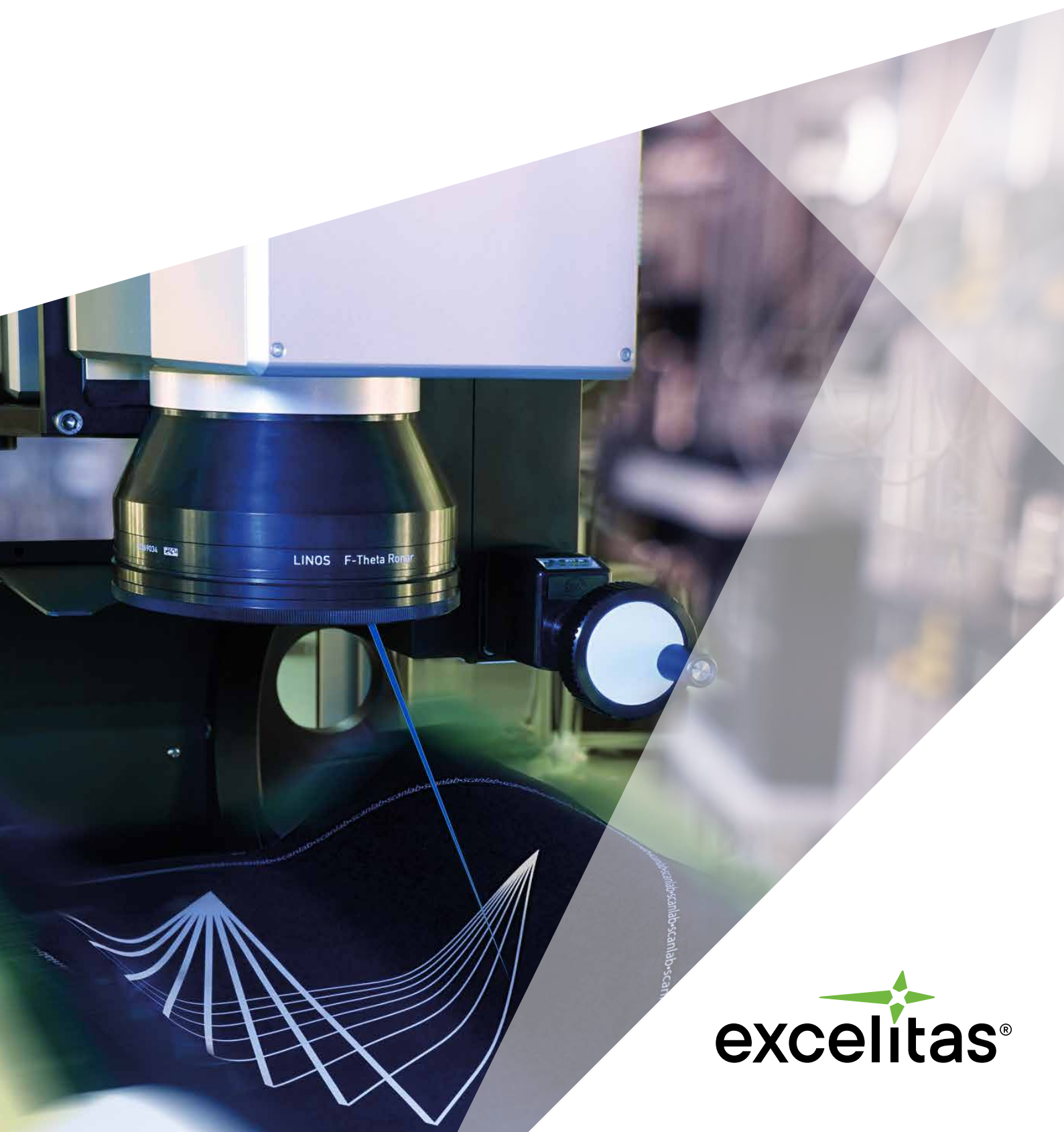
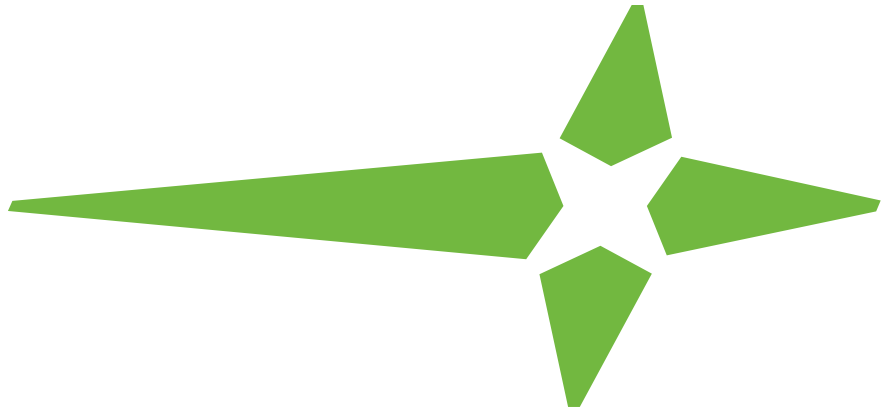


LINOS®

Laser Material Processing




excelitas®



About Excelitas

Excelitas is a leading provider of advanced, life-enriching technologies that make a difference, serving global market leaders in the life sciences, advanced industrial, next-generation semiconductor and avionics end markets. Headquartered in Pittsburgh, PA, USA, Excelitas is an essential partner in the design, development and manufacture of advanced technologies, offering leading-edge innovation in sensing, detection, imaging, optics and specialty illumination for customers worldwide.

