Image Flare measurement according to ISO 18844

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Abstract

The ISO 18844 standard that is on the way defines a flare measurement method for a camera lens system similar to the measurement described in the older video standard IEC 61146. In addition it addresses the measurement of flare over the imaging field and also the measurement of devices that do not allow for adjusting the exposure like mobile devices.

The paper provides an overview over the sources of "unwanted light" which the standard was originally supposed to address and potential ways to measure these. The current draft version only addresses the standard flare caused by a diffuse white plane mostly within the field of view of the camera. For this kind of flare three different measurements approaches are defined using a single or multiple exposures depending on the level of control the user has over the exposure of the image.

Measurements will be presented as well as inter lab comparison issues that came up during the development of the measurement procedure.

Introduction

No matter if an image is recorded on film or on a semiconductor device there has always been unwanted light that got recorded together with the light coming form the original objects. It is mostly the lens that is responsible for the unwanted light in the images and when the lens can be detached from the camera even nowadays the ISO standard 9358 [1] is used to measure the flare or veiling glare of lenses. As will be seen the terminology around the unwanted light in image capture as well as on the display side is currently a mess and when experts talk to each other a lot of explanation is required describing what they mean.
For a lot of cameras especially those in mobile devices like cell phones the lenses cannot be detached without destroying the device. For these cases and for the cases where the impact of the camera body on the flare shall be determined a different procedure than the one described in ISO 9358 is needed. That is why the ISO technical committee 42 (Photography) has decided to create an additional standard (ISO 18844) for measuring flare which they call 'image flare'. This standard follows a system approach. It defines a test scene that is captured with the specimen and the image is then analyzed. The results include impacts from all parts of the system the environment, the lens, the camera body, and the image processing. All these parts can potentially impact the amount of flare found in an image.

Definition of flare

As a starting point let us first use the term "unwanted light" because it summarizes best what most people define as flare.

The more technical definition is the one published in the vocabulary standard ISO 12231 which is:

„3.59 **flare**

light falling on an image, in an imaging system, which does not emanate from the subject point

NOTE 1 Flare is also sometimes referred to as veiling glare.

NOTE 2 See also image flare (3.59.1), veiling flare (3.59.2), veiling glare (3.189)."

The question is where does such light come from and what causes flare? Let's go through the imaging system step by step and identify those sources.

1. The first source can be anything that is between the object and the front lens of your camera. It can be haze in the atmosphere, which causes big problems e.g. in astronomy, reconnaissance or surveillance or simply a dirty windshield or window through which a photograph is taken. (This source of unwanted light is not further discussed in this paper)

2. As a second source the optical parts of a lens naturally cause inter-reflections. These can be increased by inhomogeneity, durst or particles on the surface of the optical elements. Antireflection coating can decrease these reflections to a certain extend. But they are wavelength dependent and therefore can cause colored structures and ghosting effects. Even fluorescence can occur with some optical elements.

3. The next parts are the edges and the framing of the lenses as well as the diaphragm, shutter, and the camera body and all other surfaces within the lens or camera that are exposed to light.

4. A fourth aspect is the optical system itself with spherical and comatic aberrations.

5. And last but not least there can be light leakage in the camera body e.g. light falling in from the view finder, a LED in the camera that is not completely shielded from the sensor or even a hole in the camera body that lets light from outside fall onto the sensor.

Once an image is captured it is often times not possible to differentiate the sources for flare. Therefore the measurement and testing of flare is mostly done by creating artificial scenes that are controllable and comparable between different labs.

Here are some examples:

Figure 1: around the specular highlight ghosting artifacts are visible due to reflections on surfaces within the lens.

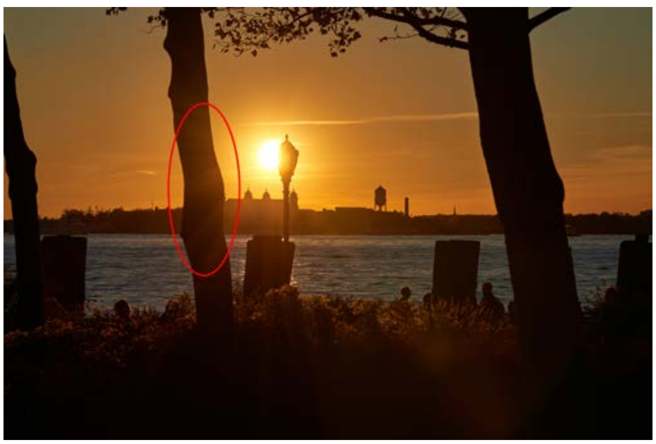


Figure 2: In the dark areas that are close to a highlight like the sun a local increase of the signal is visible due to flare.

