MMTO Internal Technical Memorandum #03-6

(An addendum to MMTO ITM #02-1)

MMT Observatory

Smithsonian Institution &
The University of Arizona®

Effects of CO_2 Cleaning and Detergent Washing on Specular and Diffuse Reflectance of the MMT 6.5m Primary Mirror

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August 2003

ABSTRACT

On August 14, 2003, the MMT 6.5m primary mirror was CO_2-cleaned and washed. Efficacies of different washing techniques are considered. Specular (***R***) and diffuse (***S***) reflectances before and after each step are given. Performance of the Minolta CM-2002 Spectrophotometer and MMT Reflectometer is discussed along with recommendations for future cleaning schedules.

INTRODUCTION

The process of recoating the MMT 6.5m primary involves tremendous effort and several man-months. An extension of the useful life of the coating from two to three years represents a significant improvement in overall operating efficiency. MMTO has undertaken a program of quantitative evaluation of cleaning techniques—this memo is the second installment in what will be an ongoing series (see MMTO Internal Technical Memorandum **#02-1**).

Two practical methods are available for maintaining mirror surfaces: 1) CO_2 "snow" cleaning, and 2) detergent washing. CO_2 cleanings presently occur at bi-weekly intervals (with exceptions for approaching storms). Before this washing, selected areas of the primary were CO_2 cleaned and measured. The methodology is well-established, and not discussed further. Options exist, however, for the wash.

MIRROR WASHING

Historically, MMT mirrors have been hand washed once or twice between coatings. A noncontact rinse and prewash with detergent solution loosened and removed particulates. The surface was then hand-scrubbed with absorbent cotton. On a 1.8m mirror, one could exercise the necessary high degree of pressure control with the cotton—all points on the zenith-pointing surface being easily reachable by an upright human being. Not so with the 6.5m mirror, either zenith or horizon pointing. After lengthy consideration of ways to safely and effectively reach the mirror surface while allowing the delicate pressure control necessary to avoid damage, no easy solution presented itself.

We decided to try a simple noncontact solution—spraying the surface with a pressure washer. A bottom-of-the-line ($100) pressure washer with fixed low and high pressure settings was purchased. Several glass and coated glass surfaces were tested using application techniques ranging from baby-gentle to brutal. The cleanings appeared to the eye to be very effective and no coated surfaces were damaged.

On August 14, the horizon-pointing 6.5m mirror was washed with the sprayer. We first tape-tested the mirror to reveal any zones that might require special care. The surface was thoroughly rinsed with plain water and then soaked with detergent. A detergent solution was then sprayed onto the surface at low pressure with the wand tip about 12" from the surface (producing a scanned strip about 12" wide). The low pressure jet was directed upward onto the surface hoping to maximize the agitation. The sprayer was also used for rinsing—at the high pressure setting, solution from the siphon tank is excluded. Pending further testing, we kept the wand at least one meter from the surface. This process was repeated before blow drying the surface with a wand supplied by mirror support system air (30 cfm @ 120 psi). This volume of high-velocity air allowed the surface to be covered quickly enough that evaporative drying was not a problem. A small region of the mirror, reachable from a standing position at 6 o'clock, was further scrubbed with absorbent cotton for comparison. Reflectance and scattering at all stages of this process are charted in Figures 1 and 2.

DISCUSSION

The CO_2 cleaning yielded the 1 to 1.5% gain in ***R*** we typically see, but was somewhat less effective at reducing the ***S*** compared to previous results. Applying detergent to the surface with the pressure washer increased ***R*** by about 3% in the blue but was not able to remove a milky film visible under the right lighting. The area scrubbed with cotton showed a further increase in ***R*** of up to a few percent and brought the mirror very close to pristine reflectance. Each step produced a significant reduction in ***S*** although we cannot approach pristine.

No surprises here but there is a definite trend worth noting (see #**02-1**). In the earlier stages of the life of the film, CO_2 cleaning is more efficacious; later on, washing produces the bulk of available improvement. Keep in mind that this mirror was two years old when washed and that the program of bi-weekly CO_2 cleanings was not instituted until six months ago. To that point, the mirror had received only sporadic snowings.

