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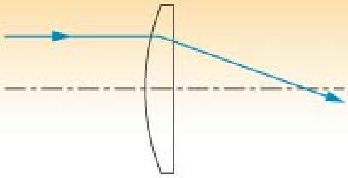
LA7660-F - August 10, 2015

Item # LA7660-F was discontinued on August 10, 2015. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

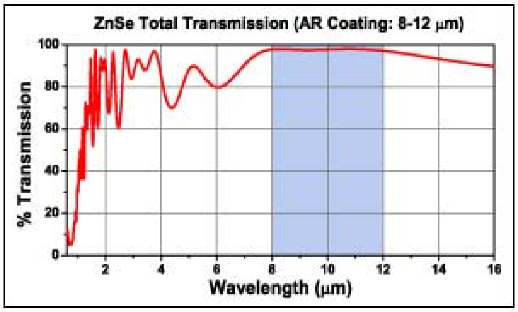
ZINC SELENIDE PLANO-CONVEX LENSES

- ► **AR Coating Optimized for the 8 - 12 µm Range**
- ► **Choose from Ø1/2" or Ø1"**
- ► **Ideal for CO_2 Laser Applications Due to Low Absorption Coefficient**
- ► **Excellent for IR Imaging, Biomedical, or Military Applications**



LA7477-F
(Ø1/2")

LA7542-F
(Ø1")



OVERVIEW

Features

- ZnSe Substrate
- Ø1/2" and Ø1" Versions Available
- Broadband AR Coating for the 8 - 12 µm Range
- Focal Lengths from 15.0 - 1000.0 mm Available

Thorlabs' Ø1/2" and Ø1" Zinc Selenide (ZnSe) Plano-Convex Lenses, which offer high transmission from 0.6-16 µm, are available with a broadband AR coating optimized for the 8-12 µm spectral range deposited on both surfaces. This coating greatly reduces the high surface reflectivity of the substrate, yielding an average transmission in excess of 97% over the entire AR coating range. See the *Graphs* tab for detailed information.

ZnSe lenses are typically used as collimators for laser applications in the 0.6-16.0 µm spectral region, such as biomedical and military applications. Due to the low absorption coefficient of ZnSe, these lenses are also particularly well suited for use with high-power CO_2 lasers.

Plano-Convex lenses have a positive focal length and approach best form for infinite and finite conjugate applications. These lenses focus a collimated beam to the back focus and collimate light from a point source. They are designed with minimal spherical aberration and have a focal length given by:

$f= R/(n-1)$,

where R is the radius of curvature of the convex portion of the lens and n is the index of refraction.

Specifications	
Material	Laser Grade Zinc Selenide
Wavelength Range	0.6 - 16.0 µm
AR Coating Range	8-12 µm
Damage Threshold[a]	5 J/cm^2 (10.6 µm, 100 ns, 1 Hz, Ø0.478 mm)
Reflectance over Coating Range (Avg.)	<1.5%
Diameter Tolerance	+0.00/-0.10
Thickness Tolerance	±0.2 mm
Focal Length Tolerance	±1%
Surface Quality	60-40 Scratch-Dig
Surface Flatness (Plano Side)	λ/2
Spherical Surface Power[b] (Convex Side)	3λ/2
Surface Irregularity (Peak to Valley)	λ/2
Centration	≤3 arcmin
Clear Aperture	80% of Diameter
Design Wavelength	10.6 µm

- Limited by the antireflection coating.
- Much like surface flatness for flat optics, spherical surface power is a measure of the deviation between the surface of the curved optic and a calibrated reference gauge, typically for a 633 nm source, unless otherwise stated. This specification is also commonly referred to as surface fit.

Usage:
To minimize the introduction of spherical aberrations, light should be bent gradually as it propagates through the lens. Therefore, when using a plano-convex lens to focus a collimated light source, the collimated light should be incident on the curved surface. Similarly, when collimating a point source of light, the diverging light rays should be incident on the planar surface of the lens.

When handling optics, one should always wear gloves. This is especially true when working with zinc selenide, as it is a hazardous material. For your safety, please follow all proper precautions, including wearing gloves when handling these lenses and thoroughly washing your hands afterward. Click here to download a pdf of the MSDS for ZnSe.