Figure 4: Unfortunately this was not a cloud of dust on the path created by the mules. A finger print of the surface of the front lens caused a huge amount of flare.

Figure 3: These images are taken at about the same time. On the upper image the contrast in the bushes behind the riders is much lower than on the lower. A slight change in the orientation of the camera to the light source outside of the field of view caused a dramatic change of the amount of flare in the image.

Of course fingerprints on the surface of lenses need to be avoided or cleaned and do not require a measurement. The other implications of flare highly depend on the scenes that are captured. In case of a point light source the effects of flare are often times locally in form of “ghosting structures” like an image of the iris reflected on the surfaces on of the optical elements but they can also can cause a general increase of light in the surrounding areas. The amount and structure of flare highly depends on the angle of incidence and on the position of the light source. Another kind of light can be a diffuse illumination. Such an illumination usually does not create visible ghosting. It only leads to a diffuse but not uniform increase of light that brightens especially the shadows in an image, like shooting through a dirty windshield.

For the testing and measurement as well as for the subjective impact on the quality of the captured image itself it sometimes is important if the light source is inside or outside of the field of view of the camera.

The general term flare covers all sources of flare including light leakage. ISO 12231 defines the part of more or less diffuse light that enters the system through the “normal entrance aperture” as veiling flare:

3.59.2 veiling flare
relatively uniform but unwanted irradiation in the image plane of an optical system, caused by the scattering and reflection of a proportion of the radiation which enters the system through its normal entrance aperture where the radiation may be from inside or outside the field of view of the system
NOTE Light leaks in an optical system housing can cause additional unwanted irradiation of the image plane. This irradiation can resemble veiling flare. [ISO 3664:2009, definition 3.19]

Veiling flare captured and processed by an imaging system is defined as image flare by ISO 18844:

3.1 image flare
unwanted increase in signal of an output processed image resulting from light detected by an image sensor that does not emanate from a corresponding subject point

This includes light from inside and outside the field of view.

The terms veiling glare and viewing flare are also defined by ISO 12231 but they are related to the viewing of images on divices or media and not to image capture devices.

3.189 veiling glare
light, reflected from an imaging medium, that has not been modulated by the means used to produce the image.
NOTE 1 Veiling glare lightens and reduces the contrast of the darker parts of an image. NOTE 2 In CIE 122, the veiling glare of a CRT display is referred to as ambient flare. [ISO 22028-1:2004, definition 3.42, ISO/TS 22028-2:2006, definition 3.22, ISO/TS 22028-3:2006, definition 3.22]

3.192 viewing flare
veiling glare that is observed in a viewing environment but not accounted for in radiometric measurements made using a prescribed measurement geometry
NOTE The viewing flare is expressed as a percentage of the luminance of adapted white. [ISO 22028-1:2004, definition 3.43, ISO/TS 22028-2:2006, definition 3.23, ISO/TS 22028-3:2006, definition 3.23]

Measuring flare

Flare can now be measured in different ways.
The most sophisticated way is to use a point light source in a dark surrounding and capture a huge set of images with the light shining into the camera from each direction and that way measuring the point spread function (glare spread function GSF in ISO 9358) [1][2]. The problem with this approach is to extract a value or function from the analysis of these images that describes the amount of flare and its distribution generated by the system for real scenes. Even though ISO 9358 describes that a value can be predicted from the convolution of the GSF nobody has come up with a proposal so far.

Another Approach is the one described as single integrating sphere method in ISO 9358 [1]. The whole standard is designed for the analysis of lenses and the latest release is from 1994.

In this case a test specimen “looks” into an illuminated integrating sphere with a light trap at one end. This method accounts for light from inside and outside the field of view over the whole range of incident angles. Different positions of the light trap in the field of view are measured sequentially. This method is mentioned to represent objects at infinite or nominally at infinite distance. Nominally at infinite distance is defined as distances greater than 10 times the focal length on the specimen. So for a 100mm lens an integrating sphere with a minimum diameter of 1m is required.

