#33-563 16MM TECHSPEC® Cx SERIES LENS

Our **TECHSPEC® Cx (Compact Flexible) Series** lenses are the modular edition of our C Series lenses. The 3-piece design allows accessories to be interchangeably placed into the system to meet your specific needs. See *Figure 1* for a cross-section of the 16mm Cx Series lens without its central accessory piece.

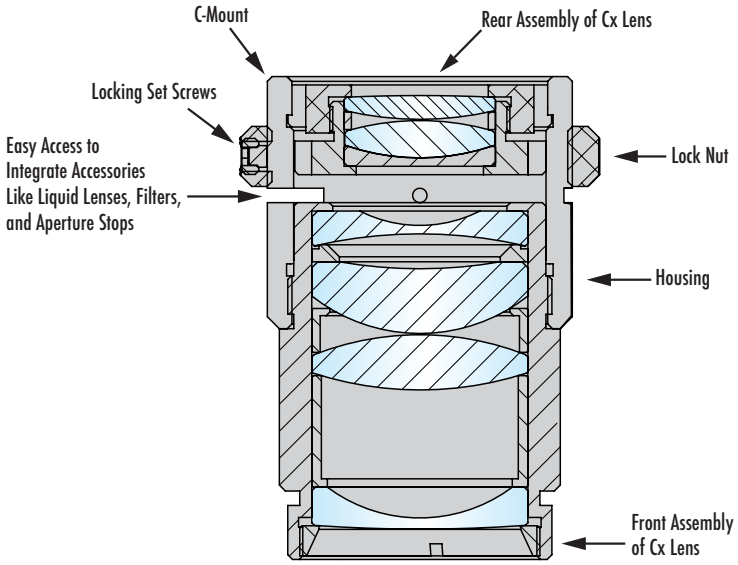

Figure 1: *16mm Cx lens without the required accessory.*

ACCESSORIES

Warning: One accessory is required to be used with the Cx Series Fixed Focal Length Lens. Accessories are not included and must be bought separately.

The standard options for accessories are apertures, filter holders, and liquid lens holders.

APERTURE

There are eight standard options for aperture f-stops ranging from f/1.5 to f/16. Apertures with a higher, slower f/# allow less light to pass through the system. This will increase the depth of field but may decrease the resolution. The stock number for each aperture can be found in *Table 1*.

f/#	Apertures for 16mm Cx Lens
f/1.5	#33-637
f/1.8	#33-638
f/2.8	#33-639
f/4.0	#33-640
f/5.6	#33-641
f/8.0	#33-642
f/11	#33-643
f/16	#33-644

Table 1: *Stock numbers for Apertures from f/1.5 to f/16.*

FILTER HOLDER

Cx lenses can accept filters that are 12.5mm in diameter, and either 1.5mm or 2.0mm thick using a Filter Holder.

Filter options can be found here. Some commonly used filters that are compatible with the Cx Lenses are:

Shortpass Filters
Longpass Filters
High Performance OD 4 Shortpass Filters
High Performance OD 4 Longpass Filters
UV-VIS Neutral Density (ND) Filters

Filter Holders are available with a range of apertures from f/1.8 to f/16. The stock numbers for the filter holders can be found to the right in *Table 2*.

f/#	Filter Holders for 16mm Cx Lens
1.8	#33-601
2.8	#33-602
4	#33-603
5.6	#33-604
8	#33-605
11	#33-606
16	#33-607

Table 2: *Stock numbers for Filter Holders from f/1.8 to f/16.*

The flexibility to insert a filter into the center of the lens assembly instead of threading it onto the front has two main advantages:

1. The filter is placed at the location in the lens where the light rays have a smaller area when compared to the front of the lens, as seen in *Figure 2*. This allows a smaller filter to be used, which is more cost-effective.

2. Light rays hit the filter very nearly normal to the surface, which improves the performance of the filter. *Figure 3* below shows an example of the detrimental effects of using a filter at a non-zero angle of incidence.