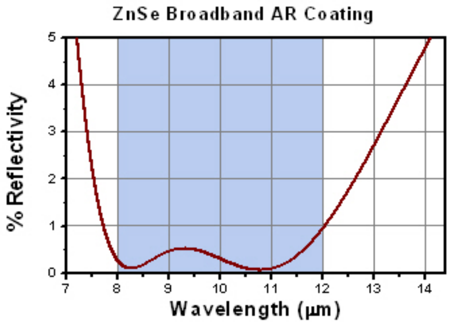
Thorlabs will accept all ZnSe lenses back for proper disposal. Please contact Tech Support to make arrangements for this service.

Zemax Files

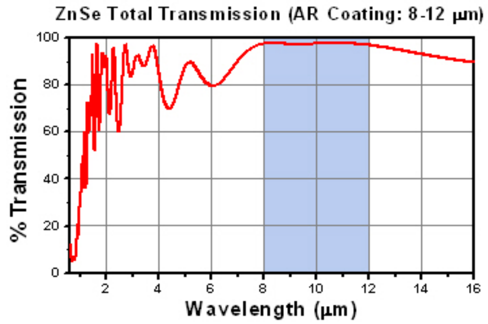
Click on the red Document icon next to the item numbers below to access the Zemax file download. Our entire Zemax Catalog is also available.

Selection Guide					
Other ZnSe Lenses	More [+]	**Other MIR Lenses**	More [+]	**Other Spherical Singlets**	More [+]

GRAPHS



Shown above is a theoretical graph of the percent reflectivity of the AR coating as a function of wavelength. The average reflectivity in the 8 - 12 µm range is <1.5%. The blue shading indicates the region for which the AR coating is optimized.



Shown above is a graph of the theoretical transmission of the AR-coated zinc selenide plano-convex lens. The blue shaded region denotes the 8 - 12 µm spectral range where the AR coating is optimized. For this wavelength range, the measured transmission is in excess of 97%.

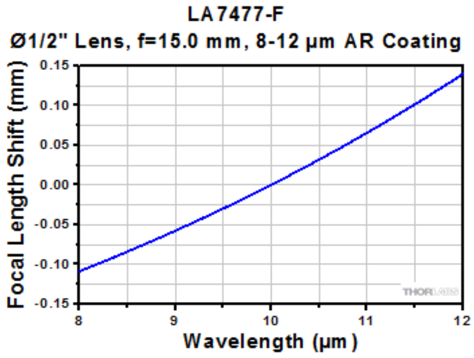
Total Transmission of Optic (ZnSe Substrate + AR Coating)

The table below gives the approximate transmission of these optics for a few select wavelengths in the 0.6 - 16 µm range. To see an excel file that lists all measured transmission values for this wavelength range, please click here. Please note that the transmission values stated for wavelengths outside of the AR coating range are approximate and can vary significantly by coating lot.

Wavelength (µm)	Total Transmission	Wavelength (µm)	Total Transmission	Wavelength (µm)	Total Transmission	Wavelength (µm)	Total Transmission
0.6	0.117	4.6	0.740	8.6	0.978	12.6	0.961
1.0	0.312	5.0	0.880	9.0	0.975	13.0	0.953
1.4	0.674	5.4	0.874	9.4	0.975	13.4	0.945
1.8	0.875	5.8	0.810	9.8	0.976	13.8	0.936
2.2	0.810	6.2	0.802	10.2	0.978	14.2	0.928
2.6	0.803	6.6	0.845	10.6	0.979	14.6	0.920
3.0	0.859	7.0	0.904	11.0	0.979	15.0	0.913
3.4	0.880	7.4	0.950	11.4	0.977	15.4	0.906
3.8	0.962	7.8	0.973	11.8	0.973	15.8	0.900
4.2	0.733	8.2	0.979	12.2	0.968		

FOCAL LENGTH SHIFT

The graphs below illustrate the focal length shift for the wavelength range of 8 µm to 12 µm for all of our ZnSe Plano-Convex Lenses. To see an Excel file that lists all theoretical focal length shift values for this wavelength range, please click here.