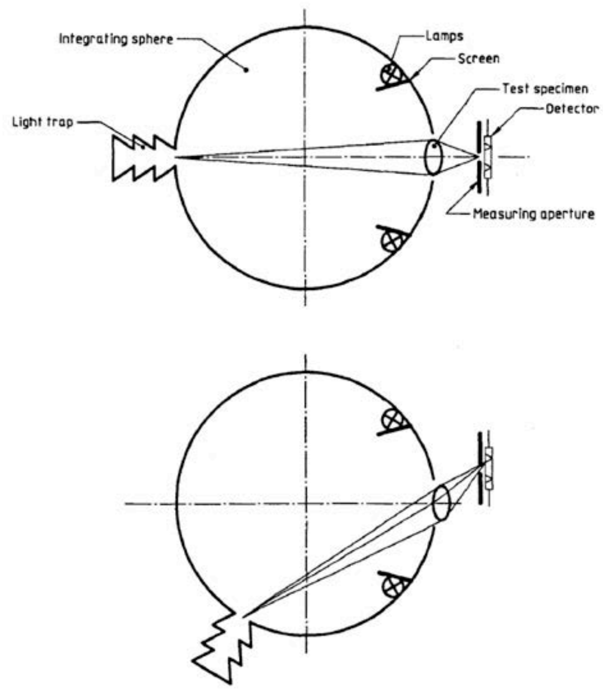


Figure 5: Integrating sphere based flare measurement according to ISO 9358.

For lenses with a large focal length the diameter of a single integrating sphere does not fulfill the 10 times f requirement and therefore a two hemisphere method is defined.

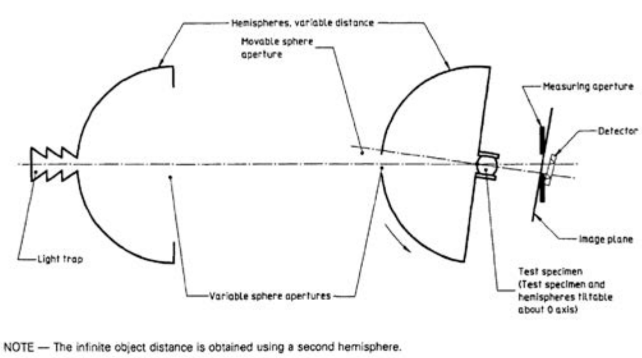


Figure 6: Two hemisphere based measurement according to ISO 9358 for lenses with large focal length.

These methods are relatively complicated and require special equipment. ISO 9358 also mentions a method for measuring veiling flare (in this standard it is called veiling glare) at finite object distances (method B). It is the basis for an alternative simplified method for camera system evaluation that was used in the IEC 61146 video standard which again is the basis for the method now defined in the upcoming still camera standard ISO 18844 and security camera standard IEC 62676-5.

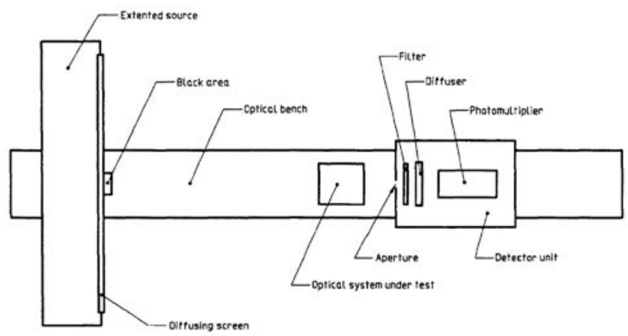


Figure 7: the setup for measurement for distances that are not infinite.

ISO 18844 approach

Setup

The method described in ISO 18844 is based on a uniform white target with one or multiple black holes or in case of a transmissive target with one or more opaque areas.

In contrast to ISO 9358 the opaque area is defined as being a maximum of 5% of the field of view instead of 10%. The uniform field extends to 1.41 times the height and width of the field of view of the camera. That way a certain amount of light from outside the field of view is taken into account as well.

Figure 8 and 9 show the setup for reflective and transmissive targets. Figures 10 and 11 describe the target layout itself for a single black measuring spot and multiple black measuring spots. Even though the standard allows for lower contrasts in specific cases it is recommended to have a contrast range between the white and black areas of greater than 3000:1. The measurement with a target of that contrast will result in a max. accuracy of 0,033%.

