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## New developments in the field of telecentric lenses

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The current main focuses in lens development at Vision & Control are around the topic of “Blue Vision” and *double-sided telecentricity*. The background for this is the announcement that the T100 and T107 series of lenses are to be discontinued on 31/12/2019. The requirements of the market and current technical trends are both included in current lens developments, with the result that all the new lenses are an adequate replacement for the lenses being discontinued, or even improve on their functionality. The new TO series with its focus on “Blue Vision” includes the current developments in the field of LED technology, in which highly-efficient blue LEDs or white LEDs with a high proportion of blue are ready for marketing.

The main focus of the new TOB series is double sided telecentricity: the nearly-symmetrical construction makes it possible for lenses to have extremely high imaging quality with distortion of less than 0.01% and lateral chromatic aberration for white and infrared light of less than 1 pixel. The result is that coloured pictures don't have coloured fringes and that images with white light on monochromatic sensors don't have ghosting.

These properties are particularly advantageous for semiconductor inspection.

### **The new TO lenses**

... are telecentric measurement lenses with an object sided telecentric optical path. They are particularly high-resolution, compact and light. The lenses from the TO series have special colour correction in the blue spectral range (450 to 490 nm). They supply maximum sharpness and the greatest possible depth of field in the efficient and high-energy blue spectrum. Thanks to the spectral composition of white LEDs with a high proportion of blue, they also have excellent imaging properties.

The lenses in the TO18 and TO30 series were designed for imaging in the object fields of 14.4 x 10.8 mm (diagonal 18 mm) and 24 x 18 mm (diagonal 30 mm). In order to display the respective maximum object field in a way that almost fills the frame for common sensor formats, four types of lens are available in each lens series with an appropriate magnification for the sensor formats 2/3”, 1/1.8”, 1/3” and 1/4”. If smaller object fields than the maximum are required, adjustments can be made by selecting sensors which are smaller than the maximum indicated. The table below offers support in making a decision about this.

In most cases, the lenses are an adequate replacement for the lenses in the old T100 and T107 ranges and are also smaller and lighter. Furthermore, lenses which can fill the screen when imaging with a 1/4” sensor (3.4 mm x 2.2 mm) are available for the models TO18/4.1-100-V-B and TO30/4.3-100-V-B.

Other features of the TO series at a glance:

- C-mount threaded connector
- Maximum sensor format: 2/3"
- Minimum pixel size 2.2 µm
- 9 megapixels
- Adjustable aperture (lockable): f-number f/10 - f/22
- Robust industrial design available

### **The new TOB lenses**

... are telecentric measurement lenses with a mutual telecentric optical path. They provide high-resolution, low-distortion and colour-corrected images.

Both sided telecentric lenses are constructed in accordance with the telescope principle and thus constitute an afocal system. They are built from telecentric system parts on the side of the object and the image. Due to this construction, each lens has a set magnification – in contrast to lenses which are only telecentric on the object side. So spacer rings can be used to achieve various working distances for a lens without changing the magnification. This constitutes one of the great benefits of both sided telecentricity. Furthermore, the near-symmetrical lens system construction of lenses with high image quality enables complete freedom from distortion and extremely low lateral chromatic aberration. The camera sensor experiences uniform light exposure as all principal ray angles are  $0^\circ$  on the image side. This means that there is no loss of illumination at the edges or so-called “shading”.

The lenses from the TOB11 and TOB22 series are for imaging in the 8.8 mm x 6.6 mm (diagonal 11 mm) and 17.6 mm x 13.2 mm (diagonal 22 mm) object fields on a 2/3” chip. Smaller sensor formats can also be used with these lenses. Due to the high resolution, there are no restrictions regarding the use of small sensor formats – it can handle pixel sizes down to 1.9  $\mu\text{m}$ .

Vibration-proof models offer the same advantages as standard lenses but with glued lenses and fixed apertures. This means that no parts can work loose during moving and accelerated applications.

