CENTRO DE
CINEMATOGRAFIA
DIGITAL

AN EVALUATION AND PHOTOGRAFIC STUDY OF THE AJA CION CAMERA. V 1.2

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INTRODUCTION

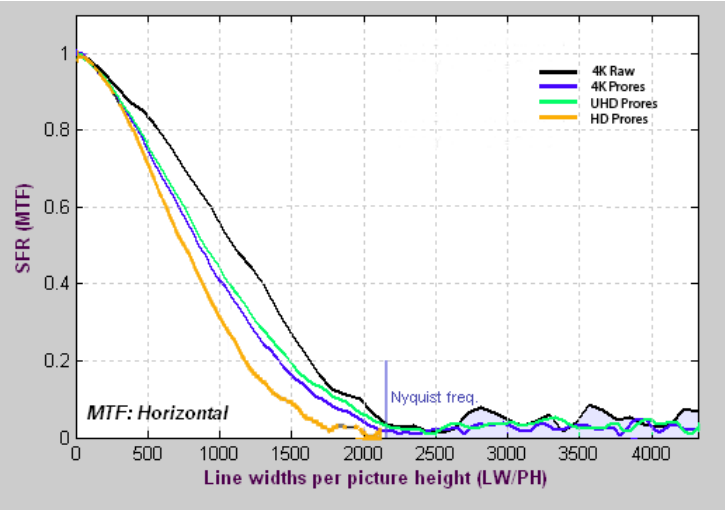
In this paper we evaluate the AJA CION camera from the photographic direction point of view. For this reason we have worked on four fundamental aspects related with the image quality: resolution, dynamic range, sensitivity and color. We have focused this work from both theoretic and practice views. In order to study the aspect theoretic we have used the next standardized reference charts: the ISO resolution, the Macbeth color and Spydercheker, in addition to other ones with textures and colors. We have study the charts with the Imatest and ImageJ programs and also with Davinci resolve, Color and Speedgrade. We have lighted the tests to both 5600ªK and 3200ªK, with Fresnel devices of tungsten, KinoFlo and HMI. The necessary adjustments have been made through an WFM/vector scope in the set, as well as with the Sekonic L-558/Cine light meter and the Minolta Color meter IIIF termocolorimeter, all of them suitably calibrated. The lenses used were the Zeiss set of lenses Compact Prime (CP). On the other hand, for the practice aspect we have shut in different places of Medellín (Colombia), places such the Seminary, the former railway depot, the theater space and the toys workshop. We have not used any kind of lighting for these shootings. We have mainly chosen the *Normal* and Expanded gamma curves with regard to their CC Normal and Flat color spaces. The postproduction were made in Crayola Film, we have worked at Scratch as well as at BaseLlight. Images of the paper are from original ones; however, since they are compressed they have watched merely as a reference.

RESOLUTION

We evaluate in this section the ability of the camera to show detail, from the lowest frequencies to the highest ones, in other words, how is the image showed by the camera regarding the sharpness, using the different available formats.

RESOLUTION

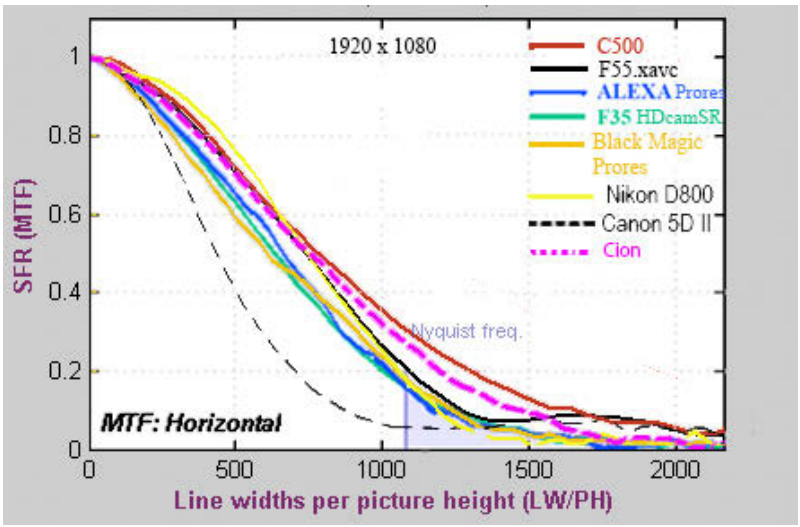
The camera can work with different formats, and so, to different resolutions, from the HD until the 4K, as well as the UHD. To evaluate completely the resolution, in addition to the CP lenses, we have used the ISO 12233 resolution charts, analyzed through Imatest, as well as our usual fabrics charts, the still-life and specific frames from natural outdoor locations. We have also put in comparison the outcomes with other cameras to the same format, but with different lenses, thus, we have placed the camera amongst of the wide offer that professionals can choose. Usually, , the charts have been shot with the CP 50mm lens to T5.6, at Prores 444 and the *Normal*, *CC Normal* gamma.



Let us see the MTF curves with the different formats that camera gives. If we shoot at RAW we can observe that the format offers the highest resolution. The 4K and UHD formats show a similar resolution, being the lowest one with the HD. Next, table shows the values that we have got with the four formats to 50%.

Values MTF al 50%	
Raw (DNG)	1052 Lw/ph
4K Prores 444	857 Lw/ph
UHD Prores 444	892 Lw/ph
2K Prores 444	748 Lw/ph
HD Prores 444	747 Lw/ph

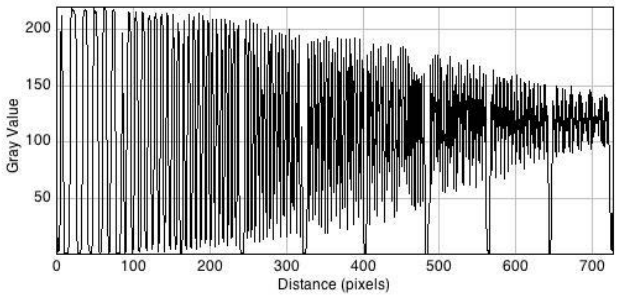
We can see that the resolution with the formats HD and 2K are between normal parameters. To confirm this fact, we show the graph that describes the comparison of such formats with other cameras. We can see that the CION camera keeps as high contrast as the other ones, for instance, it is at the same level than the high-end cameras as the F55 and close to the C500 at the low frequencies

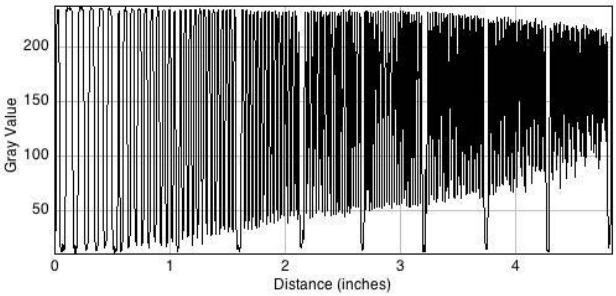


At the middle and high frequencies in comparison with the other cameras, it shows a good texture and finally has a good ability to seize fine details at such resolution.

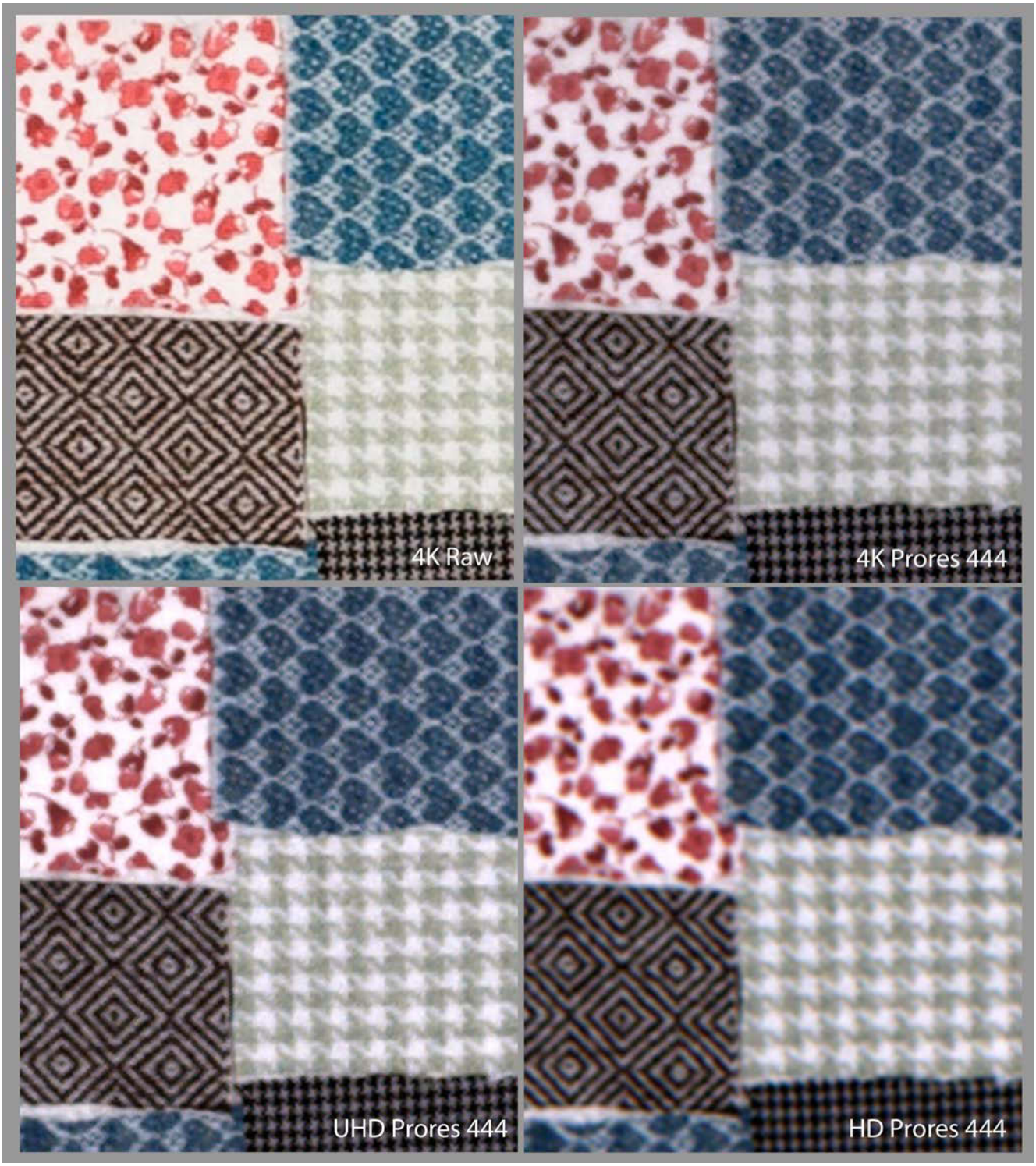
However, we are surprised because of the moderate outcomes of the camera with the 4K formats shooting at Prores, even at RAW. Such resolution value is lower than the values provided by other cameras.

We can see the different resolutions by other way using a resolution line profile, in this graphs I have used the ImageJ software.

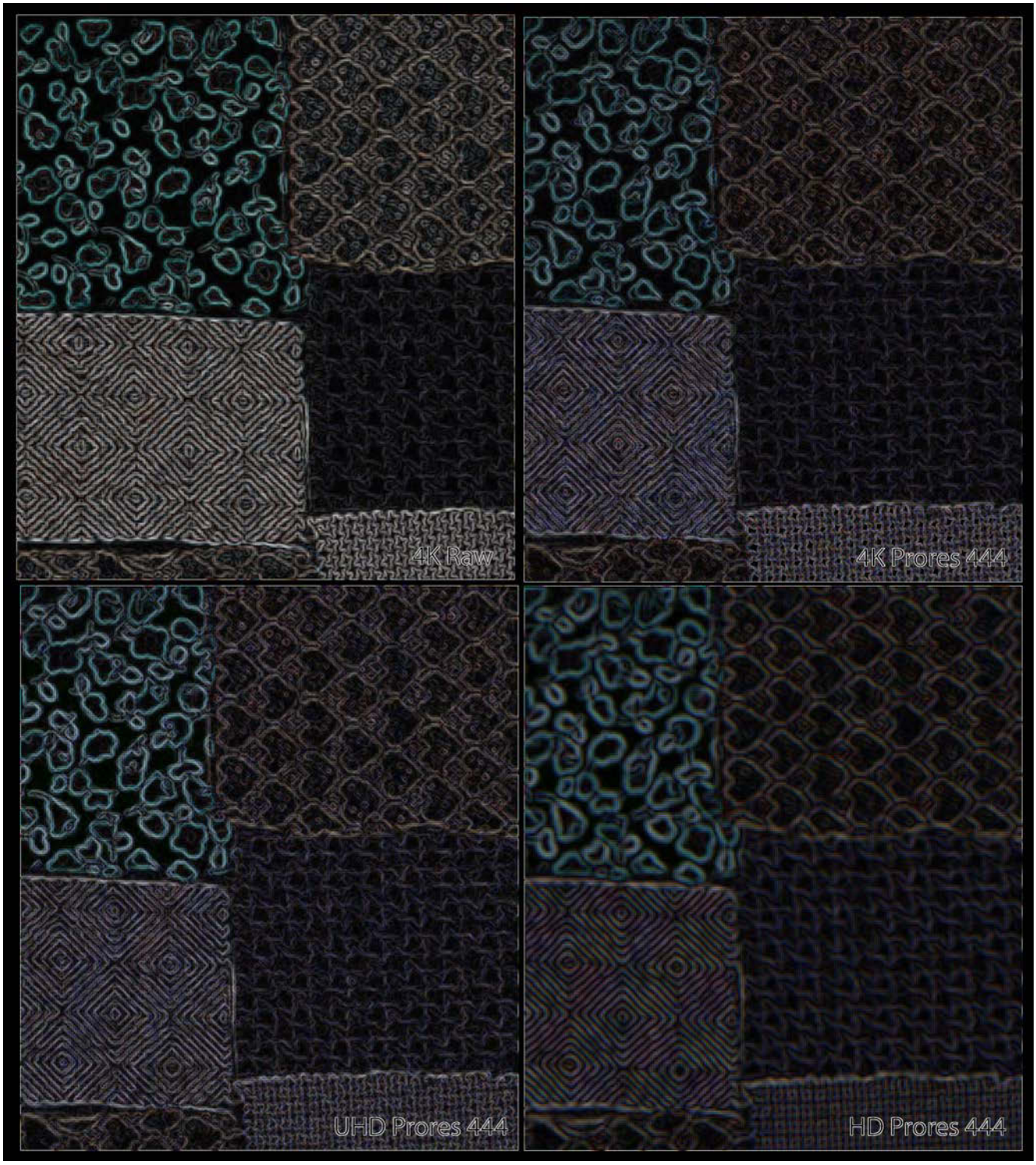




The left graph shows the resolution profile of the horizontal lines with HD opposite to the right graph, which shows the same profile, but with the RAW 4K (DNG) format. It is significance the difference of sharpness that we can see; the widest is the vertical line, the best is the resolution. These graphs corroborate what we have seen on the first graph of the MTF curves. How can we see this fact in the real world. How can we see images far from the standardized charts? Next, I show an enlarged cutting from a frame of the fabric's chart.



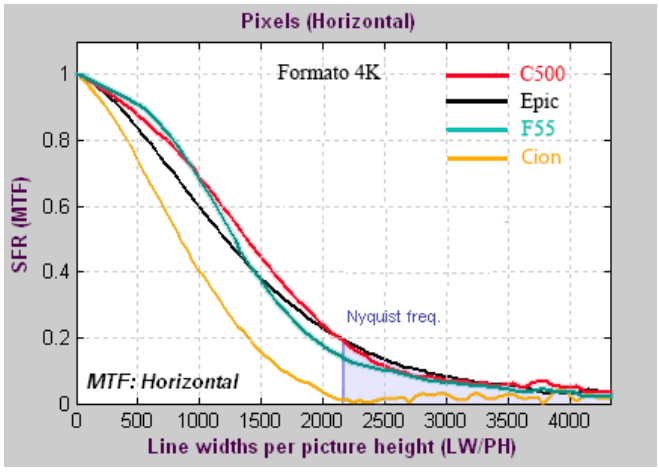
We can clearly see the difference of sharpness between the RAW format and the other ones, as well as the resemblance between the 4K and the UHD, being the lowest provided by the HD format. In order to see more accurate we have used an edge detector over the image.



