

WHT M1 Reflectivity Report spanning 10 November 2016 to 4 December 2016. Measurements, Cleaning and Report by Neil O'Mahony
 Check of Reflectivity on 11 November. 7 weeks since the last cleaning and measurement.
 Battery change on 17 November with lots of reference measurements before and after (no noticeable effect).
 Weak calima (10 ug/m3 on TNG dust sensor) during 16-20 nov.

Index	date/time	Temp. °C	Reflectivity (%R) wavelength of band (nm)							"Dust Indices" (DI)								
			365	404	464	522	624	760	970	365	404	464	522	624	760	970		
837	10/11/2016 11:41	1 WHTM1 all	21.4	91.1	89.7	89.1	89.2	88.2	85.6	91.6	4.1	4.0	4.3	3.6	4.4	3.8	4.3	
838	10/11/2016 11:43	1 WHTM1 all	21.1	91.2	89.8	89.3	89.4	88.4	85.8	91.8	4.0	4.0	4.5	3.3	4.0	3.3	3.5	
839	10/11/2016 11:46	1 WHTM1 all	20.8	91.2	89.6	89.2	89.3	88.3	85.6	91.6	4.2	4.0	4.4	3.5	4.2	3.8	3.9	
Averages				91.2	89.7	89.2	89.3	88.3	85.7	91.7	4.1	4.0	4.4	3.5	4.2	3.6	3.9	
after Aligal2-CO2, June				92.2	90.6	90.0	90.1	89.2	86.4	92.2								
after normal CO2, August				92.2	90.6	90.1	90.2	89.2	86.6	92.5								
Improvement expected if used CO2 now				1.0	0.9	0.9	0.9	0.9	0.9	0.8								

We know that CO2 can improve reflectivity by at least 1.2% and there has been no strong calima, so it's worth waiting before CO2 cleaning.
 Note visual inspection at AP3. Measurements were well distributed spatially over the bottom of the mirror.

Visual inspection and new measurements on 28th. Mirror is slightly dustier than before. Rain spots cannot be seen (but inspection at zenith).

898	28/11/2016 09:46	1 WHTM1 all	17.3	90.7	89.0	88.4	88.5	87.6	84.8	91.1	5.0	5.4	5.9	4.7	5.8	5.5	5.6
899	28/11/2016 09:46	1 WHTM1 all	17.3	90.4	89.1	88.7	88.7	87.6	85.3	91.1	5.3	4.9	5.3	4.4	5.4	4.5	5.3
900	28/11/2016 09:47	1 WHTM1 all	17.4	90.9	89.3	88.7	88.7	88.1	85.1	91.3	4.5	4.5	5.0	4.2	4.7	4.3	4.4
901	28/11/2016 09:48	1 WHTM1 all	17.4	90.3	89.0	88.6	88.7	87.9	85.2	91.2	5.4	5.2	5.3	4.3	5.0	4.5	4.8
902	28/11/2016 09:49	1 WHTM1 all	17.4	90.8	89.3	88.8	88.9	87.9	85.2	91.3	5.1	4.8	5.1	4.2	4.8	4.4	4.7
903	28/11/2016 09:50	1 WHTM1 all	17.4	90.8	89.5	89.0	89.1	88.0	85.4	91.3	4.9	4.6	5.2	4.0	4.9	4.2	4.6
averages				90.7	89.2	88.7	88.8	87.9	85.2	91.2	5.0	4.9	5.3	4.3	5.1	4.6	4.9
change since 10/11				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.9	0.9	0.9	0.8	0.9	0.9	1.0
change since August				1.5	1.4	1.4	1.4	1.4	1.4	1.3							

This loss in reflectivity is 50% more than 2 weeks previously. Both this fact and the reflectivity level warrant CO2 cleaning.

Index	Tempr. °C	Reflectivity (%R) wavelength of band (nm)							"Dust Indices" (DI)							
		365	404	464	522	624	760	970	365	404	464	522	624	760	970	
Aluminium Reference values (Haas 1961)		92.0	91.9	91.8	91.6	90.8	88.6	92.4								
current reflectivity shortfall		1.4	2.7	3.1	2.8	3.0	3.4	1.2								
ranges		0.6	0.5	0.6	0.6	0.5	0.6	0.2	0.9	0.9	0.9	0.7	1.1	1.3	1.2	

The shortfall seems large but it is similar to the average for a dusty mirror in August.

The range in reflectivity is LOWER than after Aligal cleaning, although the dust scattering range is similar.

Change in measurement of reference mirror since battery swap is much smaller, indicating the changes in M1 are real.

ref 29/11	84.60	83.70	88.40	90.60	89.50	83.50	87.00
ref 17/11	84.51	83.70	88.44	90.61	89.56	83.32	86.82
difference	0.09	0.00	-0.04	-0.01	-0.06	0.18	0.18

The difference in 2 red wavebands is the largest seen

Note M3 is in a much worse state.

