Rev: 02

Some Compatibility Findings Between AO and Reichert Objectives and Eyepieces

Systems Considered:

Manufacturer	Parfocality	Start	End	Comments
AO	34mm	1961	1985	Production of after-market service optics continued for more than 20 years after.
Reichert Austria	45mm	1971	1995	Production was continued after for a while as Leica.
Reichert Austria	34mm	1975	1988	This system used achromat and plan-achromat AO objectives from the 1960's.
AO/Reichert	45mm for series 400	1985	2002	Also branded Cambridge and Leica.
Leica Germany	45mm	1991	1997	
Leica Germany	45mm & 75mm	1995	present	

Note:

Dates are approximate but likely within 2 years of actual. The beginning and end of a system's manufactured life should include the beginning of the design initiative. Since it is not usually known when that occurs, some degree of latitude in the extent of production life is given here.

There was a considerable buildup to the launch of the infinity corrected system. The previous series 2/4/6 of 1956 also used a tube lens which extends the optical tube to right around 180mm, or very similar to the quoted 182.77mm reference focal length of the infinity system. Whether that number is a conversion from inches or includes the lens depth to the focal plane of the tube lens (maybe 2.77mm?) is unknown to me.

A historical perspective:

The AO and Reichert systems have a 182.77 mm reference length, while the Leica Germany systems have a 200 mm reference focal length.

The original system was the 34mm parfocal system patented in 1964 and designed by Robert Muller and Milton Sussman in Buffalo. All subsequent systems harkened back to that patent with small modifications made as improvements in the performance of the infinity space became necessary. Based on available patents, most of the engineering of the several system modifications and optics was done at AO, whether the manufacturing was done in Austria or not. Even though its economy was growing since its release from Soviet clutches in 1955, Austria was sufficiently less developed yet skilled, to be a highly valuable and economical manufacturing partner for AO designs.

Up until the time of development of the original AO infinity-corrected system, for apochromats it was commonplace with all manufacturers to correct as many aberrations in the objective as possible, which would always require overcorrection of CA (Chromatic Aberration) to accomplish.

The overcorrection of CA was then compensated for in the eyepiece, leaving the other corrections untouched.

Thus, we had compensating eyepieces for use with apochromats.

Achromats were usually under corrected intrinsically, requiring further correction in the eyepiece, thus apochromats and achromats used different eyepieces.

With the introduction of the infinity system, AO appears to be the first to bring achromats and apochromats to the same state of overcorrection which allowed for the use of the same eyepiece for each type. The amount of overcorrection appears to have left about 1% residual CA in the objective type.

This is compensated for largely in the telan (tube) lens with the 34mm parfocal systems, with perhaps some in the eyepiece.

Buffalo then developed the Austrian 45mm parfocal system as a somewhat improved 1970's design with an adjusted amount of compensation in the tube lens to make the infinity space more useful. The compensation then appears to be about .6% in the tube lens and .4% in the eyepiece.

By the time the new AO/Reichert 45mm Buffalo system came along in 1985, there was a recognition that compensating in the tube lens at all placed limitations on the infinity space, plus newer glass formulas allowed for less need for overcorrection, so the residual CA in the objective was reduced to .6% total and compensation was moved out of the tube lens and into the head, within the reference focal length zone.

This concept was continued with the later engineering of the Polyvar 2, which maintained compatibility with the Polyvar but moved the 1% required compensation into the head. Thus, the required 30mm tube eyepieces became W.P. (wide plan) from W.P.K. (wide plan kompensating).

In all cases, AO infinity retained their floating nosepiece design with rigid objectives, while Reichert used spring-loaded objectives. There are examples of the very same objectives when manufactured in Austria having a spring and the U.S. version having the spring replaced with a rigid spacer. At the time Reichert was firmly entrenched in expanding their existing 160mm tube length, 37mm parfocal relatively new series of microscopes.

The degree of CA and compensation zones for the Leica systems are not that clear to me yet, but they evolved from the original 1964 AO patent. The Delta (DELTA system, also known as DELTA optics), HCX (Harmonic Component System), and HC (Harmonic Compound) are all somewhat different, despite all being 200mm focal length.