Excelitas is at the forefront of addressing many of the relevant megatrends impacting the world today, including precision medicine, industrial automation, artificial intelligence, and connected devices (IoT).



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Technical Explanations

THERMAL FOCUS SHIFT

Thermal focus shift of beam guidance components is a topic especially for lasers of high beam quality and high power. When a light beam passes through an optical system, it loses a part of its energy. There is a local heating effect and thus a local deformation of the lens causing a change in the refractive index of the lens material. This results in a change in the propagation of the wave front of the laser beam in the medium and at the entrance and exit surfaces of the individual optical components. This phenomenon is referred to as a thermal lens and leads to a shift in the focus position, the so-called thermal focus shift, and deterioration of the beam quality.

It is a matter of design, material selection and production process how well a lens can withstand environmental fluctuations and energy input by laser radiation. The most important strategy for reducing the thermal focus shift is to use materials that inherently absorb less energy. Excelitas achieves this through using particularly selected high-quality fused-silica materials and a low absorption coating of the lenses. In compliance with the specified maximum absorption of the coating is monitored in batches using a specially developed absorption measuring device.

LOW ABSORPTION

Low absorption is an essential property of our fused silica lenses and is achieved by a combination of various measures. It starts with the choice of high grade materials, continues with the optimized coating and follow up with optimized production and assembly processes under clean room conditions.

LOW OUTGASSING

For upcoming UV applications with high laser powers or very short laser pulses, even higher requirements are needed. This is where cleanliness is most important. Even the smallest particles serve as a condensation core for the optics to self-destruction over the course of the operating time. This can only be prevented if the optical systems are manufactured in a special workflow. This includes avoidance of auxiliary materials, selection of materials such as a special stainless steel and high grade materials, optimized coatings and assembly processes under clean room conditions through to ultra-low outgassing packaging.

COATING

Coatings are applied on each lens surface to maximize the transmission of the complete optical system like LINOS F-Theta-Ronar lenses or LINOS Beam Expanders. The additional challenge for coatings in laser material applications lies in a high damage resistance and minimized absorption.

The fused-silica optics in the wavelength range between 400 nm and 1080 nm are coated as standard with Excelitas' newly developed "low absorption" coating, which has a specified absorption of ≤ 20 ppm at 1064 nm (typically better than 10 ppm) and ≤ 30 ppm at 532 nm (typically better than 15 ppm). The absorption is measured in batches with our own specially developed measuring device in series. Fused-silica lenses with this coating can be recognized by the product number ending -26. Furthermore, the lenses of the motorized LINOS Beam Expanders for the wavelength ranges 515-540 nm and 1030-1080 nm are coated with the "low absorption" coating.

An excellent uniform transmission over the entire scan field is achieved with our special Excelitas inhouse developed angle-optimized coatings.

The respective damage threshold of the applied coating can be found in the datasheet of the corresponding lens.

All our coatings are analyzed for laser damage threshold values. The tests are conducted according to the standardized test method DIN EN ISO 11254- 2, a multi-pulse procedure (S-on-1) with given pulse lengths.



Overview of LINOS F-Theta-Ronar Lenses

APPLICATIONS FOR LINOS BEAM GUIDANCE COMPONENTS

The wide range of different laser sources and types opens up a broad market for focusing systems. Only with the provision of process-oriented focusing systems are the extremely diverse possible applications of the laser tool fully usable. LINOS F-Theta-Ronar lenses, LINOS Focus-Ronar lenses and LINOS Beam Expanders for laser material processing guarantee the best machining results over the entire working range. They contribute significantly to the optimization of process safety, especially in demanding tasks. The fields of application are extremely versatile:

- Additive manufacturing processes with metallic and organic substances (e.g. selective laser melting)
- Welding of metals and non-ferrous metals (e.g. battery cell manufacturing)
- Drilling and fineblanking of metals and ceramics (e.g. printed circuit board micro drillings)
- Plastic welding for the local melting of surfaces allows connections of plastics without additional materials
- Structuring/perforating of metallic and non-metallic materials (e.g. solar cells, display glass)
- Labelling (e.g. smart cards, ICs, printing plates, keyboards, controls with day & night design)
- Cleaning by means of laser pulses ensures a material-sparing treatment of industrial products (e.g. wafers) as well as restoration projects (e.g. monuments)
- (Consumer) electronics manufacturing
- Display manufacturing
- PCB production



HOW THE LINOS F-THETA-RONAR LENSES WORK

A collimated laser beam is deflected, for example by galvanometer mirrors, at an angle θ with respect to the optical axis. The LINOS F-Theta-Ronar lens focuses the ray bundles in its focal plane. By rotating the mirrors and thus changing the object angle θ , the focal point moves over the working plane.

CHARACTERISTICS OF F-THETA LENSES

F-Theta lenses have two main characteristics. When a beam is deflected by a scanning mirror in front of a F-Theta lens, then the scanned distance is proportional to the scanning angle. Secondly the focus position over the entire scan field is always in the same plane.



HIGH QUALITY

Excelitas has developed a range of sophisticated F-Theta-Ronar scan lenses made of specially selected fused-silica for high-power and short-pulse laser material processing. Fused-silica lenses provide minimized thermal focus shift and higher resistance when working at high power density. A specially developed coating achieves very low reflection and absorption values.