Of course, once the film is damaged, no cleaning process can restore original performance. Applying cleaning techniques frequently enough to forestall damage seems key. The poorer the condition of the film at cleaning time, the more I would expect to see the noted trend manifest itself. It is quite possible that, with the CO_2 cleaning regimen we now have in place and regular, more frequent washings (annual or semiannual), the spraying technique alone would be sufficient to restore near-pristine reflectance. It is also likely that a "higher" low pressure spray would be more effective and other solvent solutions might more completely remove the residual contamination. If this turns out not to be the case, i.e., if cotton scrubbing is required, a fairly elaborate solution for accessing the surface will be needed. As is, the wash requires a two day window for four people.

A quick word about our radiometric measurements: The MMT Reflectometer (MMTR) has been refurbished and is once again performing well. Its coverage is now 350 nm, 400 nm, 450 nm, 550 nm, 633 nm, 700 nm, and 1000 nm. An empirical solution was found for the Minolta (decalibrating it so that results agree with our standards) and its results are now in general agreement with MMTR…on plane surfaces, that is. A new idiosyncrasy has appeared—the instrument produces different results with plane and curved surfaces. ***R*** measurements for this report had to be discarded. This condition was subsequently explored on the FLWO 60" and LPL 61" as they were coated at Sunnyside. The solution is to adjust measurement geometry so that the two agree. This instrument can collect large amounts of data easily and quickly but it remains a fish out of water when it comes to measuring the specular component of highly reflective surfaces—MMTR still provides the most accurate and consistent results.

CONCLUSION

Contact washing a badly contaminated mirror surface can restore near-pristine reflectance although there is a substantial risk of damaging the delicate film. Spraying a detergent solution at very low pressure on the surface with a pressure washer eliminates the risks inherent in any contact process but does not completely restore a surface that has been neglected. Efficiency of the spray technique as a function of pressure and solvent used needs to be investigated. It is proposed that the spray technique alone might be sufficient to maintain near-pristine specular reflectance on an aluminized mirror for three years if applied regularly and in concert with frequent CO_2 cleanings.

