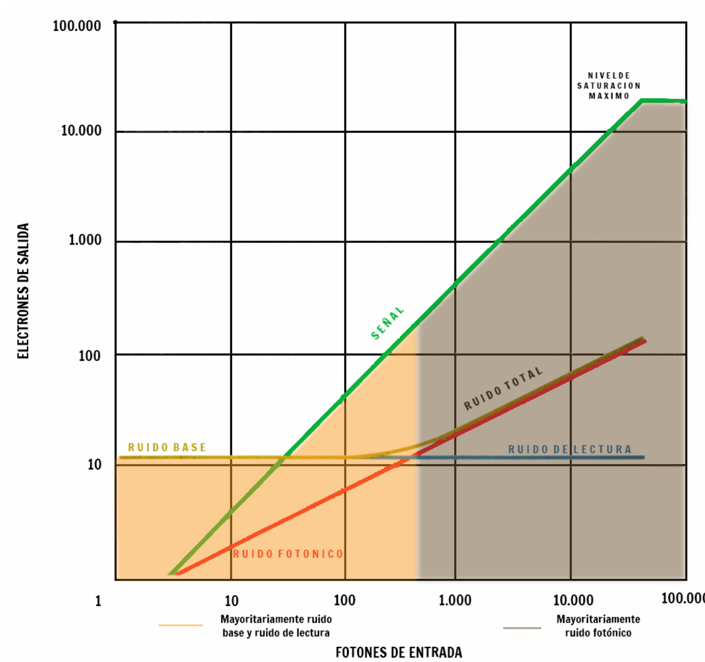
THE NOISE IN VENICE CAMERA I

By Alfonso Parra AEC, ADFC

This article intends to show some observations of the noise in the Sony Venice I camera from the perspective that a cinematographer may have, so it is not an engineering analysis, which does not correspond to me, but rather that of a cinematographer who with his tools wants to know camera noise behavior; and this in three directions, the first is simply as Edmund Hillary would say "because it is there", and simple and plain curiosity is essential to homo sapiens or homo faber, as preferred, the second because the quality of the cinematographic image it depends on the noise, and when I say quality, I mean the texture of the image, its dynamic range and the color; noise has an important influence on these factors, and thirdly because of the possibility of making noise an aesthetic factor that contributes to the narration, something that I have developed over the last few years in some series and films. Somehow, I like the destructuring that noise can cause in the image and how, by revealing its substratum, one can take a leap towards the metalanguage of form.
The noise that we observe in our images comes mainly from the base noise (dark noise) together with the photonic noise and the readout noise, although there are other factors, such as quantization noise or thermal noise (hence the importance of having good ventilation in our chambers) Figure 1.

For this noise 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, I have shot with the sensor cover on and the camera covered with black cloth for a few seconds at each ISO value, starting from the base sensitivities, 500 and 2500. I have opened these planes in Davinci Resolve with ACES and as expected the image appears completely black, to observe the noise I have proceeded to increase the exposure and modify the contrast in the same way in all ISO values, so I can observe, on the one hand the “size” of the noise, on the other its “color” and finally its movement. Therefore, the numbers that we show here are relative and serve to relate the different ISO values and their differences.



* Graphic version *from123 of digital imaging. https://123di.com/*

I have observed the noise at two different color temperatures 6500K and 3200K considering that the blue and red channels are modified in relation to green to establish a correct colorimetry.

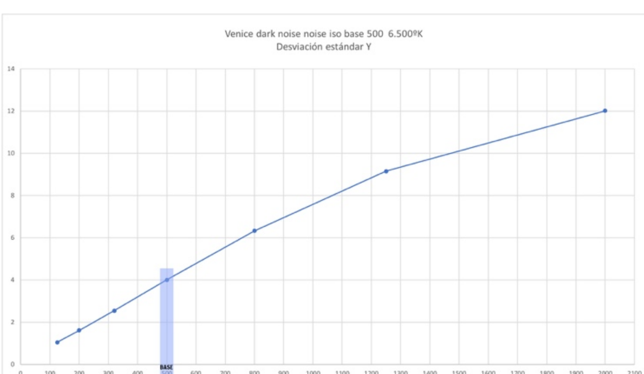


Figure 1

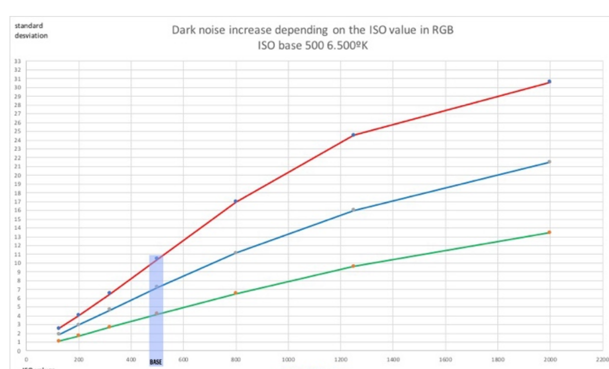


Figure 2

In the previous graphs we can see the comparison of the base noise at different ISO values taking as a base EI 500 at 6500 K, both in luminance Y (figure 1) and RGB (figure 2). The horizontal axis shows the ISO values and the vertical axis shows the standard deviation (width of variation of the intensity values) measured in the histogram. Given the random variation of the brightness of the pixels depending on the ISO value, the histogram is shown as a bell whose base gets bigger and bigger as we increase the sensitivity values, that variation in the brightness values is what it shows the vertical axis (Table 1 and 2)

ISO VALUES base 500. 6500ºK	Y
125	1,05
200	1,62
320	2,55
500	4,01
800	6,33
1250	9,15
2000	12,01

Table 1

ISO VALUES base 500 6500ºK	R	G	B
125	2,56	1,1	1,86
200	4,03	1,71	2,93
320	6,52	2,71	4,69
500	10,46	4,19	7,26
800	16,95	6,53	11,15
1250	24,56	9,6	16
2000	30,6	13,46	21,48

Table 2

The value of the red channel at 500 ISO is 10.46, a value that the green reaches at more than 1250 and the blue at slightly less than 800. It is clear that the least noise occurs with the lowest ISO values, although we remember that modifying said values modifies the distribution of the T stops in the dynamic range as shown in (figure 3). In figure 4 we show an image of the noise at the different ISO values, from 125 to 2000 with the base of 500.

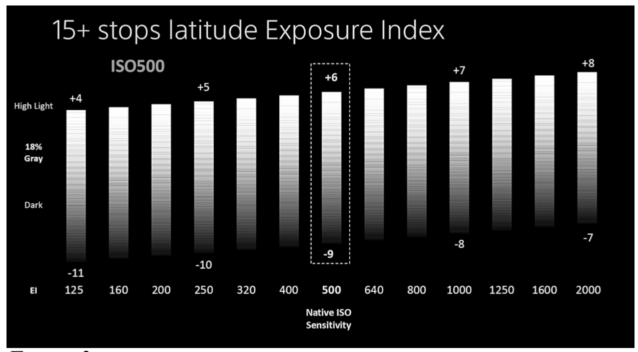


Figure 3

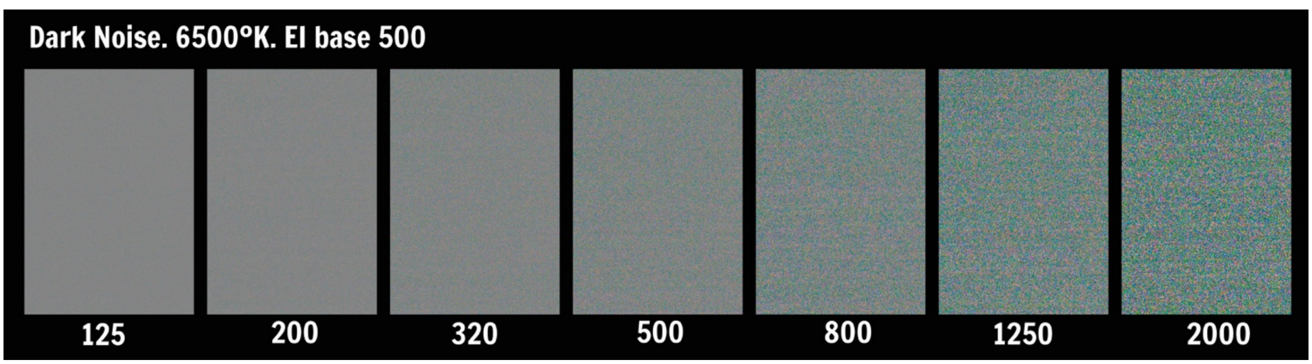


Figure 4

In figures 5 and 6 we can see the comparison of the base noise at different ISO values based on the EI 2500 6500K, again both in luminance Y and RGB (tables 3 and 4).

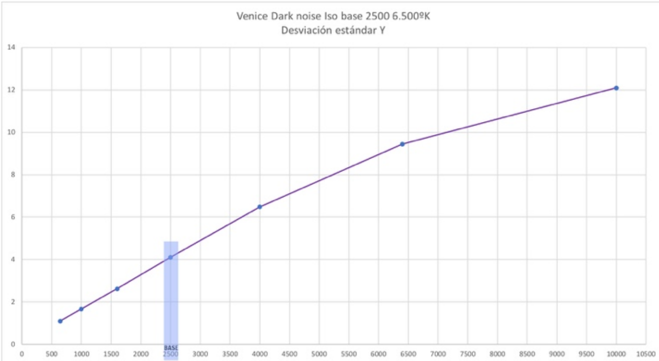


Figure 5

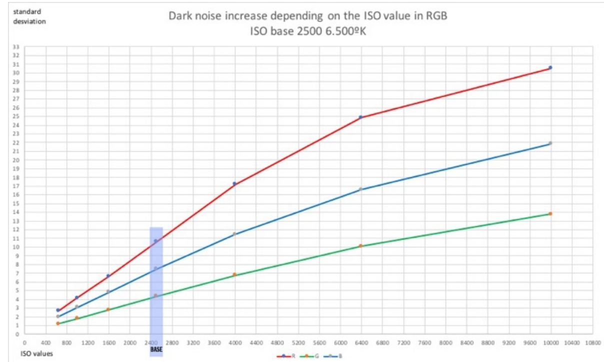


Figure 6

ISO VALUES base 2.500. 6500K	Y
640	1,1
1000	1,67
1600	2,62
2500	4,11
4000	6,48
6400	9,44
10000	12,09

Table 3

ISO VALUES base 2500 6500K	R	G	B
640	2,66	1,16	1,97
1000	4,16	1,77	3,07
1600	6,64	2,8	4,85
2500	10,62	4,34	7,49
4000	17,18	6,77	11,46
6400	24,87	10,09	16,6
10000	30,51	13,77	21,84

Table 4

Figure 7 shows the appearance of noise at different ISO values based on 2500.