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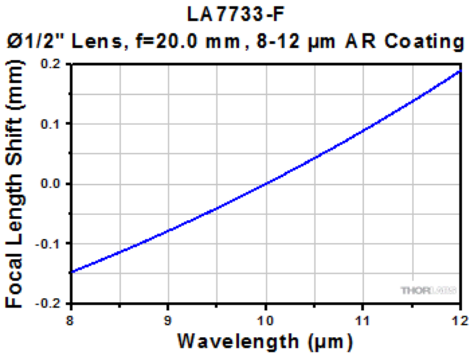

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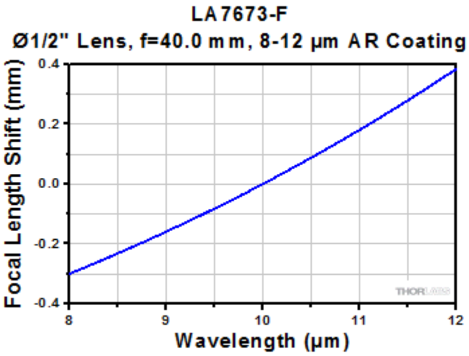

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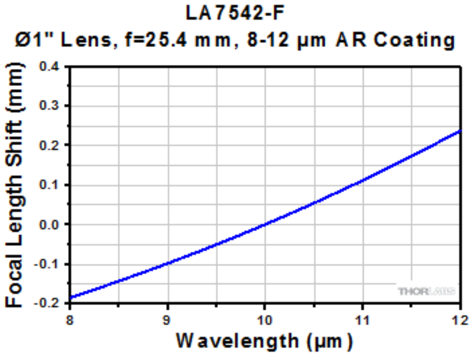

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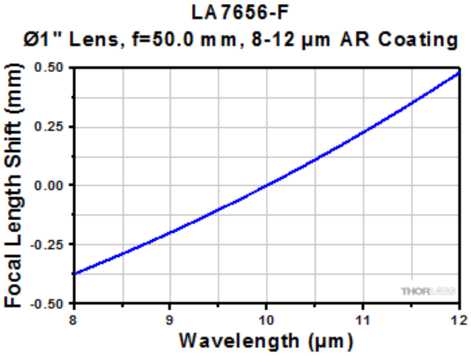

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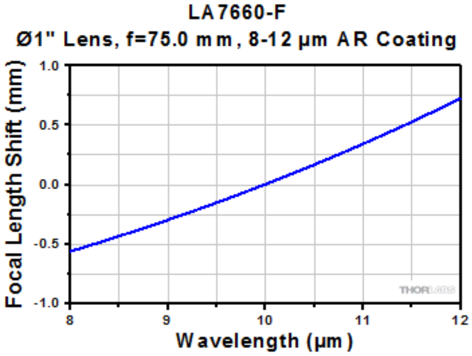

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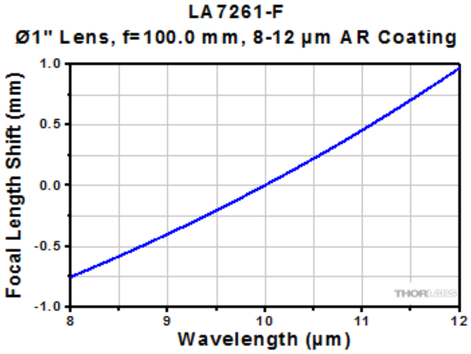

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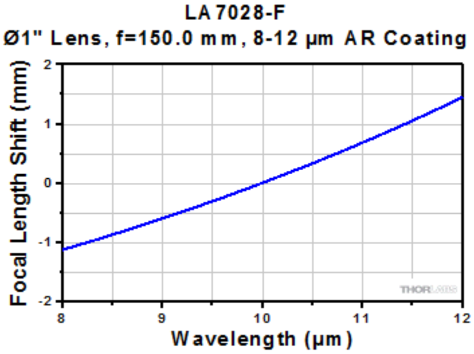