BASIC CALCULATIONS OF F-THETA-RONAR LENSES

All LINOS F-Theta-Ronar lenses achieve diffraction limited performance. The truncated entrance beam diameter and the image spot diameter refer to the intensity $1/e^2$ at Gaussian illumination and for ideal $M^2=1$. The spot size of LINOS F-Theta-Ronar lenses can be calculated with the following formula:

$$\text{Spot-}\varnothing = 1.83 * \lambda * \text{FL} / \text{beam-}\varnothing$$

Spot- $\varnothing$: image spot diameter [μm]
 1.83: factor of apodisation
 λ : wavelength [nm]
 FL: focal length [mm]
 Beam- $\varnothing$: entrance-beam diameter [mm]

The scan length in each direction x or y can be calculated by the formula:

$$2y = \text{FL} * 2\Theta_y * \pi/180 \quad \text{and} \quad 2x = \text{FL} * 2\Theta_x * \pi/180$$

$2x, 2y$: scan length in direction x, y [mm]
 FL: focal length [mm]
 $2\Theta_{x,y}$: max. scan angle Theta for each mirror [$^\circ$]
 $\pi/180$: conversion factor (into radians)

The mirror distances $m1$ and $m2$ are recommended values and may vary. A smaller entrance beam diameter allows larger scan angles and therefore larger scan fields are achievable.

APERTURE

The aperture stop position of the system is characterized in that the chief ray of the incident beam bundle intersects the optical axis. When using only one scanning element, this is located at the aperture stop position.

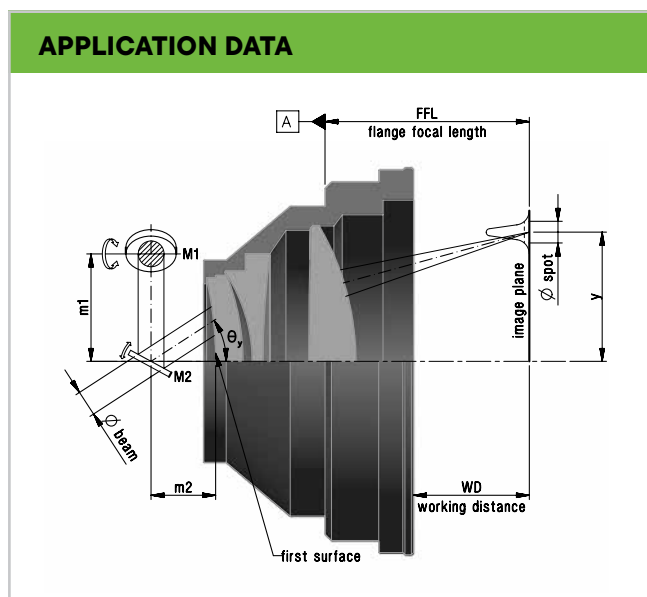
It is desirable to position the scanning element as close as possible to the first lens element of the objective lens. Thus, the impact height of the beam on the first and all subsequent lenses and thus the lens diameters are minimized. The lens becomes more compact.

For systems with more than one scanning element (e.g. scan heads) the aperture stop position is different for the different scan angles. Since all lens aberrations, with the exception of the spherical aberration, depend on the aperture stop position, they vary depending on the mirror deflection. For this reason, the number of scanning elements, the distance to each other ($m1$), and to the lens ($m2$) must be known when the lens is being designed.

MIRROR DISTANCES

The design of the scan heads has a fundamental influence on the field size and the performance of the respective lens. Depending on the aperture and model, the distance between the two mirrors and thus the aperture stop position varies. In addition, the scan heads have different maximum deflection angles. These are usually limited by the scan head manufacturers to avoid overexposure of the mirror or a collision of both mirrors in excessive distraction. The distance between the mirrors is called $m1$.

The distance $m2$ is the distance between the vertex of the first lens surface and the center of the second scan head mirror.



Product range of LINOS F-Theta-Ronar lenses

OPTICAL-GLASS LENSES

For all major applications a wide variety of lenses exist with various focal lengths ranging from 100 mm to 420 mm and for different wavelengths from 532 nm to 1064 nm.

FUSED-SILICA LENSES

Excelitas has developed a range of sophisticated LINOS F-Theta-Ronar scan lenses made of fused-silica for high-power and short-pulse laser material processing. Fused-silica lenses provide minimized thermal focus shift and higher resistance when working at high power density. These lenses are usable for wavelength ranges of 340–360 nm, 440–460 nm, 515–540 nm, 1030–1080 nm or 1900–2000 nm. A specially developed coating achieves very low reflection and qualified absorption values. The optical designs minimize damage due to back reflections onto the scanning mirrors and internal reflections. The LINOS fused-silica F-Theta-Ronar lenses are suitable for fiber- and disk lasers.

TELECENTRIC LENSES

With telecentric lenses the beam impact angle on the work target is nearly perpendicular over the entire scan field.

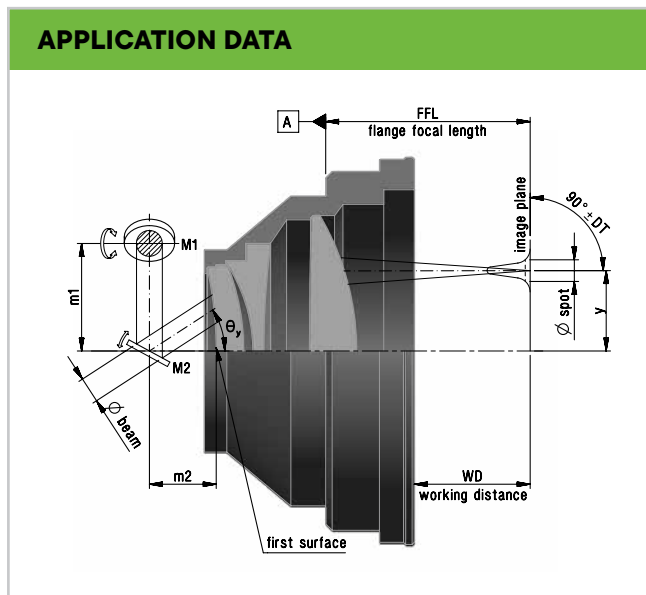
The maximum scan field of telecentric lenses cannot exceed the lens diameter. On the other hand the spot roundness and the impact angle is constant over the scan field.