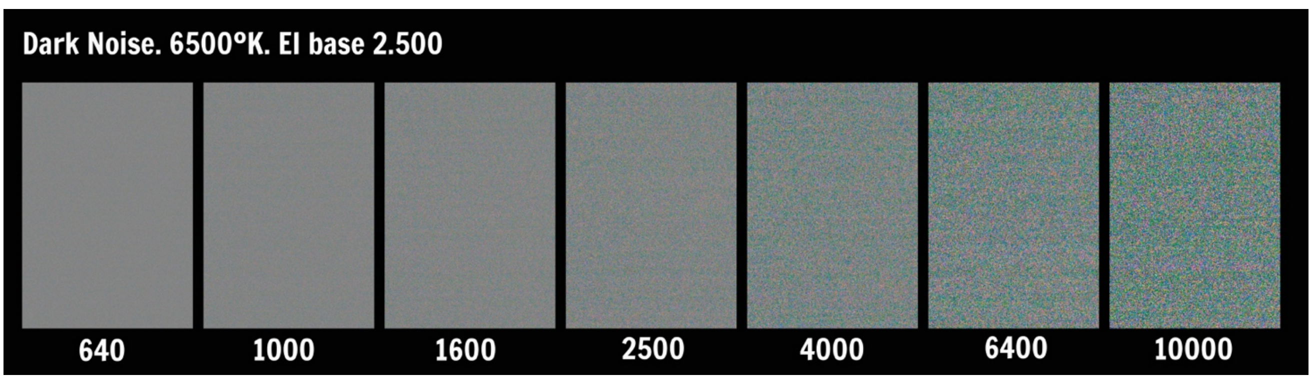


Figure 7

What we can observe is that the increase or decrease of the ISO values are practically the same between the base 500 and 2500, in such a way that with an ISO 2000 from a base of 500 I have practically the same noise as at 10000 ISO with a base 2500 (figure 8). If we superimpose the curves of both bases we will see that they are almost identical. Figure 9 shows the compared values in Y from base 500 and base 2500 (table 5).

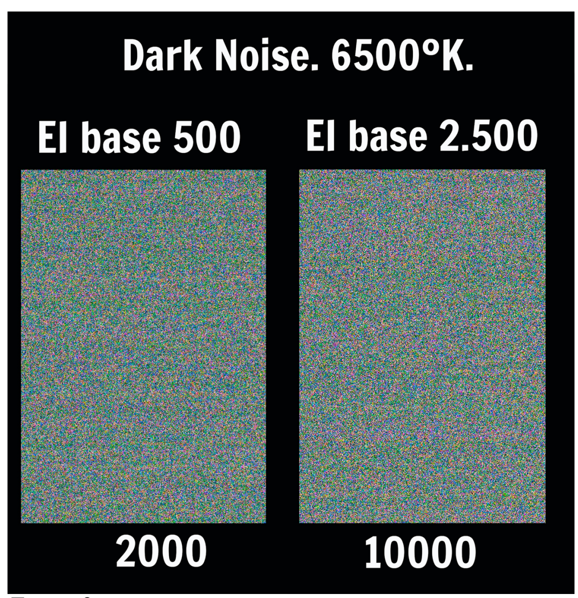


Figure 8

ISO VALUES 6500ºK	Y 500	Y 2500
125	1,05	
200	1,62	
320	2,55	
500	4,01	
640		1,1
800	6,33	
1000		1,67
1250	9,15	
1600		2,62
2000	12,01	
2500		4,11
4000		6,48
6400		9,44
10000		12,09

Table 5

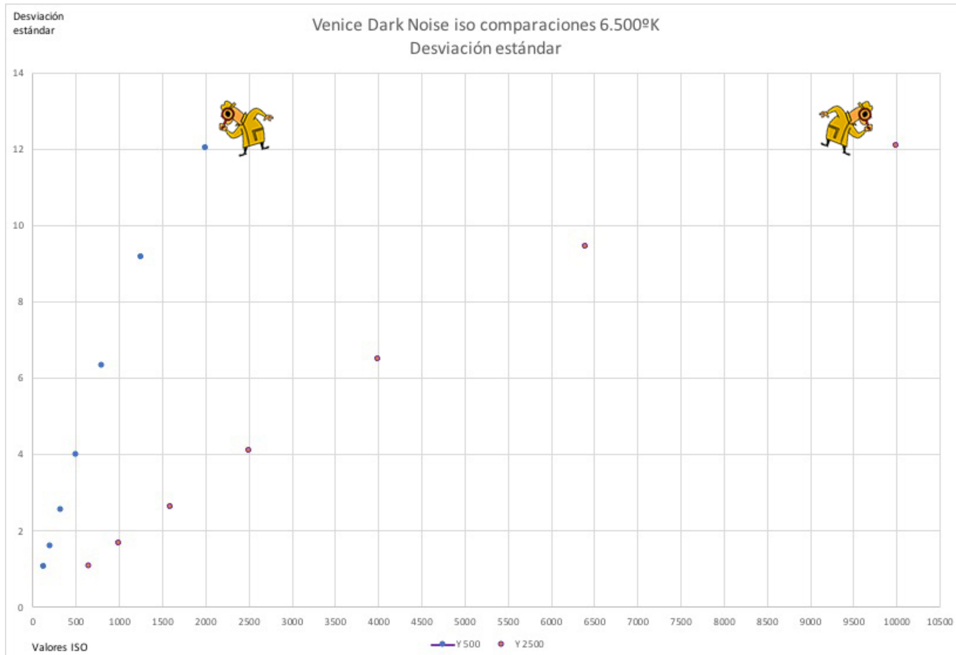


Figure 9

For example, with a base of 500 in Y the standard deviation value for ISO 2000 is 12.01 while for a value of 10000 ISO on the base 2500 the deviation is 12.09, practically the same. For an offset value of 4.01 at ISO 500 base 500, I have a similar one at ISO 2500 of 4.11 base 2500.

Base noise is very similar at 500 and 2500 when both sensitivities are base. This difference can be seen in figure 10. At the top is the noise seen as we indicated at the beginning and below is a 3D graph that represents the noise. As you can see it is extremely similar.


Alfonso Parra AEC, ADFC. Cinematographer

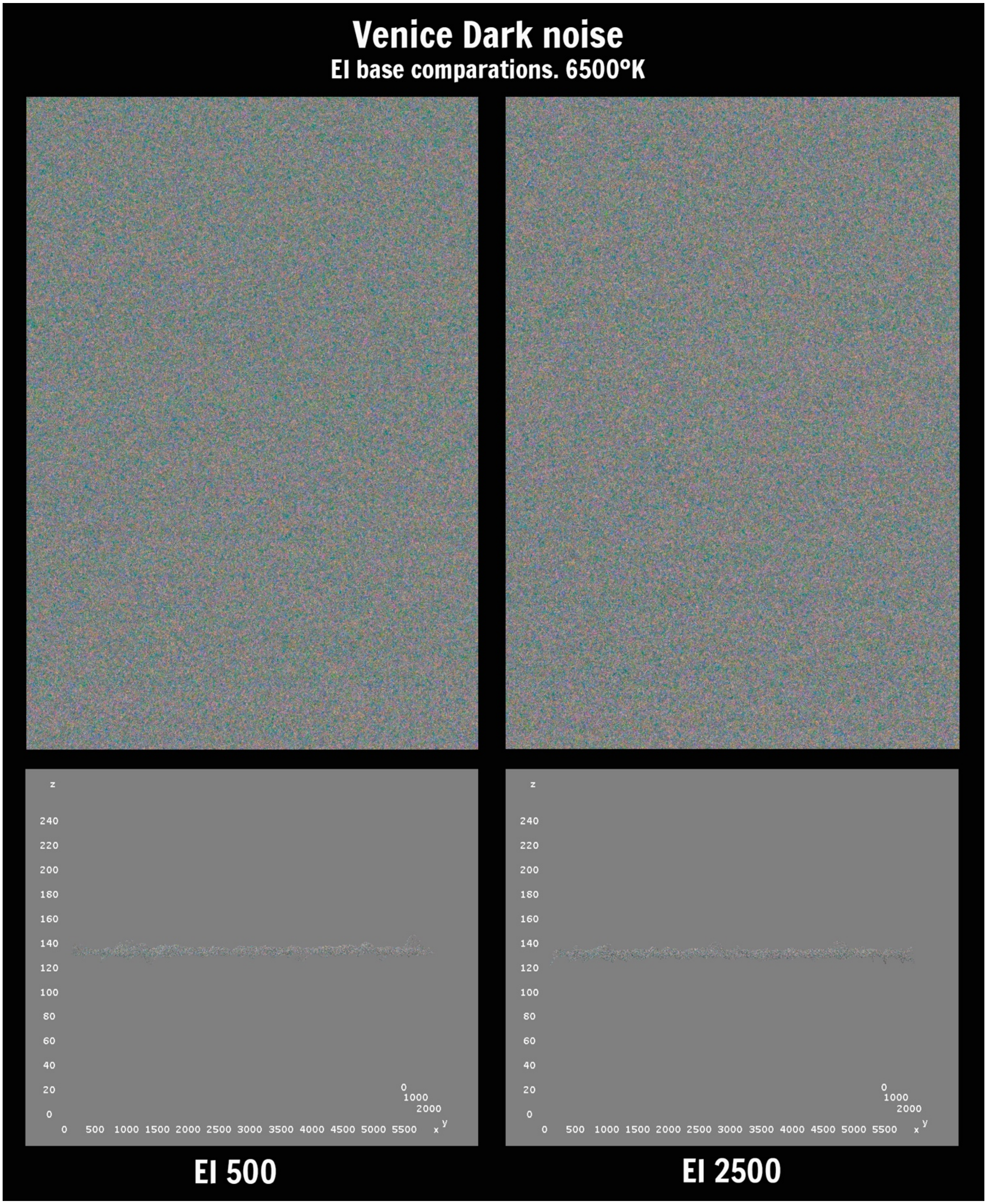


Figure 10

Now let's look at the base noise when we set the color temperature to 3200K. Let's start with the ISO values considered from the EI 500 base. Again figure 11 represents the deviation in Y and figure 12 the deviation in RGB (tables 6 and 7). The visualization is shown in figure 13.