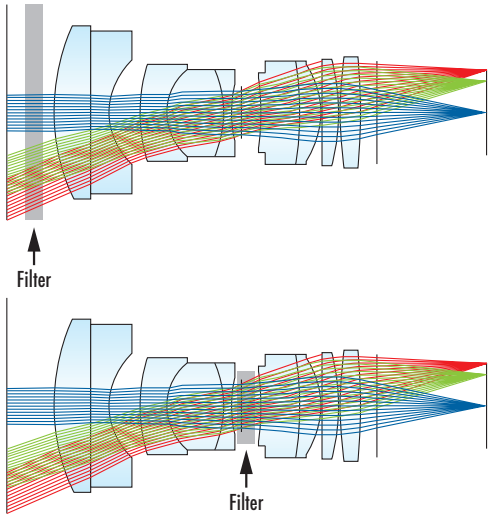

Figure 2: *A filter placed in front of the entire lens assembly, as seen on the top, must be much larger than when placed at the aperture stop, as seen on the bottom.*

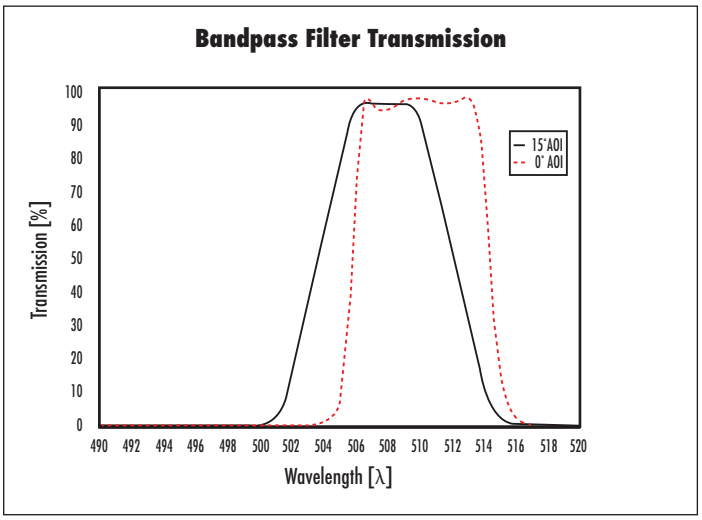

Figure 3: *The graph to the left shows the effect of using a bandpass filter at a 15° angle of incidence compared to an incident angle of 0° (surface normal). The center wavelength shifts toward shorter wavelengths, and the overall transmission profile of the filter is compromised. The optical density of the filter also lowers, broadening the FWHM (Full Width Half Max) .*

LIQUID LENS HOLDER

A variable liquid lens can be used in order to change the focal length of the Cx Lens and switch between different working distances without physically adjusting the focus. The liquid lens consists of two optical liquids encapsulated between two windows. When a voltage is applied to the unit through a wire ribbon, one of the liquids responds to the voltage and forms a curved surface. Adjusting the voltage applied through the ribbon changes the curvature of the liquid, which changes the focal length of the lens. See *Table 3* to determine which liquid lens and liquid lens holder is compatible with your Cx Series Lens. For more information about liquid lenses, visit our website.

Warning: Liquid Lens ribbon is fragile.
Use caution when assembling unit and during handling.

	12mm Cx Lens (#33-562)	16mm Cx Lens (#33-563)	25mm Cx Lens (#33-564)	35mm Cx Lens (#33-565)	50mm Cx Lens (#33-566)
Liquid Lens Model	25H0	25H0	25H0	25H0 / 39N0	39N0
Individual Liquid Lens	#34-282	#34-282	#34-282	#34-282 / #34-283	#34-283
Liquid Lens Kit	#34-284	#34-284	#34-284	#34-284 / #34-285	#34-285
Liquid Lens Holder for Cx Lens	#33-631	#33-645	#33-660	#33-675 / #33-674	#33-686

Table 3: *Stock numbers for compatible liquid lenses and their holders. Note: The 35mm Cx Lens is compatible with both the standard 25H0 and the larger 39N0, which allows for a larger aperture.*

