CALTECH OPTICAL OBSERVATORIES
Palomar Observatory

200” Telescope
Primary Mirror Reflectivity
Quality Assurance Plan

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Revision Sheet

Revision No.	Date	Revision Description
Rev. 0.1	10/08/2010	Initial draft
Rev 1.0	10/10/2010	Initial release

Contents

1 GENERAL INFORMATION

1.1 Scope

This document describes the test procedures, measurements and recording of data required to assess the quality of the 200” primary mirror reflectivity.

1.2 Definitions

Shall	We use ‘shall; exclusively to indicate a requirement
Should	We use ‘should’ to indicate a goal
Will	We use ‘will’ to indicate a statement of fact

1.3 Reference Documents

1.3.1 200_inchXPrimary_2005.xls

1.3.2 Integrated Reflectivity Template Nov-08.xls

1.4 Acronyms and Abbreviations

2 STATEMENT OF NEED

2.1 Introduction

The delivered product at an observatory is “Photons in the Focal Plane”. One aspect of this is the efficiency of delivering incident photons at different wavelengths to the detecting instrument, and this depends on the quality of the reflecting coatings on the telescope mirrors. The sharpness of the image depends on the shape of the optics and is not a subject of this discussion. This document will provide the requirements for the recording of data necessary to systematically evaluate the mirror coat. Reference documents will be provided to support these requirements.

3 SPECIFIC REQUIREMENTS

3.1 WITNESS SLIDES.

3.1.1 SLIDE TYPES:

REFLECTANCE:

These slides are intended to be sent to an outside firm for reflectance measurements. All slides should be cleaned with a method similar to that used on the primary mirror and handled with lint and powder free gloves. Standard 3” X 1” microscope slides are normally used.

THICKNESS:

These slides are intended to be used for thickness measurements at Palomar and at an outside firm. A piece of scotch tape across the slide will serve as a removable cover after aluminizing;

leaving a step that can be measured with a stylus machine like the Dektak Alpha Step 100 at Palomar. The scotch tape does not create a problem in the chamber (information source: Yeagle Technology, Ashford CT). It has been found that results are better with the tape than with spots of Glyptal that are later removed with acetone. If the slide is to be measured with Optical Interferometry at a firm like Optical Data Associates in Tucson, AZ, the slide should first be aluminized before putting on the tape and placing it in the chamber. When the tape is later removed, it will create an aluminum to aluminum step. The inteferometric method is inconsistent when the step is aluminum to glass due to a skin effect in the glass. The Alpha Step 100 stylus machine will work with either type of slide.

3.1.2 SLIDE LOCATIONS:

Samples are normally placed at 7 locations on the surface of the primary mirror. There are three locations on the outside edge which are shrouded by the earthquake restraints and can be used for samples during coating (North, Southeast, and Southwest). The central hole in the mirror is 40 inches and the shadow of the prime focus cage is 72 inches, leaving a center annulus for sample locations. Samples are normally placed at the cardinal points at a radius of 30 inches. Modeling done with ALUMPROx.MCD which includes the center obstruction shows that the coating should be full thickness from about 20” radius outwards. To maximize the information obtained, one reflectance and one thickness slide shall be placed at each location. After the aluminization, the slides should be handled with lint and powder free cotton or rubber gloves and placed in glassine or paper envelopes with the following information on the envelope: Mirror, date, and location on mirror.

3.1.3 SLIDE ANALYSIS:

REFLECTANCE:

The slides should be sent to a reputable vendor with astronomy experience for calibrated reflectance from 200nm to 3.0microns. A recommended vendor is:

Optical Data Associates LLC
5237 East 7th Street
Tucson AZ 85711-2350
(520) 748-7333
Contact person is Michael Ray Jacobson

THICKNESS:

If the slides were prealuminized so there is an aluminum to aluminum step, they should be sent to Optical Data Associates (ODA) for interferometric step height measurement. When they are returned, they should be checked on the Palomar Dektak Alpha Step 100 stylus machine which has a 1000 Angstrom gage for calibration. The samples from the shadows of the earthquake restraints are the most important since the shrouding of the inner area is not known to high precision. For sample slides that were not prealuminized, the Palomar test will be the only measurement.

