EVALUATION AND STUDY
OF ARRI ALEXA35 CAMERA

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INTRODUCTION

In this document we study the new ARRI ALEXA35 camera from the point of view of cinematographer. We have focused on the fundamental aspects of digital image quality such as resolution, dynamic range, noise, sensitivity and color, in addition to contemplating the more subjective assessments of the test participants, both cinematographers and assistants and post-production staff. The analysis of the different tests has been carried out based on theoretical considerations, working with resolution, color and texture test charts and their subsequent analysis with programs such as Arri Reference Tool, Imatest, ImagJ or Color Inspector. We have used different light sources adjusted by the Sekonic C700 spectrometer and the Sekonic L-558/Cine photometer. We have used mostly Signature lenses and sporadically Cook anamorphic and Sigma cine lenses. While we have conducted tests with various camera setups, most of them were shot in ARRIRAW at 4608 x 2592 4.6K 16:9 with the LogC4 curve, Wide Gamut v4 color space, and an EI value of 800 as the base. The theoretical tests, more technical, shot in studio, we have complemented them with shooting outdoors and natural interiors, specifically in the Tatacoa desert and Villavieja, Colombia. There we filmed how Totumo wood is still worked manually, with which the craftsman even makes musical instruments as well as jugs, bowls and many other objects, the work of a wood artisan, without forgetting the cocoa process that we have filmed, from its harvested in the tree until its final processing. In post-production the editing and colorization has been done on Davinci Resolve Studio version 18.1.4. in STD and HDR, although here we mostly show the STD Rec 709, in addition to the projection with the corresponding DCP. The images that are in this document come from the original but compressed frames, so they must be taken as references. Likewise, this document is accompanied by an illustrative video divided into three parts. The document and the videos are complementary in such a way that both help to understand each aspect of the camera that we have analyzed.

RESOLUTION

In this section we study the camera's ability to represent detail, from the lowest to the highest frequencies; that is to say, how sharpen it is the image that the camera builds in the different formats and with the different codecs.

Determining the resolution through frequency charts is the way in which we can know how sharp our image will look, how the textures will be and ultimately how the fine detail will be shown, if more or less defined. We must remember once again that format should not be associated with resolution; Although the size of the format, and with it the number of pixels, influence the resolution, they are not the resolution itself. The resolution of our image will depend on the sensor, the electronic signal processing, the recording system, the lens, the viewing system, and of course, the distance at which we see the image. For all these reasons, images with the same formats may have different resolution/sharpness, measured in TV Lines, lp/mm, cyc/pixel or any other common unit. Alexa 35 offers different formats, that is, different aspect ratios and with it different numbers of pixels in the image, as well as allowing the possibility of recording in Raw or in ProRes with different "flavors". The question that I ask myself as a cinematographer is what resolution and format I need for the project that I am going to carry out. To answer that question, I need to know the differences between the different formats and resolutions, for example, can I shoot in 4.6K 16:9 or in 4K 16:9. If we look at the MTF curve (*figure 1*) made on an IMATEST chart I can see that with 4.6K I will indeed have more sharpness in the image, more texture than at 4K. In 4.6K I have a 50% contrast in the center of the image of 1265 Lw/ph horizontally, while in 4K 16:9 it is 1117 Lw/ph. The vertical resolution is 1251 Lw/ph (4.6K) versus 1115 Lw/ph (4K) in the center of the image at 50%. We can still compare the 4.6k format with the 4K 2:1 format that we use quite often now.

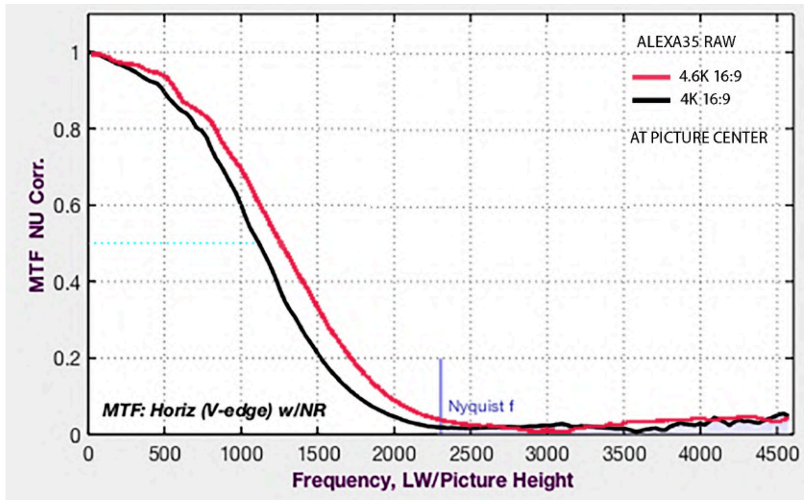


Figure 1

We can see that in 2:1 (*figure 2*) the resolution is less than 4.6K. With the 4.6K format we have a contrast value of 1265 Lw/ph (Horiz.) at 50% in the center of the image, while with 2:1 the value at 50% also in the center of the image is 974 Lw/ph (Horiz.) and 960 Lw/Ph (Vert). If we look at a texture test chart (Prêt-à-porter menu**)** we can appreciate the difference (*Figure 3*). In *figure 4* (rainbow chart) I have made a cutout of the chart and enlarged it to see the difference in texture between both formats.

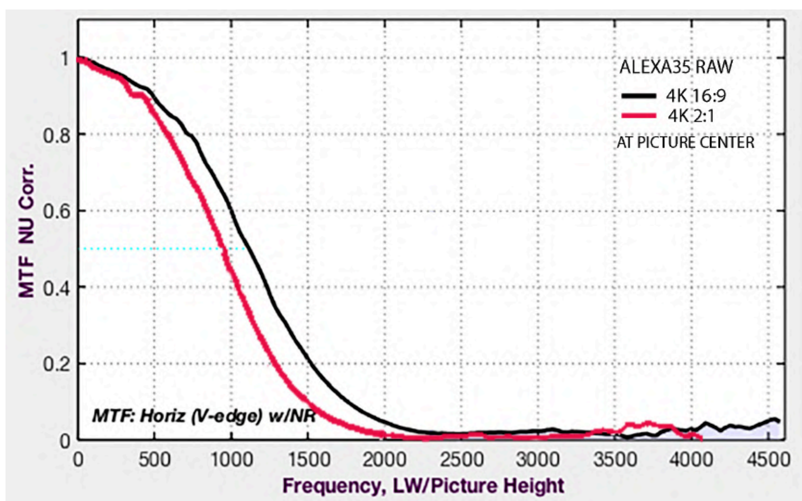


Figure 2

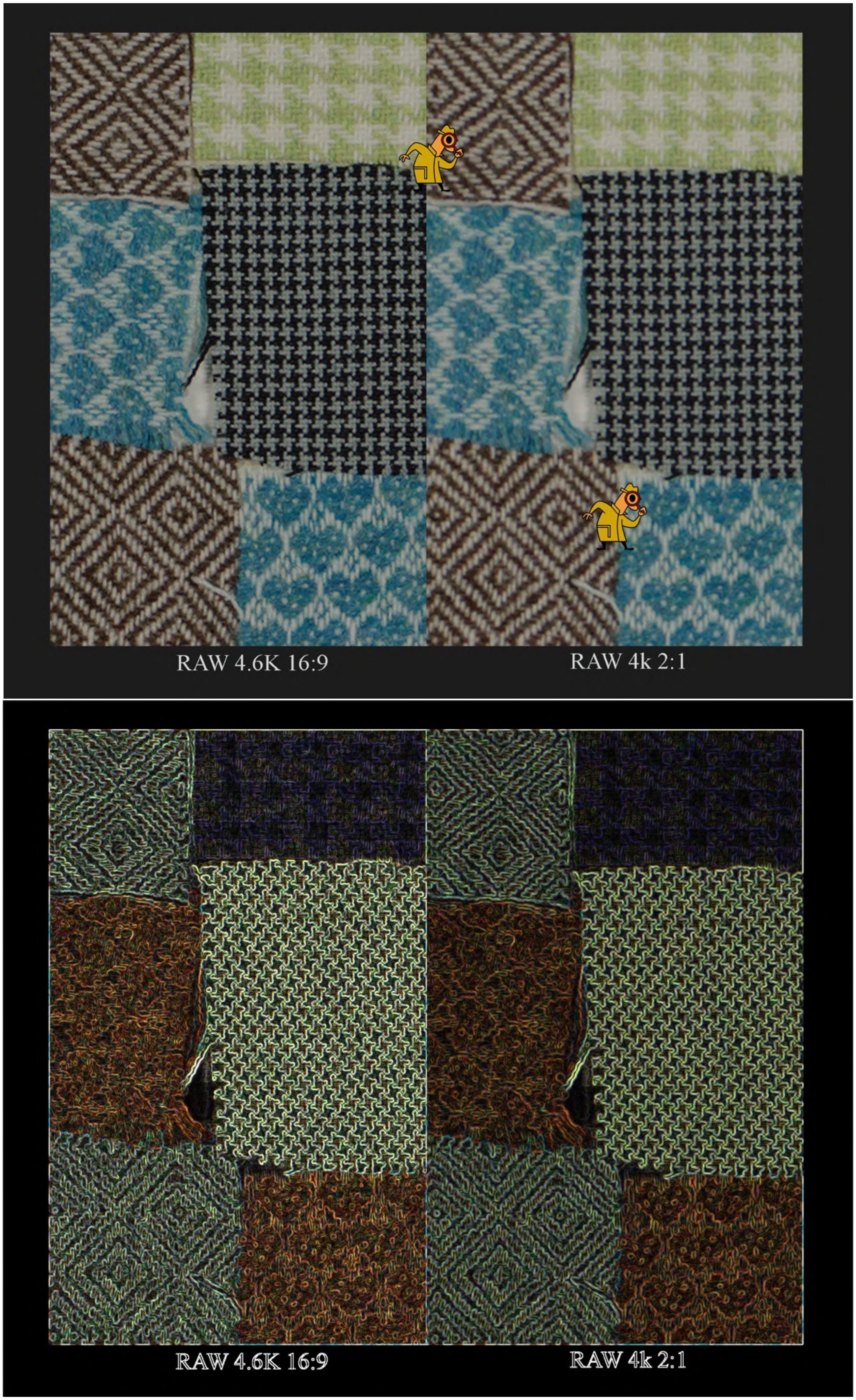


Figure 3

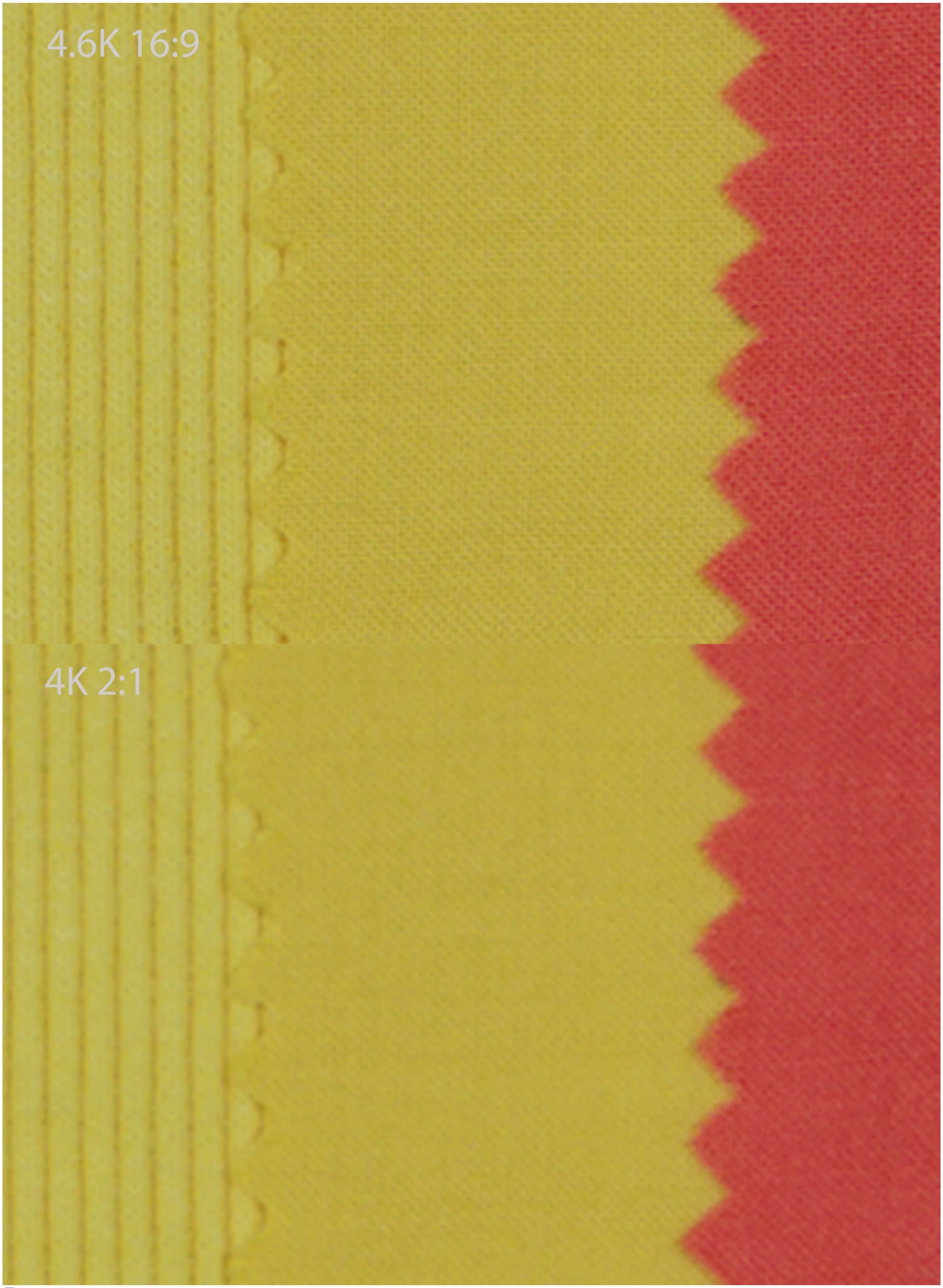


Figure 4

We have also wondered if there is any difference in terms of resolution, between recording in Raw or in ProRes. We have compared MTF curves between both recording systems and the truth is that we have not seen any distinction, comparing that with the ProRes 4444XQ. We have also compared MTF curves between spherical and anamorphic lenses. As we know, the lenses are a fundamental part of image resolution and they largely determine not only the sharpness of the image but also the very personality of our frames. Here we can see the comparison of MTF curves between two formats and two lenses, on the one hand a Signature spherical lens and on the other a Cooke anamorphic 50mm 1.8x. With the anamorphic lens we have used the 4.6K Open Gate format while with the spherical lens we have used 4.6K 16:9; with the first the contrast at 50% in the center of the image is 1408Lw/ph while with the spherical it is 1265 Lw/ph. As expected, the Open Gate format uses more photosensors to create the pixels of the image, so it has to display a little more resolution (*figure 5*). However, if we look at the side of the image comparing both MTFs we will see that with the Signature lens we have the same 1265 lw/ph, while with the Cooke lens the resolution drops to 675 Lw/Ph (*figure 6*). This difference is what precisely creates the personality of the image. Choosing one format or another or one lens or another depends on the aesthetic proposal we have for a given project.

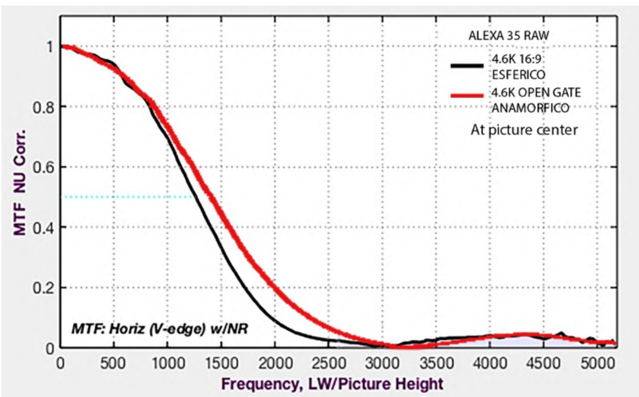


Figure 5 MTF at picture center.

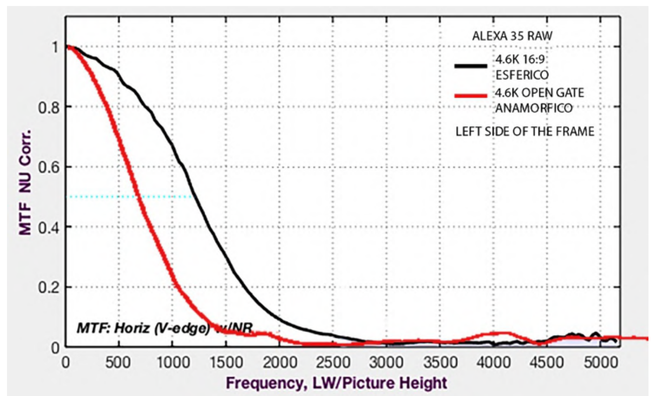


Figure 6 MTF picture side.

What is certain is that more pixels the image has or the more photosites are used to create it, the better sharpness/contrast we will have and the more organic it will be. Therefore, we decided to use the 4.6K 16:9 format which has a pixel count of 4608 x 2592 with Signature spherical lenses. We have tested other formats such as 3K 1:1 with anamorphic and 2.7K 8:9 to verify what we have already exposed, more numbers of pixels better sharpness in the image. In any case, the Alexa 35 offers many resolutions and formats to allow us to choose the most appropriate one in combination with the chosen lenses and other parameters that we will see throughout this study, always within the 35 format.

Evaluation of the resolution with the Imatest test chart.

Ultimately, as with all cameras on the market, the combination of different formats and codecs results in different sharpness values.

Let's see now some examples of images beyond the cards where we can check the sharpness, the texture and the resolution limit that we can obtain with the camera.

Figure 7 Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE EI3200ES. OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 25mm T 5.6 2/3

In this image (*figure 7*) we check the sharpness of the lines of the trees, of the cocoa fruit as well as leaves, both on the trees themselves and those that are fallen on the ground even at an EI value as high as 3200. It is an appropriate image to evaluate the detail and texture, that contrast that we can see in the highest and middle area of the MTF curve.

Figure 8 Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE EI3200ES. OBT 172.6 6500K Texture K445 Default LogC4 a Rec 709. Lens Signature 125mm T 8 1/3

In *figure 8* we can also see the structure that corresponds to the cocoa pods, this is the intermediate zone of our MTF curve. The image is rich in texture, with a lot of nuances, although soft, with an organic delicacy that we found to be very cinematographic.

The resolution, the format or the lenses are not the only factors that influence the sharpness of the image. Let's now consider how noise affects detail in the camera. The noise can be more or less visible depending, for example, on the EI value (exposure index) chosen or the degree of underexposure that an image or part of them has. In *figure 9* below I show a Putora resolution chart where I have enlarged the center of it and I have made a profile of the lines. The difference in sharpness is clear to the naked eye, however in the graph you can see how the width of the lines is greater at EI 200 than at EI 4800.

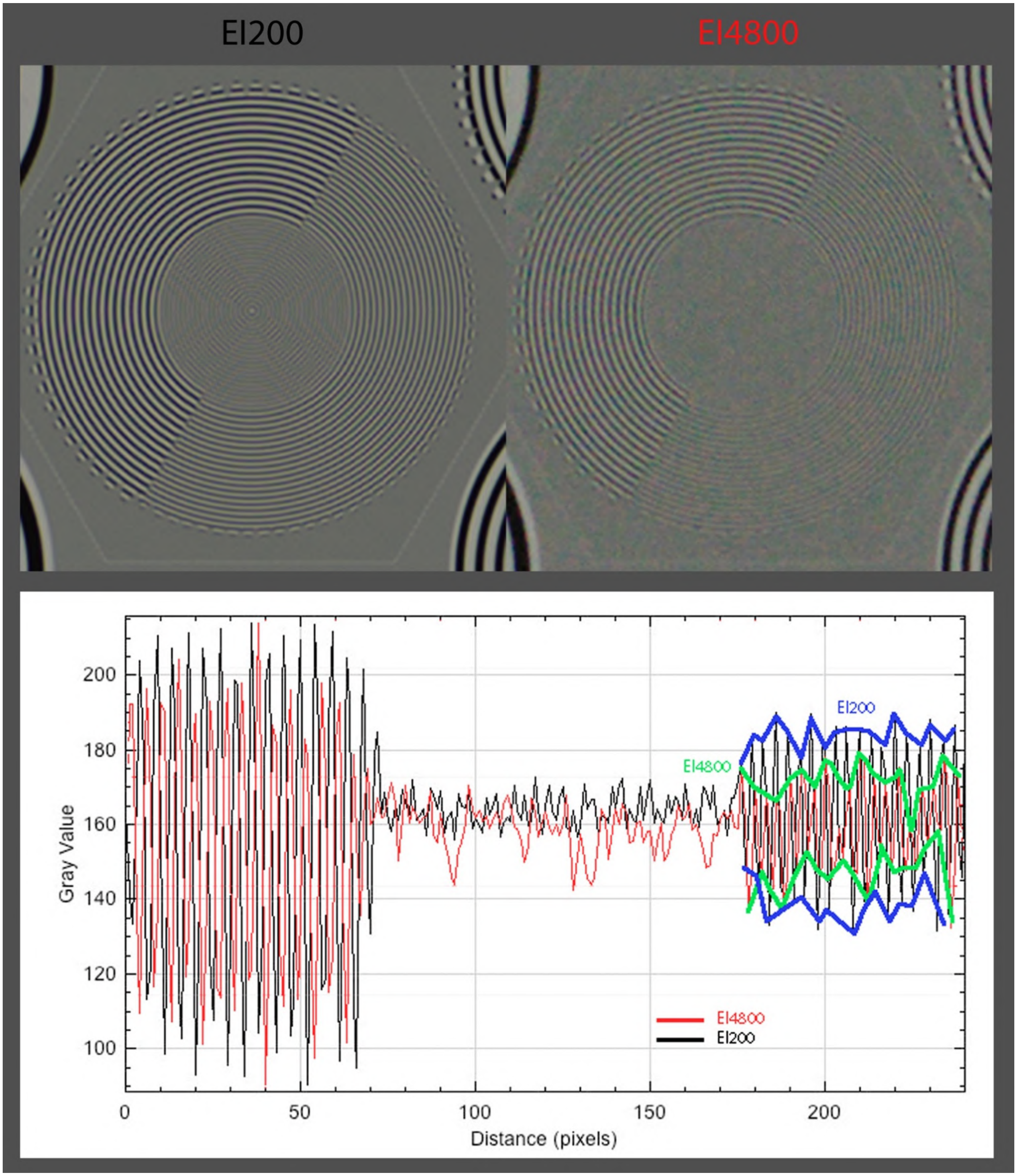


Figure 9

We can also see what happens to the resolution when the image is underexposed (closing the iris of the lens) taking as reference an EI 800 value. In this case, our still life (*figure 10*), of which I have cropped a part and enlarged. We compare a normal (base) exposure with -4 stops underexposed, and "**lifted**" this material to make it look as close as possible to the base exposure. With -4 stops corrected, we can see the loss of sharpness in the substances inside the containers, in the texture of the apple or in the painter's palette located on the right side of the frame.

Figure 10

We can also notice how some colors change their tone due to the noise that invades them, we will see this in more detail in the color section. In the colored chalks that are in the box at the back of the frame, we see how the black and dark blue lose their outline a lot, as well as their texture. However, sufficient detail can still be perceived in almost all parts of the still life. In my opinion, it is important to determine how much information I will be able to see in the shadows as well as how the sharpness of the image will be perceived in those shadowy areas, or up to how many stops below the middle gray I can see the detail clearly enough (EI 800). From this test, which will be supplemented with additional evidence, it appears that I can reasonably

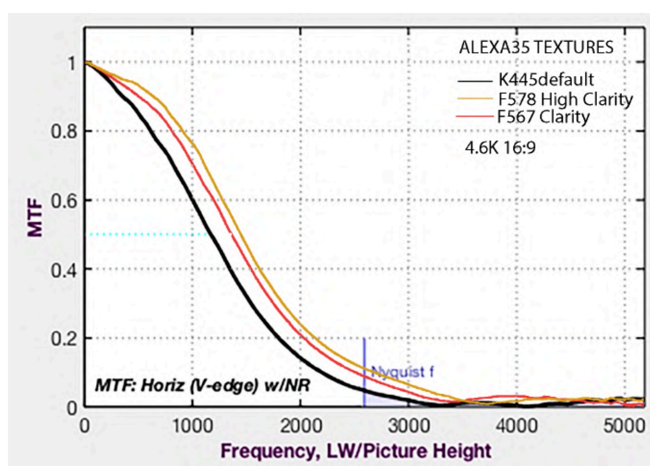


Figure 11

conclude that up to -4 stops of underexposure (closing the aperture of diafragm by four stop from the base aperture (exposure) where 18% grey is the value indicated by ARRI), I can still retain sufficient detail for a sharp image.

Alexa 35 has what we now call textures, which clearly influence the sharpness of the image, because they basically handle the detail and noise parameters, something similar to those parameters such as *detail*, *crispening* and many others that we could handle in video cameras. ARRI now offers them optimized for the Alexa35 and gives us the option to "customize" the image to a certain way. In *figure 11* we compare the MTF curves of the default K445 Default texture with the F578 High Clarity and F567 Clarity, as we can see with the last two textures we have more resolution, somewhat lower in the F567 Clarity than in the F578 High Clarity. We can also see how it affects the resolution with four different textures in the Putora test chart, especially in the high frequencies. Regarding the K445 texture, we can see that the F567 Clarity and F578 High Clarity present more sharpness (observe the width of the profile traces in the attached graphs. *Figure 12*), however, the G733 Nostalgic texture presents much more noise in the image and less resolution, to the point that the frequency of DS8 73.6 lines/mm or DS9 97 lines/mm are greatly minimized.

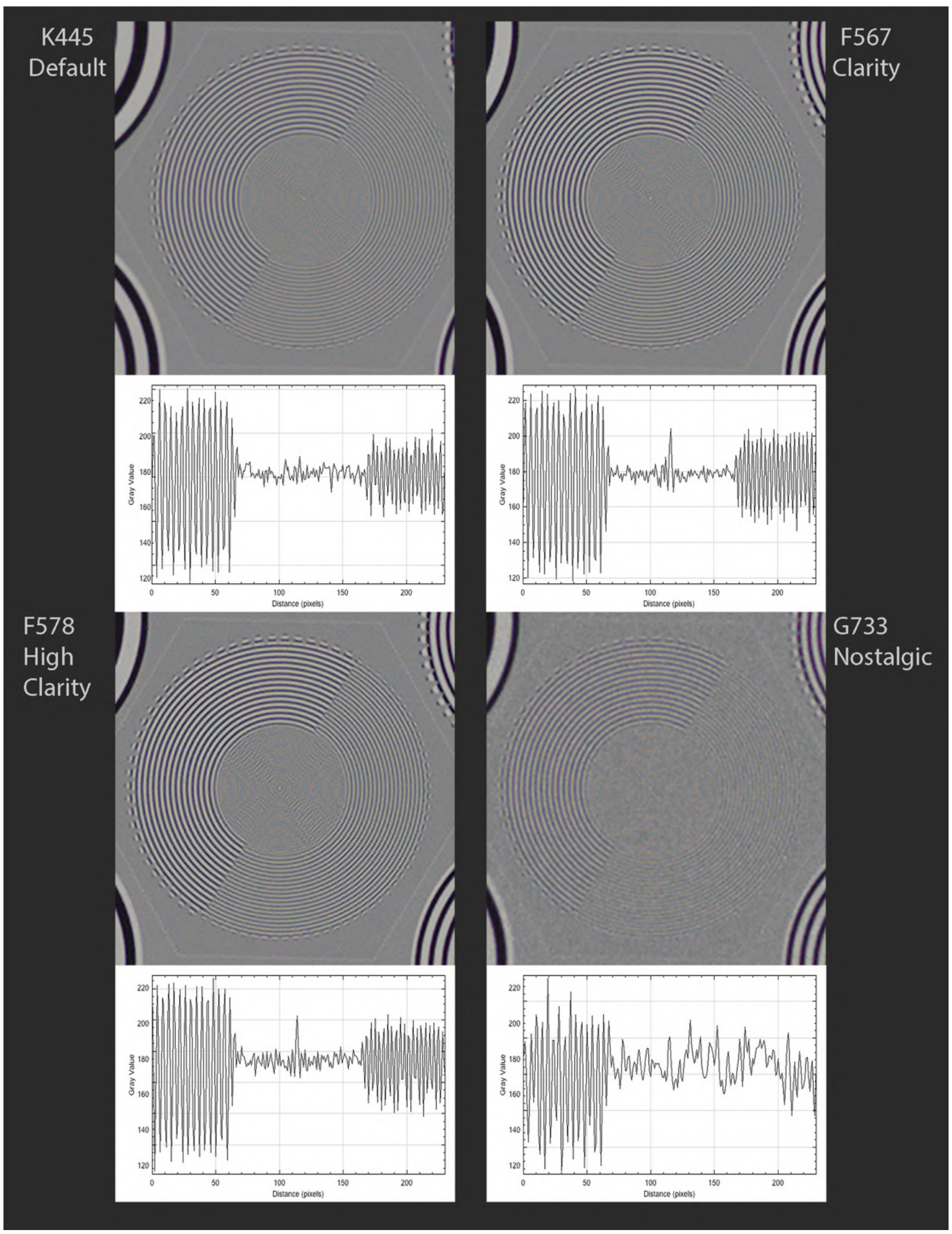


Figure 12

Let's see how this difference in sharpness is noticeable in this shot of the Tatacoa desert (*figures 13 to 15*).

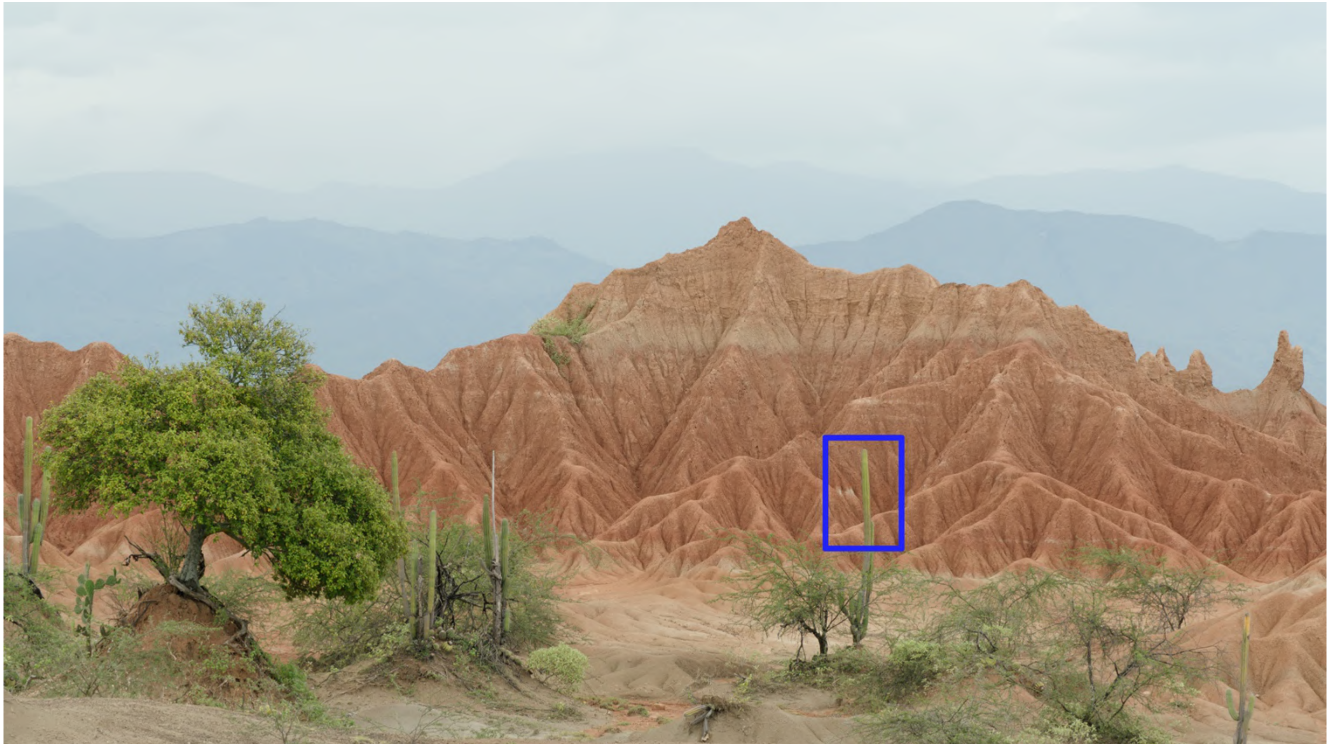


Figure 13 Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800. OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 125mm T 11

Figure 14

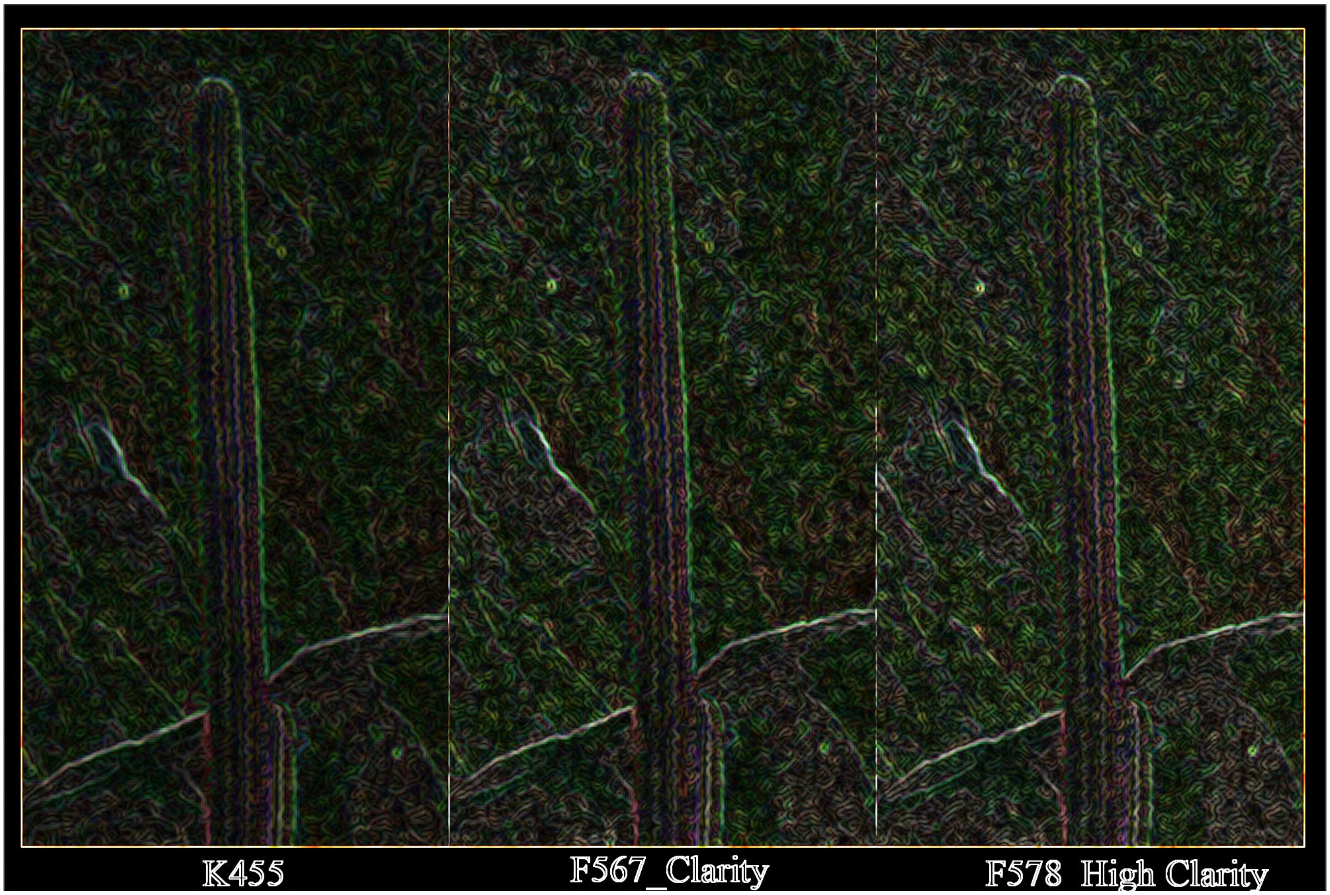


Figure 15

We have shot the same plane with three different textures and we have enlarged the part of the blue box.


Cocoa plantation. Tatacoa desert. Villavieja. Colombia. Cinematographer Alfonso Parra AEC, ADFC. 1st assistant camera William Rivera

You can see the greater sharpness of F578 compared to the default value K455 and also to F567 (see video part I overture).

As we indicated at the beginning, there are many factors that influence our perception of sharpness, here we have only seen those that have to do with the camera and the lens, in addition to the codec used to record, whether it is Raw 13 bits or the 12-bit ProRes. The transmission system used to send the image, the resolution of the receivers, the ambient light that surrounds those receivers or the distance at which we are viewing the images from our sofa are also a very important part of the perception of the image sharpness. That is why I think that from the capture itself you have to have the best possible resolution and modify it considering all the different aspects that are within our reach. Alexa 35 offers us a wide variety of formats and resolutions, so it meets the expectations for 4K UHD transmission. But beyond that convention, the resolution, measured in our MTF curve, shows a fairly smooth camera, subtle in the textures and consistent in the representation of all the frequencies that reach the camera to build the image.

SENSITIVITY, EXPOSURE INDEX AND NOISE

In this section we study the sensitivity of the camera in relation to the IE values, looking first for the nominal sensitivity to finally determine the effective IE considering the noise level and how it masks detail and texture.

