KODAK Q-60 Color Input Targets

The KODAK Q-60 Color Input Targets are very specialized tools, designed to meet the needs of professional, printing and publishing customers in setting up their scanning operations to provide the best output fromKodak transparency and reflection materials.

This document has broad scope, providing background on the subjects of color theory and calibration while also giving practical insights and procedures to use the Q-60 Color Input Targets. We strongly recommend reviewing the introduction before you access particular sections of interest to you.

Clarification or further questions can be addressed through contacting the Kodak Information Center in the US at 1-800-242-2424, extension 19, or by contacting the Kodak house in your country.

Introduction / Background

Color input scanners do not all analyze color the same way as the human eye does. These devices are designed to optimize the signal generated when typical materials are scanned. Color transparency and reflection products use various combinations of proprietary dye sets to achieve visual responses that simulate the color appearance of natural scene elements. The ability to achieve the same color appearance from different combinations of dyes is referred to as metamerism. Because both dye and scanner sensitivities vary from product to product, there is a variability in the scanner response to colors that may be visually similar on various photographic materials.

The intent of the Q-60 Targets, and the IT8.7/1 and IT8.7/2 standards upon which they are based, is to define an input test target that will allow any color input scanner to be calibrated with any photographic set that has been chosen to create the target. The emphasis is on color transparency and reflection products which are generally used for input to the preparatory process for printing and publishing.

Although the target design is currently both an ANSI and ISO standard, it was based upon the original KODAK Q-60 Targets with permission from Kodak. The target was designed to be useable for calibration by visual comparison and as measured colorimeter data in combination with software tools.

It is important to note that any color photographic product contains both image capture (sensitizing) dyes as well as image-forming dyes. While the image sensitizing dyes are a vital part of the film performance, it is only the image forming dyes that affect scanner calibration or characterization. Fortunately, only a small number of image forming dyes are used. Specifically, one set of image forming dyes can be used for KODAK EKTACHROME Films, and one for Kodak color negative papers. This means that only one Q-60 target is required to represent the complete EKTACHROME Film family and one for KODAK and KODAK PROFESSIONAL ENDURA Papers.

Kodak Target Layout

The target design provides uniform mapping in the CIELAB color space and is defined in detail in ANSI standard IT8.7/1 for transmission materials and IT8.7/2 for reflection materials. The requirements for both material types are included in International standard ISO 12641 (see References section). Both targets are based upon a similar concept that uses twelve hue angles (rows A-L) and three lightnesses at each hue angle.

At each hue angle and lightness combination there are four chroma or saturation levels. The first three of these at each lightness level (columns 1-3, 5-7, and 9-11) are specifically defined in the ANSI and ISO standards and are referred to as the common gamut area. The values of these patches were based on film and paper color gamut information provided by Agfa, Fuji, Kodak, and Konica. The patches are defined such that they are able to be produced on all the sensitized products included in the gamut comparison. The fourth chroma (columns 4, 8, and 12), represents the maximum chroma (colorfulness) that the specific product can produce at that hue angle and lightness level.

Columns 13-19 contain cyan, magenta, yellow, neutral, red, green and blue scales which are characteristic of the target dye set. The neutral scale is defined to begin at neutral D-min and end at neutral D-max in 12 steps with equal lightness (L*) increments. The cyan, magenta, and yellow scales are based on the amount of each of those dyes contained in the column 16 neutral scale. The red, green, and blue scales are combinations of the cyan, magenta, and yellow scales as appropriate.

Across the bottom of the target, there is a 22 step neutral scale, bounded by a patch representing product D-min on the light end and a patch representing product D-max on the dark end of the scale. Steps 1 through 22 are defined as neutral, with lightness (L*) values specified in the standards documents.

In addition to the areas of the target which have specific ANSI definitions, columns 20-21 were left undefined for each manufacturer to include information which might be beneficial to the end user. Kodak has included 12 flesh patches in this area recognizing the importance of flesh tone reproduction in professional applications. In addition, Kodak targets include a portrait image which will be useful in subjective confirmation of input scanner calibration. Three color separation indicators at the top of each target make it easy to identify process color films when film separations are made.

