My journey into ISO

by Malcolm McElvaney

A rule of thumb or general guideline helps us improve our photographic results and so exist for a purpose, but how often do we ask ourselves "Why did I just do what I did?". With so much to learn about photography memory aids and visual models help understand some aspects of the craft and keep moving on; however, a deeper dive into the unknown reveals new connections and surprises that lead to better photography in unexpected ways. The technology may "improve" but the principles involved generally stay the same so with some adapting still apply.

It is here that the original article disappears as I have been writing it as I go but I like that concept of how a quick reference for photography can on the surface be so useful yet give a clue to so much more. I targeted in on the exposure triangle which apparently does have some detractors as to how accurate it is or even if it is correct; however, it is not of concern in this case as ISO is still the mystery element in play here. It turns out I also rediscovered the wheel so to speak on some of my findings but I got confirmation I'm on the right path as well. Why ISO is the question you might be asking yourself?

I believe it is my tendency to explore other art forms even if I don't actually attempt to do them that drove this quest, in some ways I see film photography as another art form due to how the processes involved are so different. Film versus digital is two different mediums but have the ISO standard in common. What is ISO as it applies in this context and more importantly a digital sensor is fixed in place so has one base ISO only while film is loaded and unloaded with each roll rated at a specific number. I can select a number of ranges from 100 to 25600 for my ISO but where are the multiple ISO's coming from? This is the question this article or maybe talk preparation is going to cover in more detail.

Before I get started I would like to say that I am not an expert on many of the subjects I briefly touch on but have done my work to test what I can and put the information into the photography I do and see where it takes me. Practical or not the purpose was served and hopefully the insights I could coherently write about will be of use to you. The reference section on the last page has links to the sites I found in my search.



One of the youtube creators I listen to described his process of preparing for a topic and how to potential bring in more people by exploring the links out that tie in, so given this model the concept of what ISO is in a bigger picture does reveal some details. The first bit of the cloud I will talk about is what is the standard applied to the images we create. ISO stands for International Standards Organization and they set standards for more just digital photography so the use of ISO as a term in exposure isn't directly related but the standard to look up for further information is ISO 12232. One interesting tid bit that I found is my files are named DSC0xxxx.jpg and DSC stands for Digital Still Camera and is found in the exif data under FileSource. If one wanted to know the full standard the source documentation can be purchased for a price, I'm sure it would be a detailed and dense read but fascinating to glimpse the process used to make an image possible.

"Pushing" the ISO

This is where I actually started my journey looking into the concept as it translated from film to digital and as a mechanism has proved useful for me to put what I will cover to be used practically. At the heart of it I am talking about an exposure adjustment but the technique in film vs digital is different; however, it is the underexposure of the image and overdelevopment of same image to bring it back out.

Film – Film is rated at a specific ISO (light sensitivity) and given a set light condition usually best suited for it or not. Lets consider for a moment you have ISO-400 film loaded but it gets to dark for it to handle so what can you do. The camera should be set to ISO-400 to match your film loaded and calculate exposures correctly but if the

camera is set to ISO-800 it will underexpose by one stop but your "image" will be exposed for the light conditions present. When time to develop the film you have to develop it as if was actually ISO-800. You will loss some highlights but get more contrast as a trade off. The adjustment of underexposing and overdeveloping has been done within the mechanism of the camera used.

Digital – The CCD is the film in this camera but given the ISO selected at the time the image is taken so your camera is still calculating exposure for that selected ISO and creating the final file you will use later. Exposure compensation can be set to -1 and thus underexpose the image taking the place of setting the ISO physically on a film camera. The previous example used ISO-400 and ISO-800 so we set the camera to ISO-400 and underexpose -1 stop (ISO-800) and the resulting file is darker but in post processing can be corrected.

In reality this may not be a process we have to worry about as the camera can create some very high quality results and not require any help in this manner; however, I see this as a tool I can potentially use later on as part of visualizing a scene and post processing options available to me. The opposite of "pushing" the ISO is "pulling" the ISO and os basically overexposing the image and underdeveloping it later. It is a technique that is useful but doesn't apply here.

The CCD

CCD? CMOS? The acronyms CCD (charged coupled device) or CMOS (complementary metal-oxide-semiconductor) allow us to refer to a rather complex device in passing as we skip to the more important task at hand of capturing the image. The sensor is the "film" and its primary role is to digitize the range of light hitting the actual sensor. The photons of light that do reach the surface of the chip free up electrons building up a charge collected at each pixel in the array of many pixels making up the image. The newly exposed image created while the shutter was open is converted with an analog to digital converter to be further processed and packaged as the file we manipulate. Appreciating the degree of complexity to see the live feedback and not only that but speed it is done at is something that may be overlooked but not to be taken for granted.