3.2 ADHESION TEST.

Scotch tape is applied to the surface of the freshly aluminized mirror in the area shrouded by the prime focus cage. When the tape is peeled off, the coating should remain on the mirror.

3.3 TELESCOPE PRIMARY MIRROR REFLECTANCE TEST:

3.3.1 REFLECTANCE MONITOR:

Two reflectometers are available at Palomar: a MicroScan, which measures at 670nm in the red, and a Minolta CM-2002 which measures from 400nm to 700nm and stores multiple readings. We have a standard test coupon to calibrate the reflectometers. The Minolta is the preferred instrument because of the wavelength dependent problems with the coating. The coat is almost always acceptable at 670nm, but often shows poor results at shorter wavelengths.

3.3.2 MEASUREMENT LOCATIONS:

a. Adjacent to the locations where the witness slides were located. These will serve as a reality check in a comparison with the witness slides evaluated at ODA.

b. MULTIPLE LOCATIONS ON THE PRIMARY SURFACE. Historical data showed significant spatial variation in reflectivity, especially at the shorter wavelengths. Although some zonal readings can be 10 to 20 percentage points low on a freshly aluminized mirror, it is virtually impossible to see this with the naked eye. Because of this variation, a number of data points need to be taken to ensure that a reasonable integrated reflectivity can be calculated and to assist in improving the process. Therefore, Minolta data shall be taken at the 8 cardinal points at the following distances: 3, 6, 12, 18, 30 and 48 inches from the outside edge as shown in Figure 1.