Formats Available

The ANSI and ISO standards define a 5x7-inch format for reflection targets and three options for transmission targets. The principal transmission format is on 4x5-inch film. A 7 frame 35 mm format is defined as well as a single frame 35 mm target. The standards specifically exempt the single frame 35 mm target from meeting the tolerances specified, because at the time the standards were being written the technical community did not believe that it was technically possible to achieve these tolerances in that format. Kodak has chosen to manufacture both the 4x5-inch and 35 mm full frame target in full compliance with the tolerances specified.

These formats manufactured by Kodak are identified as follows:

- KODAK PROFESSIONAL EKTACHROME Film (4x5) Q-60E1
- KODAK PROFESSIONAL EKTACHROME Film (35 mm) Q-60E3; Q-60E3A
- KODAK PROFESSIONAL ENDURA Paper (5x7) Q-60R2

Note that there is only one target film type for use in calibrating the entire EKTACHROME Film family, and one target for calibrating KODAK and KODAK PROFESSIONAL Papers. This is made possible by the fact that Kodak photographic materials are designed to perform within a family. While the members of the family may differ in color saturation, sharpness, speed, grain, etc., the image forming dyes creating these characteristics are essentially the same within the family.

Because the image forming dye sets are the same within the family, input scanners respond to the films in the same way. Thus scanner response can be calibrated based on one Q-60 target which contains the image dye set of the photographic material family and covers the complete range of colors which can be produced by the various films or papers within the family.

Target Specifications and Tolerances (Colorimetric Aim Values)

As described above, the colorimetric values for some of the patches contained in the target are defined by the ANSI (and ISO) standard, while others are defined by the manufacturer of the material used to create the target. Furthermore, the ANSI standards define one set of aim values for film and another for paper (ANSI IT8.7/1-1993 and ANSI IT8.7/2-1993 respectively). The common aim values defined in the standards are listed in the following tables. The row and column designations refer to the rows and columns as labeled on the target and the reader is referred to either a sample of the target or one of the many illustrations provided in the sales literature. The symbol (P) in columns 4, 8 and 12 are a reminder that the chroma values for these columns are a function of the specific image forming dyeset used in the product and are determined by the film manufacturer.

Common L* and C* Values vs. Hue Angle for Film Transmission Targets

Row	Hue Angle	L1	C1	C2	C3	C4	L2	C1	C2	C3	C4	L3	C1	C2	C3	C4
A	16	15	10	21	31	(P)	35	15	30	45	(P)	60	8	16	24	(P)
B	41	20	11	23	34	(P)	40	17	34	51	(P)	65	7	15	22	(P)
C	67	30	11	22	34	(P)	55	20	40	60	(P)	70	9	17	26	(P)
D	92	25	9	18	27	(P)	50	17	35	52	(P)	75	23	46	69	(P)
E	119	30	11	22	33	(P)	60	20	39	59	(P)	75	12	25	37	(P)
F	161	25	10	21	31	(P)	45	17	35	52	(P)	65	12	25	37	(P)
G	190	20	7	14	21	(P)	45	14	29	43	(P)	65	11	23	34	(P)
H	229	20	7	15	22	(P)	40	13	25	38	(P)	65	7	15	22	(P)
I	274	25	14	27	41	(P)	45	10	21	31	(P)	65	6	12	17	(P)
J	299	10	17	34	51	(P)	35	13	27	40	(P)	60	7	14	21	(P)
K	325	15	13	26	39	(P)	30	17	35	52	(P)	55	12	23	35	(P)
L	350	15	10	21	31	(P)	30	16	33	49	(P)	55	10	21	31	(P)
Column			1	2	3	4		5	6	7	8		9	10	11	12

The neutral scale lying along the bottom of the target shall have the following L* aim values, based on the measurement conditions defined in the standard, reading from left to right across the target. C* aim values shall be 0.

