

A Guide to Neutral Density Filters

By Todd Vorenkamp | 2 years ago



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The **neutral density (ND) filter** is one of those tools that should be in almost every photographer's camera bag. However, ND filters are mysterious to some, and many folks just don't understand how, where, and when to use them. Beyond that, manufacturers seem to vary in their preferences as far as how they name ND filters—adding to the confusion. In this article, let us navigate the world of the ND filter together and see if we can make sense of the nomenclature and also name some appropriate times for their use.

What is a Neutral Density Filter?

The ND filter is basically a filter that, placed before the lens (or dropped into a filter slot) reduces the amount of light making its way into the camera. Think of the ND filter as sunglasses for your camera—albeit sunglasses that do not change the color of the light being captured by the camera and lens—hence the “neutral” nomenclature.

Photographs ©Todd Vorenkamp



Morning in downtown Brooklyn after a snow fall. Captured with a Formatt-Hitech Firecrest Ultra 16-stop ND filter.

What do Neutral Density Filters do or allow you to do?

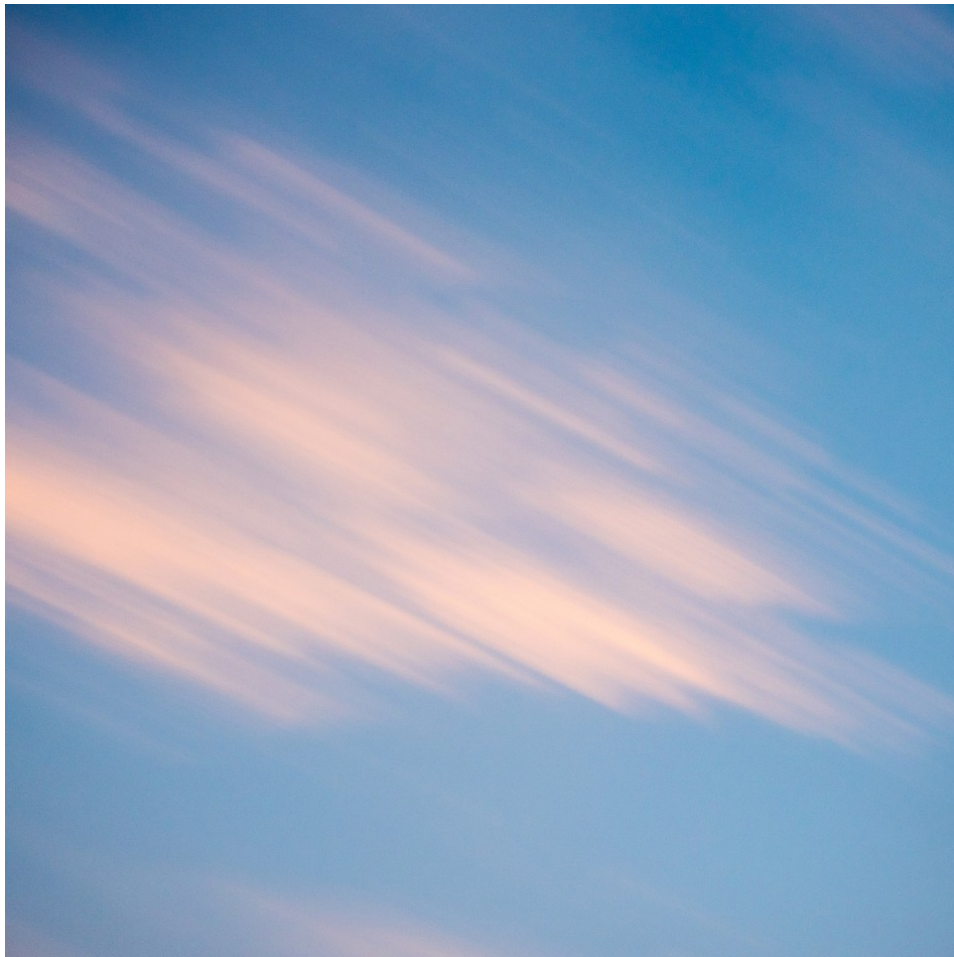
There are a couple of real-world uses for the ND filter—one involving [aperture](#) and one involving [shutter speed](#).

