Camera-Relative Transmission Measurement of Sport Sunglass Lenses with a Clear-Lens Anchor

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Abstract. Manufacturers state a single visible light transmission (VLT) figure per sunglass lens, measured on laboratory instruments a buyer cannot reproduce or compare across. We describe a low-cost, fully reproducible protocol that measures the *relative* transmission of 15 lens specimens with one mirrorless camera under locked exposure, anchored to a clear control lens of known factory rating. The anchor choice is shown to matter in field conditions: an earlier no-lens anchor produced physically impossible readings of up to 131 % in drifting daylight, which the clear-lens anchor detects and confines rather than propagates. Measured values track stated VLT closely for neutral and cool tints and read higher for strongly warm tints, consistent with the camera's spectral response.

Figure 1: Bench apparatus. One fixed geometry for all fifteen specimens; the camera, specimen holder and background never move between frames.

1 Capture protocol

Bench. Fifteen specimens (13 genuine Oakley Prizm variants, 2 counterfeits acquired alongside them) were photographed on 2026-07-23 from one fixed apparatus (Fig. 1) in two blocks: direct sun at 1/500 s, $f/8$, ISO 100 for the through-lens sample, and open shade at 1/40 s for the exterior face. White balance was fixed once on an 18 % grey card and never changed. Each specimen carries a handwritten label legible in frame, so identity is read off the photograph rather than remembered. The processing refuses to emit figures unless every frame of a block reports byte-identical exposure metadata.

Field. On 2026-07-25 the fifteen specimens, plus a bare no-lens reference frame, were photographed in seven real scenes ranging from full-sun tarmac to deep forest shade. Per scene: tripod locked, exposure locked once on the bare sensor, then one frame per lens in a fixed capture order, the lens held flat against the front element (Fig. 2). A grey card accompanied the session to check for light drift within a scene.

2 Relative transmission

Raw files are demosaiced linearly (LibRaw `dcraw_emu` [1], 16 bit, no tone curve, no auto-brightening, camera white balance, sRGB primaries). Camera JPEGs are unusable for this purpose: their highlight shoulder compresses bright values and pushed a 75 % specimen and the 93 % control toward the same reading in an early pass. For each frame we form the luminance image with the Rec. 709 weights [2]

$$Y = 0.2126\,R + 0.7152\,G + 0.0722\,B, \tag{1}$$

restrict it to a mask M of well-exposed pixels in the anchor frame ($0.05 < Y_{\text{anchor}}/Y_{\max} < 0.9$), and report the median ratio

$$\text{relT}_i \;=\; \underset{p\in M}{\text{median}}\,\frac{Y_i(p)}{Y_{\text{clear}}(p)}, \tag{2}$$

i.e. transmission *relative to the clear control*, not an absolute VLT. The median over a shared pixel mask makes the estimate robust to specular highlights and local texture without requiring the scene to be uniform.

2.1 Why the anchor is a lens, not the bare sensor

The natural-seeming anchor is the no-lens frame, and Eq. (2) with Y_{nolens} in the denominator was our first implementation. It has a structural flaw: it grants one frame veto power over the whole scene. If daylight moves between the no-lens frame and the remaining fifteen, every figure in the scene inherits the error invisibly. Field data made this concrete: under the no-lens anchor the clear control, a near-neutral filter of stated 93 % VLT, read between 84.5 % and 130.6 % across the seven scenes (Table 1), and a value above 100 % is impossible for any passive filter.

The clear control inverts the failure mode. It is a real specimen of known factory rating, present in every scene; a scene whose light drifted announces itself through the control's own reading instead of silently corrupting its neighbours. Under the clear anchor the no-lens frame is no longer pinned to 100 % and becomes a free drift detector: it must read *above* the control, and the four scenes where it read below are flagged on the published pages, their figures withheld rather than printed.

3 Verification against stated VLT

Table 2 compares the bench measurement with the manufacturer's stated VLT for the thirteen genuine specimens. Since relT is expressed relative to the clear control, an

Table 1: The clear control (stated VLT 93 %) read against the no-lens anchor, per field scene. Readings above 100 % are physically impossible and diagnose light drift between the anchor frame and the rest of the scene.

Scene	1	2	3	4	5	6	7
Clear (%)	90.4	100.9	95.0	118.4	84.5	130.6	107.8

Figure 2: Field protocol. Exposure is locked once on the bare sensor; each lens is then held flat against the front element for a single frame, sixteen frames per scene in a fixed order.

absolute estimate is relT $\times$ 0.93, using the control's stated rating. Agreement is close for neutral and cool tints: Prizm Road's estimate of 19.1 % sits within one point of its stated 20 %, and the three darkest lenses land within three points of their stated 11 %. Strongly warm tints read consistently higher than stated (Prizm Trail most of all), which is the expected signature of sensor metamerism: an orange filter concentrates its transmission where the camera's green and red channels, and the luminance weights of Eq. (1), are most sensitive, while a photometric VLT weights wavelengths by the human photopic curve [3]. The photochromic specimen carries no stated figure because its transmission is state-dependent; the value shown is its captured state on the bench.

4 Limitations

The camera sensor is not a spectrophotometer: its three colour channels have their own spectral response, so a strongly coloured filter will not read identically here and on a laboratory instrument, and relT values are same-session comparisons between these specimens, not replacements for the manufacturer's stated VLT. One specimen per model was measured; unit variance is unquantified. Field scenes carry natural light variation bounded by the drift detection above. Optional extensions that would tighten the method: a calibrated neutral-density filter of certified transmission as an independent check on the pipeline, and a second unit per lens model to bound unit variance.

5 Data and code availability

The full dataset (stated and measured figures for all specimens) is published as JSON alongside the study at bananaoptics.com/blogs/research; the capture and processing scripts (raw development, sampling, drift gates) are maintained in the study's build pipeline and available on request.

Table 2: Stated VLT versus bench measurement (median ratio to the clear control; absolute estimate = relT $\times$ 0.93). Clear defines the anchor, so its measured value is 100 % by construction.

Specimen	Stated (%)	relT (%)	Estimate (%)
Clear	93	100.0	(93.0)
Prizm Low Light	75	88.7	82.5
Prizm Trail	36	55.1	51.2
Prizm Trail Torch	35	43.2	40.2
Prizm Road	20	20.5	19.1
Prizm Ruby	17	24.7	23.0
Prizm Road Jade	15	17.6	16.4
Prizm Tungsten	14	20.8	19.3
Prizm Sapphire	12	17.6	16.4
Prizm 24K	11	13.6	12.6
Prizm Road Black	11	14.8	13.8
Prizm Black	11	13.1	12.2
Photochromic	–	37.7	35.1

A companion note covers how the published photographs compensate for the camera's exaggeration of lens darkness.

References

[1] LibRaw LLC, *LibRaw: raw image decoder library*, `https://www.libraw.org`.

[2] ITU-R Recommendation BT.709-6, *Parameter values for the HDTV standards for production and international programme exchange*, 2015.

[3] EN ISO 12312-1, *Eye and face protection, sunglasses and related eyewear, Part 1: Sunglasses for general use*. Defines luminous transmittance and the filter categories cited by manufacturers.