Step 1	82	Step 9	50	Step 17	18
Step 2	78	Step 10	46	Step 18	14
Step 3	74	Step 11	42	Step 19	10
Step 4	70	Step 12	38	Step 20	6
Step 5	66	Step 13	34	Step 21	4
Step 6	62	Step 14	30	Step 22	2
Step 7	58	Step 15	26		
Step 8	54	Step 16	22		

Common L* and C* Values vs. Hue Angle for Reflection Targets

Row	Hue Angle	L1	C1	C2	C3	C4	L2	C1	C2	C3	C4	L3	C1	C2	C3	C4
A	16	20	12	25	37	(P)	40	15	30	44	(P)	70	7	14	21	(P)
B	41	20	12	24	35	(P)	40	20	36	54	(P)	70	8	16	24	(P)
C	67	25	11	21	32	(P)	55	22	44	66	(P)	75	10	20	30	(P)
D	92	25	10	19	29	(P)	60	20	40	60	(P)	80	10	21	31	(P)
E	119	25	11	21	32	(P)	45	16	32	48	(P)	70	9	18	27	(P)
F	161	15	9	19	28	(P)	35	14	28	42	(P)	70	6	12	18	(P)
G	190	20	10	20	30	(P)	40	13	25	38	(P)	70	6	13	19	(P)
H	229	20	9	18	27	(P)	40	12	24	36	(P)	70	7	13	20	(P)
I	274	25	12	24	35	(P)	45	9	19	28	(P)	70	5	10	15	(P)
J	299	15	15	29	44	(P)	40	11	22	33	(P)	70	6	11	17	(P)
K	325	25	16	33	39	(P)	45	14	28	42	(P)	70	8	16	24	(P)
L	350	15	13	26	38	(P)	40	16	32	48	(P)	70	8	15	22	(P)
Column			1	2	3	4		5	6	7	8		9	10	11	12

The neutral scale lying along the bottom of the target shall have the following L* aim values, based on the measurement conditions defined in the standard, reading from left to right across the target. C* aim values shall be 0.

Step 1	87	Step 9	55	Step 17	23
Step 2	83	Step 10	51	Step 18	19
Step 3	79	Step 11	47	Step 19	15
Step 4	75	Step 12	43	Step 20	11
Step 5	71	Step 13	39	Step 21	9
Step 6	67	Step 14	35	Step 22	7
Step 7	63	Step 15	31		
Step 8	59	Step 16	27		

Target Tolerances

The ANSI standards provide for tolerancing of targets in several ways to make the targets most useful to the end user while keeping the cost within reasonable bounds.

Uncalibrated Targets

Targets tolerances are specified by ANSI IT8.7/1, IT8.7/2 and ISO 12641 as follows:

1. For all targets manufactured:

   For patches contained within A1 through L3, A5 through L7, and A9 through L11, 99% shall be within 10 delta E units of the aim values contained in the standard. (See the tables above).

2. For each manufacturing batch:

   99% of the patches within the manufacturing batch shall be within 5 delta E units of the reference as follows:

   – the reference for patches A1 through L19, D-min and D-max shall be the reported batch mean.

   – for the 22-step neutral scale the reference shall be the value specified in the standard. (See the tables above).

See Section 9 for information on availability of batch average data.

Calibrated Targets:

Calibrated targets are uncalibrated targets which have been measured. The measured values for each patch shall be provided together with "a certificate as to the degree of conformance of the measuring laboratory to an accredited measurement assurance program (MAP) sponsored by a recognized national standardizing laboratory." The goal is that all measurements will be accurate within 2 delta E.

Note: Although Kodak has chosen not to provide calibrated targets, the within batch variability in patch colorimetry under current manufacturing conditions, is so low that the uncertainty in batch average data meets the tolerances specified for calibrated targets.

Target Usage

When designing new films or papers, great care is taken to minimize any confusion or problems that may arise in scanning images on professional photographic materials.

The major Kodak products used as input for scanners are a part of the KODAK PROFESSIONAL EKTACHROME Film family or KODAK PROFESSIONAL ENDURA Paper family. The products in each family are designed with similar dye sets, so they perform the same during scanning. This makes scanning the image easier for the scanner operator, because the operator can establish a basic scanner tone scale and color correction setup for the entire family. Once the basic setup is established, the operator can direct his or her efforts to the challenges of the image at hand-optimizing the tone scale and gray balance for the important scene elements.

