questions, coated gloss was found to be

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Papers II *continued*

the leading paper grade (see Figure 1). The top five other paper grades used most frequently were premium uncoated, uncoated calendered, coated matte, uncoated uncalendered, and premium bond, in that order.

The Paper Selection Decision

Respondents were asked how the paper selection decision was made: by an individual within the printing company, by the customer (print purchaser), or jointly, by both parties (see Figure 2). This is important for paper producers to understand because it will affect their advertising strategies for new paper brands. Generally there seemed to be a tendency to collaborate on the selection of paper grades: about 46% of the respondents reported that they collaborate with customers to make paper decisions. However, the distribution of responses to this question indicated mixed paper selection practices. In an open-ended question, respondents were asked who within their organization makes the paper grade selection. The responses were categorized and are shown in Figure 3.

In exploring brand and paper supplier relationships, there was some ambiguity in the definition of the term "brand," which complicated the data interpretation. However, 50% of respondents indicated 5 or fewer brands in

Figure 1. Papers used very and somewhat frequently for digital printing applications, and the percentage of grades used most often.

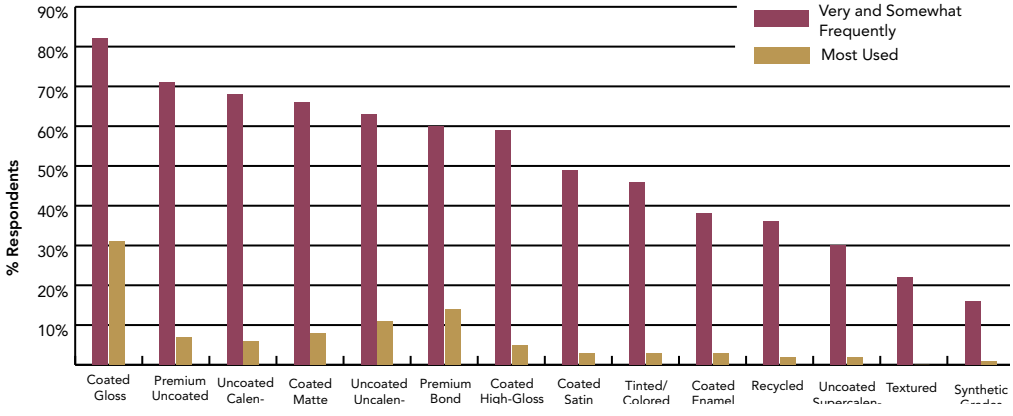


Figure 2. The paper grade selection decision.

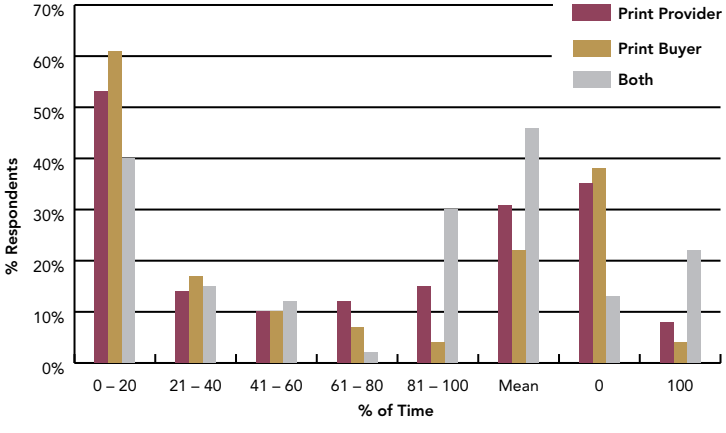
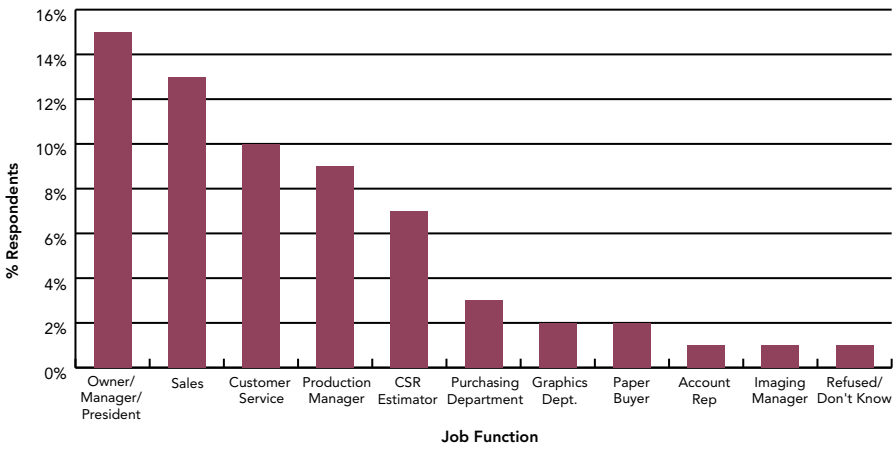