We wanted to contrast the EI (Exposure Index) values with the ISO 12232:2006 standard, which establishes that a reflectance white of 100% represents a value of 70% saturation in the captured image, assuming the linear response, and gray 18%. generates a value of 12.7%. Values above 70% are reserved for specular reflections. In our case we have considered the value of 60% white since the white of the card does not reflect 100% but rather less than 90% of the light it receives. To observe these values in the histogram we have converted the logC4 image to linear using ACES, in figure 16 we show the results.

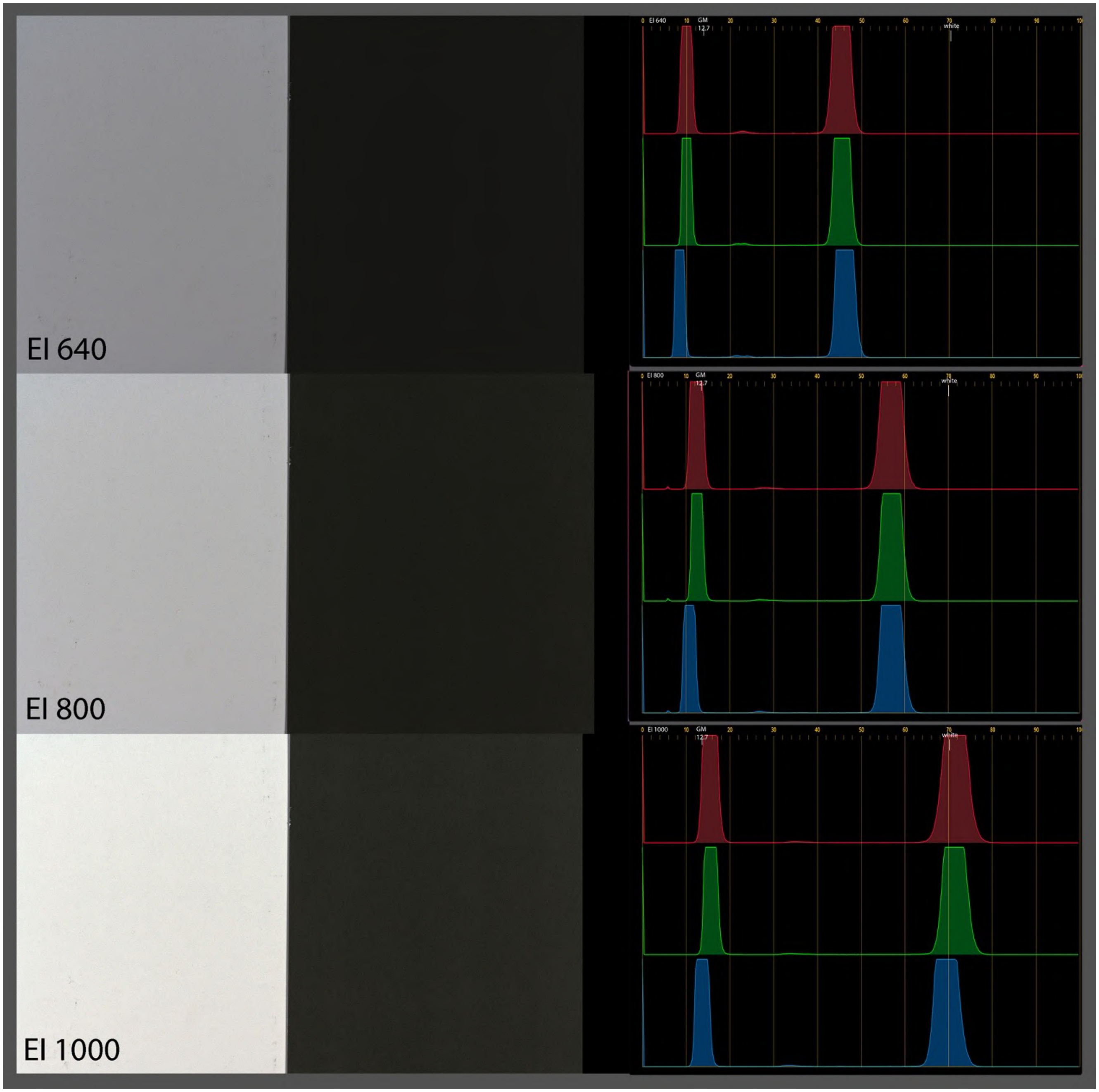


Figure 16

The EI 800 value is the closest to the established norm, gray is slightly below the 12.7% value and white is equally below 60%. With the value of EI 1000, gray exceeds the established value, just like white. The sensitivity is then situated at a value slightly above 800, but for all practical purposes we can consider the value of ISO 800 as the nominal sensitivity of the camera. It must be said that the EI (exposure index) is not exactly the sensitivity of the camera, but a value that relates sensitivity, noise and the distribution of dynamic range. Consequently, we have taken the value of EI 800 as the reference value for all the tests. For an observation of how the EI value affects detail, we have shot a textures chart with different EI values (*figure 17*).

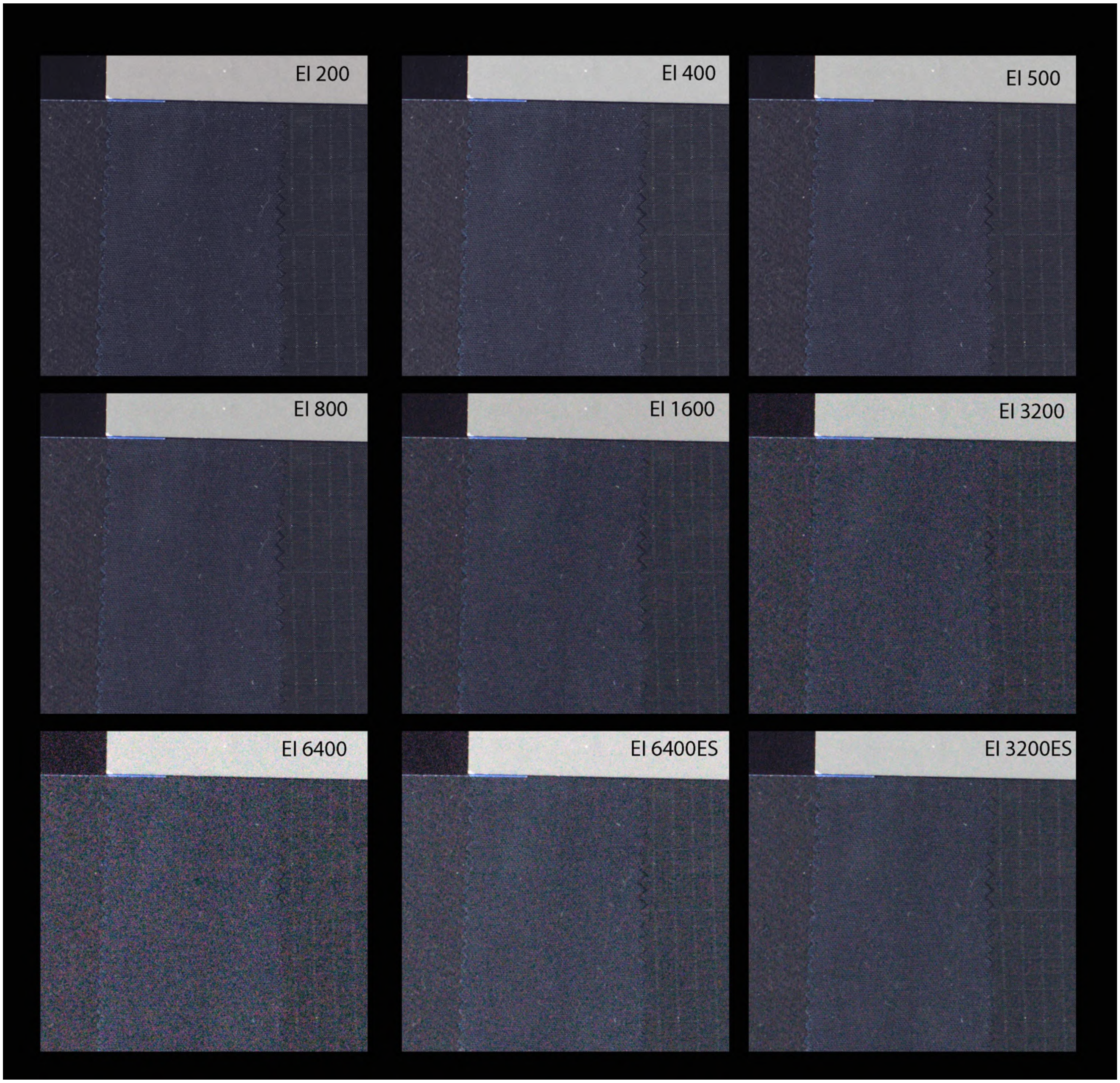


Figure 17

I have cut out the black fabric samples on the chart to compare them and as we can see there is texture in all the values except for EI 6400, but it is recovered in some way with the EI 6400ES (enhanced sensitivity). In all the EI values that we show there is texture and detail, so that we can use any EI value, recommending using the ES (enhanced sensitivity) values due to the extraordinary noise reduction they perform, without considering the distribution of the dynamic range that we will study it in the corresponding section. It should be noted that shooting with the enhanced sensitivity (ES) entails certain limitations in the shutter and the fps that we can use. Now let's see those EI values but in our still life with candles (*figure 18*).


EI 200
EI 400
EI 500
EI 800
EI 1600
EI 2000
EI 2560
EI 3200
EI 4800
EI 6400

Figure 18

The still life (*figure 19*) is only illuminated by candles with a camera color temperature of 3200K. The increase in sensitivity entails visualizing more detail in the shadows and an increase in noise. Let's take a look at this snip to see it in more detail. Although there is an increase in noise, the texture, detail and color are seen really well at the highest EI values, and it improves considerably if we use the ES values of these sensitivities (*figure 20*). See video part II.


Figure 19

Figure 20

The texture of the orange or grainy substances in the bowls and colored chalks maintain a natural appearance and the grain almost helps to give it an "analog" feel. However, the noise is there and the lack of resolution that comes with it too. *Figures 21 to 23* show the blue channel of this cut, if possible the most difficult channel, since the lighting is very warm and does not favor it and the red channel, however, presents very little noise.

Figure 21

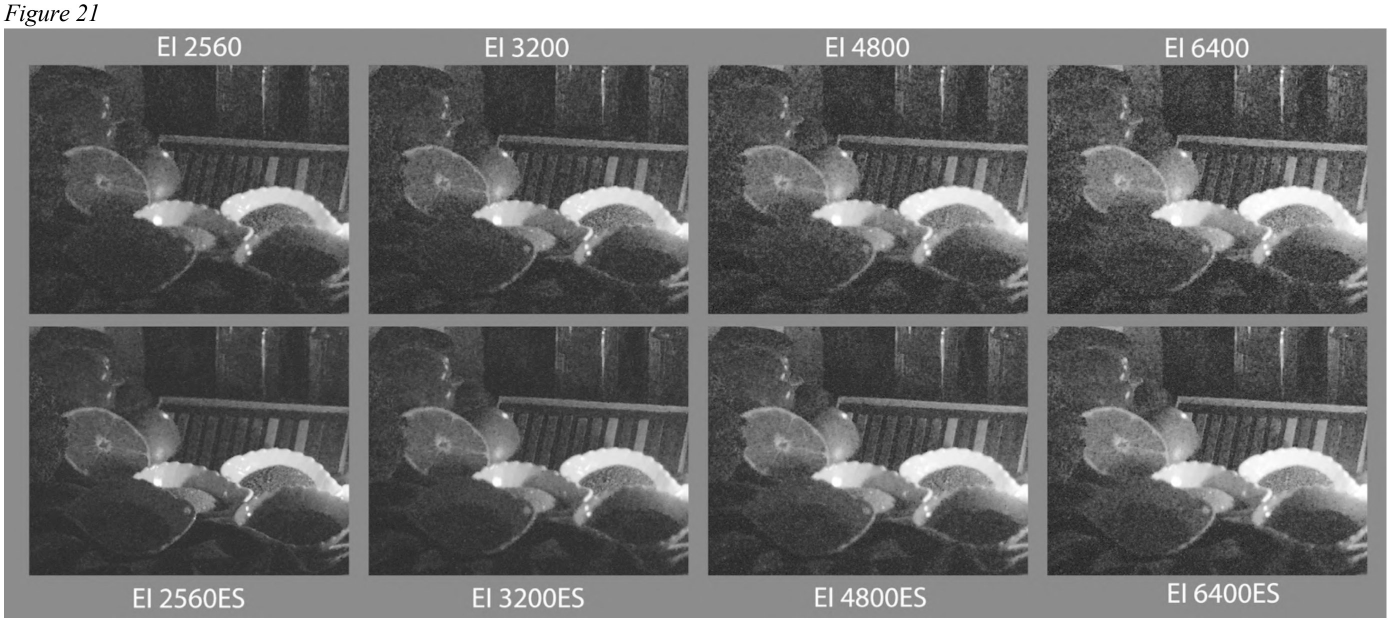


Figure 22. Blue Channel

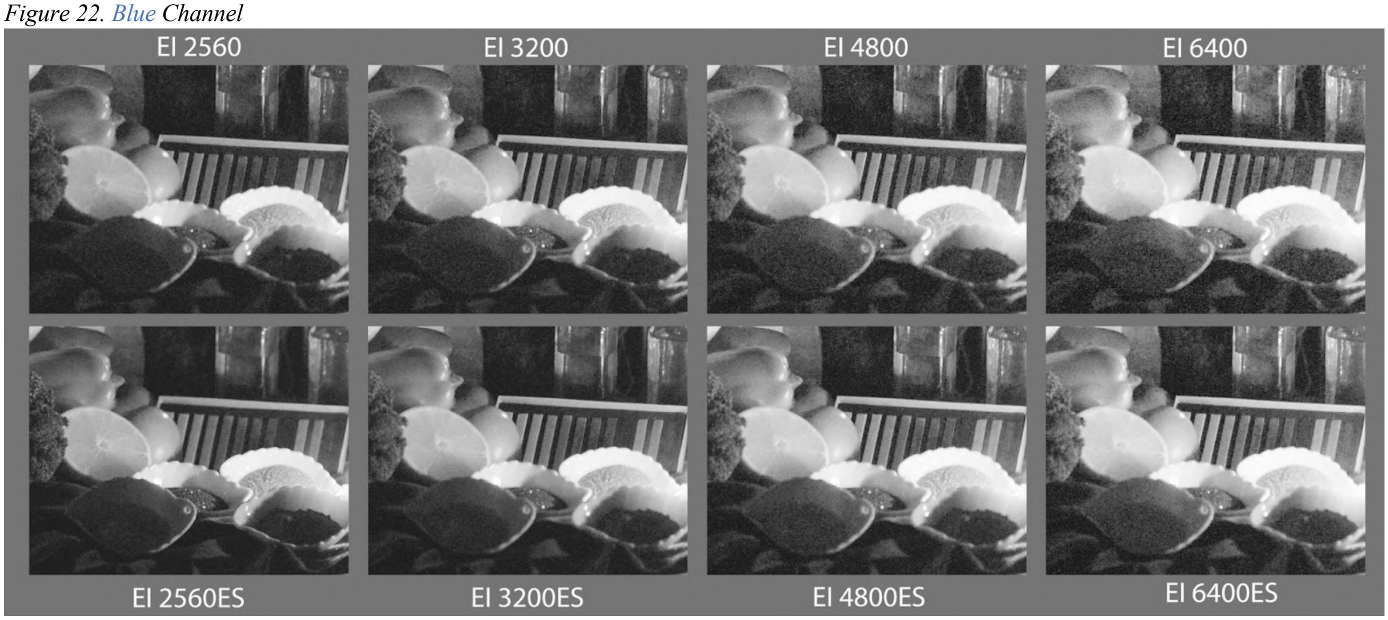


Figure 23. Red Channel

Actually, in view of these tests, one can use any EI value, since quality images are obtained in all of them, especially if we use the ES modes in the highest EI.

Figure 24

Here we see (*figure 24*) the same shot with different EI values. We can appreciate that there is not a big difference in terms of resolution, with all the EI values being usable. The texture of the faces or the totumo woods of the instruments maintain the detail and all the richness of textures, even using EI values as high as 6400. In the following image (*figure 25*) we have shot at different EI values, and as we see in the crop of it (*figure 26*) the difference in noise, even though it is visible, is not so noticeable, even without using the ES values and it does not destroy the texture so delicate of skin tone (see video part II).

Figure 25 Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 25mm T 5.6 2/3

Figure 26

In the following strip of our talents (*figure 27*) we can see how the different EI values affect the skin tone. We also see the blue channel and its noise level, for lighting at 5600K *(figure 28*)

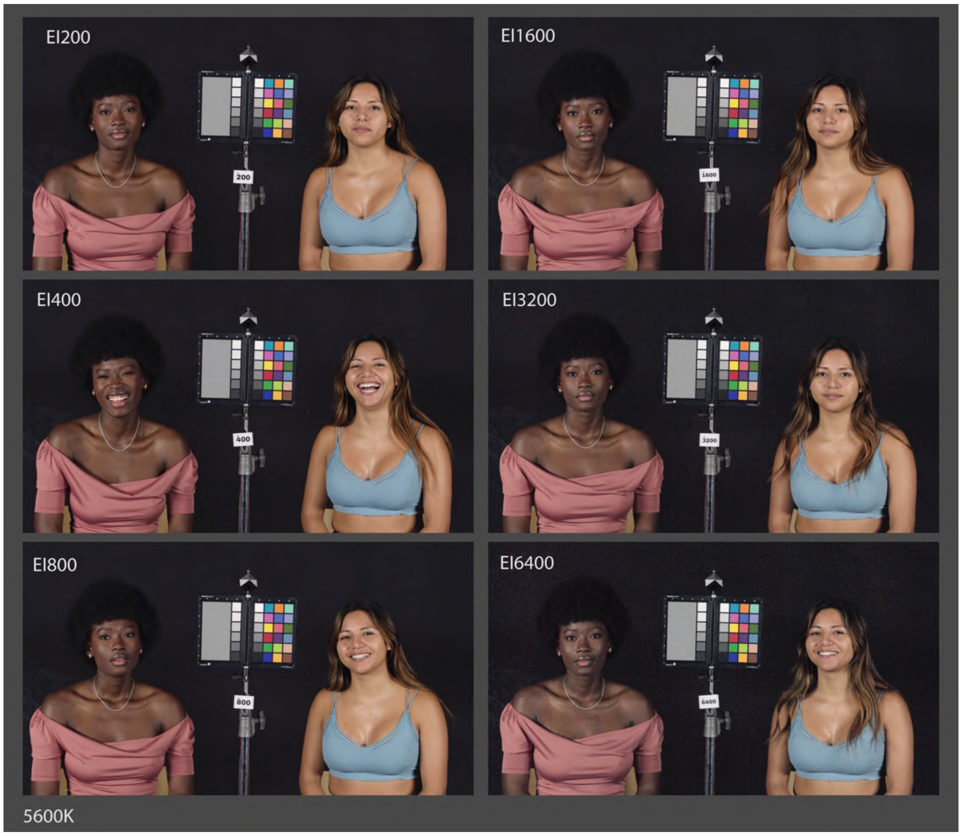


Figure 27

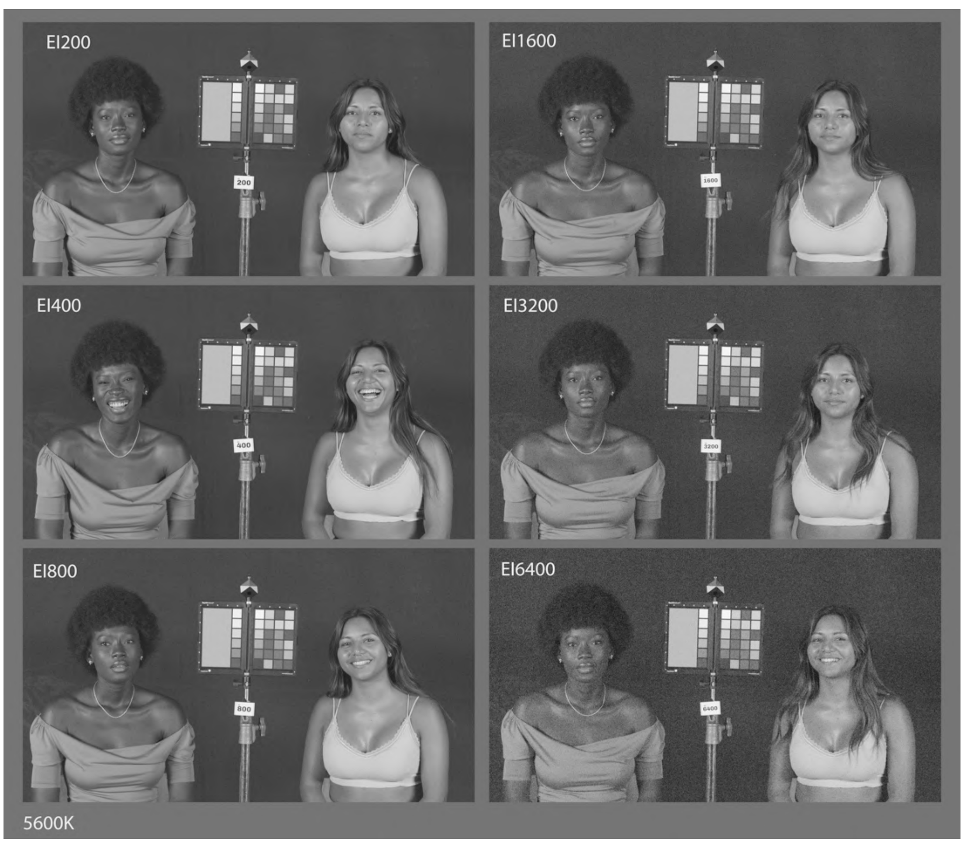


Figure 28. Blue Channel

The skin of our talents maintains texture and detail even at high EI values, a detail that improves if we use the ES mode in those high EI as we see in *figures 29 to 31*.

Figure 29

Figure 30. Blue Channel

Figure 31. Red Channel

Let's see another example, now in the old colonial house of Villavieja (*figures 32 to 35*).

Figure 32. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI2560. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 25mm T 2 1/3

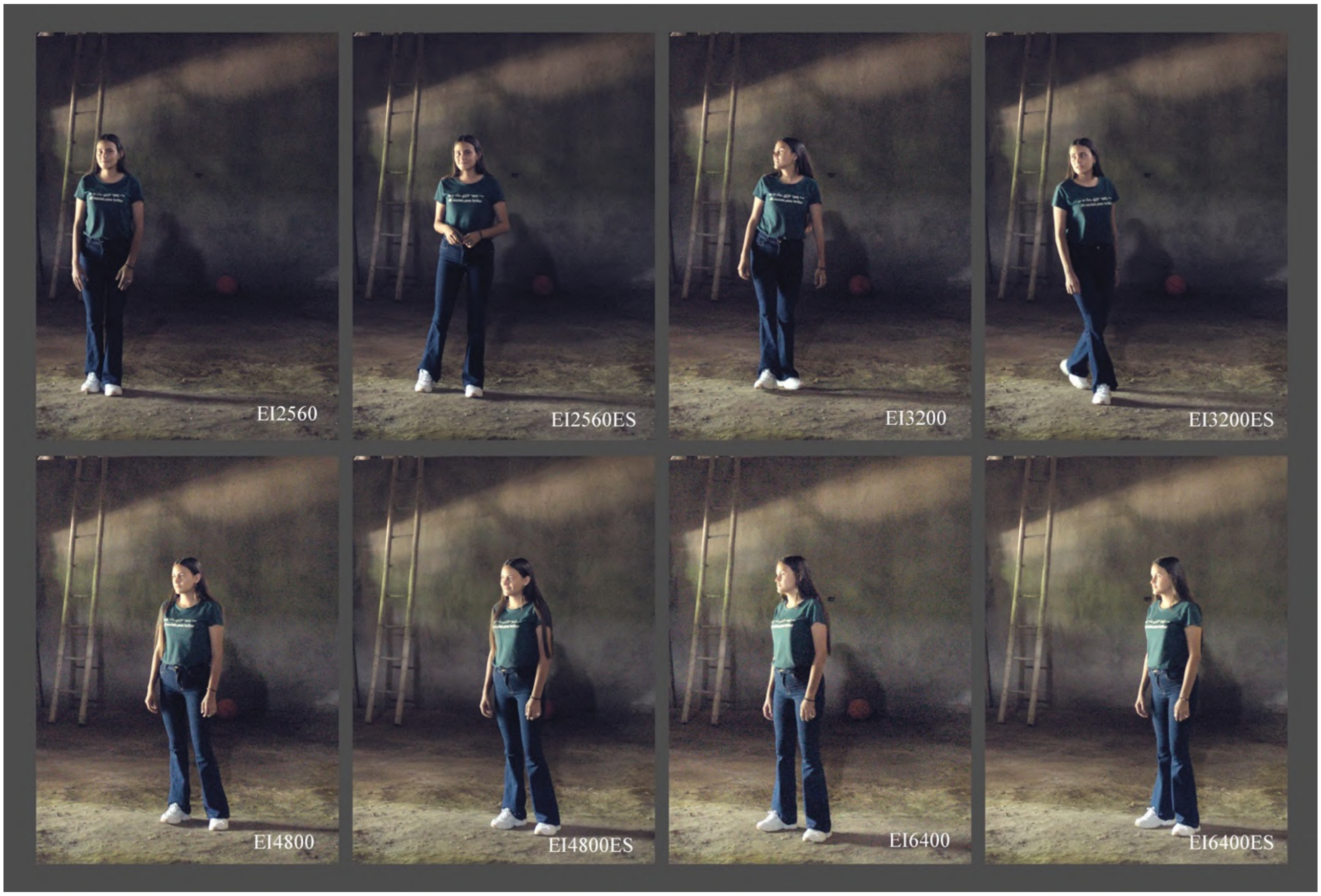


Figure 33

Figure 34. Red Channel

Figure 35. Blue Channel

This image is shot in a space with a deep shadow, there is no more light than the one that enters through the door and the window. We can check again the effective noise reduction that the ES mode does and how even with values as high as EI 6400 the image is fully usable. No texture or spatial depth is lost and the image remains completely natural.

It is important to remember that the noise level in the red and blue channels is influenced by the wavelengths present in the scene, either by natural or artificial light sources. For example, during the day, there are many wavelengths corresponding to blue, violet or cyan hues, resulting in the blue channel having more signal and therefore less noise than the red channel. On the other hand, if illuminated with candles, which is a warm light source, wavelengths towards red, yellow and orange predominate, which results in less noise in the red channel than in the blue channel.

Test to evaluate the dark noise. Christian Forero DIT

Now let's take a closer look at camera noise. For this study we have started by evaluating the base noise of the camera (dark noise), that is, the noise that is generated in the absence of light on the sensor. To do this, we have shot with the sensor cover on and the camera covered with black cloth for a few seconds at each EI value. I have opened these shots in Davinci Resolve and as expected the image appears completely black, to observe the noise I have proceeded to raise the exposure and modify the contrast in the same way in all the EI values, so we can observe, on the one hand, the " size" of the noise, on the other its "color" and finally its movement. We have studied the standard deviation in the histogram (amplitude of variation of the intensity values). Given the random variation of the brightness of the pixels as a function of the EI value, the histogram is shown as a bell whose base gets bigger and bigger as we increase the sensitivity values. Therefore, the numbers that we show here are *relative* and serve to relate the different EI values and their differences. We have observed the noise at two different color temperatures, 6500K and 3200K, in RGB and in **Y**, considering that the blue and red channels are modified in relation to green to establish an adequate colorimetry. Let's start by looking at the base noise at 6500K (*Table 1* and *2*. *Figures 36* and *37*).

EI values 6500ºK	Y
160	0,57
200	0,62
320	0,84
400	1,02
500	1,25
640	1,57
800	1,96
1280	3,1
1600	3,87
2000	4,83
2560	6,18
3200	7,7
4800	11,13
6400	13,88

Table 1

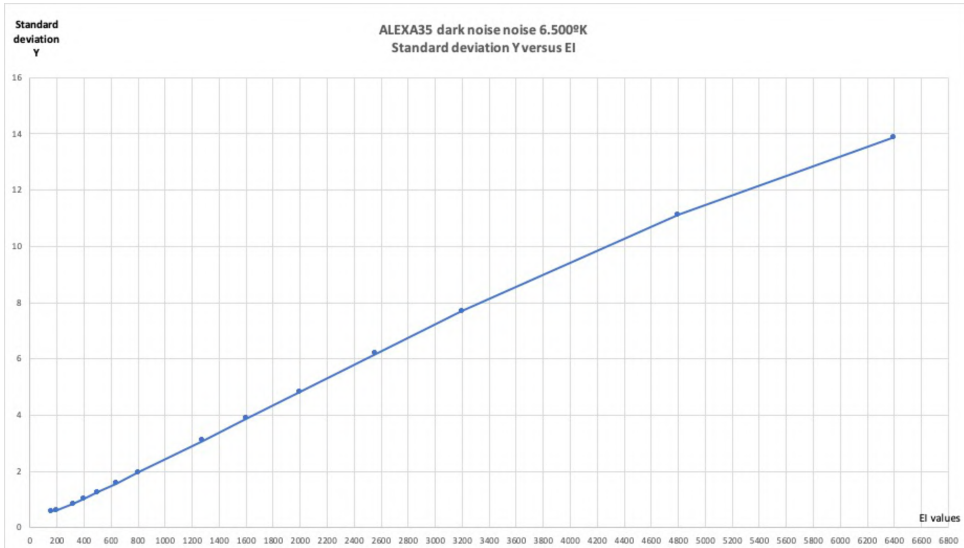


Figure 36

EI values 6500ºK	R	G	B
160	0,62	0,5	0,5
200	0,72	0,52	0,54
320	1,03	0,69	0,76
400	1,25	0,83	0,92
500	1,52	1,02	1,13
640	1,89	1,28	1,42
800	2,32	1,59	1,78
1280	3,53	2,49	2,82
1600	4,32	3,09	3,52
2000	5,25	3,89	4,42
2560	6,58	4,99	5,69
3200	7,99	6,24	7,15
4800	10,98	9,32	10,44
6400	13,54	12,36	12,65

Table 2

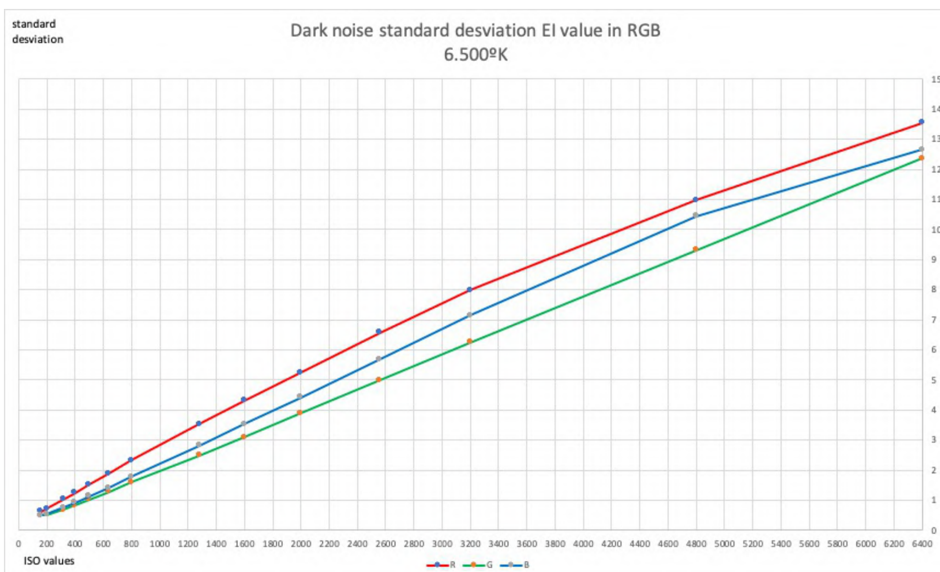


Figure 37

The deviation value in **Y** at EI 800 is 1.96, at EI 1600 it is 3.87, that is, practically double the base noise. The variation of the EI values in stop steps practically in all cases doubles the noise or decreases it by that amount. If we now look at the RGB channels, we will see that red is the one with the greatest deviation compared to the other two channels, while green is the one with the least increase. Again, if we take the EI 800 value as a reference, we will see that by decreasing the EI to 400 the difference is 54% less noise in red, 52% in green and 52% in blue, that is, practically half the base noise of EI 800. The same happens if we use EI values above the reference value of 800 in general, although for example, the change from EI 3200 to EI 6400 supposes a 60% increase in base noise in the red channel and 56% in the blue channel.

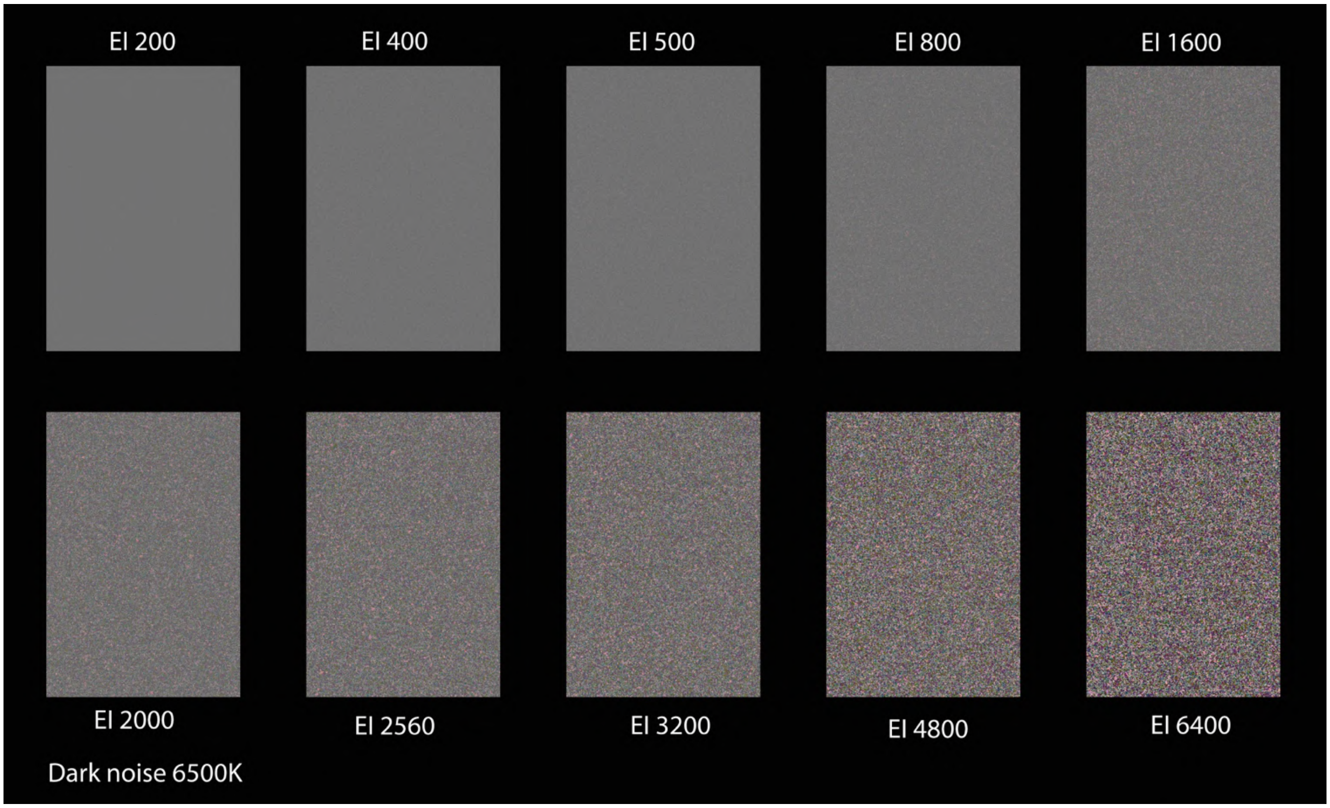
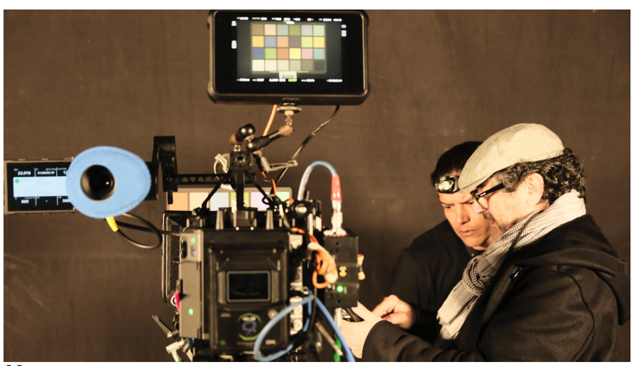


Figure 38

Figure 38 shows the increase in base noise in relation to the EI, as well as the size of the noise and its coloration (remember that we have raised the mid-gray value in post-production to be able to see the noise).



Noise test in set

Rolling shutter test

The camera allows you to choose a sensitivity mode called ES (Enhanced Sensitivity) which basically consists of applying a noise reduction system, as we have already mentioned, which allows cleaner blacks and dark grays.

In tables 3 and 4 (*figures 39 and 40*) we show the standard deviation of the EI values with ES with respect to the normal values. We can appreciate how effectively in this base noise there is a decrease in it. In **Y** the reduction of the base noise in EI 2560 ES with respect to the normal value is almost 80%, in the EI 3200 ES value it is 81% in 4800 ES it is 85% and at EI 6400 the decrease is 88%. As we can see, the decrease in base noise in the ES values is considerable, something that can be seen in the images that we have shot later.