1. Aperture — Shallow depth of field in brightly lit environments

In the world of photography, generally speaking, more light is better. But, if you have ever been outside with an older analog or digital camera and tried to shoot your 50mm f/1.8 lens in broad daylight at wide-open apertures, you might recall seeing your exposure needle seemingly glued to the top of the light meter, or your digital light meter screaming “OVEREXPOSURE!” because the camera’s shutter could not cycle fast enough for the amount of light present.

The ND filter allows photographers to shoot their wide-aperture lenses in bright light without overexposing. This allows shallow depth of field and selective focus effects while under lighting conditions that exceed the shutter speed capabilities of the camera.

Even with the blazing-fast shutter speeds of today’s professional cameras and the previously unattainable shutter speeds introduced by electronic shutters, there is still a place in photography for the ND filter here.



I could shoot cloud abstracts all day with a Formatt-Hitech Firecrest Ultra 16-stop ND filter.

2. Shutter Speed — Slowing your shutter

The more “classic” use of the ND filter regards its effect on shutter speed. With less light entering the camera, you will need to slow the shutter for a given aperture setting. The slower shutter speed will allow anything moving in your frame to become blurred.

In general, camera blur is not desired, but if you work with a [tripod](#) or [alternative support](#) with an ND filter and a slow shutter, that which is static in the frame stays static and that which moves becomes blurry.

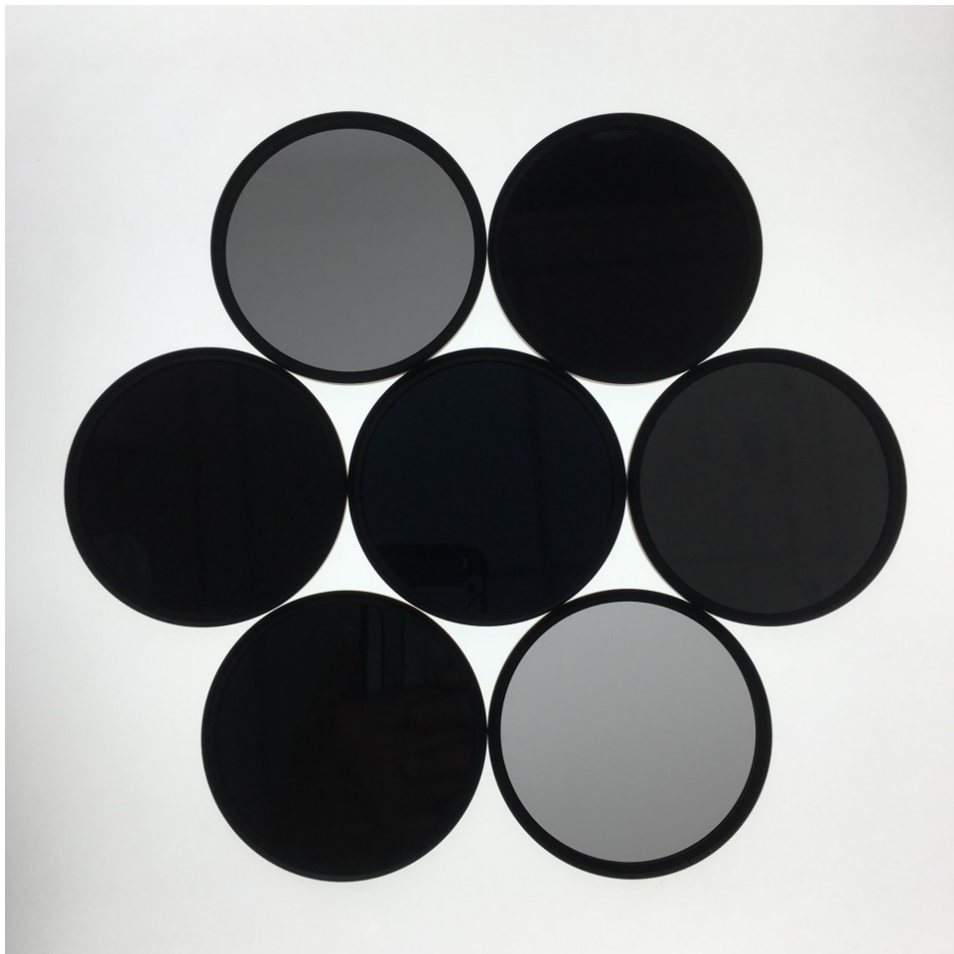
Where can you use this? Basically in any photograph with which you want to emphasize movement. Popular subjects include waterfalls, vehicular traffic, people (not usually portraits), seascapes, rivers, streams, clouds, and smoke.



