



Production Inkjet Market Survey on Print Quality Measurement and Paper Qualification

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Inkjet Insight Production Inkjet Market Survey on Print Quality Measurement and Paper Qualification

Table of Contents

Executive Summary	2
Key Findings.....	2
Introduction	3
Participant Demographics	4
Figure 1. Participant Demographics by Application Segment.....	4
Paper Qualification Priorities	5
Figure 2. Relative Importance of data driven print quality measures in paper qualification	5
Additional Participant Feedback	6
Defining the Measures of Print Quality	7
Recommendations for Inkjet Users	11
Ask for the Data You Need	11
Use Data (Appropriately) to Drive Decisions	12
Conduct Your Own Testing.....	13
Helping Manufacturers Improve Customer Satisfaction	15
Clearly Communicate the Standard Media Validation Process.....	15
Provide Qualification Data When Available.....	15
Provide Options for Enhanced Qualification and Measurement	16
Summary	16
Appendix 1 – Survey Questions	17
References.....	18

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Executive Summary

Inkjet Insight completed a survey of production inkjet users on paper qualification in November 2019. The goals of the survey were twofold; first, to understand customers' requirements for print quality measurement when qualifying papers for use on inkjet presses and second, to measure satisfaction with OEM services related to meeting those requirements.

We first queried participants' understanding of print quality analysis and then requested that they prioritize the data-driven measures that were most important to their business. Participants were also asked to compare their requirements for paper qualification data with what they currently receive from their OEM (or OEMs).

Key Findings

- Only 28 percent of respondents were satisfied with the paper qualification data supplied by OEMs while 52 percent were dissatisfied, and 20 percent were neutral.
- Only 17 percent of survey participants said that their OEMs provided additional paper evaluation data not included in standard paper listings.
- 48 percent stated that they need additional paper qualification data which their OEM did not currently supply.
- Regardless of application focus, 100 percent of respondents said that small text clarity and color gamut were important, with 46 percent and 48 percent respectively saying those measures were very important.
- Optical density and show-through were important to 93 percent of respondents with 59 percent citing show-through as a very important measure.
- Responses covered participants who reported working with a wide range of OEMS including Canon, HP, Kodak, Komori, Ricoh, RISO, Screen, Superweb, and Xerox. Many participants worked with more than one inkjet OEM.

This research paper includes recommendations for owners of production inkjet, and those evaluating equipment, when requesting paper qualification data from OEMs. Recommendations for OEMs on improving communication with customers and supporting data-driven decision making for customers is also provided. It is the perspective of Inkjet Insight, supported by customer research, that there are significant opportunities for improvement in the paper qualification process that can benefit customers, inkjet OEMs, paper mills and print buyers.

Introduction

The Inkjet Insight Paper Qualification survey conducted in late 2019 sought feedback on the importance of nine specific measures of print quality.

1. Optical density
2. Chroma – CMYKRGB
3. Show through
4. Color gamut
5. Mottle
6. Coalescence
7. Color-to-color bleed
8. Small text clarity
9. Edge clarity

Participants were asked to rank these quality measures in terms of importance to their business using the scale: *Very Important, Important, Neutral, Unimportant, Not Applicable (N/A)*.

Participants were also asked about:

- Information received from standard paper qualification listings provided by their OEM
- Whether their OEM provided additional measures not included on the standard listing
- Whether or not they needed additional paper qualification data over and above that supplied by the OEM

Participants provided feedback on additional issues not specifically in the survey, including the need for a measure or indicator of dust content, requests that qualification include validation through finishing, and the need for transparent standards in testing and measurement.

[We] “Would like to see some standards for the input data/content driving the qualification process - *anything* that creates better integrity for measurement and comparability would be valuable.”