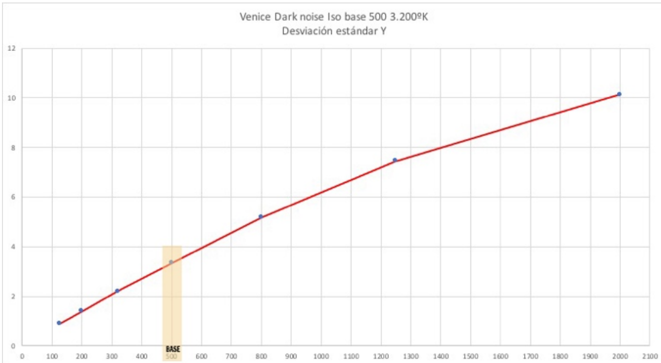


Figure 11

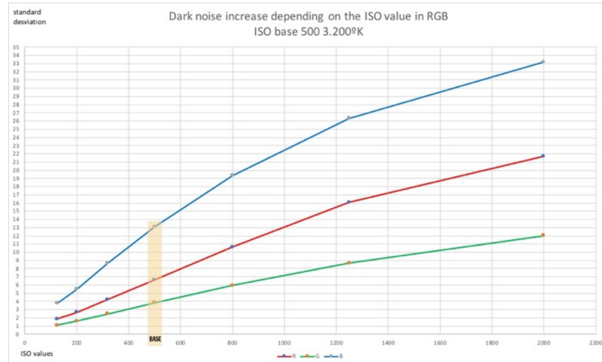


Figure 12

ISO VALUES base 500. 3200K	Y
125	0,89
200	1,4
320	2,19
500	3,34
800	5,17
1250	7,45
2000	10,13

Table 6

ISO VALUES 500 3200K	R	G	B
125	1,84	1,06	3,76
200	2,65	1,59	5,47
320	4,22	2,49	8,68
500	6,61	3,84	13,1
800	10,63	5,94	19,35
1250	16,05	8,67	26,34
2000	21,71	12,04	33,2

Table 7

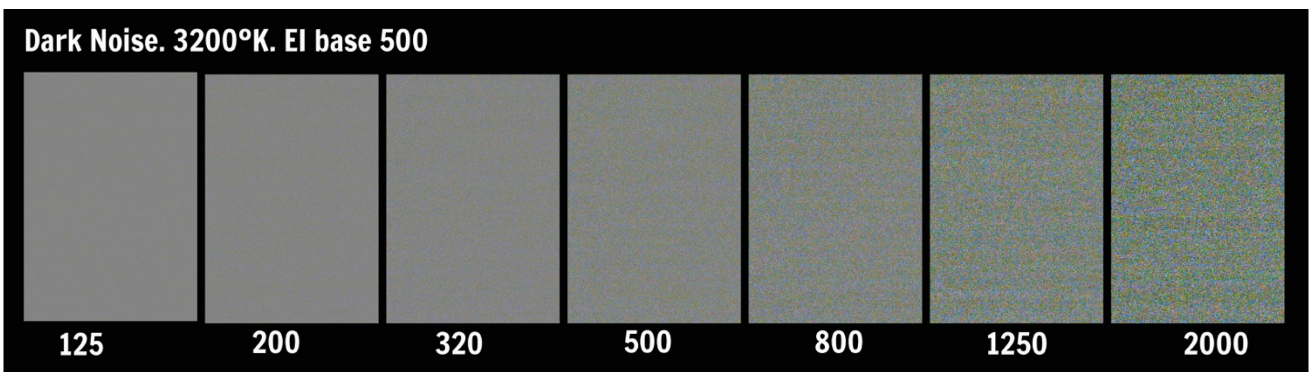


Figure 13

What we observe is that the behavior between the different ISO is similar to 6500K, although now the blue channel is the one that appears noisiest compared to red and green. At 3200K the noise of the blue channel is higher than the corresponding red channel with a color temperature of 6500K. It can be seen in figure 14. For example, the red channel with EI of ISO 500 presents a deviation of 10.46 (6500K), while with that same base at 3200K the deviation in the blue channel is 13.1, an increase of 25%approximately; at 800 ISO the increase is 14.15% or 8% at a value of 2000 ISO. That is, the blue channel is much noisier at 3200K than the red channel at 6500K (table 8).

ISO VALUES Base 500	R 6500K	B 3200K
125	2,56	3,76
200	4,03	5,47
320	6,52	8,68
500	10,46	13,1
800	16,95	19,35
1250	24,56	26,34
2000	30,6	33,2

Table 8

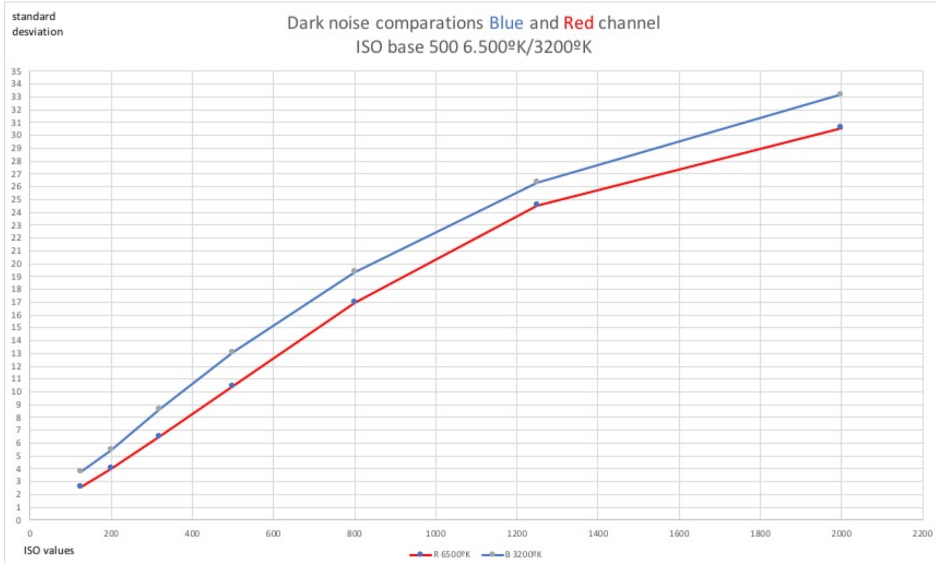


Figure 14

Now let's look at the curves with a base EI of 2500. Figure 15 shows the values in Y (table 9).

ISO VALUES base 2.500. 3200K	Y
640	0,97
1600	2,26
2500	3,48
4000	5,32
6400	7,74
10000	10,28

Table 9

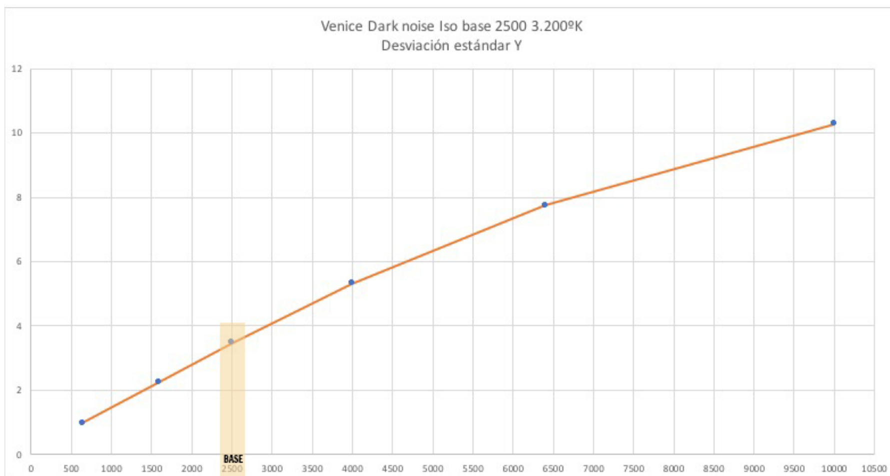


Figure 15

ISO VALUES base 2500 3200K	R	G	B
640	1,76	1,08	3,65
1600	4,34	2,58	8,96
2500	6,83	3,98	13,6
4000	10,87	6,18	19,96
6400	16,61	9,05	27,18
10000	21,8	12,34	33,44

Table 10

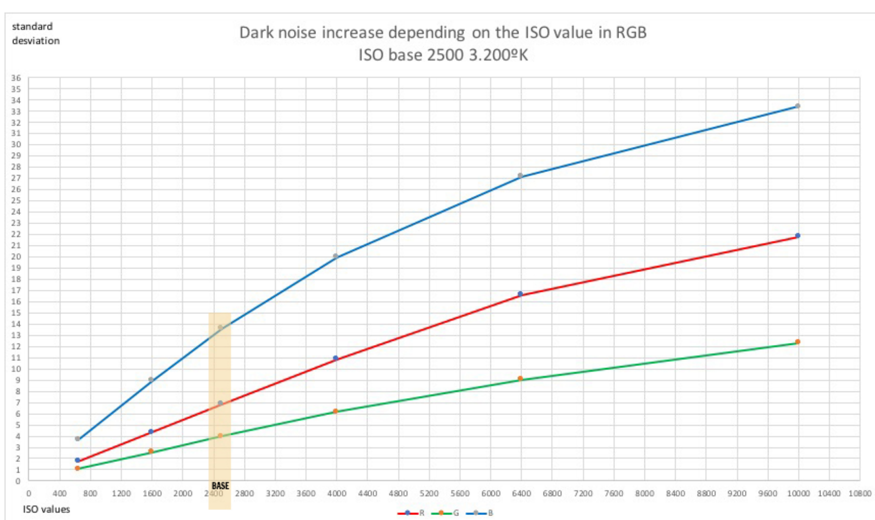


Figure 16

The noise increase in the blue channel is similar, although slightly higher than 2500 if we compare the two base ISO: 500 and 2500 (figure 16). The deviation is 13.1 at base ISO 500 and 13.6 at ISO 2500. In Y at base ISO 500 the deviation is 3.34, while at 2,500 it is 3.48. That is, 4.19% noisier (table 10). In figure 17 you can compare the ISO values although it is difficult to detect any difference with the naked eye.