This ensures that the point of impact of the beam bundle remains constant even with defocusing. Telecentricity is gaining great importance, for example, in drilling systems in the printed circuit board industry, some of which drill through millimeter thick circuit boards. In such extreme cases refocusing of the beam by beam widening is inevitable.

Excelitas offers telecentric F-Theta-Ronar lenses made of fused-silica and of optical-glass/fused-silica combination.

CUSTOMIZED SOLUTIONS

In addition to our existing LINOS F-Theta-Ronar lenses Excelitas offers customized solutions from adapted wavelength shift of standard lenses up to complete new designs. Please contact Excelitas to discuss your requests with our specialists.



Overview of LINOS Beam Expanders

LINOS Beam Expanders are optical systems for beam forming used in laser material processing. They can vary the diameter and the divergence of a laser beam and allow optimization of focus diameter, focus position and beam propagation.

The focal positions of LINOS F-Theta-Ronar or LINOS Focus-Ronar lenses can be changed by the divergence of the laser input beam. A fine focusing of the beam widening makes it possible to compensate for divergence tolerances of laser sources as well as focal length tolerances of other optical components. It should be noted, however, that the imaging performance of the lens may change.

Excelitas offers standard versions of manual and motorized variable LINOS Beam Expanders made of fused-silica and/or optical-glass.

LINOS Beam Expanders are optimally be applied in conjunction with LINOS F-Theta-Ronar lenses and LINOS Focus-Ronar lenses for applications including:



- Laser structuring of foils
- Laser scribing of ceramic substrates
- Cutting of solar cells
- Micro drilling of sheet metal
- Marking of diverse materials with encodings
- (Consumer) electronics manufacturing
- Display manufacturing
- PCB production

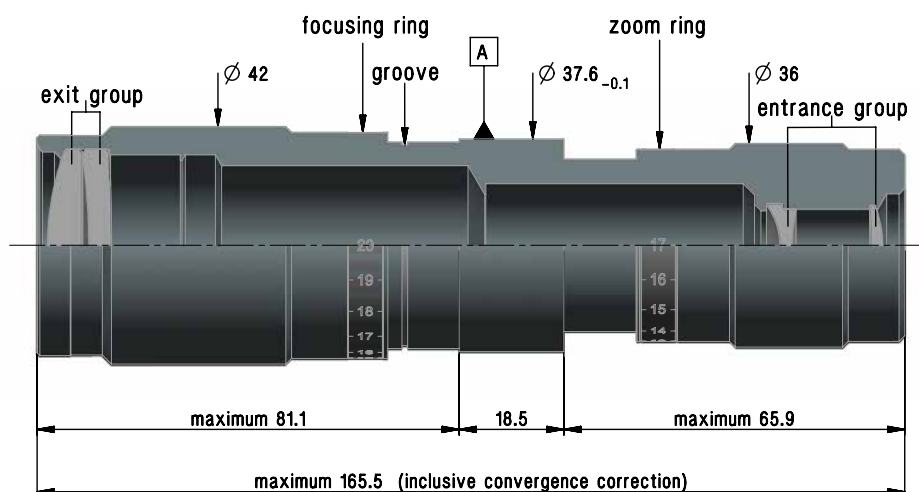
ENTRANCE APERTURE DEPENDING ON THE MAGNIFICATION FACTOR

The maximum entrance aperture has to be considered. This depends on the magnification factor and decreases with increasing magnification factor. The permissible optical entrance aperture can be found in the datasheet of your respective Beam Expander.



All LINOS Beam Expanders can also be implemented in reverse mode as Beam Reducers.

TECHNICAL DRAWING



MANUAL VERSION

Continuous magnification between 1x ... 4x (low out-gassing Beam Expander for 340–360 nm) and 2x ... 8x (Beam Expander for 355 nm, 532 nm, 633–980 nm, 1064 nm) are available. In addition Excelitas offers manual variable LINOS Beam Expanders 2x ... 8x with fused-silica entrance lenses for higher laser power.

The back focal length of LINOS F-Theta-Ronar or LINOS Focus-Ronar lenses can be modified by changing the divergence of the incoming laser beam. Fine focusing of the Beam Expander compensates the focal length tolerances of other optical components as well as divergence of the laser source.

HANDLING

Zoom and focusing rings of the manual variable LINOS Beam Expanders are set according to product specific graphs. The expansion factor is adjusted by turning the focusing ring and zoom ring. To focus the beam expansion, only the focusing ring should be adjusted.

The Beam Expander is mounted on surface A (previous page). Please take care that the laser beam is centered on the entrance lens and parallel to the optical axis of the Beam Expander (x; y; tilt adjustment).

MAXIMUM TILTING OF BEAM EXPANDERS

The LINOS Beam Expander can be operated with a max. entrance angle of up to 0.2° without vignetting. This allows a certain amount of leeway to compensate for mechanical tolerances in your system.

The tilting of the exiting laser beam is amplified by the inverse magnification factor with respect to the input beam. As a result, the laser beam does not pass through the lenses in the center of the lens, in particular on the exit side, so that the wavefront error becomes greater due to the asymmetry.