The Brooklyn-Queens Expressway during early weekday rush hour. If it only looked like this in real life. This is a 2-minute exposure using a Formatt-Hitech Firecrest Ultra 16-stop ND filter.

What do the numbers on ND filters mean?

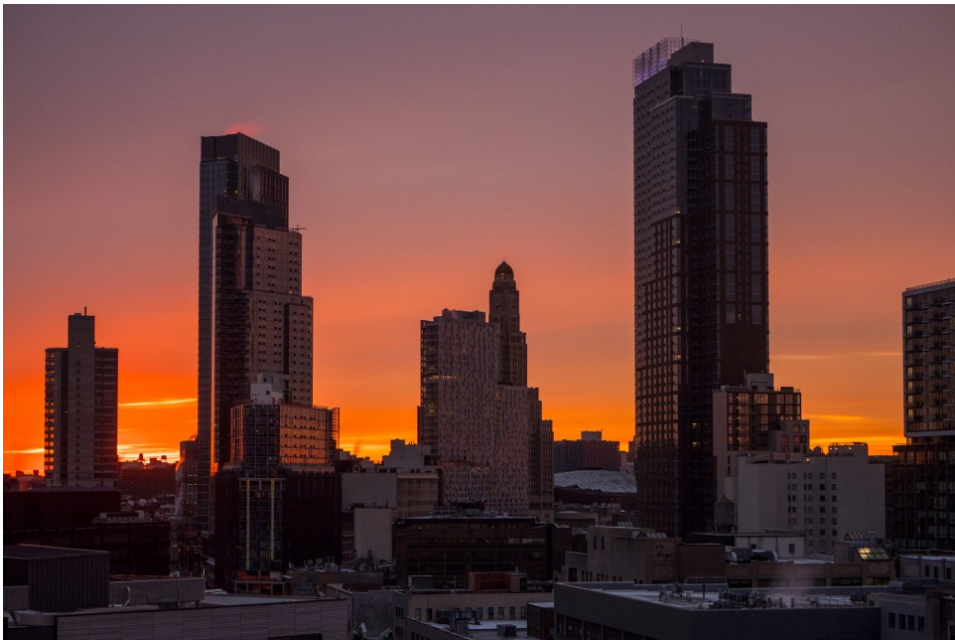
ND filters come in different strengths or darkness levels. For the photographer, the easiest thing would be to have ND filters that tell you how many **stops of light** they will darken your exposure. Designed by optical engineers, most brands of ND filters label their products with either an ND filter factor number or optical density number. Unfortunately, for the photographer, neither the filter factor nor the optical density number are equal to the number of stops by which the light is reduced.



So, here is a handy chart to reference when shopping for an ND filter or employing a filter you already own.