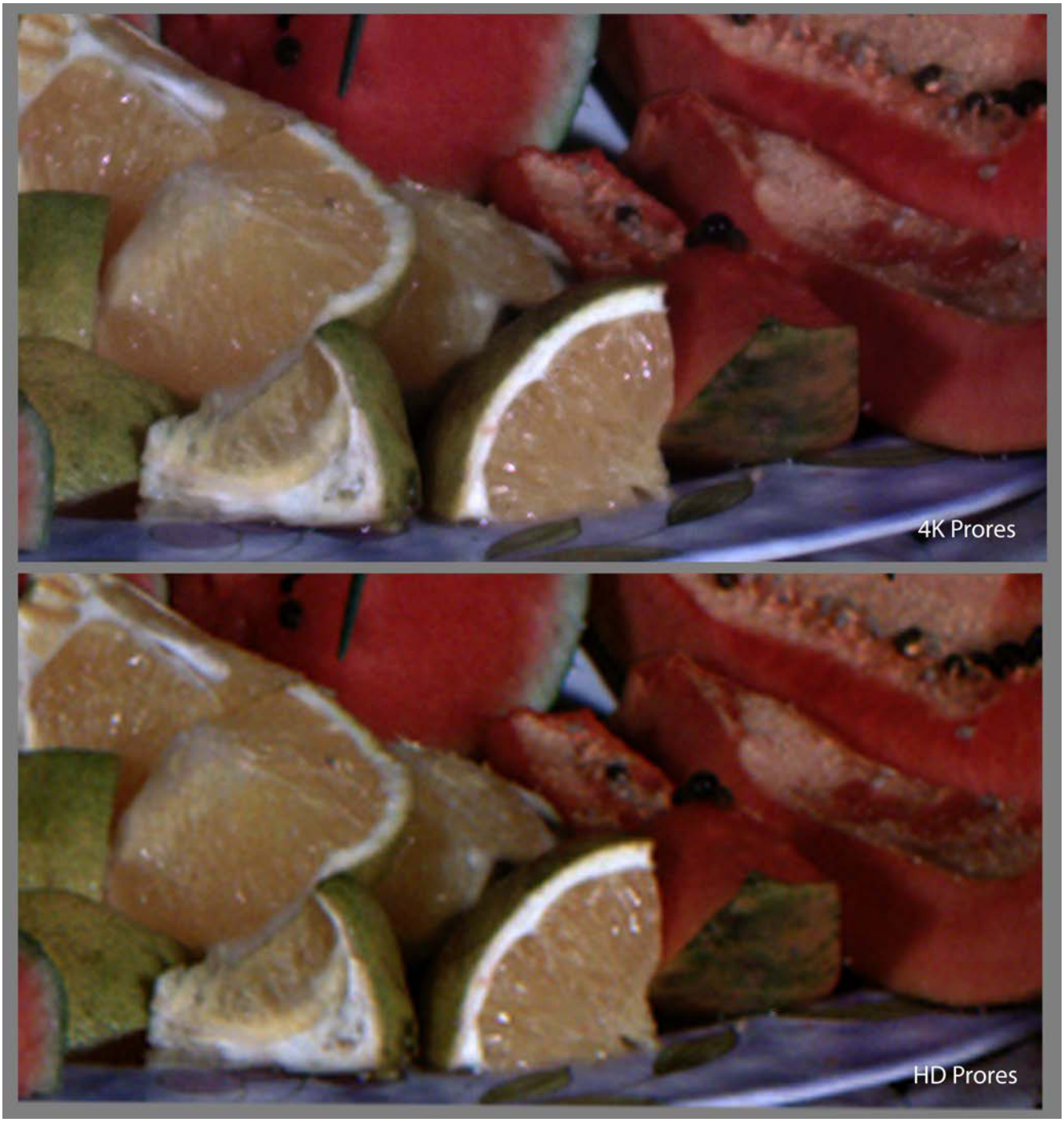
If we pay attention on the edges from the different fabrics we can observe the difference of sharpness amongst the different formats, for instance, in the fabric with flower pattern, top on the left as well as with the diagonal patterns. From the resolution point of view the RAW format is clearly much better, nevertheless the camera needs an external recorder, which is neither always available nor is comfortable to work with. We can also see that the UHD format is slightly sharper than the 4K, as we could also see on the MTF curves.

In order to clarify the resolution with the 4K, I show the comparison with three different cameras. For this occasion we have used a different lens what have been used by the CION; however it is not a justification for the huge difference that the camera shows.

On the graph of MTF curves we can see how the CION camera resolution is significantly lower than the other ones. For example, to 1000TV value, CION shows a 40% of contrast, whereas the Epic shows a 60% and both the F55 and C500 a 70%. Next, we can see it clearer on our Prêt-à-Porter chart. Top on the left image the F55 with the 4K format and its XAVC codec, top on the right the Epic with the UHD format. We can see the obvious differences with the CION, above all in the fabric with flower pattern, which is less sharp.



Next, we can see how the resolution on our still-life is. I have put in comparison the 4K (ProRes) and HD formats, first cutting the frame and after enlarged x800. We can see indeed a slightly difference over details and texture of the orange slides as well as blue fabric with leaves pattern. There is also a bit more sharpness with the 4K format on the papaya. Nevertheless, such differences of sharpness are very low if we take into account how different the two formats are. In fact, the image shows that between 4K and HD there is just one 110 TV lines of difference as we could see on above table.



Perhaps the reason of the slight difference between both formats it should be ascribed to the manufacturer intention, who should have tried to create an image with the 4K format softer than images provided for other cameras, perhaps, as he points out, to obtain a look more cinematography-like, softer with skins and less sharp outlines. We cannot dare to think that the OLPF filter which camera uses is designed for the 2K.

Next, we show a frame of a panoramic view of the Medellin city. We can see the smoothness of the image (enlarged view).

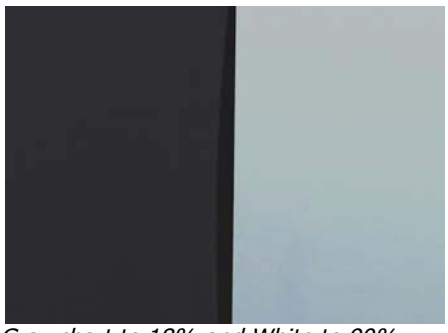
Normal gamma curve. CC Normal. 15mm focal length. UHD. T 11. ISO 320. 5600ºK. Polarizer filter + ND degraded smooth cutting 0.9

SENSITIVITY, (IE) AND NOISE

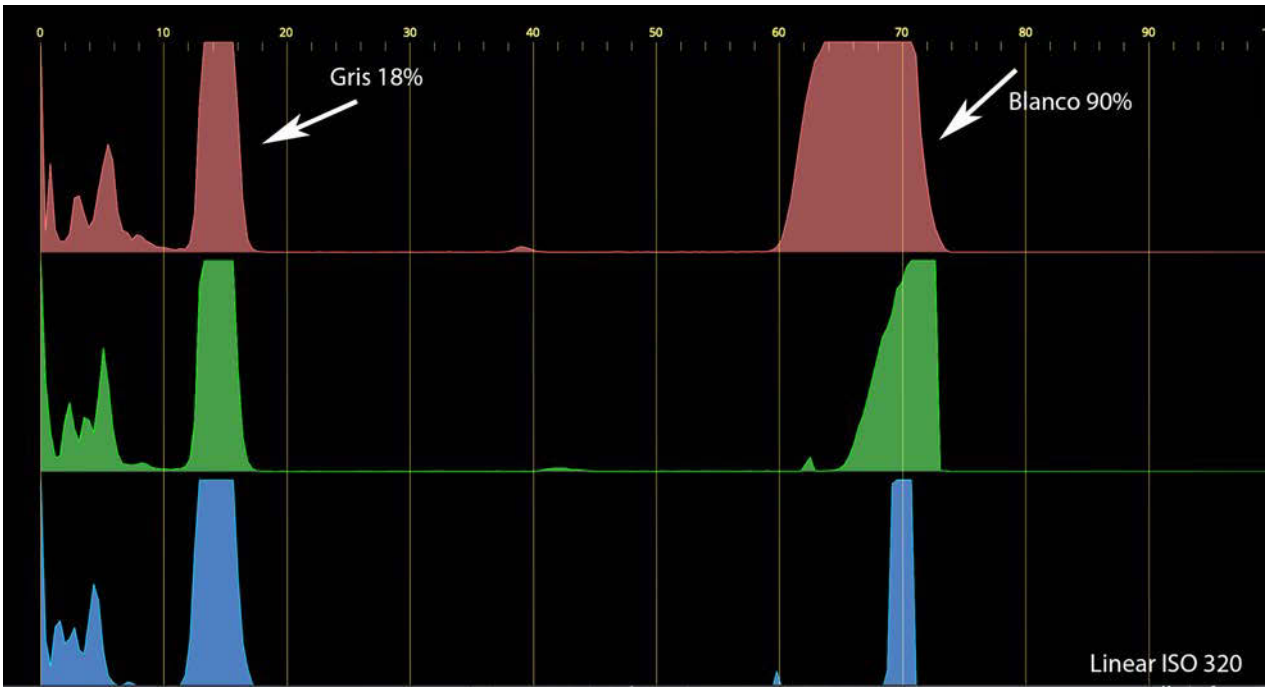
We evaluate in this section the camera sensitivity; firstly, looking for the nominal EI to settle, finally, the effective one with regard to the noise level of the different exposures.

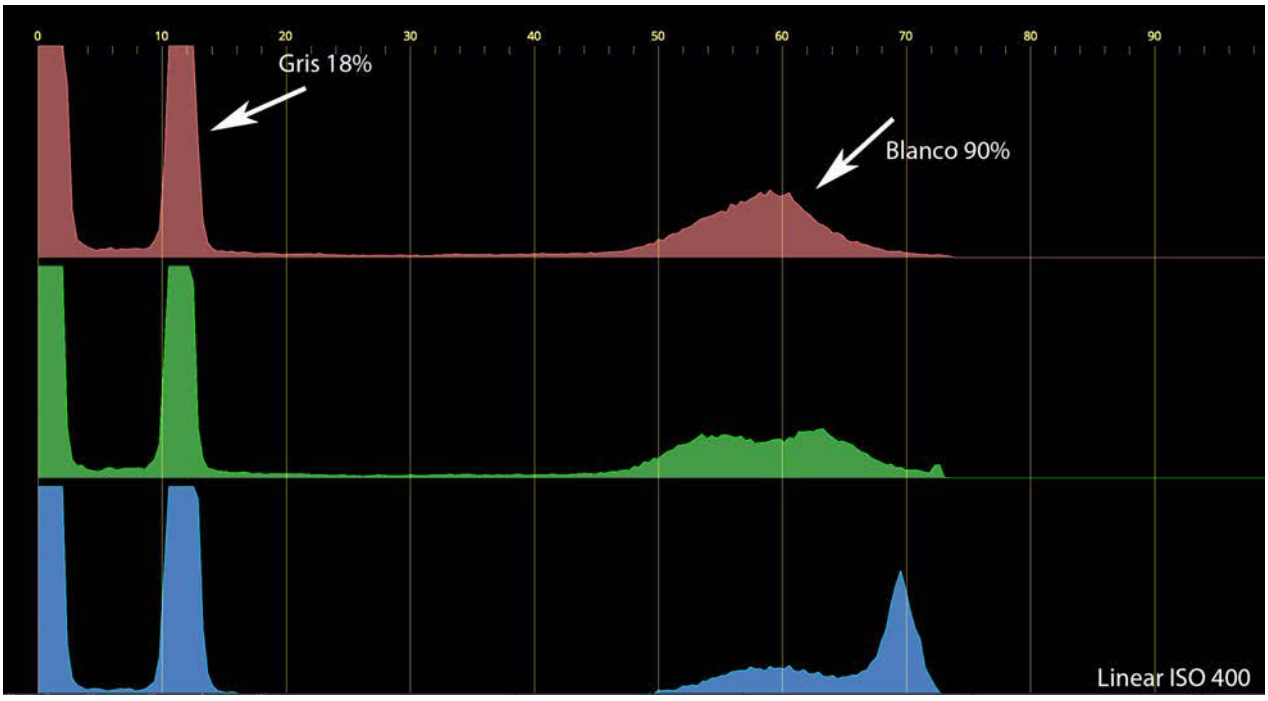
EVALUATION OF THE NOMINAL/EFFECTIVE EXPOSURE INDEX (EI).

To evaluate the nominal exposure index we have begun to watch the different ISO values which the camera provides, and then we have shut them at linear mode, that is, without applying the gamma curve, in order to study the outcomes and put in comparison with the ISO 12232:1998 standard. Such standard establishes that white with a reflectance of 100% gives in camera a 70% value as well as the 18% middle gray gives 12% value of saturation (gamma 2.2 and sRGB). To test we have shut the 18% gray chart and the white with 90% of reflectance, lighting with 2000 lux and color temperature of 3200ºK, using the manufacturer recommendations of the ISO 320. After lighting the charts, we have put the T-value in such way that the white was in the limit of clipping, or saturation in the wave monitor.



Gray chart to 18% and White to 90%. Shot at linear mode.

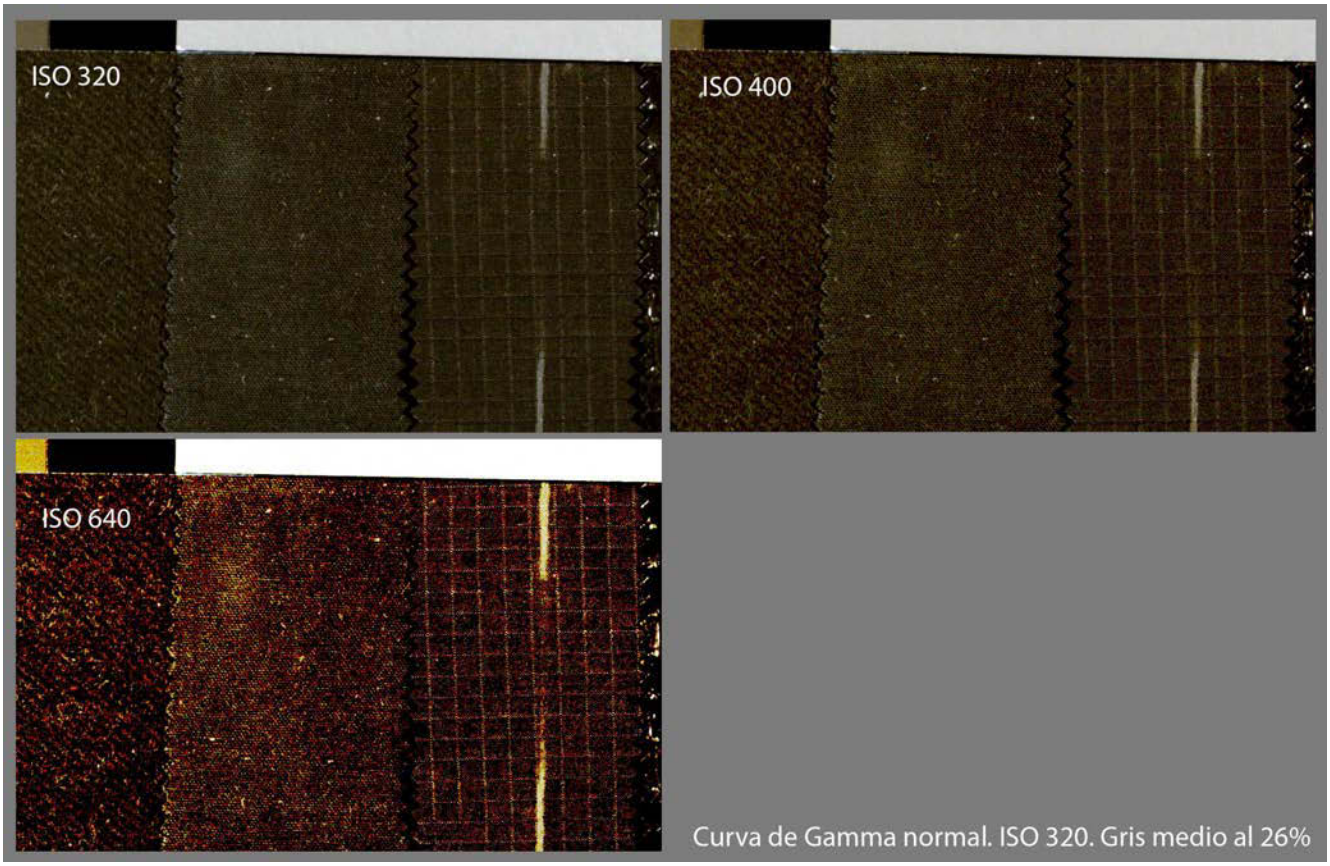




First of all, it should be pointed out that the blue channel always clips before the other two channels, and gray is neutral because we have fixed it at postproduction. In the histogram (above, first from top) we can see that the 18% gray value is slightly higher than the 12.7%, as the standard points out: it is around 15%. With white occurs the same: it is close to 70% whereas it ought to be around 60%, since white is 90% instead of 100% expected. Moreover we can see that white is clipped at both green and blue channels. With this first approach we can think that the nominal sensitivity is slightly higher than the manufacturer points out.