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ASSEMBLY INSTRUCTIONS

Parts Included with Purchase of Cx Lens

A. Front Assembly
B. Main Housing with Locknut (Nylon Tip Screw Installed)
C. Rear Assembly
D. Socket Set Screw M 3.0 x 0.5 x 2 (x3)
E. Rear Lens Cap
F. Front Lens Cap

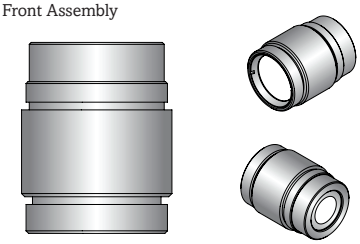
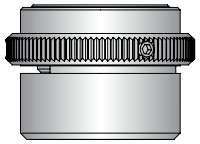
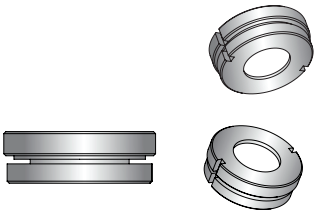
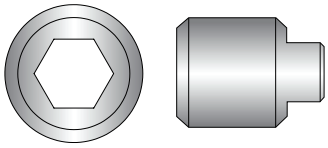
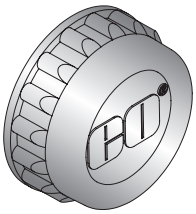
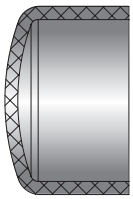
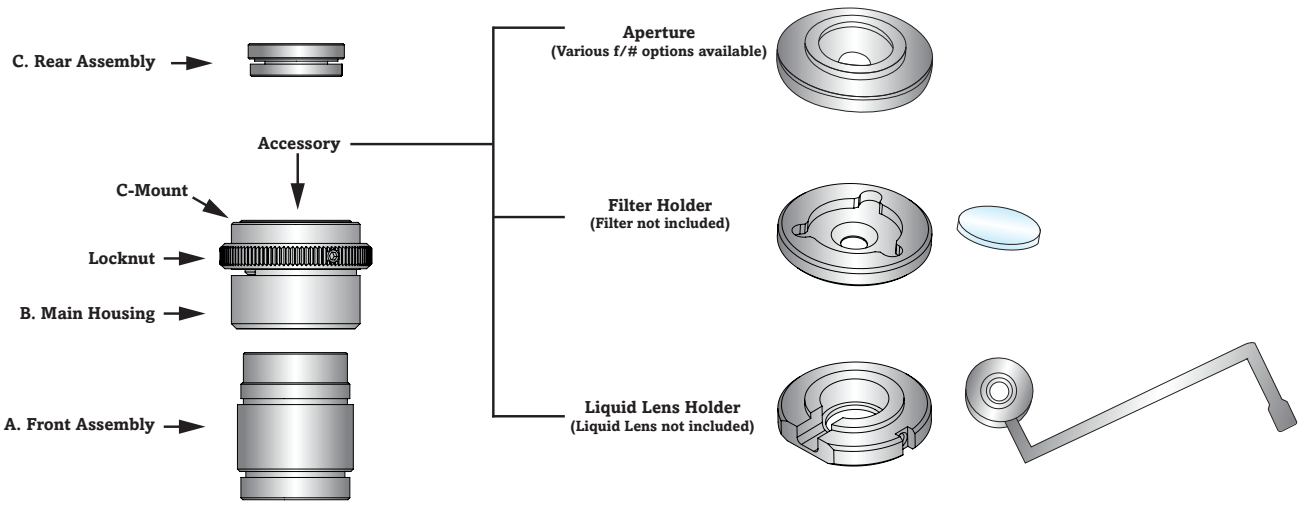
A. Front Assembly 	**B.** Main Housing (Locknut shown installed) 	**C.** Rear Assembly 
D. Socket Screws M 3.0 x 0.5 x 2 (x3) 	**E.** Rear Lens Cap 	**F.** Front Lens Cap 