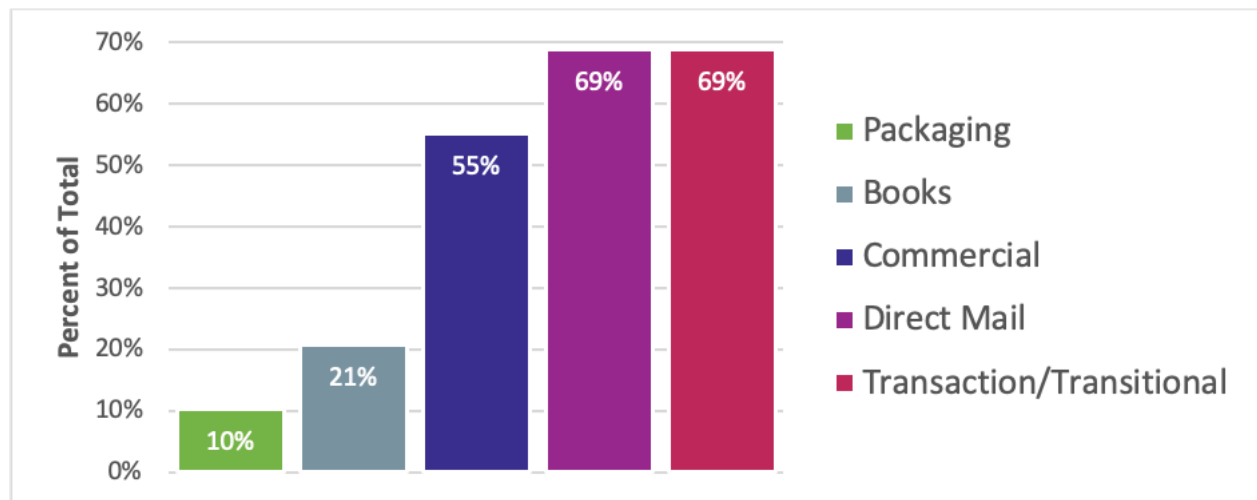
Survey Participant

Participant Demographics

Survey participation was limited to current inkjet users in the U.S. Respondents represented five major application segments with the majority indicating that they use inkjet to provide services in multiple segments.

In addition, a majority of participants self-described as knowledgeable about the subject matter; 93 percent agreed that they had a strong understanding of print quality and how it is measured, 55 percent strongly agreed. For the remaining 6 percent; 3 percent were neutral on the question and 3 percent disagreed that they have a strong understanding of print quality and how it is measured.

Figure 1. Participant Demographics by Application Segment



While participants produced output across a range of application segments, there was not a significant difference in participant responses by segment. This may be due to the fact that the majority of responding participants indicated that they operated in more than one segment and are, therefore, likely to answer each question based on the application segment with the most stringent requirements. For example, a company operating in both transaction printing and direct mail may answer based on having higher coverage or color fidelity requirements for direct mail. It is also important to note that these application segments require a wide range of paper grades and finishes, however the interest in the level of paper qualification data remains similar.

93% of survey participants reported having a strong understanding of print quality and how it is measured.