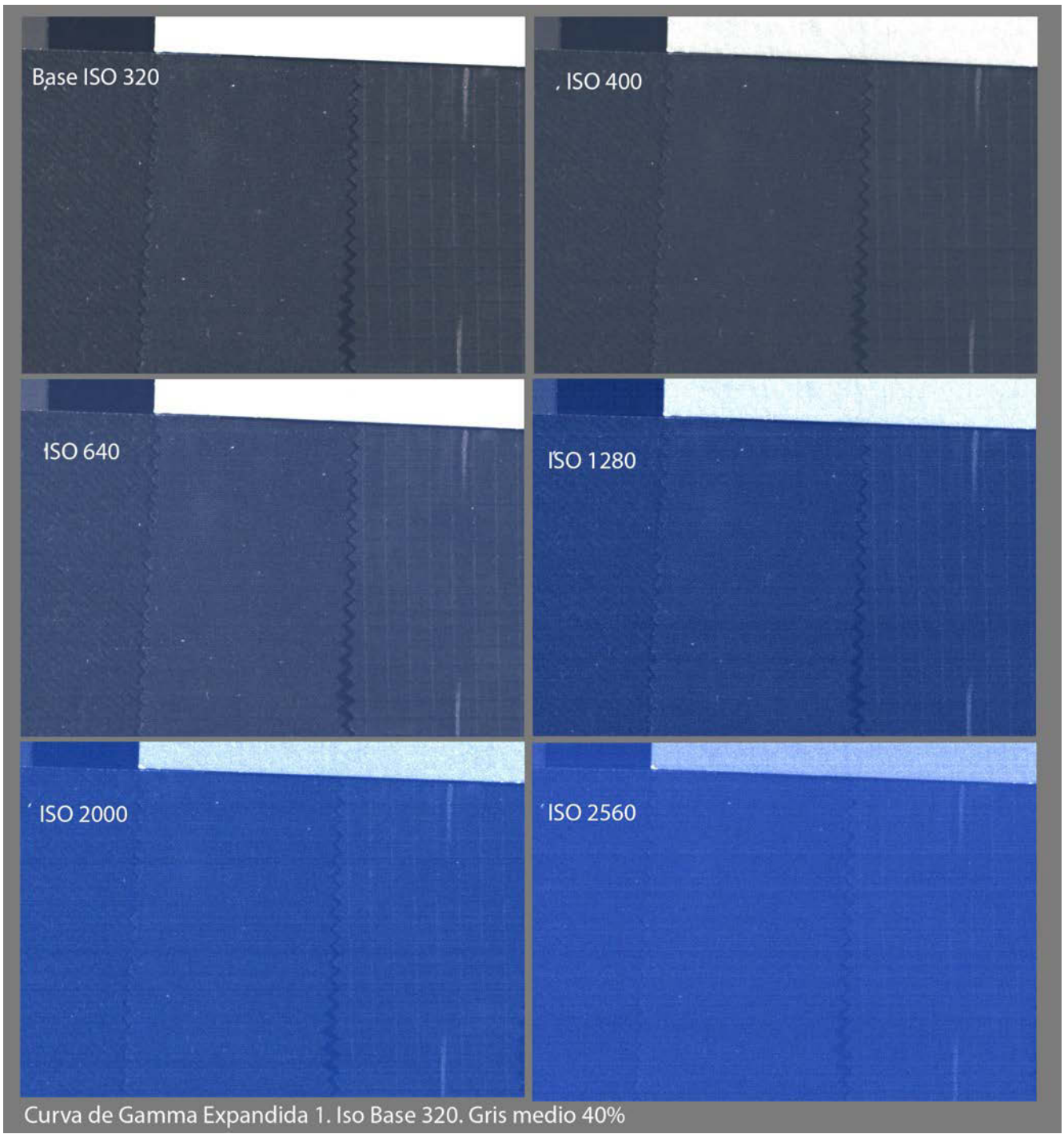
The second histogram (above, second from top) is related to our *Death* chart, with exposure -1/2 regarding the value of the base saturation, that is, an ISO value around 400/500. As we can see both 18% gray and white are placed close to the standardized values. Thus, we can point out that the nominal EI is around ISO 400.

To look for the effective EI we have watched our CMD to evaluate how much detail we can see in both shadow and light, for these reason we have focused on two gamma curves: the *Expanded 1* and *Normal*. It should be pointed out that since our sensitivity as well as the dynamic range has as reference the middle gray, it is essential to know where the middle gray has to be placed, in addition we have to place it because of the lack of information that the manufacturer provides. We have begun from a T-value given under the condition above referred. From an ISO 320 value, if we used the *Normal* curve we have seen that the gray is placed around 26%; as we have said above, with such value, whites of the chart are slightly clipped, thus, we have to underexposure to 1/3 and ½ stops, and consequently the gray value was placed around 21%. With the *Expanded1* chart, gray with ISO 320 is placed to 40% and we are in the same circumstance than with the *Normal* curve: whites are clipped and with same adjustment process, gray is corrected around 35%. In other words, briefly, to ISO 400 value the middle gray with the *Normal* curve is placed at 21% and with the *Expanded1* at 35%. It is doubtless surprising the value of the *Normal* curve; since it is "normal" should be much lighter because we understand for "normal" those curves regarding all of the ITU 709 standards. Nevertheless, the *Expanded 1* curve shows a similar value than the Log curves of other manufacturers, it ranges between 32% and 40%.



In the image (above) we can see the detail of blacks at three different ISO values of exposure with the *Normal* gamma. As we can see the ISO 320 and 400 values keep the detail and texture with blacks, but for higher ISO value of exposure does not occur the same; in this case it is not the noise what settles definition and detail but the clipping of blacks inherent to the curve which does not allow using higher ISO values. As we have already pointed out, at high lights, to an ISO 320 value, whites, that are a bit more than 2 stops, are clipped,

thus, the real ISO value should be 400, and it should be both the nominal and effective. Let us see what happens with the *Expanded1* gamma curve.



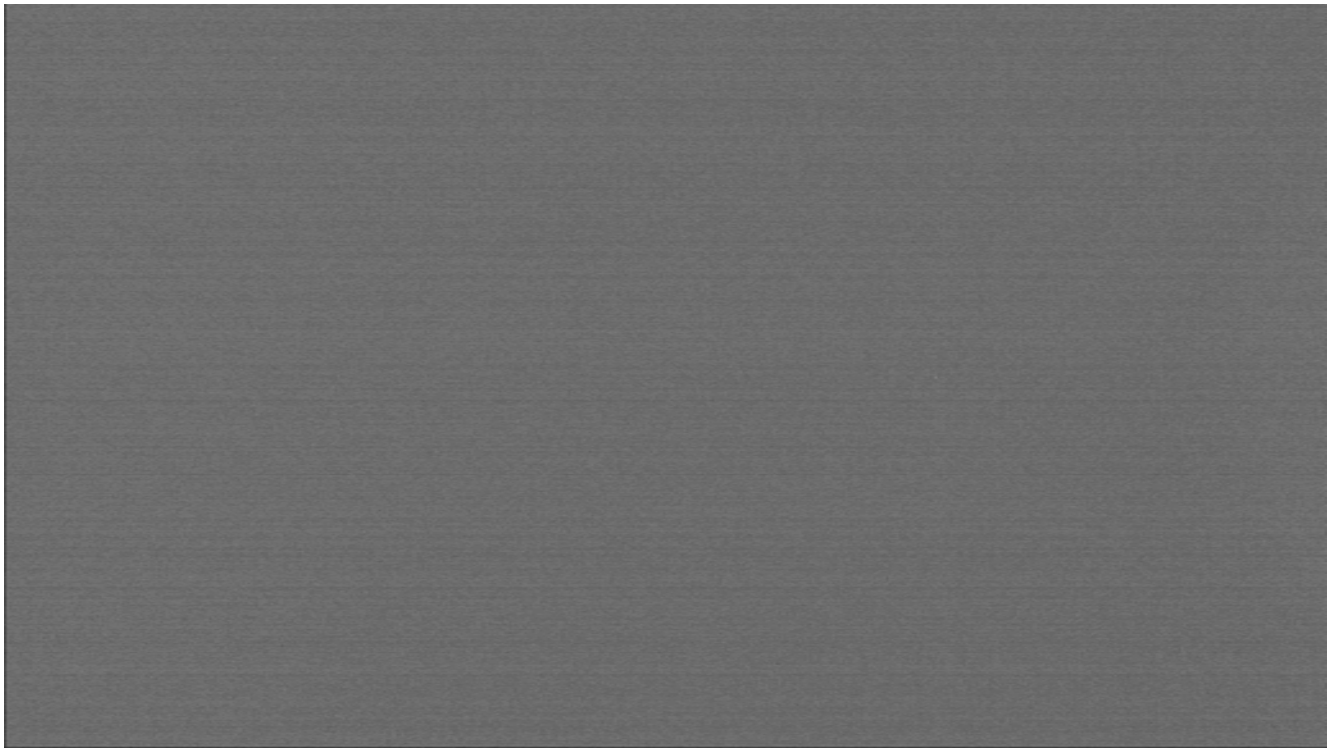
Curva de Gamma Expandida 1. Iso Base 320. Gris medio 40%

Watching the detail on the texture of blacks we can see that recuperates up to the ISO 640 values; with higher ISO values detail is lost, in addition artifacts (horizontal lines) as well as significant color deviation show up. We can suggest that the effective value of ISO ranges between 400 and 640. In spite of the camera offers different ISO values they are not the same for the different gamma curves. Firstly, in the still-life we have seen those ISO values with the *Normal* gamma curve, and then with the *Expanded1*. What we can see is that the sensitivity value increases clearly at high lights, and oddly very few with blacks and middle dark tones, what is precisely where more should be obvious. We can hardly see a bit more detail at blacks. We do not understand how the profit applied over the channels is distributed in such way: increasing more high lights than shadows. Something similar occurs with the *Expanded1* gamma curve, with which we can use just two sensitivities, ISO 320 and 500.

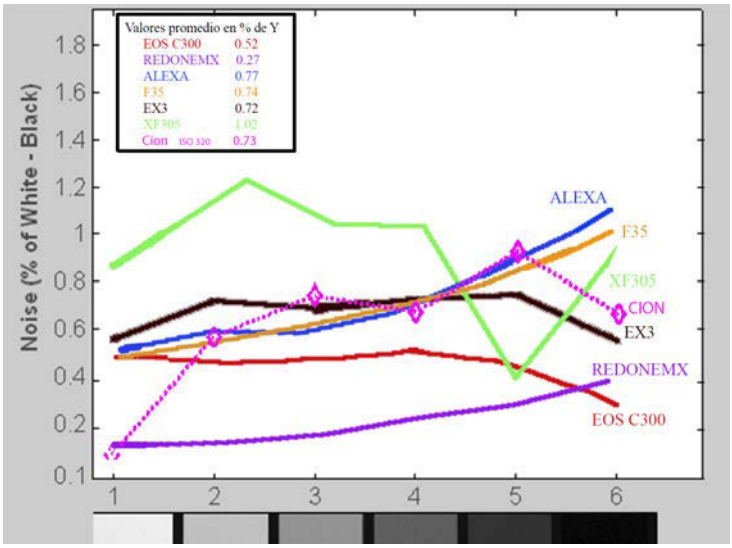
Normal gamma curve. CC Normal. 3200ºK

Normal gamma curve. CC Normal. 3200ºK

With the *Expanded1* gamma curve we have seen how the difference at shadows is small as the ISO value increases. To see clearer I use the two blue channels for both sensitivities. They do not show really much noise but show clipping at black, without detail, what is "unusual". We have confirm what we can see here studying the base noise of the camera, that is, with no value of light. We have shut with the lens covered and T totally closed. With *Normal* gamma curve to different ISO values black is alike, does not change significantly. It is the same with the *Expanded1*, it shows not only the noise but also patterns of it, which seems to be related to the amplifiers of the CMOS that has not been revised adequately.



Noise base of the blue channel with the Expanded1 gamma curve. CC Flat. ISO 320



It seems to us that the reason why we cannot see much noise is not because it is very low, but because the camera is designed to see not much detail at blacks, but to show compact blacks, which lose detail with very few stops below the middle gray, and so, blacks remain "glued". We state this fact because watching the noise evaluation of the Macbeth chart through Imatest; we have seen how the CION with a lower ISO than the used by other cameras put in comparison shows a level noise very much alike. It has a Y-average of 0.73% regarding Alexa to ISO 800 and much higher than the REDOne or Canon C500 to ISO 640. Nevertheless, it shows the same noise than the F35 to ISO 400. It should be said that the noise value practically does not change with the different gamma curves to ISO 320. Our impression after seeing these images is that they are clearly "clean", but they are so because they show hardly detail at blacks or dark middle tones. We have checked it studying our model's faces with a candle beside the still-life.

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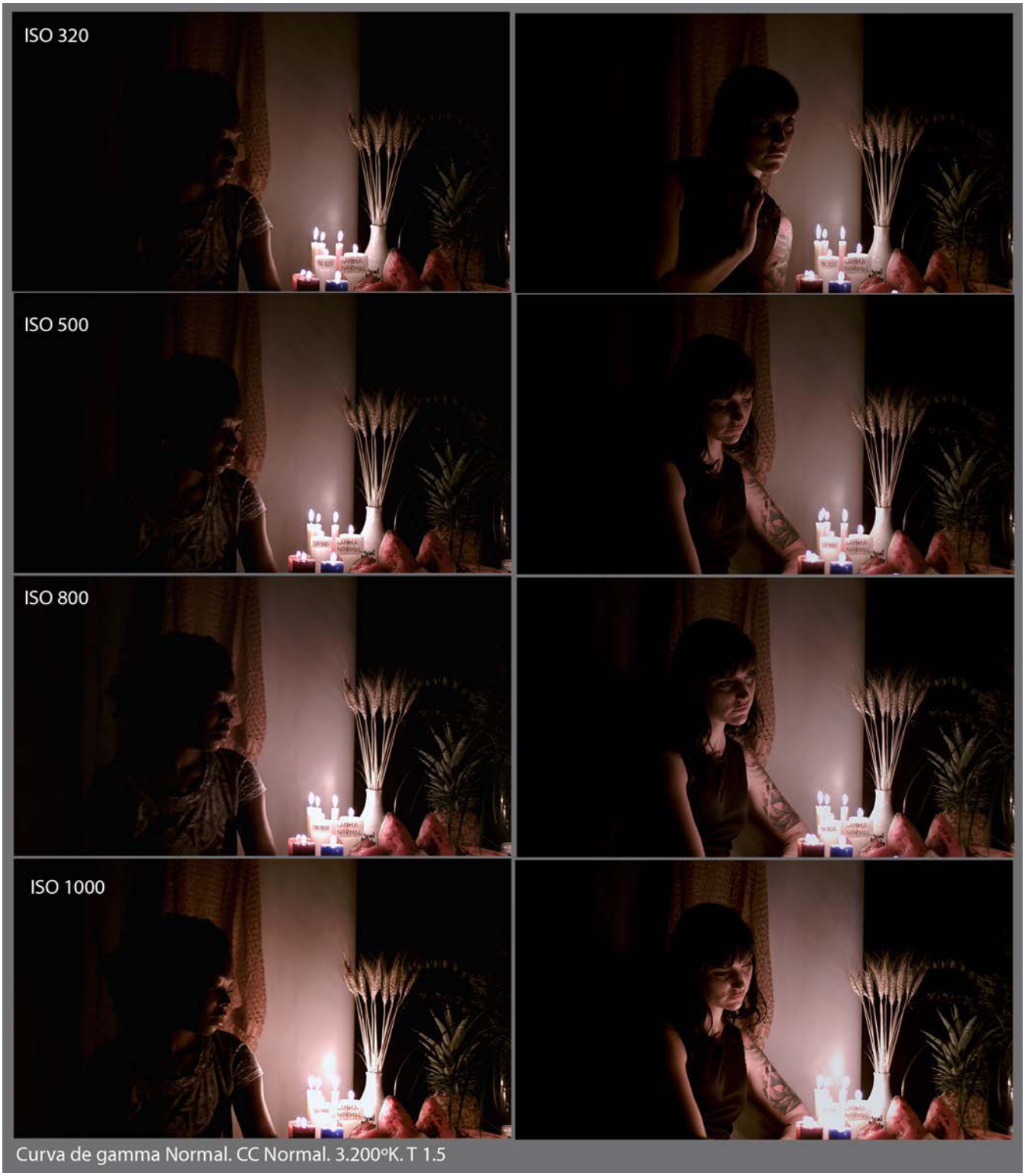


In the comparison of skin tones we can see again how can hardly see a bit more at blacks despite of using high ISO values as 1000. We see hardly the flowers branches, moreover the light from candles is totally broken and we cannot see anything either of the fabrics on the left side or back black on the right side. In order to understand what means this lack of information we put in comparison the CION with Canon C500 to ISO 500. With the same ISO value, the Canon camera gives us much more information about the darkest textures, keeping the values at high lights with both the *Normal* and *Expanded1* curves.