Diagram of Assembly



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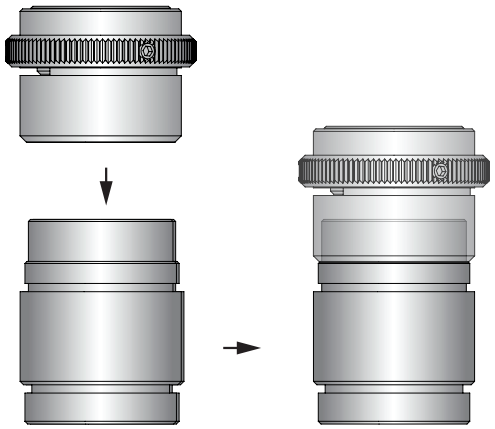
Use caution when assembling unit and during handling.

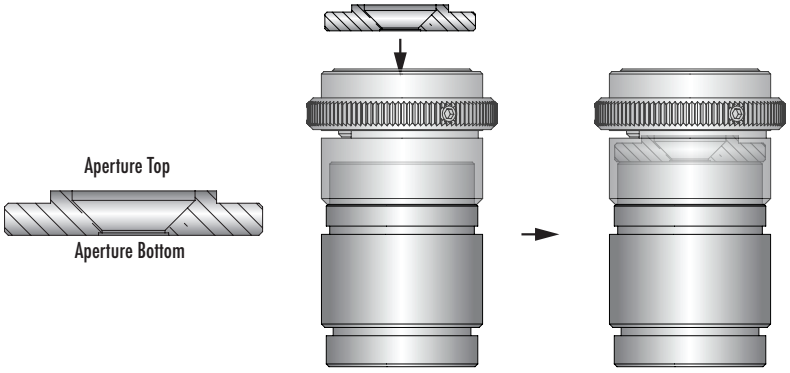
Step by Step Guide

1. Thread top of Front Assembly into bottom of Main Housing until Front Assembly bottoms out on Main Housing.



2. Select one accessory and follow the appropriate step.

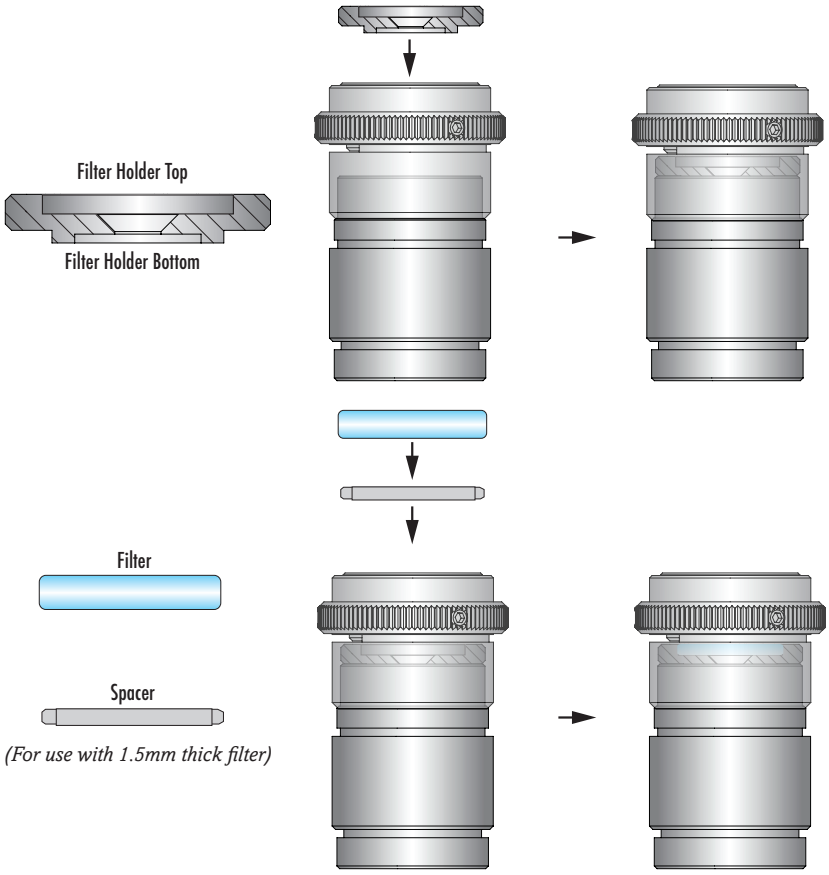
A. Aperture: Place Aperture* into Main Housing from the top, with the top of the Aperture directed toward the top of Main Housing, and the bottom of the Aperture directed toward the bottom of Main Housing.