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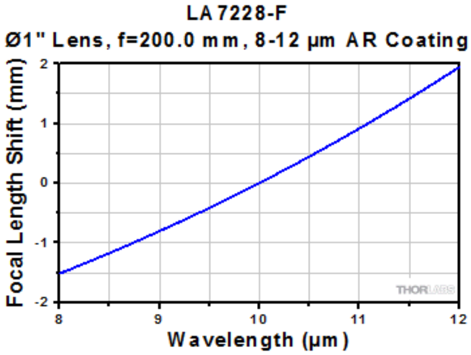

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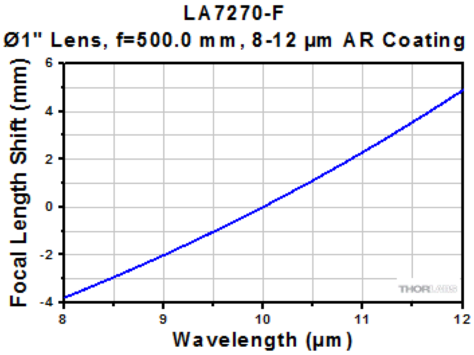

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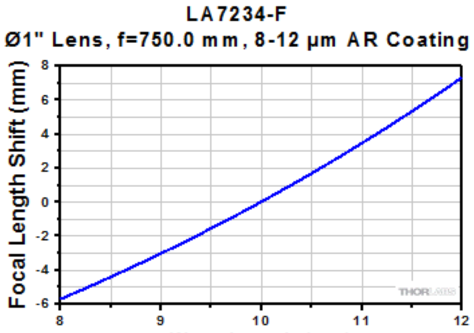

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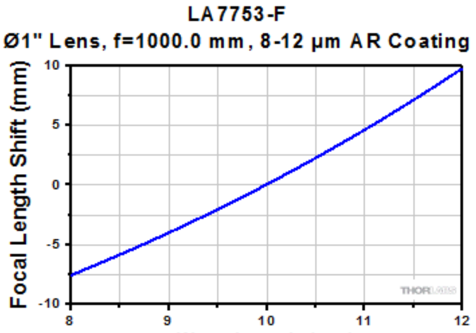

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Click Here for Raw Data

DAMAGE THRESHOLDS

Damage Threshold Data for Thorlabs' F-Coated ZnSe Lenses

The specifications to the right are measured data for Thorlabs' F-coated ZnSe lenses. Damage threshold specifications are constant for all Thorlabs' F-coated ZnSe lenses, regardless of the size or focal length of the lens.

Damage Threshold Specifications	
Coating Designation (Item # Suffix)	**Damage Threshold**
-F	5 J/cm^2 (10.6 µm, 100 ns, 1 Hz, Ø0.478 mm)

Laser Induced Damage Threshold Tutorial

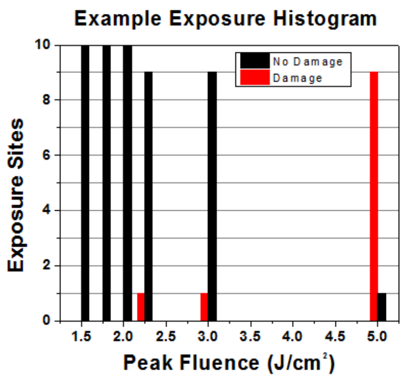
This following is a general overview of how laser induced damage thresholds are measured and how the values may be utilized in determining the appropriateness of an optic for a given application. When choosing optics, it is important to understand the Laser Induced Damage Threshold (LIDT) of the optics being used. The LIDT for an optic greatly depends on the type of laser you are using. Continuous wave (CW) lasers typically cause damage from thermal effects (absorption either in the coating or in the substrate). Pulsed lasers, on the other hand, often strip electrons from the lattice structure of an optic before causing thermal damage. Note that the guideline presented here assumes room temperature operation and optics in new condition (i.e., within scratch-dig spec, surface free of contamination, etc.). Because dust or other particles on the surface of an optic can cause damage at lower thresholds, we recommend keeping surfaces clean and free of debris. For more information on cleaning optics, please see our *Optics Cleaning* tutorial.