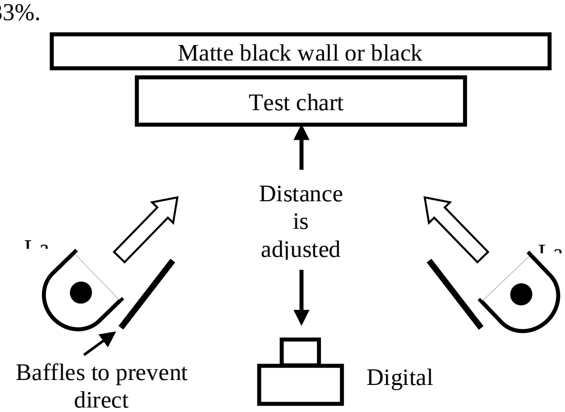


Figure 8 — Arrangement of measuring equipment for reflection-type test chart.

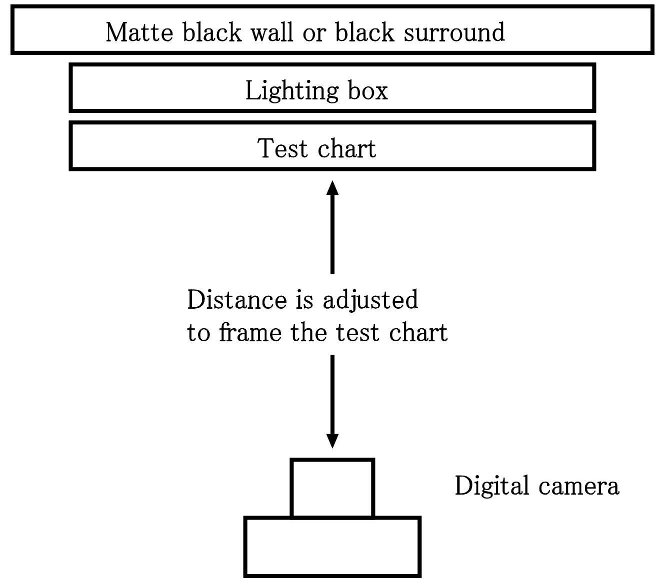
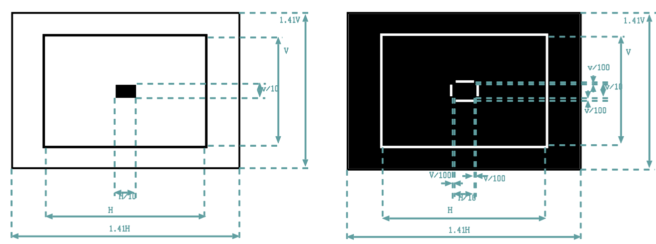
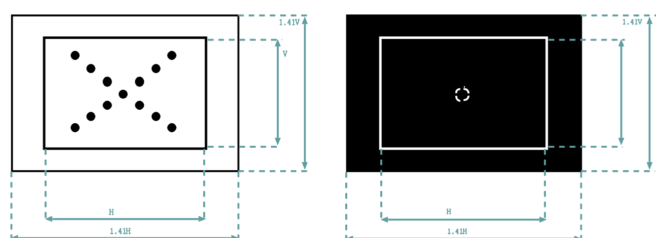


Figure 9 — Arrangement of measuring equipment for transparent-type test chart.



a) Chart 1 b) Chart 2

Figure 10 — Window pattern charts



a) Chart 1 b) Chart 2

Figure 11 --- Dot pattern charts

Evaluated area

Since the amount of flare is not uniform over the areas of the light traps evaluations would get to different results if they would choose areas with different sizes especially for the black value determination. Therefore ISO 18844 defines the areas that get evaluated as described in figure 12. For keeping the size of the chart variable the areas are defined based on the diagonal of the field of view D (inner rectangle of the chart, see figure 14).

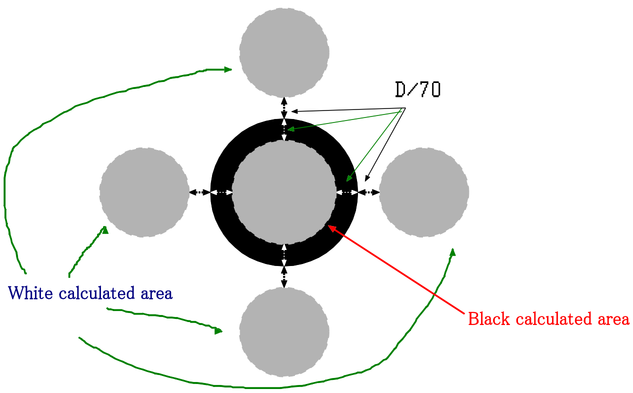


Figure 12 --- Black and white regions that get evaluated.

