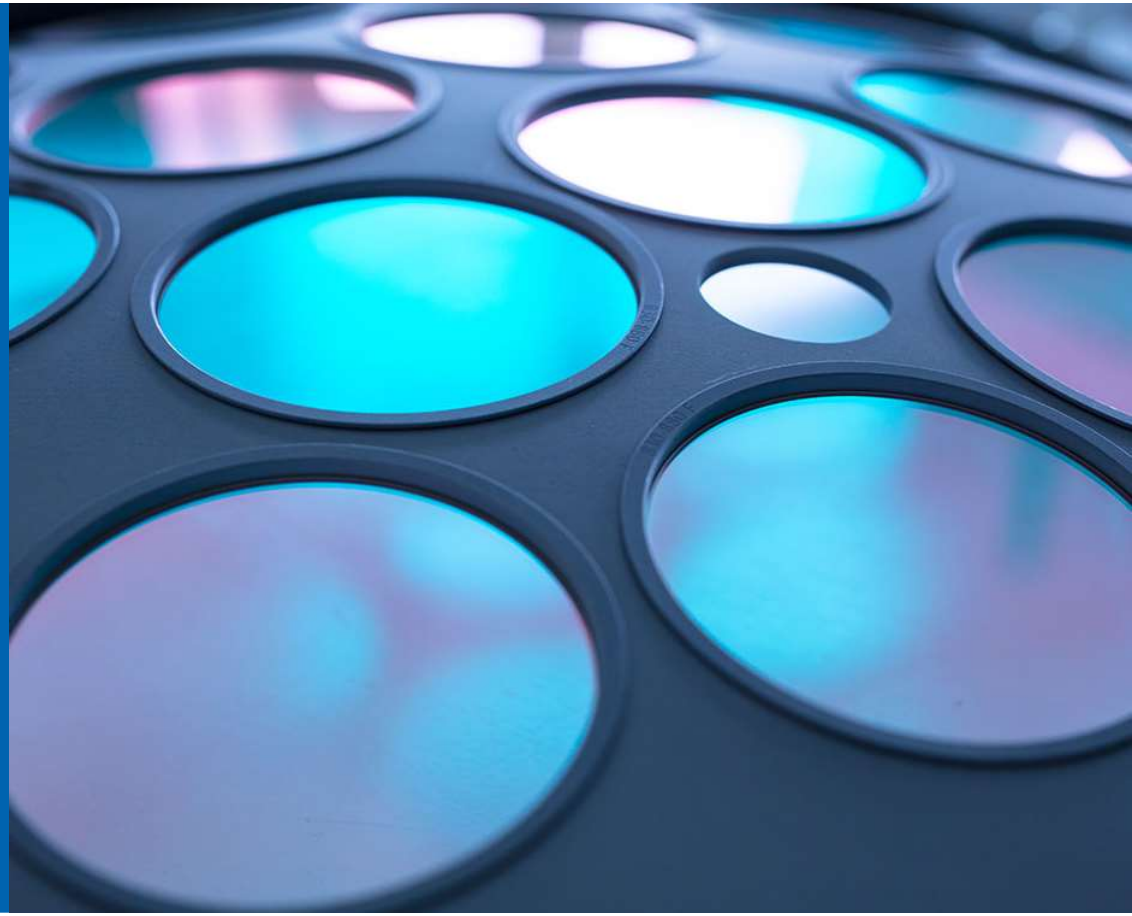
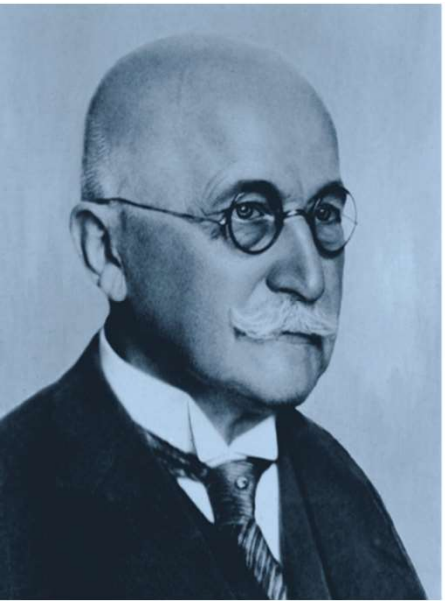
# Liquid Lenses - chance and challenge