Stops of Light Reduction (There are filters that are measured to a fraction of a stop, but, for simplicity, we are using whole numbers here with the exception of a few filters.)	Optical Density Number (Sometimes prefaced with an "ND" before the number)	ND 1 Number	Filter Factor Number (Sometimes prefaced with an "ND" before the number)	Amount Light is Reduced
0	0	—	0 (a.k.a. Clear Filter)	0
1	ND 0.3 or "ND 0.3"	ND 101	2 or "ND2"	1/2
2	ND 0.6	ND 102	4	1/4
3	ND 0.9	ND 103	8	1/8
4	ND 1.2	ND 104	16	1/16
5	ND 1.5	ND 105	32	1/32
6	ND 1.8	ND 106	64	1/64
6 2/3	ND 2		100	1/100
7	ND 2.1	ND 107	128	1/128
8	ND 2.4	ND 108	256	1/256
9	ND 2.7	ND 109	512	1/512
10	ND 3.0	ND 110	1024 (a.k.a. ND1000)	1/1024
11	ND 3.3	ND 111	2048	1/2048
12	ND 3.6	ND 112	4096	1/4096
13	ND 3.9	ND 113	8192	1/8192
13 1/3	ND 4.0		10000	1/10000
14	ND 4.2	ND 114	16384	1/16384
15	ND 4.5	ND 115	32768	1/32768
16	ND 4.8	ND 116	65536	1/65536
16 2/3	ND 5.0		100000	1/100000
17	ND 5.1	ND 117	131072	1/131072
18	ND 5.4	ND 118	262144	1/262144
19	ND 5.7	ND 119	524288	1/524288
20	ND 6	ND 120	1048576	1/1048576
22	ND 6.6	ND 122	4194304	1/4194304
24	ND 7.2	ND 124	16777216	1/16777216

So, for every stop of ND filter, you halve the amount of light entering the camera. When the light is halved, to maintain the same exposure, you need to double your shutter speed. Add another ND stop; double the shutter speed again.



Sunrise in Brooklyn. The ND filter not only smooths the clouds a bit, but, if you look closely, the steam from building heating systems shows the slow shutter speed. Captured with a Formatt-Hitech Firecrest Ultra 16-stop ND filter.

Let's see, in graphical form, how an ND filter effects exposure time:

Original Shutter Speed	ND Filter Stops	New Shutter Speed (Rounded to standard camera shutter speeds when applicable)
1s	0	1s
1s	1	2s
1s	2	4s
1s	3	8s
1s	4	15s
1s	5	30s
1s	6	1m
1s	7	2m
1s	8	4m
1s	9	8m
1s	10	16m
1s	11	30m
1s	12	1hr
1s	13	2hr
1s	14	4hr
1s	15	8hr
1s	16	16hr
1s	17	32hr
1s	18	64hr
1s	19	128hr
1s	20	256hr
1s	21	512hr
1s	22	1024hr
1s	23	2048hr
1s	24	4096hr (170 days 16 hours)



Sunlight captured in the windows of a skyscraper. The ND filter permits the shutter speed to be slow enough to allow the clouds to streak even with reflected direct sunlight in the frame. Captured with a Formatt-Hitech Firecrest Ultra 16-stop ND filter.

Practical Examples

Here is an example of the change in exposure affecting shutter speed when using an ND filter where your goal is to shoot at a slower shutter speed to blur a waterfall. Because of the bright daylight, the original shutter speed, even with the lens stepped down to $f/16$, is a fast $1/800$ th and freezes the water. You have a 6-stop ND filter in your bag and you screw it onto your lens. Here is the result:

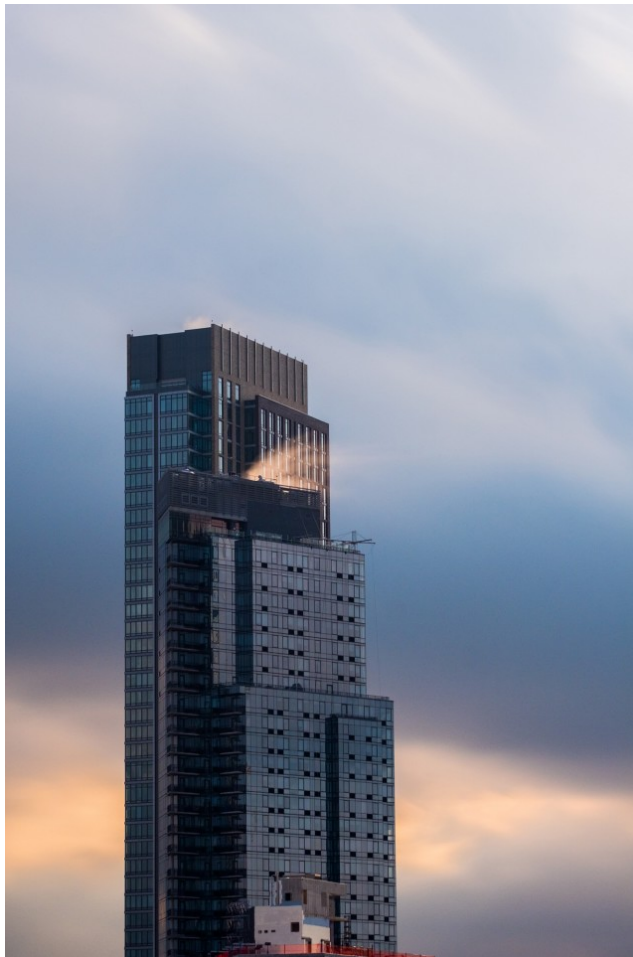
Original exposure: ISO 200, $f/16.0$, $1/800$.

Exposure with 6-stop ND filter: ISO 200, $f/16.0$, **$1/13$** .

Here is an example of an exposure adjustment for trying to maintain a specific aperture when using an ND filter. You are shooting in broad daylight and want to take a photo of a flower with a soft background. You open your lens to $f/1.4$ and your exposure meter is pegged because the camera cannot fire the shutter faster than $1/4000$ to get a proper exposure. Add an ND filter and see what happens:

Original exposure: ISO 200, $f/1.4$, $1/4000$ overexposed.

Exposure with 6-stop ND filter: ISO 200, $f/1.4$, **$1/60$** ... still overexposed, but the shutter speed is easily achievable by the camera. So, now you can shoot the same scene at, say, $1/500$ and get your shallow depth of field in direct daylight.



A building at sunrise. Again, the Formatt-Hitech Firecrest Ultra 16-stop ND filter allows the clouds to blur and the steam to streak.

Stacking Filters

One technique photographers use is filter “stacking.” If you have more than one ND filter, you may combine the two (or more filters) to get more ND stops for different photographic needs. The stacking math is easy: If you combine a 6-stop ND filter and a 10-stop ND filter, you now have a 16-stop ND filter.

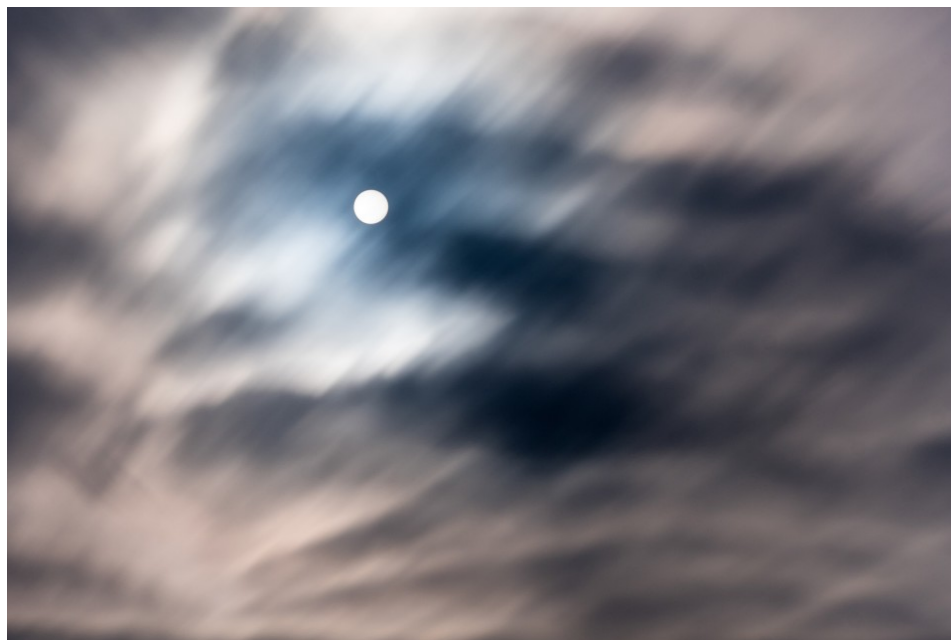
The downside to stacking filters is that, for each filter you add, you are forcing light to pass through more and more glass (or resin) elements. The more things that the light has to traverse, the more it is likely to get slightly refracted in some way that causes softness or chromatic aberrations in an image.



