The Smithsonian Astrophysical Observatory &
The University of Arizona Steward Observatory

MMT Conversion Technical Memo: October 9, 1997

TO: Jim Burge

FROM: Steve West

RE: Polishing specifications for the MMT F/9 secondary mirror.

CC: Buddy Martin, Craig Foltz, Dan Fabricant, Scott DeRigne, Bryan Smith, JT Williams, Brain Cuerden, Steve Miller

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The optical and mechanical specifications for the MMT F/9 secondary mirror are described. Initials next to the above names represent authorization of this document as official project specifications.

Optical Surface Specifications:

Based on the discussions that resulted from a recent memo[1] and the original MMT Optical Specifications[2], the following are the optical specifications for the F/9 mirror surface:

Parameter	Design	Max. Uncertainty
Conic Constant	-1.74922	± 0.0009 [a]
Vertex Radius of Curvature (mm)	2805.79	± 1.5
polishing/testing r_o (cm)[b]	69	N/A
Scattering (nm)[c] : 3% at 350 nm	$\sigma = 9.65$	N/A
Surface micro-roughness (nm rms)[d]	2	N/A

a. The uncertainties in conic constant (*CC*) and vertex ROC (R_v) are related for the holographic test: $\frac{\Delta CC}{\Delta R_v} \sim \frac{CC}{R_v}$.

b. Wavefront structure functions ($\lambda = 500$ nm) specified at the surface of the secondary (equivalent r_o at the entrance aperture is 461.6 cm). *This error specification includes the contributions from the nadir-pointing support system.*

c. loss = $(2\pi\sigma/\lambda)^2$, where σ is the rms deviation from the mean wavefront due to scattering and λ is the shortest wavelength considered.

d. rms surface variation over scales of 1 - 200 μm.

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1. West S.C., *"Optical positions vs. optical manufacturing uncertainties for the MMT,"* MMT Conversion Internal Technical Memo, April 25, 1997.
2. Fabricant, D., McLeod B., and West S., *"Optical Specifications for the MMT Conversion,"* Version 6a, January 6, 1997.

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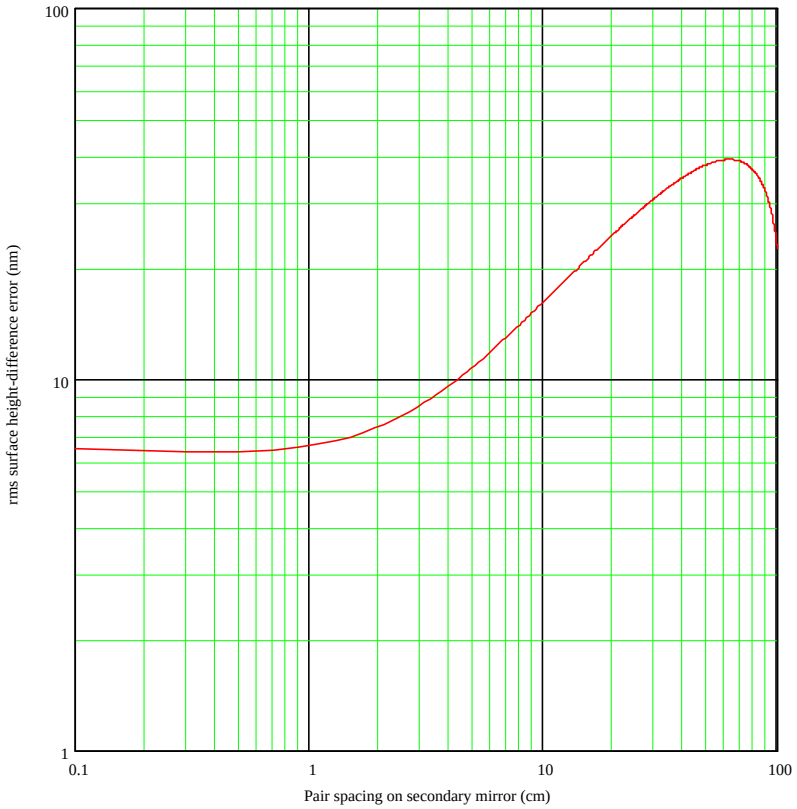
NOTES:

- During polishing, mirror interior will be pressurized to minimize quilting.
- All low-order Zernikes (esp. astigmatism) must be within the structure function specification because the support system will be incapable of removing them.
- Allowable *wavefront* errors are given by the spatial frequency spectrum of the atmospheric phase errors:

$$\delta^2(x) = \left(2\sigma^2 + \left(\frac{\lambda}{2\pi}\right)^2 6.88\left(\frac{x}{r_o}\right)^{5/3}\right)\left(1 - 0.975\left(\frac{x}{D}\right)^{1/3}\right)$$

where x is the separation between point-pairs on the surface, and D is the diameter of the secondary. The other parameters are given in the above table. This equation is valid for the secondary only if r_o is specified *at* the surface of the secondary (*i.e.*, r_o(entrance apt)/beam demagnification--the beam demagnification for the F/9 secondary is 6.69). The resulting *surface* height difference error specification is shown in the following graph:



Despace uncertainties:

The following table shows the uncertainty in the positions of the secondary mirror and focal plane (BFD) vs. the manufacturing uncertainties in the primary and secondary mirrors. The displacements were obtained by minimizing the on-axis spherical aberration by using the optimizer built into OSLO PRO.[1]

Optical Constant	Change	dSec (mm)	dBFD (mm)
Primary conic[a]	0.00025	0.52	27.42
Primary vertex radius	2.5 mm	1.25	1.25
Secondary conic	0.0009	0.17	9.35
Secondary vertex radius	1.5 mm	0.62	5.30
Total[b]	--	2.56	43.32

a. Value reflects current uncertainty in the null lens.
b. Assuming that the uncertainties add constructively at their maximum values.

NOTE: The hexapod positioner has a 20mm focus adjustment and will easily accommodate repositioning the secondary mirror cell within these uncertainties. To accommodate existing instruments, the MMT F/9 top box may need to be repositioned by as much as 43.3 mm in either direction (in order to retain the nominal 9.0-inch distance from its bottom flange to the focus).

Opto-mechanical specifications:

The following table summarizes the relationship between the optical surface and the blank's faceplate

Item	Value
Mechanical faceplate OD[a]	1029.7 mm
Optical clear aperture[b]	997.2 mm
Optic axis to mechanical axis matching	±1 mm
Maximum rolled-edge radius[c]	15 mm (for ±1 mm axis matching)
Central obstruction[d]	180 mm
Current generated faceplate edge thickness[e]	~ 7.62 - 8.89 mm

a. Measured by Byran Smith after generating the edge.
b. Calculated with OSLO PRO tracing the extreme marginal ray onto the secondary mirror for an object 6-arcminutes off-axis.
c. (Mechanical OD - Optical OD)/2 - axis matching error.
d. Projection of the diameter containing the secondary lateral supports (1199 mm) onto the secondary surface.
e. Entire faceplate thickness will be measured using ultrasound at a later date.

The last page shows a mechanical drawing of the mirror blank.