CION ISO 500. Normal gamma curve.

Canon C500. ISO 500.CanonLog curve

CION ISO 500. Expanded1 curve.

Finally, let us see some night images.

With the *Normal* gamma curve we have corrected to the ISO 320 value and have applied such correction to remainder images, always with the same gamma curve. For instance, we could see how the color changes totally to ISO 500. We could not recover any detail of the model's hair with neither of the ISO values, the same have occurred with the *Expanded1* gamma curve which seems very different regarding the other one. With the *Expanded1* and the *CC Flat* we have not reached a respectable skin tone under the circumstance of color and exposure, even detail in the darkest parts, neither to ISO 320 nor to ISO 500..

Conclusions

Summing up, we show below the table with the ISO values of exposure regarding the gamma curves as well as the middle gray values.

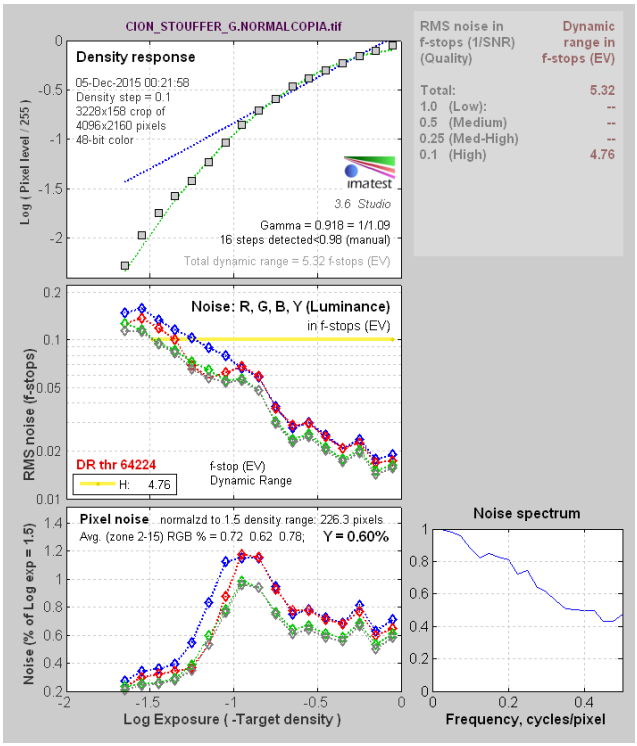
Gamma curve	Suggested EI to the exposure	Suggested 18% Gray value at WFM
Normal	400/500	21%
Normal Expanded	400/500	21%
Video	400/500	21%
Expanded1	400/500	35%

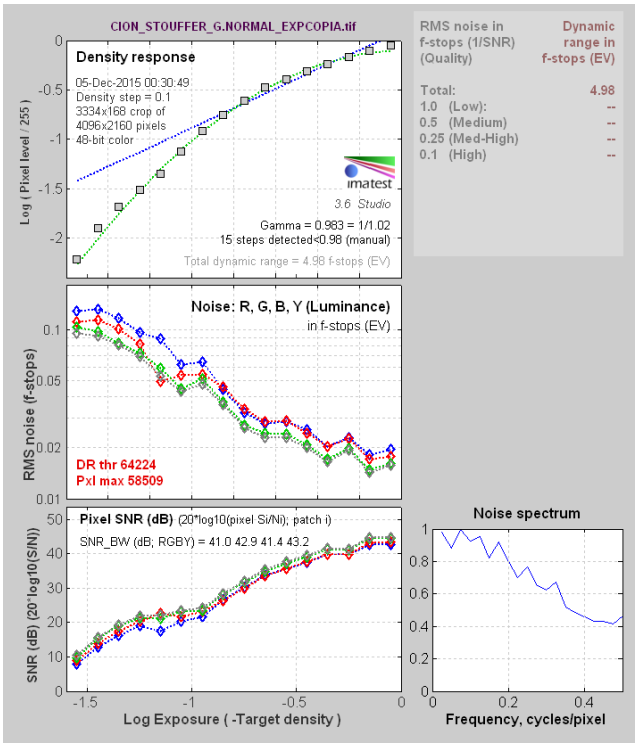
DYNAMIC RANGE

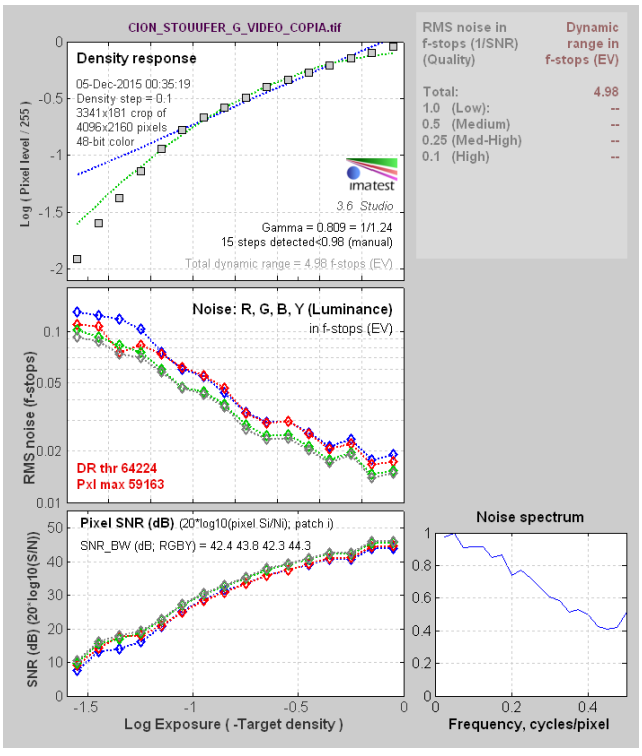
We evaluate in this section the ability of the camera to show detail at both high lights and shadows under the same exposure.

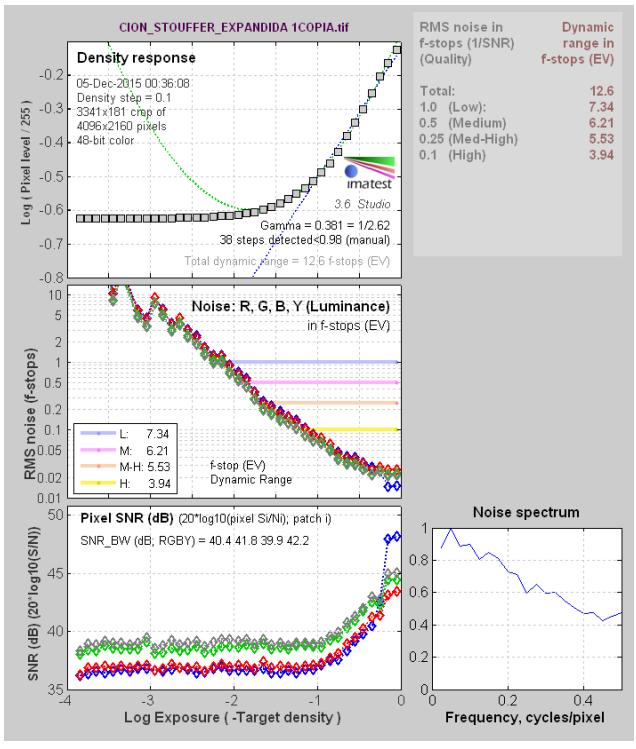
DYNAMIC RANGE

To test the dynamic range we have begun studying the Stouffer strip through Imatest. We show (below) the outcomes with the four gamma curves provided by the camera.





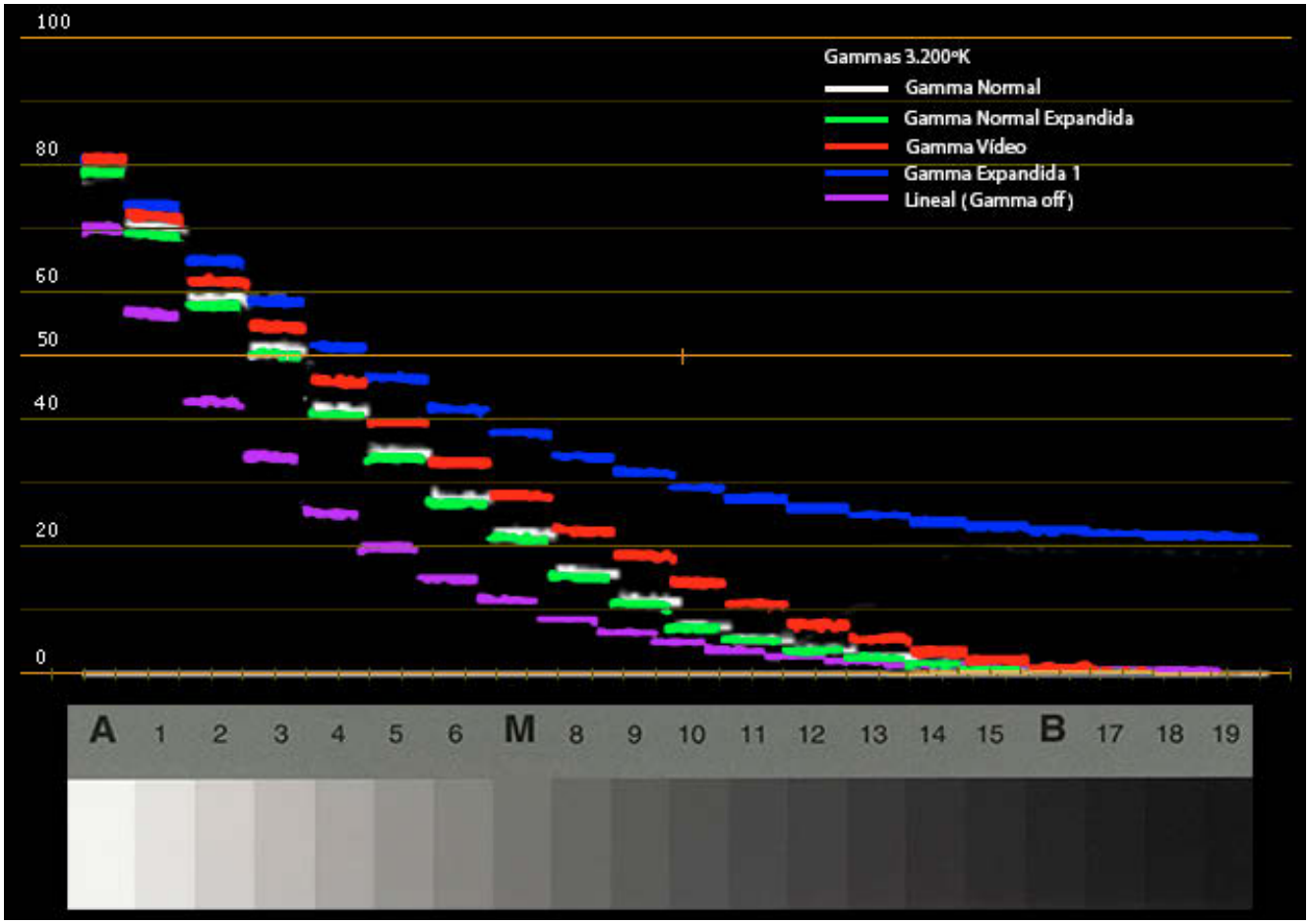




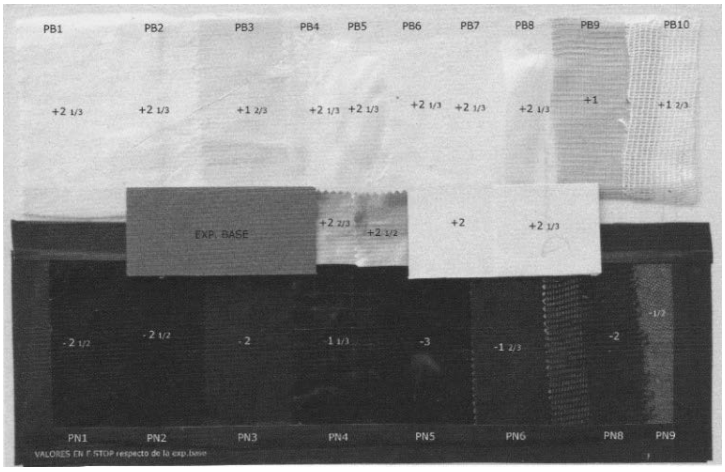
The dynamic range regarding the *Video* and *Normal Expanded* curves give the same outcome: 7.98 stops. It is curious that the range is a bit higher with the *Normal* curve then with the *Normal Expanded*, that is, 5.52. This fact already points out that the dynamic range the camera handles is low. With the *Expanded1* ought to occurs something distinct, since according to the manufacturer the camera is designed to capture the more possible range, above all under circumstances of high contrast. The total range with such curve is 12.6 stops, however, if we pay attention in the first graph shape (Density response), we can see that a lot of steps of the strip are lower than 0.6, shaping practically a line, it means that despite of the camera recognizes slight changes of brightness,

they are not usable to work with the image, in fact the Medium value regarding the noise from the analysis places the range very low, that is, at 6.21 stops.

Another way to watch the range is through the SNR value (signal noise relation) in the below graph. We can see that is in the Y-average (luminance), around 43db; it means that is near to 6 stops (6 db are 1 stop). It is doubtless surprising so little dynamic range that reminds us of the former digital cameras or reversal film, those slides which we used at analogical times. To see in other way such information we have shut a gray scale with the different gamma curves. We can observe how the *Expanded1* really behaves, it does not seem to us that behave as a conventional Log curve, but it matches with the *Normal* gamma curve, with a level of blacks very high (what we know as a blanking level).



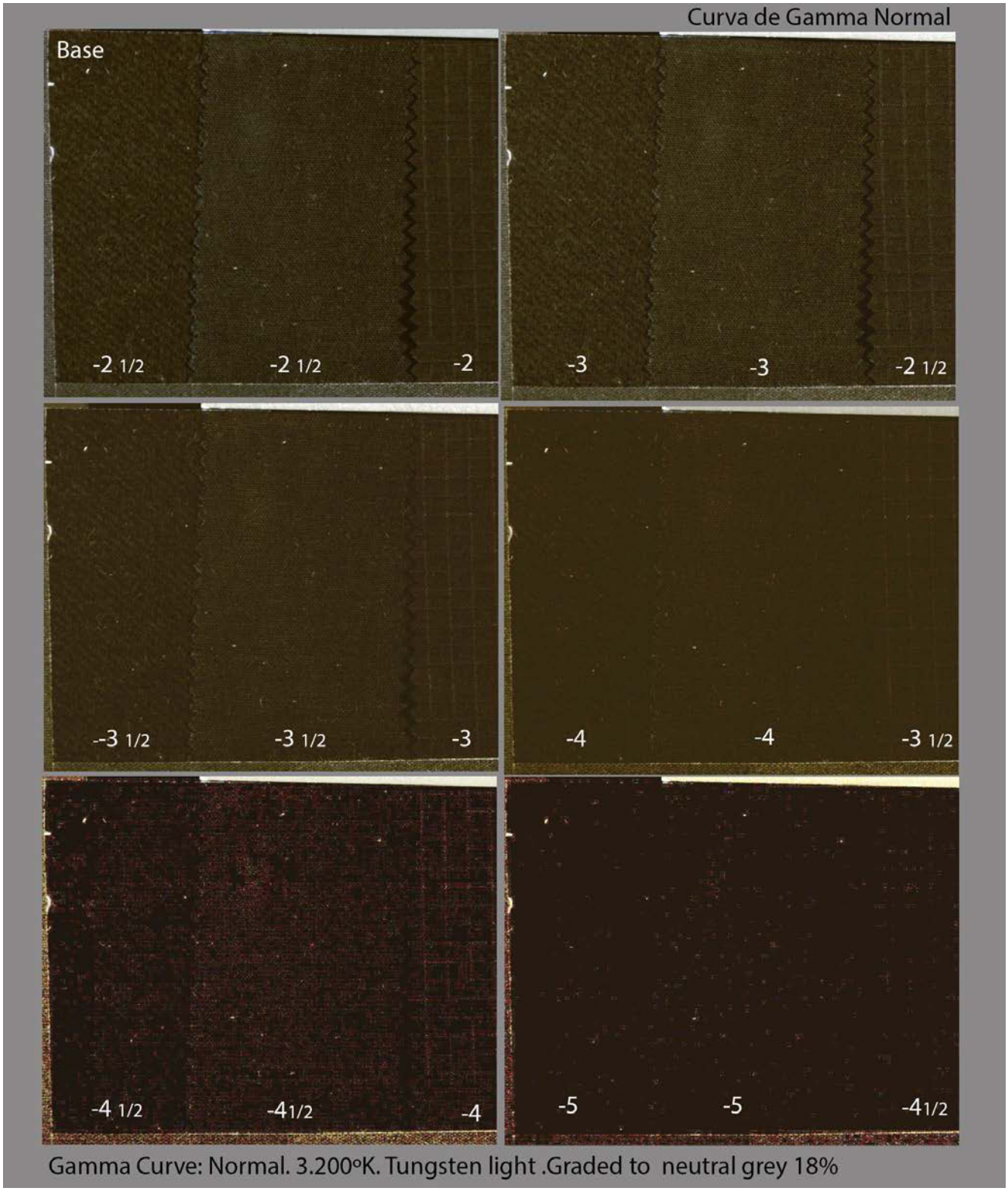
As we can see, the *Expanded1* gamma curve has level of black from 20%, and far from 14 steps has hardly changes of brightness. The *Video* gamma curve shows at the middles tones brighter than the Normal curves, and these, show much better light gradation on details of blacks than the *Expanded1*. At high lights just the *Expanded1* shows a bit less bright, around 70% opposite to 80% of the other curves. Whites are clipped to 3200ºK, it does not occur if we shoot to 5600ºK, and then clipping is 100%. We do not know the cause of such difference and the manufacturer does not explain either, just like that. Of course, we know that it is not just like with other professional cameras, which behave to both color temperatures alike. As we know how the curves behave, to the next trials we have chosen the *Expanded1* and *Normal*.