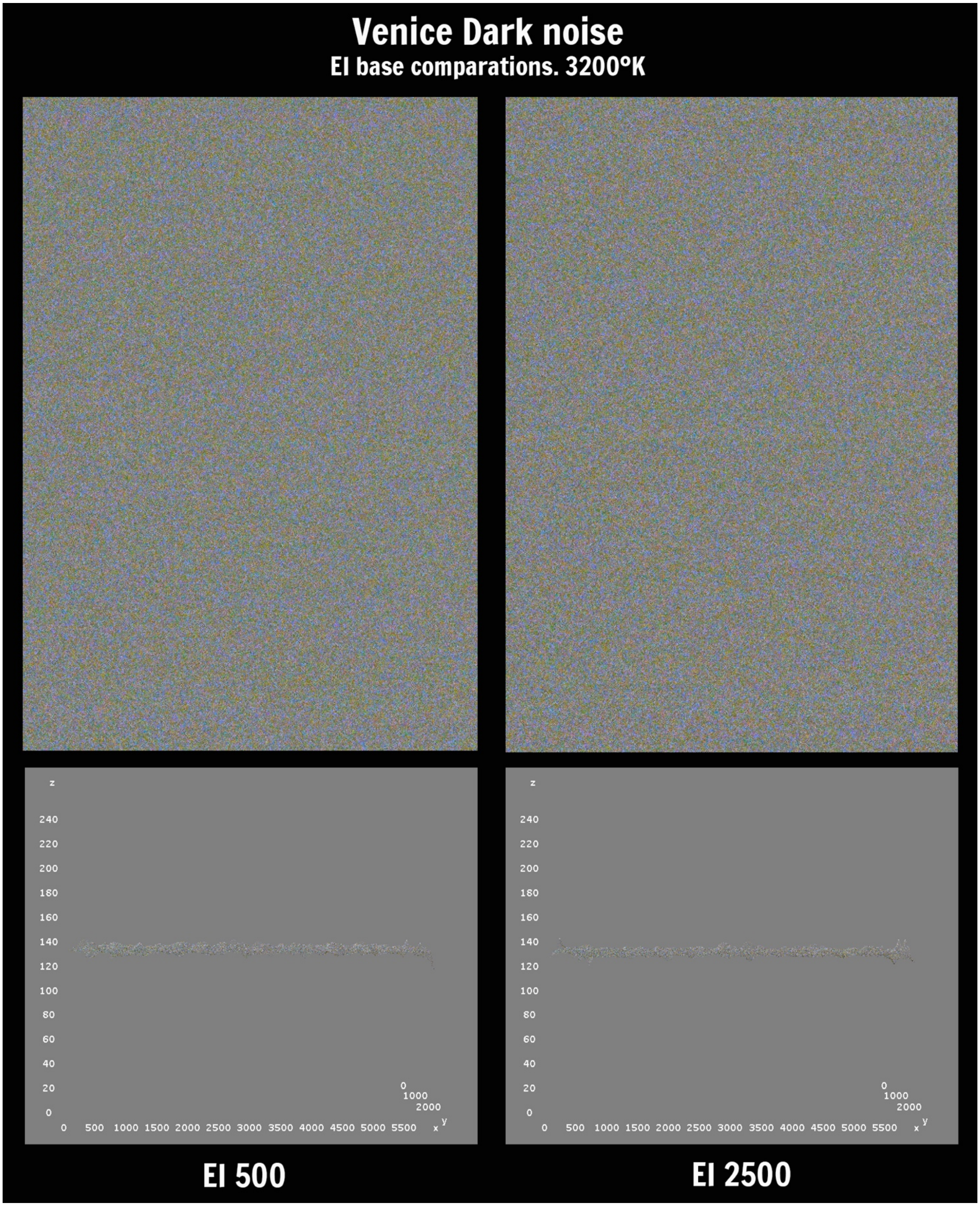


Figure 17

If we compare the values in Y with a base ISO of 500 between 6500K and 3200K we will see, as shown in figure 18, that at 6500K the base noise shows a greater deviation than at 3200K (table 11).

ISO VALUES BASE 500.	Y 6500ºK	Y 3200ºK
125	1,05	0,89
200	1,62	1,4
320	2,55	2,19
500	4,01	3,34
800	6,33	5,17
1250	9,15	7,45
2000	12,01	10,13

Table 11

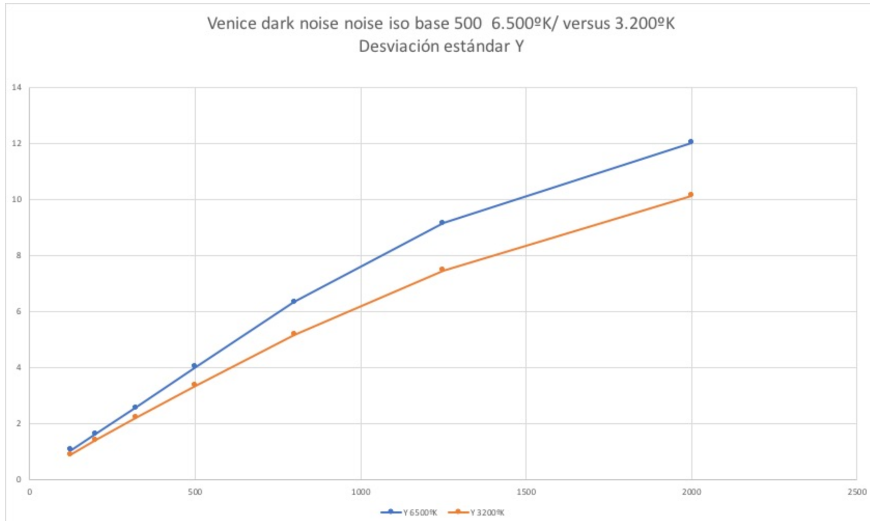


Figure 18

The same happens when we use the base ISO of 2500 (figure 19 and table 12).

ISO VALUES base 2.500	Y 6500ºK	Y 3200ºK
640	1,1	0,97
1000	1,67	
1600	2,62	2,26
2500	4,11	3,48
4000	6,48	5,32
6400	9,44	7,74
10000	12,09	10,28

Table 12

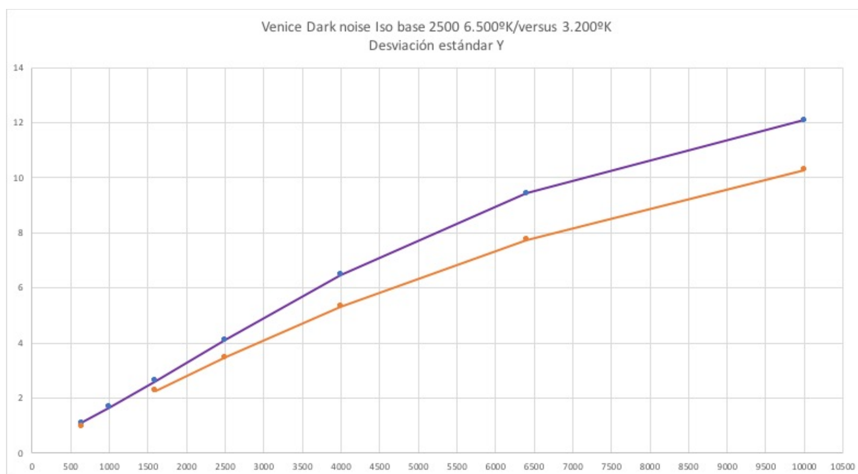


Figure 19

The same comparison, but now in RGB.

Knowing the noise helps the creation of images in Chroma. Filming of the movie El Yuppie y el guiso.

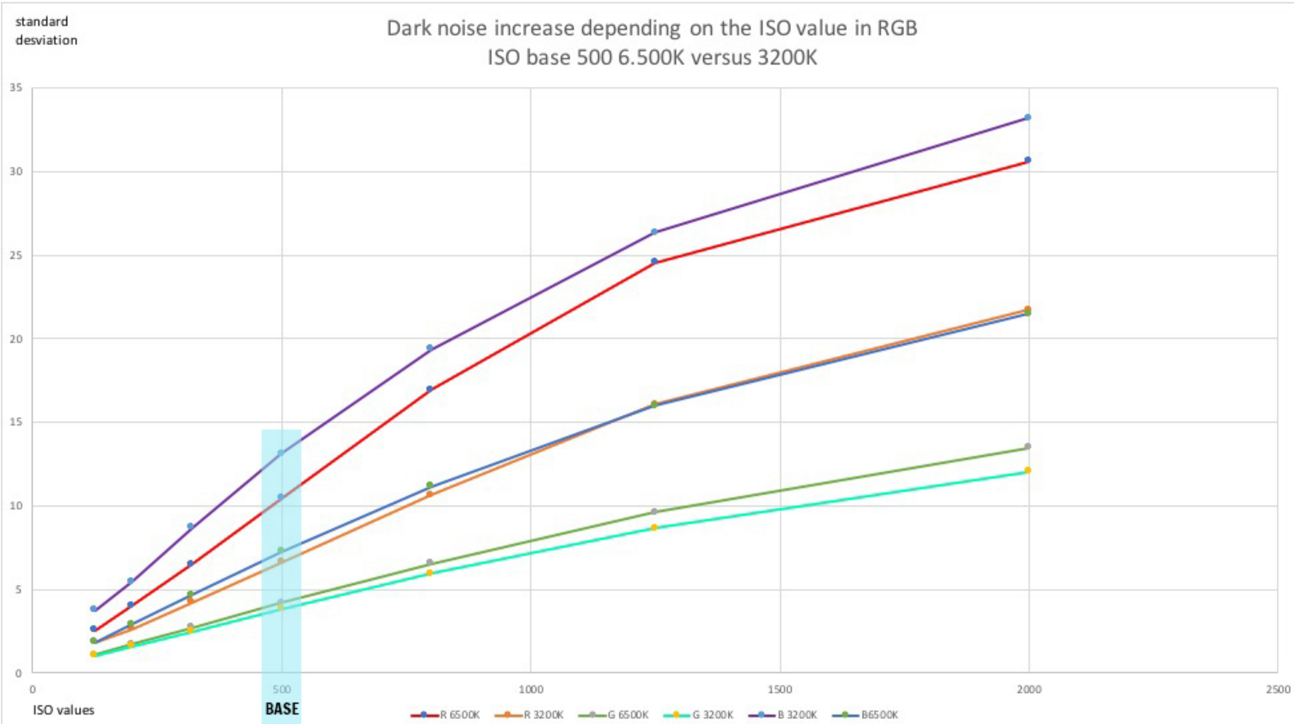


Figure 20

At the value of 500 ISO (figure 20) the deviation of red at 6500K is much higher than red at 3200K, however, in the green channel they are very similar, although at 6500K it is slightly higher than at 3200K and in the blue channel the deviation is much greater at 3200K than at 6500K. Deviation increases or decreases remain fairly similar across all ISO values tested.

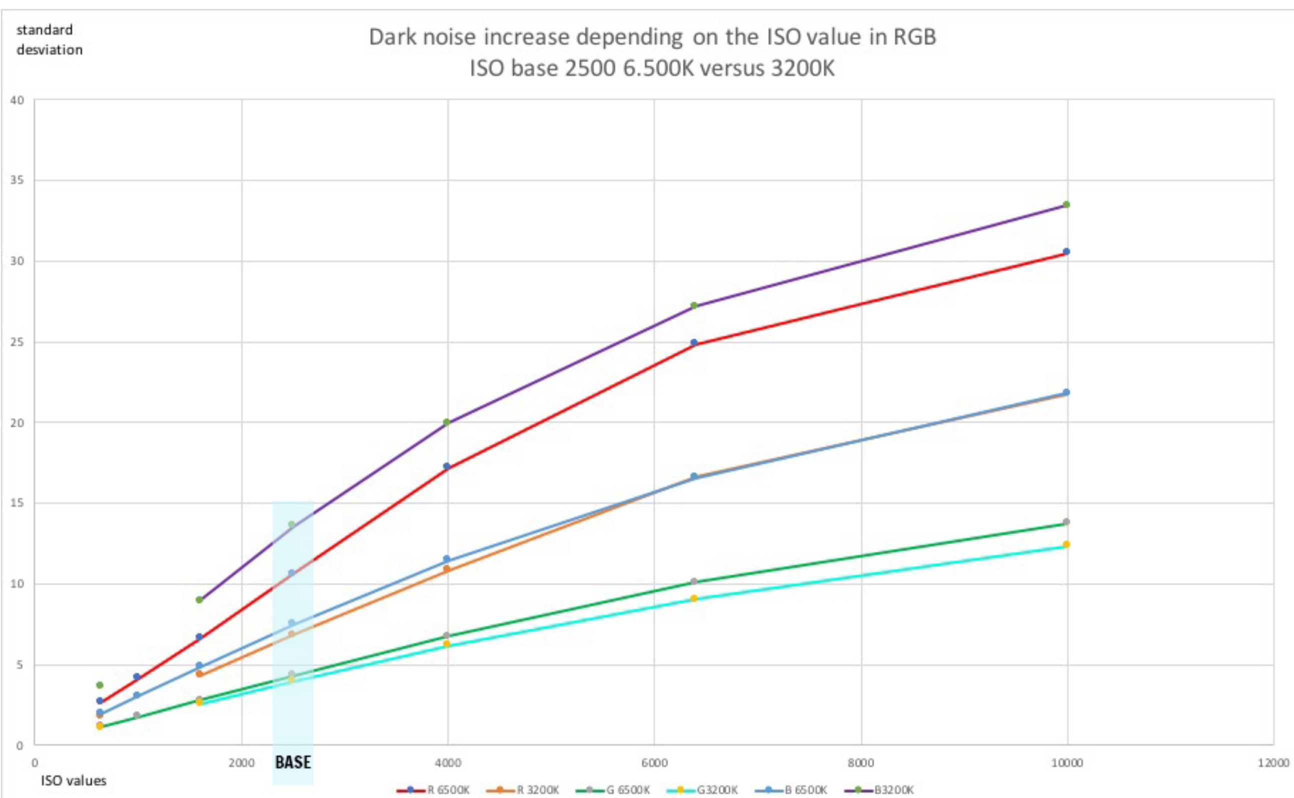
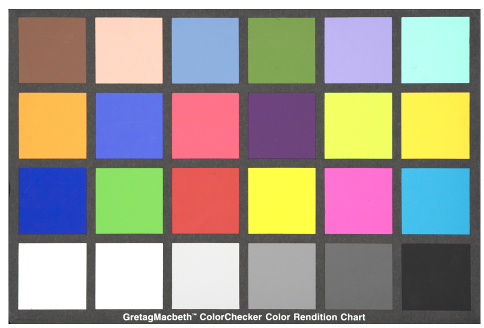