Schneider-Kreuznach, S. Mahler, March 2023



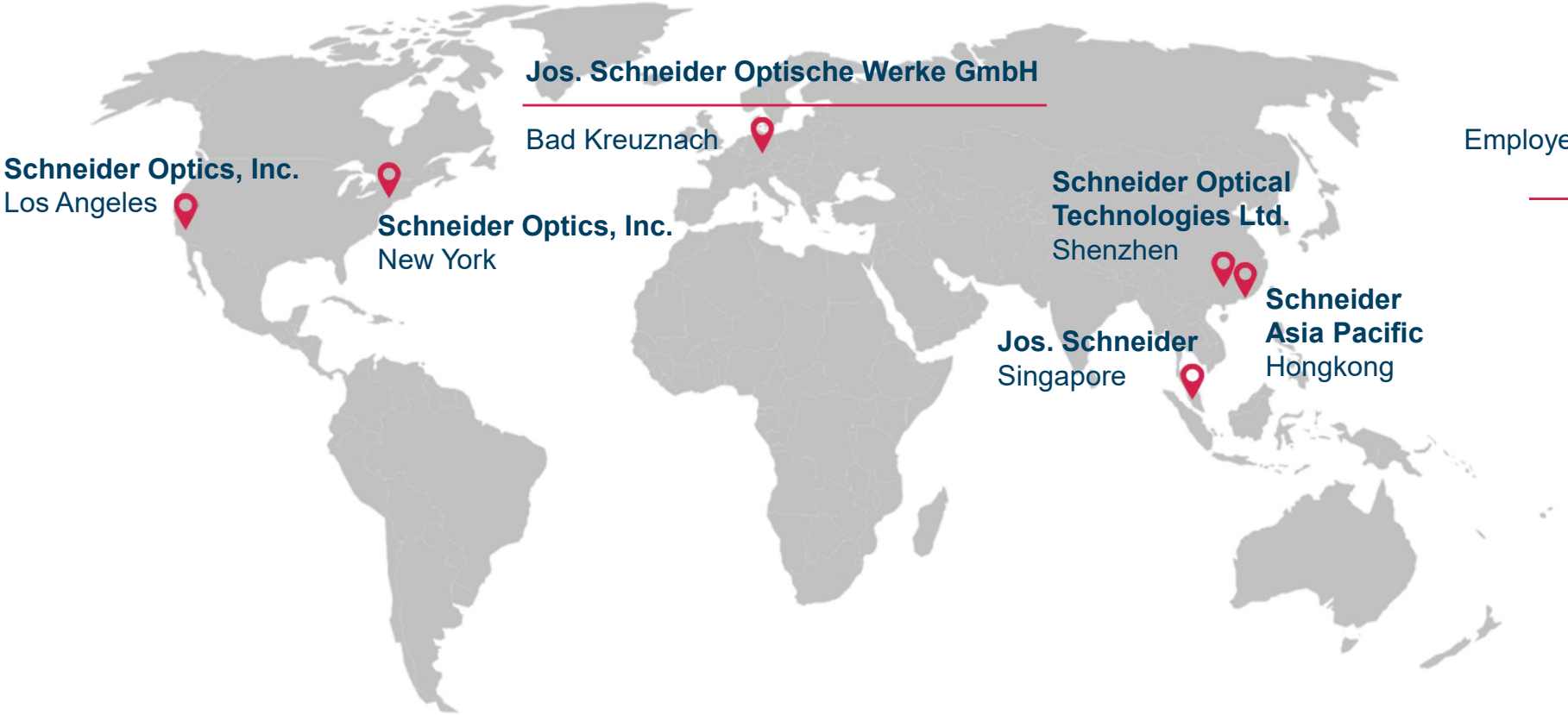
# A few words about Schneider Kreuznach





Founded in 1913 by Joseph Schneider

# Company structure




**330**
Employees worldwide

# Strategic business segments

## Industry

Lenses
Filters
Cutomized solutions

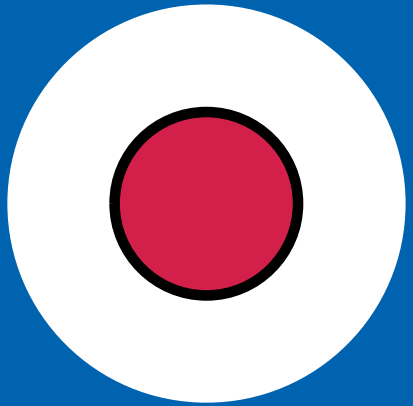
## Photo/Cine

Lenses
Filters
Accessories

## Optical systems

Future