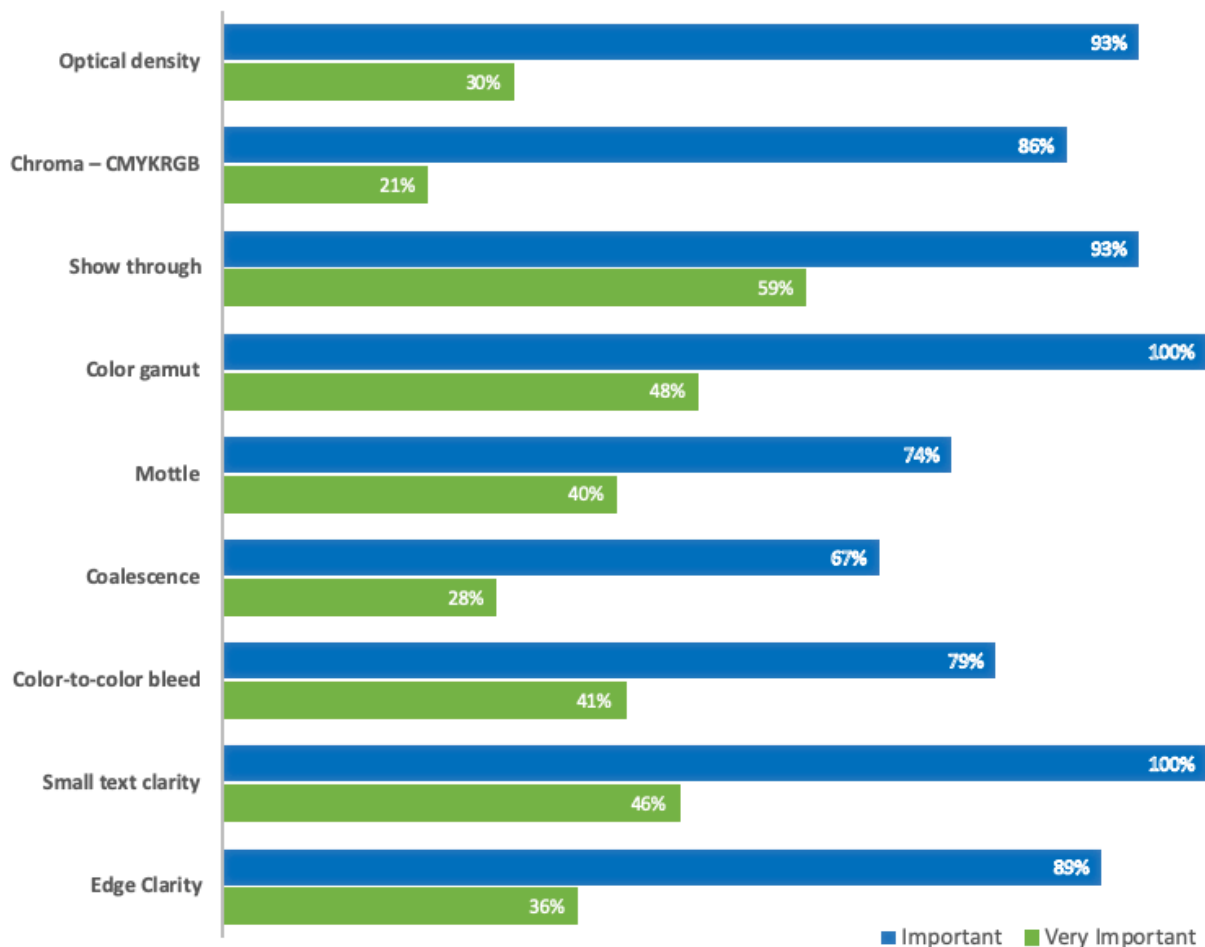
Paper Qualification Priorities

Based on the average of responses to the survey, paper qualification measurement criteria were ranked by order of importance as follows:

1. Color gamut
2. Small text clarity
3. Show through
4. Optical density
5. Edge Clarity
6. Chroma – CMYKRGB
7. Color-to-color bleed
8. Mottle
9. Coalescence

Figure 2 below shows the percentage of survey participants who ranked each of these measurement criteria, and the order in which the question was included on the survey.

Figure 2. Relative Importance of data driven print quality measures in paper qualification



Additional Participant Feedback

Participants were given the option to write in additional information that they felt was important to convey to OEMs. Below are a few, clearly stated, comments from the survey.

"For transactional applications the substrates are pretty well defined. The challenge is with the Direct Marketing space (coated/glossy), higher quality wealth management applications and heavier weights used for post cards."

"We need to see full testing results from printer manufacturers."

"We need standardized specifications, sampling and consideration on runnability for post-print including insertion and finishing"

"We need testing to include both the printer and inserters. Also a measure of dust content."

"Would like to see some standards for the input data/content driving the qualification process - anything that creates better integrity for measurement and comparability would be valuable."

"I am surprised at how little coordination seems to exist between the paper companies and the OEMs. There's some, but there needs to be a lot more if OEMs and mills want to really propel production inkjet growth"

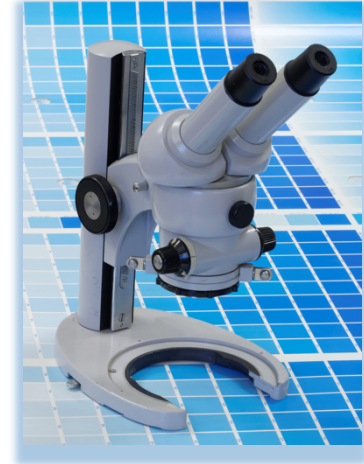
It is clear from the both the quantitative and qualitative responses that, on the whole, participant's expectations and needs for paper qualification data are not being met. Further discussion of the processes for measuring print quality is important to understanding why these problems may exist and to drive recommendations for improving industry approaches.



