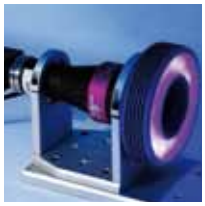
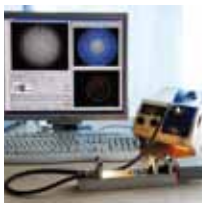
OPTO ENGINEERING
THE TELECENTRIC COMPANY

OE BI-TELECENTRIC TECHNOLOGY








Opto Engineering® has set new standards in bi-telecentric technology by continuously striving to enhance the optical performances, the quality control and the ease of use of telecentric lenses: design, test, production methods and equipment are constantly being improved by our engineering team.
For this reason, our lenses optical performances like telecentricity, resolution and distortion are typically much better than any other lens on the market while prices remain surprisingly affordable.
How we do this? Smart engineering, cost driven design and elegant solutions!

Each telecentric lens we deliver undergoes a series of careful quality control tests and is supplied with a detailed Test Report proving it is compliant to our exact specifications: at Opto Engineering® you get what we state, guaranteed.
For special applications, we are also able to perform extremely accurate optical tests by means of our proprietary design optical benches and high-end instrumentation.

Moreover, Opto Engineering® can easily, quickly and cost effectively provide custom made telecentric optics: developing and delivering telecentric lenses is our passion!

Here is why Opto Engineering® is "The Telecentric Company®"

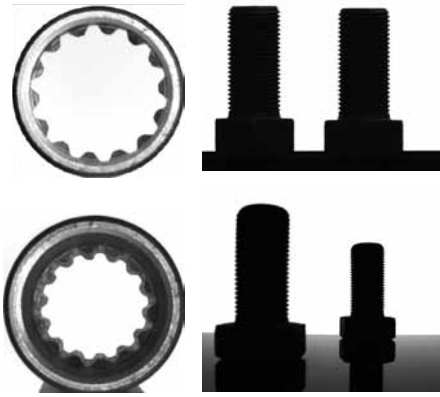
1. The Highest Optical performances available on the market
   - extra-telecentricity for thick object imaging
   - very low distortion for accurate measurements
   - excellent resolution for small pixel cameras
   - wide field depth for large object displacements

2. Advanced and Unique Features
   - bi-telecentric by design
   - pre-adjusted back focal length and working distance
   - compact and robust, tailored for industrial environments
   - easy filter insertion
   - UV patent pending version for extremel accuracy
   - TCEDGE patented technology for optical edge extraction

3. Total Quality Control
   - specific testing instrumentation for bi-telecentric optics
   - each lens comes with its own detailed Test Report
   - test images of every lens are archived for production tracking
   - no complaints on the optical quality of our telecentric lenses to date!

High Telecentricity: no perspective error

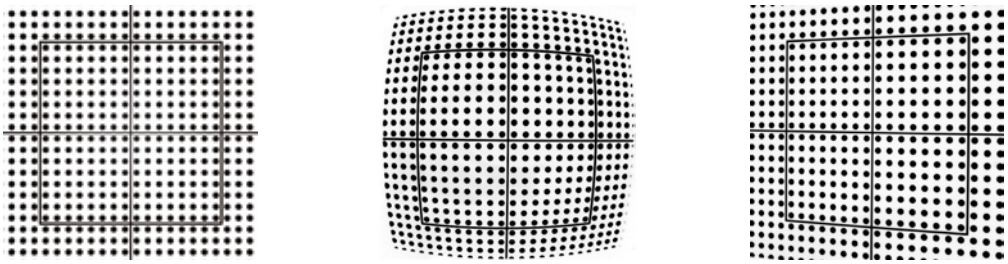
In metrology applications an orthonormal view (with no side imaging) of the object is frequently needed so as to perform accurate linear measurements.
Furthermore, many mechanical parts cannot be precisely positioned or measurements must be performed at different depths; nevertheless software engineers need a perfect correlation between imaged and real dimensions.
This can be accomplished by means of telecentric lenses: since the entrance pupil is placed at infinity, only ray cones whose "principal ray" is parallel to the mechanical axis are accepted.
Furthermore, Opto Engineering® bi-telecentric lenses are engineered according to the following optical design features:
- the principal ray is chosen as the ray striking the camera detector in the center of radiometric distribution
- the principal ray is also the axis of the acceptance cone, ensuring a symmetric grey level distribution at the edges
- OE bi-telecentric design makes our lenses truly telecentric as they also feature image-side telecentricity.