Figure 21

Figure 21 shows the comparison in RGB of the two color temperatures with the base 2500. The behavior in what has to do with the relationships of the ISO values and their deviations is notoriously the same with an ISO base 2500, as with the base of 500.

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 in both base values of the camera. Both at 500 and 2500 the increase in noise is consistent and coherent in relation not only to the amount of noise but also in the relation of the three RGB channels and the increase or decrease of the ISO values. The movement of the noise (the random variations of brightness) is discreet between the lowest ISO values and up to 5000, above these the noise acquires a certain notoriety and its movement is already somewhat "creaky". 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 said noise. On the other hand, the relationship of the three channels in relation to the indicated color temperature entails the modification of the red and blue channels in relation to green, which is the channel that does not show modification. With a warm color temperature, 3200K, the blue channel is the one that noticeably increases its noise in relation to the other two channels, and the opposite happens with the temperature of 6500K, where the red channel is the one that suffers the greatest correction and therefore, the one that shows more noise.



As we pointed out at the beginning, the noise that we observe in our images is the combination of the base noise, the reading noise and the mainly 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 $SNR_{BW} = 20\, log_{10} \left(\frac{S_{WHITE}-S_{BLACK}}{N_{MID}}\right)$ (For detailed information see https://www.imatest.com/support/docs/23-1/colorcheck/).

Let's start by looking at the base 500 and 2,500 to 6,500K SNR values in both RGB and Y figures 22 and 23 (tables 12 and 13).

SNR VALUES DB Base EI 500	R	G	B	Y
500	41,2	42,9	42,2	43,2
1000	38,4	40,3	39,7	40,6
2000	34,8	37	36,3	37,1

Table 12

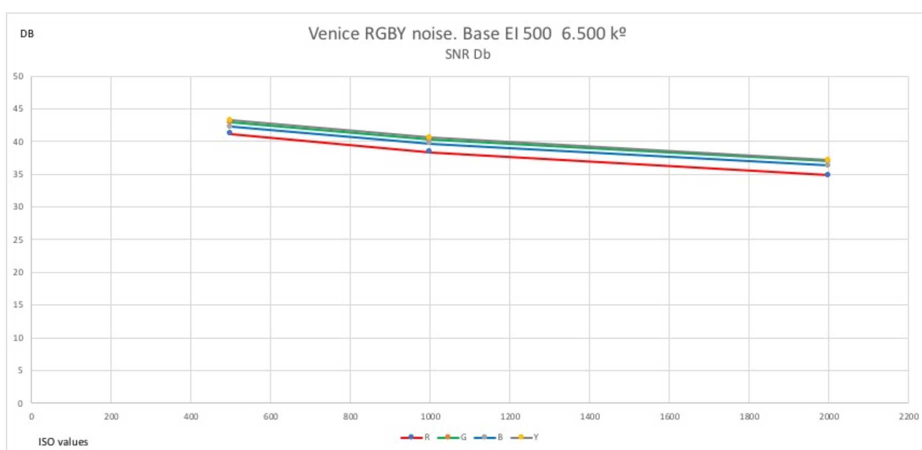


Figure 22

SNR VALUES DB Base EI 2500	R	G	B	Y
2500	35,6	37,3	36,6	37,5
5000	32,2	34	33,4	34,2
10000	29,1	30,9	30,4	31

Table 12

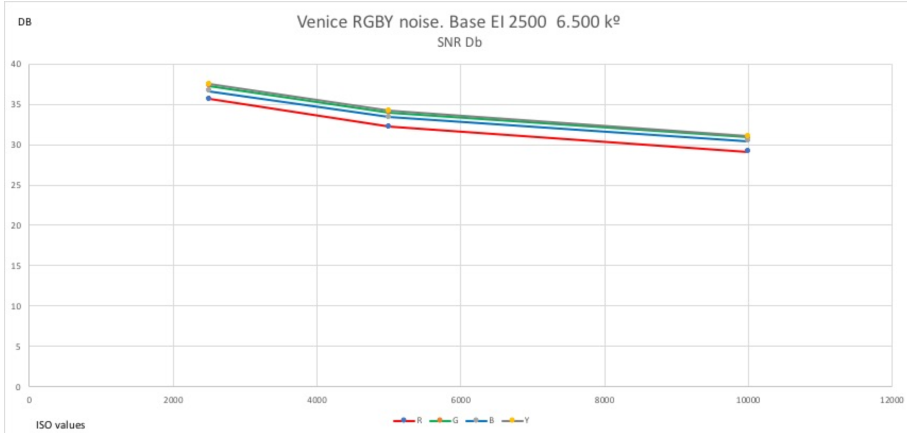


Figure 23

Here we can already see that with a base ISO 500 the SNR ratio is better in all channels and in Y, for example, in the latter we have an SNR of 43.2 db compared to 37.5 db for an ISO base of 2500 (figure 24).

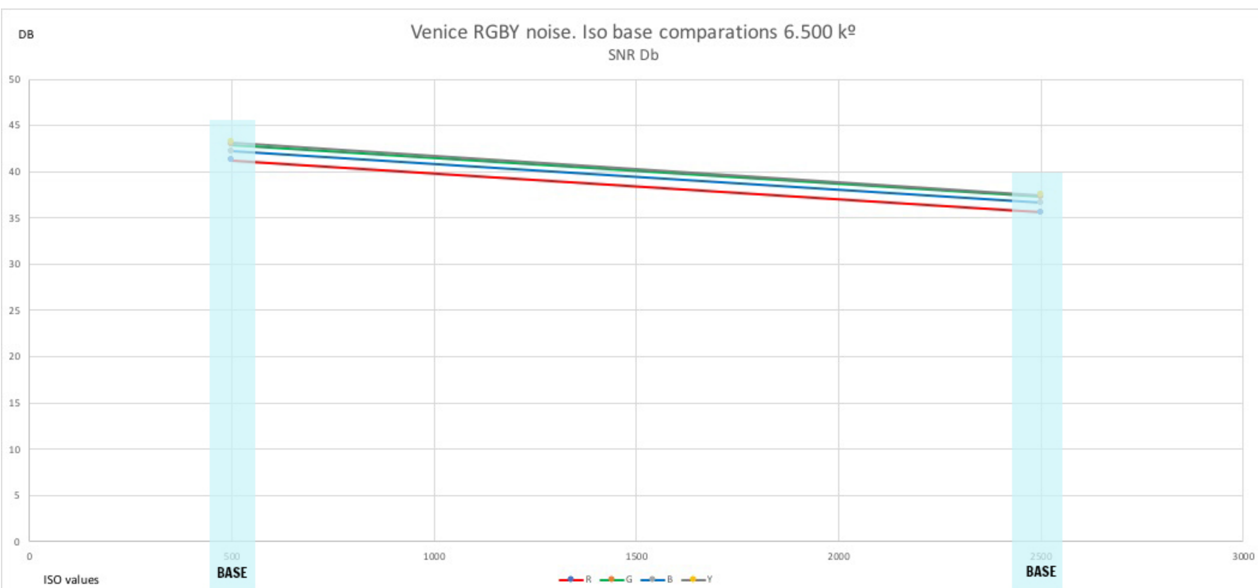


Figure 24

Between the two base ISO values there is a difference of 5.6 db in RGB and 5.7 db in Y, that is, at 500 ISO we have a 15.7% better SNR ratio, which is not much of a difference considering that we are increasing the sensitivity of the camera by more than two stops. If we compare the highest values, the difference between 2000 and 10000 is 5.7db for red, 6.1db for green, 5.9db for blue and 6.1db for Y, which means an SNR difference of about of 19.5%. We can observe this difference between 500 and 2500 in the following figure 25 where we compare sample 22 of the Macbeth chart and its 3D representation. You can see the slight difference that we find between both values, at 2500 the width of the brightness band is slightly greater than at 500, although visually the difference is little.