**Appearance of Aperture for each focal length and f-stop may vary slightly, but the side of the aperture with the larger diameter hole is always the top.*

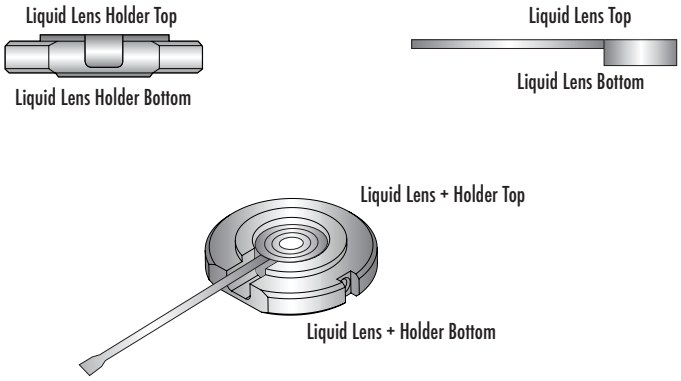
B. Filter Holder: Place the Filter Holder into the Main housing from the top, with the 12.9mm inner diameter bore facing up. Tap the Filter Holder to make sure it is all the way in. If using a 1.5mm thick filter, add the 0.5mm thick spacer into the Filter Holder first and tap it down to make sure it is seated in the bore. If using a 2mm thick filter, the 0.5mm spacer is not needed. Then insert the filter into the bore. If the filter has one side that is more reflective, it is best to put that side down. When putting the filter into the housing, handle it with a vacuum pick up tool or bamboo tweezers. Make sure the filter is seated.

As an alternative, it is possible to glue the filter into the Filter Holder before placing it into the Main Housing using a UV adhesive and a curing lamp or an RTV adhesive.

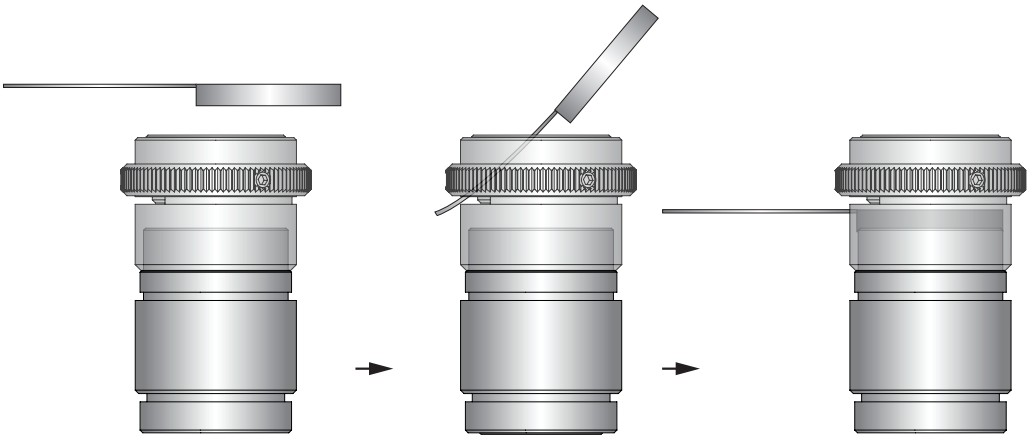


(For use with 1.5mm thick filter)