We begin with the study of our CDM, chart of white and black fabrics, to see how detail is lost at both high lights and shadows, and then to check the effective range opposite to the theoretic which are showed by the Imatest graphs.

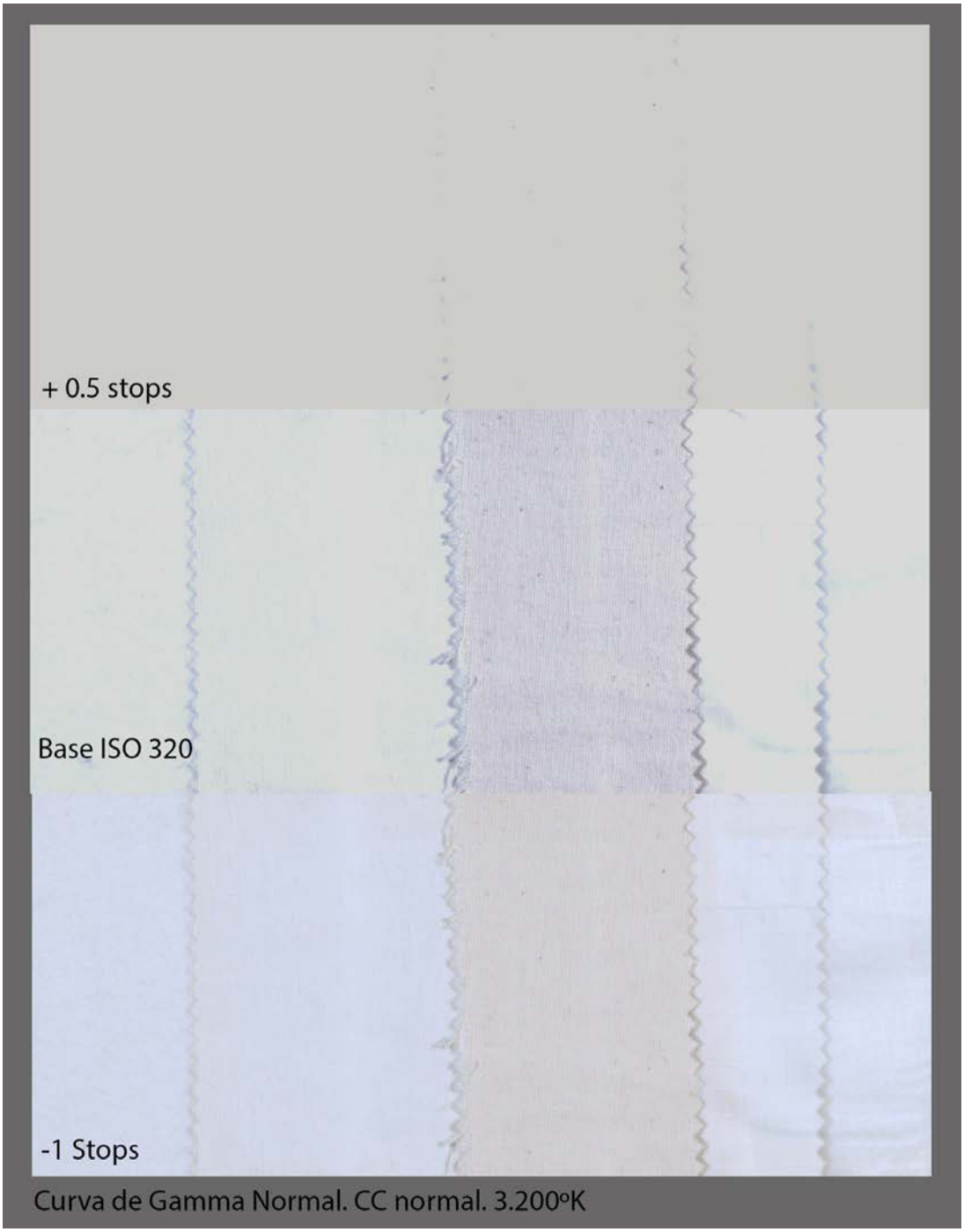
On top right image, we show the T-stops values regarding 18% gray. As we can see the value of the high lights is around 2 ½ stops and the darkest blacks is at 3 stops.

Next image, we show the cutting of the black fabrics to different exposures with the *Normal* gamma curve. Color is corrected to put the middle gray neutral.



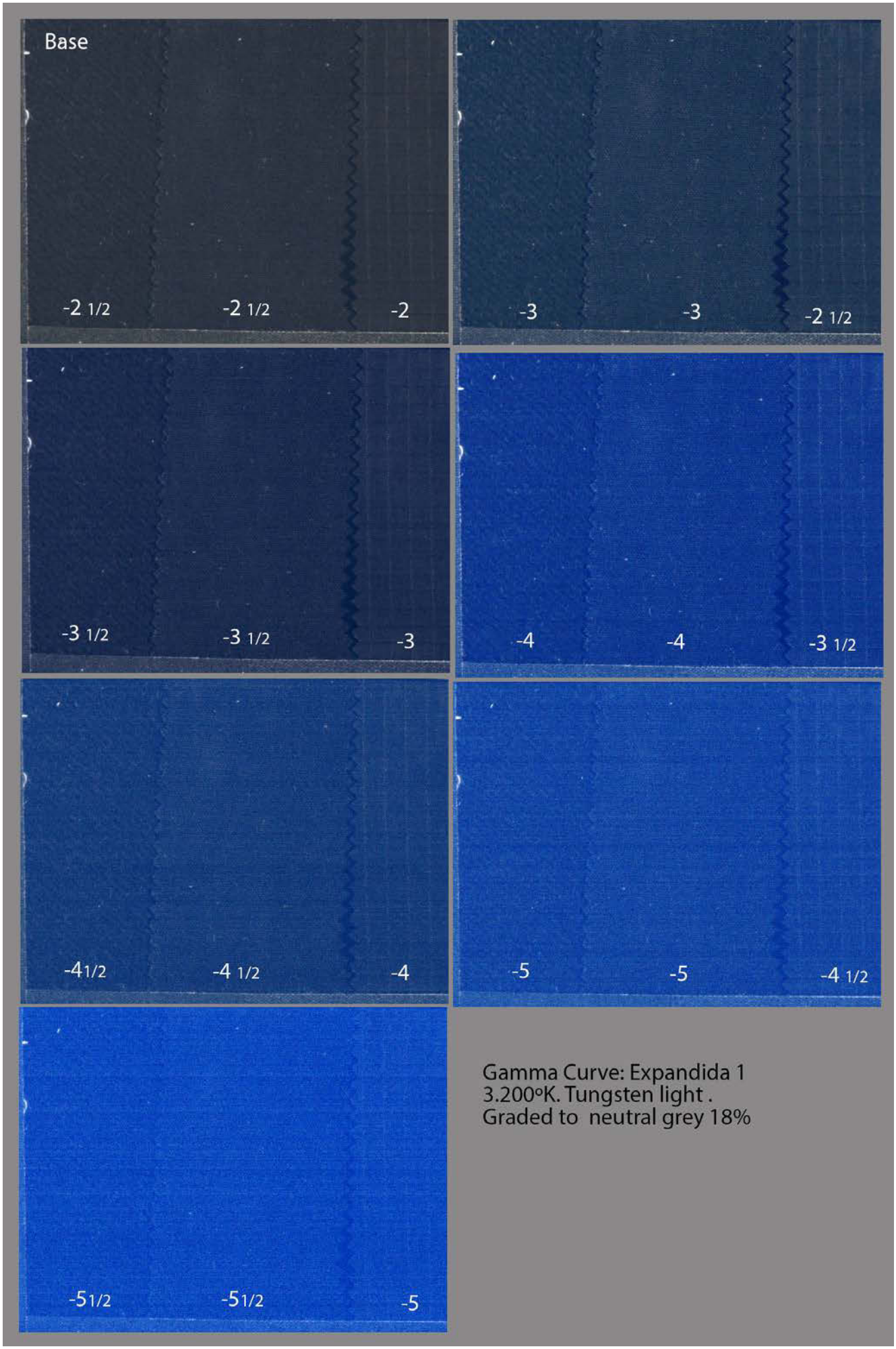
To shoot the chart we have begun with the middle gray value which already have used in the Sensitivity section, thus, we have placed the gray value at 26%. From there we have seen that underexposing –½ stop can see the textures of the samples PN1 and PN2 which are at -3; we can also see that the texture of the PN5 which is -3 ½. With underexposure of -1, PN1 and PN2 keep texture and detail, being then at -3 ½ . We can hardly see the PN5 texture which is at -4. With half more stop of underexposure, that is, -1 ½ , texture vanishes totally of the PN's and black is clipped, vanishing drastically. In other words, blacks are clipped to 4 stops below the

middle gray. There is not a gradual loss of detail at shadows, simply the whole detail vanishes. We could say that the limit with such *Normal* gamma curve is at 4 stops. Nevertheless, if we pay attention to the high lights, we can see that with such middle gray value already are slightly clipped, thus, to maintain a bit more of detail we need to expose to ISO 400/500 and middle gray value at 21%, thus, we guarantee at least 2 1/3 of range above gray and we should leave the range at shadows around 3 ½ stops. In the overexposures whites are already clipped at + ½ stops, and then there is an abrupt loss of texture typical of other period of the digital image. Moreover, it should be pointed out that the blue channel, as we already have said, clips before the other two ones, and consequently shadows and lights change regarding the neutral middle gray.



We can conclude that with the set of gamma curves *Normal*, *Normal Expanded* and *Video*, the effective dynamic range is around 5 ½ stops, the same value provided by Imatest.

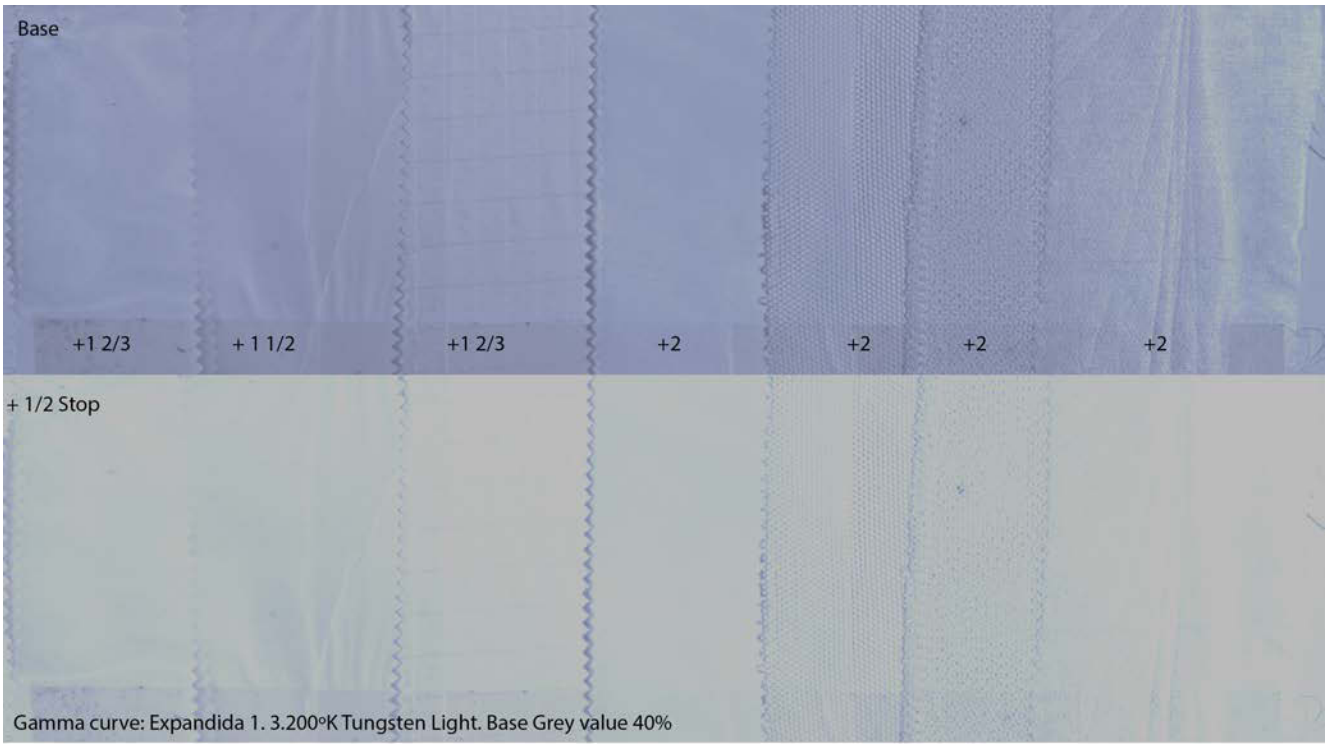
Let us see the *Expanded1* gamma, first at shadows.



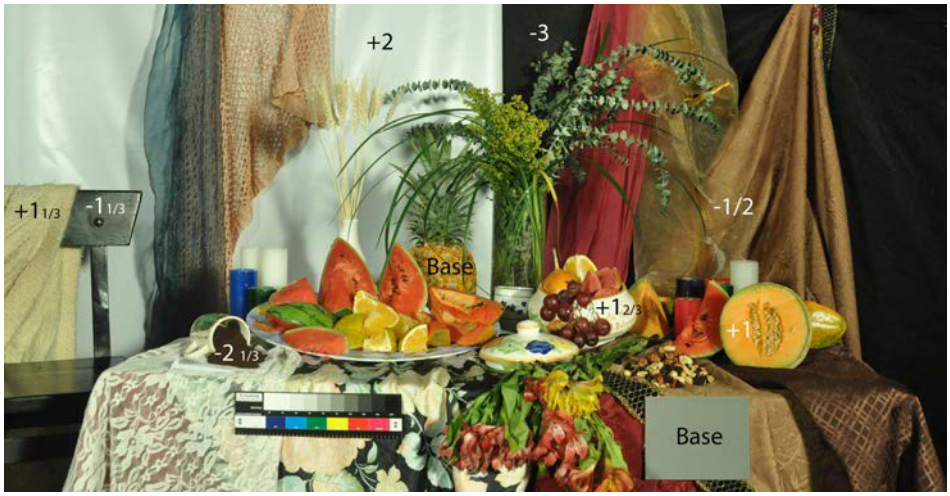
Gamma Curve: Expandida 1
3.200ºK. Tungsten light .
Graded to neutral grey 18%

First of all, we can see how shadows turn into blue meanwhile we keep the neutral gray. Like with the *Normal* curve, we have begun from the nominal value of sensitivity with the middle gray value at 40%. With -1 stop, we can see the texture of the black fabrics, with a change slightly cold but acceptable. With underexposure-2, we can still see some texture on PN1 and PN2 as well as PN5, although we can already observe noise, and above all, the horizontal lines created by the sensor. With such -2 value, fabrics are around -4 stops and PN5 should be at -5, we can still see the texture but it is very damaged for the digital "artifacts". Before giving a range below, at shadows, let us see what is happening at high lights. With the ISO 320 value and the middle gray at 40%, we can see that like the other curves, whites show already clipped, consequently we have to expose to a higher ISO (400/500) and then handling with the middle gray value at 35%. Such is exposure that we have used to the next whites chart. In spite of this exposure, we can see that with just ½ stop whites are already clipped. Thus, if we want to have at least 2½ of range at the high lights we have to underexpose, leaving the range at shadows between 3½ and 4 stops, something similar to the Normal curve that we have already seen. This is far from the range of a real Log curve, and we have confirmed during the color correction how indeed the curve handles very little information, what is thankless in postproduction.

In short, with this curve we are between 6 and 6 1/3 stops, that is, hardly 2/3 more than with the *Normal* curve.



Let us see exactly the range in both the still-life and multiexposures with the models. The reflected light values in T-stops regarding the middle gray value of the Still-life are on the left picture.