The one aspect of the process I could begin to understand is the "full" pixel concept where if you think of each pixel site as a well or pit then the electrons begin to fill them up until they overflow or bloom spilling into other pixels. Ideally this is prevented and dealt with so blooming is minimized but these constructs allow a place to start working out the details. To digitize a light range is rather vague but the term dynamic range helps to define that range and like all the math involved at this level is complex; however, based on what I know about my camera it is reported to be around 13 stops of light at the base ISO of 100.

ISO is the gain or amplification applied to the selected range being sampled to make it into a "full" pixel. Bringing back "pushing" the ISO if you move your sample point

back -1 stop that becomes ISO-200; however, the gain applied in the image you see makes it equally as bright as the base ISO (ISO-100). As the number of stops actually sampled drop the ISO number goes up along with it increasing the light sensitivity and speed of image capture. This is easy enough to understand but there is a post processing tool that behaves in a similar way to demonstrate the same process called a curves adjustment.



The curves adjustment tool allows for more finesse and better results when altering an image. Lets compare the curves tool to the "full" pixel as I have illustrated them and you will see they do relate in some ways. The pixel is digitized to 8-bits so 256 levels of grey can be recorded, both have a range of 0 to 255. On a curve you have the black point (bp) set at 0 and white point (wp) set at 255 but the "full"

pixels equivalent is also at 255 and by using a lower sampling point that "wp" is shifted back. As to how the gain is accomplished in the camera I don't know but on my curve I would take the under sampled image and by moving the white point back and altering the curve as shown can emulate the cameras results. I took some images meant to be ISO-400 or ISO-640 and after the exposure was calculated reduced my ISO back to 100. Those underexposed images once overdeveloped via a curve were similar in appearance, although, it is worth noting the forest scene was taken in full daylight and the candle in very dim light.







ISO-640 ISO-100 ISO-100 to "ISO-640" 1/15, F/9 used on both

Results will vary and what is gained by bypassing the system is up to you the artist behind the camera to decide, if less drastic steps between the two image's ISO is used maybe it is more useful. The trade off is the tone adjustments and calculations for the best image possible not getting applied in the correct way. As this is where I like to go myself, if not just because I'm curious, I did try it as a way to grasp the idea and relate it to my own thought process.



By the way of one further image taken at ISO-16000, 1/5, and F/9 in low light the noise is rather obvious in the shadows and brings up something called the signal to noise ratio (SNR) that has to be considered in images at the various ISOs shown. I will explore it as I see how it works later on but for now consider it one more concept floating around needing to be reconciled eventually. I believe it worth repeating that the reference section on the last page is worth a visit and exploring; however, even if one can simply state ISO is the gain applied as part of exposure controls then nothing has been learned. I learn by doing and visually seeing patterns so will show you my work in figuring out a system that works for me. It is based on tangible numbers I can play with and concepts that apply to my post processing methodology, so is subjective in many ways but with the information presented already and my techniques maybe something will be of use to you to spark your creativity as well.

Trust but verify

I have a dynamic range of 13 stops for my camera, Sony a6000, and the chart I got from the reviewing website clearly shows the test to get that range. It is from observing this chart I saw the stair steps of dropping dynamic range going in lock step with the higher ISO numbers. A process I had just recently discovered was "pushing" the ISO and it fit the progression.



I tested this by doing a test set from 2 secs to 1/4000 at F/5 using ISO-100 shooting a evenly lit paper attached to my monitor with a white background. Stepping back through the various shutter speeds at one full stop the histograms had a clear progression and pattern to show. A set at ISO-400 and ISO-3200 at the predicted sampling points matched what was expected. The comparison overall does tell a story by itself. (see next page for illustration)



Where is the "full" pixel? 01 for ISO-100, 03 for ISO-400, 06 for ISO-3200

Not all of the dynamic range's stops are equal. 01 to 02 is smaller in size but from 02 to 06 are about equal with the next stop compressed somewhat and disappears fast afterwards.

Is this part of the noise? In ISO-100 07 and on is recording less data; however, in ISO-400 and even more in ISO-3200 those sames stops expand but the amout of data recorded doesn't.

Where are the sampling points of the other ISO numbers? At ISO-400 it starts as a "full" pixel at 03 but is part of the gain applied; however, at the base ISO at 03 point is futhers in. For ISO-3200 starting at 06 a similiar story is told.



I'm revisiting the curves tool again and I used my images from the ISO-100 to get a value for the range each ISO seem to have. At the base ISO you have 0 to 255 but at ISO-800 I found the underexposure goes from 0 to 144 and the gain is applied to this. The idea is to add points on the curve (the circles) and raise them up to produce the curve needed. I measured the last point on the histogram of each stop down so as to get a "ball park" figure, now at least I have a starting point to define each stop in the

digitized dynamic range I see in the jpeg images from my camera.

Signal to noise

For the technical aspects others have covered it better than I can and likely confuse you just as well as I could. No one image is exactly like another and will be a mix of brighter elements to catch the eye and hide the noise within the shadows. Our perception of that ratio is subjective but when larger areas illuminate the noise or not enough light is present requiring a higher ISO it is more of a balancing act. The dueling of the opposing factors is more visible in lower light conditions. How do you compensate to not see more noise?