MAXIMUM DISPLACEMENT OF THE ENTRANCE BEAM

In case of lateral (x; y) displacement, the outer, non-central part of the laser beam is truncated. The wavefront is therefore no longer rotationally symmetric along the axis. In addition, a larger proportion of the input beam is vignettted, which results in a reduction of the transmitted energy. How much the wavefront deforms and the laser beam is vignettted depends on both the exact profile and the selected magnification.

MOTORIZED VERSION

The motorized variable LINOS Beam Expanders are highly precise and easy to integrate. They are used in automatic production processes or in application laboratories. The controller is integrated into the Beam Expander.

For high-power or short-pulse laser applications full fused-silica designs are available with excellent transmission and thermal resistance performance. The special coating with low absorption and high transmission covers complete wavelength ranges of 340–360 nm, 515–540 nm or 1030–1080 nm. The customer can select between two electrical interfaces (SubD9/RS232 or Phoenix Contact/RS232).

MOTORIZED BEAM EXPANDER FOR 355 NM, 1X ... 4X



MOTORIZED BEAM EXPANDER 2X ... 8X



SOFTWARE

The Windows™-based software developed with LabView allows an easy control of the motorized LINOS Beam Expander. After initialization, the desired expansion is achieved by moving the two independent stepper motors. The lens positions for the magnification range of 1x ... 4x or 2x ... 8x are listed for each motorized Beam Expander type in provided tables. Ten individual presets can be stored.

The LINOS Beam Expander can also be directly controlled under other operating systems via the serial interface (e.g. terminal program). All serial interface commands are listed in the manual.

Further information including 3D CAD data, product-specific graphs of variable Beam Expanders and the manual for motorized Beam Expanders are available on request.



Windows™ software mask for easy control of motorized Beam Expanders.



LINOS F-Theta-Ronar Lenses 340-360 nm



LINOS F-Theta-Ronar telecentric lens for 340-360 nm



All lenses can be used with enlarged beam diameters and various mirror distances. Scan fields and spot size diameters will change accordingly. Please contact us to discuss your specific requirements.

YOUR BENEFITS

- Fused-silica designs
- Telecentric versions available
- Angle-optimized coatings
- Includes interchangeable fused-silica protective glasses
- Dust-tight on the output side inclusive protective glass according to the criteria of IP6X

SPECIFICATIONS

- Focal lengths ranging from 70 mm to 255 mm, tolerance $\pm 1\%$
- Transmission $\geq 96\%$ with good performance in VIS-range
- Laser damage threshold coating up to 4 J/cm^2 at 355 nm, 6 ns, 100 Hz and upto 0.4 J/cm^2 at 343 nm, 200 fs, 1 kHz
- Screw thread M85x1

LINOS F-THETA-RONAR 340-360 NM, FUSED-SILICA

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{x,y}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
70 telecentric	28 x 28	± 11.3	10	5	13/19	92.5	PG4	4401-576-000-21
100 telecentric	46 x 46	± 12.7	10	7	13/29	136.7	PG11	4401-509-000-21
160	98 x 98	± 17.7	7	15	9/16	197.4	PG4	4401-399-000-21
167 telecentric	65 x 65	± 11.3	10	13	13/48	255.0	PG15	4401-511-000-21
255	170 x 170	± 19.3	10	17	13/30	318.1	PG11	4401-481-000-21
330	212 x 212	± 18.6	14	15	17/25	418.1	PG33	4401-617-000-28 ¹⁾
330	212 x 212	± 18.6	14	15	17/25	418.1	PG34	4401-617-000-29 ²⁾

¹⁾ Low outgassing version

²⁾ Reduced outgassing version

LINOS F-Theta-Ronar Lens 440-460 nm



LINOS F-Theta-Ronar for 440-460 nm



All lenses can be used with enlarged beam diameters and various mirror distances. Scan fields and spot size diameters will change accordingly. Please contact us to discuss your specific requirements.

YOUR BENEFITS

- Fused-silica designs
- High end broadband, low absorption coating 440-460 nm
- Includes interchangeable fused-silica protective glasses
- Dust-tight on the output side inclusive protective glass according to the criteria of IP6X

SPECIFICATIONS

- Focal lengths 262 mm, tolerance $\pm 1\%$, further focal lengths coming soon
- Transmission $\geq 96\%$
- Screw thread M85x1 and M110x1

LINOS F-THETA-RONAR 440-460 NM, FUSED-SILICA

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{xy}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
262	61 x 61	± 6.7	30	8	37/35	342.6	PG30	4401-611-000-26



LINOS F-Theta-Ronar Lenses 515-540/532 nm



LINOS F-Theta-Ronar telecentric lens for 515-540 nm



All lenses can be used with enlarged beam diameters and various mirror distances. Scan fields and spot size diameters will change accordingly. Please contact us to discuss your specific requirements.