Urban landscapes with a Formatt-Hitech Firecrest Ultra 16-stop ND filter

Filter Shapes

Most “solid” ND filters are round and screw onto the front of the lens. Larger lenses may have circular drop-in filters. However, some ND filters are rectangular or square-shaped and are inserted into special holders that affix to the front of the lens. The filter ratings for round and rectangular filters are identical.



That is the sun, not the moon, in the frame. The clouds were not especially thick, but the shot required a Formatt-Hitech Firecrest Ultra 24-stop ND filter.

Other Types of ND Filters

Graduated Neutral Density Filter (GND) — The GND filter is an ND filter that transitions from light to dark. The rectangular GND filters are more popular than circular because they allow the photographer to adjust the position of the transition area from light to dark. The main purpose of the GND filter is to balance exposure in an image that contains a bright sky and relatively darker foreground. Landscape photographers are big consumers of GND filters and they perform especially well when capturing sunset images.

Variable Neutral Density Filter (VND) — The VND filter gives the photographer the ability to “dial in” the amount of filtration by turning the outer ring of a dual-ring filter. The maximum and minimum ND rating differ with different filters, but the 2-stop to 8-stop variety are most popular. The advantage of the VND filter is that you only need to carry one ND filter with you to get a variety of darkness levels. The disadvantage of the VND filter is that, due to the design of the filters, as you approach the maximum ND setting, you can get a cross pattern across the image. This is remedied by dialing the ND setting back a bit.

Center Neutral Density Filter (CND) — The smallest category of ND filter, the CND filter has a darkened center and lighter edges. It serves to balance exposure across the frame when using extreme wide angle lenses.

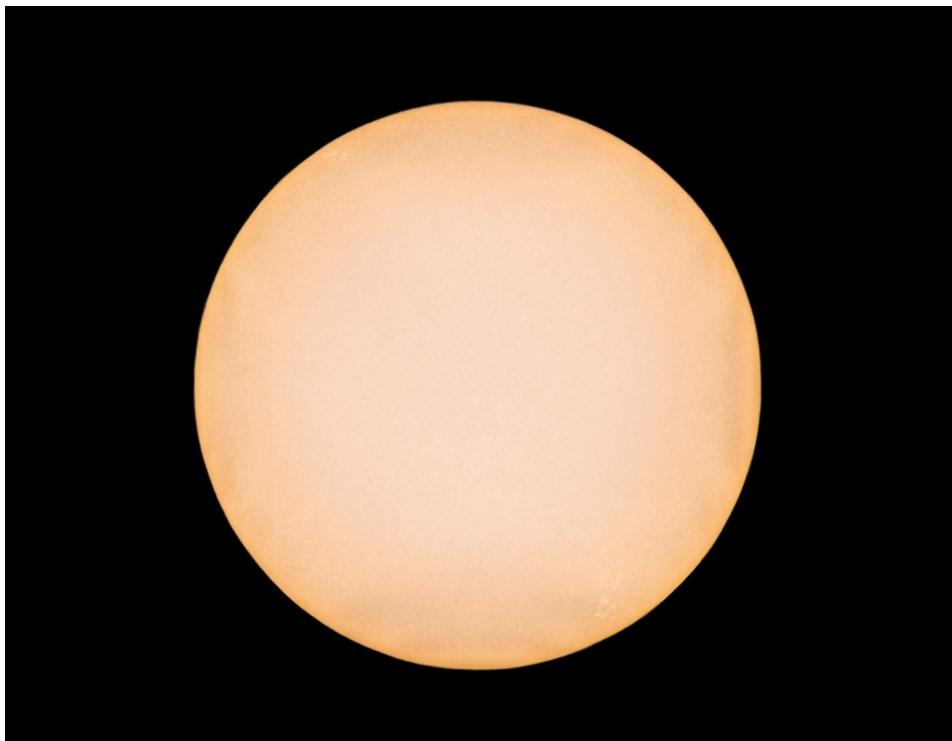
Polarizing Filter — Yep, your polarizing filter is an ND filter that you may already own. Most polarizers give a 2-stop ND filter effect while providing the cannot-achieve-it-in-post-processing polarizing effects of cutting down glare, darkening the blue skies, and seeing farther into water.