Flare determination

All calculations are done based on the linear luminance signal that is calculated from the RGB values depending on the color encoding the image is in.
Based on the level of control over the exposure the standard describes 3 different procedures to determine the amount of flare from a set of images.

If a camera has manual exposure function, measurement type A should be used. If a camera that does not have manual exposure function but does have an exposure lock feature, measurement type B should be used. If a camera with neither manual function nor exposure lock feature, measurement type C should be used.

Measurement type A (When this method is applied, the contrast ratio of the test chart shall be no smaller than 40:1.)

Step 1: An image of chart 1 shall be captured with the amount of exposure E_1 (luminance B1 or illumination L1, f/number A1, exposure time T1, and ISO sensitivity S1) so as to make output luma level (Y'_{luma}) of the white part to be 225 ± 5 digits (8-bit output). R'_{W1}, G'_{W1}, and B'_{W1} values shall be obtained from the image.

Step 2: An image of chart 2 shall be captured with the same exposure E_1 (luminance B1 or illumination L1, f/number A1, exposure time T1, and ISO sensitivity S1). R'_{B2}, G'_{B2}, and B'_{B2} values shall be obtained from the image.

Step 3: An image of chart 1 shall be captured with the amount of exposure E_3 (luminance B3 or illumination L3, f/number A1, exposure time T3, and ISO sensitivity S1) that is 8 times ± 10 % of the exposure in step 1. R'_{B3}, G'_{B3}, and B'_{B3} values shall be obtained from the image.

Step 4: Luminance signal Y_{B2} shall be calculated from the R'_{B2}, G'_{B2}, and B'_{B2} values, luminance signal Y_{B3} shall be calculated from the R'_{B3}, G'_{B3}, and B'_{B3} values, and luminance signal Y_{W1} shall be calculated from the R'_{W1}, G'_{W1}, and B'_{W1} values.

Step 5: The image flare shall be calculated by the following formula.

$$F = \frac{Y_{B3}\frac{E_1}{E_3} - Y_{B2}}{Y_{W1}} \times 100\% \qquad (1)$$

When multiple-spot measurement is conducted, YB3 and YB2 at the corresponding position shall be used.

Measurement type B (When this method is applied, the contrast ratio of the test chart shall be no smaller than 40:1.)

Step 1: An image of chart 1 shall be captured with the amount of exposure E1 (luminance B1 or illumination L1, f/number A1, exposure time T1, and ISO sensitivity S1) so as to make output luma level (Y'luma) of the white part to be 225 ± 25 digits (8-bit output). R'W1, G'W1, and B'W1 values and R'B1, G'B1, and B'B1 values shall be obtained from the image.

Step 2: An image of chart 2 shall be captured with the amount of exposure E2 ((luminance B1 or illumination L1, f/number A2, exposure time T2, and ISO sensitivity S2) under the same conditions as in step 1. If the camera can fix the exposure level according to the chart 1, the exposure should be set as the same as when capturing chart 1. If the camera can fix the f/number, the f/number shall be set to A1. R'_{B2}, G'_{B2}, and B'_{B2} values shall be obtained from the image.

Step 3: Luminance signal Y_{B1} shall be calculated from the R'_{B1}, G'_{B1}, and B'_{B1} values, luminance signal Y_{B2} shall be calculated from the R'_{B2}, G'_{B2}, and B'_{B2} values, and luminance signal Y_{W1} shall be calculated from the R'_{w1}, G'_{w1}, and B'_{w1} values.

Step 4: The image flare shall be calculated by the following formula.

$$F = \frac{Y_{B1} - Y_{B2}\frac{E_1}{E_2}}{Y_{W1}} \times 100\% \qquad (2)$$

When multiple-spot measurement is conducted, Y_{B1} and Y_{B2} at the corresponding positions shall be used.

NOTE If A2 is not the same value as A1, Y_{B2} may suffer discrepancy from the value when A2 was the same as A1. This worsens measurement precision.

Measurement type C (When this method is applied, the contrast ratio of the test chart shall be no smaller than 3000:1 and should be no smaller than 10000:1.)