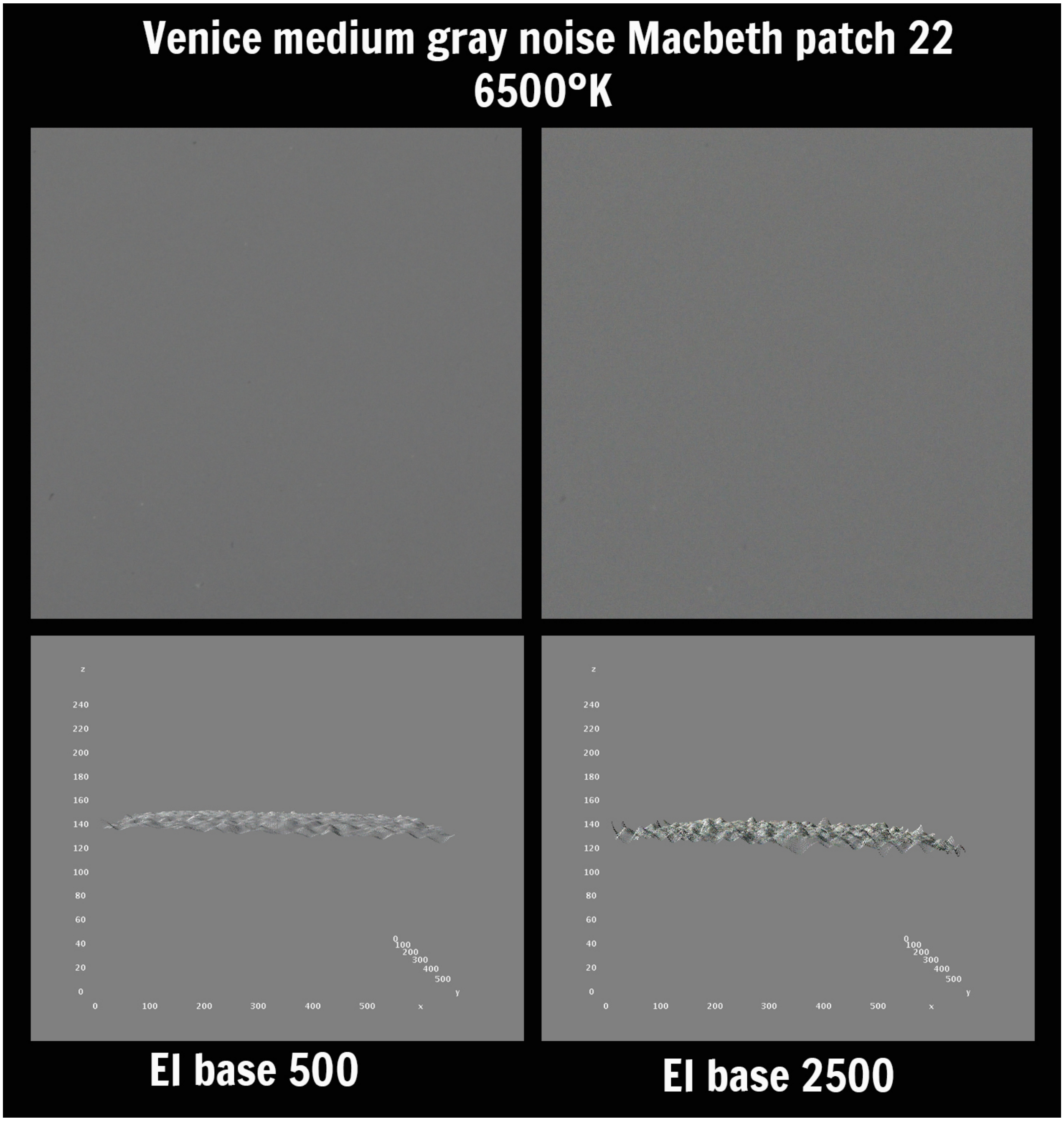


Figure 25

We are now going to compare the SNR relationship between a letter filmed at 6500K and another at 3200K with ISO base 500 and 2500. At 500 ISO base the values in the red channel, the SNR is better by 0.7% at 3200ºK than at 6500K but with this last color temperature the SNR of the blue channel is better by 2.6% than at 3200K (figure 26). All this can be seen in the frame of the model with the card (figure 27), where indeed in the red channel the noise difference between both color temperatures is small, but not in the blue channel where the noise difference is notorious, being less at 6500K than at 3200K.

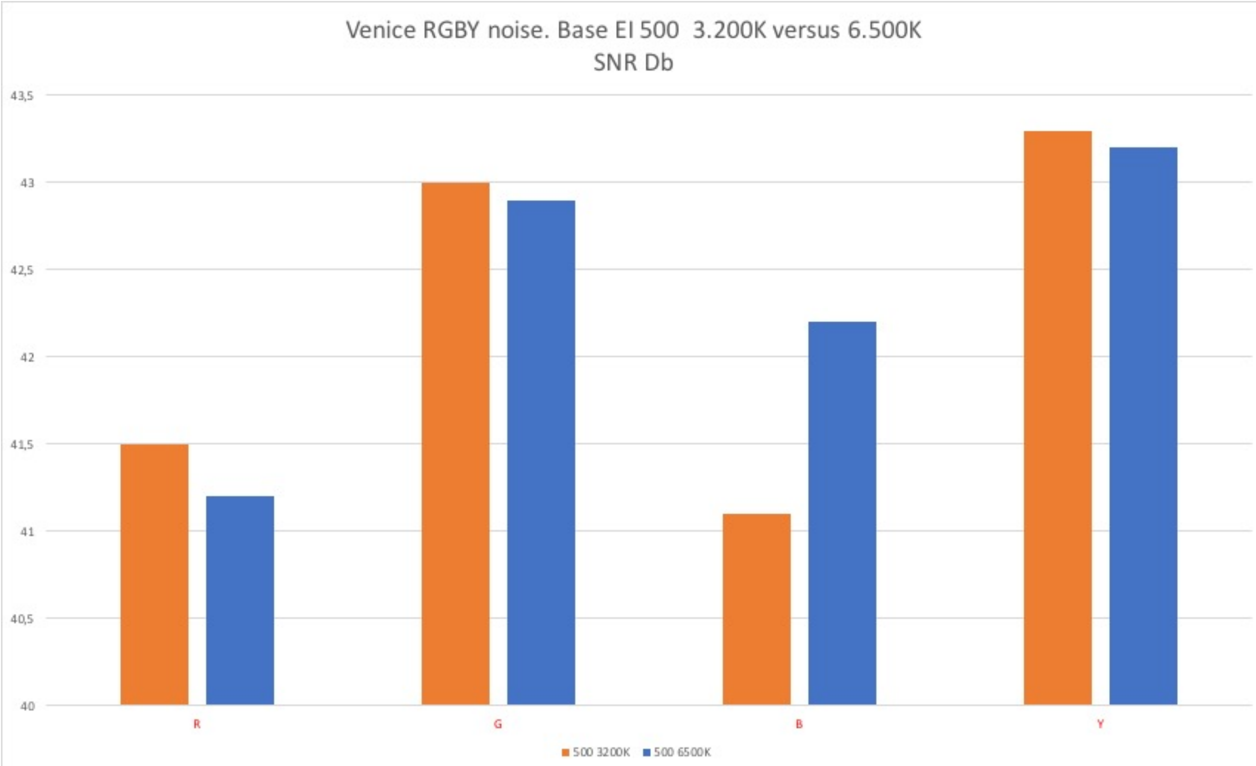


Figure 26

Figure 27

With a base ISO of 2500 the green channel and Y(luminance) are similar in both color temperatures and the red channel is almost the same in both (somewhat better at 3200K), the biggest difference occurs in the blue channel where the SNR it is 36.6 db at 6500K and 35.3 db at 3200K this is a difference of 1.3 db (figure 28). Figure 29 shows the differences indicated in the graph (figure 27). The behavior of the red channel is better at 2500 ISO than at 500 ISO.

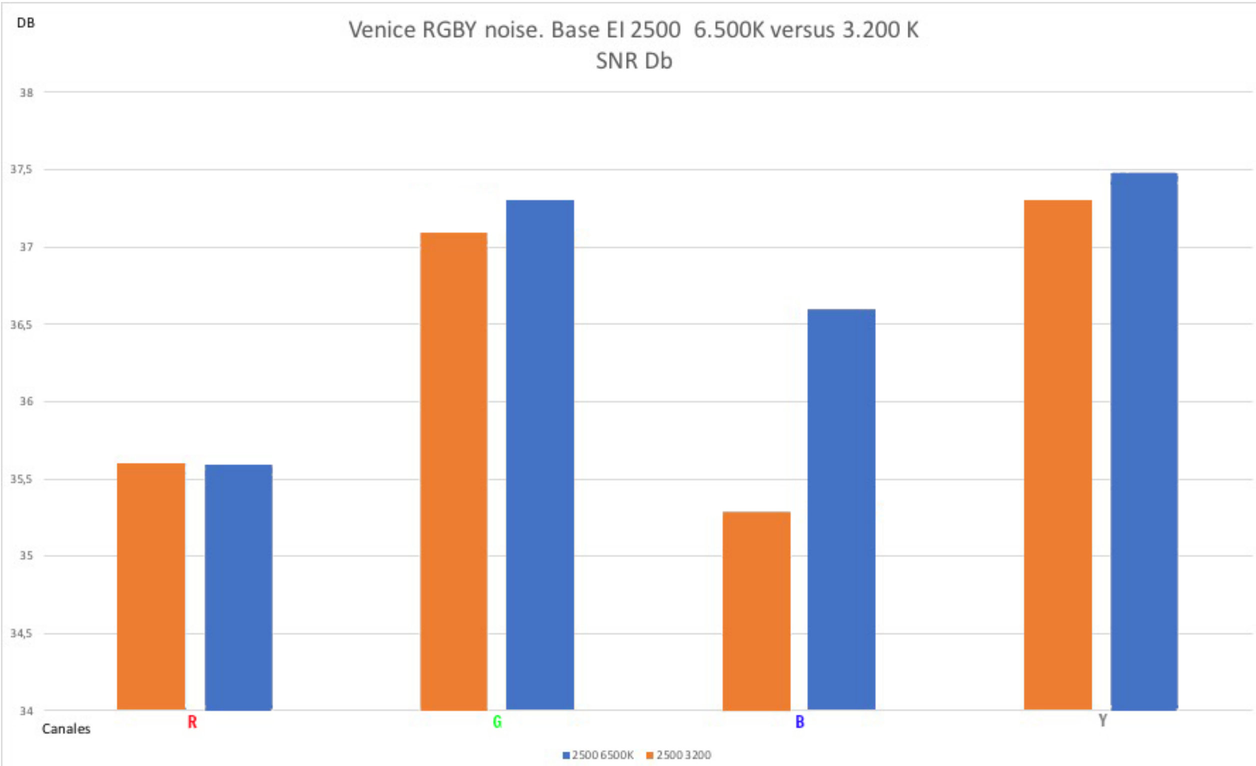
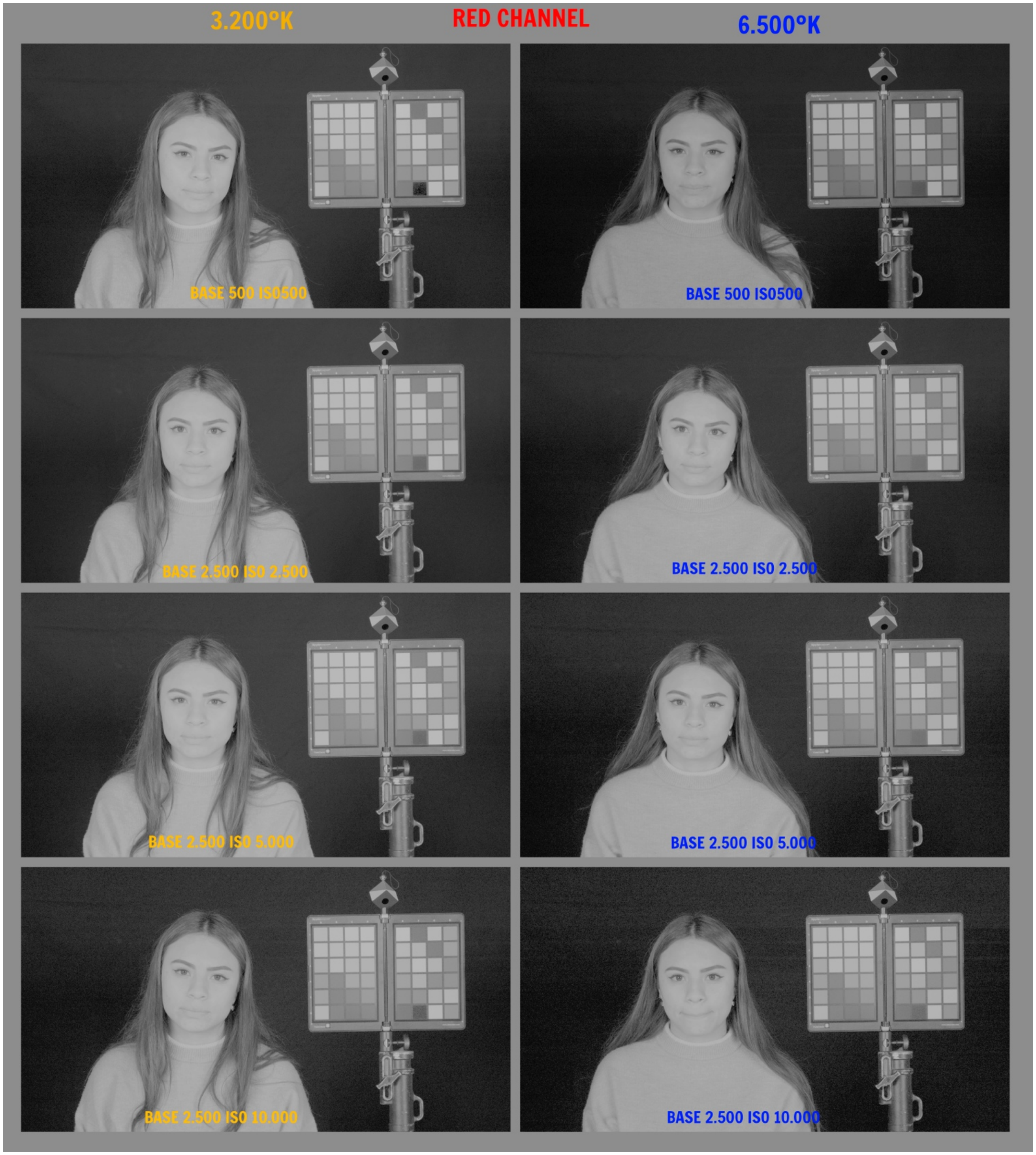