904	28/11/2016 09:51	5 WHTM3 all	17.4	84.9	84.2	84.6	85.3	85.1	83.0	89.7	18.6	17.0	15.9	11.2	11.7	8.7	7.4
		Shortfall from fresh aluminium in M3		7.1	7.7	7.2	6.3	5.7	5.6	2.7							

The first convenient date to clean was 4 December. Mirror now showed the effects of light rain: small water drop stains uniformly all over. It seems likely that the rain fell on the mirror between 28/11 and 4/12 but the inspection on 28/11 may have failed to show up spots. Thin high cloud prevailed during this period.

Measurements immediately before cleaning.

Minimum values highlighted.

Maxima in green

Index	date/time	code	type	Tempr. °C	Reflectivity (%R) wavelength of band (nm)							"Dust Indices" (DI)						
					365	404	464	522	624	760	970	365	404	464	522	624	760	970
906	07/12/2016 10:25	1	WHTM1 all	17.0	89.5	88.0	87.5	87.5	86.6	83.9	89.9	6.3	6.8	7.3	6.2	7.3	7.0	7.2
907	07/12/2016 10:26	1	WHTM1 all	16.9	89.3	88.1	87.7	87.6	86.7	84.2	89.9	6.6	6.5	7.1	5.9	7.1	6.4	6.9
908	07/12/2016 10:27	1	WHTM1 all	16.9	90.1	88.8	88.4	88.6	87.6	85.0	91.0	5.7	5.6	5.9	4.6	5.5	4.8	4.9
909	07/12/2016 10:29	1	WHTM1 all	17.0	90.5	89.3	88.8	88.9	88.0	85.4	91.4	5.5	5.2	5.5	4.3	4.9	4.2	4.4
910	07/12/2016 10:30	1	WHTM1 all	17.1	90.5	89.1	88.6	88.8	88.0	85.3	91.4	5.5	5.3	5.5	4.2	5.0	4.3	4.4
911	07/12/2016 10:31	1	WHTM1 all	17.2	90.5	89.1	88.8	89.0	87.7	85.5	91.2	5.6	5.3	5.6	4.2	5.6	4.1	4.7
912	07/12/2016 10:34	1	WHTM1 all	17.4	90.7	89.2	88.7	88.8	88.1	85.2	91.3	5.0	4.9	5.2	4.1	4.6	4.3	4.3
913	07/12/2016 10:34	1	WHTM1 all	17.6	90.4	89.0	88.5	88.6	87.8	85.0	91.1	5.5	5.4	5.7	4.6	5.2	4.8	4.7
914	07/12/2016 10:36	1	WHTM1 all	17.9	90.2	88.8	88.3	88.4	87.6	84.9	90.9	5.8	5.5	5.8	4.7	5.4	4.9	5.0
915	07/12/2016 10:37	1	WHTM1 all	18.0	90.7	89.3	88.9	89.0	88.1	85.4	91.4	5.2	5.0	5.3	4.1	4.7	4.0	4.1
A	Averages				90.2	88.9	88.4	88.5	87.6	85.0	91.0	5.7	5.6	5.9	4.7	5.5	4.9	5.1
B	Averages, omitting first 2 measurements				90.5	89.1	88.7	88.8	87.9	85.2	91.2	5.4	5.2	5.5	4.3	5.1	4.4	4.5
	Change since 28/11				-0.4	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3	0.6	0.6	0.6	0.4	0.4	0.3	0.2
C	Ranges				1.4	1.3	1.4	1.5	1.5	1.6	1.5	1.6	1.9	2.1	2.1	2.7	3.0	3.1
D	Ranges omitting highlighted minima				0.6	0.5	0.6	0.6	0.5	0.6	0.5	0.8	0.7	0.7	0.6	1.0	0.9	0.9

Note in first quadrant (right hand side at AP3), significantly lower values were measured at 2 positions. Omitting these, range looks more normal.

Reference (gauge) measurements following mirror measurements

916	07/12/2016 12:24	1	WHTM1 all	11.5	84.6	83.7	88.4	90.7	89.6	83.5	86.8	2.4	3.1	2.7	1.5	1.2	1.0	1.1
917	07/12/2016 12:24	1	WHTM1 all	11.8	84.5	83.6	88.4	90.6	89.6	83.4	86.7	2.6	3.2	2.8	1.7	1.3	1.0	1.2
918	07/12/2016 12:25	1	WHTM1 all	12.1	84.5	83.6	88.4	90.6	89.6	83.4	86.7	2.7	3.2	2.8	1.7	1.3	1.0	1.2
	Difference from 29/11				-0.1	-0.1	0.0	0.0	0.1	-0.1	-0.1							

Measurements after cleaning below. Datum no. 931 at 365 nm was invalidated by not setting instrument down before detection.