Testing Method

Thorlabs' LIDT testing is done in compliance with ISO/DIS11254 specifications. A standard 1-on-1 testing regime is performed to test the damage threshold.

First, a low-power/energy beam is directed to the optic under test. The optic is exposed in 10 locations to this laser beam for a set duration of time (CW) or number of pulses (pulse repetition frequency specified). After exposure, the optic is examined by a microscope (~100X magnification) for any visible damage. The number of locations that are damaged at a particular power/energy level is recorded. Next, the power/energy is either increased or decreased and the optic is exposed at 10 new locations. This process is repeated until damage is observed. The damage threshold is then assigned to be the highest power/energy that the optic can withstand without causing damage. A histogram such as that below represents the testing of one BB1-E02 mirror.

The photograph above is a protected aluminum-coated mirror after LIDT testing. In this particular test, it handled 0.43 J/cm^2 (1064 nm, 10 ns pulse, 10 Hz, Ø1.000 mm) before damage.



According to the test, the damage threshold of the mirror was 2.00 J/cm^2 (532 nm, 10 ns pulse, 10 Hz, Ø0.803 mm). Please keep in mind that these tests are performed on clean optics, as dirt and contamination can significantly lower the damage threshold of a component. While the test results are only representative of one coating run, Thorlabs specifies damage threshold values that account for coating variances.

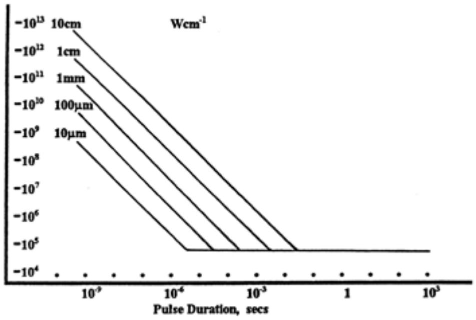
Example Test Data			
Fluence	**# of Tested Locations**	**Locations with Damage**	**Locations Without Damage**
1.50 J/cm^2	10	0	10
1.75 J/cm^2	10	0	10
2.00 J/cm^2	10	0	10

2.25 J/cm^2	10	1	9
3.00 J/cm^2	10	1	9
5.00 J/cm^2	10	9	1

Continuous Wave and Long-Pulse Lasers

When an optic is damaged by a continuous wave (CW) laser, it is usually due to the melting of the surface as a result of absorbing the laser's energy or damage to the optical coating (antireflection) [1]. Pulsed lasers with pulse lengths longer than 1 µs can be treated as CW lasers for LIDT discussions. Additionally, when pulse lengths are between 1 ns and 1 µs, LIDT can occur either because of absorption or a dielectric breakdown (must check both CW and pulsed LIDT). Absorption is either due to an intrinsic property of the optic or due to surface irregularities; thus LIDT values are only valid for optics meeting or exceeding the surface quality specifications given by a manufacturer. While many optics can handle high power CW lasers, cemented (e.g., achromatic doublets) or highly absorptive (e.g., ND filters) optics tend to have lower CW damage thresholds. These lower thresholds are due to absorption or scattering in the cement or metal coating.

Pulsed lasers with high pulse repetition frequencies (PRF) may behave similarly to CW beams. Unfortunately, this is highly dependent on factors such as absorption and thermal diffusivity, so there is no reliable method for determining when a high PRF laser will damage an optic due to thermal effects. For beams with a large PRF both the average and peak powers must be compared to the equivalent CW power. Additionally, for highly transparent materials, there is little to no drop in the LIDT with increasing PRF.

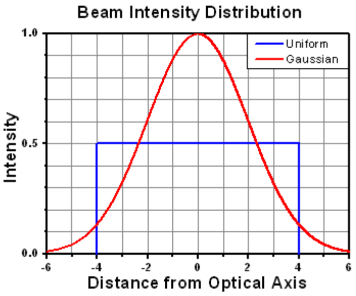


LIDT in linear power density vs. pulse length and spot size. For long pulses to CW, linear power density becomes a constant with spot size. This graph was obtained from [1].