Defining the Measures of Print Quality

While most participants in the survey indicated a strong knowledge of print quality and paper qualification measures, not all readers of this report may share their expertise. As noted previously, an understanding of the method of measuring each of these print quality characteristics provides important context for why data may not be readily available from OEMs.

Each of the quality characteristics included in the survey is defined below along with a high-level overview of its form of measure.



Optical Density

Density refers to the amount of light that is reflected from the substrate and the ink. The higher the density number, the more light absorbs into the print surface and the darker the shade. Lower density percentages mean more light is reflecting resulting in lighter shades. Optical density is measured for each color channel on the press, for example CMYK, using a 100% solid patch of each. Optical Density (OD) is measured on a logarithmic scale where:

- OD of 0 means that no light is absorbed and 100% of light is transmitted.
- OD of 1 means that 90% of light is absorbed and 10% of light is transmitted.
- OD of 2 means that 99% of light is absorbed and 1% of light is transmitted.

Chroma

Chroma describes the purity, intensity or saturation of a color and is affected by the densities of the individual and combined colors when printed. Chroma is a perceptual metric considered more suitable for comparisons between systems than optical density. A higher chroma value for C,M,Y,R,G,B represents greater purity for combined colors.

Even though black (K) lacks chroma, K measurements are captured to account for aqueous inkjet interaction with papers which include high Optical Brightener Additives (OBAs). OBAs can give K a bluish haze when absorbed, affecting quality for application segments such as books. In CIE L*C*h Color Space, chroma is represented as C* and measured as the distance from the L* or lightness axis starting at 0 and ranging to 100 (or over 100 with OBAs). Minimum and maximum chroma measures are highly dependent on ink chemistry, absorption and paper shade.

Show Through

As the name implies, Show Through describes the extent to which ink printed on one side of the media can be seen from the reverse side. Its value is determined by subtracting the L^* (lightness) of the printed area from the unprinted area on the back side of the media creating dL^* or change in lightness. Values measured include 100% primary and secondary colors (C,M,Y,K,R,G,B).

- Show through ranges from <1.0 for higher opacity uncoated and coated media (less show through) to >3.0 for lighter weight and low opacity media (higher show through).

Color Gamut

Color gamut, or gamut, defines the total number of colors that can be accurately printed with a specific press, and ink on a specific media (or other substrate). Gamut results will vary based on settings such as speed and drying temperature, as well as the use of primer or precoating.

- Gamut can range from 150,000 to 250,000 for uncoated reaching measures $>400,000$ for coated gloss papers

Mottle

Mottle refers to irregular fluctuations of visual density within a solid area and can occur as a printing defect on uncoated, porous media (as compared to coalescence which occurs with non-porous media).

There are different types of mottle: density mottle, gloss mottle, or color mottle, depending on which visual aspect is affected. All forms of mottle are typically the result of non-uniform ink or coating spread within or across the image area. Mottle is a large area measure, rather than a character or line measure.

Using the ISO-13660¹ International Print Quality protocol, the density fluctuations are calculated against a specified tile size within the measured area to determine a mottle percentage value of reflectance density. Since reflectance density is perceptual, and less relevant than $L^*a^*b^*$, other methods have been introduced using $L^*a^*b^*$ color space which better correlate to visual perception².

- Measured within a range from $<1.0 - 4.0$ %, showing null to highly visible

Coalescence

Coalescence is the uneven spreading of printed ink due to contact angle or surface tension on low porosity media. Unlike mottle, coalescence occurs higher on the print surface of non-porous media. When ink coalesces on the media, visual mottle occurs presenting dark splotchy areas as ink or coating spreads inconsistently across an image area. Coalescence is measured the same way as mottle by ISO 13660 standard or $L^*a^*b^*$ visual correlation.