Step 1: An image of chart 1 shall be captured with the amount of exposure E_1 (luminance B1 or illumination L1, f/number A1, exposure time T1, and ISO sensitivity S1) so as to make output luma level (Y'_{luma}) of the white part to be 225 ± 25 digits (8-bit output) unless the camera does not have control of exposure. R'_{W1}, G'_{W1}, and B'_{W1} values and R'_{B1}, G'_{B1}, and B'_{B1} values shall be obtained from the image.

Step 2: Luminance signal Y_{B1} shall be calculated from the R'_{B1}, G'_{B1}, and B'_{B1} values, and luminance signal Y_{W1} shall be calculated from the R'_{w1}, G'_{w1}, and B'_{w1} values.

Step 3: The image flare shall be calculated by the following formula.

$$F = \frac{Y_{B1}}{Y_{W1}} \times 100\% \qquad (3)$$

Factors that influence flare

Of course a lens hood in front of the lens influences (decreases) the amount of flare in the image. That’s what it is designed for. That means the hood needs to be in place when the measurement is performed.

Another aspect with a great impact on flare is dust and dirt as can be seen in figure 4. The measured flare can easily be higher by a factor of 10 if a fingerprint is left on the front of the lens. So it is absolutely necessary to accurately clean the lens before performing the measurement.

In addition the dark current of a camera can have a great impact on the measuring if it is not subtracted. This is currently not addressed by the standard. It should be recommended to capture a black reference image with the same exposure time and subtract the dark current from the measurement.

IEC 62676-5 approach

IEC 62676-5 follows the ISO 18844 approach but it also wants to address illumination from a wider angle than the one covered by the 18844 test chart. Similar to the two-hemisphere approach an illuminated plate is positioned in front of the camera. A hole in the center of the plate leaves the test chart with the field of view open to. Depending on the focal length of the specimen the size of the hole or the distance to the camera can be adjusted to exactly frame the test chart. A measurement can be performed with and without the illuminated plate and that way the impact of the illuminant from inside and outside the field of view can be differentiated.

This method still needs to be tested extensively to find out if it works well in all cases.

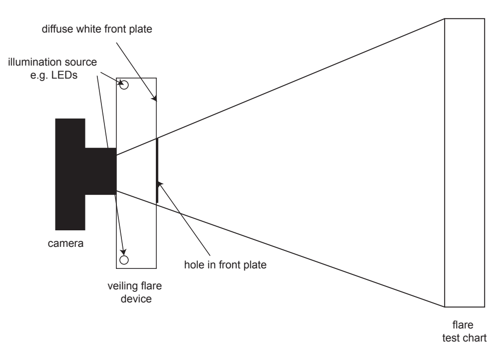


Figure 12: Flare measurement with diffuse illuminated white plate in front of the camera.

Results

For the measurements mentioned below the method type C of ISO 18844 was used.

The results show that the amount of flare is not uniform throughout the image. With light mainly from inside the field of view in many cases the flare level is higher in the center of the image. Therefore measuring it as a function of image height makes sense. For compensation of flare in the image pipe it might be best to use a flare subtraction depending on the image height. Subtracting too much of the signal for flare correction causes a loss of shadow detail. In addition the amount of flare depends on the aperture (f-number) used. Typically the amount of flare increases with higher f-numbers (smaller apertures).

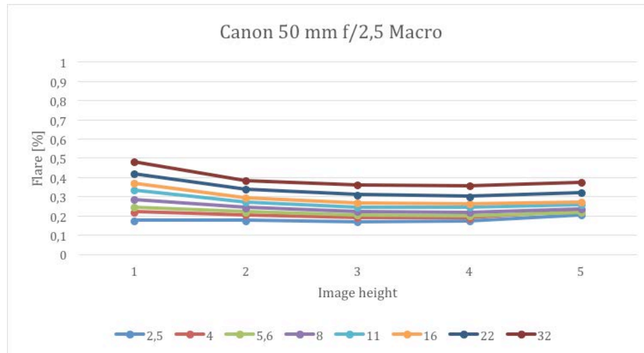


Figure 13: Measurement based on ISO 18844 compliant test chart with light traps at 5 image heights.

To find out about the impact of flare from outside the field of view a simplified approach was used by placing LEDs at the outer border of an ISO 18844 type chart which lies outside the field of view as shown in figure 14.