Yes, an object 93 million miles away can have motion blur if your shutter speed is slow enough and the Earth rotates during your exposure. This 15-minute exposure was captured with a Formatt-Hitech Firecrest Ultra 24-stop ND filter. The varying diameters of the sun is caused by refraction through passing clouds.

Solar Photography

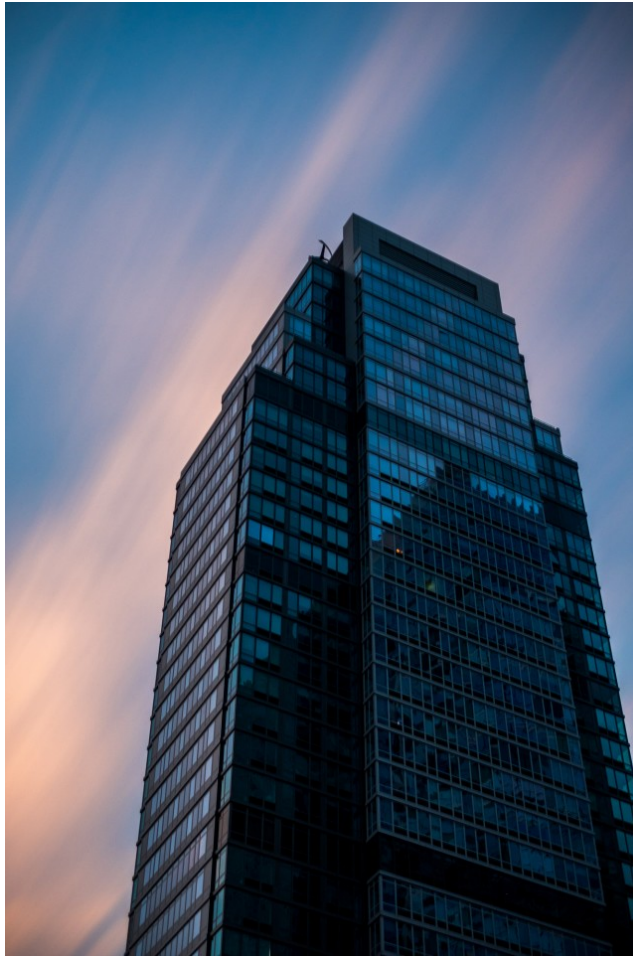
This is one more thing you can do with your ND filter(s). Many ND filter manufactures state that filters with a density of 16-stops or greater (shaded in the above table) are suitable for [solar photography](#) and [solar eclipse photography](#). WARNING: If using an ND filter (or stack of ND filters) for solar photography, do NOT use an optical viewfinder. Specialized solar imaging and viewing filters not only filter visible light, but harmful UV and IR radiation as well. ND filters do NOT provide this protection. Use them only with electronic viewfinders and/or Live View mode.



The sun captured through a Leica APO-Televid 77 spotting scope with a Formatt-Hitech Firecrest Ultra 18-stop ND filter. The orange color was added in post-processing.