VALUES EI 6500ºK	Y	VALUES EI 6500ºK	Y
160	0,57	160	0,57
200	0,62	200	0,62
320	0,84	320	0,84
400	1,02	400	1,02
500	1,25	500	1,25
640	1,57	640	1,57
800	1,96	800	1,96
1280	3,1	1280	3,1
1600	3,87	1600	3,87
2000	4,83	2000	4,83
2560	6,18	2560 ES	4,92
3200	7,7	3200ES	6,24
4800	11,13	4800ES	9,49
6400	13,88	6400ES	12,25

Table 3

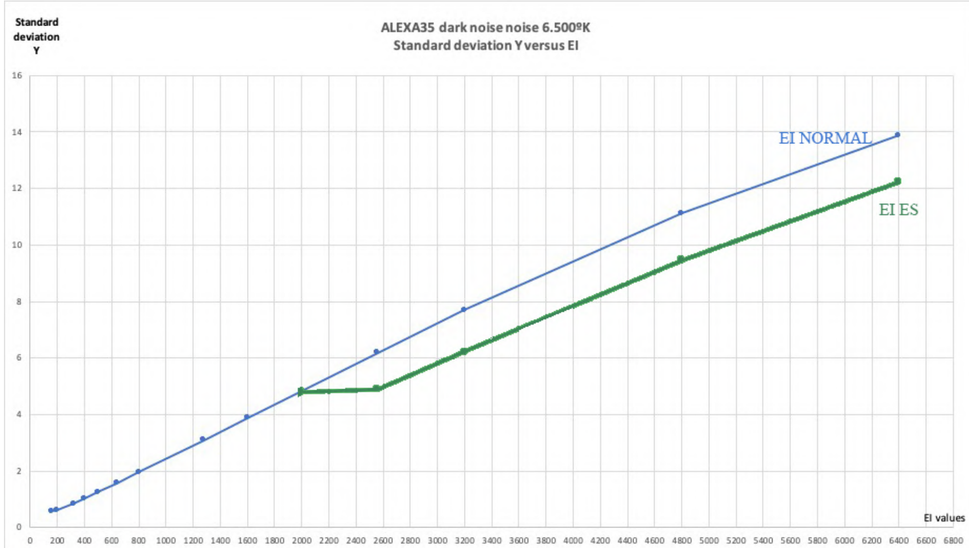


Figure 39

EI values 6500ºK	R	R (ES)	G	G(ES)	B	B(ES)
2560	6,58	4,18	4,99	4,43	5,69	4,3
3200	7,99	5,16	6,24	5,57	7,15	5,46
4800	10,98	7,43	9,32	8,59	10,44	8,13
6400	13,54	9,35	12,36	11,49	12,65	9,91

Table 4

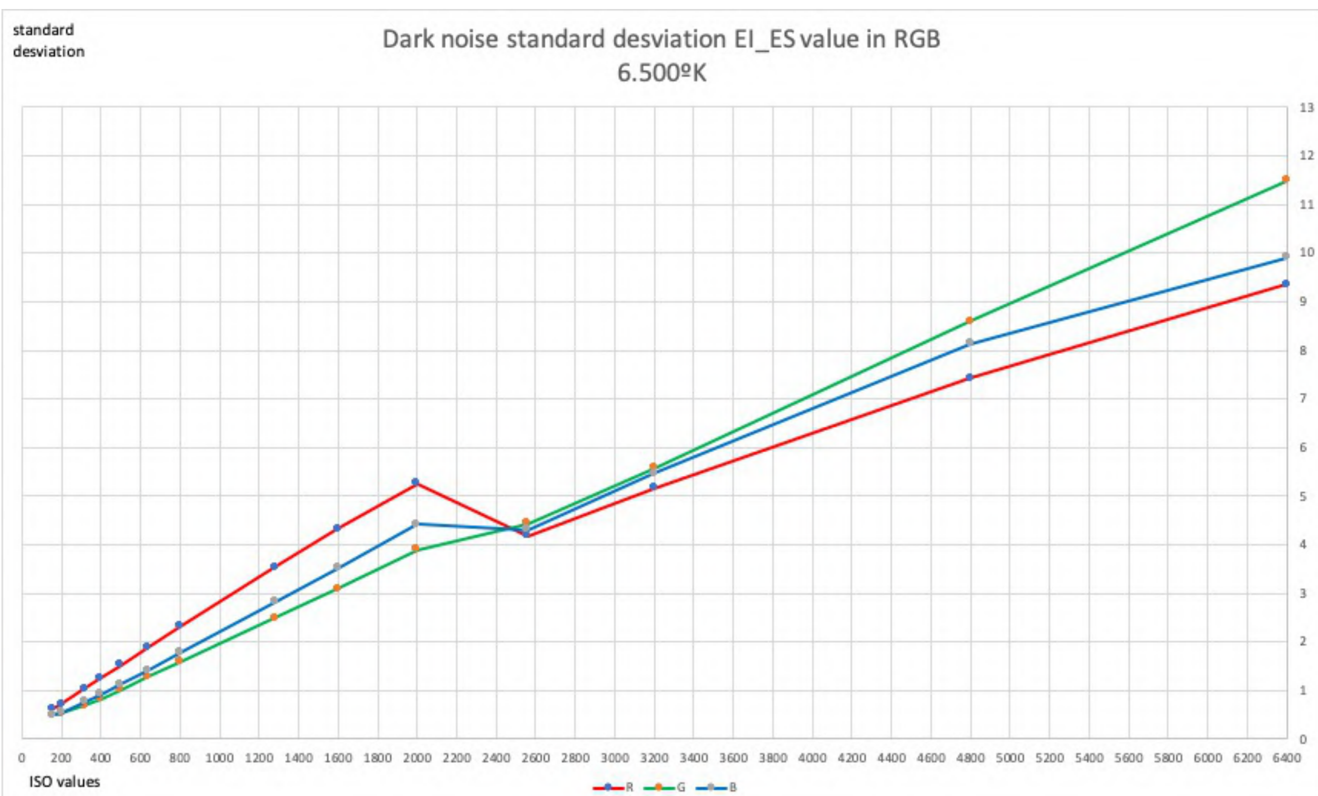


Figure 40

The smallest decrease occurs in the green channel and the strongest in the red channel, also noting a change in the noise color. We can appreciate it in *figure 41* (video part II).

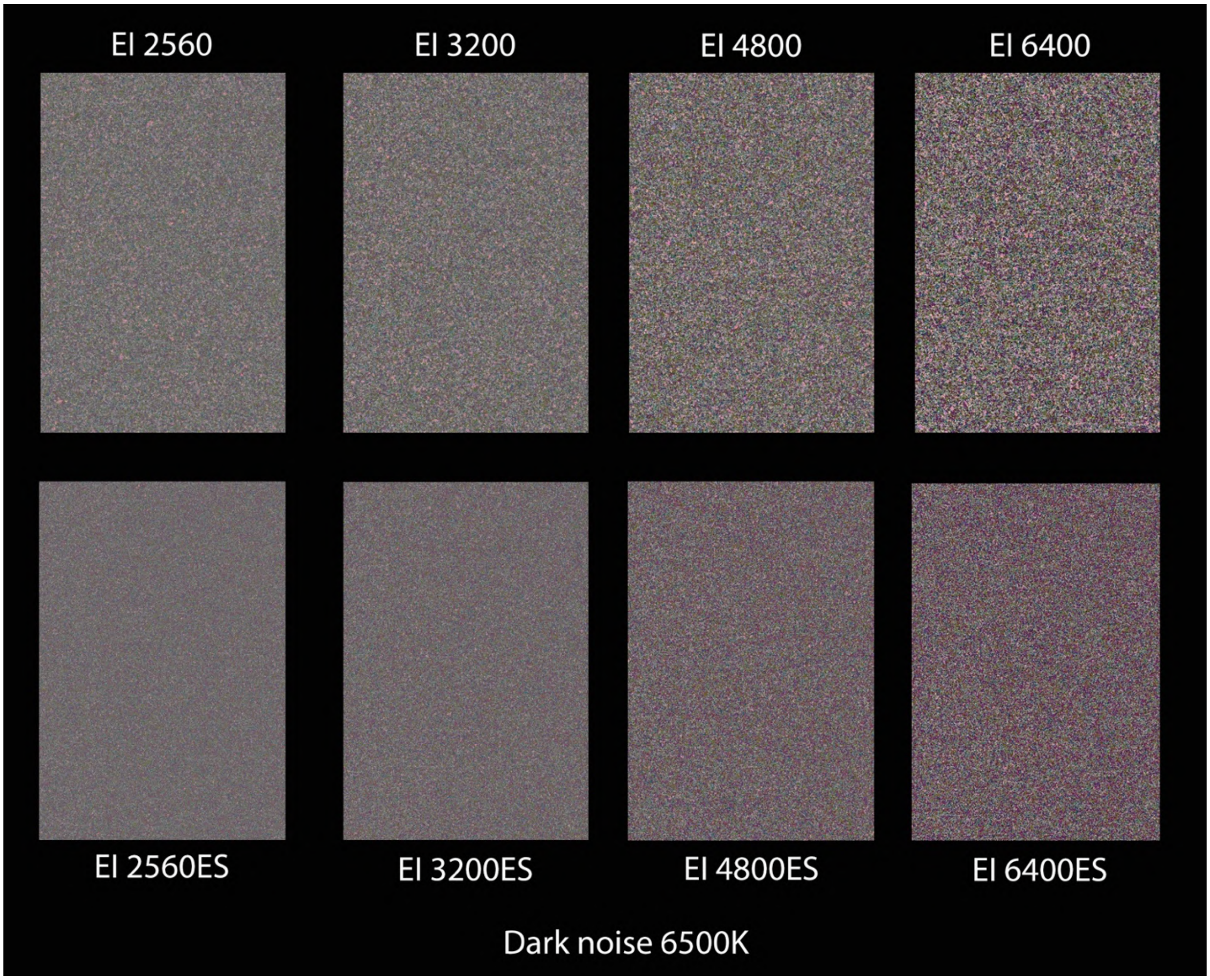


Figure 41

Let us now observe the base noise both in **Y** and in RGB with a color temperature of 3200K (*table 5 and 6. Figures 42 and 43*).

VALUES EI 3200ºK	Y
160	0,48
200	0,52
320	0,7
400	0,83
500	1,01
640	1,24
800	1,52
1280	2,36
1600	2,92
2000	3,64
2560	4,63
3200	5,72
4800	8,38
6400	10,82

Table 5

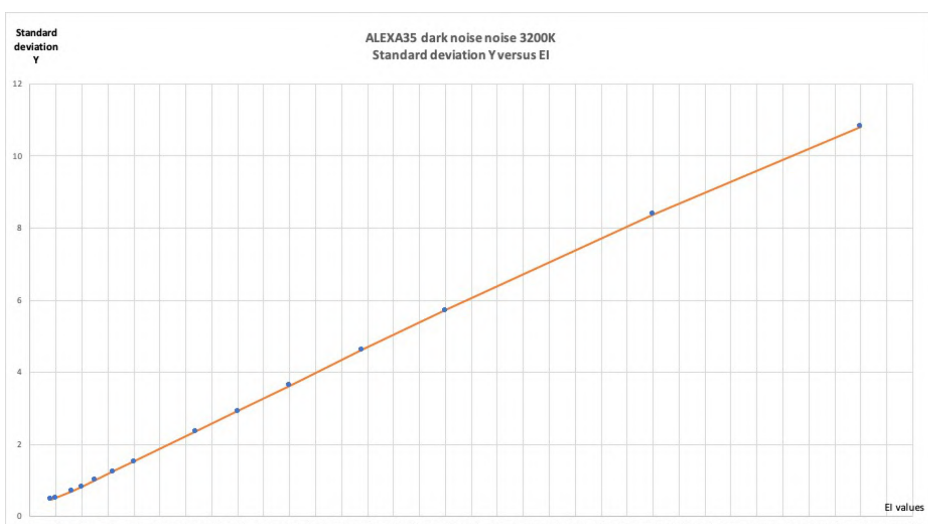


Figure 42

In general, the increases or decreases of the base noise depending on the EI at stop are double or half of it, the same happens with the 6500K color temperature. Just to mention some exceptions, going from 200 to 400 EI means a 62% increase in noise, or going from EI 160 to 320 implies an increase of 68%.

EI values 3200K	R	G	B
160	0,57	0,49	0,54
200	0,64	0,51	0,6
320	0,9	0,66	0,84
400	1,07	0,78	1,02
500	1,3	0,96	1,26
640	1,61	1,2	1,58
800	1,97	1,48	1,96
1280	3,04	2,32	3,08
1600	3,74	2,9	3,84
2000	4,65	3,63	4,82
2560	5,88	4,65	6,14
3200	7,25	5,79	7,55
4800	10,29	8,7	10,49
6400	12,78	11,46	12,39

Table 6

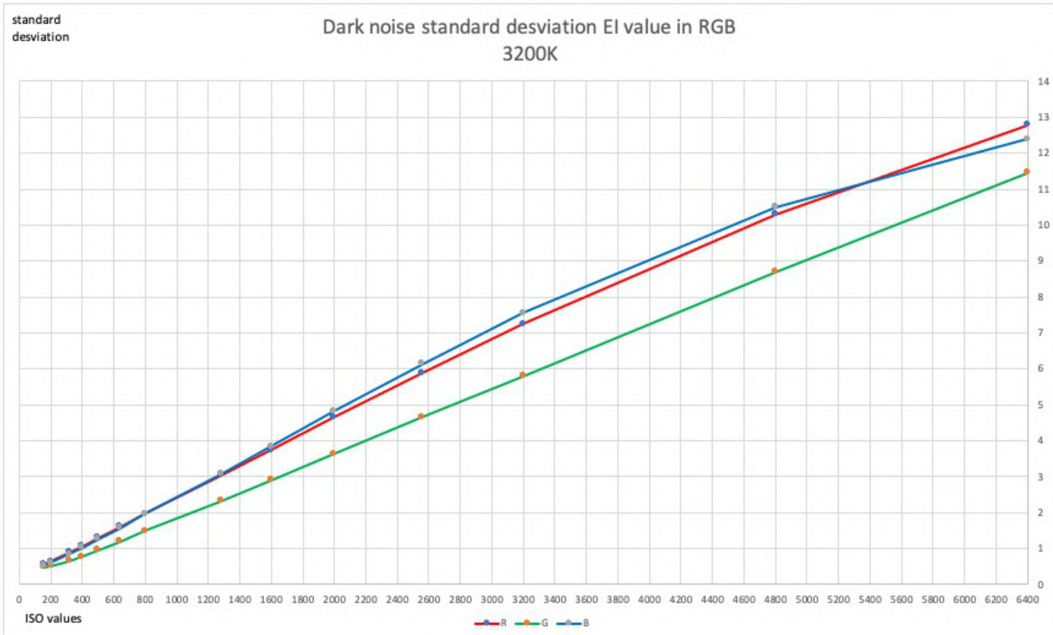


Figure 43

We observe that while green remains more or less constant, red and blue vary in such a way that both channels show a very similar deviation, being slightly higher in the blue channel. In general, again, increasing or decreasing the EI in stop values means multiplying or dividing the amount of noise by two. We found some exceptions when we go from EI 160 to EI 320, for example, where the red channel increases noise by 63%, the green by 74% and the blue by 64%. Also, we see that the red and blue channels show similar values between 800 and 2000 EI. In *figure 44* we compare the base noise at the two color temperatures. On the one hand, the color of the noise changes, which seems more neutral at 3200K (*figure 45*), without that dominant magenta that it has at 6500K and also that there is less standard deviation at 3200K than at 6500K.

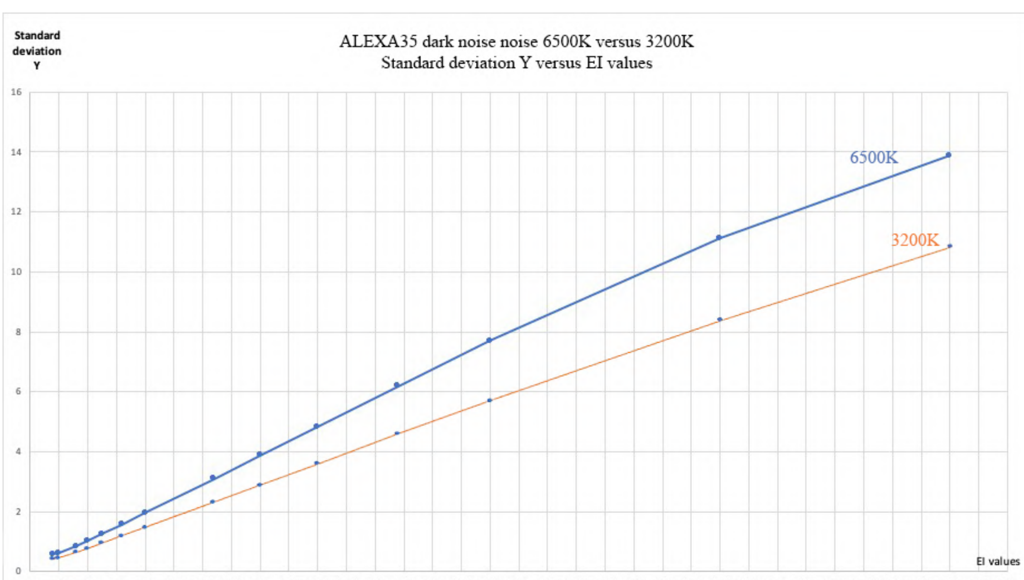


Figure 44

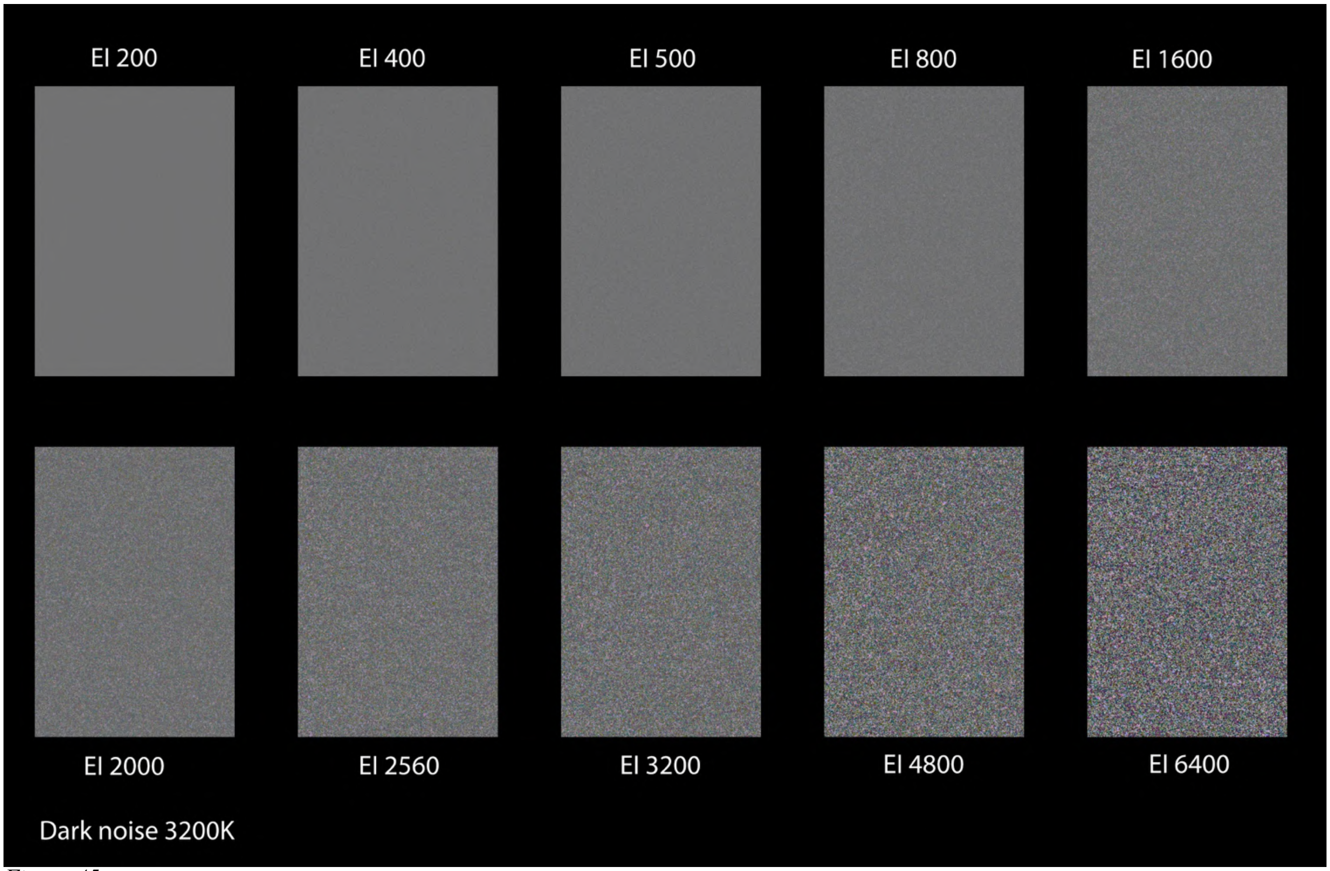


Figure 45

The ES values of the high sensitivities at 3200K in **Y** and RGB are shown in *Tables 7 and 8* and *Figures 46 and 47*.

VALUES EI 3200ºK	Y
160	0,48
200	0,52
320	0,7
400	0,83
500	1,01
640	1,24
800	1,52
1280	2,36
1600	2,92
2000	3,64
2560ES	3,28
3200ES	4,1
4800ES	6,17
6400ES	8,18

Table 7

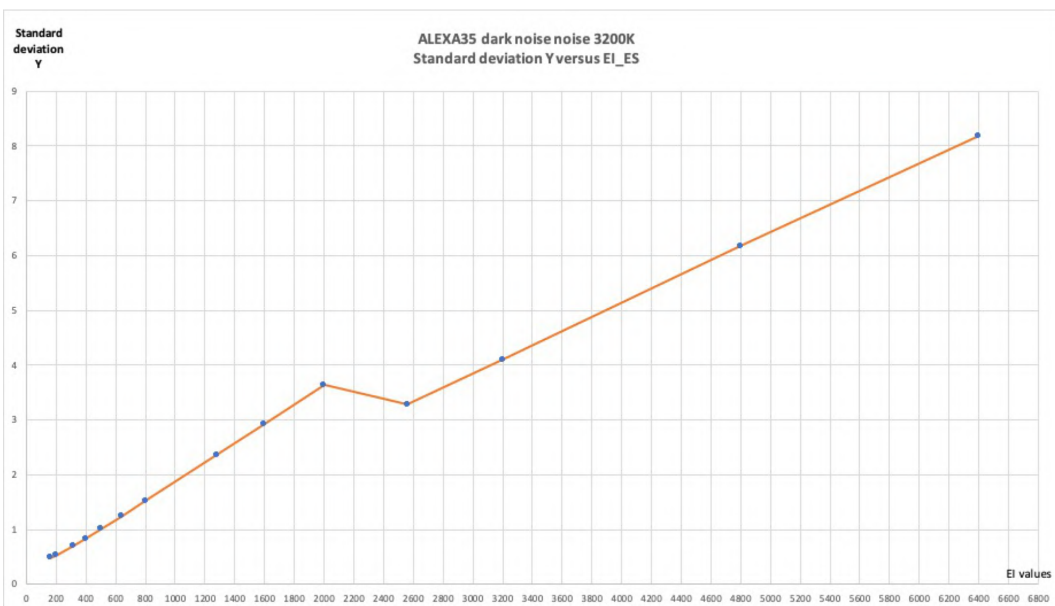


Figure 46

VALUES EI 3200K	R	G	B
160	0,57	0,49	0,54
200	0,64	0,51	0,6
320	0,9	0,66	0,84
400	1,07	0,78	1,02
500	1,3	0,96	1,26
640	1,61	1,2	1,58
800	1,97	1,48	1,96
1280	3,04	2,32	3,08
1600	3,74	2,9	3,84
2000	4,65	3,63	4,82
2560ES	4,44	3,85	4,24
3200ES	5,46	4,84	5,36
4800ES	7,96	7,36	7,45
6400ES	10,02	9,9	8,71

Table 8

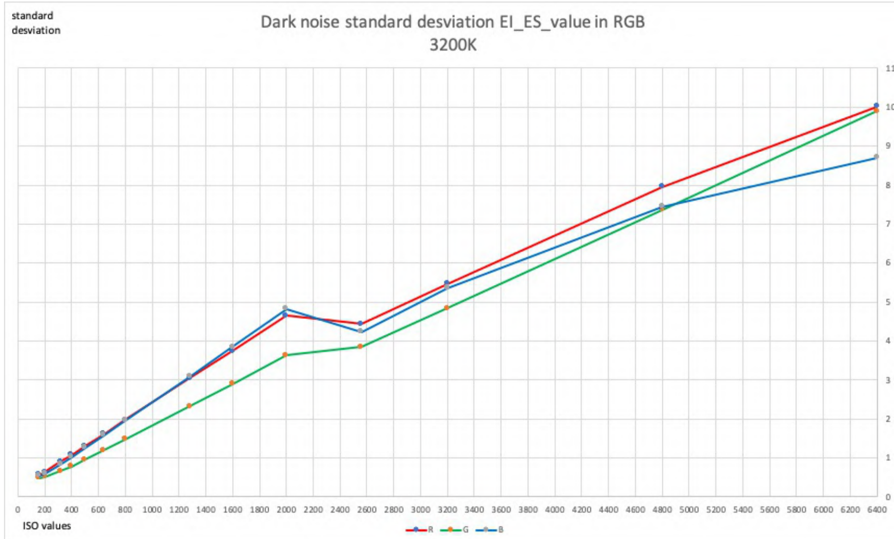


Figure 47

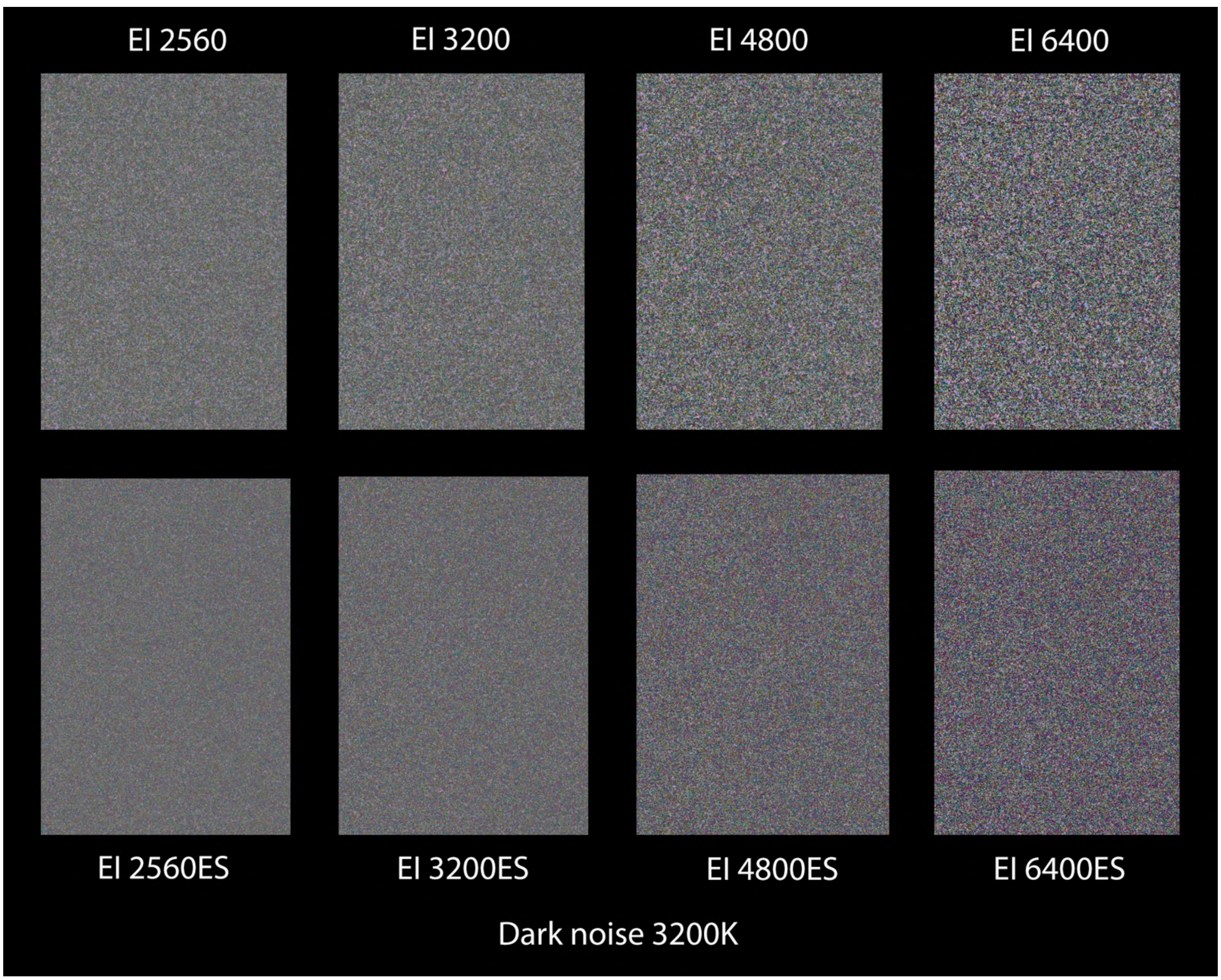
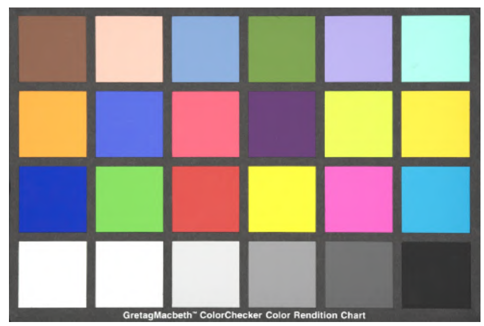


Figure 48

By introducing the ES values in the high sensitivities, we see that we not only reduce the noise but also that it changes color, pulling towards magenta as with the 6500K color temperature although with less intensity. The noise reduction with the ES values is between 70 and 75%. If we compare the two *figures 40 and 47* of standard deviation in the ES values at 6500K and 3200K we will see that the balance between the three channels is quite different, while at the first color temperature the curves of the red channel and of the blue channel are by below the green channel, at 3200k the opposite happens, that both the red and blue curves are above the green except for the EI 6400 value that the blue is below.

The evaluation of the standard deviation, in addition to the visual inspection of the base noise (dark Noise) indicates the good behavior of the noise of the camera. The increase in this is shown to be consistent and coherent in relation not only to the amount of noise but also in the relation of the three RGB channels and to the increase or decrease of the EI values. The movement of the noise (the random variations in brightness) is very discreet between the lowest EI values and up to 3200, above these the noise acquires a certain notoriety although we liked its movement and texture a lot, especially the color that takes on the noise that, saving the distances, is very reminiscent of the grain of the scanned 35mm film. We have not appreciated noise patterns or artifacts of another type. It is important to highlight that in order to maintain the adequate base noise level, a good ventilation system for the chamber is needed, since heat is an important source for the increase in noise. On the other hand, the relation of the three channels in relation to the indicated color temperature entails the modification of the red and blue channels in relation to the green, which is the channel that does not suffer so much change, these modifications are the ones that we have been observing at the compare both color temperatures.

The noise that we observe in our images is the combination, among others, of the base noise, the reading noise and the photonic noise, which is due to the fluctuations that the photons present when they reach the sensor, so the following test that we have carried out has consisted of evaluating the noise on a Macbeth color chart with the IMATEST program, evaluating the SNR (signal noise ratio) according to the formula $SNR_{BW} = 20\, log_{10}\,(\frac{S_{WHITE-S_{BLACK}}}{N_{MID}})$ (For detailed information see https://www.imatest.com/support/docs/23-1/colorcheck/).



For this test we have chosen a color temperature of 5600K and 3200K. Let's start by looking at the RGB**Y** curves at 5600K with the various EI values. *Table 9* shows these values and *figure 49* their graphical representation.

EI values 5600K	R (db)	G(db)	B(db)	Y(db)
160	39,5	43,1	44,1	43,5
200	38,4	42,2	43,1	42,5
320	40,2	41	41,9	42,4
400	39,1	40,7	41,5	42
500	38,2	40,4	41	41,6
800	35,5	39,6	39,7	40,3
1000	35,1	37,7	37,9	39,1
1280	33,7	36,9	36,6	38,2
1600	32,2	35,7	35,8	36,8
2000	31,4	34,8	34,6	36
2560	29,9	33,8	33,4	34,9
3200	26,9	32	32	32,6
4800	25,2	30,4	30,1	30,9
6400	23,3	28,5	27,8	29

Table 9

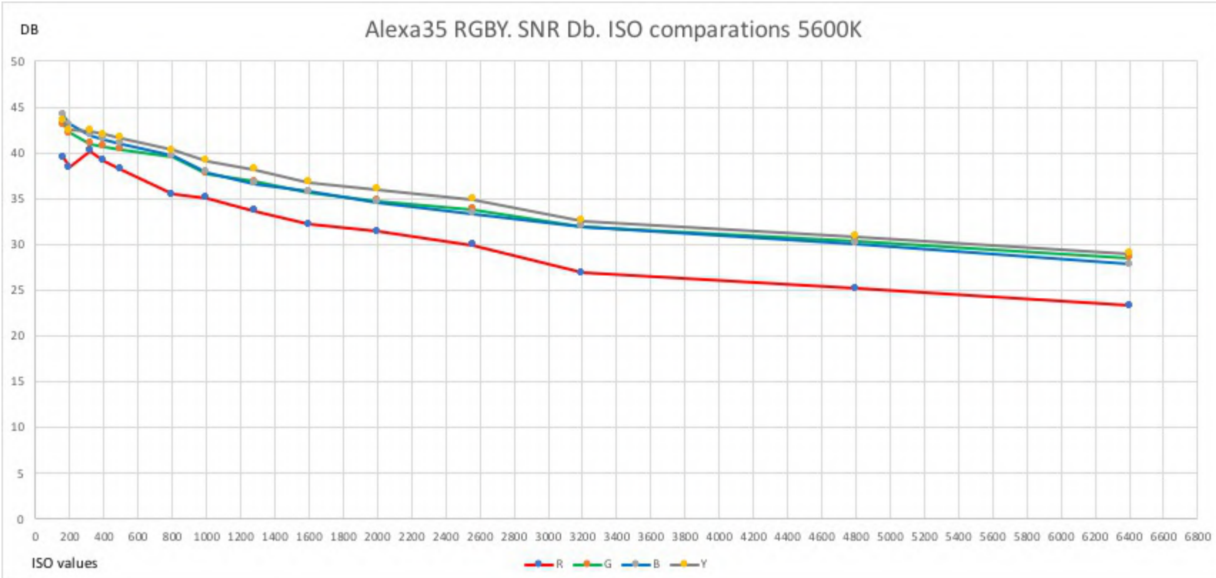


Figure 49

As expected, an increase in EI implies a decrease in SNR, for example, and taking our reference EI 800 as always in **Y** I have an SNR value of 40.3 db, while at EI 3200 the value is 32.6 db, that is, 7.7 db less, on the other hand, an EI 400 has an SNR value at Y of 42 db, so that compared to the EI 800 it shows a 1.7db higher SNR. From the graph we can also conclude that the red channel is the one that shows the worst SNR, compared to green and blue. *Figure 50* shows the comparison of noise in sample 4 (medium grey) of the Macbeth chart and its 3D representation.

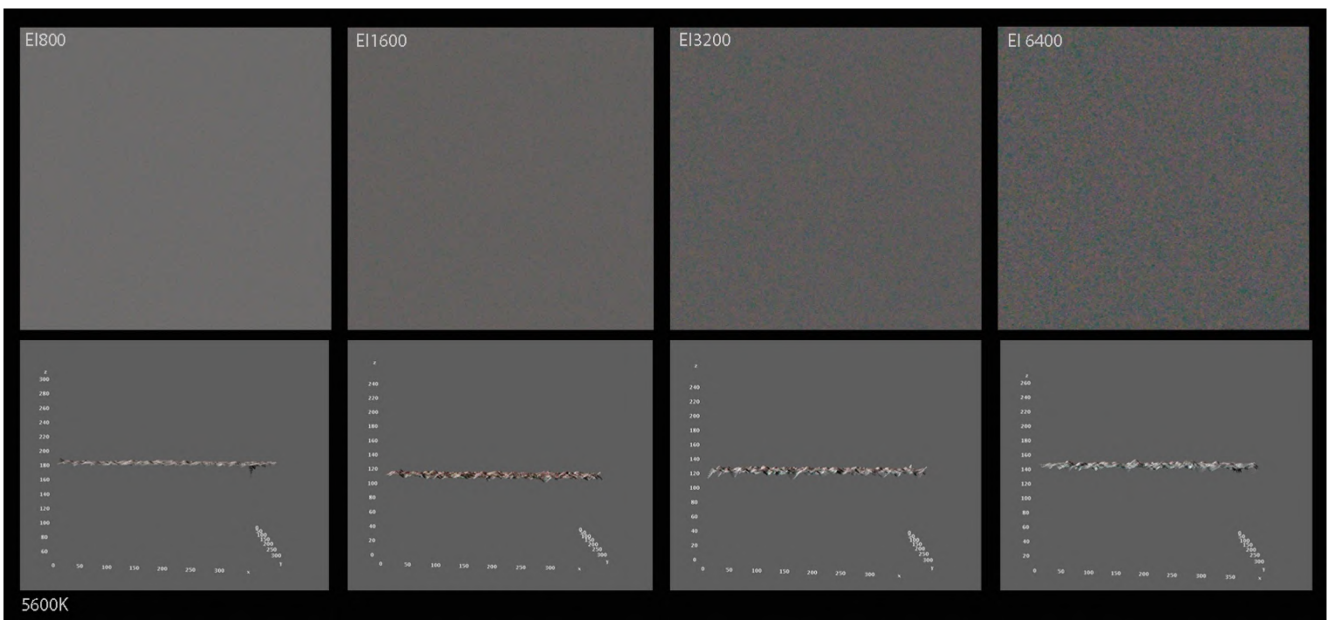


Figure 50

With the light that reaches the sensor, the noise acquires a beautiful coloration, it is soft and not at all “creaky”, and its amount increases discreetly visually speaking. There is an important improvement in the SNR value when we use the EI values with the ES mode, as we can see in *figure 51* (*table 10*).

