

# Neutral density filters

- Provide attenuation with linearity in transmission
- Usable from 200 - 2000 (quartz)
- Usable from 400 - 700 nm (glass)

These reflective-type filters consist of a thin metallic coating deposited on the surface of a transparent optic. The light transmission through the film coating depends upon its thickness. What is not transmitted is partially absorbed and partially reflected. These thin films can be deposited on glass or on UV-grade fused silica. The glass-substrate reflective neutral density filters are useable over the visible region while the silica ones can be used from the UV to the near IR.

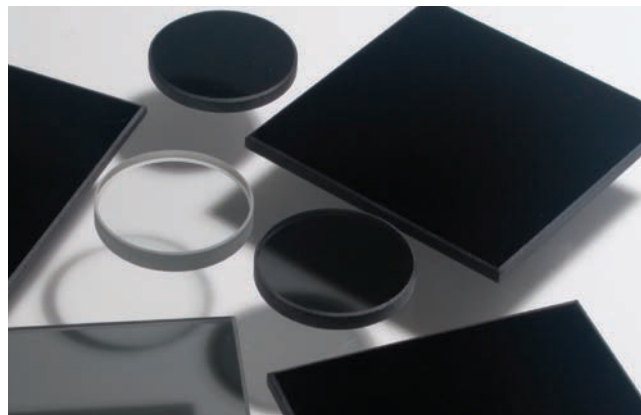
Neutral density filters are categorized by their optical density (D) which is defined as the logarithm to the base 10 of the reciprocal of the transmitted radiant power (T):

$$D = \log_{10} 1/T \text{ or } T = 10^{-D}$$

Optical density is additive, so several filters can be placed in series to obtain a specific value. Be careful, however, when aligning the filters as multiple reflections will cause a reduction in the total density value. This can be eliminated by slightly tilting the filters (approx. 10 degrees) causing only a few percent in the optical density change.

## General specifications

Thickness	1.5 mm
Dimensional tolerances	±0.5 mm
Clear aperture	90% of outside dimension
Surface quality	60/40 per MIL-O-13830B
Coating quality	40/20 per MIL-O-13830B
Coating adherence	Per MIL-M-13508C
Humidity	Per MIL-STD-810F
Max. operating temperature	+100° C
Substrate materials	Glass (350 - 2000 nm region) or fused silica (250 - 2000 nm region)
Optical quality	Glass: Flatness of 3-5 waves per inch and parallelism of 3 arc minutes or better Fused silica: Flatness of $\lambda/4$ per inch and parallelism of 30 arc seconds or better



## Incident power

These filters attenuate mostly by reflection; absorption accounts for a small percentage of the total attenuation. When the filter is exposed to a high-intensity beam in a small area, cracking is possible. We recommend the following:

- Orientate the reflective surface towards the light source
- Spread the beam over the filter
- Avoid thermal stress, e.g. do not use a mount which acts as a heat sink at the filter edge or is holding the filter rigidly
- Do not exceed a 5° C/min. temperature rise

## Filters and light sources

If you are using these filters with our arc or halogen light sources, use them in a collimated beam only. If you re-focus the beam, place the filter before the focusing lens. You can combine filter holders and lens holders in series with our flanging system that couples directly to our light sources.

When it is necessary to attenuate a high intensity source ( $\geq 300$  W) with absorbing filters it may be best to use several neutral density filters to spread the heat load, for example an attenuation by 10 may be best attained by three filters, 0.1, 0.2 and 0.7 neutral density filters with the 0.1 density filter closest to the source.

# Neutral density filters

Optical density [D]	Transmission @550 nm [%]	Maximum deviation [% T]		VIS filters		UV-NIR filters	
		VIS range 350 - 800 nm	UV & NIR 250-350 & 800-2000 nm	25 mm diam.	50 x 50 mm	25 mm diam.	50 x 50 mm
0.1	79.43	± 2.0	± 8.0	010FN52-25	010FN52-50	010FN46-25	010FN46-50
0.15	70.79	± 2.0	± 7.0	015FN52-25	015FN52-50	015FN46-25	015FN46-50
0.2	63.10	± 2.0	± 6.0	020FN52-25	020FN52-50	020FN46-25	020FN46-50
0.3	50.12	± 2.0	± 5.0	030FN52-25	030FN52-50	030FN46-25	030FN46-50
0.4	39.81	± 1.5	± 4.0	040FN52-25	040FN52-50	040FN46-25	040FN46-50
0.5	31.62	± 1.5	± 4.0	050FN52-25	050FN52-50	050FN46-25	050FN46-50
0.6	25.12	± 1.5	± 4.0	060FN52-25	060FN52-50	060FN46-25	060FN46-50
0.7	19.95	± 1.5	± 4.0	070FN52-25	070FN52-50	070FN46-25	070FN46-50
0.8	15.85	± 1.5	± 4.0	080FN52-25	080FN52-50	080FN46-25	080FN46-50
0.9	12.59	± 1.0	± 3.5	090FN52-25	090FN52-50	090FN46-25	090FN46-50
1.0	10.00	± 1.0	± 3.5	100FN52-25	100FN52-50	100FN46-25	100FN46-50
1.3	5.01	± 1.0	± 3.0	130FN52-25	130FN52-50	130FN46-25	130FN46-50
1.5	3.16	± 0.5	± 1.5	150FN52-25	150FN52-50	150FN46-25	150FN46-50
2.0	1.00	± 0.2	± 0.5	200FN52-25	200FN52-50	200FN46-25	200FN46-50
2.5	0.32	± 0.07	± 0.15	250FN52-25	250FN52-50	250FN46-25	250FN46-50
3.0	0.10	± 0.03	± 0.06	300FN52-25	300FN52-50	300FN46-25	300FN46-50
4.0	0.01	± 0.005	± 0.008	400FN52-25	400FN52-50	400FN46-25	400FN46-50

All filter sets are shipped with a hardwood storage case for protection and convenient storage.

## Neutral density sets

7-piece set	
0.10	
0.30	
0.50	
1.00	
2.00	
3.00	
4.00	

Includes seven filters with optical densities ranging from 0.10 to 4.00, in your choice of four sizes and either glass or fused silica substrates.

Size, shape & part number			
Substrate	25 mm	50 mm Ø	50 mm SQ
Glass	128FA52-25	128FA52-50	128FA52-50S
Fused silica	130FA46-25	130FA46-50	130FA46-50S

17-piece set	
0.10	0.90
0.15	1.00
0.20	1.30
0.30	1.50
0.40	2.00
0.50	2.50
0.60	3.00
0.70	4.00
0.80	

Includes 17 filters with optical densities ranging from 0.10 to 4.00, in your choice of four sizes and either glass or fused silica substrates.

Size, shape & part number			
Substrate	25 mm Ø	50 mm Ø	50 mm SQ
Glass	132FA52-25	132FA52-50	132FA52-50S
Fused silica	134FA46-25	134FA46-50	134FA46-50S

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