Business division

# Business Unit Industry



## Lenses

## Filters

## Customized solutions

# LIQUID LENSES

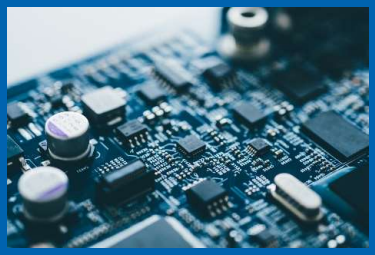
# Challenge of typical industrial applications

Package sorting

Bin picking

Robot vision

Bottle inspection



Electronics inspection

**Commonality**

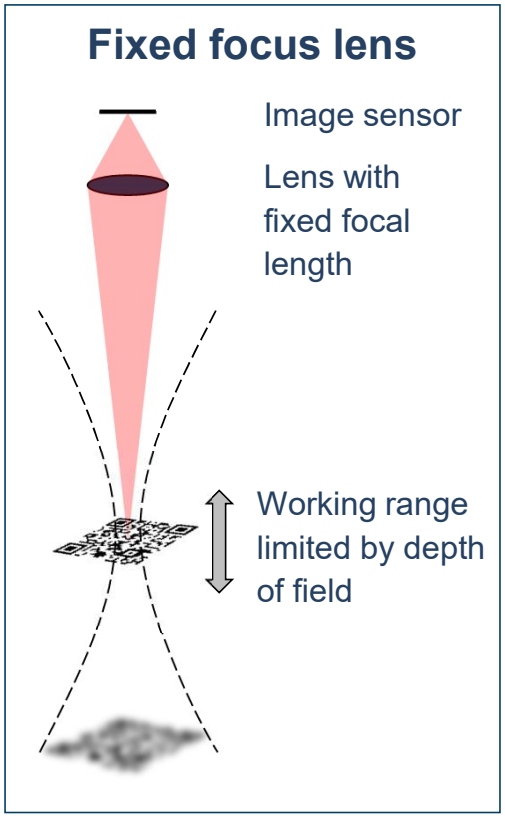
The working distance from object to lens is changing very quickly and frequently.