Index	date/time	code	type	Tempr. °C	Reflectivity (%R)							"Dust Indices" (DI)						
					wavelength of band (nm)							365	404	464	522	624	760	970
919	07/12/2016 14:13	1	WHTM1 all	17.2	90.2	88.9	88.6	88.8	87.7	85.4	91.5	6.7	6.6	6.7	4.9	6.0	4.8	4.8
920	07/12/2016 14:14	1	WHTM1 all	17.3	90.8	89.3	88.9	88.9	88.3	85.5	91.8	5.6	5.4	5.6	4.5	4.9	4.4	4.2
921	07/12/2016 14:15	1	WHTM1 all	17.4	90.6	89.4	89.0	89.1	87.7	85.7	91.7	6.1	5.5	5.7	4.3	5.9	4.1	4.4
922	07/12/2016 14:16	1	WHTM1 all	17.5	89.4	87.7	88.0	87.7	87.2	84.4	90.5	7.0	7.4	6.8	6.5	6.9	6.5	7.0
923	07/12/2016 14:18	1	WHTM1 all	17.8	91.2	89.8	89.5	89.6	88.8	86.2	92.3	5.3	5.1	5.0	3.7	4.0	3.2	3.0
924	07/12/2016 14:19	1	WHTM1 all	18.0	91.1	89.7	89.4	89.4	88.7	86.1	92.2	5.3	4.9	4.9	3.8	4.1	3.2	3.2
925	07/12/2016 14:20	1	WHTM1 all	18.3	90.6	89.2	88.9	88.9	88.2	85.5	91.6	6.3	6.1	6.2	5.0	5.2	4.6	4.5
926	07/12/2016 14:21	1	WHTM1 all	18.4	91.2	89.7	89.2	89.4	88.6	85.9	92.1	5.4	5.5	5.4	4.1	4.4	3.6	3.4
927	07/12/2016 14:23	1	WHTM1 all	18.6	90.6	89.1	89.1	89.1	88.2	85.8	91.8	5.8	6.1	5.8	4.5	5.2	3.9	3.9
928	07/12/2016 14:24	1	WHTM1 all	18.9	91.5	90.0	89.5	89.6	88.9	86.1	92.2	4.9	4.8	4.8	3.8	3.9	3.3	3.3
929	07/12/2016 14:25	1	WHTM1 all	19.0	91.2	89.7	89.3	89.5	88.6	85.9	92.1	5.3	5.0	5.1	3.8	4.3	3.6	3.4
930	07/12/2016 14:26	1	WHTM1 all	19.3	90.8	89.6	89.2	89.3	88.3	85.8	91.8	5.5	5.2	5.2	4.1	4.7	3.7	3.8
931	07/12/2016 14:27	1	WHTM1 all	19.4		88.5	88.1	88.1	87.2	84.6	90.5	6.3	6.3	6.8	5.4	6.4	5.6	5.8
932	07/12/2016 14:29	1	WHTM1 all	19.8	90.7	89.2	88.8	88.9	88.0	85.3	91.4	5.6	5.4	5.7	4.5	5.1	4.4	4.3
933	07/12/2016 14:30	1	WHTM1 all	19.9	90.9	89.5	89.1	89.3	88.4	85.7	91.9	5.4	5.2	5.3	4.0	4.7	3.7	3.7
934	07/12/2016 14:31	1	WHTM1 all	20.1	90.6	89.1	88.7	88.8	88.0	85.4	91.4	5.6	5.5	5.7	4.5	5.2	4.3	4.5
A'	Averages				90.8	89.3	89.0	89.0	88.2	85.6	91.7	5.8	5.6	5.7	4.5	5.1	4.2	4.2
	Avg. improvement by CO2 (A'-A)				0.5	0.4	0.5	0.5	0.6	0.6	0.7	0.1	0.1	-0.2	-0.2	-0.5	-0.7	-0.9
B'	Average, omitting located minima				90.9	89.5	89.1	89.2	88.4	85.8	91.9							
	Improvement omitting minima (B'-B)				0.5	0.4	0.5	0.4	0.5	0.5	0.6							
C'	Ranges				2.1	2.3	1.5	1.9	1.7	1.8	1.8	2.1	2.6	2.0	2.8	3.0	3.3	4.0
D'	Range omitting highlighted extremes				0.6	0.6	0.7	0.7	1.0	0.8	0.8							

The average improvement is about half the size of the usual. The range is 3 to 4x typical, but omitting 4 extreme measurements, approaches July values. Note that the lowest values before and after cleaning are almost identical. This indicates that the CO2 was unable to improve reflectivity much where raindrops had stained surface. Visual inspection shows raindrops look identical after cleaning. **See photo on next page**
 Even looking at the most optimistic values, the improvement in any given waveband is less than 1%.

Photo of raindrop stains on WHT primary mirror as seen under oblique lamp illumination through the mirror cover porthole (no. 3)
Note the rest of the mirror is dark because the mirror petals are shut. The geometric shape seen is the reflection of petal boundaries.
The minimum values of Reflectivity above are likely to correspond to measurement at the precise location of a raindrop.



