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The ibml FADGI Reference Guide

Information management professionals tool for ensuring image quality:

Launched in 2007, FADGI is an effort by U.S. federal agencies to articulate a common set of technical guidelines, methods, and practices for archival of digitized and born digital documents that are of historical and cultural importance. These standards took on a greater sense of urgency with the U.S. government's initiative to stop the flow of analog materials into the National Archives after 2022, in favor of electronic records.

FA DGI

This document provides ibml customers an overview of the FADGI standard and its benefits:

- **The FADGI standard**
- **How FADGI measures image quality**
- **How images are evaluated for FADGI compliance**
- **The impact of document scanners on FADGI compliance**
- **The benefits of achieving FADGI compliance**

An understanding of FADGI will help ibml customers comply to this standard and future-proof their operations.

The FADGI Standard

FADGI objectively quantifies quality standards for the document digitization process.

Developed by the FADGI Still Image Working Group and U.S. federal agencies, FADGI breaks new ground by providing businesses and government agencies with technical guidelines and best practices for achieving high-quality images when scanning and digitally capturing documents for archival, information extraction, post processing, and other information management purposes.

Image quality is a hot topic when it comes to document scanning. Images are closely monitored to ensure that they meet whatever standards an organization uses (their own or someone else's).

A document scanner consists of single or multiple cameras to capture the documents and a post-processing system to interpret the captured pixels and restructure these into an image format. Until recently, the quantification of image quality in scanned documents has been a difficult task. The most straightforward method for inspecting image quality was "visual inspection" of random scanned documents. However, this inspection requires a trained and experienced operator to identify any defects in the image, such as color defects or other aberrations. And these quality results vary from operator-to-operator and cannot be quantified appropriately for advanced analysis and comparison.

Standards such as FADGI were built to quantify various image quality parameters more effectively. This quantification can prove beneficial for complex image analysis within each imaging system and for comparison and analysis between imaging systems. This quantified data also provides a dependable and stable image evaluation procedure that can be automated and reproduced.

The quantified results are also excellent for evaluating the imaging system's efficiency and ensuring that each document captured through the scanner conforms to a standard image quality metric.

How FADGI Measures Image Quality

The FADGI evaluation system defines four image quality levels from one star to four stars. The higher the star rating, the higher the image quality and the applicability for different uses:

1. **One-star rating:** Should be considered informational, in that images are not of a sufficient quality to be useful for optical character recognition (OCR).

2. **Two-star rating:** Images may or may not be suitable for OCR.

3. **Three-star rating:** A very good professional image capable of serving for almost all uses. These images should not require rescanning or the storage of document hard copies. A three-star image accurately represents the original document as viewed by a human eye.

4. **Four-star rating:** Images represent the state-of-the-art in image capture and are suitable for almost any use. A four-star image is measurably more accurate than the 3-star but most-likely not discernable to a human eye.

Evaluation software is used to determine the FADGI quality rating assigned to scanned images.

FADGI image quality ratings are based upon aspects such as:

- **Tone response (luminance)**
- **Color accuracy and misregistration**
- **White balance error**
- **Modulation Transfer Function**
- **Illumination**
- **Noise levels**

The following table explains the FADGI evaluation parameters and performance levels in detail:

	★	★★	★★★	★★★★
Master File Format	Tiff, JPEG 2000, PDF/A	Tiff, JPEG 2000, PDF/A	Tiff, JPEG 2000, PDF/A	Tiff, JPEG 2000, PDF/A
Resolution	All	All	All	All
Bit Depth	150 ppi	300 ppi	300 ppi	400 ppi
Color Space	Grey Gamma 2.2 SRGB	Adobe 1998 SRGB ProPhoto ECIRGBv2	Adobe 1998 SRGB ProPhoto ECIRGBv2	Adobe 1998 SRGB ProPhoto ECIRGBv2
Color	Greyscale or Color	Color	Color	Color
Measurements Parameters				
Tone Response (OECF) (Luminance)	± 9 count levels ≤ 8	± 9 count levels ≤ 8	± 6 count levels ≤ 5	± 3 count levels ≤ 2
White Balance Error (Luminance)	± 8 count levels ≤ 8	± 6 count levels ≤ 6	± 4 count levels ≤ 4	± 3 count levels ≤ 2
Illuminance Non-Uniformity	< 8%	< 5%	< 3%	< 1%
Color Accuracy (Mean ΔE2000)	< 10	< 8	< 5	< 4
Color Channel Misregistration	< 1.2 pixel	< .80 pixel	< .50 pixel	< .33 pixel
MTF10 (10% SFR)	sampling efficiency > 60% and SFR response at half sampling frequency < 0.4	sampling efficiency > 70% and SFR response at half sampling frequency < 0.4	sampling efficiency > 80% and SFR response at half sampling frequency < 0.4	sampling efficiency > 90% and SFR response at half sampling frequency < 0.4
MTF50 (50% SFR)	50% of half sampling frequency: [30%, 85%]	50% of half sampling frequency: [30%, 85%]	50% of half sampling frequency: [35%, 75%]	50% of half sampling frequency: [40%, 65%]
Reproduction Scale Accuracy	< +/_ 5% of AIM	< +/_ 3% of AIM	< +/_ 2% of AIM	< +/_ 1% of AIM
Sharpening (Maximum MTF)	< 1.3	< 1.2	< 1.1	< = 1.0
Noise ΔL * St. Dev (Luminance)	> 6 count levels < 4	> 5 count levels < 3	> 4 count levels < 2	> 3 count levels < 1

Globally, FADGI builds upon existing International Standards Organization (ISO) 19264 and Metamorfoze standards for analyzing imaging systems and quantifying the measurable characteristics of digitized images. While the parameters for each standard slightly vary in nature and tolerance levels, FADGI aligns with the ISO 19264 and Metamorfoze image quality standards.

Below is a high-level comparison of the FADGI, ISO and Metamorfoze standards:

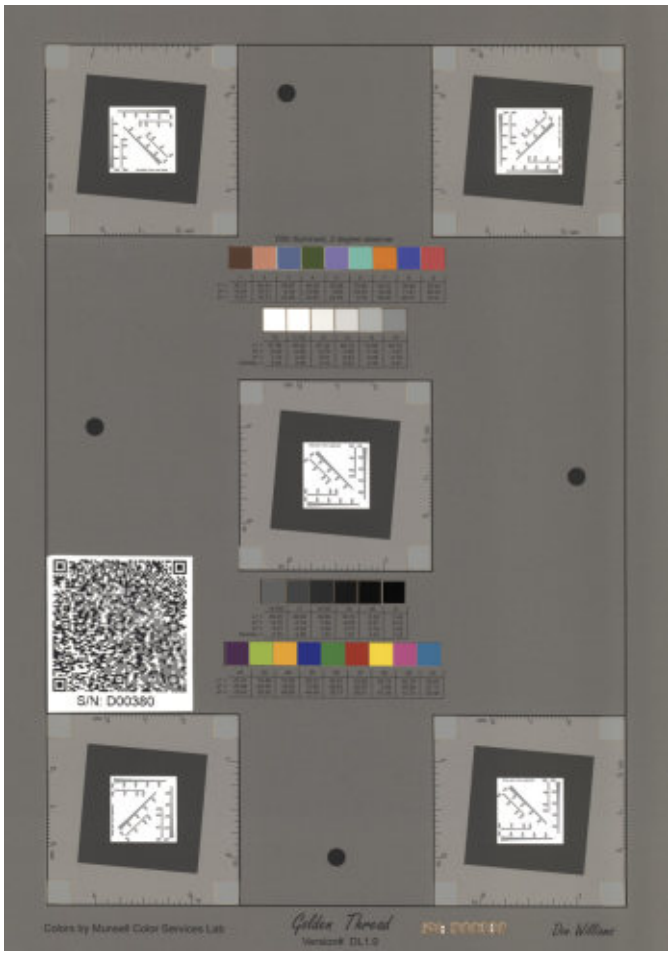
FADGI: ★★ = ISO 19264-1 Level C = Metamorfoze extra light

FADGI: ★★★ = ISO 19264-1 Level B = Metamorfoze light

FADGI: ★★★★ = ISO 19264-1 Level A = Metamorfoze full

How Images are Evaluated for FADGI Ratings

The FADGI quality ratings are determined using Digital Imaging Conformance Evaluation (DICE) test image targets and analysis software. This is a independent third party provided test target and software for evaluation that ibml uses and is currently the accepted standard for testing and validation. Using test image targets and analysis software ensures precise and repeatable analysis of imaging variables. Test image targets are scanned and analyzed for quality based upon color, resolution, uniformity, resolution, noise, and other factors. The DICE targets comply with ISO image quality specifications. On the right is a test image target used by DICE.