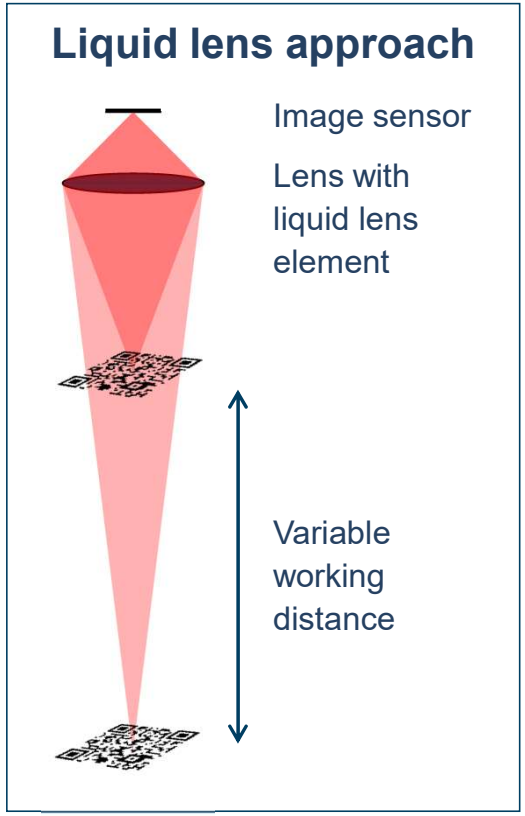
A lens with a fixed focus setting is not able to keep the object in focus all the time.

# The solution – liquid lenses

Combining a conventional imaging lens with an electrically tunable lens, also known as liquid lens, allows the easy adjustment of the working distance in an industrial environment.

- Extremely fast (response time few milliseconds)
- Long lifetime > 1 billion cycles
- High repeatability



# Optotune or Varioptic®

There are 2 major manufacturers of liquid lenses:

- Optotune (Switzerland)
- Corning® Varioptic® (USA)

**The final decision was taken for Optotune**

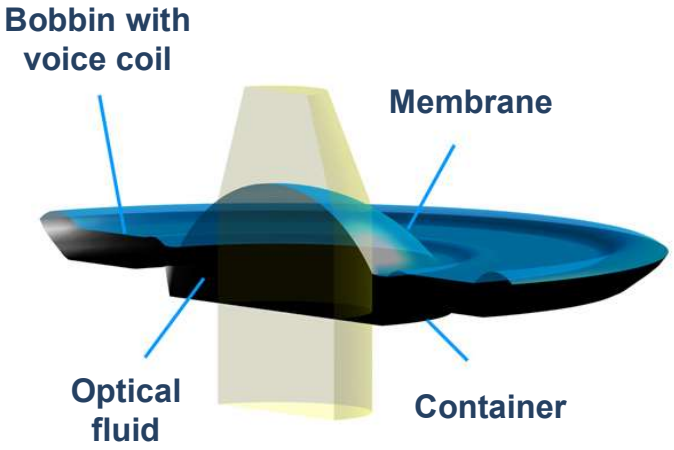
The larger clear aperture of up to 16 mm diameter for the electric driven lenses offers the highest flexibility in combination with our machine vision lenses.

**Optotune EL-16-40-TC**

# Optotune working principle

## Key components

Voice coil actuator, membrane, fluid and container



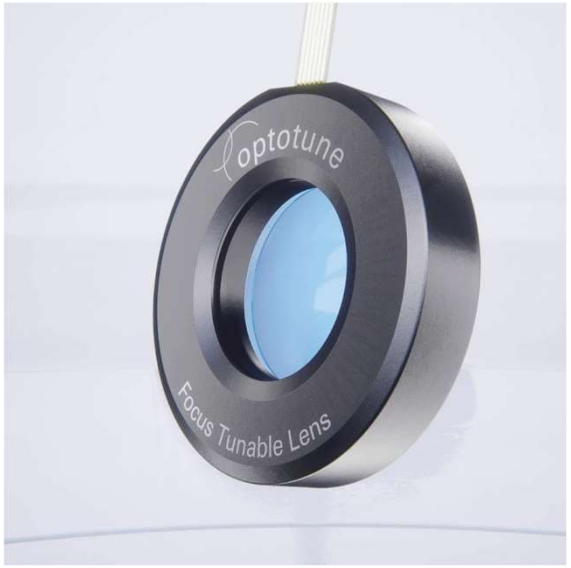

optotune

See also: https://www.optotune.com/tunable-lenses

# Optotune working principle

## In action

How current influences the membrane shape



# Lens design goals

Most of the existing lenses with liquid lens element are limited to 1.1“ sensor size. The following design goals were defined:

- For 1.3” sensors and larger
- Integrated design
- Large working distance range
- Performance similar to prime lens

# The lens solution - PYRITE LF

Combining two well-known lenses from the PYRITE lens series with the OPTOTUNE EL-16-40-TC led to the following lenses:

- PYRITE 4.0/60 C-LF (image circle 24mm)
- PYRITE 4.0/60 TFL-LF  (image circle 32mm)
- PYRITE 4.0/80 C-LF (image circle 24mm)
- PYRITE 4.0/80 TFL-LF (image circle 36mm)
- Optional extension tubes for closer working distance

**PYRITE 4.0/60 C-LF**

**PYRITE 4.0/80 TFL-LF**

# PYRITE LF optimization

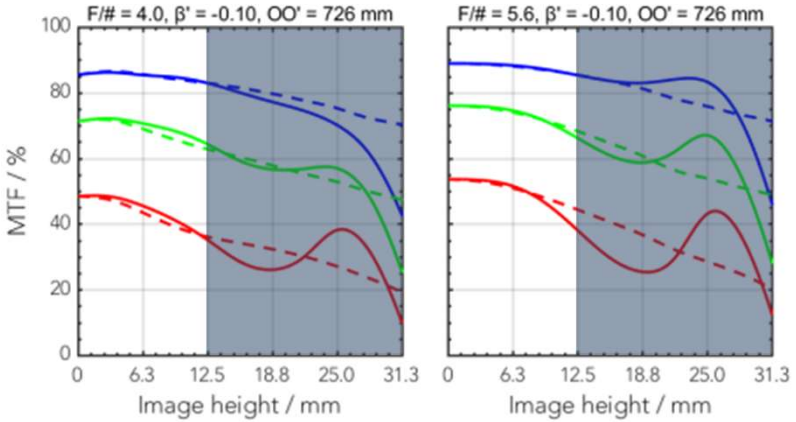
It is not just a simlpe combination of prime lens and liquid lens:

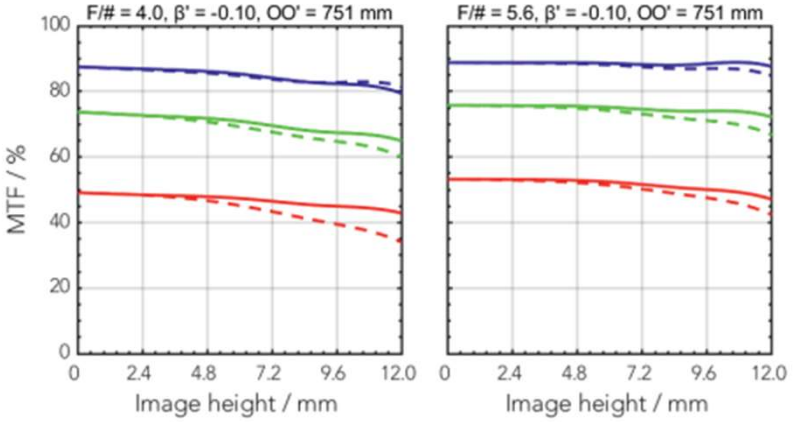
- Optimized position of liquid lens between prime lens and sensor
- Tuned prime lens
- Extension tubes for extended WD range
- Two mounts (C-/TFL-) for increased flexibility and larger image circle up to 36mm