EI values 5600K	R(N)	R(ES)	G(N)	G(ES)	B(N)	B(ES)	Y(N)	Y(ES)
2560	29,9	30,4	33,8	35	33,4	35,4	34,9	35,6
3200	26,9	32,2	32	35	32	34,9	32,6	36,2
4800	25,2	28,4	30,4	32,6	30,1	32,8	30,9	33,4
6400	23,3	26,1	28,5	30,6	27,8	29,7	29	31,3

Table 10

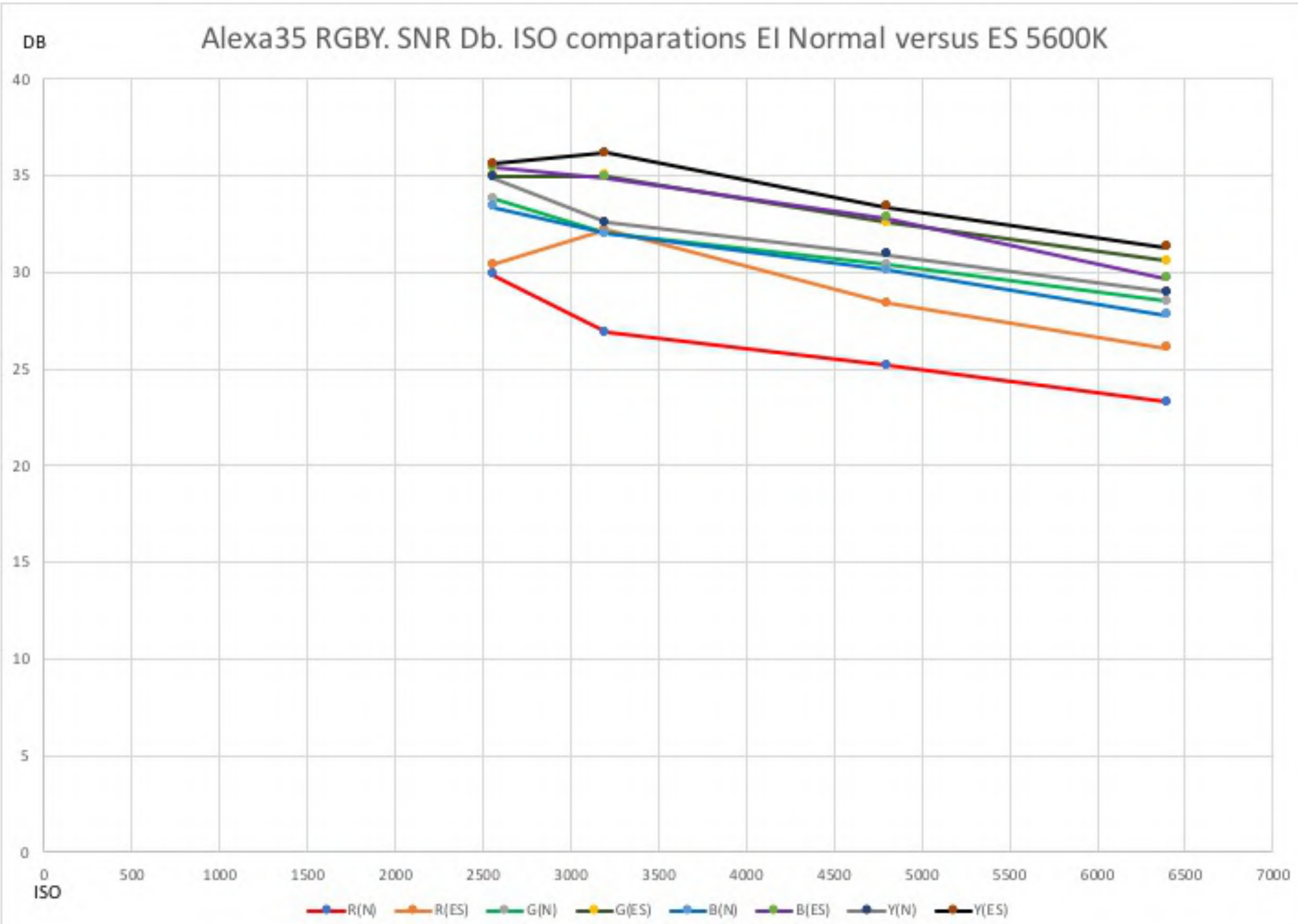


Figure 51

Let us now see the response at 3200K (*Table 11. Figure 52*)

EI values 3200K	R(db)	G(db)	B(db)	Y (db)
160	40,4	44,7	43,2	45
200	39,5	43,7	42,4	44,1
320	38,2	41,8	41	42,5
400	37,5	41,5	40,2	42,2
500	36,7	41	39,3	41,7
800	35,5	39	36,5	40,1
1000	34,2	38,5	36,3	39,4
1280	33,2	37,8	35,3	38,7
1600	32,3	36,4	33,6	37,5
2000	31	35,7	33	36,6
2560	30,5	35	31,9	35,9
3200	29,1	33,6	30	34,5
4800	28,1	32	28,6	33
6400	25,3	29,9	26,3	30,8

Table 11

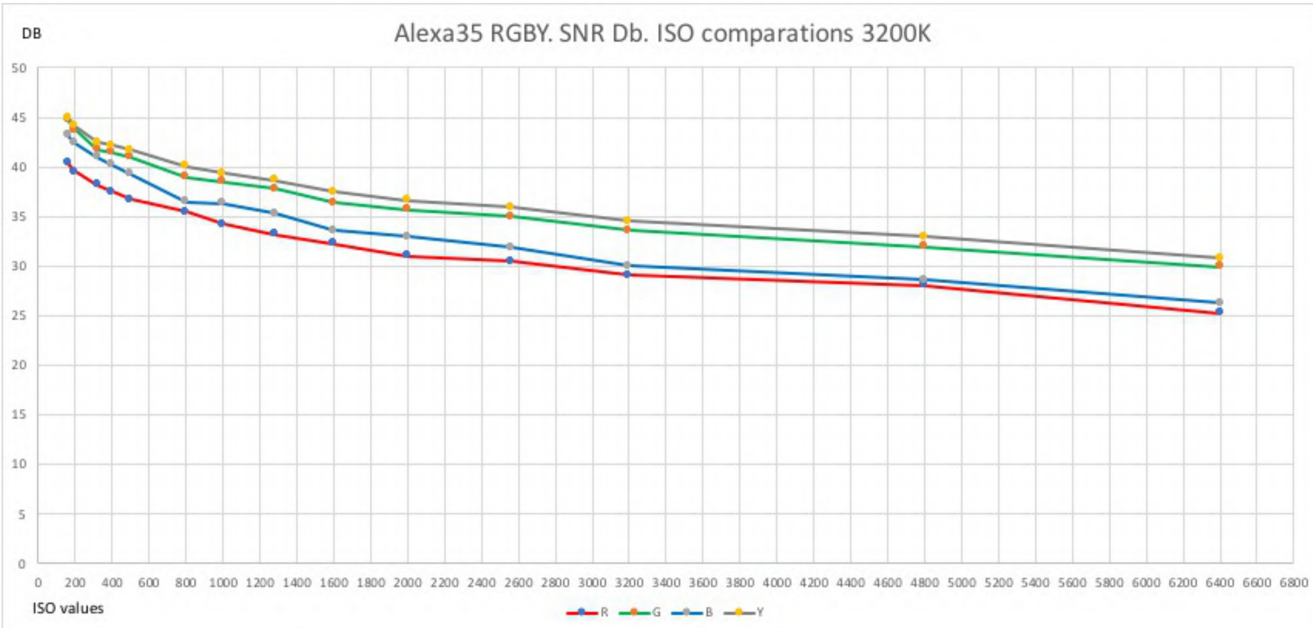


Figure 52

Like the temperature of 6500K, the SNR ratio decreases as we increase the EI value, for example, with EI 800 the value in **Y** is 40.1db, practically equal to the value of 6500K; with an EI 3200 the SNR is 34.5 db, this is a difference of 5.6 db with respect to the EI 800, a much smaller difference than what we could observe at 6500K. With an EI 400, the SNR value is 42.2 db, which represents a difference of 2.1 db compared to the EI 800, a difference that is greater than what we observe in 6500K.

EI values 3200K	R (N)	R(ES)	G(N)	G(ES)	B(N)	B(ES)	Y(N)	Y(ES)
2560	30,5	32,7	35	37,1	31,9	34,1	35,9	37,9
3200	29,1	31,2	33,6	35,6	30	32,6	34,5	36,4
4800	28,1	30,9	32	34,1	28,6	31,2	33	35,2
6400	25,3	27,9	29,9	32,3	26,3	29,2	30,8	33,1

Table 12

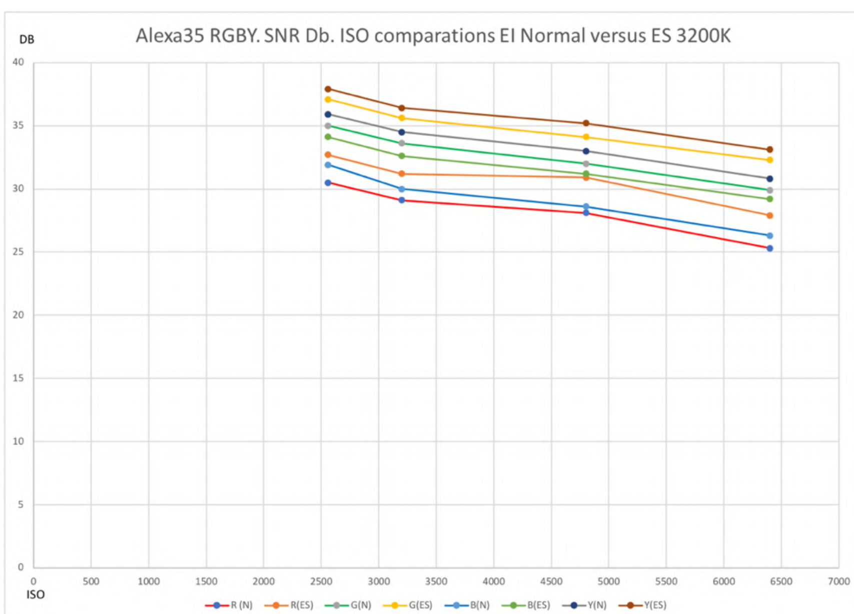


Figure 53

With the ES mode, the SNR value increases in all the EI values to which it is applied (*Table 12. Figure 53*)

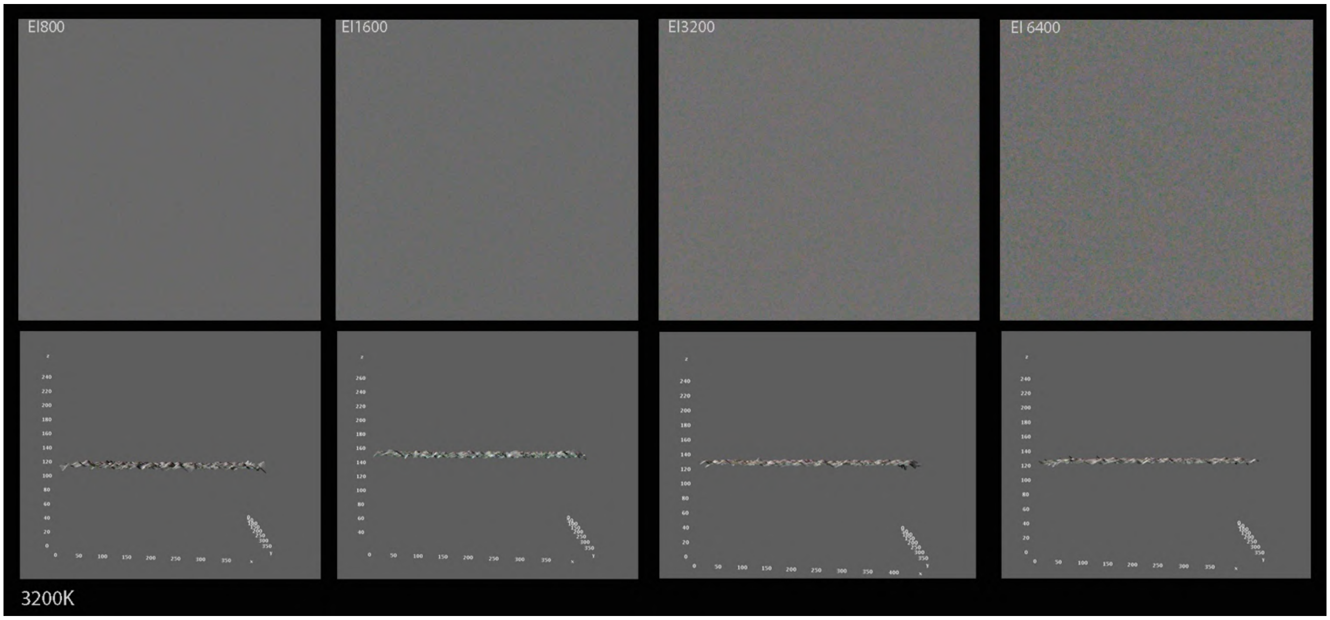


Figure 54

Again, the gray sample of the Macbeth letter (*figure 54*) with its representation in 3D. Also, with an excellent behavior in the appearance of noise and its quantity, up to even very high values such as 6400. Let us now see the comparison of the two color temperatures in RGB**Y** (*Tables 13 to 16. Figures 55 to 58*).

EI values	Y5600K(db)	Y3200K(db)
160	43,5	45
200	42,5	44,1
320	42,4	42,5
400	42	42,2
500	41,6	41,7
800	40,3	40,1
1000	39,1	39,4
1280	38,2	38,7
1600	36,8	37,5
2000	36	36,6
2560	34,9	35,9
3200	32,6	34,5
4800	30,9	33
6400	29	30,8

Table 13

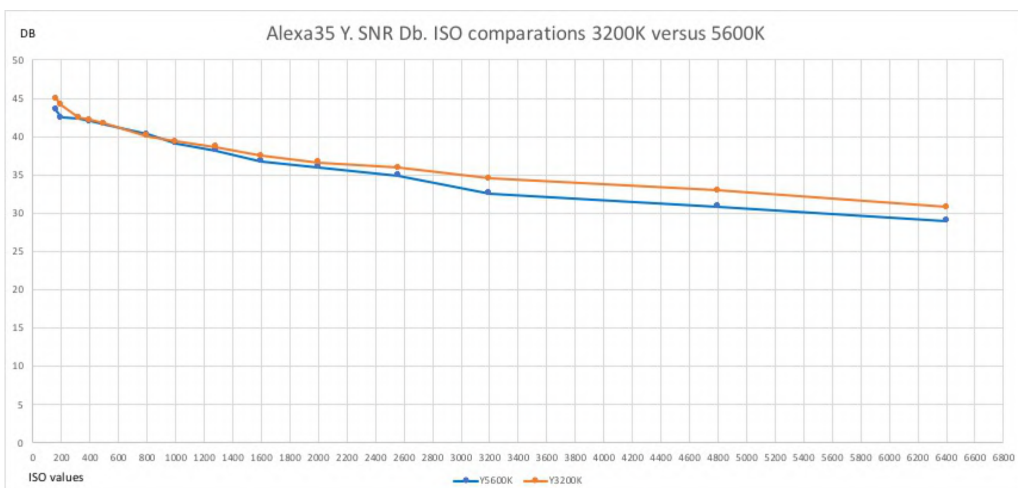


Figure 55. Y comparison

EI values	R5600K	R3200K
160	39,5	40,4
200	38,4	39,5
320	40,2	38,2
400	39,1	37,5
500	38,2	36,7
800	35,5	35,5
1000	35,1	34,2
1280	33,7	33,2
1600	32,2	32,3
2000	31,4	31
2560	29,9	30,5
3200	26,9	29,1
4800	25,2	28,1
6400	23,3	25,3

Table 14

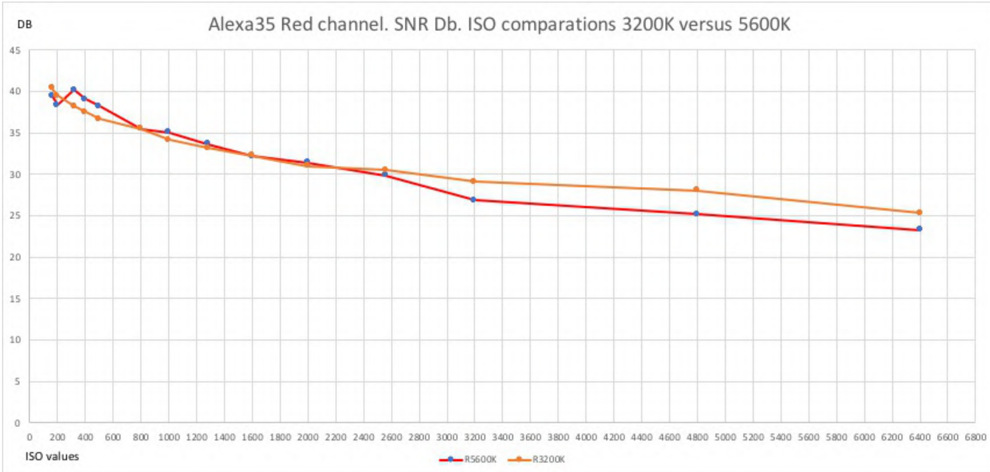


Figure 56. Red Channel comparison

EI values	G5600K	G3200K
160	43,1	44,7
200	42,2	43,7
320	41	41,8
400	40,7	41,5
500	40,4	41
800	39,6	39
1000	37,7	38,5
1280	36,9	37,8
1600	35,7	36,4
2000	34,8	35,7
2560	33,8	35
3200	32	33,6
4800	30,4	32
6400	28,5	29,9

Table 15

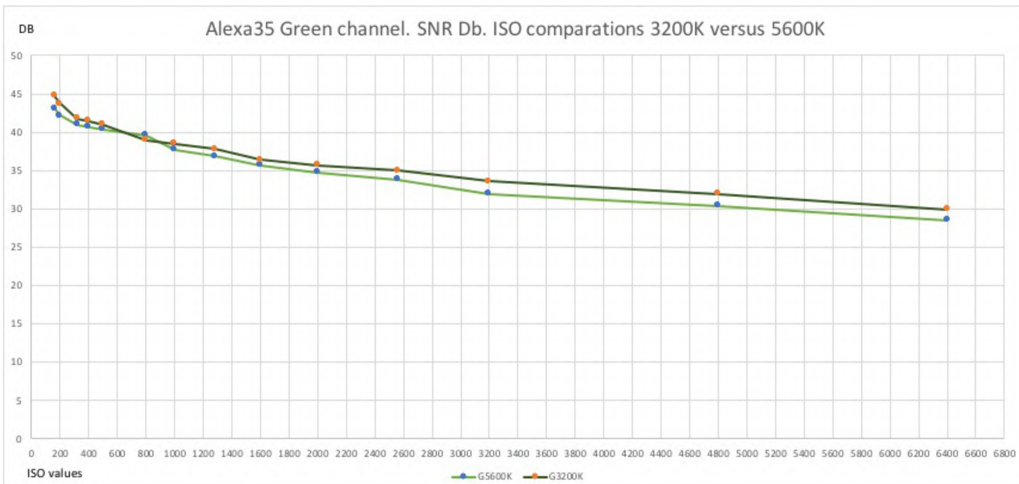


Figure 57. Green Channel comparison

EI values	B5600K(db)	B3200K(db)
160	44,1	43,2
200	43,1	42,4
320	41,9	41
400	41,5	40,2
500	41	39,3
800	39,7	36,5
1000	37,9	36,3
1280	36,6	35,3
1600	35,8	33,6
2000	34,6	33
2560	33,4	31,9
3200	32	30
4800	30,1	28,6
6400	27,8	26,3

Table 16

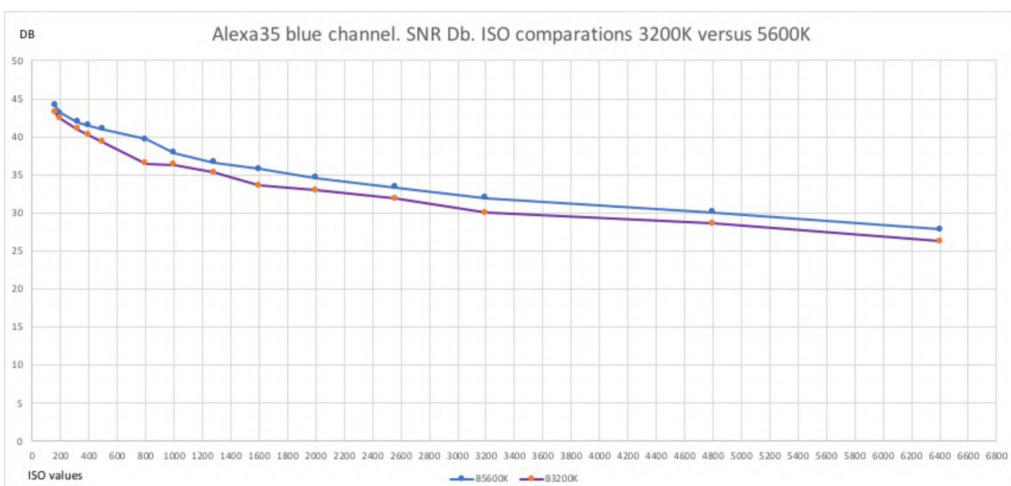


Figure 58. Blue Channel comparison

Both in **Y** and in the green and red channels, the 3200K color temperature shows a better SNR, not the blue channel where the 5600K color temperature shows better SNR values. In **Y**, values between 400 and 1600 EI show a very similar SNR signal, something that also happens in the green and red channels, in this one even more, since the values are similar between 800 and 2560, from this value the SNR at 3200K is better at all EI values than at 6500K. What we can determine with this is that in general and between values that go from 400 EI to 2560 the SNR remains more or less constant in what has to do with the relationship between the channels, not like that, of course in the decrease of the SNR due to the increase in noise with higher EI values. We can consider that SNR values above 36 db are more than enough for use without having to worry about loss of detail or excessive visibility of noise, this will allow us to use EI between 160 and practically 4800ES without problems, if we also consider using noise reducers in post-production, the range of EI values that we can use are all that the camera offers, so we can consider that this is an effectively high-sensitivity camera. I want to insist again on the nature of the noise, which, as I have already indicated, we have liked a lot. Having noise in the image that moves in a fairly random way and in color reminiscent of emulsion layers also serves to create a texture, a sensation of "support" that helps create atmospheres and therefore narrative discourses.
Let's see some images shot abroad.

Figure 59. Grinding Cocoa. Tatacoa desert. Colombia. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI3200ES. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 25mm T 4 1/3

This image (*figure 59*) is shot at EI 3200ES, which allows us to have a lot of information in the interior as well as a greater dynamic range in the highlights, as shown in the exterior vegetation, seen through the door. The noise doesn't mask the texture of the face, nor does it mask the hair, which even though well below medium gray still retains some texture.
In this other shot already shot at dusk, and where the talents are only illuminated by the bonfire, we analyze the noise at different EI and ES values (*figures 60 and 61*).

Figure 60

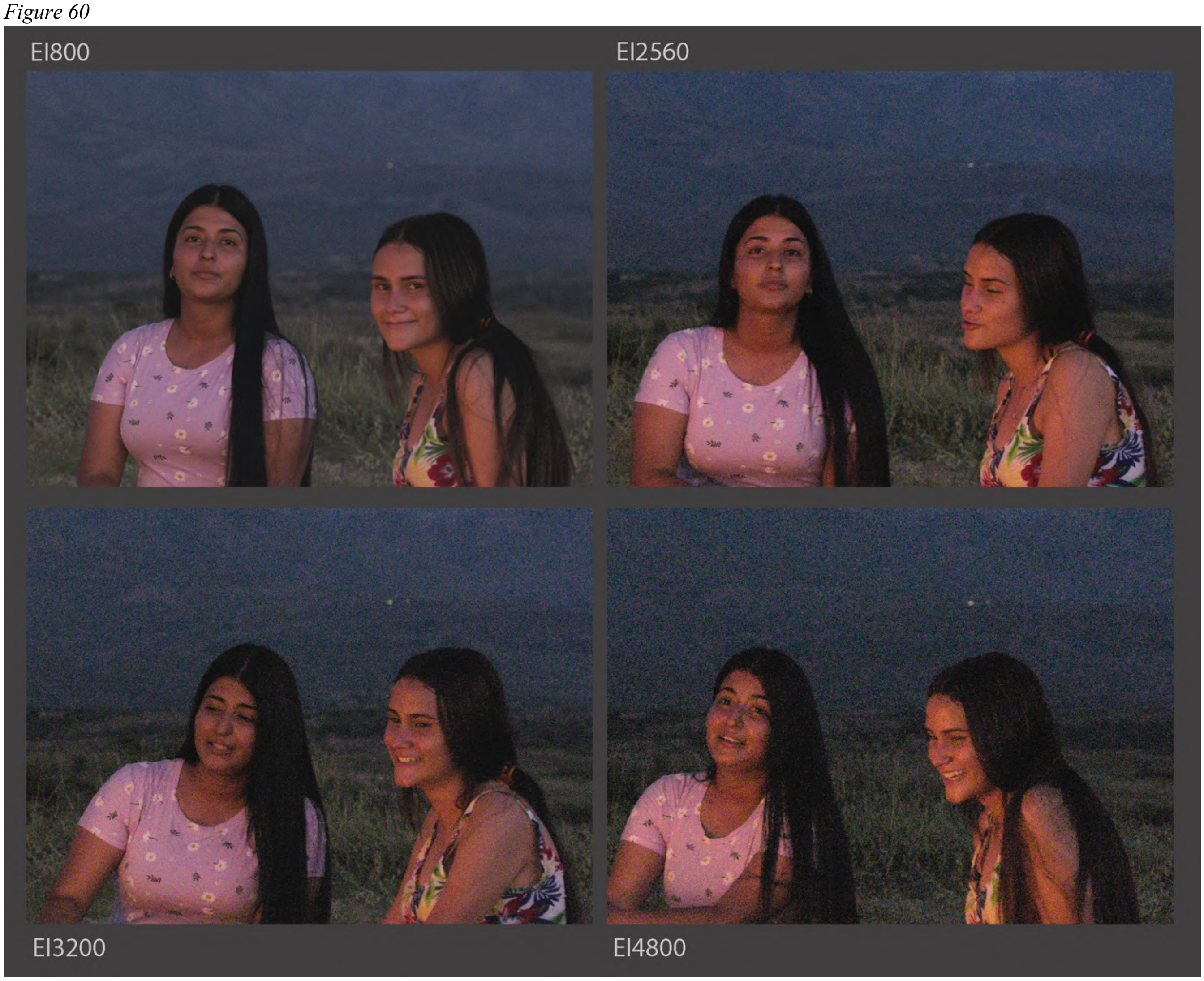


Figure 61

At EI 800 the noise is irrelevant and it is also at 2560, at 3200 it is already noticeable and much more at 4800, however visually it is still more than acceptable. The noise noticeably decreases when the ES sensitivity mode (Figure 62) is applied.

Figure 62

Figure 63. Blue Channel

Figure 64. Green Channel

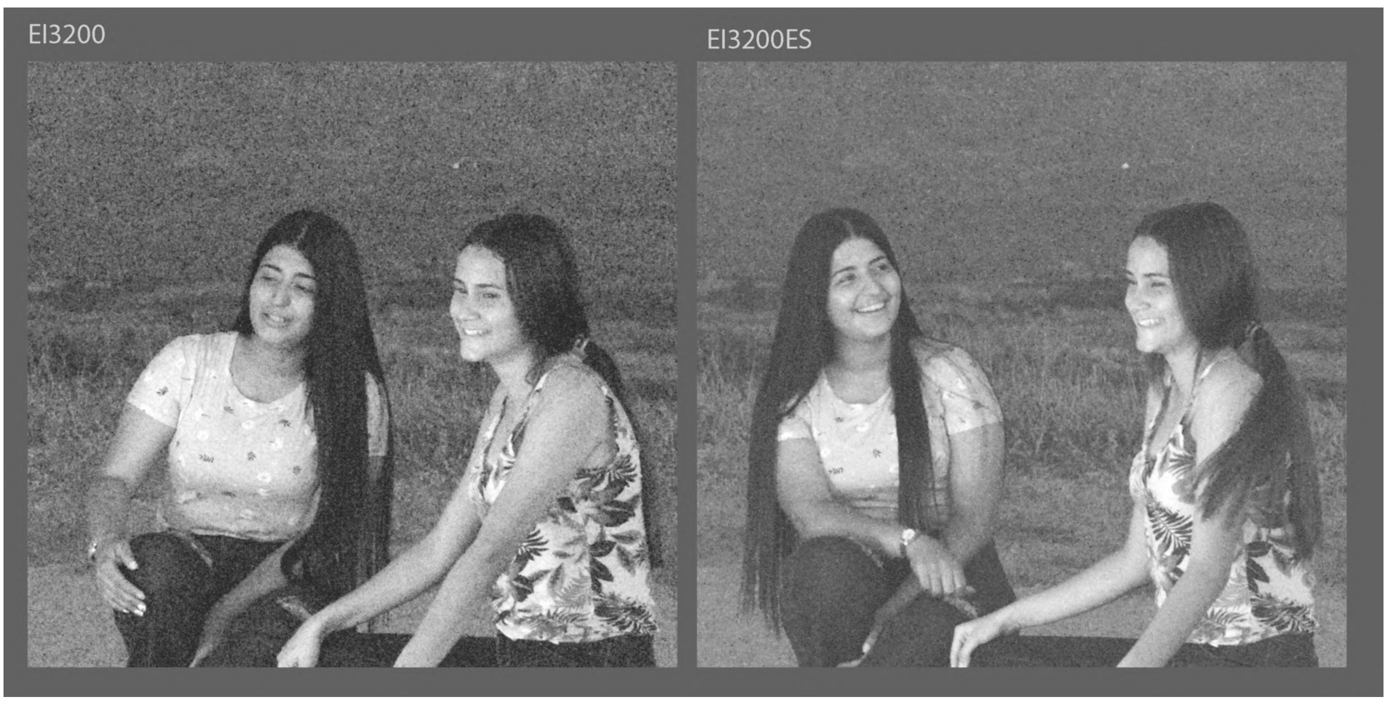


Figure 65. Red Channel

The red and green channels appear quite clean in ES mode, as is the blue channel, which, being the noisiest and therefore the one that loses the most sharpness in the image, is very acceptable in ES mode (*figures 63 to 65*). As a conclusion of this analysis we can say that all the EI modes are usable, especially at high sensitivity with the ES mode, which allows the camera to adapt with quality to practically all possible lighting situations.

DYNAMIC RANGE

Here we study the camera's ability to show detail in highlights and shadows in the same exposure, assessing it in T stop with respect to the 18% neutral gray value indicated by ARRI.

One of the most interesting aspects when evaluating the camera is the dynamic range, although this concept is not always clear, so we are going to start by defining the dynamic range from the ISO 15739 document according to the formula $R = L_{sat}/L_{min}$ where L_{sat}t is the luminance saturation value considering a pixel level of 0.995 and L_{min} is the luminance level when the SNR value (signal noise ratio) is equal to 1. The dynamic range is thus the ratio (the relationship) that we establish between the maximum exposure level that gives a pixel value just below the clipping in the highlights and the minimum exposure value that can be captured considering the SNR=1 value, that is, the signal and noise value is equal. https://imago.org/projects/itc/photon_path/diagram/. The dynamic range is usually expressed in T stops (log in base 2) or also in db by evaluating the SNR (signal noise ratio). To evaluate dynamic range beyond the methods employed by manufacturers in their laboratories, we utilize gray step charts such as DSCLab's Xyla chart, Image Engineering's TE269 V2D chart, or Imatest's VisNir chart, among other options.

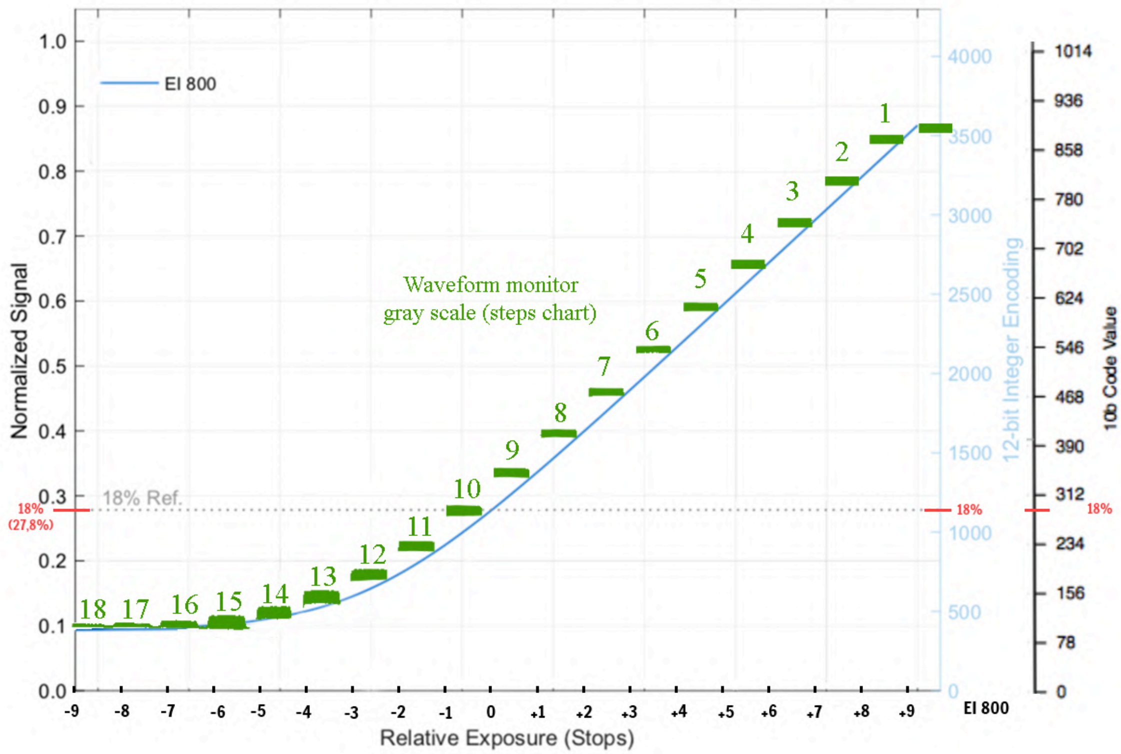


Figure 66

The dynamic range that the camera can see is around almost 17 stops, considering a value of SNR=1 as determined by our previous definition. In figure 66 we show the Logc4 curve with EI 800 and on it the chart values seen on the wave monitor. We appreciate even slight variations in brightness beyond 17 stops, up to 18 stops. It is indeed a very high RD.

It should be noted that the distribution of these grays in relation to the average gray is different depending on the EI that we choose (*figure 66A*), although with this camera the curves at the different EI are identical, in the sense that they have the same contrast and always maintain the same ratio for the middle gray. That gray value with LogC4 curve is lower than previous ARRI cameras and sits at an IRE of 27.8% which means a value of 285 cv at 10-bit full, or 1140 cv at 12-bit full. This value of 27.8% has been our exposure reference for the different tests. The use of the luts developed by ARRI transforms this Log values to normal values to which we are accustomed.

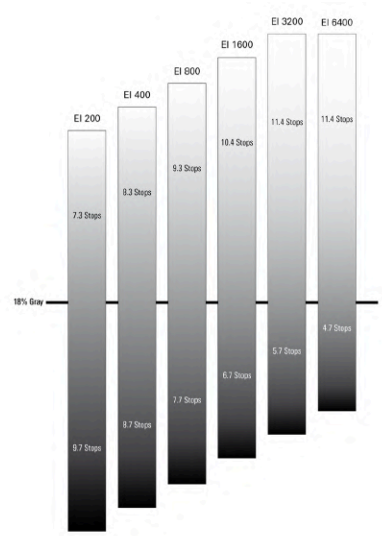


Figure 66A

We have verified how effectively at high EI values we have more luminosity in the image, including blacks, with more detail in the highlights, but we have less information in the shadows, less texture, than when we shot at lower EI. In *figure 67* we can see the comparison of a gray scale at different EI values.