Figure 28

Figure 29

In figure 30 we show the differences in the red channel at the two different color temperatures and different ISO values. We especially wanted to show the highest ISO values based on 2.500 to highlight noise at high sensitivities.


3.200°K
RED CHANNEL
6.500°K
BASE 500 ISO500
BASE 500 ISO500
BASE 2.500 ISO 2.500
BASE 2.500 ISO 2.500
BASE 2.500 ISO 5.000
BASE 2.500 ISO 5.000
BASE 2.500 ISO 10.000
BASE 2.500 ISO 10.000
Figure 30

Next, the same ISO values but in the blue channel (figure 31).

Figure 31

In figure 32 I show in red the box that I have enlarged X500 and then I modified the exposure and contrast of that area (figure 33) to appreciate the noise as a whole, especially also paying attention to the definition of the model's hair and see which is practically not lost even at high values like 10000 ISO.

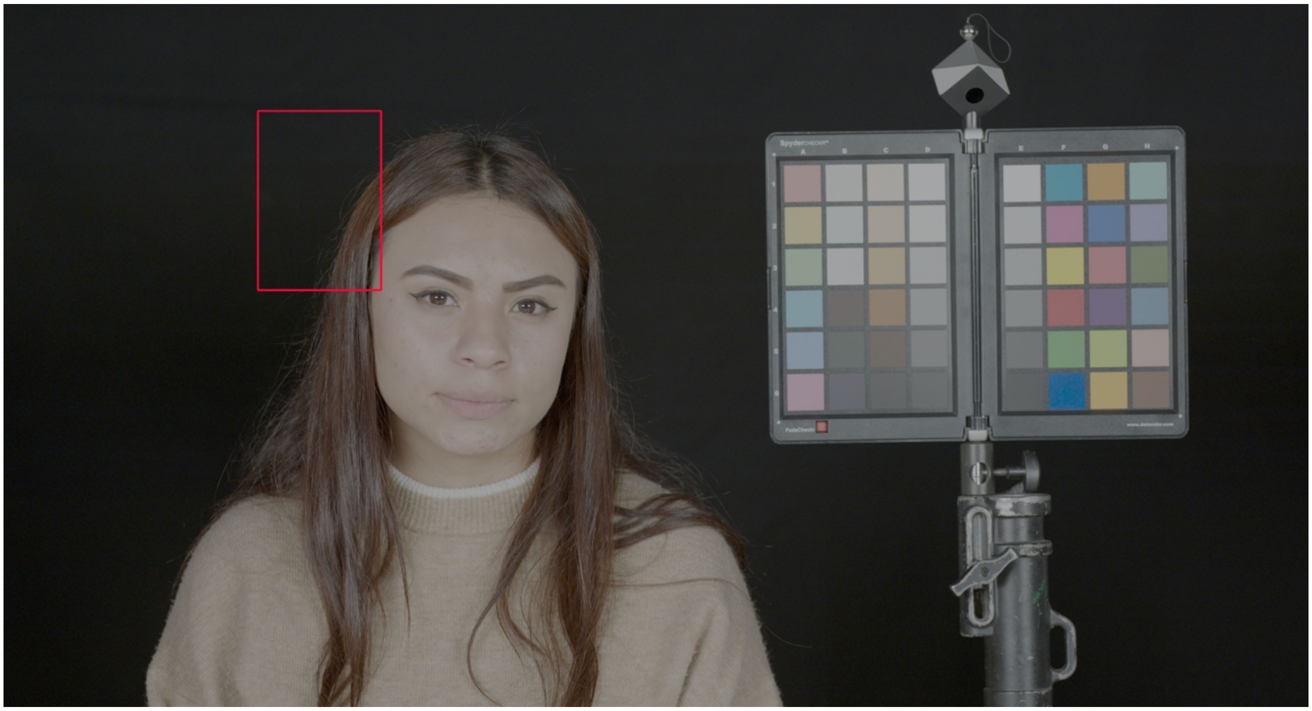


Figure 32

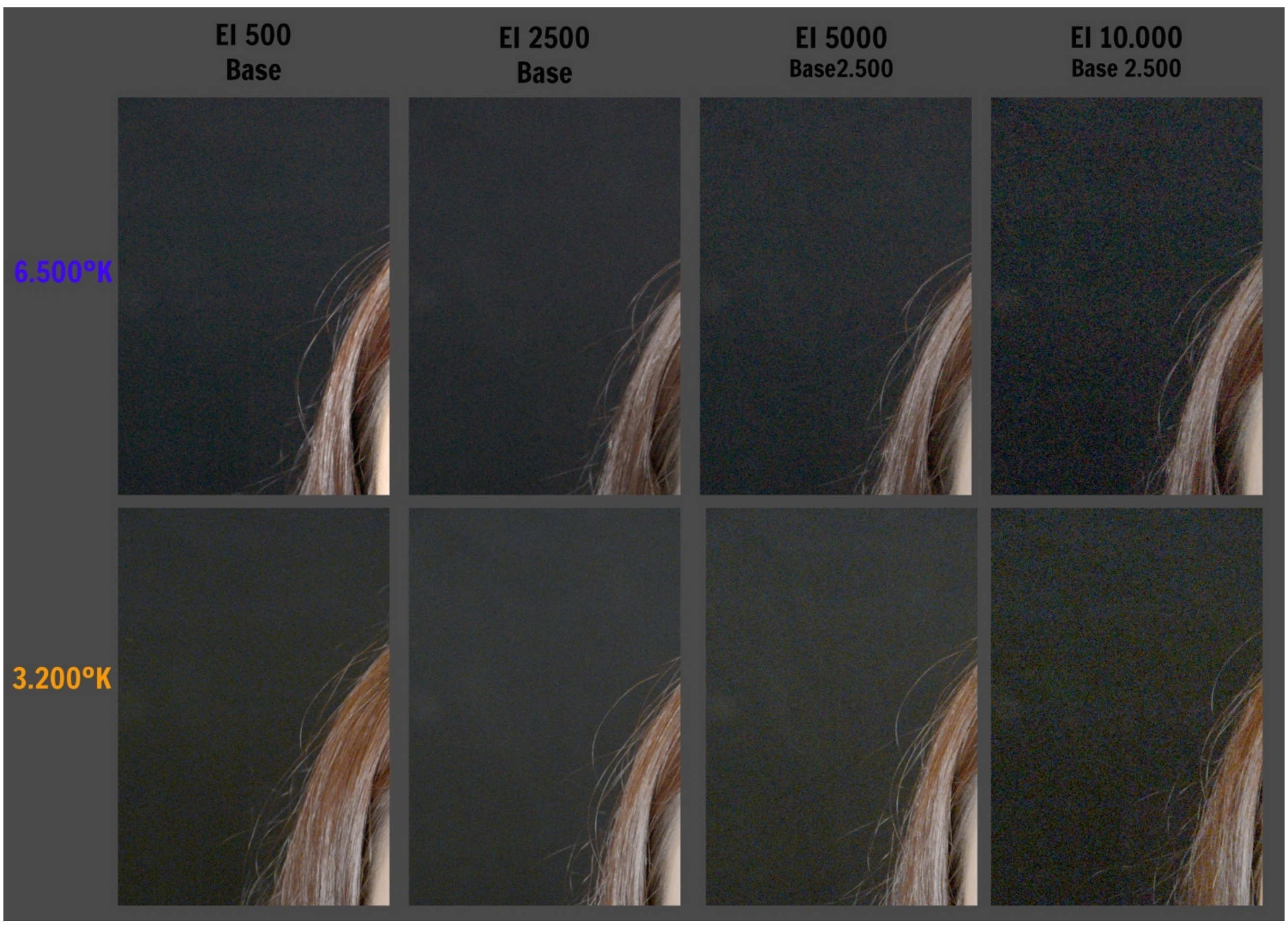


Figure 33

Now let's see some images of the movie "El yuppie y el guiso" shot with Venice I FF 2.39:1 6048x2534 in X-OCN XT with Slog3/S-Gamut3.cine (figures 34 to 38)

Figure 34. Venice I 24 fps 180º (1/48 sg) EI 2500 (base) 3.200K. Sony Raw X-OCN XT. SLog3/S-gamut3.cine. T 2.3