Other features of the TOB series at a glance:

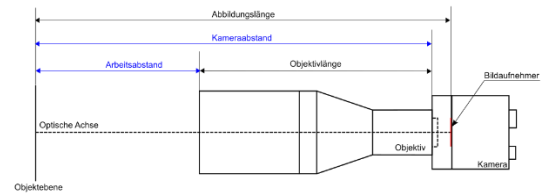
- C-mount threaded connector
- Maximum sensor format: 2/3"
- Minimum pixel size 1.9  $\mu\text{m}$
- 9 megapixels
- Very high telecentricity on the object’s side (telecentric angle  $<0.05^\circ$ )
- Distortion-free lens available ( $<0.01\%$ )
- Lateral chromatic aberration for white light  $<1$  pixel (pixel size of 3.45  $\mu\text{m}$ )
- Broadband: visual and near-infrared spectral range
- Low image field curvature
- Adjustable aperture: f-number f/6 - f/22
- Robust industrial design available

### **Accessories**

A comprehensive range of accessories suitable for our newly-developed lenses is available:

- Telecentric lights
- Deflection mirror for deflecting the beam’s path by  $90^\circ$
- Beam splitter unit for working with top lights
- Colour filter
- Lens holder

### Comparing TO18 and TO30 series with previous series:



Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-281	T100/0,6		0.549	20	16.0 x 12.0	12.9 x 9.8	11.6 x 8.7	8.7 x 6.5	6.1 x 4.0	77	234	260
2-05-280	T100/0,7		0.733	15	12.0 x 9.0	9.6 x 7.3	8.7 x 6.5	6.5 x 4.9	4.6 x 3.0	41	203	280
2-05-538		TO18/11.0-80-V-B	0.616	18	14.2 x 10.7	11.5 x 8.5	10.3 x 7.7	7.7 x 5.8	5.5 x 3.5	80	163	95
2-05-284	T100/0,36		0.365	21.9			17.5 x 13.2	13.1 x 9.8	9.3 x 6.0	72	215	270
2-05-283	T100/0,39		0.391	23.1		18.2 x 13.8	16.4 x 12.3	12.2 x 9.2	8.7 x 5.6	33	162	230
2-05-282	T100/0,48		0.481	22.9		14.7 x 11.2	13.2 x 9.9	9.9 x 7.4	7.0 x 4.5	103	253	270
2-05-537		TO18/9.0-85-V-B	0.5	18		14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	85	160	87
2-05-284	T100/0,36		0.365	16.4				13.1 x 9.8	9.3 x 6.0	72	215	270
2-05-283	T100/0,39		0.391	15.3				12.2 x 9.2	8.7 x 5.6	33	162	230
2-05-536		TO18/6.0-95-V-B	0.334	18				14.3 x 10.7	10.1 x 6.5	95	159	77
2-05-535	<b>NEW</b>	TO18/4.1-100-V-B	0.232	18					14.6 x 9.4	100	157	70

Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-297	T107/0,36		0.355	31	24.7 x 18.5	20.0 x 15.2	18.0 x 13.5	13.5 x 10.1	9.5 x 6.1	93	244	240
2-05-296	T107/0,39		0.391	28.2	22.5 x 16.8	18.1 x 13.8	16.3 x 12.2	12.2 x 9.2	8.7 x 5.6	115	269	250
2-05-550		TO30/11.1-80-V-B	0.374	30	23.5 x 17.6	18.9 x 14.4	17.1 x 12.8	12.8 x 9.6	9.0 x 5.8	80	191	160
2-05-291	T107/0,25		0.246	36.6		28.8 x 21.9	26.0 x 19.5	19.4 x 14.6	13.8 x 8.9	83	226	230
2-05-295	T107/0,25L		0.269	33.5		26.4 x 20.1	23.8 x 17.9	17.8 x 13.4	12.6 x 8.1	105	247	194
2-05-290	T107/0,33		0.318	34.6		22.3 x 17.0	20.1 x 15.1	15.1 x 11.3	10.7 x 6.9	86	232	250
2-05-549		TO30/9.1-85-V-B	0.308	30		23.0 x 17.5	20.7 x 15.5	15.5 x 11.6	11.0 x 7.1	85	191	152
2-05-292	T107/0,2		0.195	30.8				24.6 x 18.4	17.4 x 11.3	56	194	230
2-05-293	T107/0,2A		0.192	31.3				25.0 x 18.7	17.7 x 11.4	82	220	230
2-05-291	T107/0,25		0.246	24.4				19.4 x 14.6	13.8 x 8.9	83	226	230
2-05-295	T107/0,25L		0.269	22.3				17.8 x 13.4	12.6 x 8.1	105	247	194
2-05-548		TO30/6.0-100-V-B	0.202	30				23.7 x 17.8	16.8 x 10.8	100	198	141
2-05-547	<b>NEW</b>	TO30/4.3-100-V-B	0.146	30					23.3 x 15.0	100	192	133