- Measurements range from $<.5$ to $>4.0\%$, showing null to highly visible coalescence.

Color-to-Color Bleed

Color-to-color, or intercolor bleed happens when one or more colors spread into other colors causing edge raggedness. This effect can occur from ink incompatibility or improper drying. Bleed measurements are captured in $\text{mm}/\mu\text{m}$ based on the distance by which one color encroaches on another from a set edge. While the amount of color-to-color bleed is measurable, there is not an acceptable standard in $\text{mm}/\mu\text{m}$. A higher μm of intercolor bleed on uncoated media is typically more acceptable than on coated media. Color-to-color bleed may be a causal factor in the acceptable level of other measures such as Small Text Clarity.

Small Text Clarity

Quantifying text clarity, or stroke, requires measurement of both positive and negative sans serif text quality using 4pt text of 1, l or L characters at a 1x print capture. Text clarity is a combination of stroke properties measured including stroke width, blurriness, raggedness, density, contrast, and fill (voids). The algorithms for determining each of these properties are based on ISO13660 international standard for image quality measurements.

- Depending on capture requirements, measurements can be totaled for an averaged overall text quality score or can be evaluated individually.

Edge Clarity

Edge clarity is determined by measuring the raggedness of a straight edge of line art of any color, or combination of a single color, that is not touching other colors. Raggedness measurement determines the cleanliness of a graphic elements hard edge. ISO-13660 measured algorithms capture worst case (lead to trail) of a measured edge. Edge clarity is affected by ink spread, jetting accuracy and motion control.

- Measurements range from $<.01$ to >10 , showing null to highly visible.

From the definitions provided, it should be clear that significant effort is required to capture specific measures of quality rather than simply deeming a paper grade “runnable.” Measurement requires specialized equipment, professionals trained in the use of the equipment and the time and budget to complete these measures.

It can require 2 – 4 hours to capture proper samples on each paper. Results will then need to be measured from simplex samples printed on both the wire and felt side of the paper. When working with presses that support multiple resolutions and speeds, samples need to be qualified in each “mode” adding a multiplier effect to the testing effort. This also makes it imperative that customers know the press settings and profiles used to conduct testing as well as the results of the test. Selecting a paper that was “qualified” at a reduced production speed for use in production at top speed will result in disappointment at best.

For an OEM to test one paper on a single press with a single profile, they must arrange to receive the paper, prepare the press, capture quality samples and measure at an average effort of 6 hours, including all processes and changeovers. By extension, testing 100 papers (each gsm requires individual testing) requires an effort of 600 hours - plus machine and ink costs. It is more likely that tests will need to be run with at least 2 profiles of different TAC levels, bringing the effort to 1,200 hours, and this does not yet account for testing with finishing equipment.

Keep in mind that a test with finishing equipment is not a valid unless the equipment is installed in-line, or is immediately available off-line, so that test runs can be processed in a time frame which models production. Otherwise, additional drying time between print and finishing tests may suggest that a sample is compatible with finishing when under normal circumstances drying issues may have occurred. In addition, whenever inks or dryers are updated by the OEM, the paper should be requalified. Likewise, if the press is available in multiple ink or drying configurations – each should be tested individually driving extra cost.

To further complicate matters, while customers in different application segments stress the importance of the same measures, their level of quality tolerance for those measures may differ dramatically. A combination of media, press and ink that are totally unacceptable for a high coverage commercial print application may be very attractive to someone producing low-coverage transaction printing work, or perhaps monochrome forms production.

With presses in high demand for customer testing during the sales process, press availability for paper qualification can be as much of an issue as the [significant] cost.