The KODAK Q-60 Color Input Target is designed to help the scanner operators establish the basic tone reproduction and color correction set ups for the various families of products. These targets are manufactured in accordance with ANSI standards IT8.7/1 and IT8.7/2, and ISO Standard 12641, and are intended to represent the color spectrum reproducible in each product family. They are useable for calibration and characterization of input scanner systems either through visual comparison or numerical analysis in appropriate software programs.

The Q-60 Color Input Targets are used to establish base-line scanner settings for all originals on a particular family of Kodak materials, allowing high quality reproduction from original photographic images.

They allow customers to adjust how the color gamut of these materials is handled through their system through visual evaluation of the output from their system compared to the input target.

Photographers select a film or prototype material for the particular look the product produces. This look is a function of contrast, color balance, color saturation, graininess, sharpness, spectral response, etc. Targets made in accordance with these standards do not address any of these product characteristics. Targets only characterize the way the input scanner reacts to the image forming dyes contained in a final image.

Note: Optimal results will be obtained with professional products; however, where non-professional products are used, Q60 targets also provide the best starting point for establishing scanner set ups.

It must be emphasized that any scanner calibration is intended to optimize the starting point for the color separation of a particular image. It will allow the response of the scanner to be calibrated to the spectral characteristics of the films to be scanned. It will allow scans of images that look the same, but are on products from different film/paper families, to produce comparable results. Scanner calibration will NOT result in optimal scans of every individual image. The scanner controls, or the software image manipulation tools, must be optimized for each image and its intended application. In particular, the tone and gamut compression between the photographic original and the printed reproduction may require subjective manipulation.

Calibration

Analytical

When calibrating color scanners, we need to recognize that there are at least two distinct ways in which a scanner may be operated. The calibration procedure for each is different. The two methods are described as follows:

1. **Color digitizer** - In this mode the scanner has a simple objective; to capture the color information of the original image being scanned for subsequent processing elsewhere. The output data must, therefore, bear some unique relation to the tristimulus values of the original. In general, the data output by the scanner will be typically coded as RGB. If the digitizer has a suitable calibration facility this may be converted to XYZ, a different RGB (e.g. gamma corrected suitable for HDTV), L*a*b or L*u*v prior to coding.
2. **Gamut "mapped" color digitizer** - In this mode, the scanner is operated in a device dependent manner. The calibration facilities (software or hardware) in the scanner convert the RGB data directly into that required by the output device. It may directly define the colorant amount required (e.g. CMYK printing) or the exposure levels required (e.g. RGB transparency recorders) or the gamma corrected drive voltages required (e.g. CRT displays). A special case may be that in which the required gamut mapping is applied to the original data but the data may still be transmitted as XYZ, L*a*b or L*u*v color data rather than, say, colorant amount specification. The output data in this mode must, therefore, bear some unique relationship to the tristimulus values of the reproduction.

The primary objective of the target is to enable the user to calibrate his system using whatever calibration facility exists. The precise detail of the calibration procedure cannot be specified; it depends upon the particular application. In general terms, however, the image will be scanned using the default setting of the scanner. The calibration package(s) provided would then be used to obtain the correct color output. Note that this frequently includes gamut compression, generally such an assessment is subjectively made by the user.

The input target will provide colors which cover the full color gamut of the specific material on which the target has been imaged. Further, these colors are in a fixed physical arrangement and have known XYZ values which allows software packages to provide analytical color calibration.

Visual

Analytical calibration is dependent upon the availability of appropriate software and is most often used in the "color digitizer" mode of operation. Where the "gamut mapped color digitizer" mode of operation is desired, visual assessment - possibly supplemented by color or density measurement - can be used instead of analytical techniques.

The neutral and color scales are useful for evaluating the issues relating to tone reproduction. The hue angle, lightness, chroma patch combinations are useful in evaluating the gamut compression compromises at the highlight, midtone and shadow portions of the image.

To use visual assessment, the target is scanned and output through the intended process (or proofing system that simulates the intended process). Visual assessment under controlled viewing conditions is then used to determine the quality of the required gamut compression and the color match. Choices may need to be made regarding optimal tone reproduction and balance, possibly compromising neutral reproduction to enhance the hue and chroma of non-neutral colors.

