Evaluating Claims of Zapruder Film Alteration

Supplement to Part 1

How Much of the Light in Dealey Plaza Fit onto the Film

Kodachrome II and the limits of what the Zapruder film could record

By Craig Bouzarth

Readers who have looked into this subject will have encountered several different figures for the brightness range of Kodachrome II. Eleven stops is often quoted. So is eight. So is five. The numbers appear to contradict one another, and the disagreement has produced a good deal of confused argument in the assassination literature.

They do not contradict one another. They answer three different questions, and only one of the three bears on what Zapruder's camera could record. This supplement identifies which is which, measures the relevant figure directly from Kodak's published curve, and sets the result against the brightness range of the scene on Elm Street.

Why this matters to the alteration question

A recurring argument for alteration runs like this: a region of the Zapruder film is dark, no detail can be found inside it, and therefore something was painted or masked over it.

That inference holds only if the film would otherwise have recorded detail in that spot. If the film could not have held detail there no matter what stood in front of the lens, then an empty dark region is what the film produces on its own, and it is evidence of nothing at all. Choosing between those two readings requires knowing how much of a scene's brightness this particular stock could capture. Establishing that figure is the purpose of what follows.

What a stop is

A stop is a doubling or halving of light. Two stops is four times the light, three stops eight times, ten stops roughly a thousand times.

Brightness gets described this way because the ratios involved are enormous. Sunlit pavement can be a thousand times brighter than the shaded interior of a car in the same photograph. Counting in doublings keeps such numbers manageable, and it matches how cameras work, since each click of the aperture ring or the shutter dial halves or doubles the exposure.

Three numbers, three questions

The confusion in the literature comes from a single ambiguity. Several distinct quantities travel under the loose heading of “dynamic range,” and they produce very different figures for the same film.

The figure	What it measures	Roughly
Density range	How opaque the darkest part of the developed film is, compared with the clearest. A property of the processed strip.	11 stops
Total exposure range	How much scene brightness the film registers at all, from the first tone it holds to the last.	8 stops
Usable exposure latitude	How much scene brightness the film reproduces with tones still clearly separated from one another.	5 stops

The first figure describes the film. The second and third describe the world in front of the camera, and the third is the one that governs whether shadow detail survives.

All three are correct. Quoting the first in an argument about what Zapruder could record, which has happened repeatedly in this literature, produces an error of more than a factor of two.

Why a vivid film has short latitude

Kodachrome was engineered to look vivid. It takes a narrow band of scene brightness and stretches it across the full range of the film, which is what produces its saturation, its punch, and its deep blacks.

An amplifier with the gain turned up behaves the same way. A quiet input drives the speakers to full volume, so the output range is wide, but only a small range of input fits before the sound distorts at both ends. Turn the gain down and a much wider range of input becomes usable, at the cost of a flatter, duller sound.

Kodachrome is the amplifier with the gain turned up. Its wide density range and its short exposure latitude are not two separate facts about the film. They are one fact seen from opposite ends. A film cannot have both. This is why reversal stocks of this era were unforgiving of exposure error, and why Kodak’s own instructions stressed accurate metering.

Measuring the curve

Kodak published the measurement that settles this, in the form of a characteristic curve relating the light falling on the film to the density that results after processing. The curve appears on page 2 of the technical data sheet for Kodachrome 25 Movie Film, the immediate successor to Kodachrome II and closely comparable to it. This is the document Roland Zavada supplied to researchers as representative of the Kodachrome II response.

How to read it

The two axes answer different questions, and this is where most of the confusion originates.

The vertical axis shows density, which describes the developed film. Measuring vertically gives the eleven stop figure and tells us nothing about the scene.

The horizontal axis shows log exposure, which describes the light arriving from the scene. Measuring horizontally gives the answer we want. The width of the curve, from the exposure that first lifts the film off its darkest value to the exposure that drives it to its lightest, is the range of scene brightness the film could accommodate.

> For the numerically inclined: density is a base-10 logarithm of opacity and a stop is a factor of two, so one stop equals $\log_{10}(2) = 0.301$ density units. Inverted, one full unit on the exposure axis equals $1 \div 0.301 = 3.32$ stops. That is close to three and a third, so any span quoted below can be checked against the printed curve without doing logarithms.

What the measurement gives

On the published plot, the horizontal axis runs from log exposure −4.0 to +2.0 and the vertical axis from density 0.0 to 4.0. Working from these calibrations:

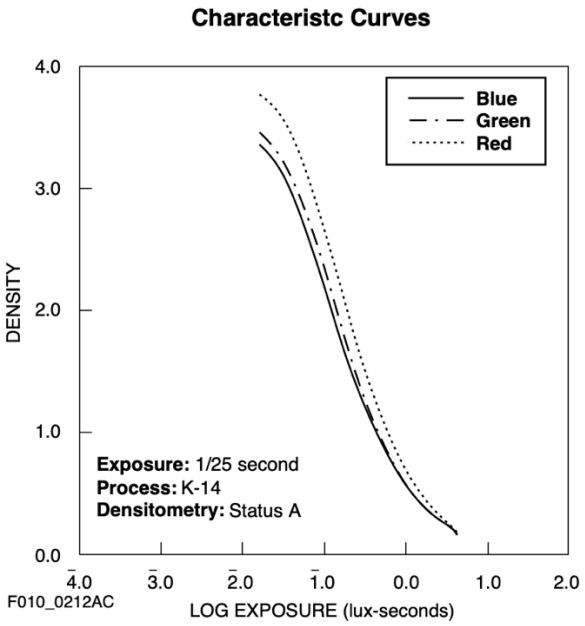
The curves occupy the range from log exposure −1.80 to +0.64. That span of 2.44 log units is 8.1 stops, which is the total range of scene brightness the film registered at all.