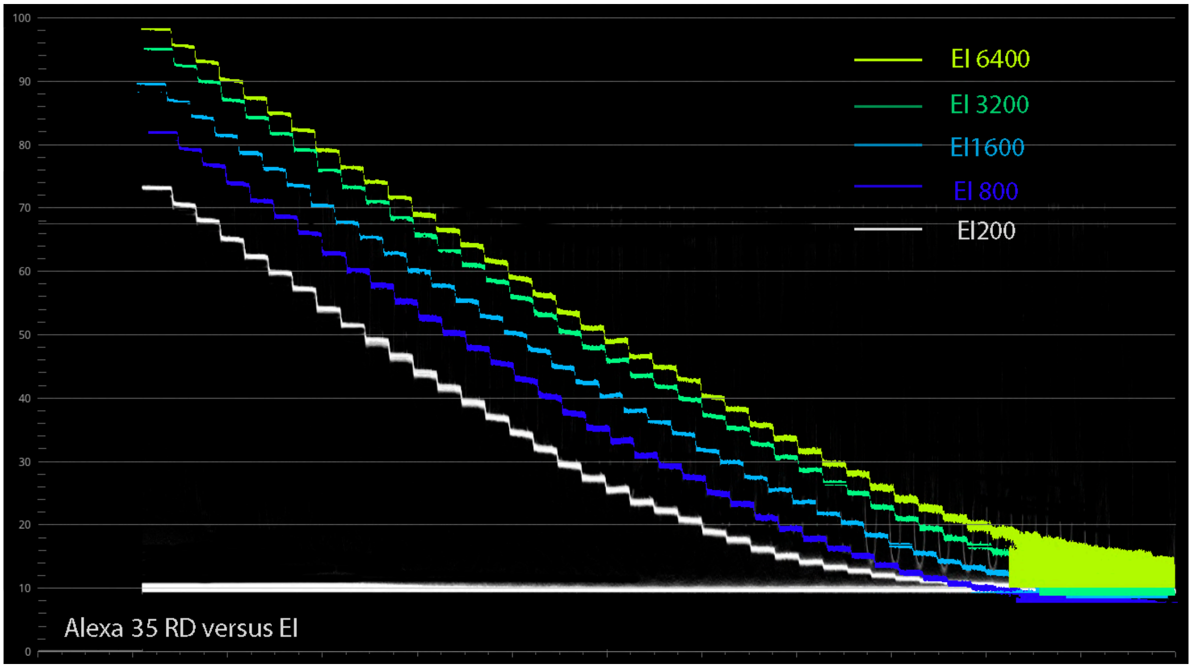
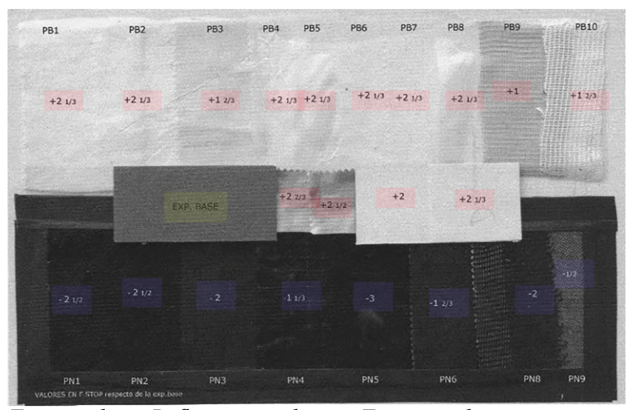


Figure 6. Stouffer strip 41 steps.

In the highlights we have less ability to represent luminosity values at EI 200 than at EI 1600 for example, and in the shadows, with EI 800 I distinguish some steps in the deeper shadows than at 6400, where these steps are brighter though they are all merged in noise. In the handmade textures test chart crop, we can see the comparison between the EI 800 and 3200 with an underexposure of -3 stops. At EI 800 I can still see texture down to -5 ½ stops, something that doesn't happen at 3200, where nothing remains of texture except noise (*figure 68*).



Texture chart. Reflectance values in T stops with respect to medium gray.

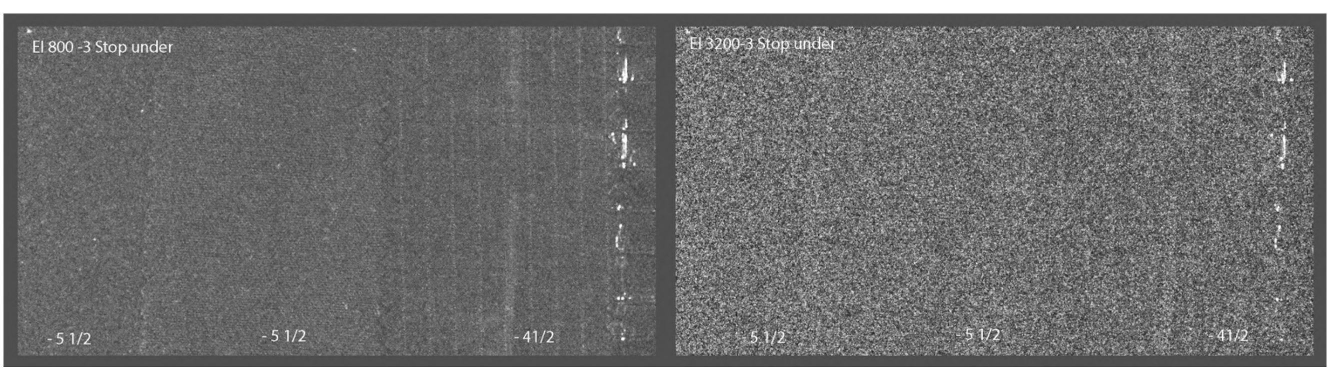


*Figure 68. -3 stops underexposed and **medium gray raised** in post-production*

The opposite happens with the highlights. With EI 800 +8 stops overexposed the detail of the white fabrics is completely lost, however, at EI 3200, I still have the texture of the fabrics that are with it +8 stops overexposed to 10 1/3 (reflected light values) stops above the gray medium (*figure 69*).

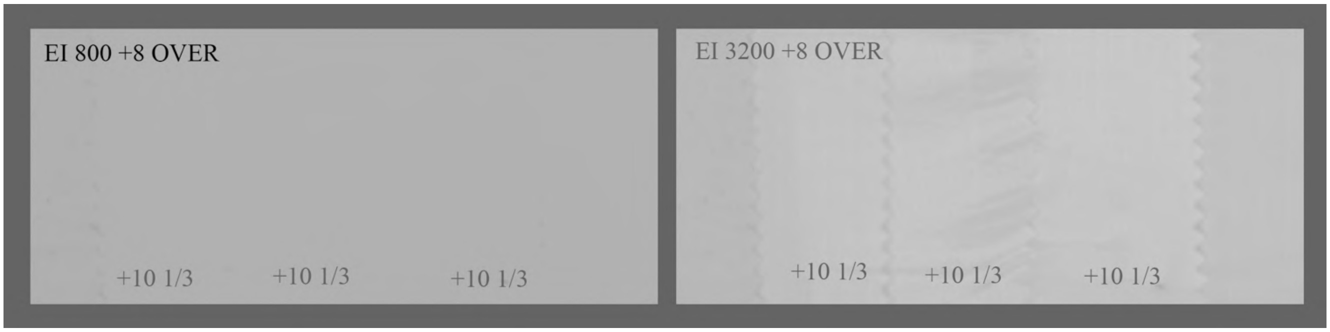


Figure 69. +8 stop overexposed and ***lowered mid-grey*** *in post-production*

Thus, the choice of the EI value, not only supposes that we will have more or less luminosity in the image, or more or less noise, but also more or less detail in the highlights and deep shadows.

There is another way of looking at the RD and that is to do it considering the SNR value, that is to say how the noise affects the detail and texture in the shadows, for this we do not consider the SNR value=1 but a value of 2, that is to say 0.5 (value quadratic RMS), this value that I usually take as a reference when I use Imatest for the analysis of the range with the charts of steps. To better clarify this other perspective from which to analyze the dynamic range I put figure 69B.

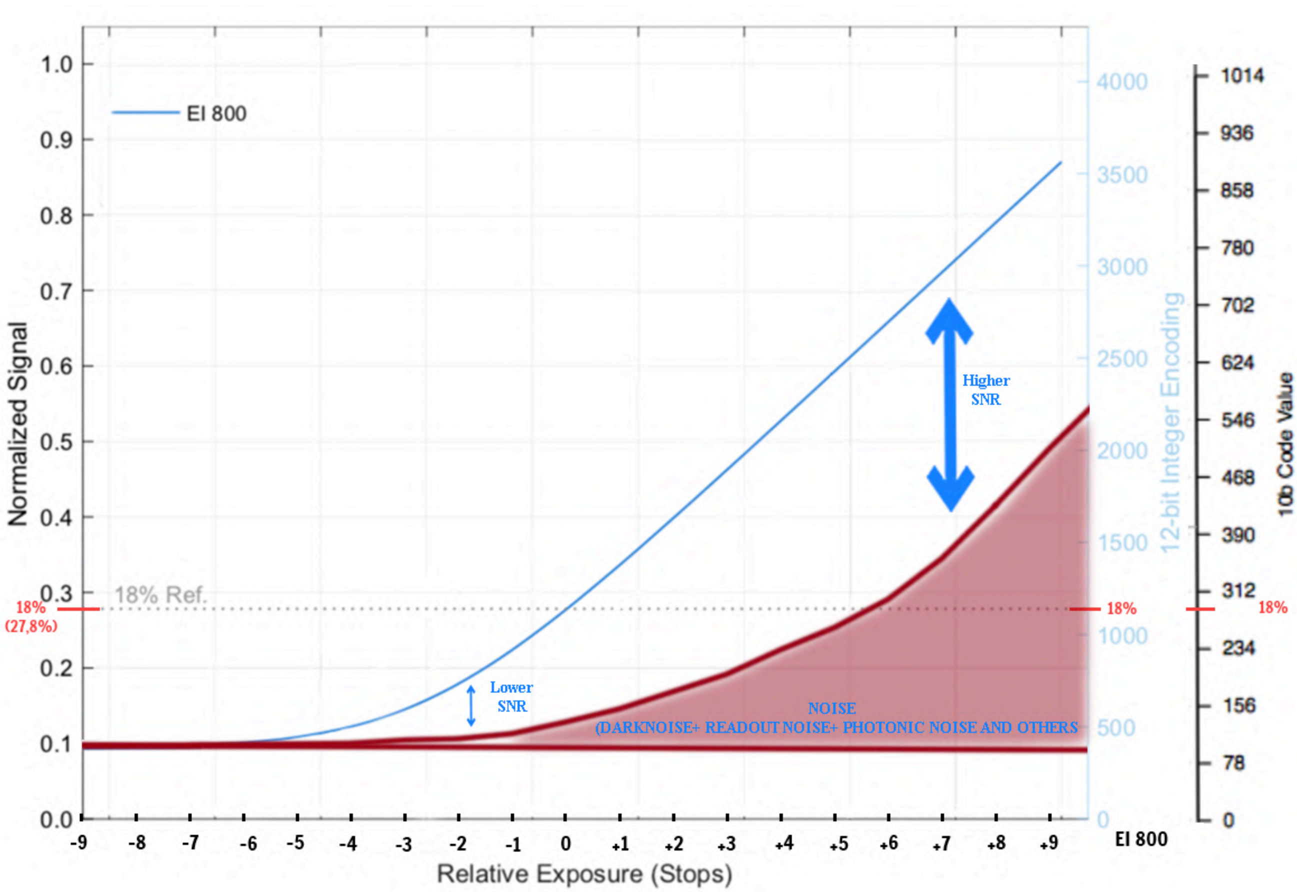


Figure 69B. The camera does not record at less than 12 bits, however I have put the 10-bit scale as a reference, as it is still widely used. At 12 bits there are many more values below the mean grey than at 10 bits.

The blue curve is the representation of the brightness values with LogC4 and I have added the red curve and the area that it covers showing in a generic way the noise that comes from the base noise, plus the reading noise, the photonic noise, and others that could be. What must be noted here is that with high values above the middle gray the SNR is greater than with values below said gray (the distance between the blue and red curve is greater in the first case and less in the second; only to put

some numbers, with a value of +8 stops above the middle gray, the **Y** value of the SNR is 56.6 db, while with -4 stops below the gray it is 25.5 db (values measured with Imatest on the chart color).
To visually specify this assessment of the range, we have used the black and white of texture chart, overexposing and underexposing to observe when we lose detail (*figure 70*) with the EI 800 value that we have taken as reference.

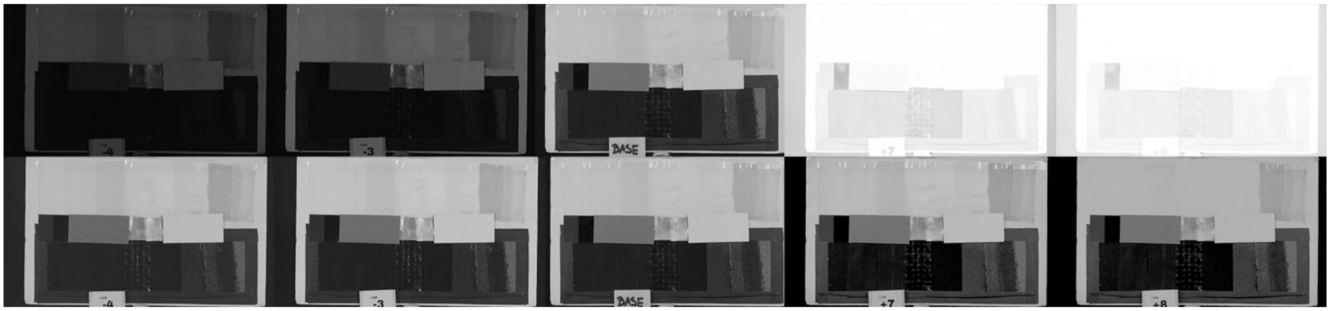


Figure 70

The upper part of the strip of images shows the chart corrected to a light, that is, we have applied in Davinci the lut ARRI_LogC4-to-Gamma24_Rec709-D65_v1-33 to all overexposures and underexposures. The lower part shows those same values but corrected so that the different exposures resemble the base exposure, trying to recover as much detail as possible. In the highlights with an overexposure of +7 stops we recover all the detail of the white fabrics, which are +9 1/3 stop (reflected light values) above the medium gray. With a +8 stop dodge, we already lose all the detail in the fabrics, which would now be +10 1/3 stops above the medium gray. Let's not forget that if instead of this value EI 800 used the EI 3200, it would have detail in the fabrics at that value of +10 stop 1/3. That range in the highlights is really amazing. We see it in detail in *figure 71*.

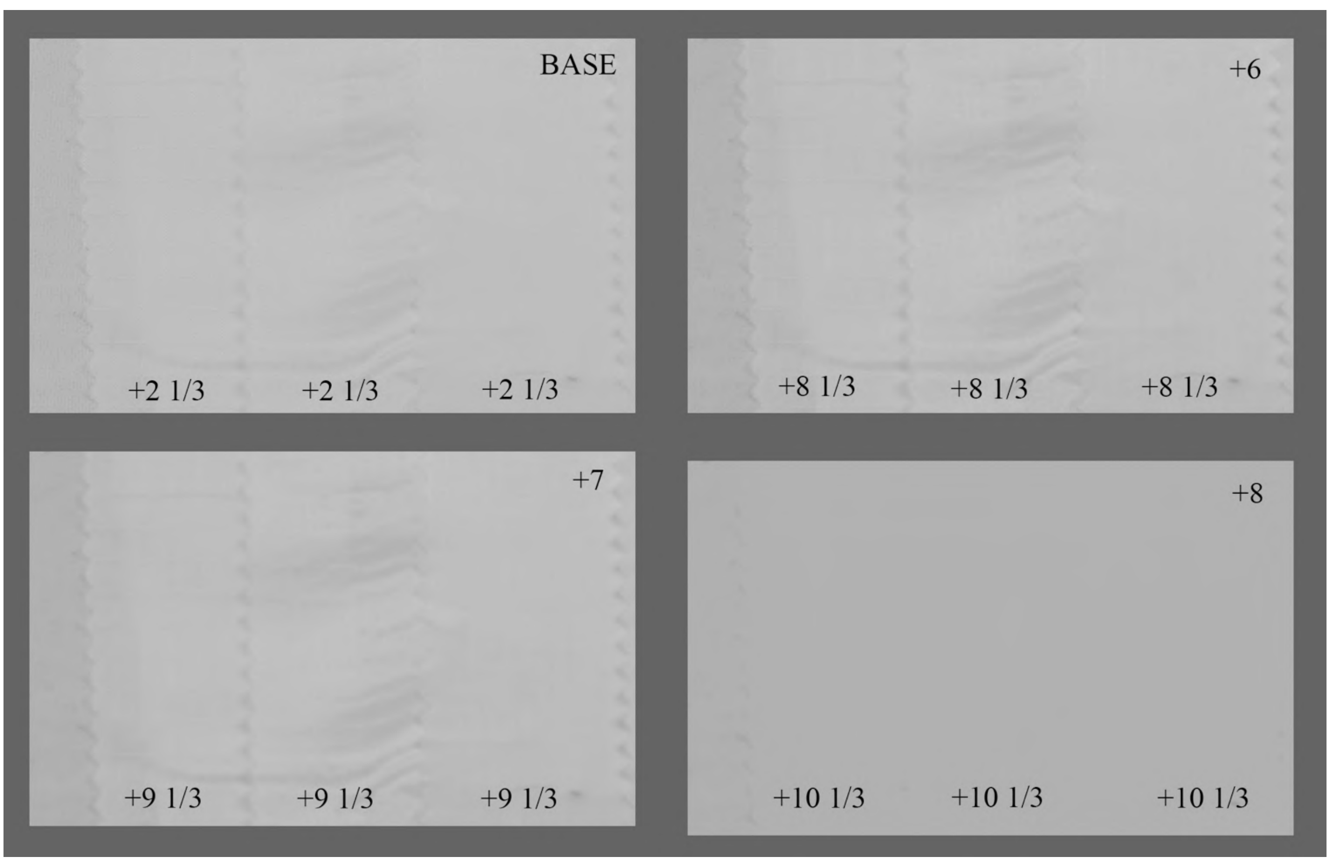


Figure 71

As for the shadows with EI 800 (*figure 72*), I get to perceive texture up to -5 ½ (reflected values) although already with noise. With an underexposure of -2 the detail of the black fabrics that are at -4 ½ (reflected values) is fully recoverable and looks quite clean. With underexposures beyond -3 the noise is considerable and there is no way to recover texture. We can also see it in detail in *figure 72.*

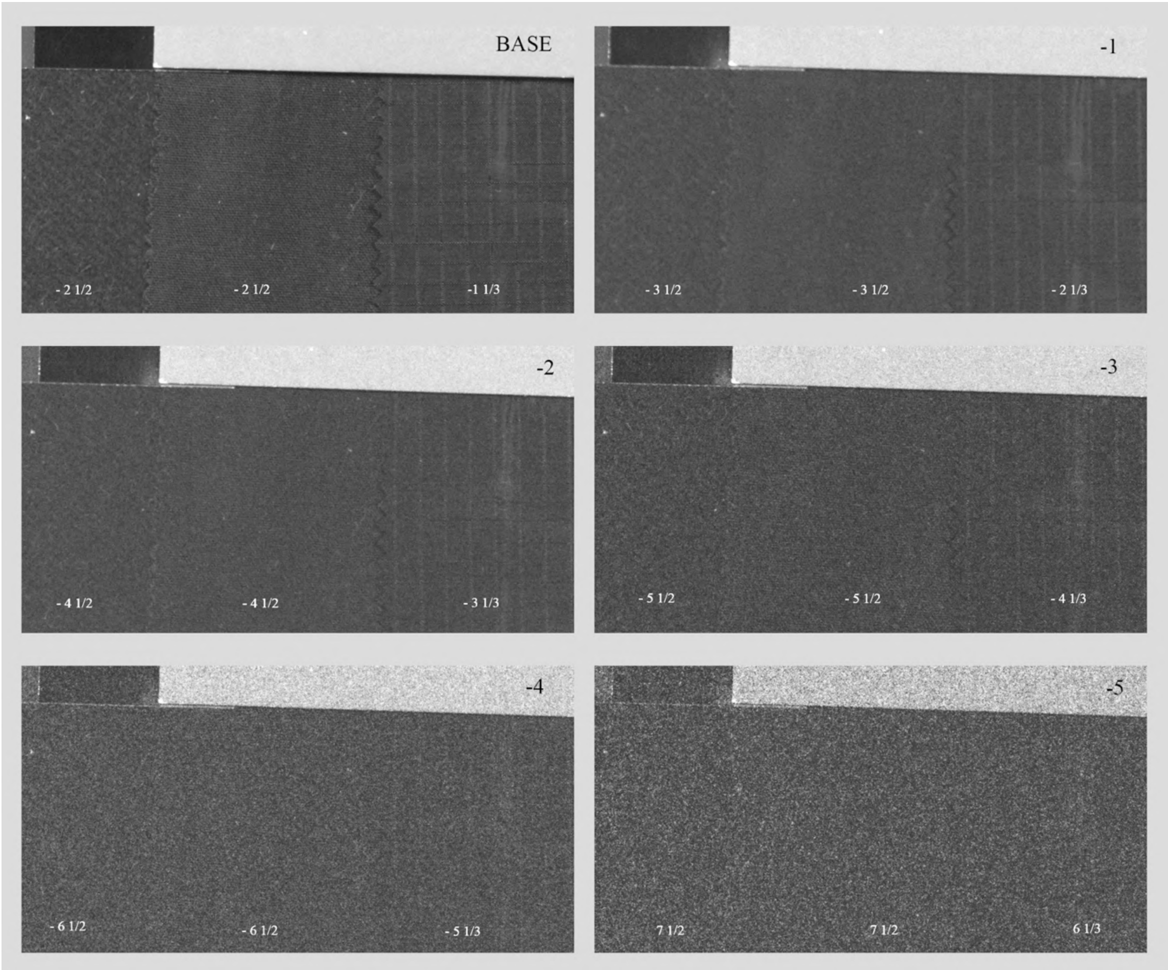


Figure 72. In the upper right part of each crop are placed the stops below the stop that corresponds to the middle-gray determined by ARRI. Underexposure obtained by closing the iris of the lens. At the bottom of each crop are the stop values reflected with respect to the mid-grey at each underexposure level.

With this first analysis we can establish that with an EI 800 the *dynamic range in relation to noise* is just over 9 stops above the middle gray and just over 5 stops below gray, in total between 14 and 15 stops. It should not be forgotten that although the detail and texture are seriously affected by noise at more than 5 stops in the shadows, the camera continues to distinguish luminosity values and some texture beyond 7 stops, which makes shadows have great depth with a very consistent spatial sense of black.

We have checked this range again with three different tests, on the one hand we have overexposed and underexposed our still life (*figure 73*),

Figure 73. Still life. Some reflectance values in T stop referred to neutral gray 18%

on the other, the same with our talents and then we have shot in natural spaces.
We will see the still life multi-exposure strip in the color section, but I am interested in showing here how we effectively lose texture in black based on certain values.

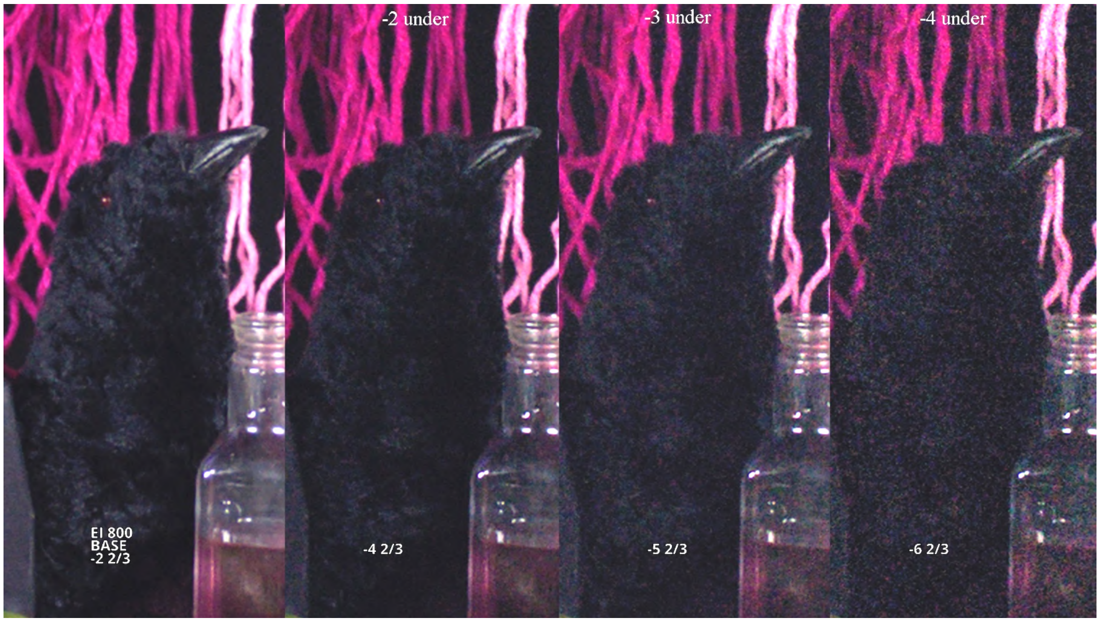


Figure 74. In the upper part underexposed stops (closing the iris). In the lower part the values in T stops (reflected) with respect to the reference T value.

In the enlarged image of the black bird, we see how the noise affects the detail from -3 stops of underexposure. The reflectance value of the bird at those -3 stops under is -5 2/3 stops with respect to the medium gray and it is already heavily contaminated by noise, although some texture can still be distinguished. When the texture is practically at -5 stops we see it still acceptable and without the noise masking it (see video 1 Overture).

In the highlights, our deer (figure 75), which is at +2 ½, does not lose detail even with overexposures of almost 7 stops.

Figure 75

Next let's see the multi-exposure strip with the talents at EI800 again. *Figure 76* shows the overexposures first. In the first column is the original LogC4, in the second the correction to a light with the ARRI 709 Lut indicated above and the third column shows the correction of all exposures to make them as close as possible to the base exposure (see video 1 Overture).

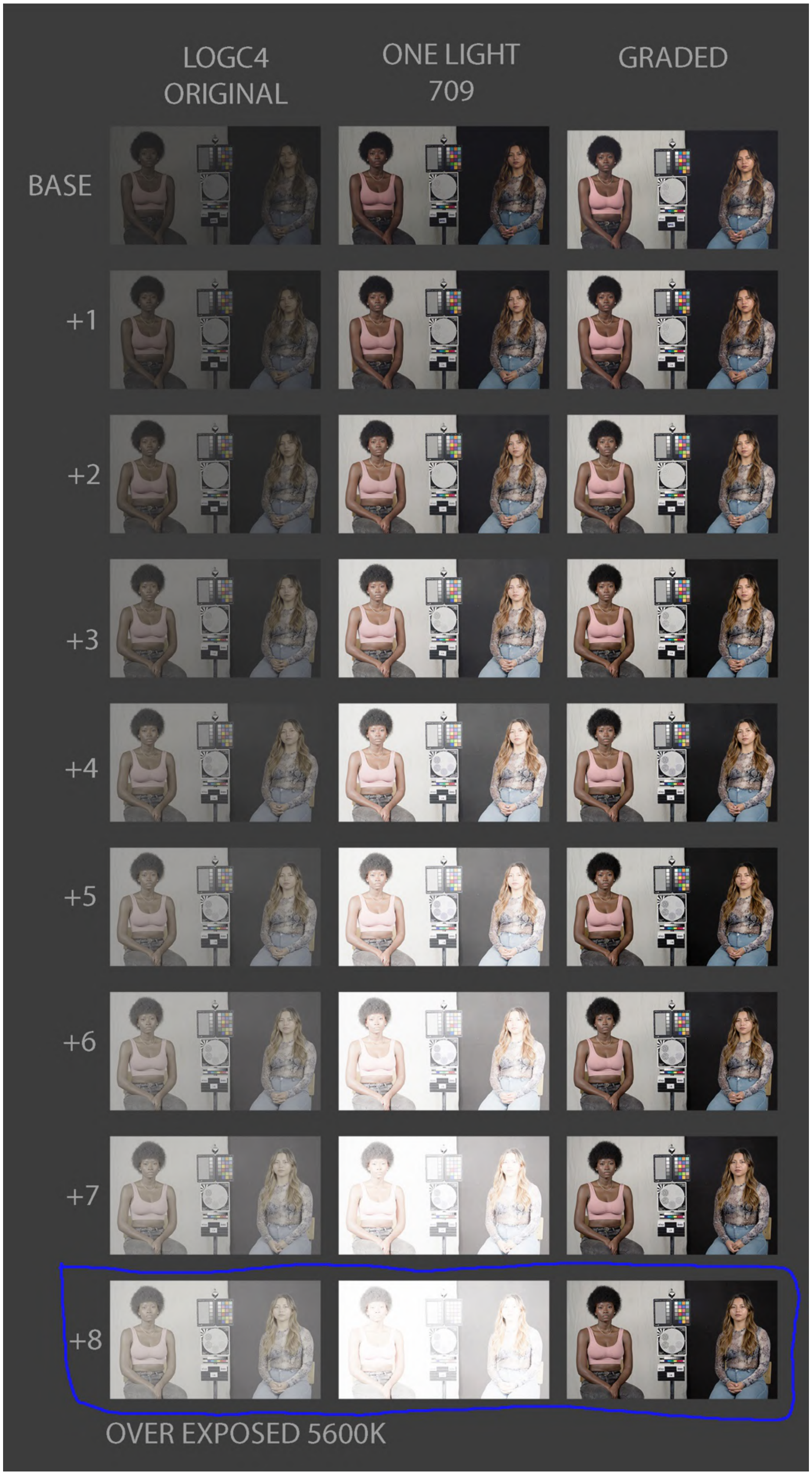


Figure 76

In this test we verified not only the excellent recovery of highlights but also the constancy of the skin tone of our talents and the consistency of the tones in our color chart. With + 8 overexposed stop (achieved by opening the lens iris compared to the reference diaphragm of the base exposure, where the middle grey corresponds to 27.8%) we recover all the detail in the skin of our lighter talent, as well as the textures of the clothes.

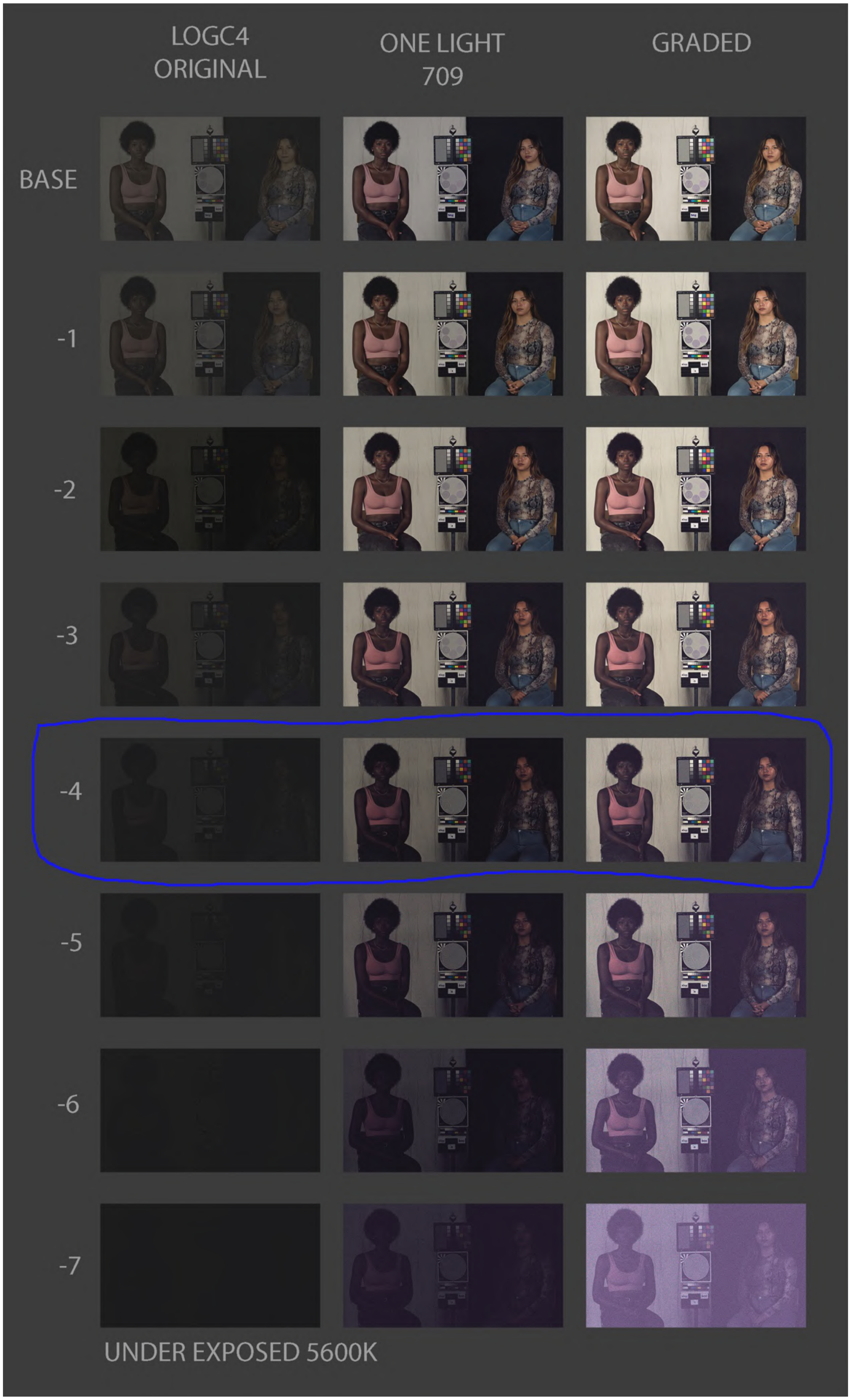


Figure 77

Regarding the underexposures (achieved by closing the lens iris compared to the reference diaphragm of the base exposure, where the middle grey corresponds to 27.8%) (*figure 77*) we can confirm that the maximum level of underexposure that allows us to recover information is -4 stops. With -2 and -1 detail is recovered without problem and skin tones are maintained very well. With -3, detail and color tone are also recovered well, although there is already some noise. With -4 you can still recover the information if you work with a reducer at the cost of losing some sharpness in the image, this can be seen in the resolution Putora chart (*figures 78 and 79*). From -5 the noise is very noticeable and nothing can be recovered. However, as we indicated above, up to -7. I see the figures of the talents, even still the face of the dark-skinned talent, as well as the gray scale and the color chart. Obviously, I've lost all the middles and highs frequencies, but this camera's ability to still resolve in such deep darkness ensures a dense, rich, spatial black, not one with a flatter, "two-dimensional" cutout.

Figure 78. -4 stop under. Raised the medium gray to look like the base exposure with noise reduction in post.

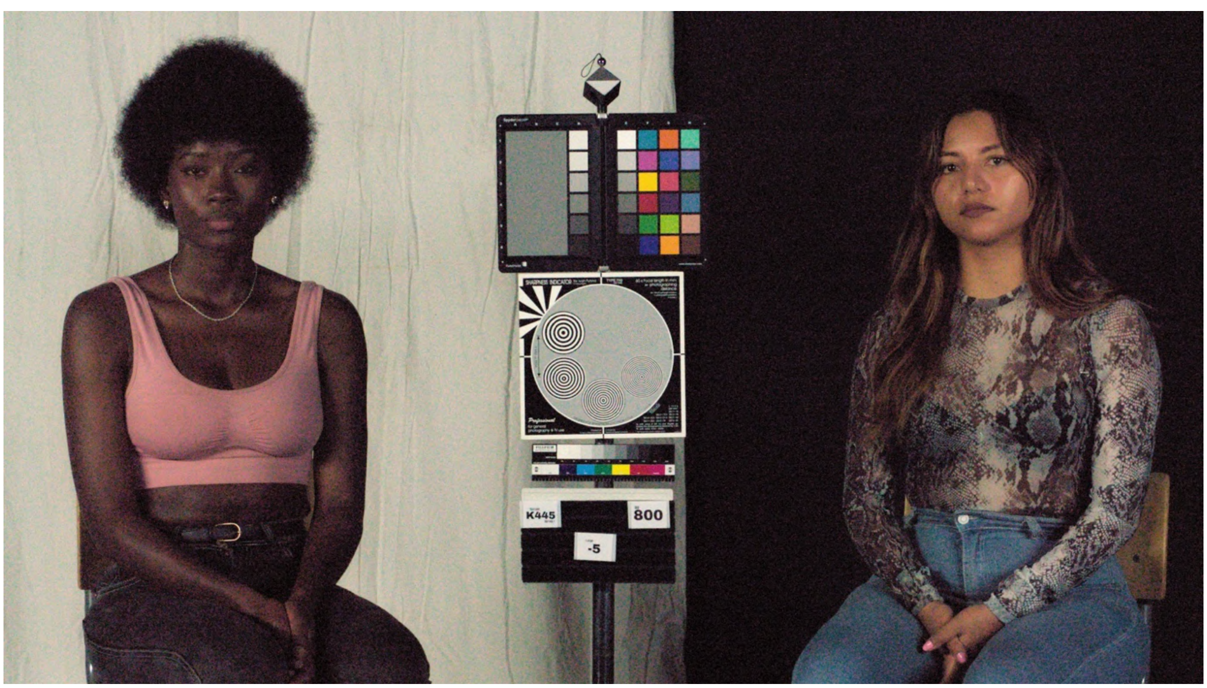


Figure 79. -5 stop under. Raised the medium gray to look like the base exposure.

Let's take a closer look at the effect of overexposure and underexposure on the talents' faces (*figures 80 and 81*), considering, let's remember the EI 800, in different exposures that we have corrected, raising or lowering them in post-production to "see".