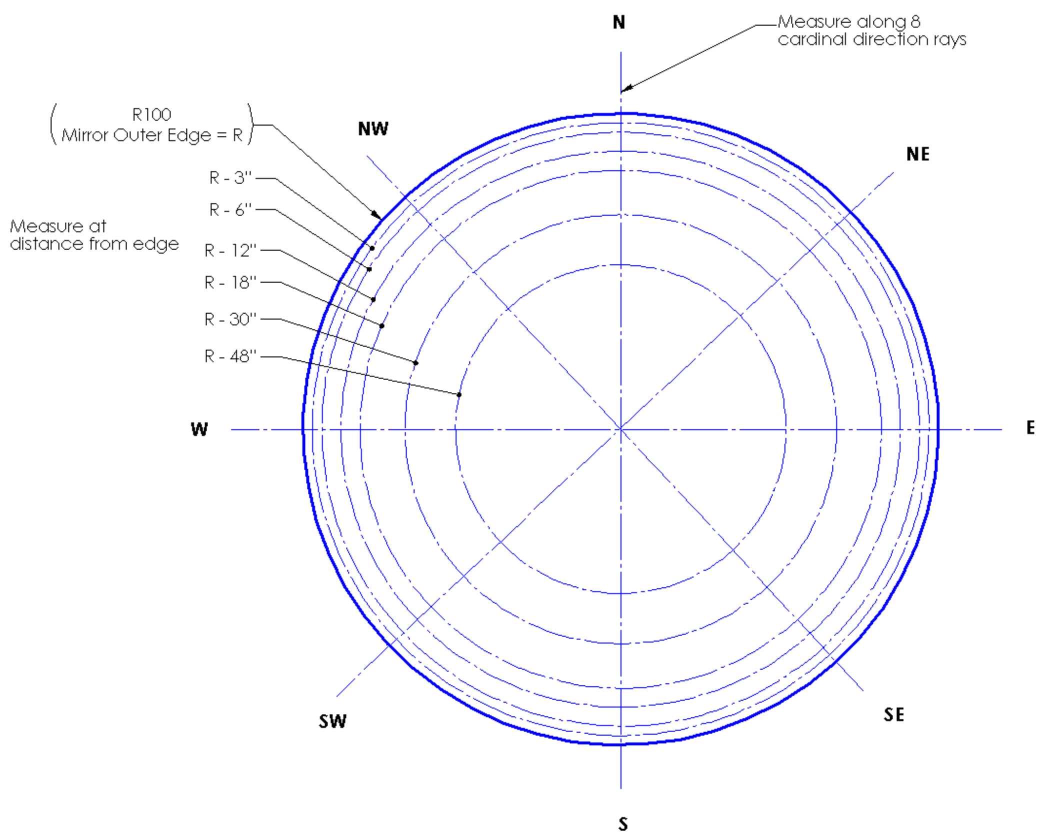

Figure 1: 200" Primary Mirror Reflectivity Measurement Locations

3.3.3 SPECTRAL RANGE:

With the Minolta reflecometer, readings are taken between 400 and 700 nm in 10 nm steps. For analysis later, only the data at 50 nm steps will be used.

3.3.4 DATA REDUCTION:

To provide an accurate throughput number for a mirror that has spatial and wavelength variations, an integrated reflectance versus wavelength table is the final product. Conceptually, the idea is to average the readings for a given radius at each wavelength. Multiply this average by an annular area centered on the radial location. Do the same for each radial location and sum the products. Divide the sum of the products by the total area to get a weighted average reflectance for the whole mirror as a function of wavelength.

A spreadsheet that provides a suggested format for recording reflectance of witness slides and mirror data is shown in the file titled “200_inchXPrimary_2005.xls”. The actual lay out of the spreadsheet will be left to the discretion of the data recorder. A template to be used for recording of corrected reflectance data and calculation of the integrated reflectance can be found in the file titled ”Integrated Reflectivity Template Oct-2010.xls”.

3.4 ACCEPTANCE CRITERIA

It is a goal to establish a well defined acceptance criteria to be used in determination of the quality of the of a new mirror coating and to assist in the planning for future required aluminizing operations. To support this goal, the following Acceptance Criteria is a guideline to be used as a tool to assess a fresh mirror coating. It should be applied with the understanding that may further development and refinement may be required since all determining factors and their consequences may not have been realized.

3.4.1 HAZE (BLOOM)

A visual inspection from the Catwalk Level and from the top of the dome shall be made and the presence and extent of any haze estimated. Document with photographs.

1. No Haze: Acceptable for several years.
2. Haze up to 10% of mirror: Accept and schedule realuminzation for the next year.
3. Haze 10% to 20% of mirror: Realuminize if schedule permits, otherwise reschedule for 6 months.
4. Haze greater than 20% of mirror: Reschedule observers and realuminize.

3.4.2 REFLECTANCE

Multiple measurements at 3, 6, 12, 18, 30, and 48 inches from the outside edge of the mirror along the eight cardinal radii with the Minolta Reflectometer between 400 and 700 nm should be taken and recorded. The Minolta data should be normalized against a NIST Standard. A weighted average/integrated reflectance value for 400, 450, 500, 550, 600, 650 and 700 nm shall be calculated (see Integrated Reflectivity Template Oct-2010" for an example spreadsheet for the type of geometry described).

1. Within 2% of the NIST Standard at all wavelengths: Acceptable for several years.

2. Between 2% and 10% below NIST Standard: Realuminize if schedule permits, otherwise schedule for 6 months.

3. Greater than 10% below NIST Standard: Reschedule observers and realuminize.

3.4.3 THICKNESS

The desired thickness is no greater than 800 Angstroms. Test slides will be placed at the 30" radius on the cardinal points and in the spaces on the outside edge of the mirror where the earthquake restraints will shadow. All 7 locations should meet the following criteria:

1. Greater than 800 Angstroms and no haze: Acceptable.
2. Less than 800 Angstroms and greater than 400 Angstroms: Acceptable for several years.
3. Less than 400 Angstroms and reflectance criteria met: Acceptable and reschedule for 1 year.

3.5 PERIODIC MEASUREMENTS

In an effort to provide an ongoing assessment of the condition of the mirror reflectivity, periodic reflectance measurements are to be taken. The measurements will be made through the 3 inspection ports on the mirror cover using the Minolta reflectometer every three months starting on the first day the newly coated mirror is installed on the telescope. Three measurements are to be taken at each port. The data is to be recorded as a function of wavelength in 50 nm increments from 400 to 700nm in the same format as the overall mirror reflectance in section 3.3.4.