YOUR BENEFITS

- Fused-silica and optical-glass designs
- Telecentric versions available
- Transmission $\geq 96\%$ with good performance in the VIS-range
- Low absorption coating for fused-silica lenses ≤ 30 ppm at 532 nm
- Includes interchangeable protective glasses
- Dust-tight on the output side inclusive protective glass according to the criteria of IP6X

SPECIFICATIONS

- Focal lengths ranging from 75 mm to 420 mm, tolerance $\pm 1\%$
- Laser damage threshold coating for fused-silica lenses up to 20 J/cm^2 at 532 nm, 8 ns, 100 Hz and up to 0.6 J/cm^2 at 515 nm, 204 fs, 50 kHz
- Laser damage threshold coating for optical-glass lenses up to 10 J/cm^2 at 532 nm, 6 ns, 100 Hz
- Screw thread M85x1 except 4401-605-000-26: M85x1/M110x1

LINOS F-THETA-RONAR 515-540 NM, FUSED-SILICA, LOW ABSORPTION

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{x,y}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
75 telecentric	24 x 24	± 9.5	14	5	17/24	85.8	PG28	4401-599-000-26
100 telecentric	43 x 43	± 12.2	14	9	17/28	138.5	PG13	4401-547-000-26
114 telecentric	65 x 65	± 17.0	10	11	13/28	144.5	PG13	4401-608-000-26
160	83 x 83	± 15.2	14	12	17/23	215.8	PG13	4401-587-000-26
167 telecentric	86 x 86	± 15.4	14	12	17/33	215.5	PG21	4401-517-000-26
250 telecentric	69 x 69	± 8.0	14	17	17/40	374.6	PG21	4401-616-000-26
255	183 x 183	± 20.9	10	25	13/25	318.1	PG13	4401-496-000-26
265	133 x 133	± 14.7	20	13	25/32	346.9	PG21	4401-605-000-26
420	251 x 251	± 17.1	14	29	17/24	498.6	PG13	4401-590-000-26

LINOS F-THETA-RONAR 532 NM, OPTICAL-GLASS

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{x,y}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
100 telecentric	53 x 53	± 15.7	14	7	17/36	126.6	PG7	4401-461-000-21
160	98 x 98	± 17.7	10	16	16/12	176.1	PG8	4401-305-000-21
250	154 x 154	± 17.7	20	12	22/24	288.5	PG7	4401-289-000-20

LINOS F-Theta-Ronar Lenses 940-980 nm



LINOS F-Theta-Ronar lens for 940-980 nm



All lenses can be used with enlarged beam diameters and various mirror distances. Scan fields and spot size diameters will change accordingly. Please contact us to discuss your specific requirements.

YOUR BENEFITS

- Includes interchangeable protective glasses

SPECIFICATIONS

- Transmission $\geq 97\%$
- Transmission $\geq 75\%$ at VIS-range
- Focal lengths ranging from 162 mm to 420 mm, tolerance $\pm 1\%$
- Screw thread M85x1, except 4401-527-000-21: M76x1

LINOS F-THETA-RONAR 940-980 NM, OPTICAL-GLASS

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{x,y}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
162	84 x 84	± 14.8	14	20	17/33	183.7	PG18	4401-527-000-21
254	120 x 120	± 13.6	20	23	26/28	294.2	PG17	4401-526-000-21
330	202 x 202	± 17.6	20	30	26/28	386.0	PG17	4401-524-000-21
420	253 x 253	± 17.3	20	37	26/28	491.7	PG17	4401-525-000-21



LINOS F-Theta-Ronar Lenses

1030-1080 nm / 1064 nm



LINOS F-Theta-Ronar lens for 1030-1080 nm



All lenses can be used with enlarged beam diameters and various mirror distances. Scan fields and spot size diameters will change accordingly. Please contact us to discuss your specific requirements.

YOUR BENEFITS

- Fused-silica and optical-glass designs
- Telecentric versions available
- Transmission $\geq 96\%$ with good performance in the VIS-range
- Low absorption coating for fused-silica lenses ≤ 20 ppm at 1064 nm
- Includes interchangeable protective glasses
- Dust-tight on the output side inclusive protective glass according to the criteria of IP6X

SPECIFICATIONS

- Focal lengths ranging from 70 mm to 420 mm, tolerance $\pm 1\%$
- Laser damage threshold coating for fused-silica lenses up to 40 J/cm^2 at 1064 nm, 12 ns, 100 Hz and up to 0.9 J/cm^2 at 1030 nm, 291 fs, 5 kHz
- Laser damage threshold coating for optical-glass lenses up to 10 J/cm^2 at 1064 nm, 9 ns, 100 Hz
- Screw thread M85x1, except 4401-261-000-21: M76x1 and 4401-604-000-26: M85x1/M110x1

LINOS F-THETA-RONAR 1030-1080 NM, FUSED-SILICA, LOW ABSORPTION

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{x,y}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
70 telecentric	26 x 26	± 10.9	14	10	17/17	87.5	PG22	4401-551-000-26
100 telecentric	44 x 44	± 12.2	14	15	17/28	137.0	PG14	4401-561-000-26
118 telecentric	50 x 50	± 15.5	14	17	17/28	233.9	PG14	4401-607-000-26
163	85 x 85	± 15.2	14	23	17/23	219.3	PG14	4401-589-000-26
167 telecentric	84 x 84	± 14.9	20	16	26/28	215.4	PG16	4401-513-000-26
251 telecentric	63 x 63	± 14.4	20	25	25/30	372.3	PG16	4401-631-000-26
255	187 x 187	± 21.3	10	50	13/25	317.4	PG14	4401-499-000-26
270	136 x 136	± 14.8	20	27	25/32	352.0	PG16	4401-604-000-26
340	176 x 176	± 15.1	20	33	26/26	441.6	PG16	4401-546-000-26
420	254 x 254	± 17.3	20	42	26/24	510.9	PG14	4401-508-000-26