PYRITE 4.0/60 C-LF

PYRITE 4.0/80 TFL-LF

# Theoretical performance



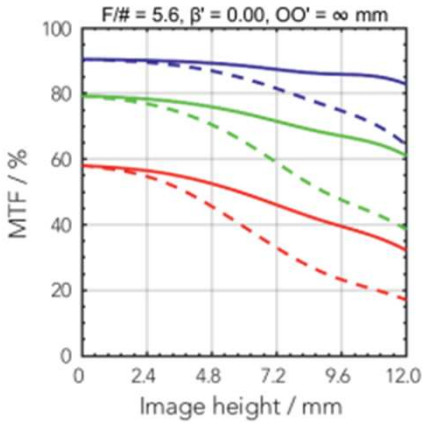

## PYRITE 4.0/60 V38 (w/o liquid lens)

- Image circle diameter 62.5 mm
- Only 24 mm relevant for comparison

## PYRITE 4.0/60 C-LF (with liquid lens)

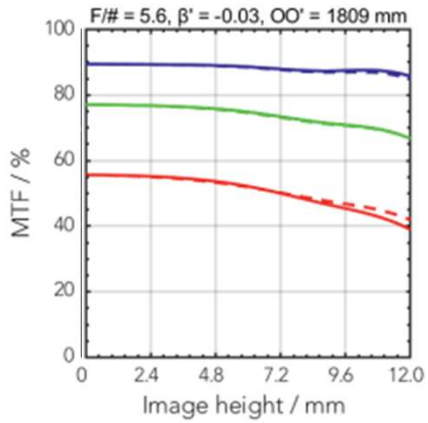
- Image circle diameter 24 mm
- Liquid lens at medium setting
- No loss in performance

# Theoretical performance



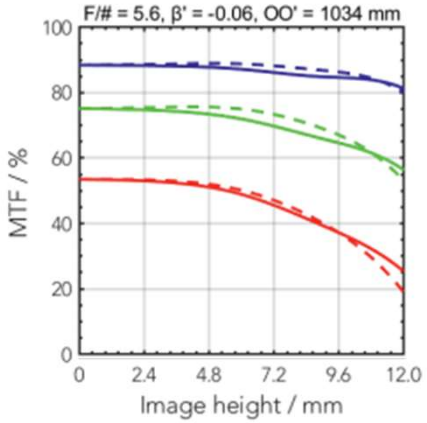

## PYRITE 4.0/60 C-LF

- Performance at infinity
- Negative current applied




## PYRITE 4.0/60 C-LF

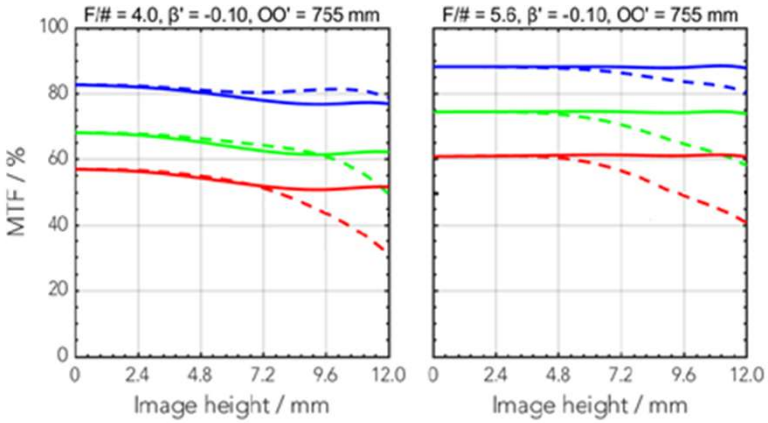
- Performance at 1.8 m
- No current applied