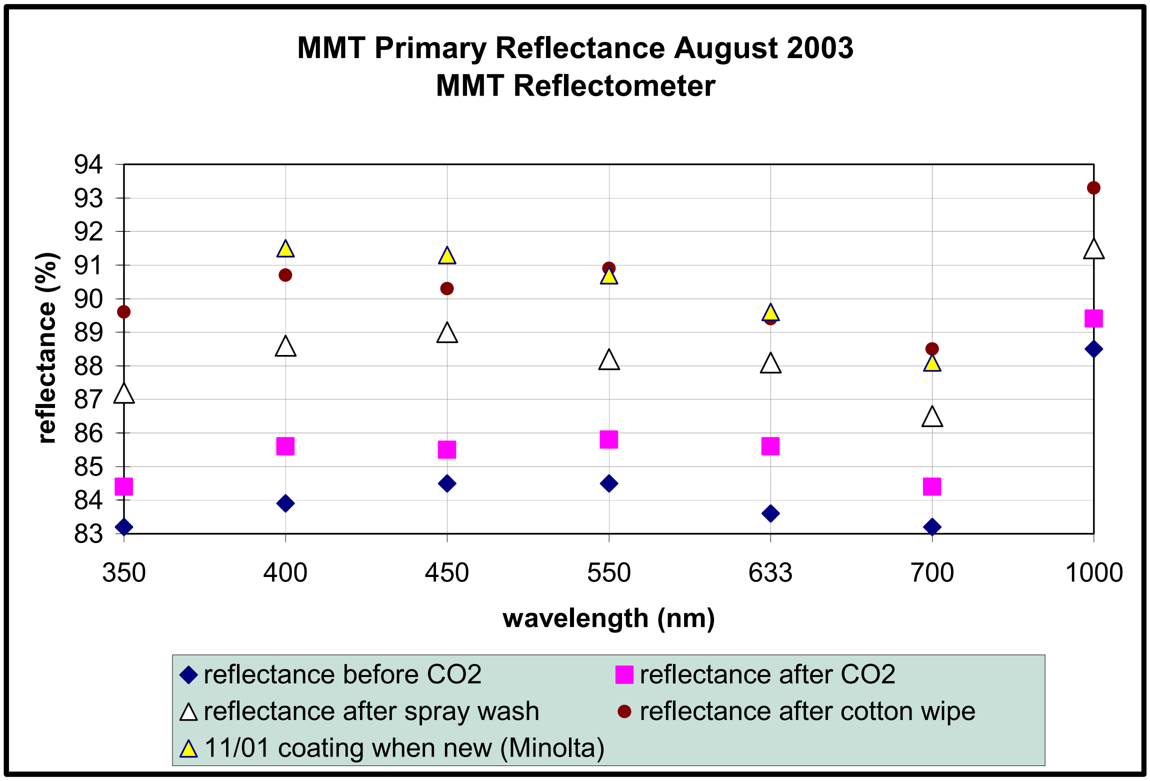

Figure 1. Reflectance at various stages of cleaning.

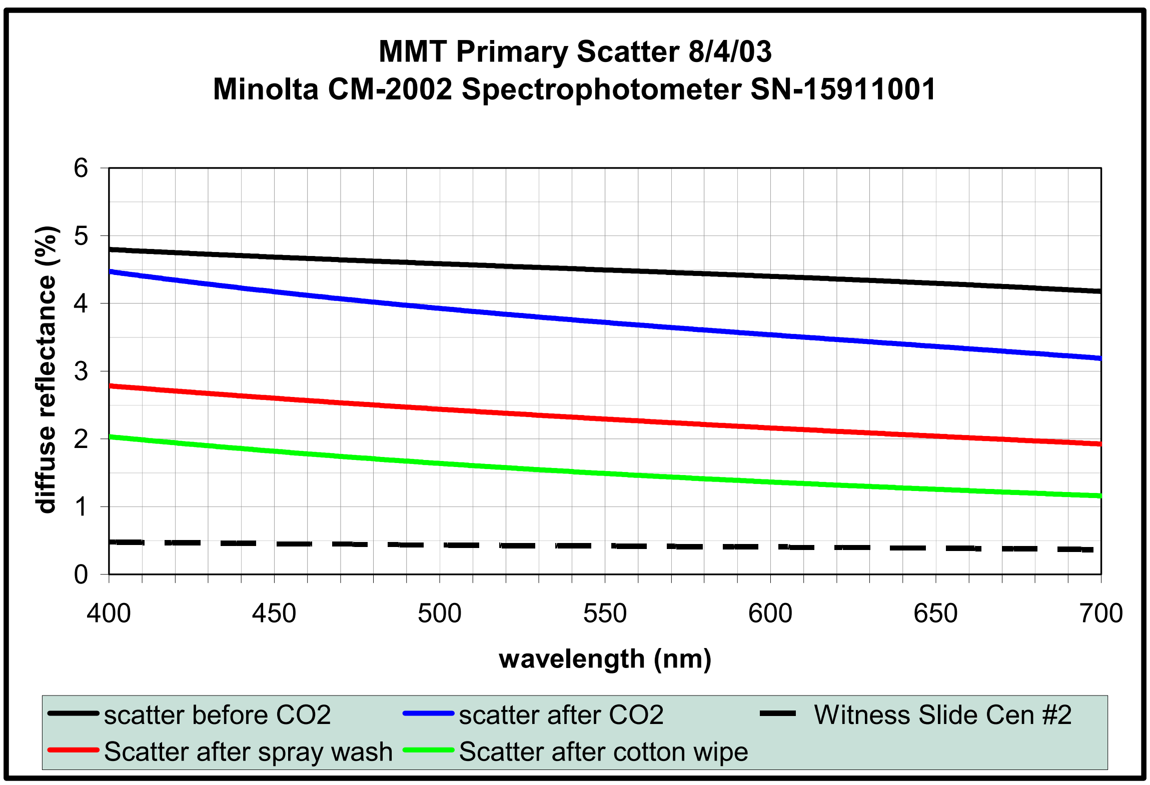

Figure 1. Scattering at various stages of cleaning.