On the left: an image of an internal spline on a cylindrical object taken with a telecentric lens (top) and the same object viewed by an ordinary lens (bottom).
On the right: an image of two identical machine screws 100 mm apart, taken with a telecentric lens (top) and an ordinary lens (bottom).

Nearly zero distortion

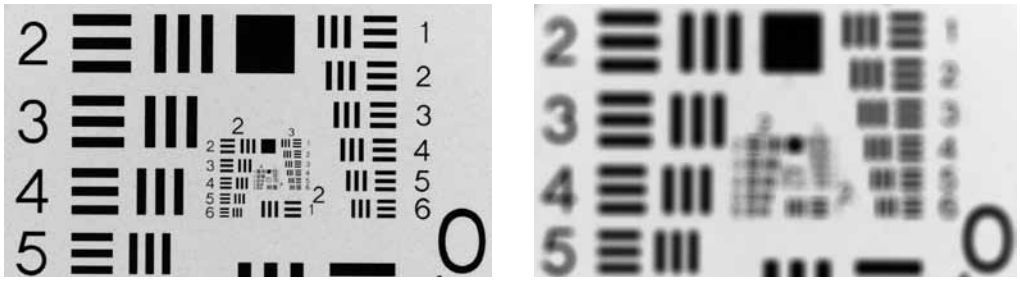
Distortion is computed as the percentage difference between the actual object dimensions and the object dimensions as imaged onto the camera detector. Common machine vision lenses often exhibit more than 1-2% distortion. This could severely limit accuracy in a dimensional measurement application (e.g. with such lenses an object whose real width is 50 mm would appear to be 51 mm wide on the image plane).
Opto Engineering® lenses exhibit a less than 0.1% radial distortion (e.g. a 50 mm wide object won't appear to be any larger than 50.05 mm in the image plane, 20 times less distortion) which is nearly state-of-the-art technology and a measurement limit for most advanced optical test instruments.
Trapezoidal distortion (also known as "keystone" or "thin prism" effect) is another important parameter to be minimized in a lens as it is asymmetric and very difficult to calibrate by software.
OE lenses are manufactured and certified to keep this error well under 0.1%.



On the left an image of a distortion pattern taken with a telecentric lens, where no radial or trapezoidal distortion is present.
In the middle the image of a lens showing strong radial distortion.
On the right an example of trapezoidal distortion.

High resolution

Image resolution is decribed by CTF (contrast transfer function) which quantifies the contrast ratio at a given spatial frequency on the camera detector plane, expressed in lp/mm (line pairs per millimeter).
Quite often, machine vision integrators tend to combine cameras with tons of small pixels with cheap, poor resolution lenses, resulting in blurred images; the resolution provided by our lenses is compatible with even the smallest pixel sizes and the highest resolution cameras like 5.5 Mpix 2/3" detector cameras.



High and low contrast images of a standard USAF test pattern achieved with different CTF grade optics.

Bi-telecentricity: real telecentricity and wide field depth

Image side telecentricity is beneficial in maintaining a very good image contrast even when looking at very thick objects.
Besides enhancing the natural field depth as per the lens aperture and magnification factor, OE lenses bi-telecentricity makes these optics true telecentric: no magnification change occurs when the object is moved from its nominal working distance as the ray slope in image space remains unchanged. The standard aperture of our telecentric lenses is specifically selected to ensure the largest possible field depth without effecting resolution due to the diffraction limit. Our lenses can also be supplied with different apertures to accommodate specific applications; however, you should always consider that larger apertures will reduce field depth while smaller apertures will reduce resolution, also requiring brighter illumination.