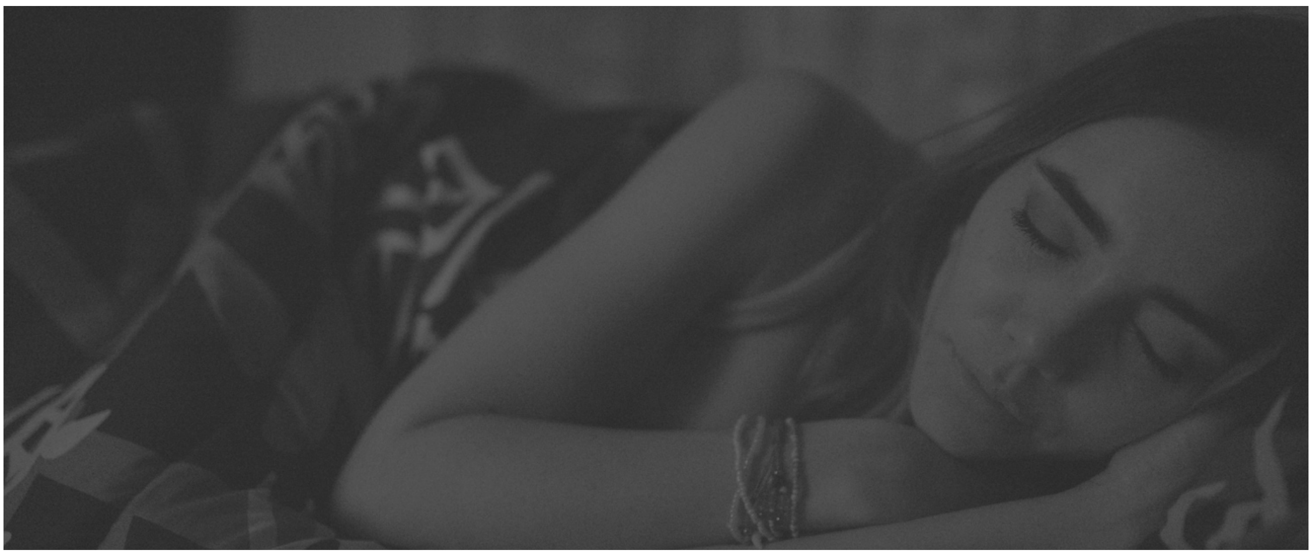


Figure 35. Red Channel

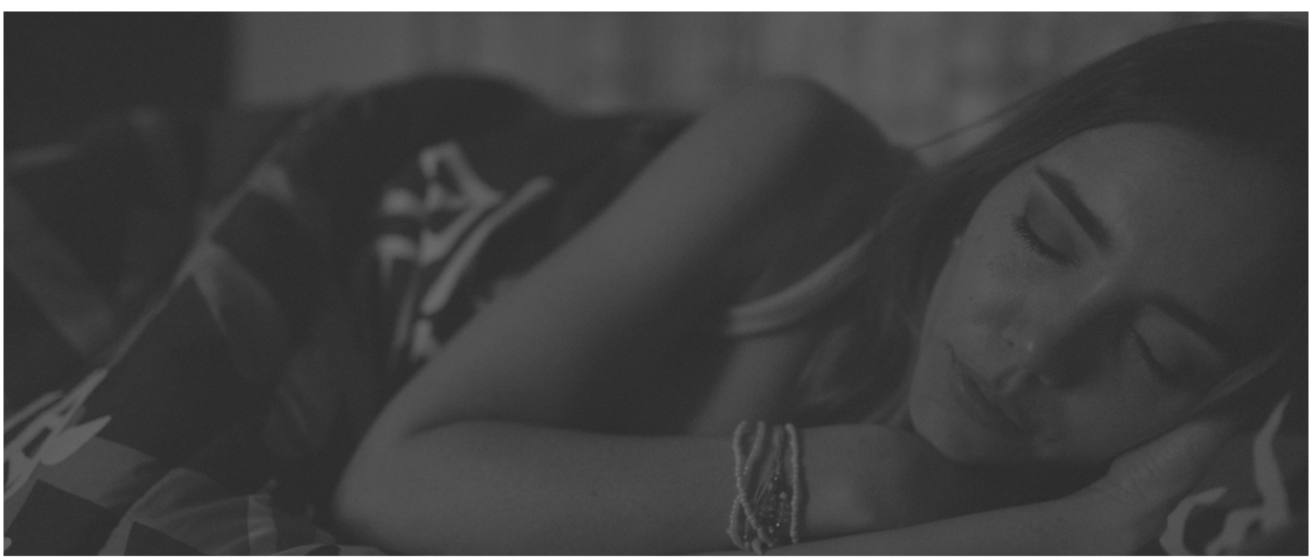


Figure 36. Green Channel

Figure 37. Blue Channel

Figure 38. SLog3/S-Gamut3.cine with Lut 709.

At this color temperature, the blue channel shows the most noise, followed by the red channel and finally the green channel with the best SNR. This is what I would expect after the noise tests and from them I know that I can underexpose the image (here the face is underexposed 2 stops from the mid gray value for this Slog3 curve) and create a dark gloom but with detail and the noise is not masking the finer detail and is not visually significant. Another example, in this case, an outdoor/night sequence where there are sodium vapor lights on the street, as well as mercury lights with very different color temperatures. My lighting is set to 3.200K and consists of Titan astera tubes placed on the light poles of the street itself and a very diffused 4Kw HMI for the backgrounds (figures 39 to 43).

Figure 39. . Venice I, 24 fps 180º (1/48 sg) EI 2500 (base) 3.200K. Sony Raw X-OCN XT. SLog3/S-gamut3.cine. T 3.1

Figure 40. Red Channel

Figure 41. Green Channel

Figure 42. Blue Channel

Figure 43. SLog3/S-Gamut3.cine with Lut 709.

Finally, let's look at this frame (figure 44 to 48) of an Ext/day sequence where the exposure is set to outside to get a dark gloom at the back of the store. The interior of the store, where the lady is, is illuminated with two astera Helios tubes.

Figure 44. Venice I, 24 fps 180º (1/48 sg) EI 500 (base) 6.500K. Sony Raw X-OCN XT. SLog3/S-gamut3.cine. ND 6. T 5.6

Figure 45. Red Channel

Figure 46. Green Channel

Figure 47. Blue Channel

Figure 48. SLog3/S-Gamut3.cine with Lut 709.

In this shot there is an important difference between the exhibition of the exterior and the interior of the store. The noise is greater in the brightest parts (actor's face, jacket, etc.) although we do not perceive it as if we could do it in the dim light of the store. The darkest part of the store is between the -6 and -7 stops while the actor's face is +2/3 above the middle gray value, that is, there is practically a difference of approximately 7 stops between the darkest part and the skin tone. From the tests we have carried out with the camera, we know that between -4 and -5 stops detail can be recovered in the shadows, but beyond these and even though the camera continues to distinguish very small different brightness values, the noise masks the detail losing resolution and texture as shown in figure 49 where we have cut out a part of the interior of the store in the three channels and we have passed these through the edge detector which, as we can see, indicates that there is not much difference between the three channels in terms of It has to do with the loss of detail.

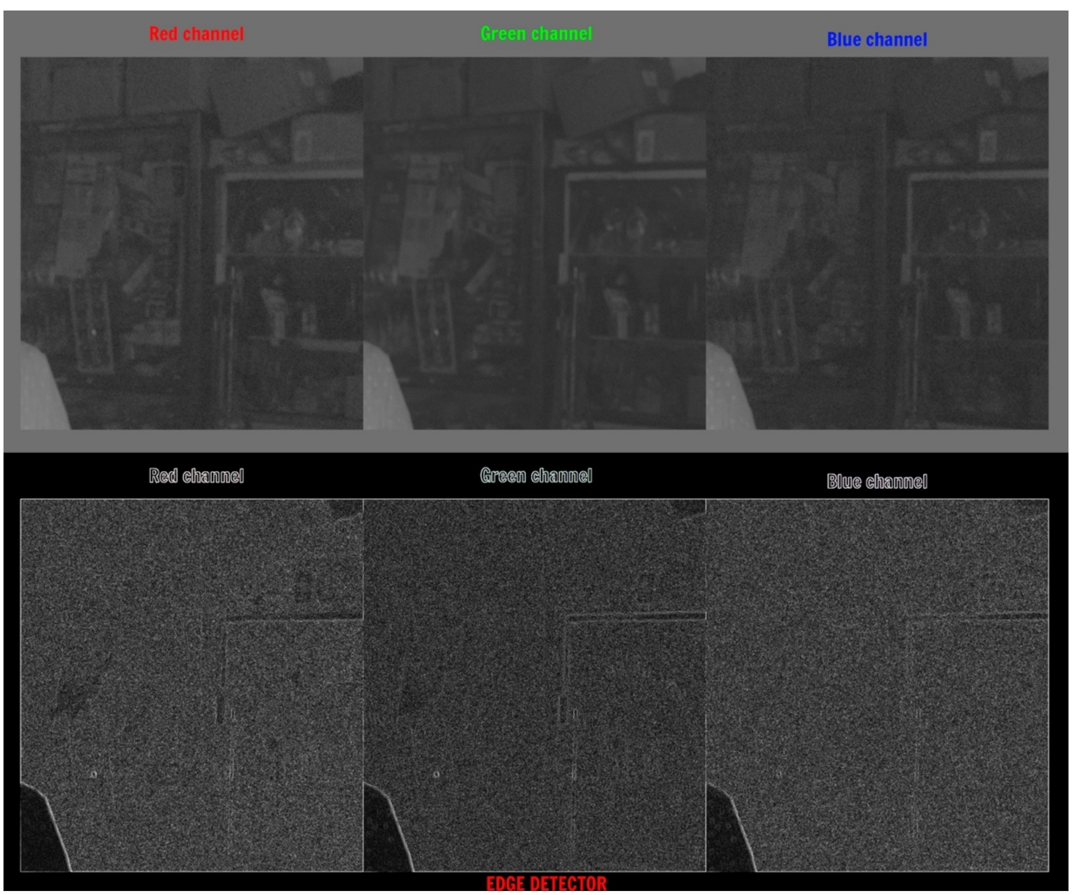


Figure 49

Ultimately, the noise that the image shows will depend not only on the base, reading and photonic noise, but also on our exposure, as well as the shutter or the selected ISO value. And equally there is some degree of subjective appreciation on the amount of noise that each one accepts or how to obtain a certain level of noise to build texture in the image. In this sense, paraphrasing the advertising slogan of the designer Adolfo Dominguez, “noise is beautiful”, and it can constitute the basis of the texture of the image when it is required in the audiovisual narration, a decision that corresponds to the cinematographers and their visual proposal and no to QC (Quality control) of platforms, channels or production companies. An in-depth understanding of how noise manifests itself in the camera allows us to manage it in all senses, from its most absolute minimization to its most aggressive manifestation, all of which I insist, within the framework of image creation, which is the responsibility of the director of photography.

The Venice I camera that this study deals with shows more than manageable noise levels, even at high ISO values. If we want very clean images, the value of EI 500 and 2500 work perfectly, although the former shows better SNR. The base noise is very minimized in all the values and there is some symmetry between the two base ISOs when it comes to how said noise increases by varying the ISO from one base or the other. It must be considered that, if you want to use intermediate ISO values, it is always better to go down from the base ISO than to go up from it, for example, to shoot at an EI of 1000 it is better to go down from the base 2500 than to go up from 500, I insist if what we want is to minimize the noise, although we must also consider the variation of the dynamic range distribution that we already indicated at the beginning of the text. If we want to have acceptable noise, we can work without problems up to 5000 ISO, but if we want to have noise to create texture, we can work perfectly up to 10000 ISO or work from base 500 and go up to 2000.

Undoubtedly, this article is just observations and each cinematographer would have to do his tests to determine precisely what amount and type of noise he needs for his audiovisual creation.

* All frames are courtesy of DGP

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