Refer to the procedures outlined below which detail the steps in visual calibration.

Recommended Viewing Conditions

- 5000 Kelvin lighting with a CRI between 90 and 100
- Walls and table surfaces should be neutral gray with a matte surface and free from glare.
- Refer to Reference 4 (in the References section) for further review of specifications on standard viewing conditions.

Procedural Flow

- Scan the target at scanner default settings.
- Output separation films and generate a color proof, or produce a direct digital color proof.
- Evaluate the overall color match between the proof and the target standard.
- Make adjustments to the scanner and repeat the proofing procedure.
- Record the scanner settings after a successful visual match is achieved.

Evaluation Recommendations

- Examine proof for obvious adjustments which affect entire image. Rescan and make a new proof at any point when adjustments in scanner settings are required.
- Compare the gray scale at the bottom of the target and column 16 scale. The proof and target should visually match although there may be slight deviations from neutral color balance in the target steps.
- The bottom scale should be carefully examined for tone reproduction. There should be a distinct density difference between each step.
- Examine the CMY and RGB scales in columns 13-19. Hues on the proof should match the target within the

capabilities of the proofing materials.

- Examine each hue across rows A-L for the following
- characteristics:
  - Changes in color saturation in the proof should simulate target appearance.
  - Tonal levels should reproduce with the same lightness and darkness.
  - Hues should reproduce the full range of density between highlight and shadow.
- Compare the near neutral pastel hues in Column 9 with the target. The proof should maintain hue variations.
- Flesh tones in the pictorial image visually match the target, maintaining subtle hue differences.

Maintenance of Standard Settings

- The settings derived from the procedure should be recorded and used to scan originals for each respective families of photographic products.
- Individual transparencies may require subtle adjustments, i.e., setting highlight and shadow points and adjusting tone reproduction curves depending on the characteristics of the original image and color cast correction.
- Return to standard settings for a given film family after adjustments for specific image scans.
- Recalibration.

Storage and Handling

Always protect these processed targets from strong light. Store in a cool dry place; preferably 70°F (21°C) and not exceeding 50% RH. Handle the film targets carefully to avoid kink marks, scratches and fingerprints. Return the test targets to their protective enclosures immediately after use.

For additional information, see KODAK Publication E-30, "*Storage and Care of KODAK Photographic Materials—Before and After Processing*."

Image Stability

The useable life of a target is a function of its exposure to light, handling, and the storage conditions used. The ANSI and ISO standards require each manufacturer to provide the monitoring procedure to be used for each target type as a part of the packaging of the targets.

The Kodak recommended procedure for critical applications is as follows:

- When purchasing targets, always purchase one extra target to be used as a control.
- Using a well calibrated densitometer, measure and record the densities of the D-min, and D-max patches as well as steps 1, 7, 14, and 22 of the grey scale (see Section 3 for a description of the location of these patches) on BOTH the control target and on all targets used for scanner calibration. Although the densitometer status used is not critical, as long as it is recorded and used in the subsequent evaluations, Status A densitometry as defined in ISO 5-3 is preferred.
- Store the control target in a light tight and air tight sealed container that can be kept in a temperature conditioned environment. Ideally this would be at temperatures of 0°F (-18°C)—a freezer. (Caution: Whenever film is stored at less than room temperature, the container should be allowed to come into equilibrium with room temperature before being opened to avoid condensation problems.)
- Whenever there are suspicions that a target has changed in value (due to frequent use, inappropriate storage, etc.), re-measure both the working target and the control target using the same status densitometry as was used initially.
- Compare the DIFFERENCES in density between the patches measured on the control target and the working target vs the DIFFERENCES measured on these same two targets when initially tested. If these differences show a change of greater than 0.03 or 0.04 in density the target can be assumed to have changed more than the allowable tolerances.

Note: The change in differences are compared because this removes the absolute calibration of the densitometer as a contributor in the evaluation process.

- When a target needs replacement, it is suggested that the replacement target become the new control and the former control become the working target This allows this evaluation procedure to be used at virtually no extra cost in targets. Under recommended storage conditions and low usage, a significant change may occur in approximately three years. Targets that have exceeded the maximum change specification would still be useful for visual calibration of scanning systems.