Recommendations for Inkjet Users

Companies using production inkjet equipment will have different tolerances for print quality depending on the application segments they support and range of papers used for production. What they have in common is a need to quickly find suitable media to meet their customer's demands. If that information is not readily available from their inkjet OEM, inkjet users must:

1. Ask OEMs for the necessary data
2. Use data appropriately to drive decisions about paper qualification
3. Conduct internal testing to supplement OEM data

Ask for the Data You Need

If a paper you are interested in has been tested by your OEM, ask how paper was qualified and why it is or is not deemed suitable for your application segment. Be clear about the metrics that your company requires, such as small text clarity, color gamut and show through for qualifying a paper for your business. If the data has been captured, use it to make your own suitability assessment and discuss with your OEM (see using data to drive decisions below.) If your OEM has not captured these metrics for the media that you are interested in, request that testing be conducted and that profiles and measurements be shared.

Now prepare to get in line! As noted previously, press time is precious, and OEMs are likely to focus on testing papers with the widest use for established application segments. In addition, you or the OEM will need to coordinate with the mill on delivery of the paper. The mill may or may not provide a test roll for free. You may get faster results by requesting that OEMs provide print capture and profile information while you take on responsibility for analysis and measurement, and agree to share data with the OEM and mill in exchange for paper and sample capture time. (See Conduct Your Own Testing)

Press time is precious. Be prepared to wait.

Use Data (Appropriately) to Drive Decisions

Define the minimum and/or maximum acceptable values for the metrics requested. If you support more than one application segment, be clear about the segments in which you expect to use the paper and the acceptance criteria for each. You may find that a paper qualifies for one application segment but not another.

If qualifying papers as part of a press evaluation, understand that the same paper on different presses will produce different results, but those results may not be indicative of the best possible results for each press. OEMs are sensitive to paper qualification data being used to make comparisons that are not fair or relevant and this can feed their reluctance to share metrics. To objectively evaluate the best results that a press can deliver, allow each OEM to recommend a paper that meets your cost and formation characteristics. A company may be required to evaluate presses on a specific paper in order to maintain consistency of paper with other equipment – particularly when printing across a mixed environment of offset and digital equipment. In those cases, it may be worth testing additional papers to see if a change in supply is merited by improved quality or ability to manage ink volumes on another stock.

Regarding ink limiting, it is also important to review the profiles used for sample capture. As part of an evaluation that includes press comparisons of total cost of ownership, samples may be captured by the OEM using settings intended to deliver acceptable results while managing ink consumption. Comparing results with a paper and press combination with an ink limited profile to a paper and press combination tuned for maximum quality would not be a fair comparison.

It is also important to note that the metrics supplied for paper qualification by an OEM will not be an exact match for the results achieved on a delivered machine. Every press is slightly different, in addition, and batches of paper from the same mill can vary in color and formation – particularly if produced on different machines. Eventually, you will need to test and tune papers on your own press.



Testing the same paper on different presses may not demonstrate the best quality the press (or paper) can deliver.

Use data appropriately.