Figure 3. Job function or title of person selecting paper grade within the printing company.



their portfolios. This indicates a degree of brand loyalty, but 71% of respondents reported that they are not limited to a specific brand choice.

Respondents were asked to rank seven factors that impact their evaluation of different sources or brands of paper for digital printing. These factors were rated as follows:

- runnability and print quality (two separate factors that were given equal weight by respondents),
- availability of grade,
- appearance properties,
- price,
- multipurpose functionality across different printing technologies, and
- product range.

In general, the leading paper characteristics considered when making a purchase decision were found to be:

- toner / ink adhesion,
- accurate sheet dimensions,
- dimensional stability, and
- moisture level.

Table 1 gives a more comprehensive picture of how respondents evaluated paper characteristics, and demonstrates that performance parameters were considered to be more important than appearance-related factors.

Acceptability of Current Digital Paper Grades

The area of improvement in digital papers that printers want to see most is an extended product range, with more sizes, finishes and basis weights available for their digital presses. The presses currently owned impose paper choice limitations on size, basis weight, thickness, and surface treatment requirements. Only eight respondents indicated that they would like to see a lowering of paper price. This is consistent with the observation from previous questions that price is not a leading driver in the brand selection and purchase decision.

Paper costs to printers were reported by 70% of respondents to have increased either significantly or somewhat over the last two years (2002–2004). Nearly half of the companies experiencing paper cost increases pass these on to their customers.

Looking to the Future

Overall, it appears that there is room for product development to meet the growing potential for digital printing applications. This imposes a significant

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Papers II *continued*

Tabel 1. Relative Importance of Paper Characteristics in Selecting a Grade

	Percent Respondents						
Property	Critically Important	Quite Important	Somewhat Important	Not Important	Don't Know	Most Important*	Second Most Important
Toner/Ink Adhesion	84	11	4	0	1	52	17
Uniformity	69	22	4	1	4	7	10
Accurate Sheet Dimensions	68	17	10	2	3	10	12
Dimensional Stability	51	24	19	5	1	4	13
Moisture Level	45	27	21	6	1	4	6
Surface Finish	39	36	21	2	2	3	5
Surface Smoothness	31	34	25	7	3	4	7
Basis Weight	30	31	29	5	5	2	1
Brightness	24	31	41	3	1	0	10
Opacity	24	35	36	1	4	3	0
Color	21	31	37	10	1	0	0
Surface Strength	19	30	35	11	5	0	2
Storage and Handling	14	40	32	13	1	1	1
Lightfastness	14	32	29	19	6	0	0
Stiffness	13	28	38	14	7	2	0
Sheetweb Strength	10	20	37	28	5	0	4

* Separate question

challenge to paper manufacturers since there are currently many different press technologies with a wide range of required sheet and roll sizes. In 2005, a wide range of new digital papers and new product lines were introduced, with more color options, a wider range of basis weights and sizes, and new textures and finishes. But technical issues remain, and printers will continue to look for papers with improved runnability, printability, and fitness for use in the new generation of production digital presses.