In order to use the specified CW damage threshold of an optic, it is necessary to know the following:

1. Wavelength of your laser
2. Linear power density of your beam (total power divided by 1/e^2 spot size)
3. Beam diameter of your beam (1/e^2)
4. Approximate intensity profile of your beam (e.g., Gaussian)

The power density of your beam should be calculated in terms of W/cm. The graph to the right shows why the linear power density provides the best metric for long pulse and CW sources. Under these conditions, linear power density scales independently of spot size; one does not need to compute an adjusted LIDT to adjust for changes in spot size. This calculation assumes a uniform beam intensity profile. You must now consider hotspots in the beam or other nonuniform intensity profiles and roughly calculate a maximum power density. For reference, a Gaussian beam typically has a maximum power density that is twice that of the uniform beam (see lower right).



Now compare the maximum power density to that which is specified as the LIDT for the optic. If the optic was tested at a wavelength other than your operating wavelength, the damage threshold must be scaled appropriately. A good rule of thumb is that the damage threshold has a linear relationship with wavelength such that as you move to shorter wavelengths, the damage threshold decreases (i.e., a LIDT of 10 W/cm at 1310 nm scales to 5 W/cm at 655 nm):

$$Adjusted\ LIDT = LIDT\ Power\left(\frac{Your\ Wavelength}{LIDT\ Wavelength}\right)$$

While this rule of thumb provides a general trend, it is not a quantitative analysis of LIDT vs wavelength. In CW applications, for instance, damage scales more strongly with absorption in the coating and substrate, which does not necessarily scale well with wavelength. While the above procedure provides a good rule of thumb for LIDT values, please contact Tech Support if your wavelength is different from the specified LIDT wavelength. If your power density is less than the adjusted LIDT of the optic, then the optic should work for your application.

Please note that we have a buffer built in between the specified damage thresholds online and the tests which we have done, which accommodates variation between batches. Upon request, we can provide individual test information and a testing certificate. The damage analysis will be carried out on a similar optic (customer's optic will not be damaged). Testing may result in additional costs or lead times. Contact Tech Support for more information.

Pulsed Lasers

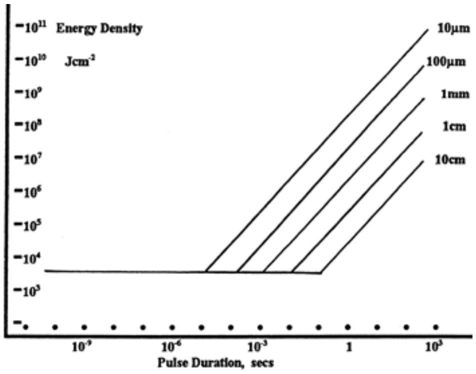
As previously stated, pulsed lasers typically induce a different type of damage to the optic than CW lasers. Pulsed lasers often do not heat the optic enough to damage it; instead, pulsed lasers produce strong electric fields capable of inducing dielectric breakdown in the material. Unfortunately, it can be very difficult to compare the LIDT specification of an optic to your laser. There are multiple regimes in which a pulsed laser can damage an optic and this is based on the laser's pulse length. The highlighted columns in the table below outline the relevant pulse lengths for our specified LIDT values.

Pulses shorter than 10^{-9} s cannot be compared to our specified LIDT values with much reliability. In this ultra-short-pulse regime various mechanics, such as multiphoton-avalanche ionization, take over as the predominate damage mechanism [2]. In contrast, pulses between 10^{-7} s and 10^{-4} s may cause damage to an optic either because of dielectric breakdown or thermal effects. This means that both CW and pulsed damage thresholds must be compared to the laser beam to determine whether the optic is suitable for your application.

Pulse Duration	$t < 10^{-9}$ s	$10^{-9} < t < 10^{-7}$ s	$10^{-7} < t < 10^{-4}$ s	$t > 10^{-4}$ s
Damage Mechanism	Avalanche Ionization	Dielectric Breakdown	Dielectric Breakdown or Thermal	Thermal
Relevant Damage Specification	N/A	Pulsed	Pulsed and CW	CW

When comparing an LIDT specified for a pulsed laser to your laser, it is essential to know the following:

1. Wavelength of your laser
2. Energy density of your beam (total energy divided by $1/e^2$ area)
3. Pulse length of your laser
4. Pulse repetition frequency (prf) of your laser
5. Beam diameter of your laser ($1/e^2$)
6. Approximate intensity profile of your beam (e.g., Gaussian)



LIDT in energy density vs. pulse length and spot size. For short pulses, energy density becomes a constant with spot size. This graph was obtained from [1].