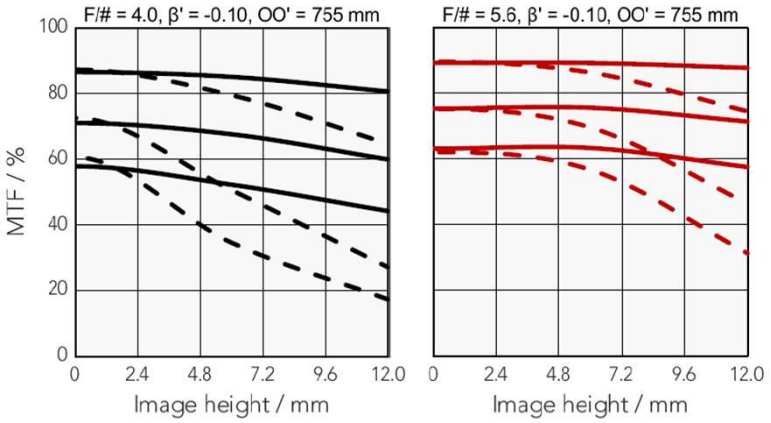



## PYRITE 4.0/60 C-LF

- Performance at 1 m
- Positive current applied

# Theoretical vs. practical performance




## PYRITE 4.0/60 C-LF

- Theoretical performance
- 20/40/60 lp/mm

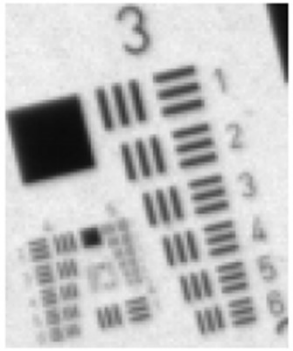
## PYRITE 4.0/60 C-LF

- Measured performance, vertical orientation
- 20/40/60 lp/mm
- Reasonable performance drop

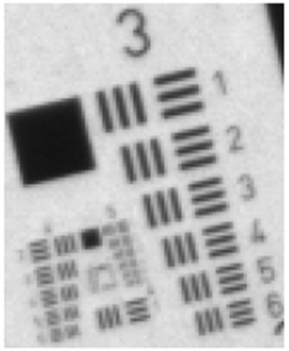
# Vertical vs. horizontal performance

# Vertical vs. horizontal performance

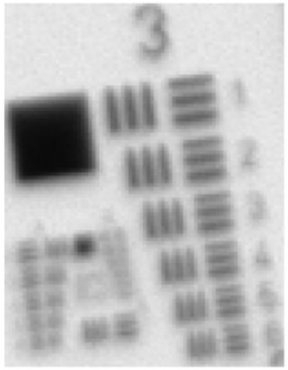
# Vertical vs. horizontal performance



Center



Edge



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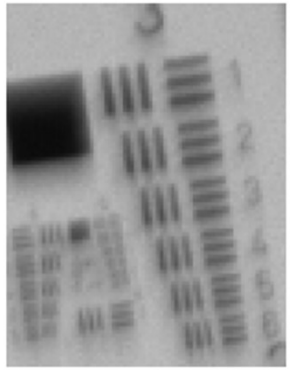


Edge

**PYRITE 4.0/60 C-LF**

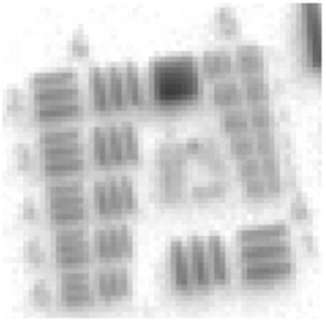
- Vertical orientation
- F4, WD 480 mm

Full test report: https://www.optotune.com/elm-f-serie.com

**PYRITE 4.0/60 C-LF**

- Horizontal orientation
- F4, WD 480 mm
- Significant loss in performance

# Horizontal – stopping down



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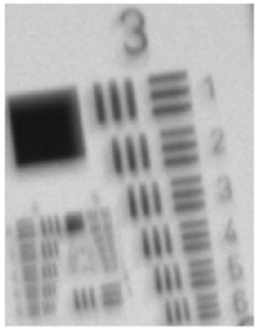
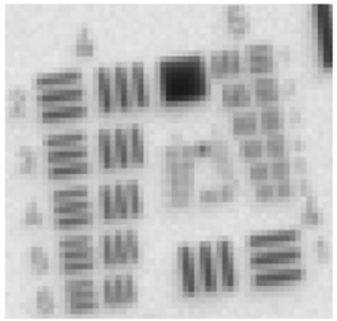