Composition of the image is one place to create better opportunities to minimize noise but using one image to encompass all the challenges within require some compromises and so you pick your main focus. While the disadvantages of longer exposures and camera shake might be an issue I have been using two images to help expose for the highlights and details while the second image is pushing the shadows into fuller stops by overexposing the image. Consider this a modified bracketing approach but only two images in the acquired set. A full bracketed set has three or more exposures to extend the dynamic range and works well in full light. I'll show you an example of a "bracketed" set for a worst case scenario.



Taking an extreme case and getting something useable out of the candle lit scene will show a more detailed look at my process and areas I was looking at when working with each layer. My process is not exactly the same with every image but this is what I learned from this particular set of images.

Layer 1 – 6042 blendmode=normal @ 100%

The base image sets the overall look for the combined results and is modified by additional layers placed above it. This was the underexposed image in a +/- 2 stops in three exposures total. I actually composed the picture with this in mind and set my shutter speed to two stops longer for the nuetral image. While I could leave the order as is it would take one image between before the image I need is taken, therefore I force the sequence to work in my favor.

Layer 2 – unsharp mask for 6042 mask=6042 blendmode=addition @ 50% Layer 1 – 6042 blendmode = normal @ 100%

What is an unsharp mask you maybe asking yourself? The mask is actually used to sharpen the image but how I implement it is my own take on it. The mask is created with this process.

Layer 2 – 6042 filter=gaussain blur of 4.0 blendmode=subtract @ 100% Layer 1 – 6042 blendmode=normal @ 100% The unsharp mask created is copied into layer 2 with a mask of the positive image of 6042. Essentially the layers contents only shows for the upper section of the image (highlights) areas. It is blended with addition at 50% to transfer the details and sharpen the highlights. I use Gimp so this particular blending mode maybe called something else, maybe linear dodge.

Layer 3 – 6042 filter=gaussain blur @ 4.0 [mask=6042 – inverted] blendmode=normal @ 50 Layer 2 – unsharp mask for 6042 [mask=6042] blendmode=addition @ 50% Layer 1 – 6042 blendmode = normal @ 100%

My base image (6042) does have noise issues due to low light in the scene and the higher ISO involved to capture it so I do need to address it somehow. In camera we do have an option as the photographer to reduce noise reduction or turn it off, this route may not be ideal but is an option if you wanted to do the reduction in post. I let the camera do the work but since I have the enhanced detail in (6041) I blurred the lower range to minimize it here if possible. Inverting the mask swaps the upper and lower pixel values so the shadows and darker get applied instead. The blendmode normal is used as it the same image.

Layer 4 – 6041 [mask=6041 – inverted] blendmode=addition @ 33% Layer 3 – 6042 filter=gaussain blur @ 4.0 [mask=6042 – inverted] blendmode=normal @ 50 Layer 2 – unsharp mask for 6042 [mask=6042] blendmode=addition @ 50% Layer 1 – 6042 blendmode = normal @ 100%

What the base image lost in the shadows this image of the pair has so I am putting in a percentage of that information to match the overall tone of the former. Having blurred the underlying detail, cleaned it up, the greater details in the same region of the scene get added in.

Layer 5 – unsharp mask for 6041 [mask=6041 – inverted] blendmode=addition @ 100% Layer 4 – 6041 [mask=6041 – inverted] blendmode=addition @ 33% Layer 3 – 6042 filter=gaussain blur @ 4.0 [mask=6042 – inverted] blendmode=normal @ 50 Layer 2 – unsharp mask for 6042 [mask=6042] blendmode=addition @ 50% Layer 1 – 6042 blendmode = normal @ 100%

I sharpened the detail in the highlights and details and did the same for the shadows I added to my lost details. If there is a point where the adjustment doesn't look correct then try cutting back on the opacity of the blending applied. I start at 100% then cut back

to 1/3 of that for 33% and maybe 11%, dialing back in this manner I can fine tune and get the results I want.

Like I did in layer 2 I created a new unsharp mask for the other image. The process is simular.

Layer 2 – 6041 filter=gaussain blur of 4.0 blendmode=subtract @ 100% Layer 1 – 6041 blendmode=normal @ 100%



The completed result of the two images being combined in better detail. What I like about my manual way of using layers and multiple images is the ability to experiment and apply new ideas. If you haven't used this method before and rely on presets more that is perfectly fine and likely faster; however, the time I put in may be longer for an image but the flexibility and happy accidents make up for it.

If you made it all the way to this point hopefully it all made sense and provided some new insights to inspire you.

References

Diving into Dynamic Range - YouTube (Filmmaker IQ channel) <u>https://www.youtube.com/watch?v=2sshGdMgJxQ&t=3s</u>

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