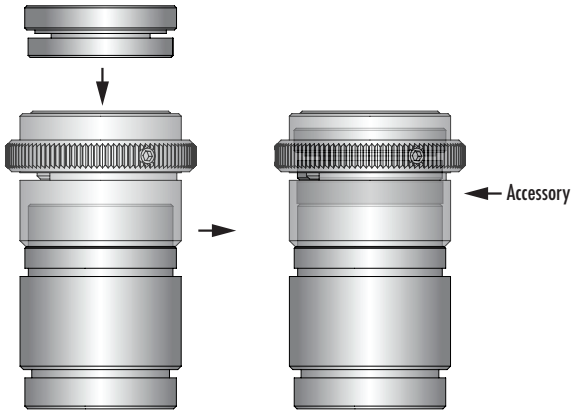
C. Liquid Lens Holder: Place the Liquid Lens into the Liquid Lens Holder with the top of the Liquid Lens aligned with the top of the Holder, with the ribbon exiting on the flat edge of the Holder. Tighten the screw on the side until the Lens is firmly in place. Thread the ribbon through the slot in Main Housing. Carefully insert liquid lens from the top of Main Housing, with the top of the Liquid Lens directed toward the top of Main Housing, and the bottom of the Liquid Lens directed toward the bottom of Main Housing.



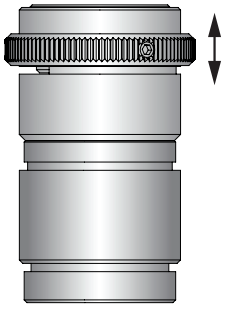
Warning: Liquid Lens ribbon is fragile.
Use caution when assembling unit and during handling.



3. Using a spanner wrench, thread the bottom of Rear Assembly into the top of Main Housing until it is flat against the accessory, hand tightening torque or about 2.5-5kgf*cm. If using a Liquid Lens, hold the Liquid Lens in place while tightening the Rear Assembly into Main Housing by inserting a paperclip into one of the holes to the side of the Liquid Lens Holder. *(Optional: spanner wrench #35-029 can be used)*



4. Adjust Locknut position until desired focus is achieved. See section on Working Distance and Field of View below to find Locknut positions. Tighten Nylon Tip Set Screw into place for a focal position that can later be readjusted–the nylon tip will protect the threads. To set focal position permanently, install the socket head screws. Do not overtighten screws.



5. Thread entire assembly into C-Mount camera from the top of Rear Assembly until the top of the Locknut is flush against the camera C-Mount.

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WORKING DISTANCE AND FIELD OF VIEW

Working distance is set by adjusting the location of the locknut, which will change how far the Cx lens will thread into the C-mount camera. The locknut position is defined in two different ways: A and B. Locknut Position A is defined as the distance from the bottom of the Front Assembly to the top (image side) of the locknut, and Locknut Position B is defined as the distance from the top of the locknut to the top of the Main Housing, as seen in Figure 4. Locknut Position A and Locknut Positon B are two different ways to measure one locknut location. The position of the locknut will correspond to different fields of view based upon which accessory is used with the lens assembly. See below for how to set the locknut for different accessories. Note that the values in the table are merely examples, and not the only options for focusing the lens. For example, the 16mm lens will focus from 100mm to infinity, not just as 300mm.

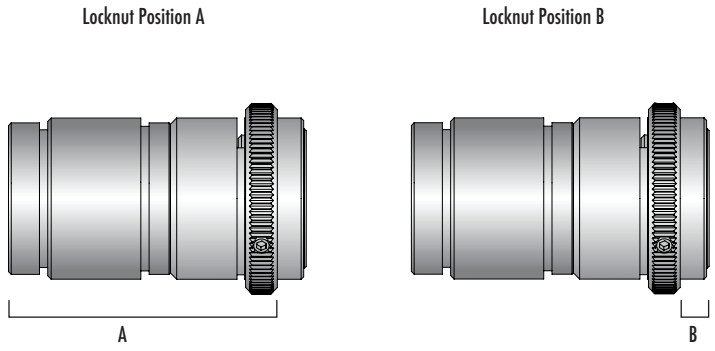

Figure 4: *Locknut Position A illustrated on the left and Locknut Position B illustrated on the right.*

APERTURE

Table 4 shows the nominal working distance for each lens, and the corresponding horizontal fields of view.