The multiexposures which are showed here are graded, that is, each exposure are corrected to be similar to the base exposure, keeping the middle gray as neutral as possible for each one..

We can see that the base exposure (first from top) the black value has detail at -3 and the oilcloth is slightly clipped on the edges, although show texture yet. With +1 texture of such white vanishes as well as texture of the white porcelain. The wood's shines also are clipped.

With -1 (second form bottom) we can still see certain texture on back black, although with some noise and totally turn into red. With -2 the black texture vanishes totally, in addition can be seen clear posterization effect due to the inadequate quantification.

Colors desaturate very much to underexposures and saturate very much to overexposures.

In the next page we show the still-life with the *Expanded 1* curve *CC Flat*. The left strip is corrected to one light, that is, we have graded the base exposure and then have made the same correction with all of the exposures. The right strip shows the different exposures corrected to bring near as much as possible to the base exposure.

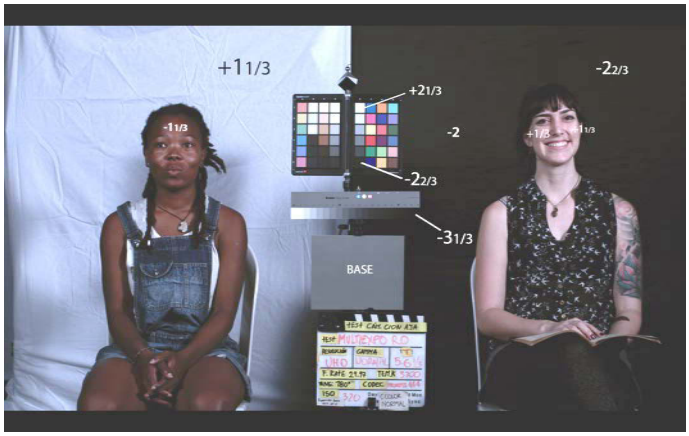
With the strip to one light, we have seen how whites are clipped just with ½ of overexposure, as well as thick blacks hide fabrics on right side of the picture at -2 1/2 . We can see that camera does not create really soft half-lights, degraded and with a lot of gray tones, but goes from the light to the shadow with hardly transition or hues.

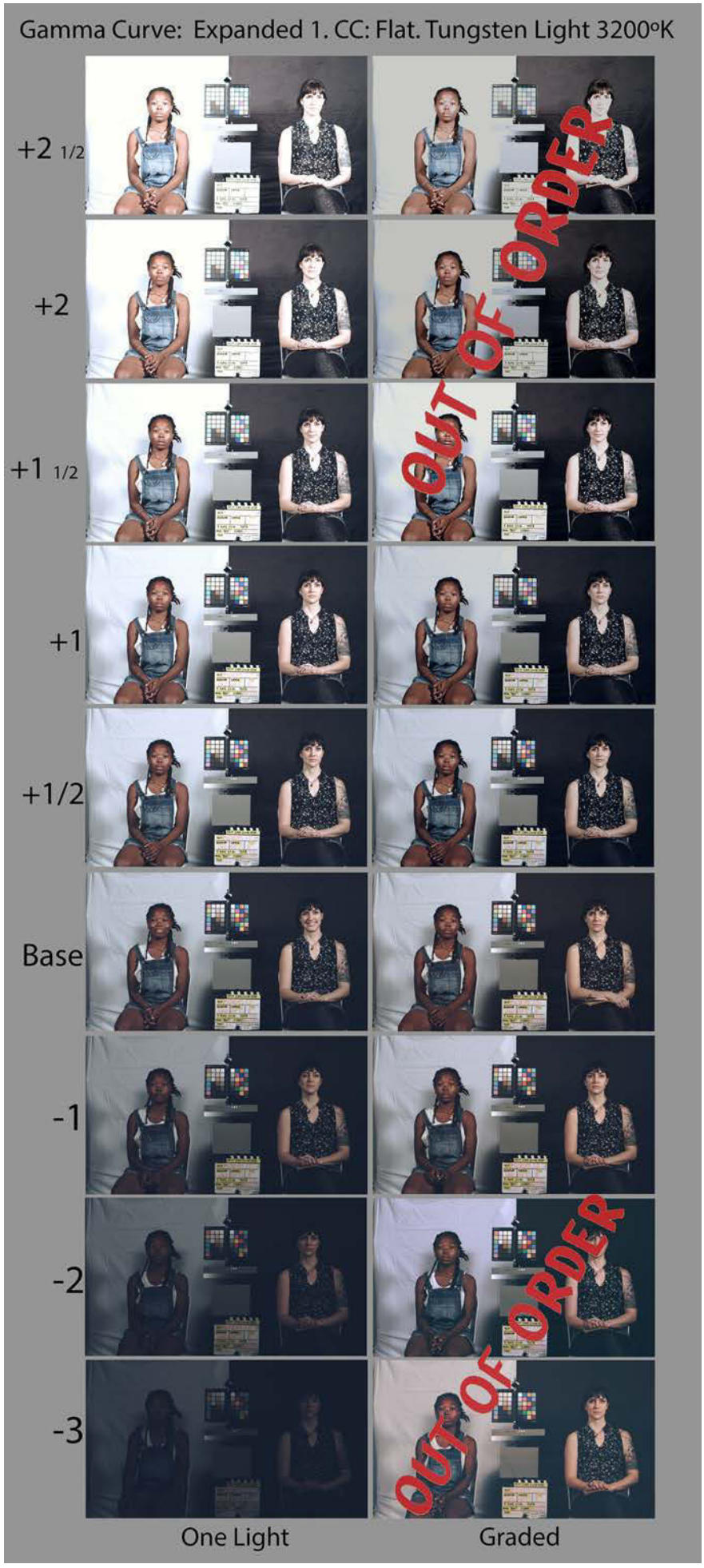
On the corrected strip, with -2stops, black fabric, which is at -3, has significant noise, and on the 18% gray we can already see the horizontal ribbons we have mentioned above. With -2 ½ , ribbons are clearly visible on black, which should be at -5 1/2 . With -3 there is no detail on black and we have only see noise and horizontal ribbons. -1 ½ black should be at -4 ½ and it is possible to see the whole texture. Thus, we can think that exposing gray at 40% should be in the limit of 5 stops below, however taking into account an exposure at 35% or 36% in order to obtain more detail at high lights, the range below should keep in around 4 ½ , fact which is confirmed by the CMD.

Besides, it should be pointed out the huge desaturation produced in the deepest underexposures, as well as the changes of the high and low lights regarding the neutral gray.

At the high lights, with +1/2 stop, the oilcloth, which should be at +2 ½, already clips, without chance of recovering. With +1, the oilcloth, is totally clipped like whites of the Fuji scale, as well as the white fruit bowl, which should be at +2 2/3. As we have said, if we correct the base exposure to 35% of middle gray, detail at high lights is placed around 2 ½ stops, and below we should keep around four.

Finally, we are going to confirm the result with the strip of multiexposures with the models.




Gamma Curve: Expanded 1. CC: Flat. Tungsten Light 3200ºK
+2 1/2
+2
+1 1/2
+1
+1/2
Base
-1
-2
-3
OUT OF ORDER
OUT OF ORDER
One Light
Graded

In the strip with the models we have again confirmed the same that we have seen with the other trials for the range: the scant margin that the camera has. In this case we pay attention on skin tones; with +1, the Paulina's white skin is on the limit of clipping, it is not much natural, whose skin tone is at +2 1/3. With one more step of underexposure, texture of the skin vanishes totally. The half-lights turn into gray excessively the skin tone of both Gloria and Paulina, they are not much natural or kind. Let us confirm theses results with frames from natural outdoor and indoor locations. The frame (below) belongs to a panoramic where we evaluate the relation between outdoor and indoor. The T-stop values regarding exposure's diaphragm are showed next.

Expanded1 gamma curve. CC Flat. 5600ºK. ISO 320. 35mm focal length T 5.6. .Polarizer filter

With the *Expanded1* gamma curve and exposing to outdoor until clipping limit, the skin tones of our models are not recoverable, lacking of texture. If we do the same with the Normal we can see the result next


Normal gamma curve. CC Normal. 5600ºK. ISO 320. 35mm focal length T 5.6. Polarizer filter

There are no details on the faces models'. If we expose to indoor then the outdoor remain absolutely clipped.

Normal gamma curve. CC Normal. 5600ºK. ISO 320. 35mm focal length T 2.8 1/3. Polarizer filter

The lack of dynamic range for both the *Normal* and *Expanded1* gamma curves is significant. Let us see one more example.

Expanded1 gamma curve. CC Flat. 5600ºK. T 16. High lights exposure. Graded

Expanded1 gamma curve. CC Flat. 5600ºK. T 4. Shadow exposure. Graded

Conclusions RD.

The dynamic range of the camera for whatever configurations is very low and really inexplicable for a professional camera of the 21st century. The next table summarize the section.

Gamma curve	Suggested EI to the exposure	Suggested 18% Gray value at WFM	Effective dynamic range T-stops	Range above middle gray (high lights)	Range below middle gray (shadows)
Normal	400/500	21%	5 1/2	2	3 1/2
Normal Expanded	400/500	21%	5 1/2	2	3 1/2
Video	400/500	21%	5 1/2	2	3 1/2
Expanded1	400/500	35%	6	2 1/2	3 1/2 a 4

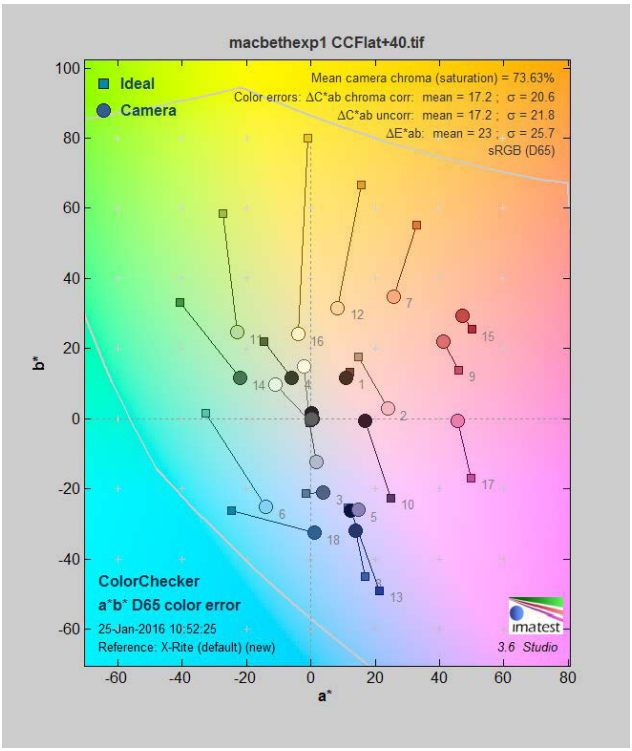
COLOR

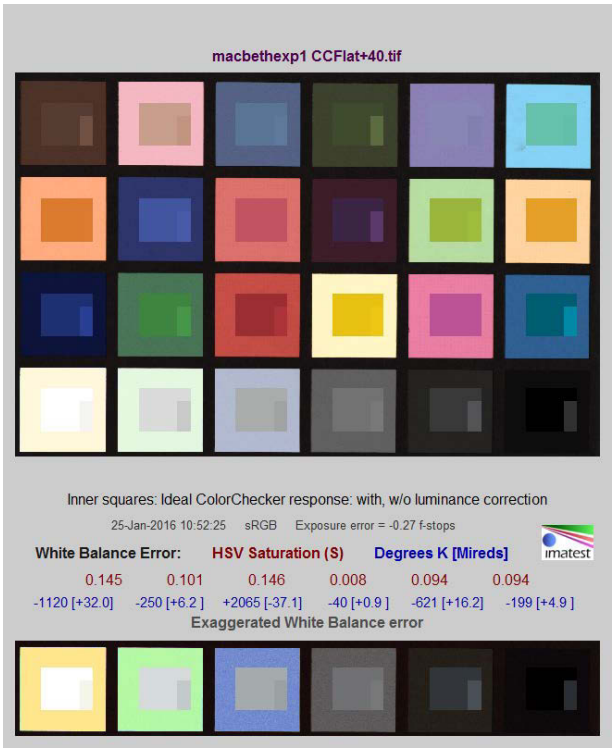
We evaluate in this section how the camera represents the color with both the most objective analysis and the most subjective opinion about how we feel it.

COLOR

To evaluate the color we have begun analyzing the different color charts, as well as the colors of both the still-life and skin tones. We have chosen the *Expanded1* and *Normal* gamma curves with two different color profiles as well as two color temperatures of 3200ºK and 5600ºK. We show the analysis of the Macbeth chart through Imatest program next. As we have already said other times, the evaluation is useful to know how the camera, under certain circumstances, represents color regarding a standardized values (ideals). The evaluation uses the sigma σ (RMS) which quantifies the deviation.

Expanded 1 gamma curve. CC Flat. 3200ºK

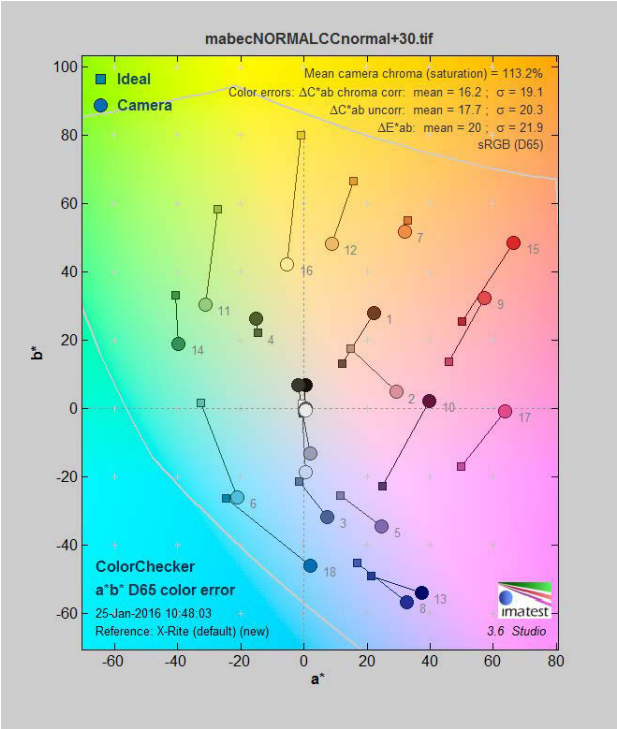


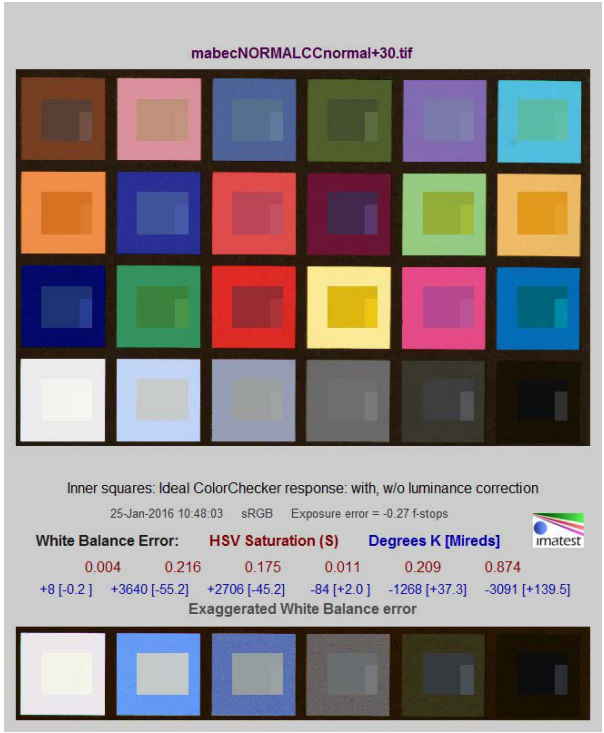


The above graph shows the chart with the *Expanded1* gamma curve and the *CC Flat*. The image on the left shows the shutting of the chart colors regarding an ideal value. The chart is exposed to 3200ºK and adjusted to 18% gray of itself. If we pay attention to de central point where the two axes cut each other, we can see a clear deviation of the three whites, the white (19) of the gray scales turn into yellow green-like, the N.8 (20) does the same, but a bit more yellow and the N 6.5 (21) turn into opposite way, towards blue. The sigma value, adjusting the chroma, is placed at 20.6. It means that there is a significant color deviation, really high. Let us see the cyan (18); it shows a clear deviation towards blue, giving a tone blue-like/violet-like, or for example the yellow (16) which shows a great desaturation. It does worth stopping to watch the graph on the right side. . The greatest square is the color exactly the way it was photographed, and matches the circles on the left graph. The small square, in the center of the great one, is the ideal value for colors of the chart, corrected by the luminance of shooting. Finally, the small rectangle is the ideal values for color without luminance correction. We can see clearly the difference of tone on the cyan or in the blue green-like sample. The dark skin tone adjusts very well to the chart, however the white skin shows a deviation towards magenta, being the tone much more "pink-like". We have also seen a significant deviation on the purple (10).