Numerical Target Data

The ANSI and ISO standards specify that for all targets the batch-specific mean value and standard deviation for each patch shall be available. Mean and standard deviation values shall be provided as X,Y,Z tristimulus values. Mean values shall also be provided as CIELAB and standard deviation as CIE deltaE. All values shall be provided to two decimal places. The data shall be available on 3.5 inch MS-DOS formatted 720 kbyte magnetic disk in the data format specified in Section 4.10 of IT8.7/1 or IT8.7/2. Other data may be provided as optional information (e.g. CIELAB, other illuminants, etc.). For those receiving data on magnetic discs, Kodak has chosen to provide a single floppy disk that will contain the batch specific data for all uncalibrated targets. These will be updated each time a new batch is prepared and will contain all prior batch data.

However, the preferred source of this data is via a direct electronic file transfer. Today a link is currently available from the Kodak-Japan World Wide Web homepage (www.kodakj.co.jp) and will soon be available from the Corporate homepage (www.kodak.com). However, direct FTP access to these data is provided at ftp://ftp.kodak.com/gastds/q60data.

Although Kodak has chosen not to provide calibrated targets, the within batch variability in patch colorimetry, under current manufacturing conditions, is so low that the uncertainty in batch average data meets the tolerances specified for calibrated targets. Section 10 provides guidance for the interpretation of the batch variability data, as contained in the batch average data files.

Interpretation of Numerical Data

As noted above, mean and standard deviation data is required for each batch of targets manufactured. Mean and standard deviation of the XYZ tristimulous values for each batch are statistically determined based on appropriate sampling of the production run. These data, as well as the mean CIELAB data need no further explanation. The interpretation of mean and standard deviation of delta E however is not as straight forward. Kodak has chosen to report the mean DeltaE and has substituted the chi-squared parameter in place of the standard deviation in DeltaE. This is a more meaningful parameter and is explained below.

Statistical Distribution of DeltaE

A recent technical presentation (Ref 8) suggests that the distribution of the deltaE of printed samples is represented by the three-dimensional chi-squared function. This approach uses the average standard deviation (s-avg) of L*, a* and b* as a single parameter to characterize the probability. The quantity "deltaE/s-avg" when squared follows the chi-squared distribution. This provides a convenient estimate of the distribution of deltaE which is more realistic than the use of gaussian statistics.

Evaluation of a large number of samples of the Kodak Q-60 targets showed that the deltaE characteristics of individual samples compared to the batch mean followed this same statistic.

We have therefore chosen to use the chi-squared statistics to characterize the within-batch variability of the individual patches of Kodak Q60 targets and are reporting the value, identified above as s-avg, as STDEV_DE in the Kodak Q-60 batch average data files.

For reference, the chi-squared distribution indicates that 99% of the samples will have a deltaE less than 3.35 time the chi-squared parameter (s-avg). Typical values for s-avg on individual patches in recent production runs of the Q60 targets are about 0.5. A value of 0.5 means that 99% of the targets will be within a deltaE of 1.7 of the batch average value.

References

1. ANSI Standard IT8.7/1-1993, Graphic technology—Color Transmission Target for Input Scanner Calibration
2. ANSI Standard IT8.7/2-1993, Graphic technology—Color Reflection Target for Input Scanner Calibration
3. ANSI Standard CGATS.5-1993, Graphic technology—Colorimetric measurement and computation for graphic arts images
4. International Standard ISO 12641, Graphic technology—Color Targets for Input Scanner Calibration
5. ANSI Standard PH 2.30-1989, American National Standard for Graphic Arts and Photography—Viewing Conditions
6. "Design Criteria for an Input Color Scanner Evaluation Test Object" by T.O. Maier and C.E. Rinehart, 1988 TAGA Proceedings, Technical Association of the Graphic Arts.
7. The KODAK Q-60 Color Input Target. KODAK Publication No. Q-60INSTR. Eastman Kodak Company. (November 1992).
8. Appraisal of Production Run Fluctuations from Color Measurements in the Image, Friedrich K. Dolezalek, FOGRA, Munich, Germany, TAGA Proceed

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