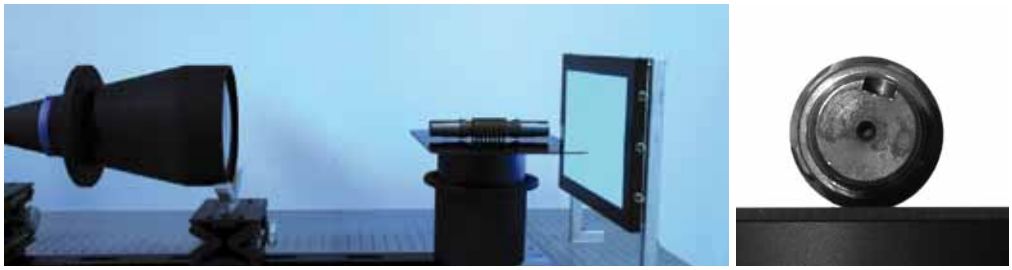
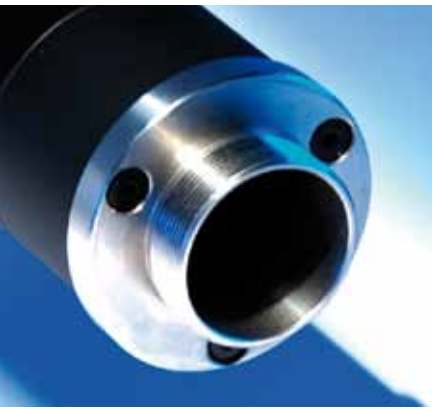


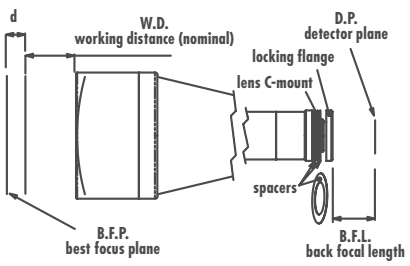
Image of a long object viewed along its field depth. The depth of field of OE telecentric lenses can hardly be achieved by other telecentric lenses.

Opto Engineering® lenses bi-telecentricity also yields even illumination of the detector, which proves useful in several applications such as LCD, textile, and printing quality control. Moreover, when integrating dichroic filters, bi-telecentricity assures that the ray fan axis strikes the filter normal to its surface thus preserving the optical band-pass throughout the entire image plane.



Fitting industrial applications

A simple and robust design is essential to ensure precise opto-mechanical alignment and high level optical performances.
All our large size lenses are hermetically sealed in order to prevent dust and humidity intrusion. A focusing mechanism is avoided on purpose to prevent the lens from disassembling or disadjusting due to vibrations or operator disregard; moreover this feature, which would be used just once in product lifetime, would only make the lens less accurate and more expensive.
For the same reasons, an iris mechanism has been intentionally avoided as it would compromise the accuracy of stop positioning: lens distortion and telecentricity would be much worse and difficult to define, as the aperture shape would be polygonal, not round!
When designing optics and mechanics, we always keep in mind that we are producing precision lenses for industrial applications, not laboratory or photographic equipment and we like to know that our customers will be using our lenses in the same exact conditions as we have tested them.



Back focal adjustment

Each Opto Engineering® telecentric lens has its back-focal length precisely adjusted in accordance to the C-mount standard (17.52 mm) but, since several industrial cameras don't exactly fulfill this specification, re-tuning of the back-focal length may be required.
For this reason our lenses are delivered with a "spacer kit" and the necessary instructions to tune the back-focal length, ensuring the lens is operating at the nominal working distance.
Although a lens may work properly even at different working distances than the nominal, this adjustment ensures that the highest resolution and lowest distortion are achieved.