> *Note: Delta, HCX, and HC are Leica-specific terms. See:*
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> *https://www.leica-microsystems.com/science-lab/microscopy-basics/optimization-of-the-interplay-of-optical-components-for-aberration-free-microscopy/*
>
> *for the details.*

According to Leica, Delta and HCX are compatible and HCX and HC are compatible. but not Delta and HC. This probably has to do with having differential compensation in the eyepiece between Delta and HC but also, wider fields of the later objectives probably play a role.

Compatibilities:

This chart establishes which stand/head, objective and eyepiece combinations can be used when expecting accurate planarity and peripheral corrections. I have included only the more flagship stands. Student stands such as the 50, 150, or ATC 2000 can be implied to follow suit.

Note: FOV = Field of View; WF = Wide Field of View; OD = Eyepiece Outer Diameter; WP = "Widefield Plan"; WPK = "Widefield Plan Kompensating"

System Stand	Objective System Used in Stand	10X Eyepiece required
U.S.A. 34mm parfocal Series 10/20 100/110/120 and Austrian Neovar 2.	34mm parfocal USA or Austria-manufactured.	#176 (18.2 mm FOV) for the 10/20. The #180 (20mm FOV) for the 100/110/120. The #176A appears to be targeted for achromat objectives and may be the same as WF10X used on the Neovar 2. All 23.2 mm OD.
	45mm parfocal made for Austrian stands.	#176, #180 and WF10X; all 23.2mm OD.
	45mm parfocal U.S.A. and Austria-made for the Series 400 U.S.A. made microscopes.	I have not found an AO or Reichert eyepiece that is both a 20mm FOV and slightly correcting, and that works perfectly for this combination. Correcting W.F. oculars such as PZO 10X SK work well but are 18mm FOV. The best otherwise is a Bausch & Lomb 10X WF stereo eyepiece, Cat# 31-15-71, which has only a tiny bit of CA over the outer 1/2mm of the periphery. 23.2mm OD required.
Austrian-made stands Diavar 2, Univar, and Polyvar.	34mm parfocal USA or Austria-manufactured. 11mm spacer required for parfocality. Some of the older and student objectives have narrower fields but most of the Plans are 24mm, so should be OK.	WP 12.5X, 23.2mm OD. for the Diavar 2. WPK 10X/24 30mm OD for the Univar and Polyvar.
	45mm parfocal Austria-made.	WP 12.5X, 23.2mm OD. for the Diavar 2. WPK 10X/24 30mm OD for the Univar and Polyvar.
	45mm parfocal U.S.A. and Austria-made for the Series 400 U.S.A. made microscopes.	WP 12.5X, 23.2mm OD. for the Diavar 2. WPK 10X/24 30mm OD for the Univar and Polyvar.
Polyvar 2.	34mm parfocal USA or Austria-manufactured.	WP 10X/24 30mm OD.
	45mm parfocal Austria-made.	WP 10X/24 30mm OD.
	45mm parfocal U.S.A. and Austria-made for the Series 400 U.S.A. made microscopes.	*? Unable to test - would require a highly correcting 30mm OD eyepiece.*

45mm parfocal U.S.A. Series 400.	34mm parfocal USA or Austria-manufactured. 11mm spacer required for parfocality. be OK.	Cat# 145 eyepiece. 23.2mm OD.
	45mm parfocal Austria-made.	Cat# 145 eyepiece. 23.2mm OD.
	45mm parfocal U.S.A. and Austria-made for the Series 400 U.S.A. made microscopes	Cat# 181, Cat# 188, and Cat# 191. 23.2mm OD.

Note: Photo eyepieces are still being tested but generally the same visual eyepieces work well. That branch of the optics requires much further testing, especially in the series 400 and Polyvar 2, which have reduced compensation in the tube lens. I can confirm, however, that the AO #145 eyepiece works well as a photo lens on the series 400 stands.