Recommended ND Filter Factors

Many landscape photographers recommend that you head out into the field with a 6-stop ND filter that should be perfect for slowing your shutter speeds enough to show smooth motion in mountain streams and waterfalls. Add your polarizer to make it an 8-stop ND stack.



Clouds passing overhead. Image shot with a Formatt-Hitech Firecrest Ultra 16-stop ND filter.

Some wedding and portrait photographers prefer the 3-stop ND filter to give them a wide-open aperture option while shooting in sunlight. Combine this with a 6-stop for a 9-stop combo when needed.

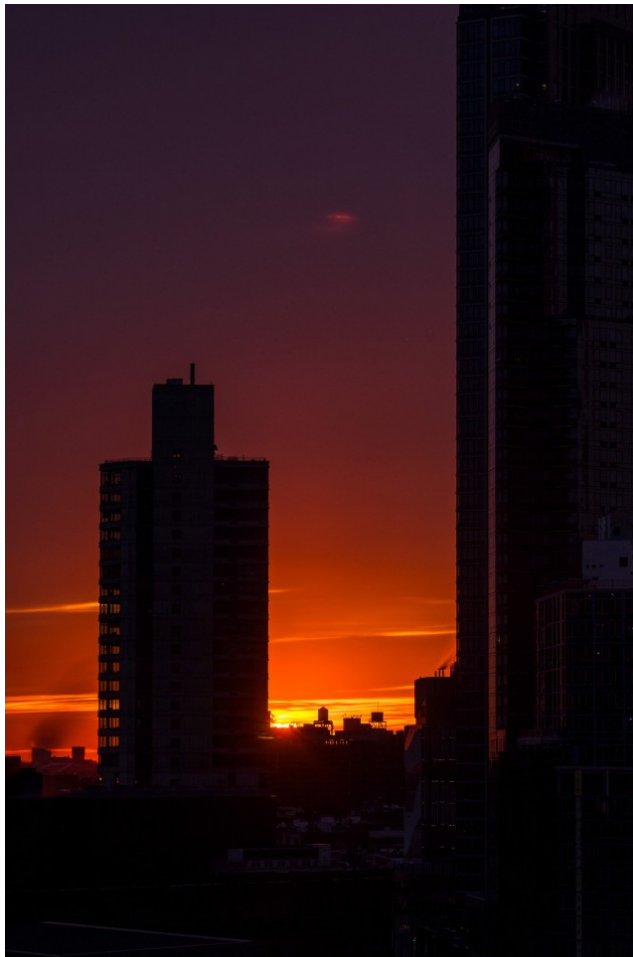
The 10-stop and darker ND filters are becoming popular with many photographers as they allow extremely slow shutter speed shooting and extremely wide aperture shooting under bright sunlight. If you have the time to crank out night photography-like shutter speeds, you can get some pretty cool effects with these super-dark filters in urban and natural settings. At the extreme end, the 24-stop ND filter is great for images with the sun directly in the frame.



Sunset behind Manhattan through a Formatt-Hitech Firecrest Ultra 18-stop ND filter. Not the smooth waters and sky.

Formatt-Hitech Firecrest Ultra Neutral Density Filters

The images used to illustrate this article were captured using [**Formatt-Hitech Ultra Neutral Density Filters**](#). Firecrest filters feature extremely neutral optical coatings in between two pieces of optical glass—protecting the coatings from wear and tear and delivering enhanced durability and lifespan over normally coated filters. The new Firecrest Ultra filters are the only photographic filters that undergo an additional finishing process referred to as “lapping & polishing” that brings the filters up to cinema-grade standards of clarity, sharpness, and optical flatness.



The moment of urban sunrise. The sun is directly peeking into this frame, but the Formatt-Hitech Firecrest Ultra 24-stop ND filter allows some blurry steam action regardless.

Do you have any questions about neutral density filters or ND filter photography? Do you have some creative uses for ND filters? Feel free to ask questions or leave comments below!