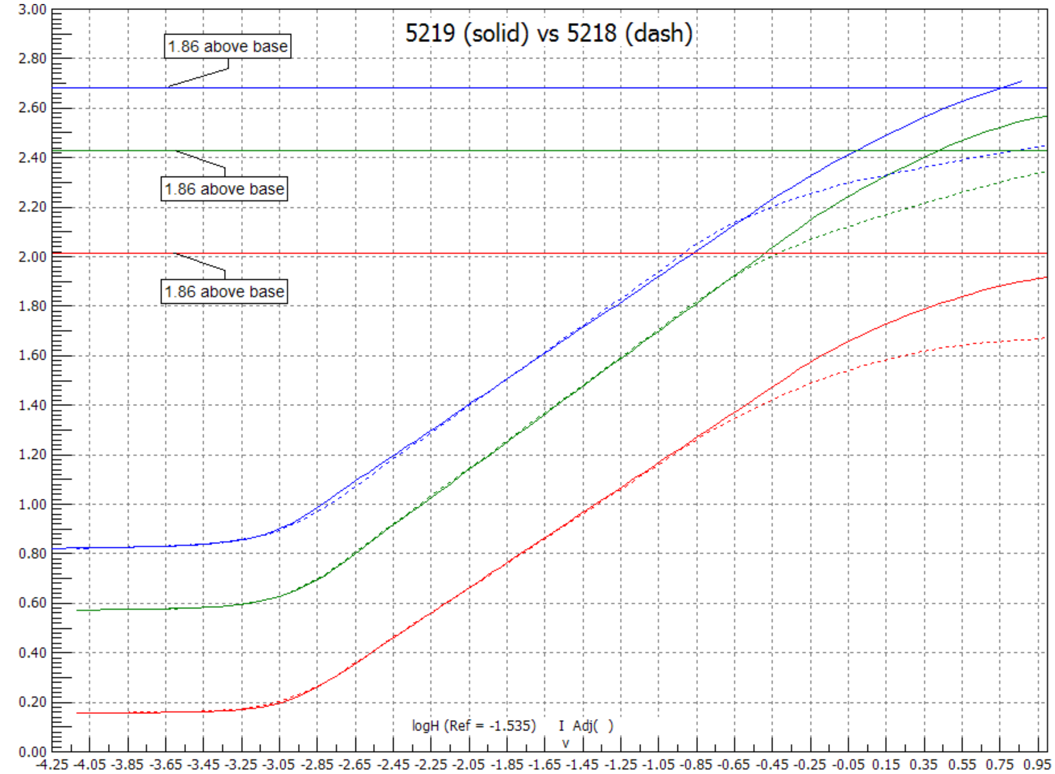
SCANNING RECOMMENDATIONS FOR EXTENDED DYNAMIC RANGE CAMERA FILMS

Prepared by Eastman Kodak Company in collaboration with:
ARRI
Cintel International
Digital Film Technology
FilmLight Ltd.
Lasergraphics Inc.

Scope:
The KODAK VISION3 Color Negative Films utilize proprietary Advanced Dye Layering Technology delivering reduced grain in shadows and higher signal-to-noise ratios when scanning low-light scenes. Extended highlight latitude delivers greater flexibility when lighting extreme situations. Digital "dodging and burning" is a very powerful tool in the colorists' toolkit, now made more powerful by the wider dynamic range of the KODAK VISION3 Color Negative Films. Its wider latitude further differentiates film capture from the limited dynamic range of digital capture.

When capturing scenes with very high dynamic range, KODAK VISION3 Color Negative Films produce images with extended density ranges. If traditional 10-bit scanner data encoding schemes are used to digitize films having extended density range, highlight information stored on the film could be lost. This paper provides scanner setup recommendations for efficiently extracting the full density range stored on high dynamic range films.

Traditional Scanning with 10-bit Encoding:
In conventional 10-bit film scanning, the density range is represented by 1023 equally spaced code values (CVs). The density change assigned to each CV is typically 0.002 units, yielding a maximum encoded density range of 2.046 (1023 x 0.002) density. When D-min position is set at the traditional code value of 95 (D= 95 x 0.002 = 0.19), the resultant density above D-min which can be encoded into a DPX file is limited to 1.856 (2.046 – 0.19). This density range successfully covered most of the earlier VISION2 Color Negative Film latitude but may be insufficient for encoding very high dynamic range scenes captured with extended latitude films.



10-bit DPX clipping limits with 5219 and 5218

Note 1 – The plot shows the clipping limits with normally processed film.

Note 2 – Sensitometric comparison in Printing Density space with D-min and speed matched

Example Image:

The example below is a conventional 10-bit DPX scan of a scene shot on KODAK VISION3 Color Negative Film 5219. The reflections from the boxer's chest are being clipped.

Sample image scanned @ 0.002 D/CV

Same image with highlight clipping identified

Options for Increasing Encoded Density Range:
It's important to note that not all scenes will experience clipping. The image exposure information which may clip is more than 7 stops higher in exposure than a normally exposed 18% grey card. In addition, even content which does experience some clipping may not have a visually noticeable impact. Therefore, in many cases, the traditional (10-bit 0.002 D/CV) scanning set-up will be acceptable.