LINOS F-THETA-RONAR 1064 NM, OPTICAL-GLASS

Nominal focal length (mm)	Scan field (mm ²)	Max. scan angle $\pm\Theta_{x,y}$ (°)	Beam diameter truncated at $1/e^2$ (mm)	Spot diameter at $1/e^2$ (μm)	Mirror distances m1/m2 (mm)	Working distance (mm)	Protective glass	Part No.
100	62 x 62	±17.7	12	16	16/12	97.7	PG2	4401-302-000-21
100 telecentric*	57 x 57	±17.0	14	14	17/29	126.0	PG6	4401-464-000-21
160	99 x 99	±17.7	12	26	16/12	176.2	PG2	4401-301-000-21
163	115 x 115	±20.2	10	32	13/24	185.9	PG5	4401-261-000-21
254	157 x 157	±17.7	20	25	26/23	296.2	PG6	4401-288-000-20
330	217 x 217	±18.7	16	40	18/24	387.6	PG6	4401-360-000-21
420	291 x 291	±19.8	15	55	30/16	494.2	PG6	4401-350-000-21

* Entrance lens made of fused-silica



LINOS Low Outgassing Manual Variable Beam Expander



YOUR BENEFITS

- Continuous variation of magnification 1x...4x and exit-beam divergence
- Fused-silica design
- Optimized design for 355 nm wavelength
- High end broadband coating 340-360 nm for high power and short pulses
- Includes interchangeable and coated fused-silica protective glasses
- Precise scales allow reliable and intuitive settings with high repeatability
- Pointing stability < 0.3 mrad

SPECIFICATIONS

- Laser damage threshold coating up to 4 J/cm² at 355 nm, 6 ns, 100 Hz and upto 0.4 J/cm² at 343 nm, 200 fs, 1 kHz
- Transmission T (340 - 360 nm) ≥ 95 % and > 90 % @ 635 nm
- Laser damage threshold coating for fused silica lenses up to 4 J/cm² at 355 nm, 6 ns, 100 Hz and up to 0.4 J/cm² at 343 nm, 200 fs, 1 kHz
- Max. entrance beam diameter:
 - up to 10 mm for the intensity 1/e²
 - up to 12 mm (truncated)
- Max. exit-beam diameter up to 24 mm (truncated)
- Different mechanical interfaces: M30x1 (entrance side), M46x0.5 (exit side), Ø 62_{h9}

LINOS MANUAL VARIABLE BEAM EXPANDER 1X ... 4X, FUSED-SILICA, LOW OUTGASSING

Wavelength (nm)	Expansion factor	Max. entrance-beam diameter at 1/e ² / truncated (mm)	Part No.
340-360	1x - 2x	10.0 / 12.0	4401-613-000-28
	2x - 2.5x	8.0 / 9.6	
	2.5x - 3.0x	6.5 / 7.8	
	3x - 4x	5.0 / 6.0	

LINOS Manual Variable Beam Expanders



LINOS Beam Expander with a variable expansion factor 2x to 8x for 1064 nm

YOUR BENEFITS

- Continuous variation of magnification 2x...8x
- Choice between fused-silica or glass entrance lens
- Continuous variation of exit-beam divergence
- Wavelengths 355 nm, 532 nm, 633/780/830/980 nm or 1064 nm
- Precise scales allow reliable settings and high repeatability

SPECIFICATIONS

- Max. exit-beam diameter 31 mm
- Max. length 165.5 mm
- Max. diameter 42.0 mm
- Mounting diameter 37.6-0.1 mm, reference on surface A (see page 9)

LASER DAMAGE THRESHOLD COATING UP TO:

	Laser damage threshold (J/cm ²)	Pulse length (ns)
355 nm Fused-silica	5	5
532 nm Optical-glass	10	6
515-540 nm Entrance lens fused-silica	20	6
633/780/830/980 nm Optical-glass	6	6
1064 nm Optical-glass	20	9
1030-1080 nm Entrance lens fused-silica	30	9

LINOS MANUAL VARIABLE BEAM EXPANDER 2X...8X

Wavelength (nm)	Max. entrance-beam diameter truncated at 1/e ² (mm)	Material	Part No.
355	3.4	Fused-silica	4401-402-000-20
515-540	4	Fused-silica + Optical-glass	4401-446-000-20
532	8	Optical-glass	4401-257-000-20
633/780/ 830/980	8	Optical-glass	4401-258-000-20
1030-1080	4	Fused-silica + Optical-glass	4401-359-000-20
1064	8	Optical-glass	4401-256-000-20

Entrance beam diameter max. = 31 mm / zoom factor.



LINOS Motorized Beam Expanders



Motorized Beam Expander for 355 nm, 1x ... 4x



Motorized Beam Expander 2x ... 8x

YOUR BENEFITS

- Continuous variable magnification 1x...4x and 2x...8x
- Fused-silica designs
- Continuous variation of exit-beam divergence
- Wavelengths 340–360 nm, 515–540 nm or 1030–1080 nm
- Adjustment from 2x to 8x in about 7 s
- Software running on the Windows™ platform
- Reduce machine setup times by automatic change of magnification
- Maintains laser-protection class during readjustment of the Beam Expander
- All-in-one design, controller integrated
- Pointing stability < 0.5 mrad
- CE and ROHS conform
- IP 20
- 10 individual presets for magnification and divergence
- Includes interchangeable protective glasses

SPECIFICATIONS

- Max. exit beam diameter 31 mm
- Laser damage threshold coating up to J/cm² at 355 nm, 6 ns, 100 Hz and up to 0.4 J/cm² at 343 nm, 200 fs, 1 kHz
- Laser damage threshold coating up to 20 J/cm² at 532 nm, 8 ns, 100 Hz and 0.6 J/cm² at 515 nm, 204 fs, 50 kHz
- Laser damage threshold coating up to 40 J/cm² at 1064 nm, 12 ns, 100 Hz and 0.9 J/cm² at 1030 nm, 291 fs, 5 kHz
- Mechanical dimensions: length 167 mm (1x...4x), 203 mm (2x...8x), width 58 mm, height 55.5 mm
- Mechanical interface via high-precision holes ϕ_{H7} (recommended) or mounting diameter 39_{H11}
- Different electronic interfaces: SubD9/RS232, Phoenix Contact/ RS232
- Baud rate: 9600 bit/s
- Power input 7–12 V, Phoenix Contact 7–24 V