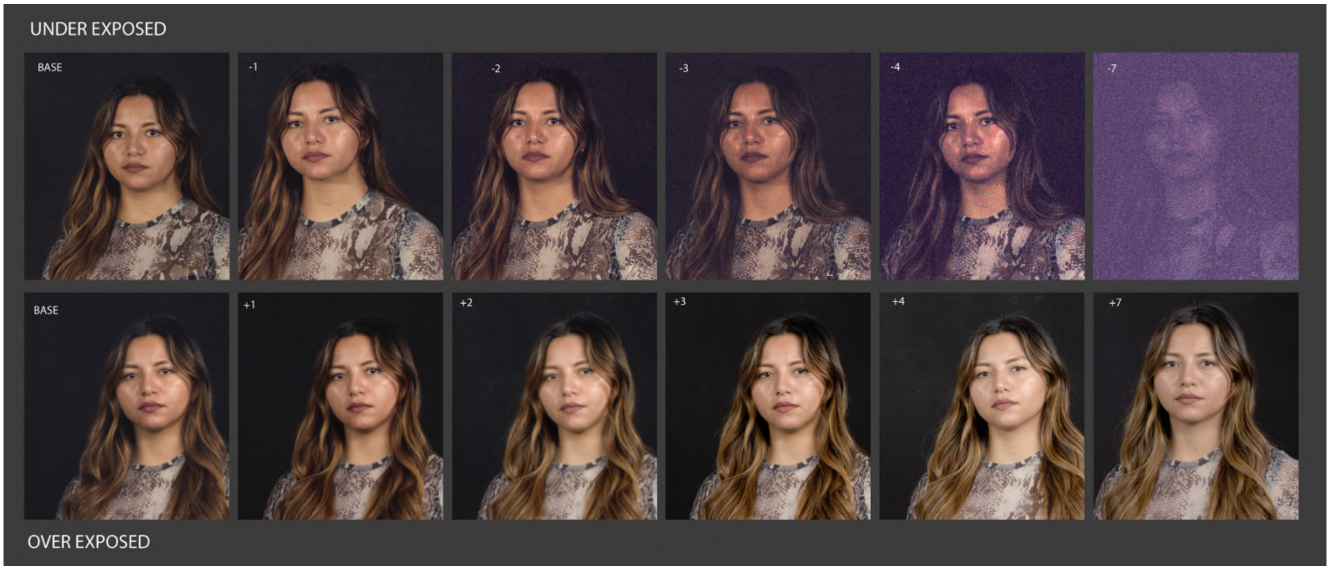


Figure 80. To overexpose or underexpose means to open or close the lens diaphragm with respect to the reference iris where the middle grey is at the value indicated by ARRI.

With overexposed there is no limit up to a value as high as +7. With underexposure up to -3 there is no problem in recovering the skin tone and with -4 the noise already colors the skin in a slightly purple tone due to the increase in noise. In colorization we have verified that the color tone can still be recovered, and it is also necessary to put a noise reducer as previously indicated. Beyond -4 the skin tone can no longer be recovered due to the presence of a lot of color noise. The same considerations can be applied to the talent with darker skin.

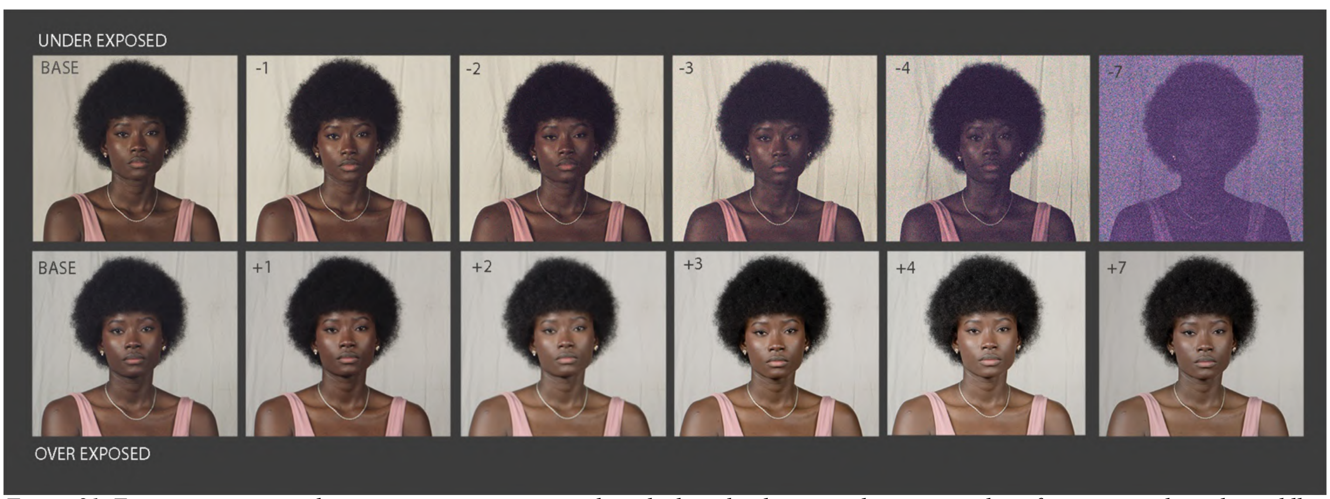


Figure 81. To overexpose or underexpose means to open or close the lens diaphragm with respect to the reference iris where the middle grey is at the value indicated by ARRI.

I want to clarify here that the method used to see what happens in the deepest shadows is the same one that we used in the analysis of film emulsions, that is, underexpose the image and then try to recover as much information as possible in color grading to see what happens there. As it is obvious, the exposure that we cinematographers do in general does not consider underexposing the image by 4 or 5 stops and then using it as if the exposure had been correct, just as we do not use the reference 18% gray value to expose, but we do it according to the narrative needs. What this DR test in relation to noise shows is how our penumbras and shadows will look, which is what we have effectively verified in shooting natural locations.

Outdoors we have searched for images where the contrasts were as high as possible and we have to confess that we have practically not found a high light that the camera could not represent. In these images we present frames with the average values of the three channels indicated in the LogC4 curve corresponding to their EI value. The frames that we show are the original ones in LOGC4 without correcting.

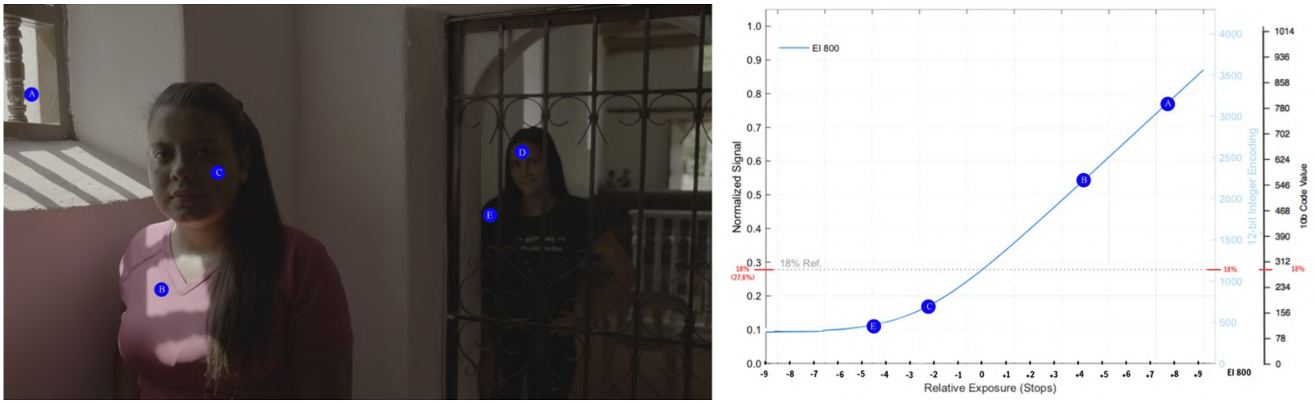


Figure 82. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 25mm T 5.6 2/3

In *figure 82* we have our two talents, one near the window and another in the shadows behind it. The highest value corresponds to the white wall illuminated directly by the sun, this value is 8 stops above the middle gray (A), the darkest part (E) is -4 ½ below the gray, that is, the camera is covering a scene range of about 13 stops, and everywhere there is enough detail, the texture of the white walls is extraordinary, as well as the detail in the shadows of the faces and of the talent in the back of the frame. At -4 ½ we have all the texture on the talent's shirt, without noticeable noise.

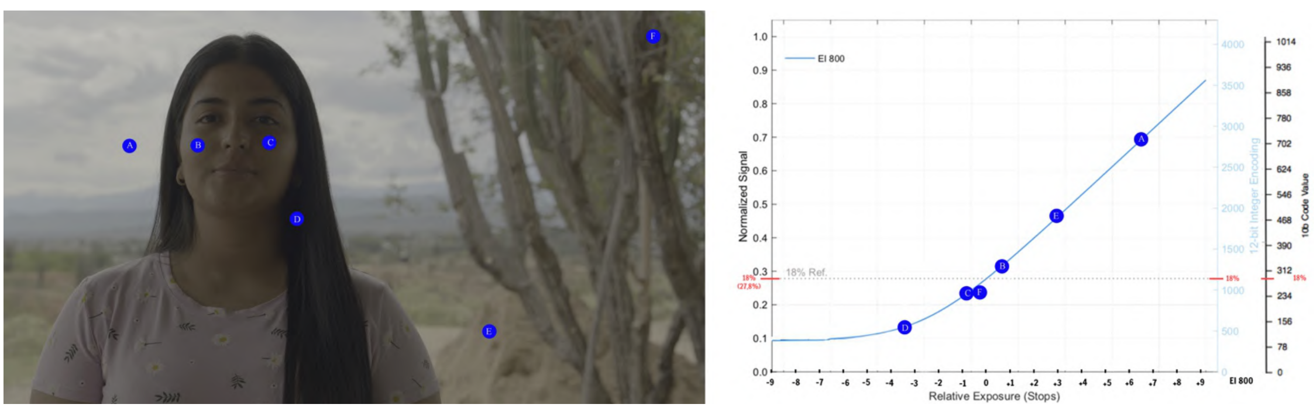


Figure 83. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800. ND 0.6 OBT 172.6 6500K. Texture P425Cosmetic. LogC4 to Rec 709. Lens Signature 58mm T 5.6 2/3.

Shooting in Villavieja. Woodwork. DOP Adriana Bernal ADFC

In this other frame (*figure 83*), the talent against the illuminated sky in the background has all the texture not only in the face but also in the hair (D), and the sky (A) preserves all the detail in the clouds and their different luminosities.

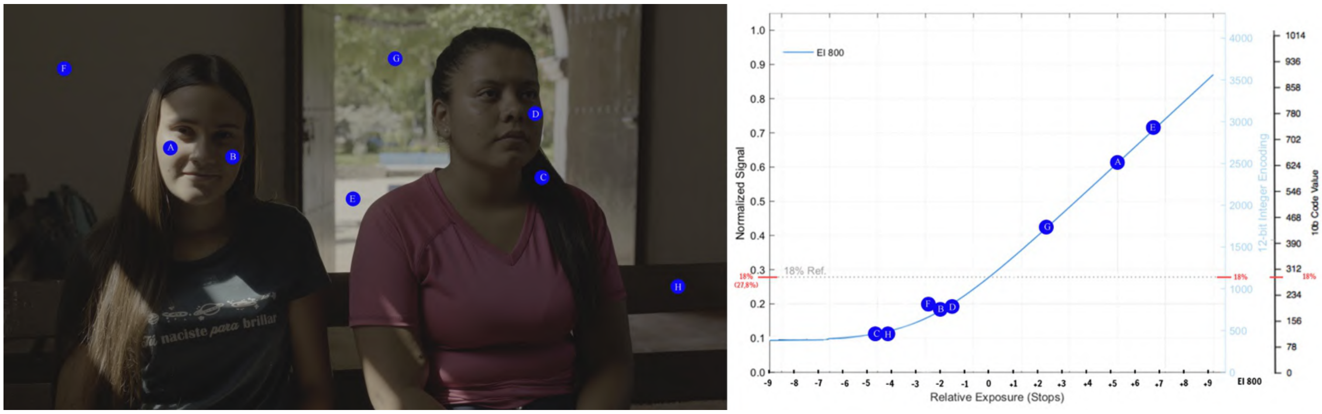


Figure 84. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 40mm T 4 ½

In this frame (*figure 84*) we have our talents inside the church and in the background, through the open door, we can see the park that is a little more than +7 stops (E) above medium grey. The shadow areas on the faces are between -1 and -2 stops (B and D), with the lower values for the wood on the bench (H) and the talent's hair (C), between - 4 and -5. As we saw in previous tests and we have verified here, that texture of both the hair and the wood of the bench can be recovered to the point of building blacks with texture and depth.

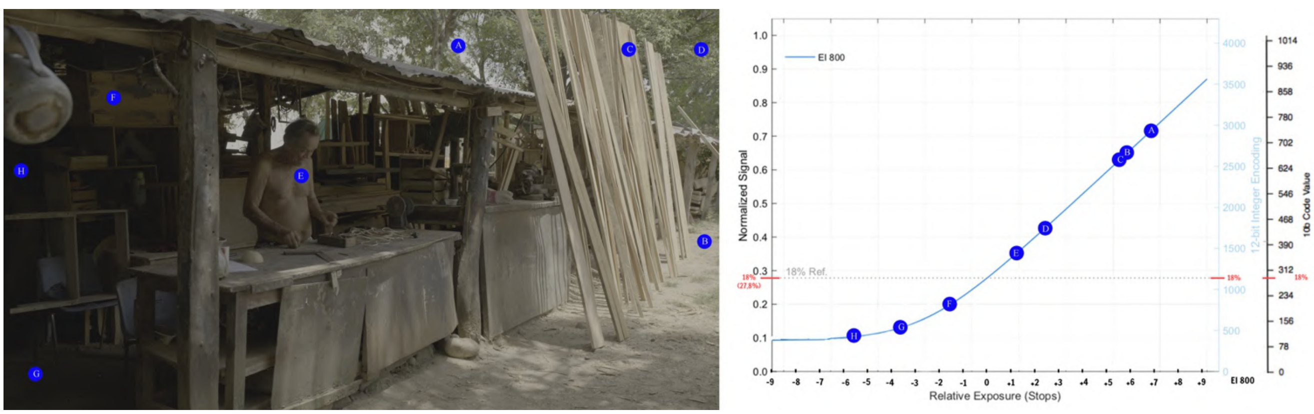


Figure 85. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 25mm T 4 1/3

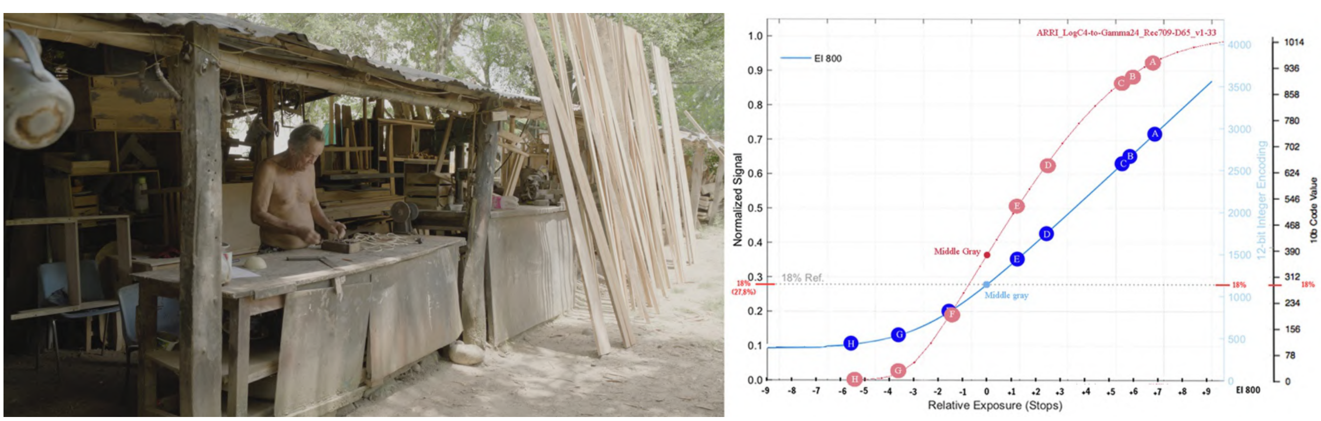


Figure 85B

In the frame of the carpenter (*figure 85*) we have a scene range of about 14 stops that the camera resolves without any problem. The entire exterior preserves the texture of the woods (C), the trees and the sand on the ground (B). Inside we can see detail up to -5 (H). Figure 85B shows the corrected image with the ARRI 709 lut. In the graph of the curves we have superimposed the Logc4 EI 800 with the lut to see how the brightness values change as a function of it. We see that the shadows are buried quite a bit, something that we have observed in all tests. The value of the middle gray in logC4 is 27.8% when we apply the Lut this value becomes approximately 37% (*figure 85C*), a value below the 42% standardized for Rec709 curve. When it comes to color correction with this Lut, we have had to increase the middle gray and the shadows to have an image less buried in the blacks.

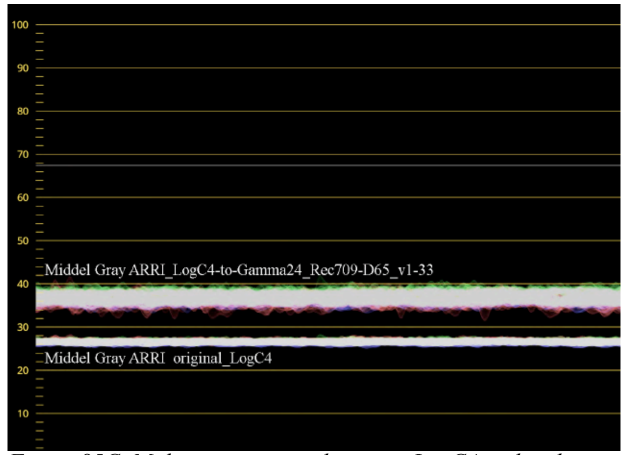


Figure 85C. Mid gray in original camera LogC4 and with Rec709 applied.

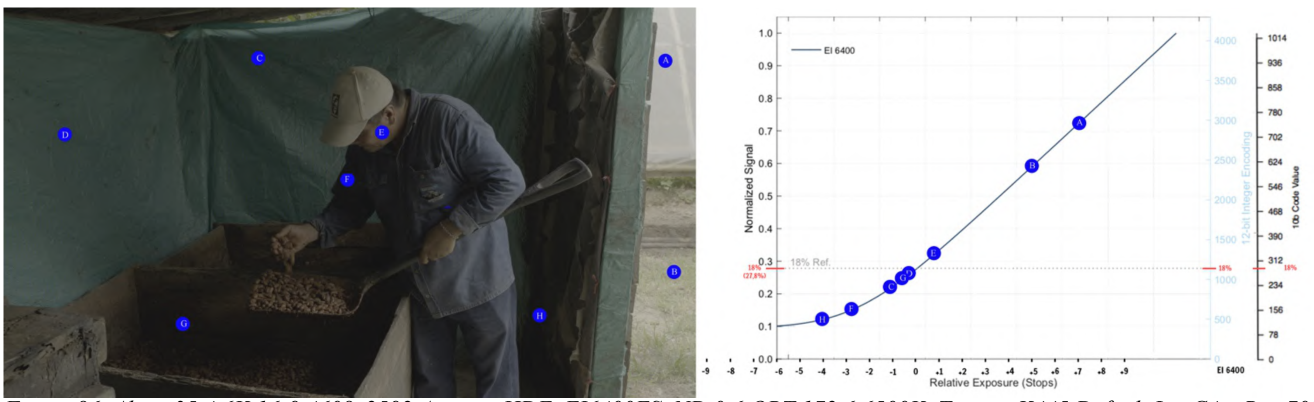


Figure 86. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI6400ES. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 a Rec 709. Lens Signature 25mm T 8.

In the following image (*figure 86*) we see the cocoa fermentation process. The dynamic range increases in the highlights, and decreases in the shadows as we have already observed when we increase the EI. In this case, the EI has been 6400ES, all the exterior that can be seen in the frame is more than 7 stops (A) above gray, and the darkest areas reach -4 stops (H), with which we have detail in all areas. It must be said that in this plane it is only illuminated by the light that enters through the door and that begins with it being closed.

The camera's ability to see so much range in highlights allows us to shoot with lower EI, without having a problem recovering texture in highlights.

In *figure 87* we show a scene of the talents in the desert with two different EI values, 200 and 400. At EI 200 the highest value, which is the clouds, is about +5 stops (A) above gray, while at EI 400 it is at +6. These EI changes are not compensated by the diaphragm value, precisely to be able to see that even by overexposing the image, the values are still in the range that the camera can reproduce. With EI 200 I can get to represent about 7 stops above the gray, while with EI 400 I can reach 8 stops, and that is indeed the case.

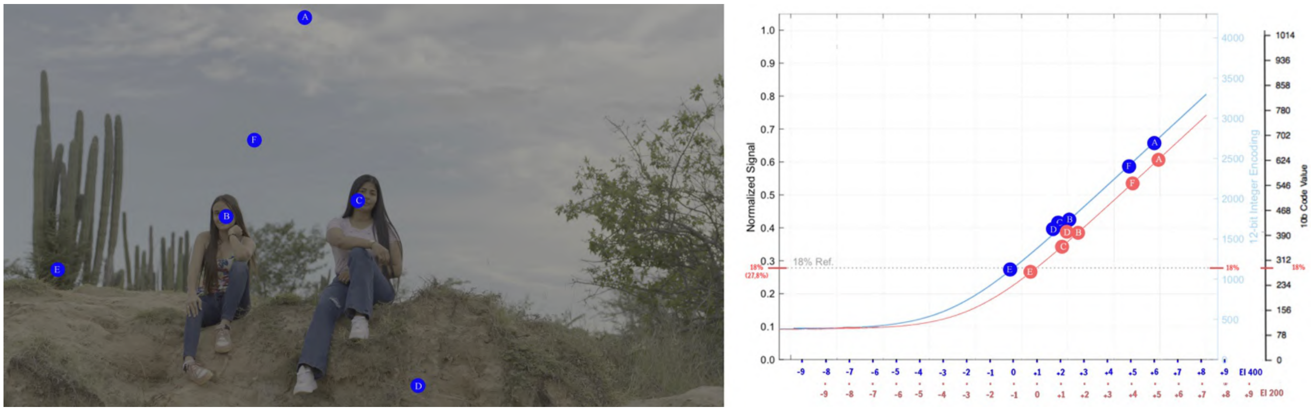


Figure 87. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI200. ND 0.6 OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 58mm T 28 1/3

With all these tests we can conclude that the dynamic range of the camera is about 17 stops if we consider all the luminance values that the camera can discern and that taking into account the noise in the shadows we can place it between 14 and 15 stops. The distribution of this range in relation to the mean gray is conditioned by the EI. If we take as a reference the value of EI 800 then the range above the medium gray is 9 1/3 stops and slightly more 5 stops below considering the noise (SNR value) as a factor that conditions the texture and detail in the shadows (Figure 87A).

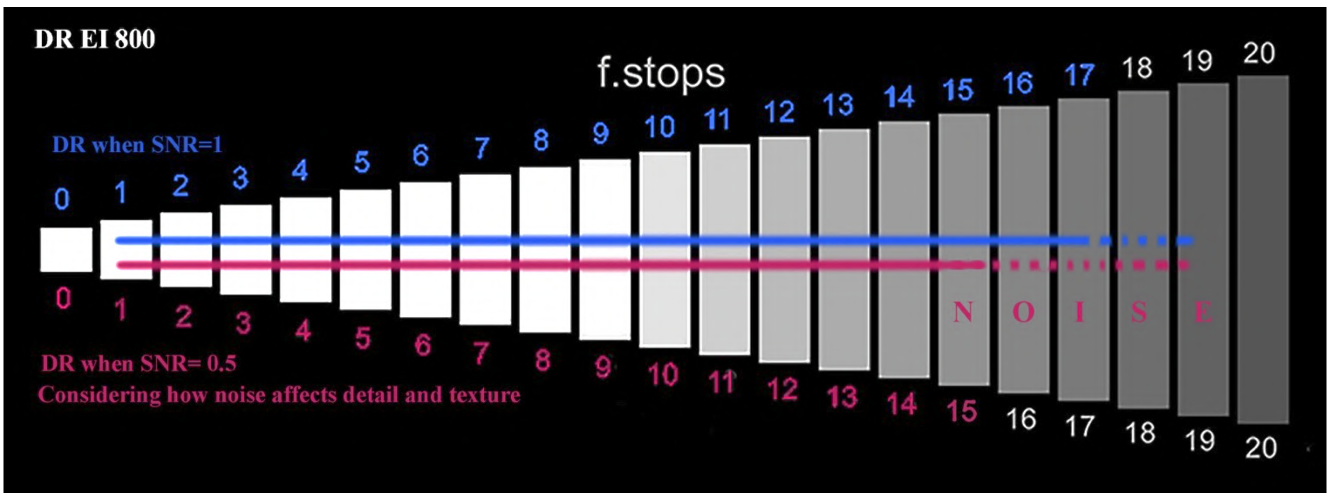


Figure 87A

COLOR

Chapter dedicated to the study of how the camera represents color, from the most objective analysis of the charts to the most subjective opinion of how we feel it.

There are several aspects of color that we have evaluated: its consistency throughout the different exposures, the different EI values, the response to different light sources, as well as the ND of the camera or the IR effect, among others. We have also evaluated our perception of this new science of color (Reveal) both in SDR and in HDR monitors and cinematographic projection. To assess the color consistency, we have shot the rainbow test chart first at different EI values. In *figure 88* we show the chart with its vectorscope at EI 200, 800 and 6400. If we ignore the noise, the tones are maintained throughout the different EI without noticeable deviations.

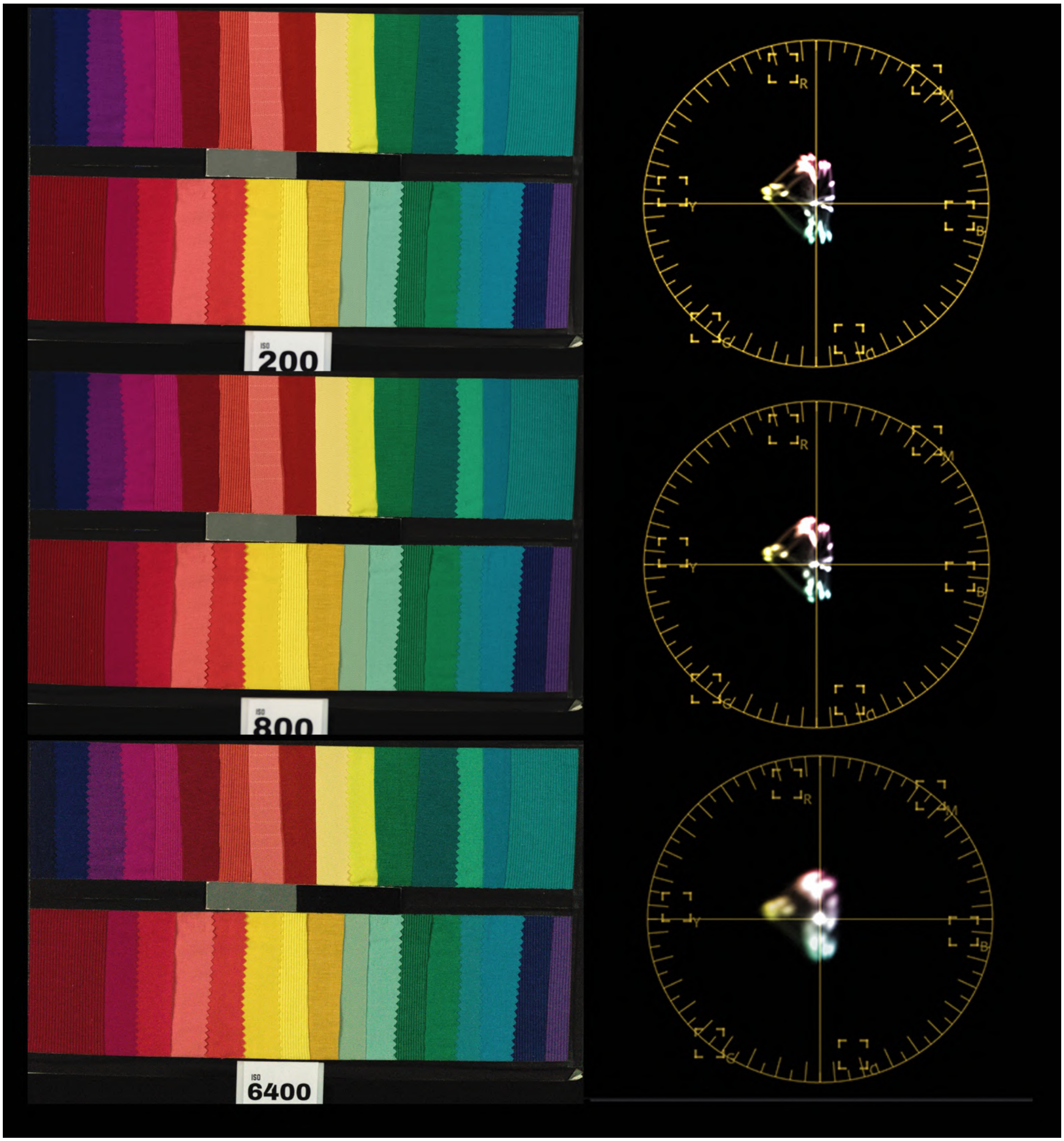


Figure 88

Let's see how the different EI values affect the talents (*figure 89*). There are no color deviations at the various EI values.

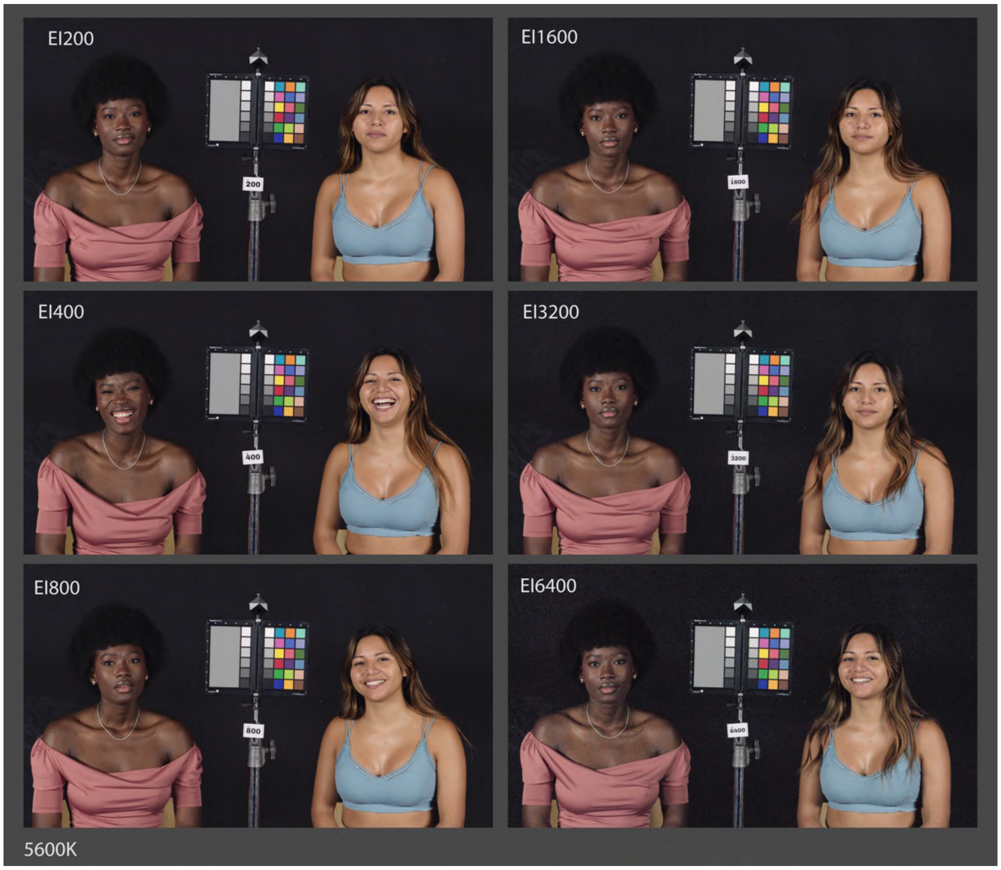


Figure 89

The contrast ratio in our talents shows that the color tone is maintained in both highlights and shadows with a very natural color appearance (*figure 90*).

Figure 90

On the rainbow chart's overexposed strip, there is no deviation in tones, even with +8 (*figure 91*). (See video part III).

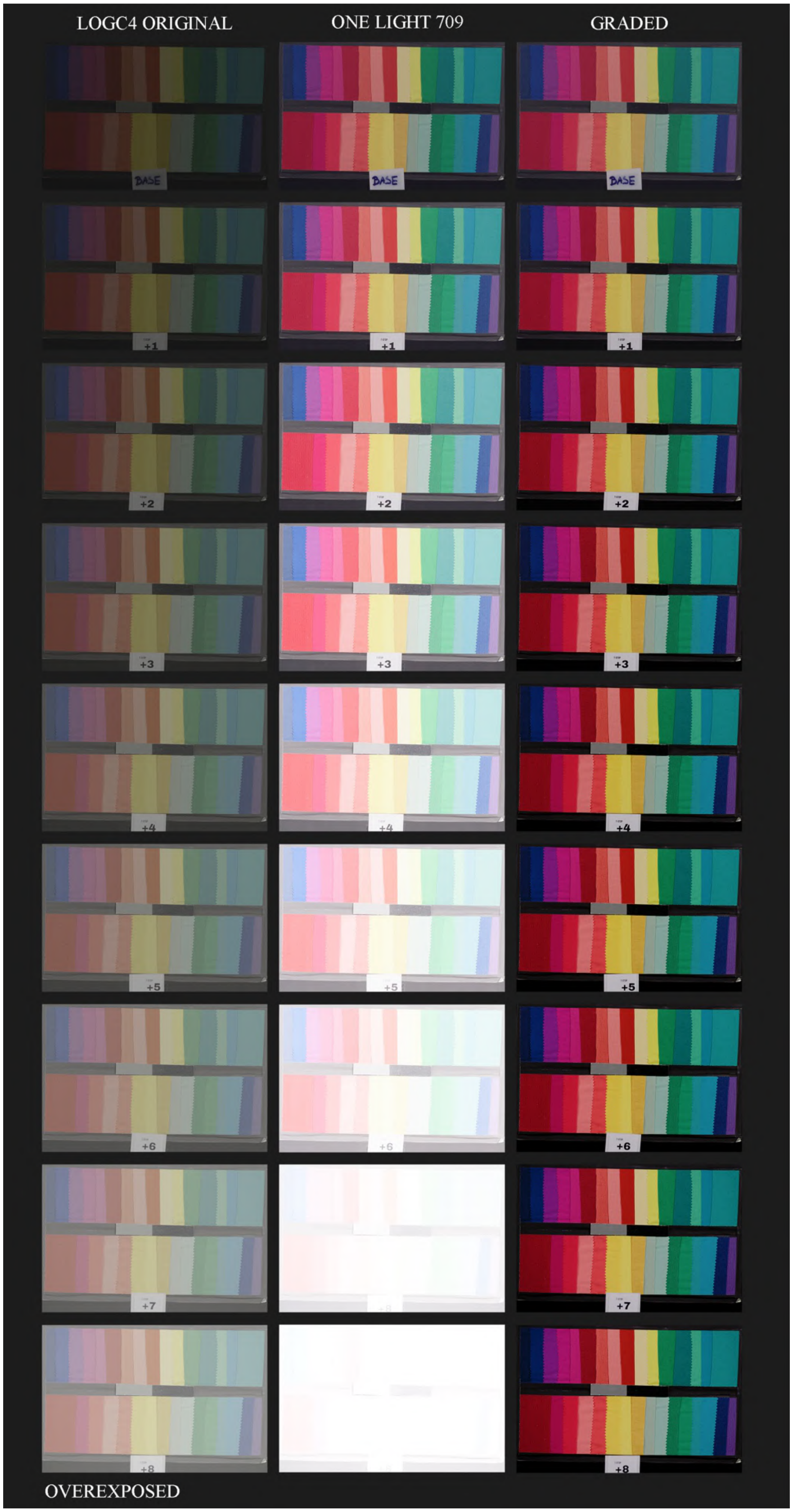


Figure 91

However, in underexposures from -4 when we want to match these exposures to the base, without modifying the color balance of the middle gray, the noise masks the tones, shifting them towards magenta/violet (*figure 92*)

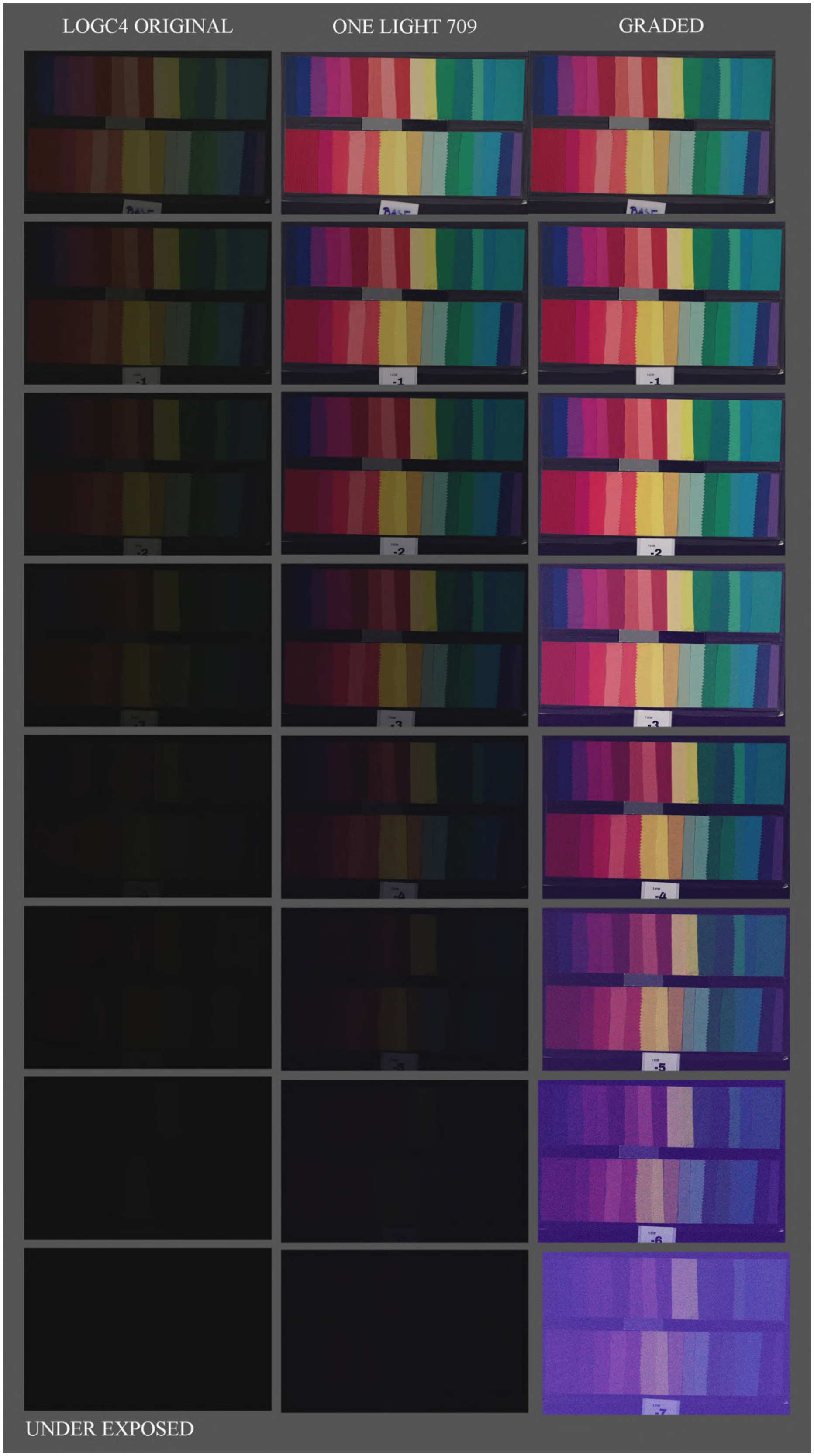


Figure 92

We can see it in more detail in *figure 93*. Again, remember that with an EI 800 we have been closing or opening the diaphragm in steps of one stop, without correcting the light, and then in post-production we compensate these changes of light by matching them to the correct exposure, that is, the one that has the gray at 27.8 with the LogC4 curve, or the value of 42% with an STD 709 curve.