The energy density of your beam should be calculated in terms of J/cm². The graph to the right shows why the energy density provides the best metric for short pulse sources. Under these conditions, energy density scales independently of spot size, one does not need to compute an adjusted LIDT to adjust for changes in spot size. This calculation assumes a uniform beam intensity profile. You must now adjust this energy density to account for hotspots or other nonuniform intensity profiles and roughly calculate a maximum energy density. For reference a Gaussian beam typically has a maximum energy density that is twice that of the $1/e^2$ beam.

Now compare the maximum energy density to that which is specified as the LIDT for the optic. If the optic was tested at a wavelength other than your operating wavelength, the damage threshold must be scaled appropriately [3]. A good rule of thumb is that the damage threshold has an inverse square root relationship with wavelength such that as you move to shorter wavelengths, the damage threshold decreases (i.e., a LIDT of 1 J/cm² at 1064 nm scales to 0.7 J/cm² at 532 nm):

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Wavelength}{LIDT\ Wavelength}}$$

You now have a wavelength-adjusted energy density, which you will use in the following step.

Beam diameter is also important to know when comparing damage thresholds. While the LIDT, when expressed in units of J/cm2, scales independently of spot size; large beam sizes are more likely to illuminate a larger number of defects which can lead to greater variances in the LIDT [4]. For data presented here, a <1 mm beam size was used to measure the LIDT. For beams sizes greater than 5 mm, the LIDT (J/cm2) will not scale independently of beam diameter due to the larger size beam exposing more defects.

The pulse length must now be compensated for. The longer the pulse duration, the more energy the optic can handle. For pulse widths between 1 - 100 ns, an approximation is as follows:

$$Adjusted\ LIDT = LIDT\ Energy\sqrt{\frac{Your\ Pulse\ Length}{LIDT\ Pulse\ Length}}$$

Use this formula to calculate the Adjusted LIDT for an optic based on your pulse length. If your maximum energy density is less than this adjusted LIDT maximum energy density, then the optic should be suitable for your application. Keep in mind that this calculation is only used for pulses between 10^{-9} s and 10^{-7} s. For pulses between 10^{-7} s and 10^{-4} s, the CW LIDT must also be checked before deeming the optic appropriate for your application.

Please note that we have a buffer built in between the specified damage thresholds online and the tests which we have done, which accommodates variation between batches. Upon request, we can provide individual test information and a testing certificate. Contact Tech Support for more information.

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[1] R. M. Wood, Optics and Laser Tech. **29**, 517 (1997).
[2] Roger M. Wood, *Laser-Induced Damage of Optical Materials* (Institute of Physics Publishing, Philadelphia, PA, 2003).
[3] C. W. Carr *et al.*, Phys. Rev. Lett. **91**, 127402 (2003).
[4] N. Bloembergen, Appl. Opt. **12**, 661 (1973).

Ø1/2" ZnSe Plano-Convex Lenses

Item #	Diameter	Focal Length	Radius of Curvature	Center Thickness	Edge Thickness*	Back Focal Length**	Reference Drawing
LA7477-F	1/2"	15.0 mm	21.0 mm	3.0 mm	2.0 mm	13.8 mm	ⓘ
LA7733-F	1/2"	20.0 mm	28.0 mm	2.7 mm	2.0 mm	18.9 mm	
LA7673-F	1/2"	40.0 mm	56.1 mm	2.4 mm	2.0 mm	39.0 mm	

*Edge thickness given before 0.2 mm at 45° typical chamfer.
**Measured at the design wavelength, 10.6 µm
Suggested Fixed Lens Mount: LMR05