Normal gamma curve. CC Normal. 3200ºK

We show graphs shooting the chart with the *Normal* gamma curve *CC Normal* to the same 3200ºK next.





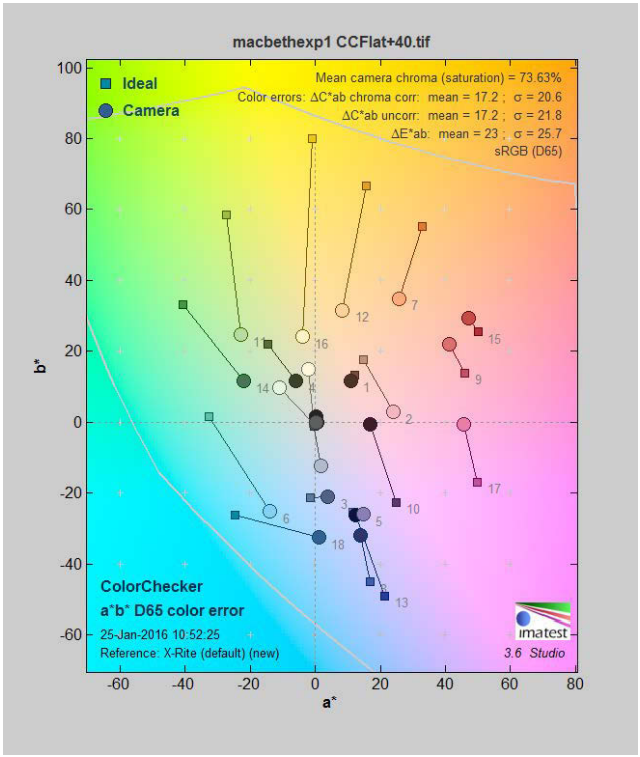
As with the above configuration, again we have found great color deviations, on both the skin tones and the blues; the sigma value, adjusting the chroma, is placed at 19.1, which is also high. Pay attention into the deviation of the blue (18), turquoise (6) or purple (10).

The camera gives different color profiles (CC).We show the σ-value of the chart for such profiles with the two chosen curves.

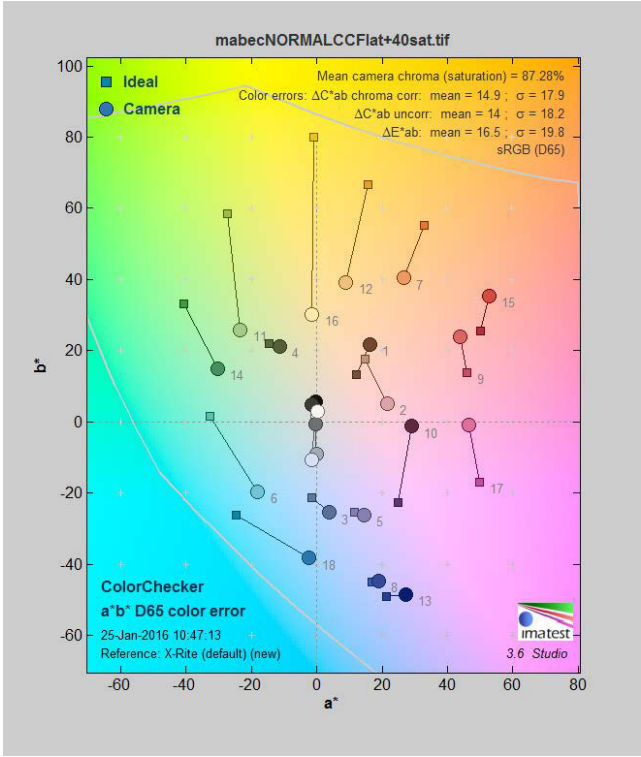
SIGMA (σ) value with adjusted chroma	NORMAL gamma curve	EXPANDED1 gamma curve
CC Flat	17.9	20.6
CC Normal	19.1	22.1
CC Skin Tones	19.2	20.7
CC Video	15.9	18.6

With the two gamma curves, every CC shows great deviations regarding the standardized values, being the Video profile which less deviation shows, moreover all of them show a deviation of whites and blacks regarding the neutral middle gray.

In these two first comparisons we have used the *Normal* curve gamma beside the *CC Normal* space. The curve is designed for not making color correction and the *Expanded1* beside *CC Flat* for working in postproduction. Nevertheless, I would like put in comparison the two gamma curves beside the same profile, the *CC Flat*, since it should be the one which more color hues represents.



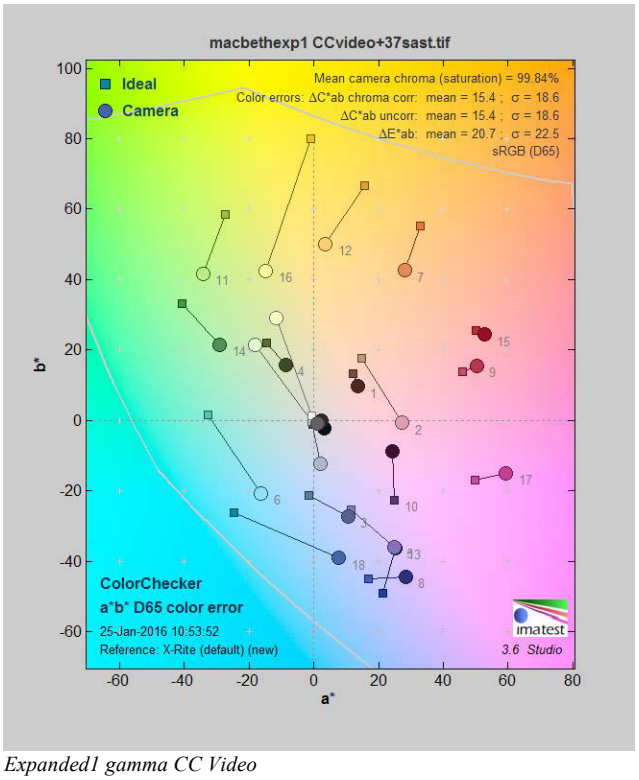
Expanded1 gamma CC Flat



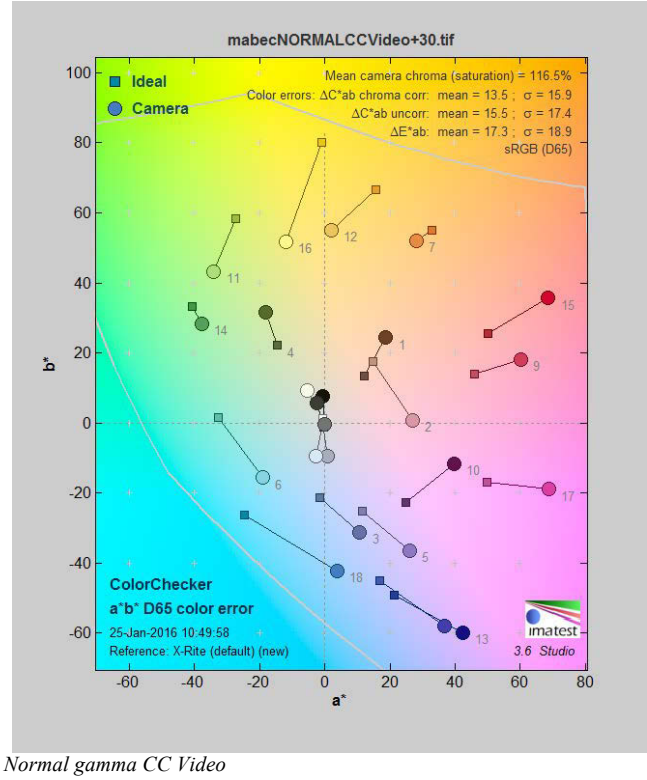
Normal gamma CC Flat

We have to pay attention into the huge differences that we find between the two curves regarding the balance of the white, black and middle tones. Moreover, we can also see differences amongst blues (8), (13) and purple (10); as well as slight differences amongst reds, being colder with the *Normal* curve.

One more comparison:



Expanded1 gamma CC Video



Normal gamma CC Video

In short, with this first approach to the camera's color we can see firstly what irregular is the behavior of the different profiles regarding the gamma curves, and secondly that we need to watch one by one with the different color spaces in order to choose the suitable combination. We think that probably each gamma curve matches its color's profile that fits into its gamma color, being inadvisable to use another different. Thus, the

Normal gamma curve matches the *CC Normal*, *Expanded1 CC Flat* and *Video CC Video*. We think that the *CC Skin Tones* matches *Normal* and *Normal Expanded* as well as *Video*.

There is no doubt that we need to see how the real color is, far from the charts. For this reason we have used the still-life. First, let us see to 3200ªK of color temperature.

Expanded1 gamma. CC Flat. 3200ºK. Saturation corrected and adjusted to 18% neutral gray

Normal gamma. CC Flat. 3200ºK. Saturation corrected and adjusted to 18% neutral gray

If we put in comparison the still-life with the adjusted neutral gray, we can see that with the *Normal* curve and *CC Normal* tones are warmer and turn into yellow, as well as reds are stronger and more orange-like, being the color with the *Normal* more vibrant regarding the *Expanded1* and *CC Flat* which is a bit colder and dull. There is no doubt that color correction of the still-life with *CC Flat* should approach both images until we could see that the tone range is not very wide regarding both of them. The tones of the watermelon and papaya, as well as the fig do not represent the true tonal difference that really is. On the other hand, as we have already

seen in the evaluation of the dynamic range, there are clear differences of color on both whites and blacks regarding the two gamma curves, above all, with the *Expanded1,* with which white turns into blue/violet to a correct exposure. The same occurs with the *Normal* but it is not so significant. To very high overexposures, the white clipping with the *Expanded1* turns into yellow-like; it means that the three channels do not have the same cutting point, thus, looking for a chromatic balance is not easy throughout the different exposures. This fact was clear during the evaluation of the Macbeth chart; we had seen how the gray scale had deviated from the center of the graph. In addition, again with the same gamma curve, black is slightly cyan to the correct exposure and with the *Normal* gamma curve black is slightly red.

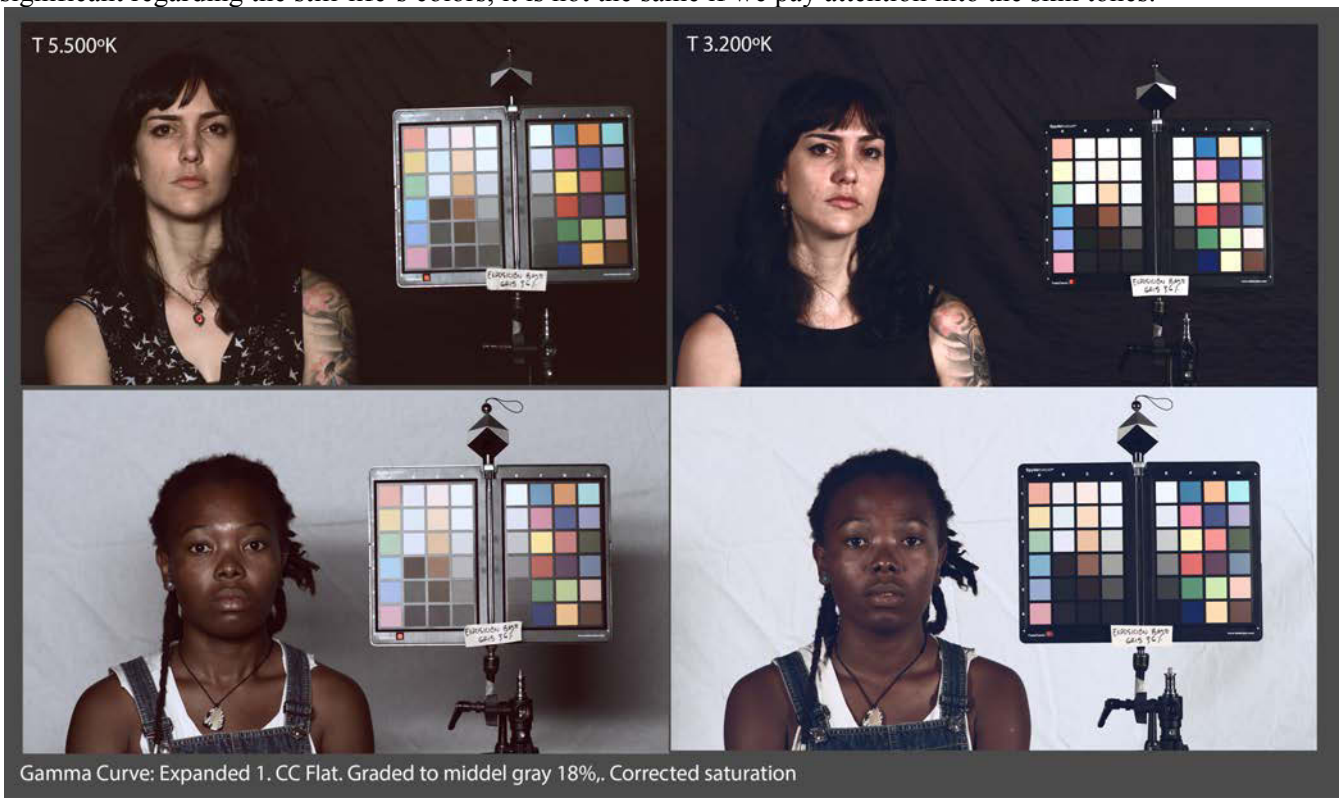
Expanded1 gamma. CC Flat. 5600ºK. Saturation corrected and adjusted to 18% neutral gray

Normal gamma. CC Flat. 5600ºK. Saturation corrected and adjusted to 18% neutral gray

Lighting to 5600º, the *Expanded1* gamma curve shows the tone slightly warmer as a whole, shows less texture on strong colors as reds than the *Normal*. Blacks are slightly red-like and whites changes to blue. We can

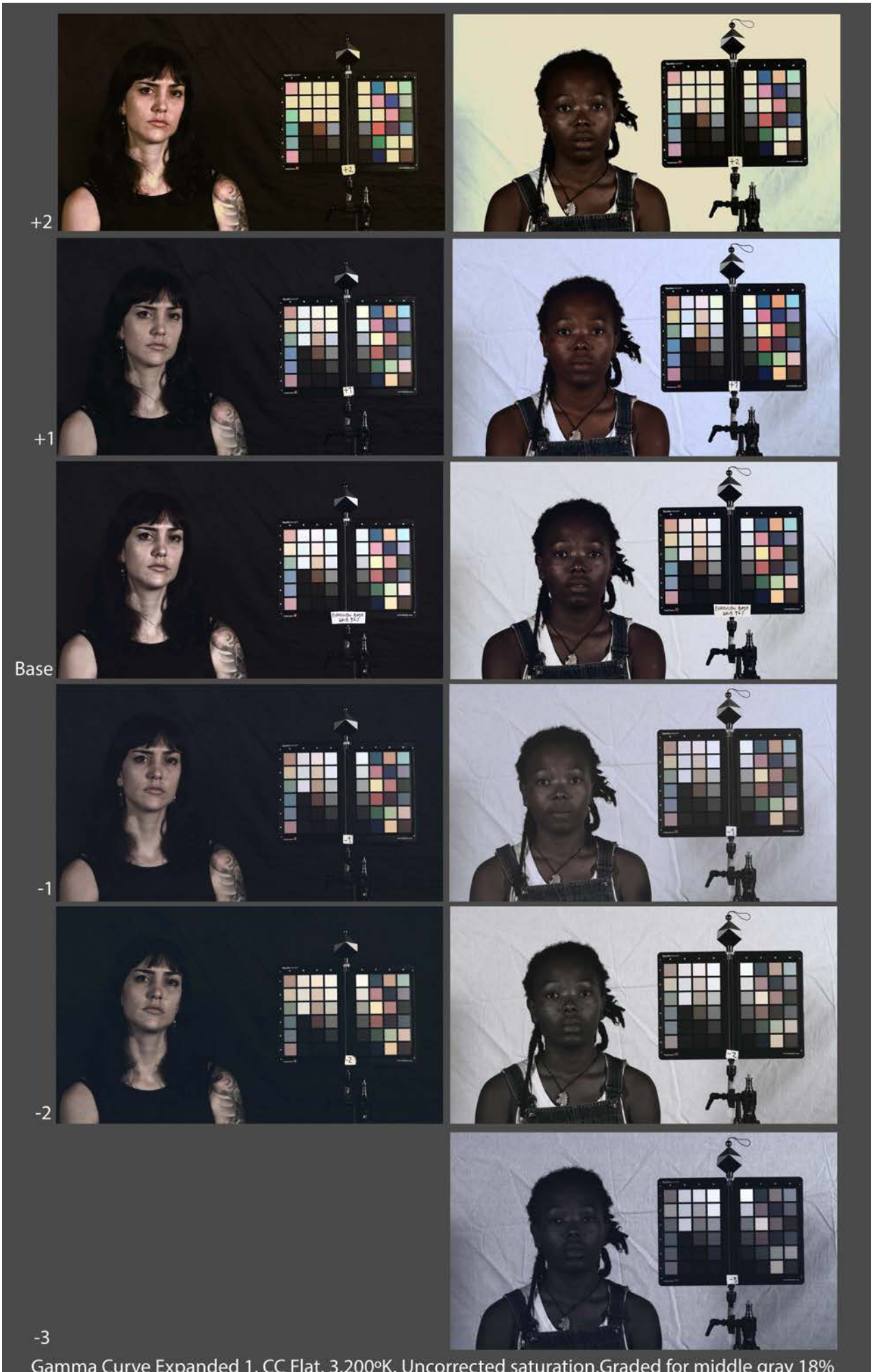
see that there are no so much color's hues to both curves. The *Normal* is slightly colder and shows colors more vibrant and strong with a bit more of texture. Blacks, with the last curve, change more into orange and whites cool down slightly.