Focal Length	Cx Lens Stock Number	Working Distance [mm]	Locknut Position A [mm]	Locknut Position B [mm]	Nominal Working Distance [mm]	Horizontal Full Field of View by Sensor Size [mm]				
						1/3"	1/2.5"	1/2"	1/1.8"	2/3"
12 mm	#33-562	100 - ∞	25.0	4.8	250	104.8	126.1	140.5	158.5	194.7
16 mm	#33-563	100 - ∞	35.5	4.7	300	92.6	111.3	123.7	139.3	170.7
25 mm	#33-564	150 - ∞	21.3	5.1	350	65.7	78.9	87.6	98.6	120.6
35 mm	#33-565	225 - ∞	32.9	5.2	450	59.9	71.9	79.9	89.9	109.9
50 mm	#33-566	300 - 1675	49.4	5.3	600	56.9	68.2	75.8	85.3	104.3

Table 4: *Field of view at nominal working distance.*

FILTER

Table 5 shows the optimal working distance for each lens, and the corresponding horizontal fields of view. The field of view will be slightly different depending on the thickness of the filter that is being used.

Focal Length	Cx Lens Stock Number	Working Distance [mm]	Filter Thickness [mm]	Locknut Position A [mm]	Locknut Position B [mm]	Nominal Working Distance [mm]	Horizontal Full Field of View by Sensor Size [mm]				
							1/3"	1/2.5"	1/2"	1/1.8"	2/3"
12 mm	#33-562	100 - ∞	1.5	25.7	4.1	250	104.3	125.5	139.7	157.6	193.7
			2.0	25.7	4.1		104.7	125.9	140.2	158.2	194.4
16 mm	#33-563	100 - ∞	1.5	36.2	4.0	300	92.5	111.1	123.6	139.2	170.5
			2.0	36.2	4.0		92.6	111.3	123.7	139.4	170.7
25 mm	#33-564	150 - ∞	1.5	22.0	4.4	350	65.4	78.5	87.2	98.2	120.1
			2.0	22.4	4.0		64.9	77.9	86.6	97.5	119.3
35 mm	#33-565	225 - ∞	1.5	33.6	4.5	450	59.7	71.7	79.6	89.6	109.6
			2.0	33.6	4.5		59.9	71.8	79.8	89.8	109.8
50 mm	#33-566	300 - 1675	1.5	49.4	5.3	600	56.9	68.2	75.8	85.3	104.3
			2.0	46.7	8.0		59.2	71.1	79.1	89.0	108.8

Table 5: *Field of view at optimal working distance.*

LIQUID LENS

There is an inverse relationship between the voltage applied to the liquid lens, and the working distance of the lens assembly. Each Cx Lens has a liquid lens voltage that corresponds to a working distance of infinity for the system. Adding additional voltage above this value decreases the working distance. Table 6 showing key information and graphs depicting the working distances and voltages for each Cx Lens can be found to the right. The values in the graphs assume that the Locknut Position is set according to the value in the accompanying table. For more detailed information on how the voltage relates to working distance, see the section on Performance with Liquid Lenses below.

Warning: Liquid Lens ribbon is fragile.
Use caution when assembling unit and during handling.

Focal Length	16
Cx Lens Stock Number	#33-563
Liquid Lens Holder Stock Number	#33-645
Locknut Position A [mm]	35.9
Locknut Position B [mm]	4.3
Voltage for Infinite WD	36
f/# of Assembly When Liquid Lens Contributes Zero Power	f/6