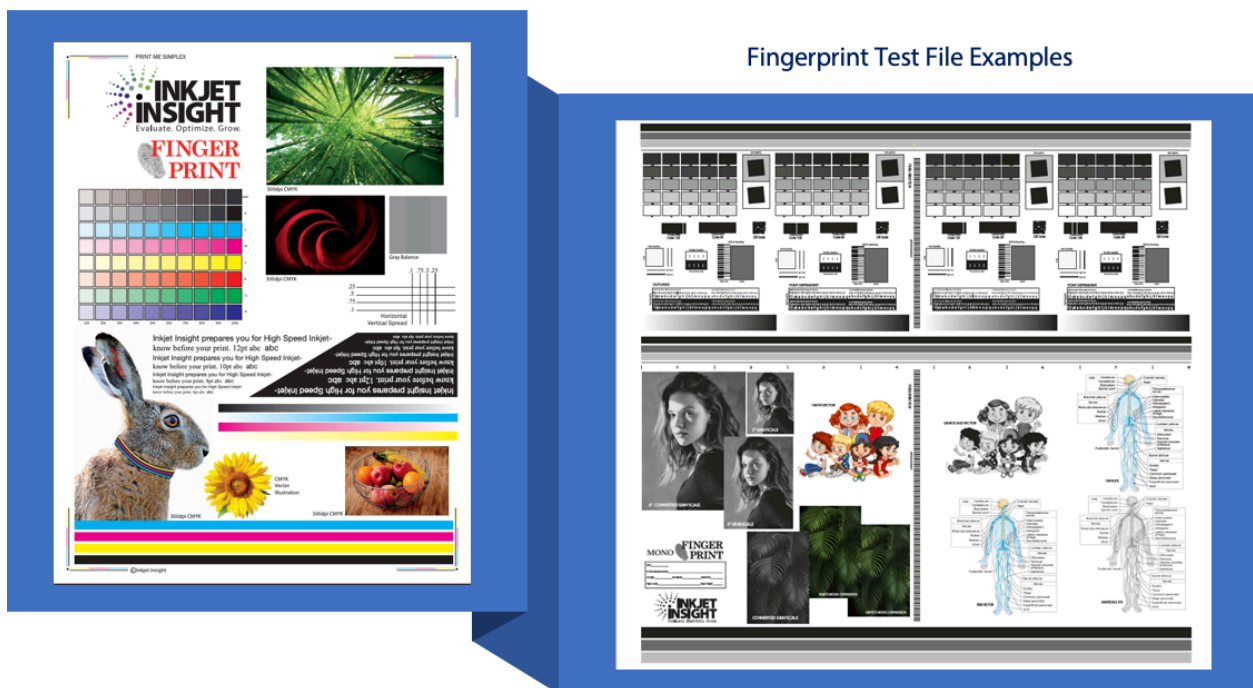
Conduct Your Own Testing

There are numerous reasons to conduct your own paper qualification testing:

- Gather qualification data not provided by OEMs for qualified paper
- Reduce time necessary to qualify new papers when OEM presses are backlogged
- Improve metrics by gathering data on your production machine and tuning profiles on qualified papers to your requirements

There are also challenges with conducting testing in-house. Any cost burden for testing that the OEM was willing to absorb has now shifted to you. There may also be limitations on qualifying new papers as part of your warranty depending on the device. This is due to OEM concerns about protecting heads from damage from papers that are too thick or too rough or that cast-off significant paper dust.

As noted, for OEMs that are not willing or able to supply measurement data, there is the middle ground of requesting that OEMs provide print sample capture and profile information while you take on responsibility for analysis and measurement. If taking this approach, you will want to use a standard fingerprint file for testing (Inkjet Insight provides a variety of free files for members.) You will also need measurement equipment such as a densitometer and/or spectrophotometer, a quality analysis system and an area with controlled lighting in which to capture measures.



Measuring samples requires an investment in software, hardware and training. If you don't have the necessary equipment or expertise to measure the quality of samples on your own, you can have samples shipped to a print quality analysis consultant at an independent lab.

When engaging a consultant, make sure to be clear about the measures that you want captured and the consultant's qualifications for capturing those measures. If working with a consultant, take time to understand the measurement equipment and methodology used and the format in which the data will be reported to you.

An independent color management consultant may also be able to help you "cut the line" for paper testing by arranging sample capture on your site, or at a production location with the same press configuration. If paper qualification is your main goal, you may be able to defray costs by working with a peer group to qualify multiple papers and share data.

Whichever approach you choose, it is important to communicate with your OEM. In the best scenario, you will be in close communication with your OEM, paper provider, finishing partner and color consultant (if engaged) during the testing process.

Assessment



Qualification

Helping Manufacturers Improve Customer Satisfaction

OEMs must strike a balance between protecting competitive information and providing the data that their customers need to operate efficiently. This starts with improving communication around the media validation process. Our intention with this research paper is to educate customers and enable ongoing improvements to the process.

Clearly Communicate the Standard Media Validation Process

OEMs are under pressure to identify and approve papers that are compatible with their presses. As noted, this is a costly and time-consuming process. In order to develop the most robust list of “qualified” papers possible, OEMs may opt for a minimized testing process in order to deem a paper runnable on a particular device. This process allows more media to be evaluated in a shorter period of time, but pushes the responsibility for further measurement and assessment to the customer. That tradeoff is reasonable if customers understand what “qualified” means and that further testing is required.