The DICE test image target was developed by Image Science Associates (ISA).

Golden Thread Software supplied by Imaging Science Associates (ISA) then evaluates the scanned image and compares the measured image parameters to a set of standard parameter values. Evaluation software from ISA is used to measure the quality of images against the FADGI guidelines and requirements. The software testing is compliant with FADGI and ISO19264 image quality standards. The software provides a result page with an overall pass/fail (for each FADGI "star") as well as the pass/fail details for various parameters pertaining to image quality.

The parameters evaluated by the DICE program are:

- **Sampling Frequency:** the spatial resolution of the scanned image in a physical pixel count unit such as pixels per inch (ppi) or pixels per millimeter. Sampling frequency is used to estimate the image size and the level of recorded details corresponding to the image size. The resolution measurements are defined according to the standard ISO 12233-2014.

- **Tone Response or Opto-Electronic Conversion Function (OECF):** how accurately the light levels are converted into digital pixels by the imaging system. The shape of the OECF curves is affected by the image processing applied to the pixels after the input exposure to digital pixel conversion. The OECF measurements are defined according to the ISO 14524:2009.

- **White Balance Error:** the color neutrality of the digital images. A color image is formed by mixing the primary intensity channels: red, green, and blue. The quality of the scanner determines the mixing, and this parameter measures the deviation from true white and any color tints.

- **Illuminance Non-uniformity:** how uniform the intensity or luminance values are recorded in the image. The variation from the center of the image to the edges and points in-between are tested. Any non-uniformity can be attributed to lighting and camera/lens performance. The shading measurements are defined by ISO 17957:2015.

- **Color Accuracy:** the delta-E color difference (delta-E2000) between the scanned test image values and physically pre-measured values are used to estimate the color accuracy. The imaging test target contains the L*a*b* (luminance and chrominance channels) values pre-measured for each of the color patches. The average deviation or mean is measured of these patches by comparing to the scanned image values. Color accuracy measurement is defined by the ISO 13658:2000 standard.

- **Color Channel Mis-registration:** the camera/lens performance in lining the red, green, and blue light precisely. If these are not captured in perfect alignment, the red, green, and blue pixel mis-registration occurs.

- **Modulation Transfer Function/Spatial Frequency Response (MTF/SFR):** the resolution accuracy and sampling frequency. MTF measures the contrast difference between the imaging target and the scanned digital images. It is defined by the modulation ratio of the scanned image and the ideal image. SFR deals with the ability of imaging system to maintain contrast in smaller image details.

- **Sharpening:** the level of manual sharpening applied to the image. This artificial sharpening is usually applied to enhance the image details. The three type of sharpening processes in an image processing pipeline are: capture sharpening, post-processing sharpening, and output sharpening.

- **Noise:** the artifacts in the scanned digital image that do not correspond to the original image. DICE measures the visible noise (that arises from different sources) based on a single measurement value.

Clearly, there is a direct correlation between a FADGI star rating, and the technical performance required of the operator and the imaging system used for scanning and digital document capture.

The Impact of Document Scanners on FADGI Compliance

The FADGI guidelines objectively evaluate the efficiency and quality of a digitization process.

Any digitization process is significantly impacted by two factors:

1 Scanning productivity

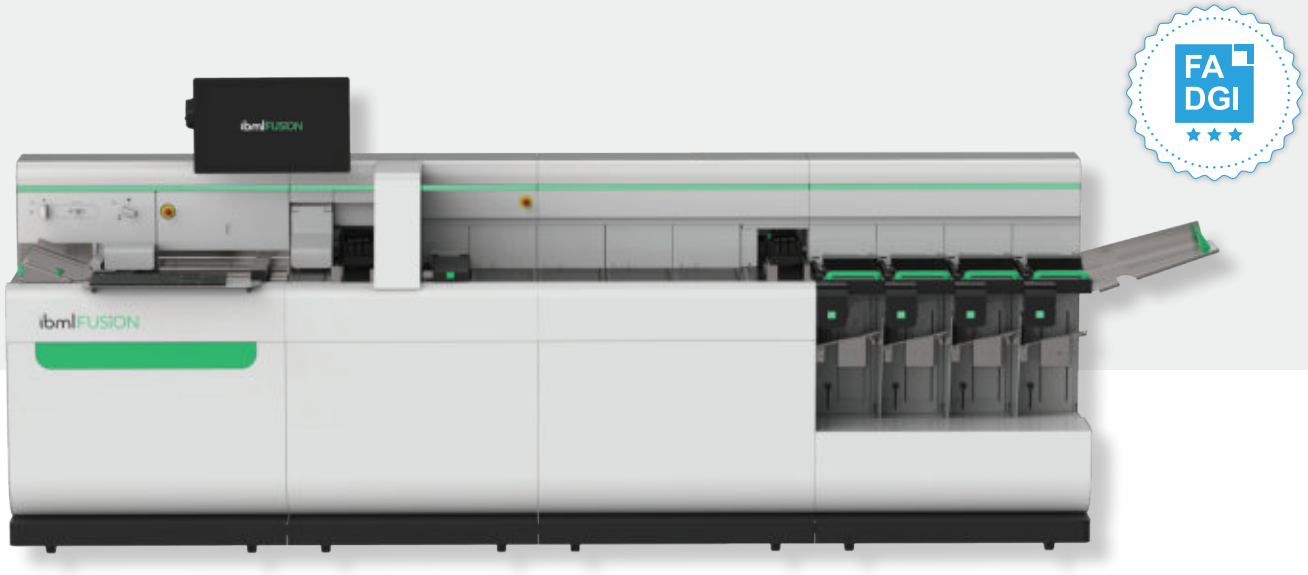
2 Image quality

These factors are interconnected. If image quality is inferior, the digitization process is inefficient; it will require retesting and documents will need to be rescanned, which costs considerable time.

ibml scanners are designed to operate at high speeds, without compromising image quality.

ibml FUSiON document scanners generate FADGI-certified images with a three-star rating. As noted earlier, the three-star rating defines "a very good professional image capable of serving almost all users." Three-star ranked images are not only most discernible to the human eye but also help preserve and transform the paper information to digital information accurately, enabling organizations to avoid rescanning or the need to store hard copies of scanned documents.

Importantly, ibml document scanners generate excellent images while operating at the worlds highest speeds. The ibml FUSiON production scanner operates at scanning speeds of 292 - 730 pages per minute (PPM).



ibml FUSiON production scanner operates at speeds of up to 730 pages per minute.

The Benefits of Achieving FADGI Compliance

Organizations benefit from generating archival-quality images in accordance with FADGI:

Assurance of high image quality: FADGI is an important new standard for measuring and evaluating image quality. FADGI aligns closely with the ISO's image analysis procedures; each of FADGI's image quality characteristics and requirements correspond to the best recommendations from ISO and other leading industry experts. Organizations can use FADGI guidelines to be sure that their images are of archival quality thus enabling high accuracy in information capture from digitized documents.

No need to compromise on document scanning speed: The information management industry has long been challenged with balancing the needs for fast turnaround and high image quality. The FADGI guidelines provide ibml customers with the peace of mind that they are not compromising image quality for speed. ibml scanners are designed for round-the-clock operations for intensive and heavy-volume digitization projects, thus providing robust scan outputs across huge volumes of documents. Meantime the scanners use patented hardware and software technologies to ensure excellent quality. ibml's FADGI-compliant FUSiON scanners can digitize documents at high speeds up to 730 ppm.

Future-proof digitization: The digitization of documents in most scenarios are intended to transfer the information from stored hardcopies to digital and cloud platforms, accessed across different devices all over the world. Digitally storing documents also is cheaper and potentially more resilient and secure than storing paper documents. And digitizing documents opens the possibilities of using this information for various applications, such as OCR and data extraction, and applying the latest trends in machine learning. By creating images that have a three-star FADGI rating, ibml customers can be assured they can achieve the full advantages of document digitization.

Conclusion

FADGI breaks new ground in setting standards for image quality.

Your scanning system can be a boon or a bane. if not selected properly it can become a bottle neck to your digitization initiatives and very expensive for your operations.

With ibml FADGI three-star rated scanners, you don't have to to compromise image quality to achieve high-speed scanning.

ibml customers can rest easy knowing that its scanners use patented hardware and software-based technology to capture documents at blazing-fast speeds, while delivering images that achieve a three-star FADGI quality rating. By achieving high-quality images in accordance with FADGI standards, ibml customers can help future-proof their information management operations.