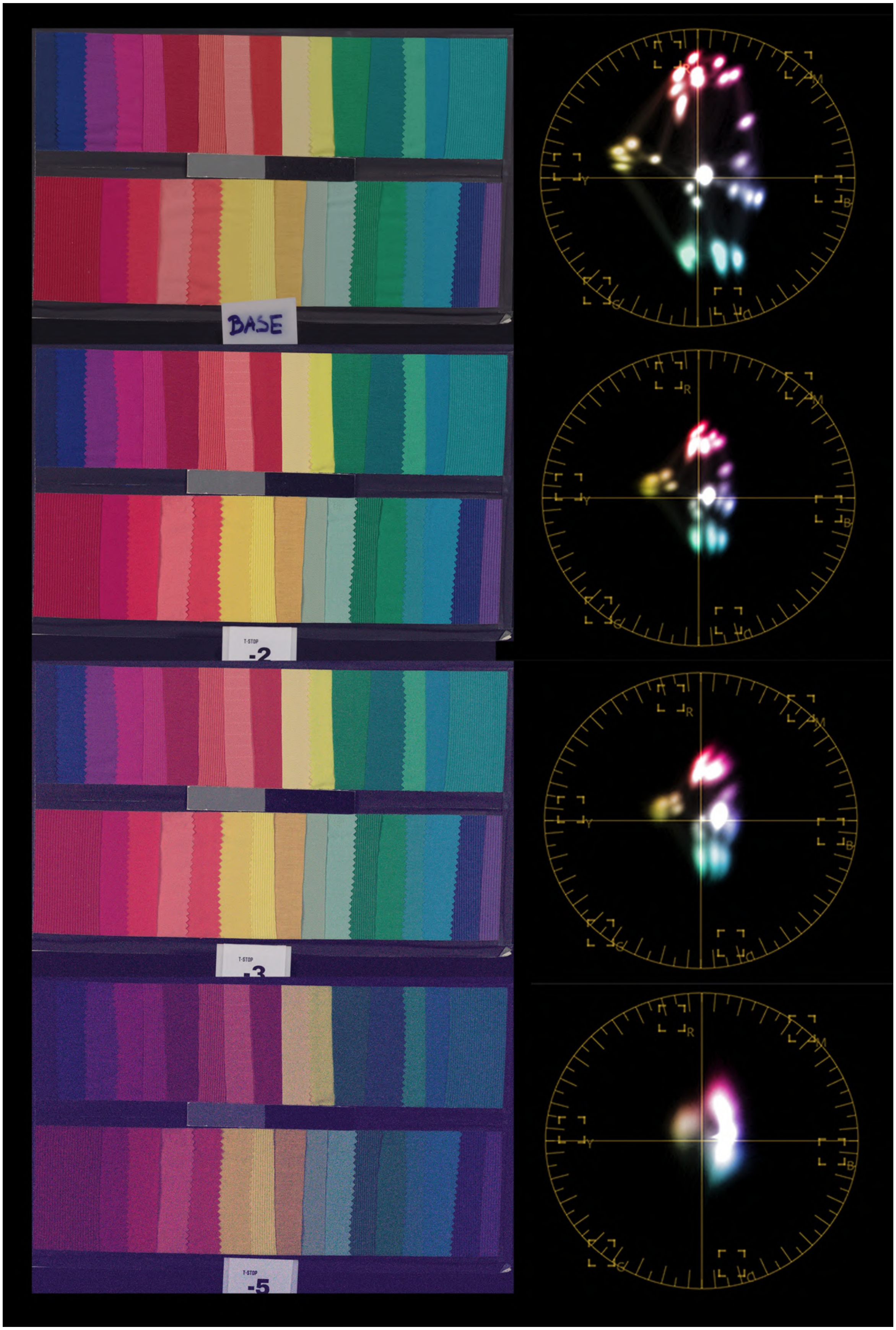


Figure 93

Now let's see the behavior in the still life. With overexposures (*figure 94*) the colors remain in their hue up to very high exposures, with no drift even when whites are clipped at 9 1/3 stops. (See video part II).

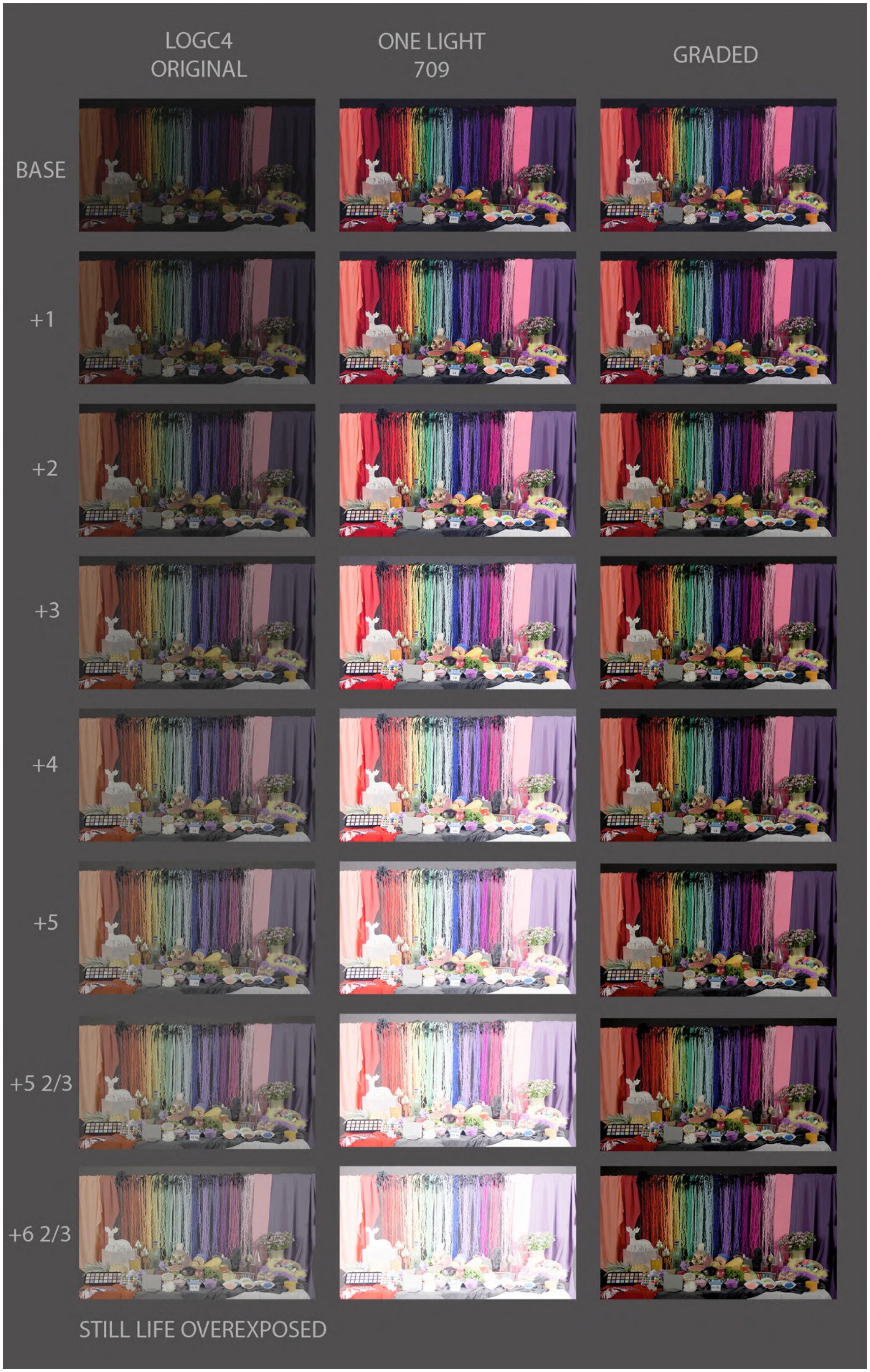


Figure 94

In underexposures (*figure 95*) the same thing happens as we have seen with the rainbow chart. From -4 there is a deviation towards magenta/violet that changes the tones. (See video part II).

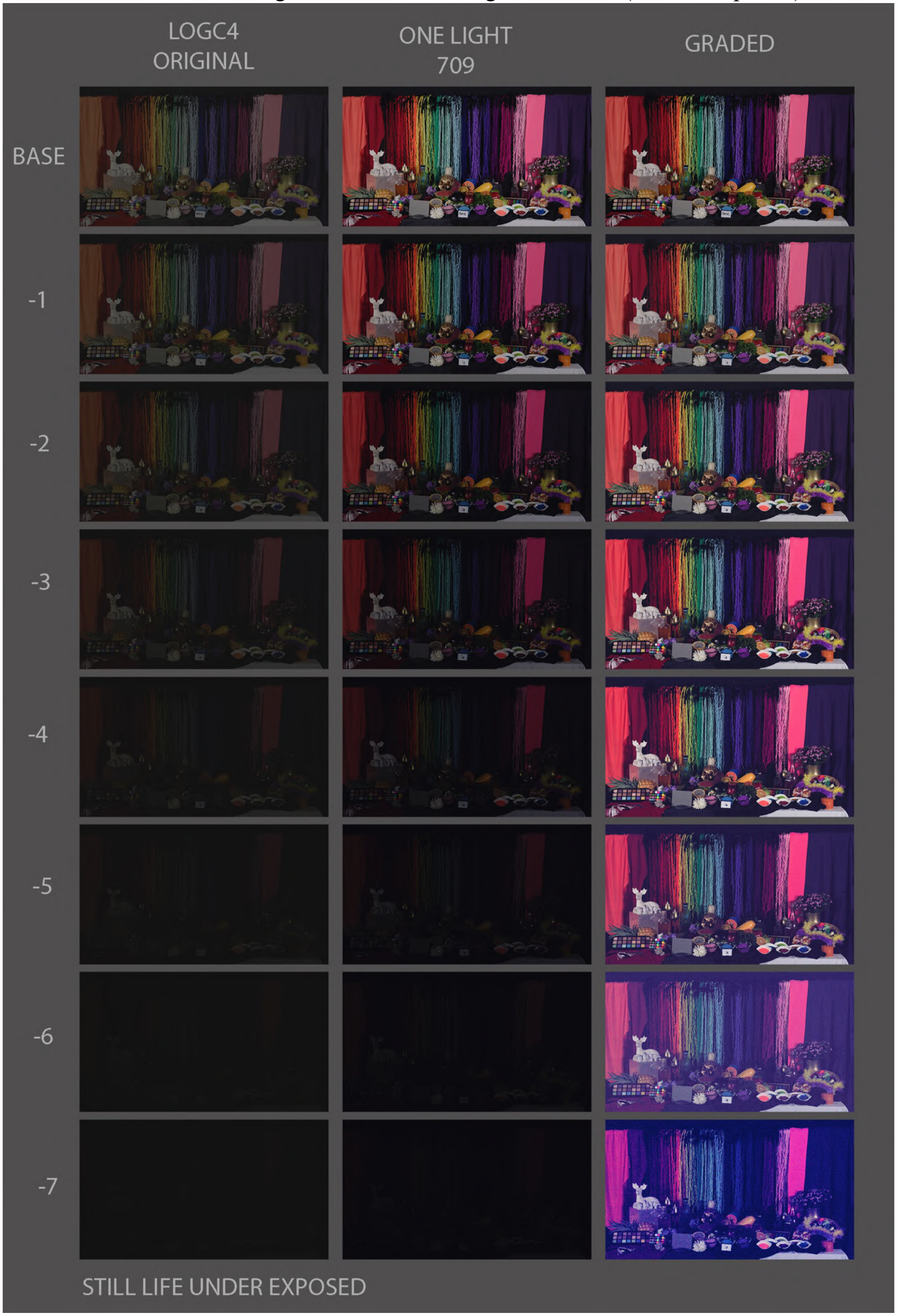


Figure 95

We can consider that the color is constant at EI 800 between the highest values of overexposure, up to a little more than +9 stops and in the shadows up to -4 stops.

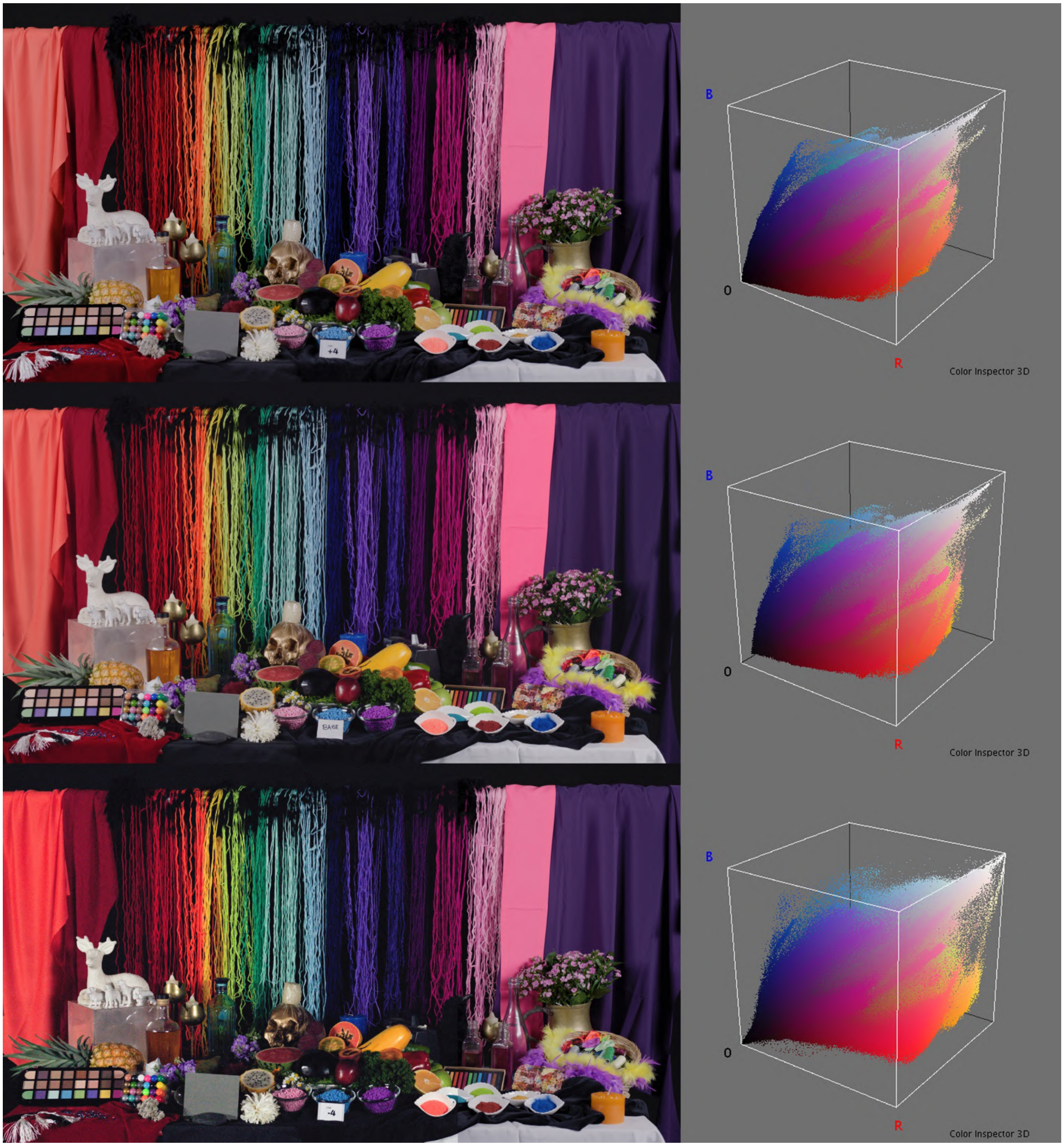


Figure 96

Figure 96 shows the still life with the base exposure in relation to +4 and -4. We have adjusted the base exposure to the 18% gray card and then adjusting only the light we have balanced the other two exposures, to the right of each frame we have put the color distribution in RGB space. In general, the tones are maintained in the exposures, although with -4 the red of the canvas in the corner of the frame is saturated and with +4 it is slightly desaturated, which is normal. The important thing here is that in all that range of exposures the tones do not change substantially.

The color is not affected by other aspects such as, for example, the IR effect (*figure 97*) or the ND filters (*figure 98*). With the ND, only a very slight deviation towards magenta / red is noticeable in the vectorscope with the ND 1.2 and with 1.8 towards the red, but in the usual use of the camera it is irrelevant.

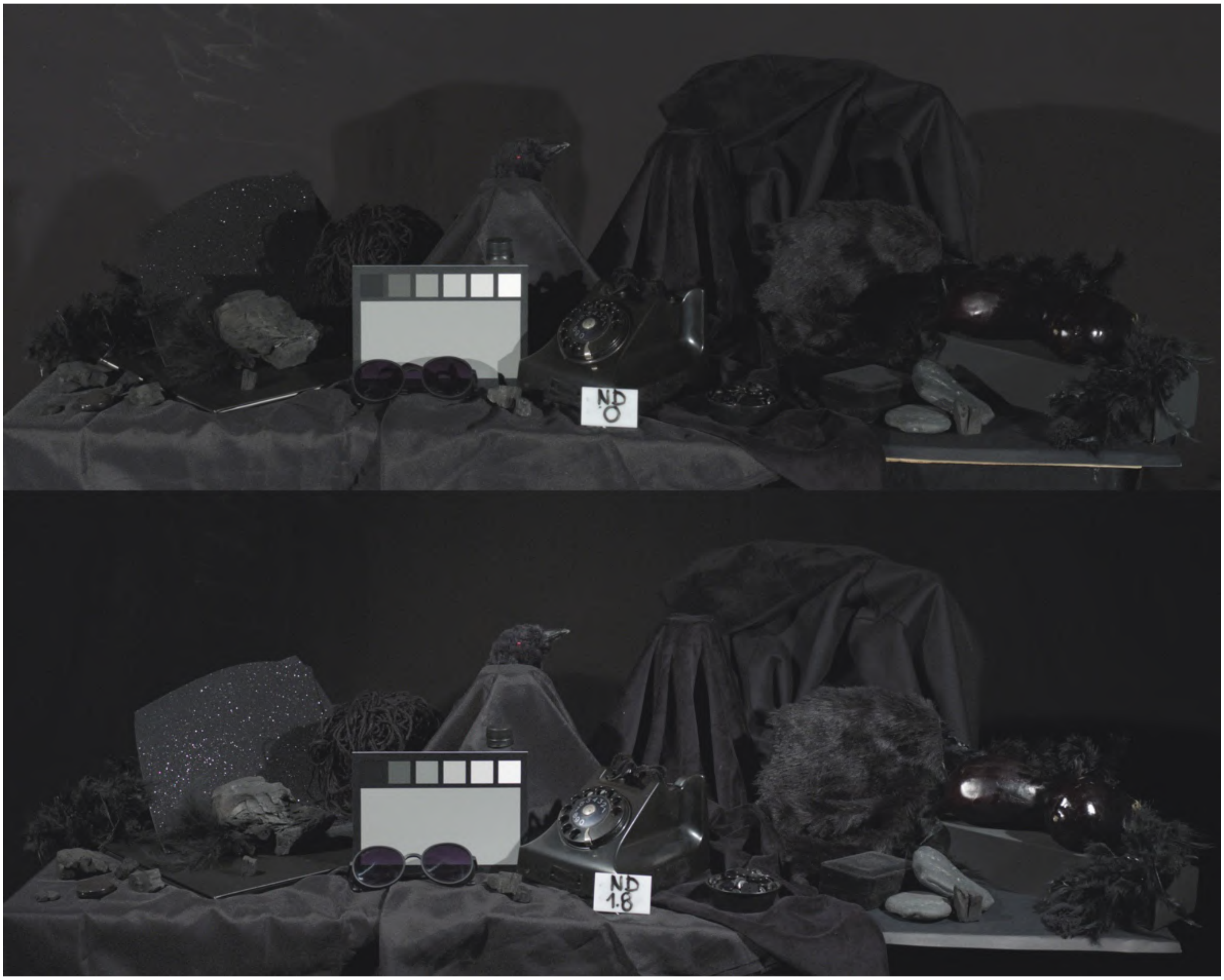


Figure 97


Preparing the still life

It is not necessary to put any type of IRND filter in the camera if we are using its internal filters, since these correct infrareds very effectively, as we show in the figure, there is no deviation in the blacks of the still life, which it is illuminated with tungsten, between ND 0 and the largest of them ND 1.8.

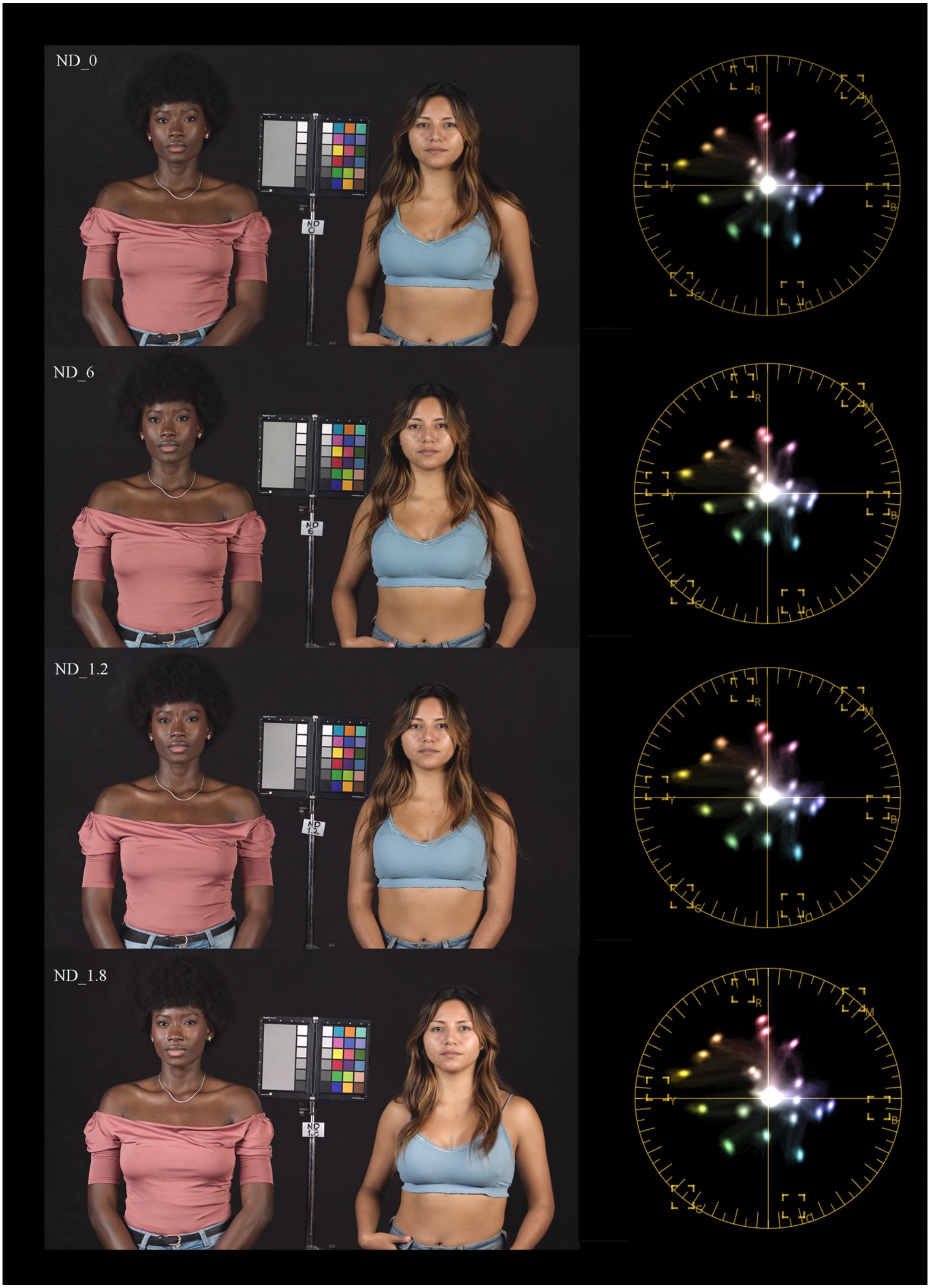


Figure 98

Let us now consider the color depending on the lighting devices and their different spectral responses, for this we have photographed our talents adjusting the color temperature of the light sources with the spectrometer to the appropriate color temperature in the camera, adjusting all the parameters to obtain a balanced light source. In postproduction we have revised the medium gray and left it completely neutral. The Arri wide gamut 4 color space (*figure 99*) shows some new primaries compared to the previous space and a capacity to show more color tones and that widely covers the 2020 space, so the deviations that we can find in the color, on all in skin tones, are easily controllable in the coloring process.

In figure 100 we show the comparison between two color temperatures 3200K and 5600K with different light sources, the HMI are two ARRI 575W, the LEDs are two ARRI Skypanels, which we have used at the two color temperatures, the fluorescents are two KinoFlo both with 5600K and 3200K tubes and finally two ARRI 2k tungsten devices.

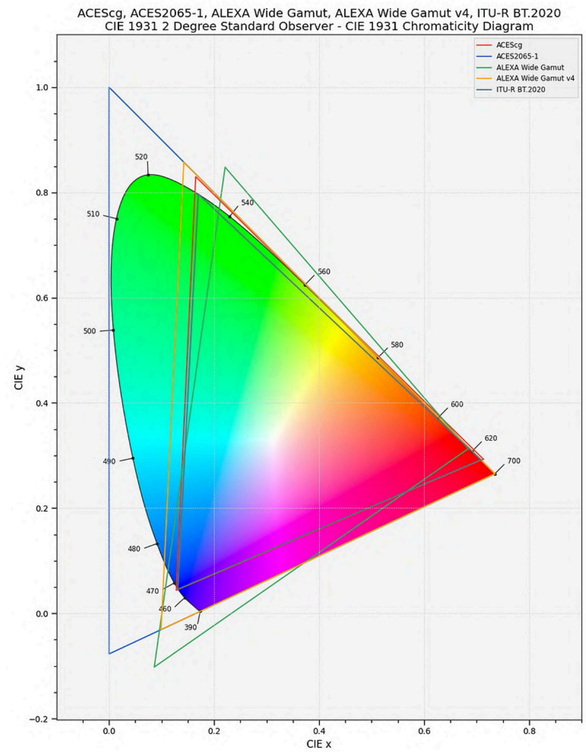


Figure 99

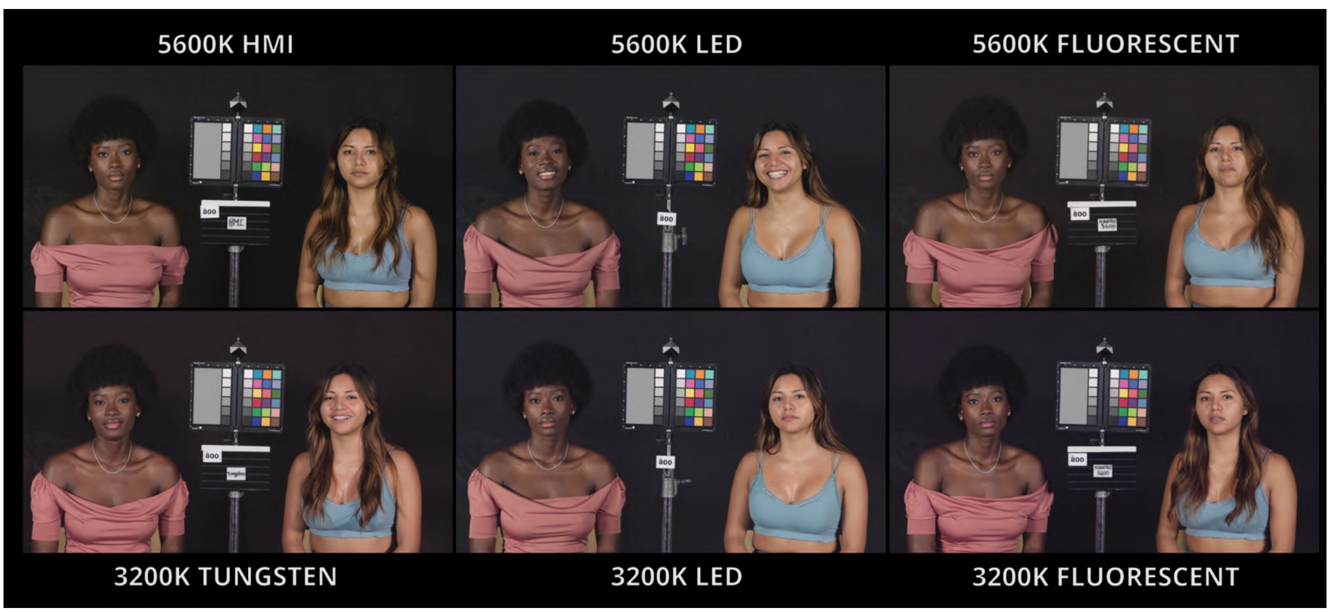


Figure 100

In all the frames the middle gray of the card is identical and is the one we have used as a reference. We haven't touched any color in the colorization. We have already observed that with HMI the skin tones are more green/yellowish than with tungsten which are redder, with led light at 5600k they are less yellowish than with HMI, although less red than their corresponding 3200K, the same result seems to show the kinoFlo. In *figures 101 and 102* we show the cutout of the faces of the talents to see the differences in detail (see video III).

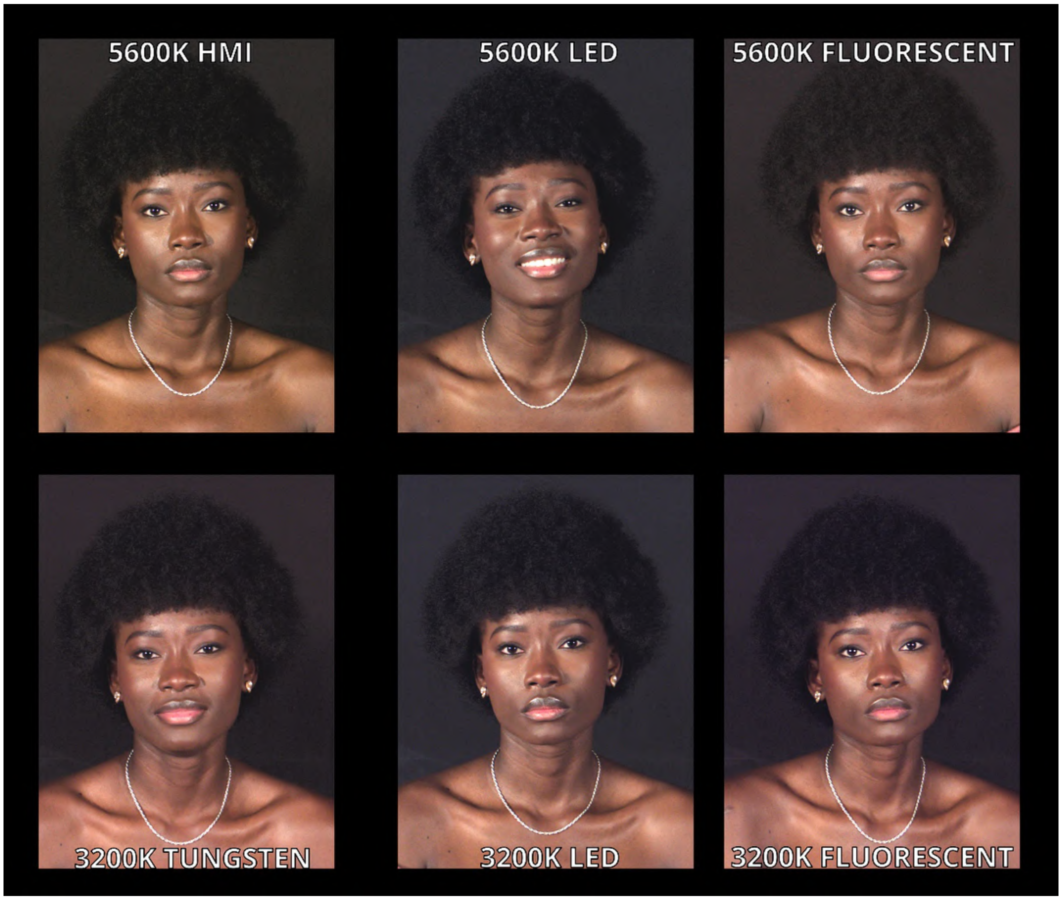


Figure 101

Figure 102

Figure 101B

Figure 102B

For a more detailed view I have compared the different lighting devices in a split image of the faces of the talents (*figures 101b and 102b*).

These color differences are perfectly manageable in post-production, due to the wide color space used by the camera, as well as the bit depth used in RAW to encode and record the image.
These images attest to the delicate ability to capture color and then process it with the new color science developed by ARRI.

Figure 103. Tatacoa desert. Colombia. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800.OBT 172.6 6500K Texture K445Default LogC4 to Rec 709. Lens Sigma 14mm T 8

We like not only the texture of this image (*figure 103*), but also the representation of the color of the earth, of its small nuances, captured in all its breadth. The image is delicate, natural, organic in the relationship of light and shadow, in the small contrasts of the earth that give it volume.

Figur3 104. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800.OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 125mm T 4

The skin tones are simply natural, soft and with many nuances, both in color and texture (*figures 104 to 107B*). The same happens with the colors *(figure 108*).


Figures 105 and 106 Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800.OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709.Lens Signature 58mm T 2

Figure 107. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI2560ES.OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709.Lens Signature 125mm T 4

Figure 108 Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800.OBT 172.6 6500K. Texture K445 Default LogC4 to Rec 709. Lens Signature 58mm T 2.8 1/2


Figure 107B. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800.OBT 172.6 6500K. Texture K445Default LogC4 to Rec 709.Lens Signature 125mm T 2.8 1/2

Finally, in this color section, we have tried to make a chroma with our talents. We have not found any problem in the creation of the mask or the creation of the final assembly. No artifacts or noise has been a condition for effective integration (*figures 109 to 111*)



Figures 109 and 110. Alexa 35 4.6K 16:9 4608x2592 Arriraw HDE. EI800.OBT 172.6 5600K. Texture K445 Default LogC4 to Rec 709. Lens Signature 58mm T 8 2/3


Figure 111. Final composition

TEXTURES

In this section we evaluate the textures that the camera allows you to choose from its menu and with which we can customize our image.

The Alexa35 camera offers a series of textures that allow you to change the image from the standard one and which basically consist of modifying the resolution and noise, the latter both in quantity and in sharpness and color. The changes that occur with these textures need to be seen on a large screen, either a monitor or in projection. In our case we have seen its effects on the 48” screen in the Crayola color room, as well as on the cinematographic screen of Cinecolor Colombia. We are going to look first at the resolution *(figure 112*), although we already had the opportunity to see how the textures affect the sharpness of the image in the resolution section.