Customers should be made aware of the following information regarding the test:

- Visual of the test pattern used for standard testing
- Settings used for testing (e.g. press configuration, speed, ink limits, drying options)
- Qualification criteria for approval and month/year of testing

Since testing at this point is simply about ink, machine and media compatibility the criteria may simply be that the test run didn’t mess up the inside of the press with roller contamination or web breaks from wet output. Perhaps the output is also visually checked (not measured) for color to color bleed, coalescence and mottle. This type of testing should come with the caveat that the paper will run but further print quality assessment is required by the customer.

Providing print quality assessments in generalized formats such as star ratings or “good, better, best” without supporting data is virtually useless to the customer and can be misleading.

Provide Qualification Data When Available

While providing assessment of quality without supporting metrics is not recommended, OEMs should provide the data that is collected. When performing a measured print quality analysis on qualified papers, OEMs should at minimum indicate that this additional information is available on request to customers.

Provide Options for Enhanced Qualification and Measurement

There are several ways that OEMs can balance the need for fast paper qualification with customer's needs for qualification metrics. They typically require a commitment to transparency and industry collaboration that some OEMs may be more comfortable with than others.

- Leverage user groups to develop or simply encourage peer groups of press users to share paper testing expenses and data
- Provide customer training, or recommendations for third-party training on paper qualification and measurement
- Provide customers with recommendations for third-party color management consultants with experience on OEM's inkjet presses
- Collaborate with mills to support funding of third-party paper qualification for customers with the proviso that captured data will be made publicly available
- Support industry standards for reporting of minimum media qualification data

Summary

Companies using inkjet printers require paper qualification data in order to expedite and improve media buying decisions. Representative companies have indicated dissatisfaction with the level of data currently provided by OEMs, however, some of this dissatisfaction may be solved through improved communication.

Expanding the universe of qualified media for use on inkjet presses benefits the entire industry. Hold-back of data by OEMs due to concerns about customer knowledge or competitive misuse can hamper industry growth. Hoarding of data by customers who test independently is self-defeating since once a mill or merchant begins selling a paper for use on a particular type of press at one customer site, they will naturally want to make it available to other customers using that press.

Transparency, collaboration and standardized metrics are the tools that the industry can use to qualify more media and support continued growth of inkjet volumes.

Inkjet Insight would like to thank all of the people who took the time to complete our survey and contribute their perspective and insight.

Appendix 1 – Survey Questions

Participants were given the following statements and then asked to rank their agreement on a scale of **Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree**

1. “I have a strong understanding of print quality and how it is measured.”
2. “The paper qualification data I get from my OEM’s standard paper listing completely meets my needs.”
3. “My OEM provides additional data that is not in their standard paper listing that meets my needs.”
4. “I need additional paper qualification data that my OEM does not currently supply.”
5. Participants were asked to “Rank each of the following quality measures in terms of its importance to you” using a scale of **Very Important, Important, Neutral, Unimportant, Not Applicable**.
 - Optical Density
 - Chroma – CMYKRGB
 - Show through
 - Color gamut
 - Mottle
 - Coalescence
 - Color-to-color bleed
 - Small text clarity
 - Edge clarity

In addition to the above scaled questions, participants were asked,

6. “For which of the following market segments do you use your inkjet device(s)?”
7. “Which OEMs have you worked with to evaluate paper for production inkjet?”
8. “What type of ink do you use for your inkjet device?”
9. “Which paper mills have you worked with to evaluate paper for production inkjet?”
10. “Please share any other thoughts on how the inkjet paper qualification process could be improved.”

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About Inkjet Insight

Top industry experts combined their resources, creativity and brainpower to offer a deep dive into the world of production inkjet. The result is InkjetInsight.com, the most complete, unbiased and valuable source of information for companies evaluating and using production inkjet. Find specifications for inkjet presses, important software and workflow products and compatible finishing and media along with downloadable tools for evaluating products and measuring quality.

Inkjet Insight works with OEMs, mills and inkjet users to qualify media on inkjet presses using a standardized, measurable process and an independent testing facility. Our Inkjet Ambassadors make their presses available for peer group testing and benefit from reduced paper qualification costs.

For more information visit inkjetinsight.com

For consulting, analyst or speaker inquiries, contact Help@inkjetinsight.com

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