Generally, we can say that the differences of color between both curves regarding their CC are not very large; we cannot derive a great profit from the *CC Flat* which, according to the manufacturer, was designed to profit as much as possible throughout the colorization process. Whether such differences do not seem to us so significant regarding the still-life's colors, it is not the same if we pay attention into the skin tones.



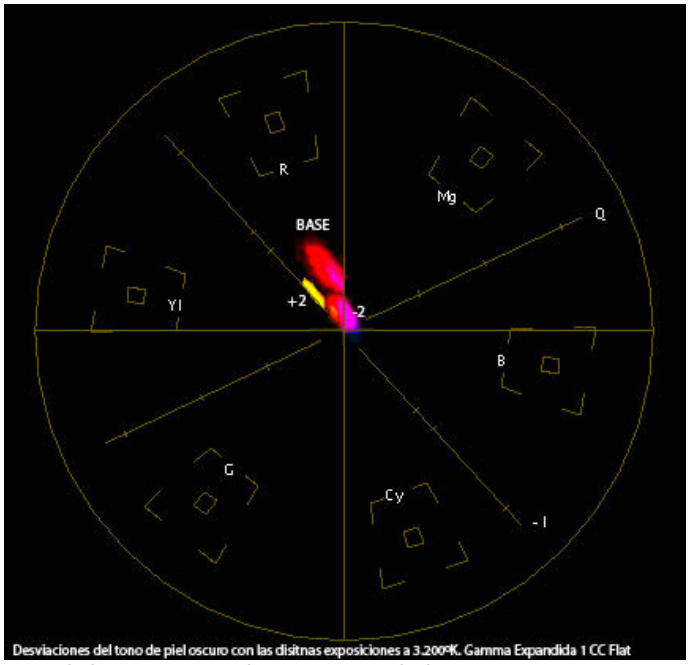
The white skin's tone to 5600ºK is yellow/green-like, whereas to 3200ºK is red-like, a bit cold, towards magenta. The black skin's tones to 3200ºK is clearly red changing into magenta, in addition, to 5600ºK, Gloria, our model, shows a horrific color of black olive (Kalamata variety). Since the images are corrected to 18% neutral gray, if we look for skin tones more favorable the whole chromatic scale should be affected, and consequently the rest of the colors should spoil.

Gamma Curve Expanded 1. CC Flat. 5.500ºK. Uncorrected saturation.Graded for middle gray 18%



Gamma Curve Expanded 1. CC Flat. 3.200ºK. Uncorrected saturation.Graded for middle gray 18%

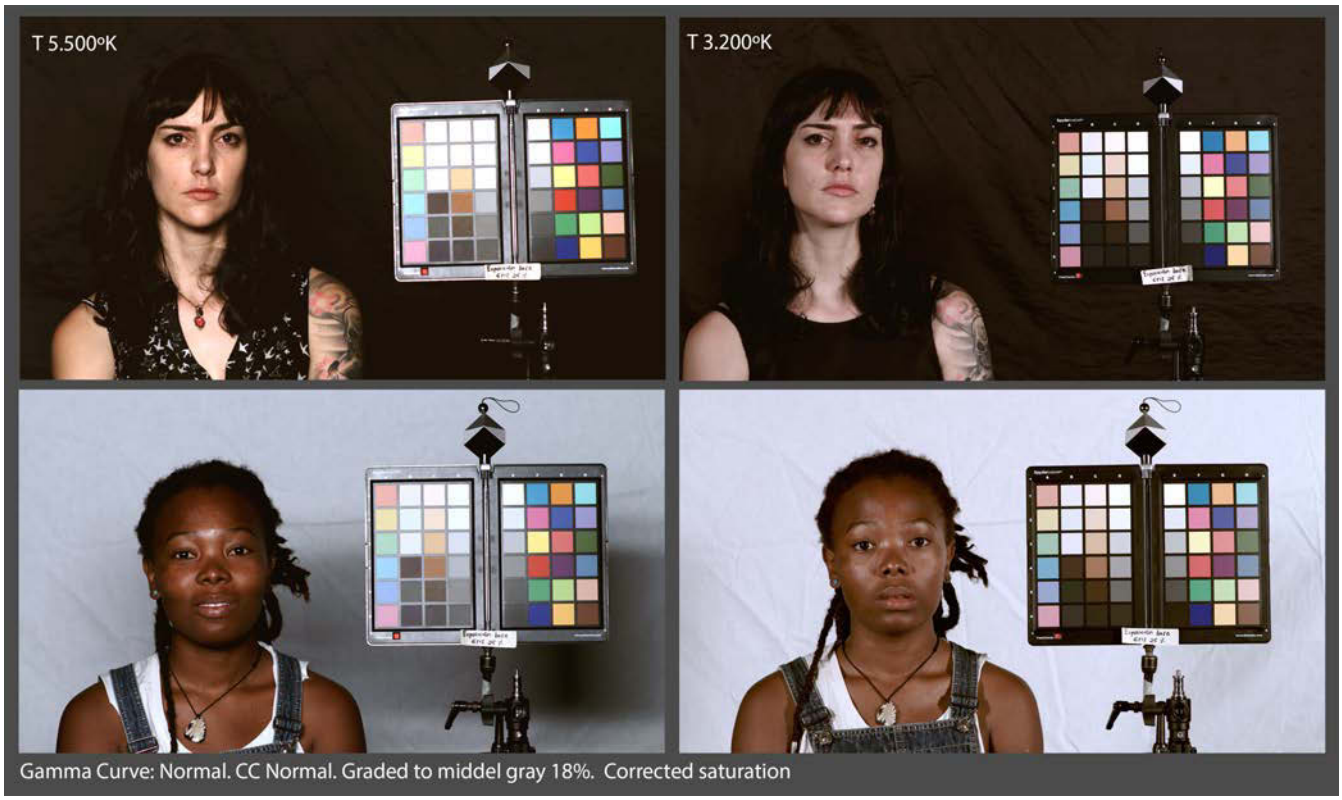
The previous images show strips of multiexposures with the *Expanded1* gamma curve and the *CC Flat*. We have chosen such configuration because according to the manufacturer gives more chances in the color correction. As usual, we have corrected to the neutral gray each exposure in order to make alike as much as possible to the base value. Let us see the strip to 3200ºK of color temperature.



Expanded 1 gamma. CC Flat. 3200ºK. Dark skin

As we have already said regarding the base exposure, the Gloria's skin tone is red/magenta. With a value at +1, such tone changes slightly towards yellow, turning more into orange-like. With +2, tone changes still more towards yellow. With +3, skin tone is really awkward. We have to pay attention into the color deviation of both whites and blacks, such deviations agree with the evaluation of the Macbeth chart that we have already expounded at the beginning of this section. To underexposures we can see a clear desaturation and turning into gray of the color tones. With -2, Gloria's tone is clearly red magenta, changing close to purple. With regard to Paulina, our model of white skin, shows a slightly red-like tone to the base, with a clear deviation towards yellow at +2 however, to the underexposures tone remains constant although with the characteristic desaturation.

If we observe the strip to 5600ºK, we can see that the Gloria's black skin changes towards yellow to the overexposures, whereas towards magenta to underexposures. The Paulina's skin tone shows slightly yellow green-like to the base, and as we overexpose changes increase, whereas to the underexposures the no goes slightly towards purple. It should be pointed out that the camera response is much better working to 5600ºK than 3200ºK, nevertheless and despite of this fact, the skin's tones are not coherent at all to the variety of exposures, and generally, are not very natural.



In the previous image we show the comparison of the skins' tones to the two color temperatures, with the *Normal* and *CC Normal*, corrected to the middle gray. As it happened with the *Expanded1* and *CC Flat,* the

Paulina's skin tone to 5600ºK is yellow/green-like, whereas to 3200ºK is colder, slightly red/magenta. However, the Gloria's skin tone is yellow-like to 3200ºK and more red-like/orange-like to 5600ºK.

Normal gamma curve. CC Normal. 5600ºK. 50mm. T 2.8. Graded

Normal gamma curve. CC Normal. 5600ºK. 135mm. T 4. Graded

In the previous frames we can observe the skins' tones with natural light. We can see how the skins' color tones are slightly different regarding the gray gradation. With Paulina, the white skin which is under the light shows a natural and kind color, however on the right side, where the skin is darker, it shows an excessive brown. It happens the same with Gloria; the chocolate tone of her skin is not uniform to the different gradations of light and shadow that fall upon her face. It is slightly magenta on the forehead and a bit yellow-like on shady parts.

The camera provides a color correction named *Skin Tones*. We have made a trial in order to contrast the skin tone with both the *CC Normal* and *CC Skin Tones*. We show the images next.

Curva de Gamma NORMAL. CC NORMAL. 3200ºK

Curva de Gamma NORMAL. CC SKIN TONES. 3200ºK

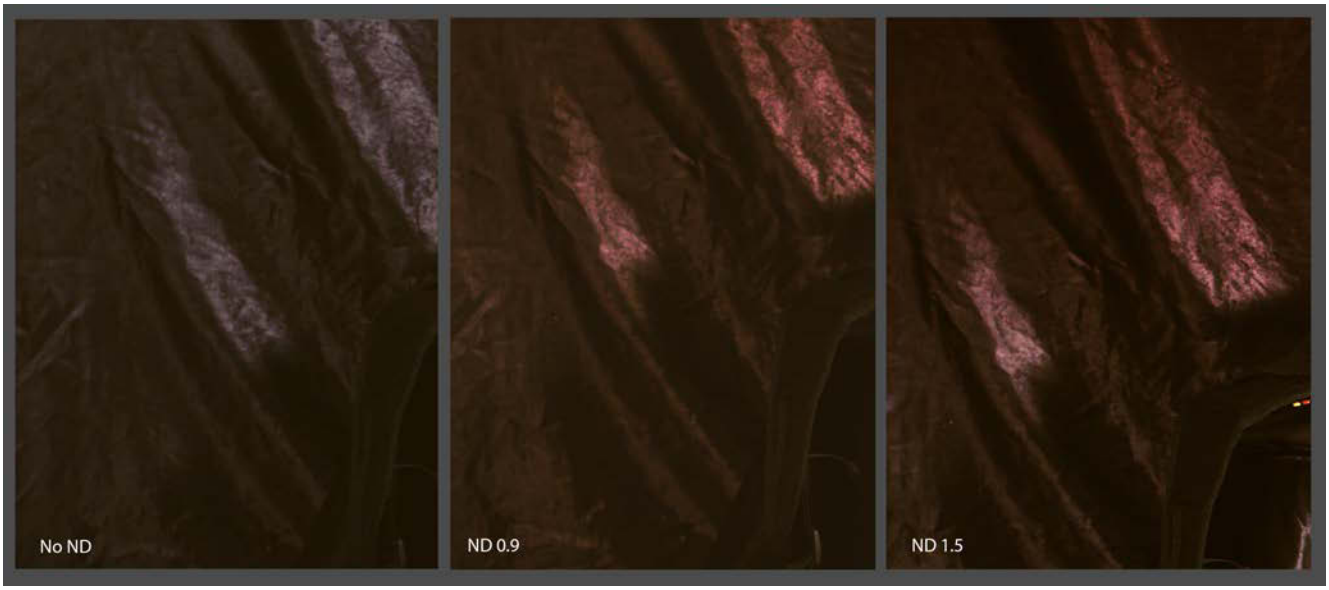
We have used the vector scope with each single image indicating the models' skin tones. As we can see, the tone does not change between the *CC Normal* and *CC Skin* Tones, just the saturation of some colors changes, being lower with the *Skin Tones* than the *Normal*. What we have indeed seen on the chart is that some colors change not only saturation but also slightly tone, thus, blue (13) is more purple with the *Skin Tones* profile than the *Normal*, which show more cyan. The green sample (14) is more yellow with the *Skin Tones* than with the *Normal*, which looks more turquoise. The purple blue (8) is blue with the *CC Normal* whereas is more purple with the *Skin Tones*. Really, the Skin Tones profile helps very little to improve the skin's tones, just desaturates some colors, and amongst them, not all affect fundamentally to the look of our models' skin.

Finally, we show a frame in which we can see the vibrant, saturated and strong colors that the camera provides to a right exposure with the *Normal* gamma and *CC Normal*.

Metamorphosis. Normal gamma curve. CC Normal. 35mm focal length. T 2.8. 5600ºK. fps 29.97. Shutter 180

IR EFFECT

Meanwhile we have shut the trials with our tungsten lamps; we have seen a clear tendency of blacks towards red. We should have thought that such tendency was due to an unbalanced adjustment of the gray scale or the IR effect. Nevertheless, such circumstances could not be expected because the camera was not using any neutral; in addition, the manufacturer states that the sensor is protected by its own IR. In spite of the information, we have made an IR trial, which show next. Light is from 3200º tungsten.



We can see indeed how the characteristic red-like dye shows as we use filters of high neutral density. Therefore, it is profitable to use neutral filters which have their respective IR built-in to avoid such dye on our shadows.

CHROMA KEY

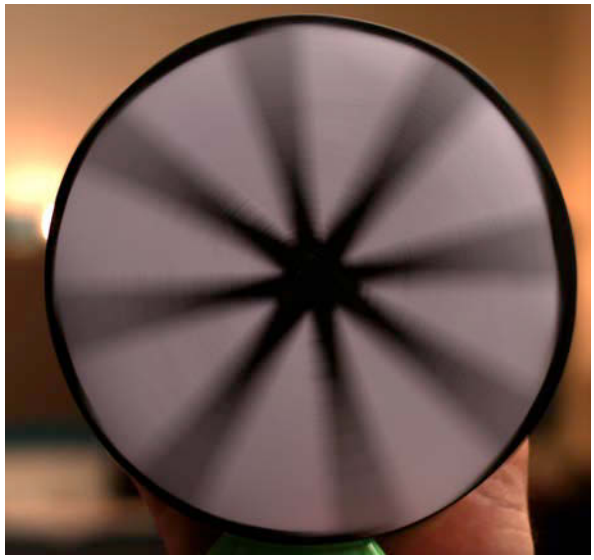
We show a frame of our models over back chroma next.

Normal gamma. CC Normal. 3200ºK. ISO 320. Blue channel

In spite of the light gradation of the chroma, the masks are pretty clean due to the both noise and Prores 444 codec.

Conclusions about color

The camera shows a color representation which although are vibrant and strong regarding certain gamma curves and color corrections, do not cover a large range of tones, being very limited its ability to show different color schemes from the same chromatic range. In addition, the lack of tonal consistency and cohesion regarding the different brightness makes really hard the adjustment of the skin's tones, which generally show no much natural, coming up very clear tendencies regarding the different brightness. Such features are not modified significantly with the changes of color corrections (CC) of the camera, not even for those which the manufacturer recommends as *Flat*, which does not apply any color correction, thus, the correction remains for the color correction process. In such process we have used Baselight and Scratch and we have seen the difficulty to get the proper skin's tones caused by the fact mentioned previously, being particularly unrewarding what the manufacturer points out as suitable, that is, the conjunction of the *Expanded1* gamma curve and the *CC Flat*.



SUPPLEMENTARY OBSERVATIONS

Global shutter effect

We have also tested the shutter system of the camera. As the manufacturer mentions, such system is global, that is, we do not have the typical cream caramel or jelly effect, characteristic deviation of cameras which do not have such shutter. On the disc, which rotates, we can see how the vertical and horizontal lines remain as they are, without folding in any direction.

TEST VIDEO
https://vimeo.com/170384037

CREDITS

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Sound:

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Set designer:

Paulina Restrepo

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Paulina Restrepo

Model 2:

Gloris Mosquera

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Theatre assistant:

Camilo Franco

Art director:

Javier Jurado, Paulina Restrepo

Metamorfosis' actresses and actors:
Gregorio: Sergio López
Madre: Andrés Castañeda
Padre: Daniel Ocampo
Criada: Natalia Martínez
Dirección: Javier Jurado

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