Edge



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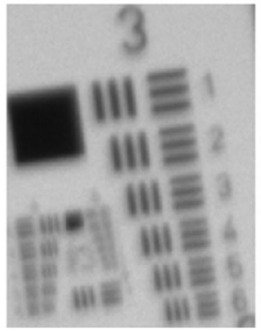


Edge

**PYRITE 4.0/60 C-LF**

- Horizontal orientation
- F4, WD 320 mm

Full test report: https://www.optotune.com/elm-f-serie.com

**PYRITE 4.0/60 C-LF**

- Horizontal orientation
- F5.6, WD 320 mm
- Significant improvement by stopping down

# Ease of Installation

## Required components

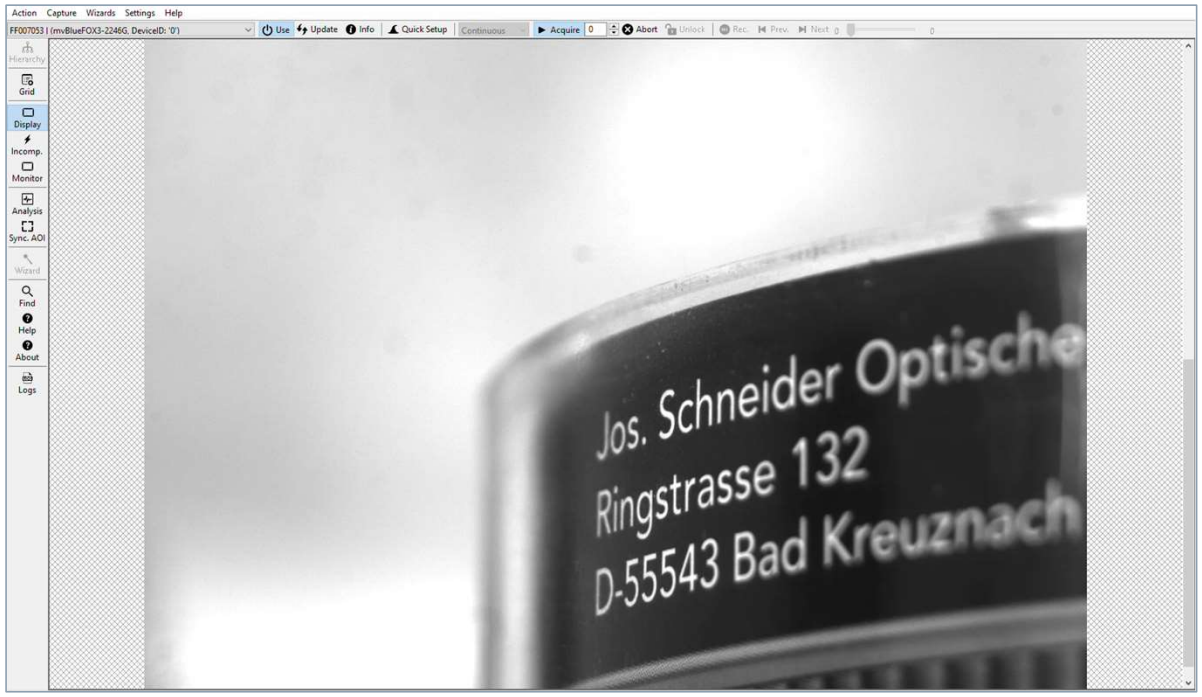
- Lens with liquid lens element
- Camera with cable and software
- Optotune lens driver, cable and software
- Computer
- 2 Objects

Setup time incl. installation <15min

# Liquid lens in action

## Setup

- Lens PYRITE 4.0/80 C-LF
- Horizontal orientation
- WD for close object: 20 cm
- WD for far object: 3 m
- Stopped down to F8
- Low speed setting



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