Steepness is not constant across that span. It peaks at a gradient of about 2.1 near log exposure −0.96, and falls away toward both ends, where the curve flattens and neighboring brightnesses in the scene record as very nearly the same density. Averaged across the whole printed span, the gradient is about 1.4.

Requiring that tones remain reasonably well separated narrows the figure considerably:

Steepness retained	Log span	Stops	Density covered
50% of peak	1.59	5.3	0.63 to 3.30
60% of peak	1.33	4.4	0.80 to 3.16
70% of peak	1.00	3.3	1.02 to 2.96
80% of peak	0.76	2.5	1.25 to 2.79

Where to draw that line is a matter of judgment rather than a published Kodak specification, and the honest way to present the result is to give both ends of it. The film registered about eight stops in total. Something closer to five carried tonal separation good enough to show detail. Neither figure comes close to what the scene presented.



Excerpt from Kodak's Data Sheet – See Sources section

Kodak said the same thing in plainer words

The curve is confirmed by something far more homely, namely the exposure guidance Kodak printed on the same data sheet. For average frontlit subjects in daylight, from two hours after sunrise to two hours before sunset, at a camera speed of 16 to 18 frames per second, the recommendations were these:

Lighting condition	Lens opening
Bright or hazy sun on light sand or snow	f/16
Bright or hazy sun, distinct shadows	f/11 to f/16
Weak hazy sun, soft shadows	f/8
Cloudy bright, no shadow	f/5.6
Heavy overcast, open shade	f/5.6

Kodak footnotes the open shade case as a subject shaded from the sun but lit by a large area of clear sky. Each full f-stop is one doubling of light, so the spread from the brightest recommendation to the shaded one is about three doublings.

The significance lies in what Kodak is instructing the user to do. It is telling the home movie maker to pick one setting or the other, because a single setting will not serve a sunlit subject and a shaded subject at once. Kodak described the limitation from the customer's end without ever using the word latitude. The assassination occurred at 12:30 in the afternoon, well inside the window this table covers.

What the scene presented

Set eight stops, or five, against the brightness range in front of Zapruder. A heavily overcast scene may span only five or six doublings. A sunlit scene containing open shade commonly runs ten to fourteen, and more if a specular reflection such as chrome or glass falls in frame. Elm Street at midday on November 22, 1963, with sunlit roadway, shaded limousine interior, and abundant chrome, sat firmly in the upper part of that range.

Human vision handles this easily, and the eye keeps readjusting as it moves around a scene. Estimates of visual range vary with how the question is posed, but figures on the order of ten to fourteen doublings are commonly given for a fixed state of adaptation, with a far larger total available as the eye adapts. These are orders of magnitude rather than precise values, since measurement conventions differ from source to source.

The mismatch is the entire point. The scene spanned something like ten doublings or more. The film held eight at the outside, and about five with usable separation. Zapruder's camera metered for the sunlit street, which is what its meter was built to do, and everything meaningfully darker than that pavement was pushed toward the bottom of the film's range, where tonal differences first compress and then disappear.

A second effect in the shadows: the layers separate

Kodachrome carries three separate emulsion layers, and the data sheet plots a curve for each. They do not track one another.

At the highlight end the three curves converge. At the shadow end they pull apart. Red climbs to a maximum density of about 3.77 while blue stops near 3.36, a divergence of roughly four tenths of a density unit.

The practical consequence is that the darkest parts of a Kodachrome frame become unreliable in color as well as in tone. Well before any layer reaches its limit, the layers have stopped responding together, so the color balance shifts. A faint hue seen inside a deeply shadowed region of the Zapruder film therefore carries much less evidentiary weight than the same hue would in a well-lit part of the frame, whichever conclusion it is being cited to support.

An objection worth raising first

The opening paragraph of the same Kodak data sheet says the film features good exposure latitude and tone reproduction. Anyone disputing the argument here can quote that sentence from the very document being cited for the opposite conclusion.

Two things about it. It is comparative marketing copy, describing the film against others in its class, in a publication whose purpose is to sell the stock. And it carries no number at all. The curve on page 2 of the same document does, and when a printed measurement and a promotional adjective disagree, the measurement governs.

What follows from this

Three consequences bear on claims of alteration.

First, information outside the film's range at the moment of exposure was never recorded. It is not faintly present and waiting to be recovered. It is absent. No scanner, however modern, and no amount of processing can restore what was never captured.

Second, copying makes matters worse. Each duplication generation raises contrast, which narrows the range further. A shadow holding faint detail on the camera original can be solid black three generations later. This matters a great deal in practice, since most researchers work from later generation copies.

Third, and most important, a featureless dark region is the normal, expected output of this film wherever the subject fell below its range. Such regions appear throughout the shaded portions of the Zapruder frames, including in many places no one has ever suggested were altered. Finding one in a particular location is therefore not evidence that anything was added there. The absence of information is not evidence of added opacity.

None of this establishes that the film was unaltered. It establishes something narrower and still necessary: the darkness of a region, considered by itself, carries no weight as an argument in either direction.

Sources

KODACHROME 25 Movie Film (Daylight)/7267, Technical Data, Color Reversal Film, Kodak Publication No. H-1-7267, April 2002. 125px.com/docs/motionpicture/kodak/7267_zh_CN.pdf Characteristic curves, spectral sensitivity, spectral dye density, and modulation transfer curves all appear on page 2. Densitometry is Status A; exposure 1/25 second; Process K-14.

Basic Photographic Sensitometry Workbook, Kodak Publication No. H-740. kodak.com/content/products-brochures/Film/Basic-Photographic-Sensitometry-Workbook.pdf Kodak's own tutorial, for readers who want to learn to read a characteristic curve for themselves.

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