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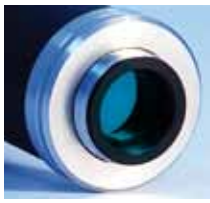
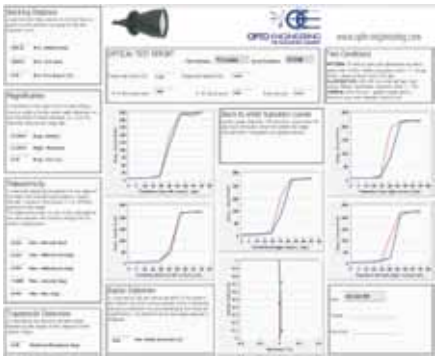
Easy filter insertion



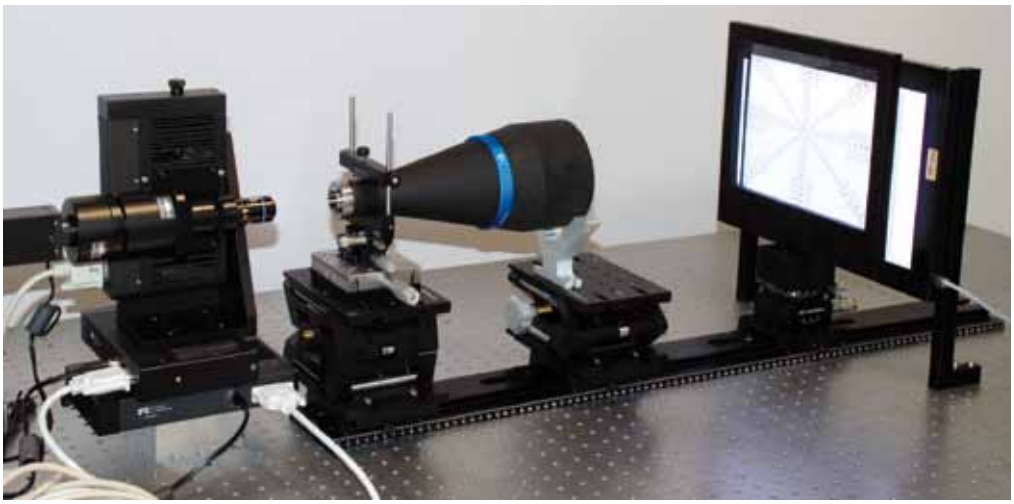
The main issue with integrating filters into large telecentric lenses is concerned with the size of the front optical element which requires a front-mount filter to be very large and consequently very expensive. To overcome that, Opto Engineering® thought up a very simple and cost-effective solution for C-mount telecentric lenses: by means of an adapter a much smaller filter can be integrated in the rear part of the optics.

High end quality control

We guarantee that 100% of the lenses we deliver meet or exceed our written specifications thanks to our state-of-the-art quality testing system.
Each lens is checked by an experienced operator who measures all the main optical parameters, combining strict laboratory procedures with the old craftsmanship still needed for precision optical testing.
Each lens is accompanied by its own optical test report; we also store several test images acquired with each lens we supply to be able to track down any kind of problem that may occur.
Opto Engineering® has developed reliable test procedures for our quality assurance and high end instrumentation specifically designed for bi-telecentric lens testing.
Besides our own standard QC instrumentation, we designed and developed a special optical test bench, integrating top-notch components and providing leading-edge optical parameter measurement and analysis. By means of this system we are able to undertake special projects, where highly demanding optics are needed and a scientific measurement of optical parameters must be performed.



Our standard test report accompanies every lens we deliver. Distortion (radial and trapezoidal), telecentricity, magnification and resolution are all carefully checked.



Our special optical test bench enables us to measure CTF (contrast transfer function) up to 500 lp/mm and distortion with an accuracy of 0.01%.
Field curvature, lens alignment, back focal and focal length are measured with accuracies of 0.05%.

UV optics for extra-high resolution

OE TC UV SERIES Telecentric Lenses are specifically designed to ensure the highest image resolution today available in the machine vision world. Common lenses and traditional telecentric lenses are useless with very small pixel sensors which are becoming increasingly popular among industrial cameras.
TC UV telecentric Lenses, by operating in the 365/425 nm range, provide much higher image contrast at high spatial frequencies and are therefore compatible with the tiniest pixel sizes. When used in combination with standard cameras, the resolution of these lenses is so high that they can tolerate much larger object displacements than VIS lenses before any image defocusing becomes evident.