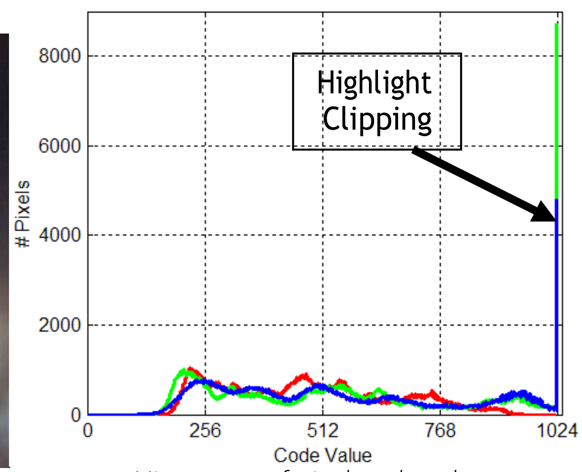
In cases where one would like to expand the encoded density range, there are two approaches that readily permit the expansion. Assuming a scanner has the opto-electronic subsystems capable of measuring the full density range contained on the film, one may choose to use either 16-bit encoding or 10-bit encoding with modified density per code value relationships.

16-bit Encoding Option:
The first option employs a 16-bit encoding scheme. This is an excellent technical solution. A 16-bit architecture provides both improved precision and an extended density range, while retaining the normal scene contrast position encountered in postproduction. 16-bit scanning is currently available for use in modern scanners today. This high dynamic range scanning technique fully covers the extended density range produced by KODAK VISION3 Color Negative Films. Details regarding a standardized approach are being developed by the Academy of Motion Picture Arts and Sciences.

The use of 16-bit scanning solutions requires an increase in storage requirements and data transfer bandwidth. This is the preferred technical solution.

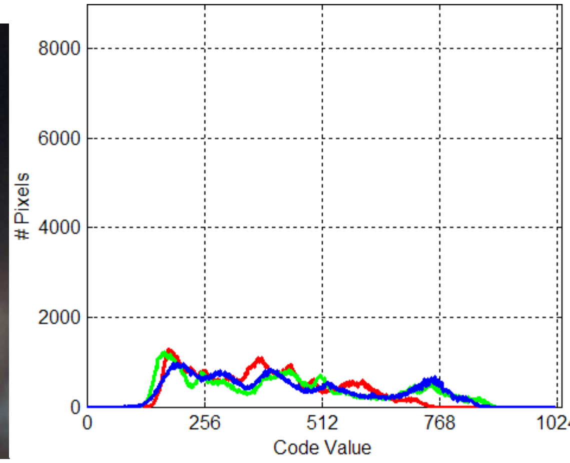
10-bit Encoding with Adjusted Density Per Code Value Mapping:
Another option, to enable the ability to get the most out of high dynamic range films, would be to increase the density per-CV step, thus expanding the total density range encoded with 10 bits. Specifically, the use of 0.0025 density-per-CV mapping will provide 0.512 more film density range, which is equivalent to about 2.8 stops more film exposure range. VISION3 Color Negative Films provide about two stops more dynamic range than the earlier VISION2 Color Negative Films, so this method fully covers the added film density and provides a safety factor for exposure and processing variability. In order to ensure that the scanner setup information remains associated with the scanned image, we recommend that the DPX file fields specified to contain “max data value” and “max data quantity” be utilized. This would allow for communicating whether a film was scanned with the normal 10-bit encoding (1023, 2.048) or the new extended density range 10-bit encoding (1023, 2.560). Many scanner vendors write these fields as described above.

Enlarged image scanned @ 0.002 D/CV



Histogram of pixel code values

Enlarged image scanned @ 0.0025 D/CV



Histogram of pixel code values

Experimental Results:
While adjusting the density per code value position is compatible with existing scanner architectures, it was initially believed to increase the risk of contouring artifacts.
Contouring occurs when the density change between adjacent CV bins exceeds the visibility threshold. Our experience tells us that while systems without capture or projection noise may be prone to this (hence the 12-bit encoding schemes for DC-28 digital projection guidelines), the presence of film grain masks contouring by dithering the pixel values of density gradients among multiple CV bins.

To verify the effectiveness of grain-induced contour masking in motion picture systems, uniform surfaces with very gradual lighting gradients were shot with KODAK Color Negative Films. The resulting images were scanned at 10 bits with a series of density-to- CV mappings greater than 0.002 density, to increase the encoded density range. The scanned images were rendered such that the center of the frame was balanced at an equivalent midtone density point and the final contrast matched print film in each case.
The images were projected with a cinema-grade digital projector and examined under critical viewing conditions. The results of these critical viewing studies confirmed the ability of prequantization noise, provided by film grain, to successfully mask contouring, while providing density-to-CV increments in a 10-bit encoding system that are large enough to cover the full density range stored on high dynamic range films.

Postproduction Considerations:
Although the header files should contain the relevant scanner setup information, communication between the scanning facility and the postproduction and visual effects houses continues to be an important element. Increasing the density-per-CV mapping to 0.0025 results in image files with 25% lower contrast. Two postproduction activities may be affected by these changes. First, when images are composited for visual effects, the contrast between the scanned image and the visual effect will need to be reviewed. Second, images scanned in this matter will need to have their contrast raised in the color correction suite. In our testing, we have found this contrast reduction to be easily compensated with either a matrix or a manual adjustment applied. Visual effect compositors and colorists have the contrast controls readily available and are very familiar with their usage. Manual contrast adjustment is also beneficial since it enables the most valuable scene tones to be preserved in cases where the dynamic range of the camera film exceeds the range delivered by the film recorder.

Links to Scanner-Specific Setup Procedures:
This document provides the technical foundation for creating scanner setups devoted to digitizing extended dynamic range films; however, your best source for creating these setups on specific scanner models can be found by navigating the links listed below or talking with your scanner representatives.

ARRI (www.arri.com)
Blackmagic Design (www.blackmagicdesign.com)
Digital Film Technology (www.dft-film.com)
Lasergraphics Inc. (www.lasergraphics.com)