Comparing TOB11 and TOB22 series with previous series:

Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-282	T100/0,48		0.481	22.9	18.3 x 13.7	14.7 x 11.2	13.3 x 10.0	10.0 x 7.5	7.1 x 4.6	103	253	290
2-05-281	T100/0,6		0.549	20	16.0 x 12.0	12.9 x 9.8	11.7 x 8.7	8.7 x 6.6	6.2 x 4.0	76.5	233.5	260
2-05-280	T100/0,7		0.733	15	12.0 x 9.0	9.7 x 7.4	8.7 x 6.6	6.6 x 4.9	4.6 x 3.0	41	203	280
2-05-519		TOB22/11,0-50-V-WN	0.5	22	17.6 x 13.2	14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	50	220.5	282
2-05-518		TOB22/11,0-60-V-WN	0.5	22	17.6 x 13.2	14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	60	227.5	279
2-05-517		TOB22/11,0-80-V-WN	0.5	22	17.6 x 13.2	14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	80	242.5	265
2-05-516		TOB22/11,0-100-V-WN	0.5	22	17.6 x 13.2	14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	100	257.5	256
2-05-515		TOB22/11,0-120-V-WN	0.5	22	17.6 x 13.2	14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	120	272.5	243

Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-283	T100/0,39		0.391	23.1		18.2 x 13.8	16.4 x 12.3	12.3 x 9.2	8.7 x 5.6	32.5	160.9	230
2-05-519		TOB22/11,0-50-V-WN	0.5	18		14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	50	220.5	282
2-05-518		TOB22/11,0-60-V-WN	0.5	18		14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	60	227.5	279
2-05-517		TOB22/11,0-80-V-WN	0.5	18		14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	80	242.5	265
2-05-516		TOB22/11,0-100-V-WN	0.5	18		14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	100	257.5	256
2-05-515		TOB22/11,0-120-V-WN	0.5	18		14.2 x 10.8	12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	120	272.5	243

Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-284	T100/0,36		0.365	21.9			17.5 x 13.2	13.2 x 9.9	9.3 x 6.0	72	214.5	270
2-05-519		TOB22/11,0-50-V-WN	0.5	16			12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	50	220.5	282
2-05-518		TOB22/11,0-60-V-WN	0.5	16			12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	60	227.5	279
2-05-517		TOB22/11,0-80-V-WN	0.5	16			12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	80	242.5	265
2-05-516		TOB22/11,0-100-V-WN	0.5	16			12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	100	257.5	256
2-05-515		TOB22/11,0-120-V-WN	0.5	16			12.8 x 9.6	9.6 x 7.2	6.8 x 4.4	120	272.5	243

Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-266	T51/1,2		1.195	9.2	7.4 x 5.5	5.9 x 4.5	5.4 x 4.0	4.0 x 3.0	2.8 x 1.8	34	143	203
2-05-265	T51/1,4		1.382	8	6.4 x 4.8	5.1 x 3.9	4.6 x 3.5	3.5 x 2.6	2.5 x 1.6	28	147.6	225
2-05-500		TOB11/11,0-60-V-WN	1.0	11	8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	60	197	238
2-05-501		TOB11/11,0-70-V-WN	1.0	11	8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	70	197	223
2-05-500		TOB11/11,0-80-V-WN	1.0	11	8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	80	197	209

Order no.	Previous series	Replaced by	Magnification	Max. object field diagonal (mm)	Object field (mm <sup>2</sup> ) for					Working distance (mm)	Camera distance (mm)	Weight (g)
					2/3"	1/1.8"	1/2"	1/3"	1/4"			
					8.8 x 6.6	7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2			
2-05-269	T51/0,7		0.685	13.2		10.4 x 7.9	9.3 x 7.0	7.0 x 5.3	5.0 x 3.2	63	147	147
2-05-268	T51/0,8		0.891	10.1		8.0 x 6.1	7.2 x 5.4	5.4 x 4.0	3.8 x 2.5	52	142	160
2-05-267	T51/1,0		0.995	9.1		7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	42	141	181
2-05-500		TOB11/11,0-60-V-WN	1.0	9		7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	60	197	238
2-05-501		TOB11/11,0-70-V-WN	1.0	9		7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	70	197	223
2-05-500		TOB11/11,0-80-V-WN	1.0	9		7.1 x 5.4	6.4 x 4.8	4.8 x 3.6	3.4 x 2.2	80	197	209