Part Number	Description	Price	Availability
LA7477-F	**Ø1/2" ZnSe Plano-Convex Lens, f = 15.0 mm, AR-Coated: 8-12 µm**	**$155.00**	**Today**
LA7733-F	**Ø1/2" ZnSe Plano-Convex Lens, f = 20.0 mm, AR-Coated: 8-12 µm**	**$155.00**	**Lead Time**
LA7673-F	**Ø1/2" ZnSe Plano-Convex Lens, f = 40.0 mm, AR-Coated: 8-12 µm**	**$155.00**	**Today**

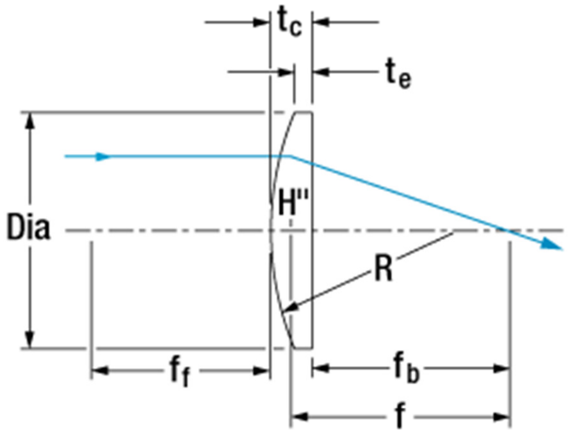
Ø1" ZnSe Plano-Convex Lenses

Item #	Diameter	Focal Length	Radius of Curvature	Center Thickness	Edge Thickness*	Back Focal Length**	Reference Drawing
LA7542-F	1"	25.4 mm	35.6 mm	4.3 mm	2.0 mm	23.6 mm	ⓘ
LA7656-F	1"	50.0 mm	70.2 mm	4.0 mm	2.8 mm	48.4 mm	
LA7660-F	1"	75.0 mm	105.2 mm	4.0 mm	3.2 mm	73.3 mm	
LA7261-F	1"	100.0 mm	140.5 mm	4.0 mm	3.4 mm	98.5 mm	
LA7028-F	1"	150.0 mm	209.0 mm	4.0 mm	3.6 mm	147.3 mm	
LA7228-F	1"	200.0 mm	280.5 mm	4.0 mm	3.7 mm	198.3 mm	
LA7270-F	1"	500.0 mm	701.3 mm	2.1 mm	2.0 mm	499.1 mm	
LA7234-F	1"	750.0 mm	1052.0 mm	2.1 mm	2.0 mm	749.1 mm	
LA7753-F	1"	1000.0 mm	1402.7 mm	2.1 mm	2.0 mm	999.1 mm	

*Edge thickness given before 0.2 mm at 45° typical chamfer.
**Measured at the design wavelength, 10.6 µm
Suggested Fixed Lens Mount: LMR1

Part Number	Description	Price	Availability
LA7542-F	**Ø1" ZnSe Plano-Convex Lens, f = 25.4 mm, AR-Coated: 8-12 µm**	**$283.00**	**3-5 Days**
LA7656-F	**Ø1" ZnSe Plano-Convex Lens, f = 50.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Today**
LA7660-F	**Ø1" ZnSe Plano-Convex Lens, f = 75.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Lead Time**
LA7261-F	**Ø1" ZnSe Plano-Convex Lens, f = 100.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Lead Time**
LA7028-F	**Ø1" ZnSe Plano-Convex Lens, f = 150.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Lead Time**
LA7228-F	**Ø1" ZnSe Plano-Convex Lens, f = 200.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Today**
LA7270-F	**Ø1" ZnSe Plano-Convex Lens, f = 500.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Today**
LA7234-F	**Ø1" ZnSe Plano-Convex Lens, f = 750.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**Today**
LA7753-F	**Ø1" ZnSe Plano-Convex Lens, f = 1000.0 mm, AR-Coated: 8-12 µm**	**$283.00**	**3-5 Days**

Visit the *Zinc Selenide Plano-Convex Lenses* page for pricing and availability information:
https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=1781



Dia: Diameter
f: Focal Length
f_f: Front Focal Length
f_b: Back Focal Length
R: Radius
t_c: Lens Thickness
t_e: Edge Thickness
H'': Back Principal Plane