LINOS MOTORIZED BEAM EXPANDER 1X ... 4X, FUSED-SILICA

Wavelength (nm)	Max. entrance beam diameter truncated at $1/e^2$ (mm)	Low absorption	Part No.
340 - 360	8		4401-596-000-20
340 - 360	8		4401-596-000-21
515 - 540	8	✓	4401-597-000-20
515 - 540	8	✓	4401-597-000-21
1030 - 1080	8	✓	4401-598-000-20
1030 - 1080	8	✓	4401-598-000-21

Entrance beam diameter max. = 31 mm / zoom factor.

LINOS MOTORIZED BEAM EXPANDER 2X ... 8X, FUSED-SILICA

Wavelength (nm)	Max. entrance beam diameter truncated at $1/e^2$ (mm)	Low absorption	Part No.
340 - 360	6		4401-634-000-20
340 - 360	6		4401-634-000-21
515 - 540	8	✓	4401-515-000-20
515 - 540	8	✓	4401-515-000-21
1030 - 1080	8	✓	4401-514-000-20
1030 - 1080	8	✓	4401-514-000-21

Entrance beam diameter max. = 31 mm / zoom factor.

Part No. suffix for PC interface

SubD9/ RS232	-20
Phoenix Contact/ RS232	-21



Protective Glasses



YOUR BENEFITS

- Optimum protection for diverse optical systems
- Coated on both sides
- High transmission for the corresponding wavelength or wavelength range
- High laser damage threshold
- Short delivery time

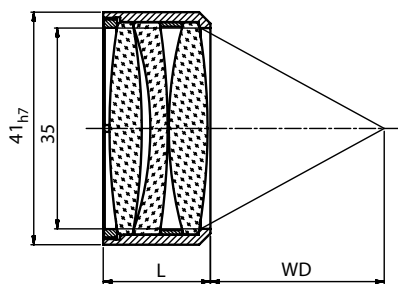
PROTECTIVE GLASSES, FUSED-SILICA

Protective glass	Protective glass diameter (mm)	Protective glass thickness (mm)	AR coated for λ (nm)	Part No.
PG 4	75	1.5	340-380+633	4401-399-005-00
PG11	113	3	340-380+633	4401-481-005-00
PG13	113	3	515-540, low absorption	4401-496-005-01
PG14	113	3	1030-1080, low absorption	4401-499-005-00
PG15	113	3	340-380+633	4401-511-823-00
PG16	132	3	1030-1080, low absorption	4401-513-006-00
PG21	132	3	515-540, low absorption	4401-517-006-00
PG22	75	1.5	1030-1080, low absorption	4401-551-016-00
PG23	113	3	1900-2000	4401-568-004-00
PG24	132	3	1900-2000	4401-569-005-00
PG25	17.5	1.6	1030-1080, low absorption	4401-514-006-00
PG26	17.5	1.6	515-540, low absorption	4401-515-006-00
PG27	17.5	1.6	340-380+633	4401-516-006-00
PG28	75	1.5	515-540, low absorption	4401-599-006-00
PG30	132	3	440-460, low absorption	4401-611-006-00
PG31	35	1.5	340-380+633	4401-613-008-00
PG32	132	3	340-380+633	4401-619-006-00
PG33	132	3	340-380+633	4401-617-820-00
PG34	132	3	340-380+633	4401-617-821-00

PROTECTIVE GLASSES, OPTICAL-GLASS

Protective glass	Protective glass diameter (mm)	Protective glass thickness (mm)	AR coated for λ (nm)	Part No.
PG 2	75	1.6	1064+VIS	4401-301-001-00
PG 5	100	3	1064+VIS	4401-261-004-00
PG 6	113	3	1064+VIS	4401-288-005-01
PG 7	113	3	532	4401-289-007-00
PG 8	75	1.6	532	4401-304-005-00
PG17	113	3	940-980	4401-524-004-00
PG18	100	3	940-980	4401-527-004-00

LINOS Focus-Ronar Lenses 1064 nm + 532 nm



Focusing lenses are optimized for high precision applications, as used in laser systems for welding, cutting, drilling and structuring.

YOUR BENEFITS

- Focal lengths ranging from 58 mm to 122 mm
- Flexible lens exchange without any adjustment
- Good inspection performance at VIS wavelengths
- Three-lens-element designs

SPECIFICATIONS

- High clear aperture up to 35 mm
- The coating is optimized for 1064 nm, $T \geq 97\%$ and $T(532 \text{ nm}) \geq 96\%$
- Laser damage threshold coating 10 J/cm² at 1064 nm, 9 ns, 100 Hz
- Laser damage threshold 6 J/cm² at 532 nm, 6 ns, 100 Hz
- Housing diameter 41_{h7} mm

LINOS FOCUS-RONAR 1064 + 532 NM, OPTICAL-GLASS

Focal length at 1064 nm (mm)	Length L (mm)	Working distance for 1064 nm (mm)	Working distance for 532 nm (mm)	Part No.
58	24.6	48.3	47.8	4401-505-000-20
77	18.9	72.2	71.6	4401-486-000-20
90	33.6	73.7	73.1	4401-490-000-20
122	24.0	111.5	111.6	4401-420-000-21





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