To read about this research in detail, download the monograph from: http://print.rit.edu/pubs/picrm200506.pdf

Printing Applications Laboratory

www.printlab.rit.edu

The Printing Applications Laboratory (PAL) offers a wide range of evaluation services and certification programs for companies who want to optimize their products and processes. PAL's experts routinely help industry clients to develop and evaluate consumables used in offset, flexographic, and digital printing; namely, substrates, inks, fountain solutions, blankets and plates. Companies that manufacture the various components that go into these printing consumables also come to PAL for advice and testing. The Printing Applications Laboratory's flexible approach to experimental design means you'll get exactly what you need to meet your goals, whether it's a simple experiment or a full-scale print trial under controlled, repeatable conditions.

Trial and Evaluation Services

- Evaluations of Printing Consumables
- Digital Media Evaluation
- Print & Materials Analysis
- Printing Process Measurement and Control
- Competitive Benchmarking

Facilities and Equipment

RIT is home to the most complete collection of printing equipment dedicated to education and research you'll find anywhere in the world, from conventional presses to digital printing engines to advanced analytical labs. RIT's $10 million Goss Sunday 2000 web offset press, augmented by nearly $2 million worth of auxiliary equipment in a new environmentally-controlled laboratory, provides industry with the foremost facility in the world for education and research in web offset printing.

Industry Education Programs

RIT has been a leading provider of education for the printing and imaging industries for over 50 years. Education and training is provided in both traditional and digital technologies using world-renowned instructors, RIT's comprehensive prepress and press labs, and the latest imaging facilities. While seminars are scheduled throughout the year, customized programs can be designed to suit a company's specific needs at any time, and are offered either at RIT or on-site.

OCTOBER

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Register online or email Ken Posman at krptpd@rit.edu

Workforce Education & Training

October 2 – 4
Flexographic Relationships and Variables (*New*)

October 4 – 5
Implementing Variable Data Printing (*New*)

October 11 – 13
Lithographic Troubleshooting

October 25 – 27
Print Buying Essentials

October 30 – Nov 3
Orientation to the Graphic Arts

November 1 – 2
IT Requirements for Successful Digital Printing (*New*)

November 8 – 10
Color Control for the Production Pressroom

November 14 – 17
Printing Process Identification and Image Analysis for Forensic Document Examiners

November 29 – Dec 1
Web Offset Lithography

December 4 – 7
Matching Proof and Press

December 11 – 13
Stochastic Printing — Fact vs. Fiction

About the Center

Rochester Institute of Technology (RIT) was selected by the Alfred P. Sloan Foundation in 2001 to join the family of Sloan Industry Centers located at prestigious universities across the U.S. The Printing Industry Center at RIT is a joint program of the School of Print Media and RIT's College of Business, emphasizing Sloan's long-standing tradition of applying a broad multidisciplinary approach to industry investigations and findings.

Dedicated to the study of major business environment influences in the printing industry brought on by new technologies and societal changes, the Printing Industry Center at RIT addresses the concerns of the printing industry through educational outreach, research initiatives, and print evaluation services. The Center creates a forum for printing companies and associations worldwide to access a neutral platform for the dissemination of knowledge that can be trusted by the industry, to share ideas, and to build the partnerships needed to sustain growth and profitability in a rapidly changing market.

With the support of RIT, the Alfred P. Sloan Foundation, and our Industry Partners, it is our mission to continue to develop and articulate the knowledge necessary for the long-term economic health of the printing industry.

More information on the Printing Industry Center at RIT and its research activities can be found online at http://print.rit.edu.

Industry Partners

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print review
Volume 3: Fall 2006

About the PrintReview

The Print Review is produced quarterly exclusively for Affiliates of the Printing Industry Center at RIT. Membership and PrintReview subscription is free upon request. To register, go to: http://print.rit.edu/affiliates/ or call 585-475-4231

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