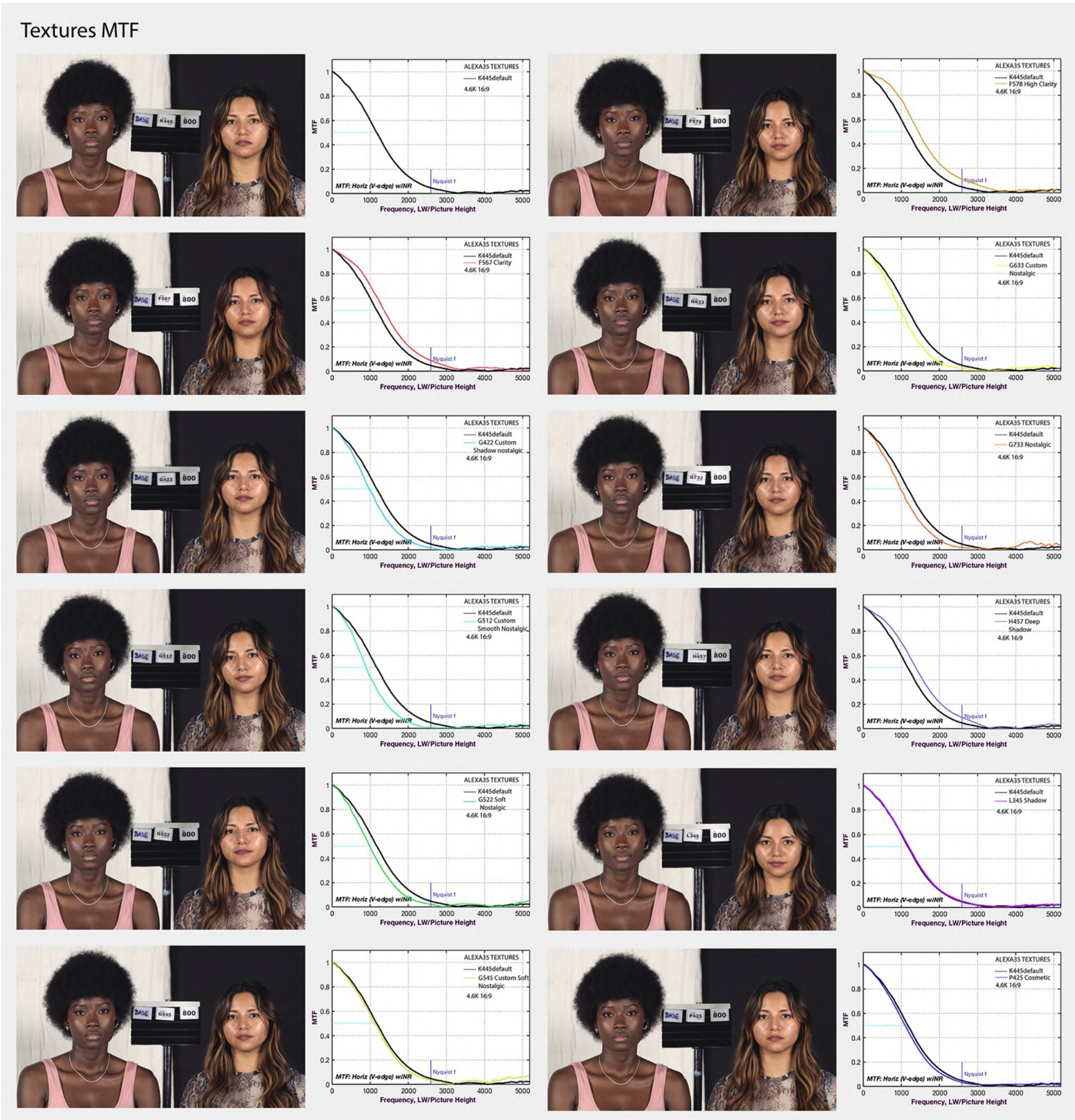


Figure 112

Next to each frame with its texture I have put the corresponding MTF curve comparing it with the K445 which is the default in the camera. The F567 Clarity and F578 High Clarity textures show greater sharpness in the image. The first shows a resolution in the center of the image of 1362 Lw/ph at 50%, the F578 High clarity gives 1449 Lw/ph against the 1172 Lw/ph of the default K445 texture. The H457

Deep Shadow texture also shows better resolution, 1383 Lw/ph in the center of the image and at 50%. Other textures such as the L345 Shadow or the G545 Custom Soft nostalgic do not present, in terms of resolution, substantial differences. There are other textures that are softer on the contrary, with less sharpness than the K445, for example, the G733 Nostalgic that gives a resolution of 973 Lw/ph compared to 1172 Lw/ph. The differences can be seen in *table 17* and *figure 113*

EI values	LW/PH 50% (AT PICTURE CENTER)
K445	1172
F567 CLARITY	1362
F578 HIGH CLARITY	1449
G422 CUSTOM SHADOW NOSTALGIC	975
G512 CUSTOM SMOOTH NOSTALGIC	895
G522 SOFT NOSTALGIC	987
G545 CUSTOM SOFT NOSTALGIC	1110
G633 CUSTOM NOSTALGIC	960
G733 NOSTALGIC	973
H457 DEEP SHADOW	1383
L345 SHADOW	1190
P425 COSMETIC	1101

Table 17

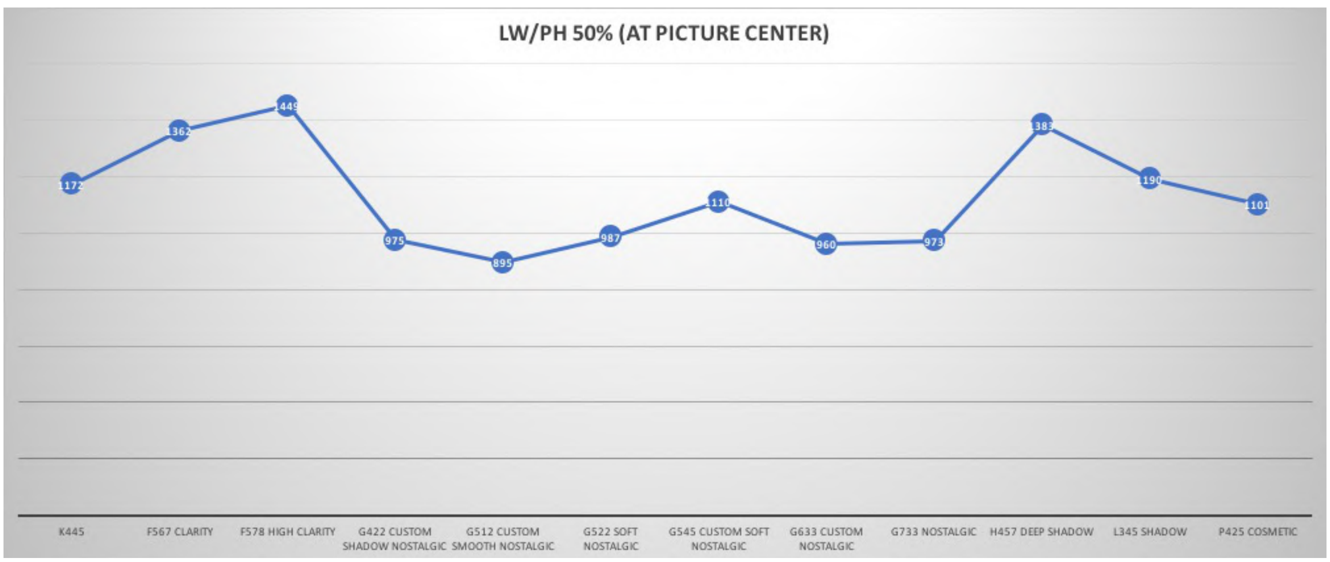


Figure 113

Tatacoa desert. Cinematographer Adriana Bernal ADFC on camera

With this table, we can know which textures will appear with more or less sharpness, and with the one we present now we can evaluate the noise. We have shot a Macbeth chart and through the Imatest analysis we have obtained the SNR values in each of the textures in **RGBY** (*table 18 and figure 114*)

TEXTURES	R (DB)	G (DB)	B(DB)	Y(DB)
445 Default	34,4	37,2	36,7	39
F567 Clarity	32,1	37,5	33,9	40,6
F578 High Clarity	31,8	35	33,9	37,2
G422 CUSTOM SHADOW NOSTALGIC	33,5	36,8	33,6	38,4
G512 CUSTOM SMOOTH NOSTALGIC	30,3	35,2	30,9	37,8
G522 Soft Nostalgic	30,1	34,9	30,8	37,4
G545 CUSTOM SOFT NOSTALGIC	30,1	34,3	30,7	36,5
G633 CUSTOM NOSTALGIC	30,2	34,9	30,7	37,3
G733 Nostalgic	29,9	33,6	30,3	35,4
H457 Deep Shadow	33,9	39,8	35,9	42,9
L345 Shadow	37,5	40,8	39,5	42,4
P425 Cosmetic	37,7	42,5	40,2	44,4

Table 18

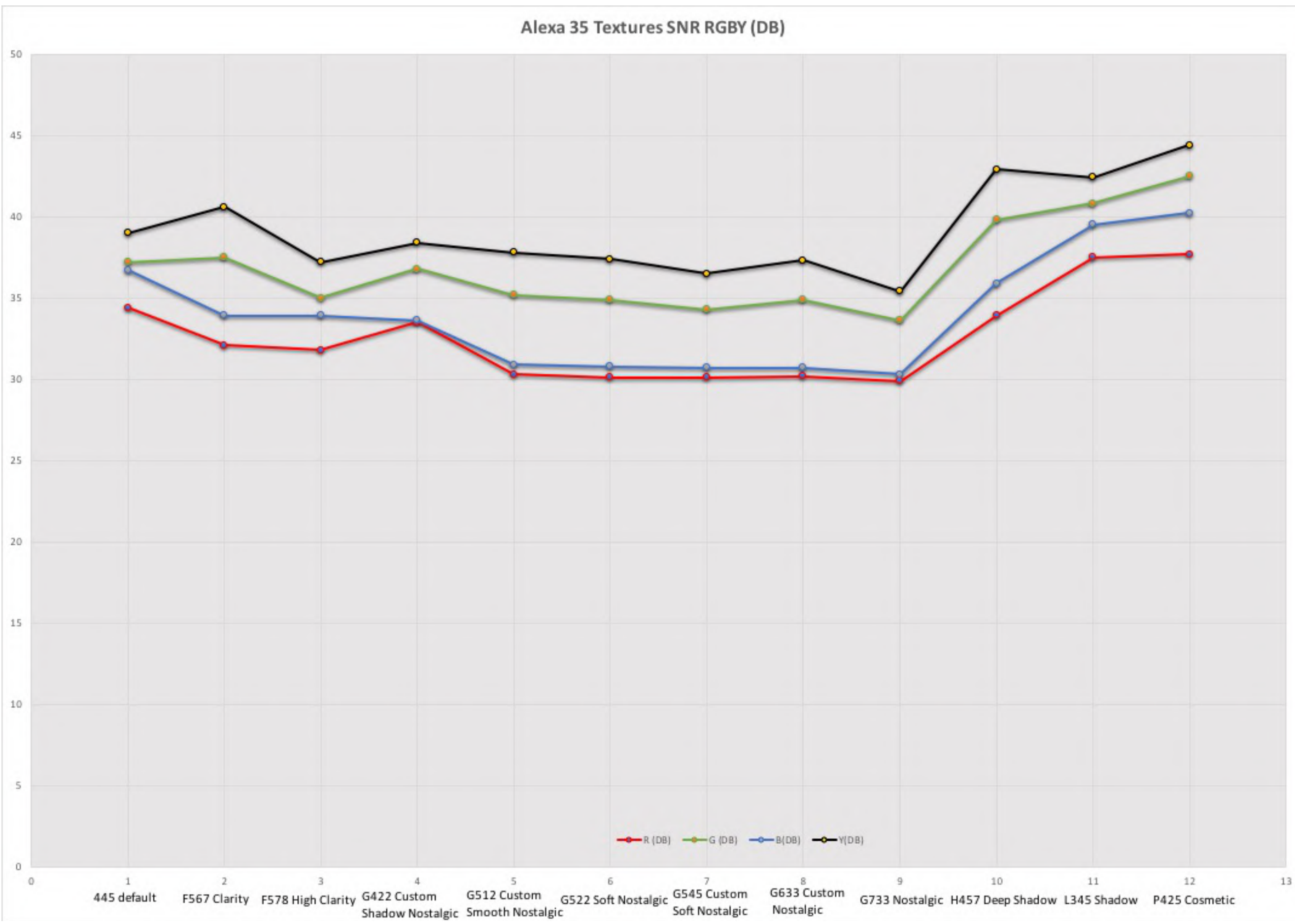


Figure 114

In **Y**, F567 shows better SNR than K445 the default texture, but not so F578 High Clarity. The H457 Deep Shadow, L345 Shadow and P425 cosmetic textures are the ones that show a better SNR, above 42db compared to the K455, which stands at 39db. And all those that refer to the concept "nostalgic" have a lower SNR, for example G733 Nostalgic has an SNR value of 35.4db compared to 39db of the K445. We will see that this texture actually has more noise and a different color than the default texture. *Figure 115* shows the talent with the color and resolution charts together with its image passed through the edge detector in order to better visualize the differences in sharpness, not only in the contours of the figures but also in noise.

Figure 115

Totumo Museum. Villavieja. Colombia

Figure 116 shows the different textures with the vectorscope corresponding to the color chart of each one. As we can see, there is no difference in the color tones, but in how they look with more or less noise, for example, compare the P425 cosmetic texture with the G733 Nostalgic texture.

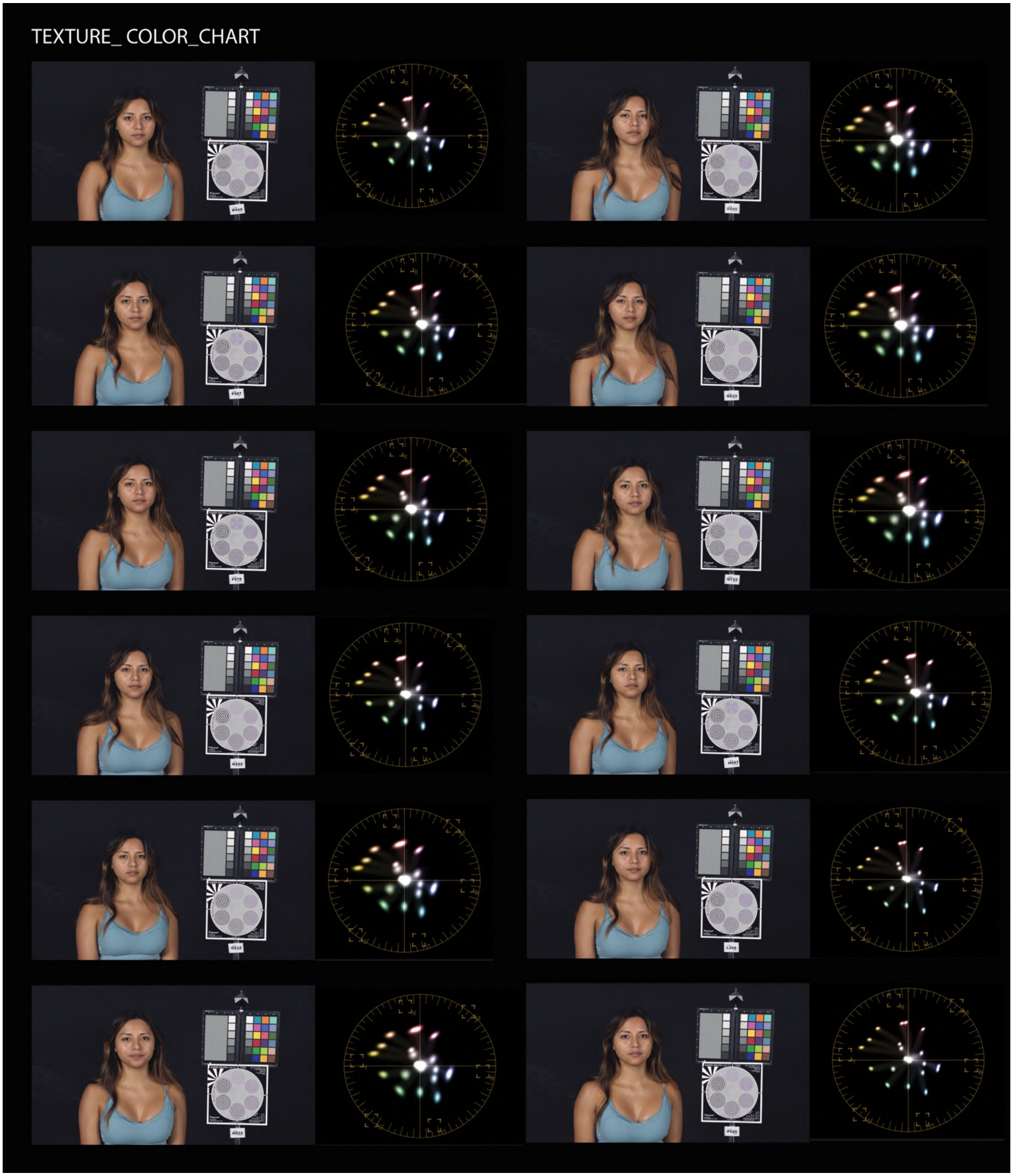


Figure 116

Filming in the Tatacoa desert.

The mixture of "detail" and "noise" configure the different textures. We have proceeded to shoot our talents with all the textures and then we have enlarged their faces to better visualize these modifications. All enlargements have been made on the same scale.

Figure 117

Figure 118

These two textures (*figures 117 and 118*) are the ones that show the greatest sharpness in the image, it can be seen well in the eyes, on the lips and on the talent's own skin.

Figure 119

The P425 Cosmetic texture (*figures 119 and 120*) appears slightly smoother and with less noise (see Part III video).

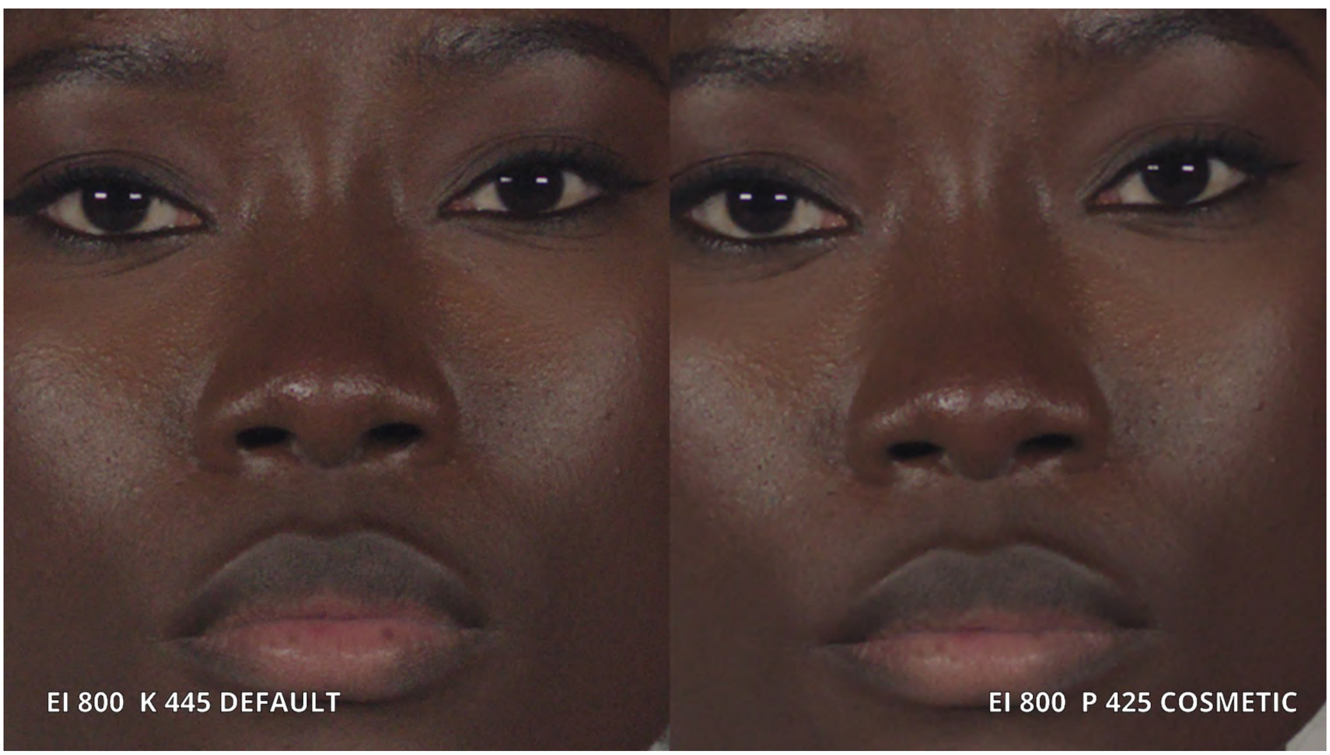


Figure 120

Figure 121

The G733 Nostalgic texture displays with more noise and less sharpness than the K445. The difference with the color talent is also clearly visible (*figures 121 and 122*).

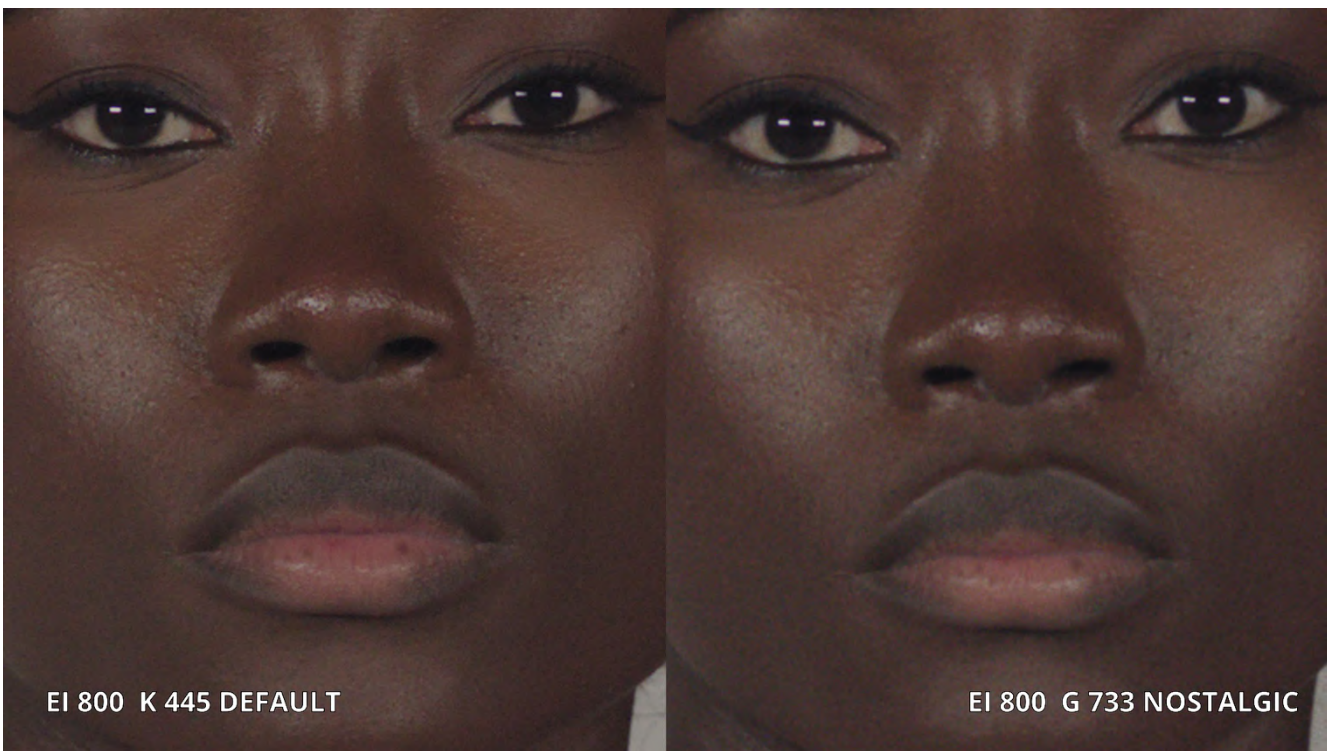


Figure 122

And a joint vision of four of the textures (*figure 123*).

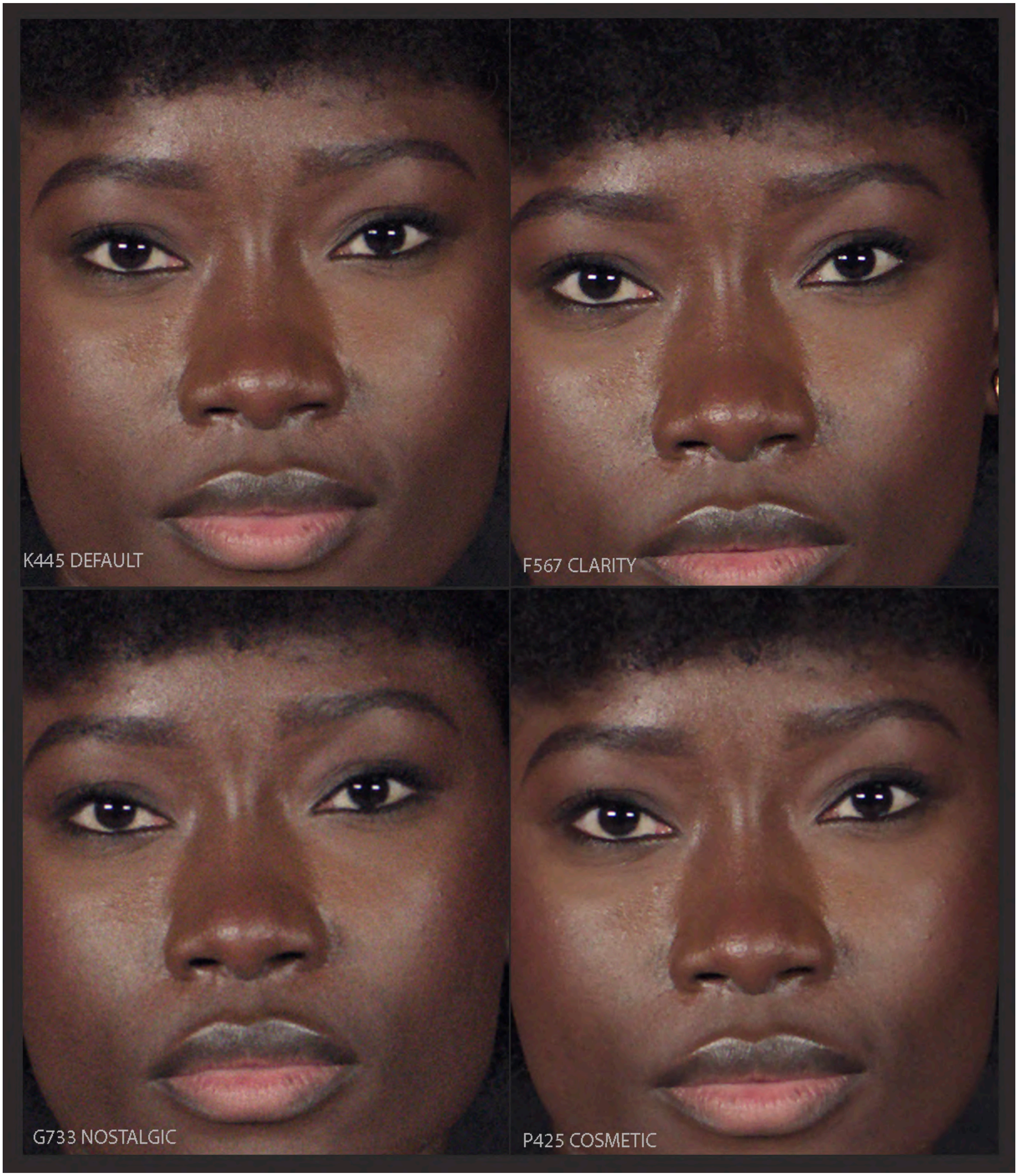


Figure 123

Finally, we show this frame that we have shot with three different textures (*figures 124 and 125*)

Figure 124

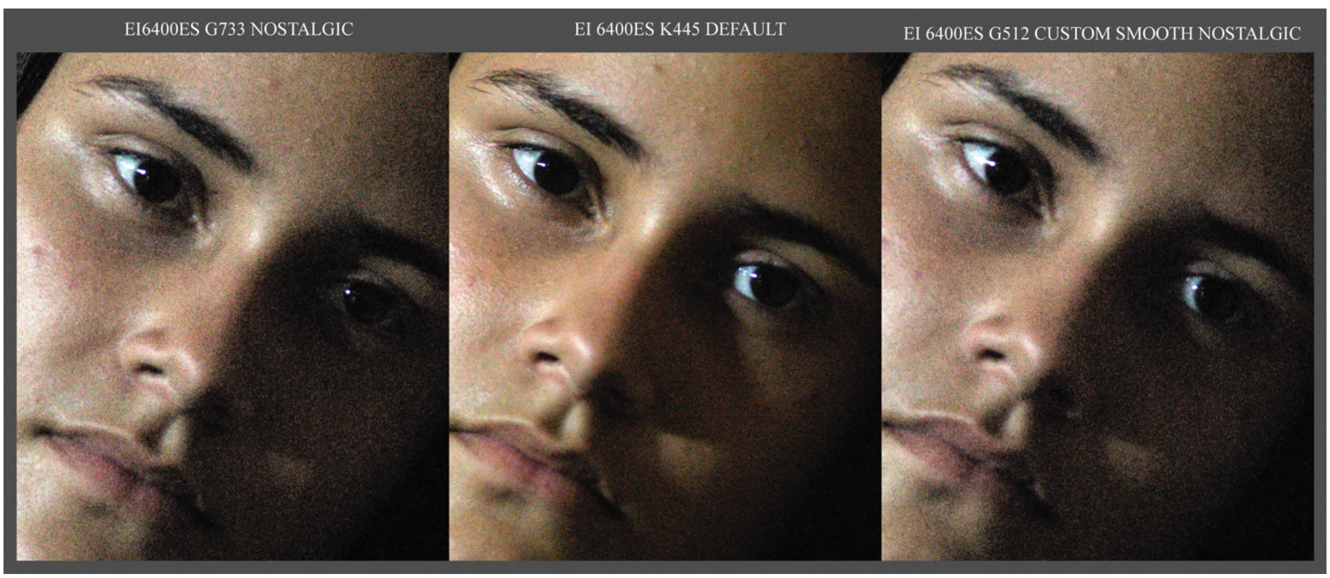


Figure 125

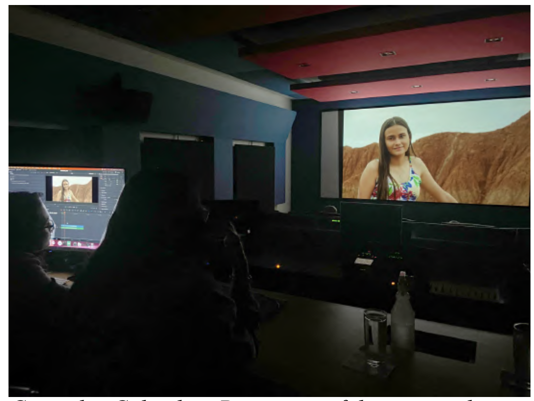
The G512 texture is smoother than the G733 and with a little less noise and a little more saturated. The difference with the K445 texture is notorious (see Part III video).

The textures have seemed very subtle and elegant, without creating dramatic changes and they do provide another aspect to the image than the default texture of the camera. We find them very interesting to explore. Of all the ones we have tried, I am especially interested in the F567 Clarity, the H457 Deep Shadow and also the G512 to create an image with a soft grain, which gives the image a lot of personality.

CONCLUSIONS

After this study we can conclude that the new ARRI camera follows the path of its predecessors in the attempt to show digital images that recall the goodness of emulsions in capturing highlights and in the texture of noise. The resolution of the camera is soft, which means that it shows a moderate 50% contrast within the 35 format, certainly below Full Frame systems and this helps to moderate that sensation of extreme sharpness that the image sometimes shows digital, also adding the ability to show the texture in a natural and very organic way; when we say organic, we want to point out that all the elements that make up the image, from the contrast ratios, the high lights of the cloudy desert skies, to the earth tones of the eroded image itself, constitute a balanced whole where each of the parts is in perfect harmony they equate to what our eyes could feel. And with natural we mean how the images created by the camera recall our looking at the same place and location of the shoot. The high dynamic range of the camera 17 stops, especially in highlights, something truly exceptional that exceeds 9 stops (EI800) is one of the fundamental pieces in this representation of reality, there is currently nothing comparable to this ability to capture detail in highlights, to the point that the image can be overexposed up to at least 3 stops without losing detail, which allows more information in the shadows with less noise. In the shadows is where the camera is more conventional within the range of high-quality cinematographic cameras, with a capacity to show detail and texture of up to -5 stops considering how noise affects them, although we continue to see different luminance values up to -7 and -8 stops at least. However, it must be noted how noise looks different, its completely random movement is very reminiscent of film emulsions, and not only because of the movement, but also because of the color of the noise, which emulates the color of the "grain".

Jorge Román Colorist. Crayola Films



Cinecolor Colombia. Projection of the tests in the color room.

On the other hand, ARRI provides us with some textures that, managing the noise in its quantity and color, as well as the detail in the camera, allows us to customize the image in some way according to our narrative discourse. If the dynamic range is important, the sensitivity of the camera is no less important, and therefore the handling of noise, which allows us to film with very high EI values without major noise problems or loss of resolution. The sensitivities with which we can shoot are all those shown by the cameras, although my range is between 160 EI and 3200ES. The ES values make a huge noise reduction compared to the same normal EI and with a practically irrelevant loss of resolution. So, the range of sensitivities that we can use is very large, although I don't rule out increasing it by shooting at 4800ES and 6400ES, especially since, if necessary, I can count on the noise that appears there as a first-rate narrative tool, in fact, in the tests I really liked running at 6400ES with the G512 texture. The color of the camera is following the same path, which has seemed really different to us, because not only is the color maintained constant in the exposures, in the highlights and in the shadows, but also that you show many tones that in a very subtle, they create that organic and natural condition that we mentioned above. The camera results in images full of color nuances, subtle and delicate, especially skin tones.
The camera requires more power, so it is recommended that the batteries have a high capacity, as well as the resources both in the DIT station (see annex 1) and in post-production where we have observed that the files actually require more machine than for example, with the MiniLF. For the rest the camera has worked without problems in all areas in which we have used it.

Lastly, I want to review the app that allows you to control the camera from your phone, which has worked perfectly and has turned out to be very comfortable.

Video links

Obertura Parte I
https://vimeo.com/manage/videos/831300189
Parte II
https://vimeo.com/manage/videos/831538908
Parte III
https://vimeo.com/manage/videos/833648108
Video Tatacoa Desert. Villavieja. Colombia
https://vimeo.com/manage/videos/838475196
Video Making of
https://vimeo.com/manage/videos/838821592

Studio shooting crew

Location shooting crew. Río Magdalena. Colombia

References:
- Arri website https://www.arri.com/en/camera-systems/cameras/alexa-35
- Arri textures Alexa 35. Technical Note
- Alexa 35 workflow & Post guide. Guideline
- Arri Alexa 35 User manual
- Arri LogC4. Logarithmic Color Space. Specification
- Alexa 35 Recording Formats.
- Film and digital Times. Alexa 35 Camera Report. Issue 115
- Cined Lab tests https://www.cined.com/arri-alexa-35-lab-test-rolling-shutter-dynamic-range-and-latitude-plus-video/

Acknowledgment

This test is the result of the collaboration of many people who I cannot help but thank for all their help, affection and professionalism with which they have worked. To all of them my most sincere appreciation. However, I would like to highlight Adriana Bernal ADFC, Juan Pablo Bonilla, Christian Forero, Jorge Igual, Adriana García, Gabriela Pérez, Nicolás García, Fernando Parra, Jorge Román, Robert Breitenstein, Art Adams, Oscar Guarín and ITC members, especially to Philippe Ros, Aleksej Berkovic and David Stump.

** This test has been sponsored by ARRI, who has covered all the expenses associated with its execution. It is important to note that the manufacturer's sponsorship does not in any way influence the test results. The test presents the results objectively, as well as the impressions of different cinematographers who have used the camera. The sponsorship solely pertains to the financial support provided by ARRI for conducting the test and does not impact the integrity or impartiality of the results and evaluations presented.*

Collaborating companies

ANNEXE I

We include here our DIT's annotations about the on-set workflow.


Christian Forero DIT

1. The new .mxf container for the camera RAW, and the HDE processing system allow the files to have a smaller weight of between 55% and 60% of the total RAW file, allowing savings of up to 45% in the storage space required for a production.
2. One of the advantages in terms of image monitoring that Alexa35 incorporates is that its SDI outputs can be used independently and with support for up to 12G 444, which allows UHD signal monitoring, ideal for HDR streams (Having Note that a Lutbox and transmitters that support 12G, or failing that 6G, are also required).
3. In order to make use of HDE processing, download software such as silverstack, shotput pro, hedge, etc. You need to have a version higher than 7.0.0 of Codex Device Manager (Only on MacOS platform). The tool developed by Arri, HDE Encoder, can also be used.
4. It is important to consider the hardware that is used when working with HDE files. Being a "processed" file we need power in the machine with which we work: CPU, RAM, GPU, etc. As a result of this, material download speeds vary considerably from machine to machine. On a Macbook Pro with Intel I7 and 16GB RAM you can get an average download speed of 480MB/s, while with M1 Pro, M2 chipsets, these speeds can go up to 800MB/s, depending on the destination drives.
5. If you have poor hardware, it is possible that the download of material is interrupted by the download software, this is under evaluation with different hardware configurations.
6. The camera's wi-fi connectivity and control module is very stable, and works in complete harmony with the Arri Companion app, allowing more efficient remote control, very useful in situations where access to the camera is limited.
7. Our tests were carried out in studio with temperature controlled situations, and outdoors with temperatures up to 39 C, however, the construction of the cooling system does a great job allowing the sensor to work in a stable temperature of 40 C.
8. If you need a Genlock system, it is advisable to use a device that allows timecode and Genlock to be sent simultaneously.
9. One of the main advantages in terms of the construction and operation of this new camera is that it incorporates nine new user buttons allowing extensive customization for different jobs on set: photographer, camera operator, first assistant and DIT.
10. These tests were carried out with tools developed by POMFORT, Silverstack and Livegrade in their latest updates, with full support for the new Arri Loc4 and Arri Gammut in version 1.3.0 of ACES.

Software used in tests

❖ LiveGrade Studio 8.3.3
❖ Silverstack Lab 8.5
❖ Davinci Resolve Studio 18.2 ❖ Drive DX
❖ Codex Device Manager 7.0.2
❖ Arri Reference Tool
❖ Arri Frame & Ilumination Tool ❖ LUT Calc 3.0

Hardware used in tests

❖ Macbook Pro i7 16GB RAM, 2GB GPU
❖ OWC Thunderbay 4 Thunderbolt 3 16TB ❖ FSI Box IO Lutbox
❖ Codex Compac Drive Dock
❖ G Tech Armorlock 4TB Drives
❖ 1Gbit Ethernet Switcher

Monitor

❖ Flanders Scientific DM220