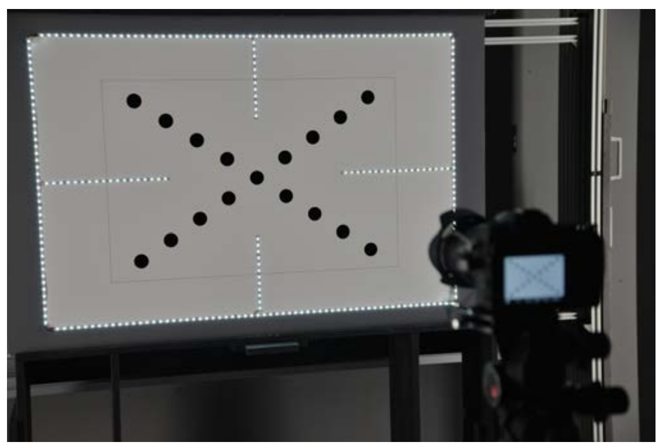
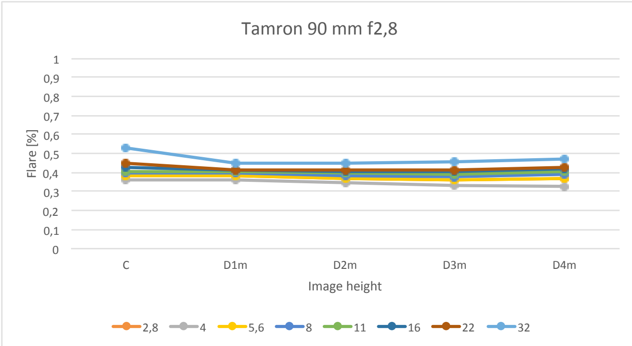


Figure 14: Measurement based on ISO 18844 compliant test chart with the addition of LEDs around the frame of the chart.

As figure 15 shows the results measured with and without the LEDs switched on are significantly different.



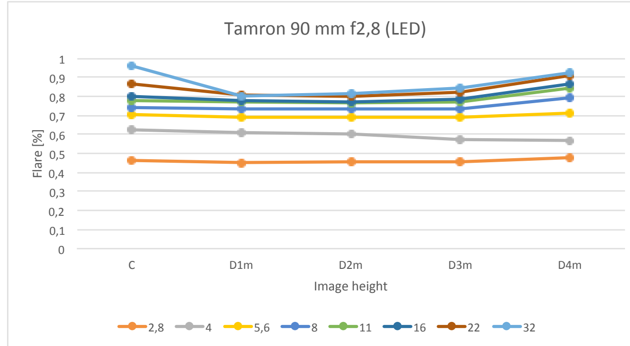


Figure 15: Measurement of flare without LEDs on the right and with LEDs on the left.

Conclusions and future work

To get the full picture of the behavior of a camera lens combination in relation to flare it is necessary to measure flare originating from inside and outside the field of view.

ISO 9358 covers all the issues except a measurement of multiple areas in the image from the same image. The downside of the approach is the related investment in special and expensive equipment.

ISO 18844 as it stands only covers flare originating mostly from light inside the field of view and therefore is not sufficient to characterize a camera. The simplified approach mentioned in the IEC 62676-5 may work and needs to be tested as soon as a diffuse plate as described is manufactured and tested.

A general estimation of flare in images of real scenes based on the measurement and image statistics seems to be possible and can lead to automated flare subtraction in the image processing.

However in case of directed (non diffuse) light sources a correction is almost impossible due to the angle dependent effects. The best way to correct flare is to minimize it by using the right materials, surface treatment and orientation, and production processes in the lens production.

References

[1] ISO 9358, Optics and optical instruments --- Veiling glare of image-forming systems --- Definitions and methods of measurement.

[2] Julian Achatzi et al., Measurement and analysis of the point spread function with regard to straylight correction, Proc. SPIE 9404, Digital Photography XI, 940406 (27 February 2015).

[3] ISO 18844, Photography — Digital cameras — Image flare measurement.

[4] IEC 62676-5, VIDEO SURVEILLANCE SYSTEMS FOR USE IN SECURITY APPLICATIONS – Part 5: Data Specifications and Image Quality Performance for Camera devices

Author Biography

Dietmar Wueller studied photographic technology at the Cologne University of applied sciences. He is the founder of Image Engineering, an independent test lab that tests cameras for several photographic and computer magazines as well as for manufacturers. Over the past 20 years the company has also developed to one of the world's leading suppliers of test equipment. Dietmar Wueller is the German chair of the DIN standardization committee for photographic equipment and also active in ISO, the IEEE CPIQ (Cellphone Image Quality) group, EMVA (European Machine Vision Association) and other standardization activities..