Table 6: *Liquid lens information for 16mm Cx.*

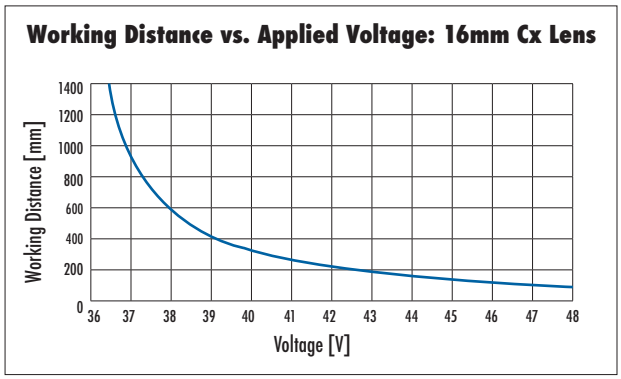

Figure 5: *Working distance as a function of voltage applied to liquid lens for 16mm Cx Lens.*

For additional information on working distances and fields of view, please contact our Technical Support.

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PERFORMANCE WITH LIQUID LENSES

Adding voltage to a liquid lens increases the curvature and power in the lens. Adding voltage always serves to move the focal plane closer to the Cx Lens assembly. When the liquid lens is more curved, it imparts more aberrations into the system. To achieve the highest resolutions, it is therefore best to minimize the curvature needed to bring a range of working distances into focus. Set the locknut position to the location that corresponds to the Cx Lens being in focus at the farthest working distance that will be needed with the liquid lens at zero optical power (voltage set to "Voltage for Infinite Working Distance"). Now that this maximum focal positon is set, the liquid lens can be used to bring the focal position in closer towards the lens. In addition to improving performance, this also increases the sensitivity to which the working distance can be adjusted with the voltage. As an example of the performance difference that occurs based on the locknut position, consider *Figure 6* to the right.

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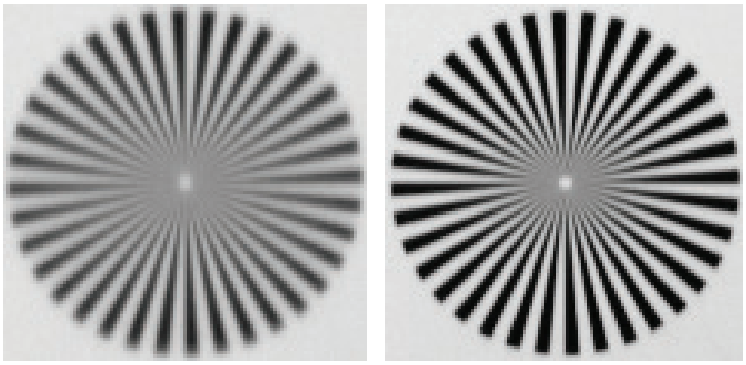

Figure 6: *The image on the left was taken with the locknut position set to have a working distance of infinity, and a liquid lens was used to bring the working distance to 200mm. The image on the right was taken of the same object at the same working distance, but the locknut position was set to have a working distance of 300mm, so the liquid lens was only required to move the working distance by 100mm. The second scenario on the right required less applied voltage to the liquid lens, and therefore resulted in better resolution.*

For specific information on performance, please contact our Technical Support.

FAQ'S

Q: What are typical applications for Cx Lenses?

A: *There is a wide range of applications in which Cx Lenses can be integrated due to their flexible nature. They are especially well suited to scenarios in which expensive filters must be used, and machine vision systems that must quickly image varying working distances.*

Q: Are the Cx Lenses limited to just the three accessories listed, or is it possible to have custom accessories made?

A: *It is certainly possible to make custom accessories for the Cx Lenses. They are meant to be a platform to allow for prototyping and easy integration, so as long as there is room, there is no limitation to what can be done.*

Q: Can I use more than one accessory with a Cx Lens?

A: *Due to the limited spacing between the Front Assembly and the Rear Assembly, it is not possible to put more than one standard accessory inside the Cx Lens. However, if you wish to use a filter with a liquid lens, it is possible to use the threading on the front of the lens to add an external filter.*

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Q: Can I use a Cx Lens without an accessory?

A: *While it is certainly possible to use a Cx Lens without an additional accessory, it would be better to consider our C Series Lenses or our Ci Series Lenses.*

Q: Are lens prescriptions available?

A: *Please contact us if you are interested in Zemax lens prescriptions.*