

REPORT

Intercomparison of Near Infrared Diffuse Reflectance Measurements

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by D H Nettleton, Head, Centre for Optical and Environmental Metrology

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1 INTRODUCTION

The currently available absolute scale for diffuse reflectance measurements in the near infrared is provided by values for the absolute diffuse reflectance of barium sulphate as reported by Morren et al in 1972¹. The values are quoted at 100 nm intervals for four different samples of barium sulphate from different suppliers. To form a scale the quoted values must be assumed to be representative for all like samples.

The NPL scale of diffuse reflectance in the near infrared is based on the Morren scale. To avoid a discontinuity with the NPL scale for diffuse reflectance in the visible region the Morren values as quoted provide the scale above 1200 nm, and between 800 nm and 1200 nm the scale is interpolated between the visible scale and the Morren scale to ensure a smooth transition region. All NPL calibrations of diffuse reflectance in the near infrared are based on this hybrid scale. This is not a satisfactory situation as all barium sulphate pressings will, in reality, be different and NPL is working to develop the National Reference Reflectometer² - an instrument able to make absolute diffuse reflectance measurements from 320 nm to 2500 nm. This instrument will then define the absolute scale for diffuse reflectance across the entire wavelength range.

Near infrared diffuse reflectance measurements are used widely in industry; as a tool for chemical analysis - particularly in the pharmaceutical and food sectors, for military applications, and for satellite earth observation. In industry near infrared diffuse reflectance measurements are made on spectrophotometers that have a scale either based on that described above (disseminated via a calibrated transfer standard) or, more commonly, a scale based on the assumption that a particular white reference material has 100% reflectance across the entire near infrared range. This reference material is scanned with the spectrophotometer to set the 100% level, against which sample measurements are then made. Not only is an error introduced to the subsequent sample measurements due to the fact that the white reference material is not 100% reflecting but, several different white materials of differing reflectance are in use to set the 100% level. This leads to further discrepancies in values for the diffuse reflectance of samples.

NPL has conducted an intercomparison of near infrared diffuse reflectance measurements to determine the variation in measurements across industry. 13 industrial companies and one university participated in the intercomparison.

2 THE INTERCOMPARISON

The 14 participants in the intercomparison were divided into three groups and a set of samples was circulated around each group. Two groups measured diffuse reflectance in the integrating sphere geometries (specular included and/or specular excluded) and one group in the 0/45 geometry. The sets of samples were made up of four neutral spectralon discs: white; black; light grey; dark grey and an NPL-BCRA ceramic white tile (see appendix 3). The integrating sphere geometry sets contained an additional front surface mirror to identify any integrating sphere errors. The samples were calibrated before initial distribution on a Perkin Elmer Lambda 19 spectrophotometer against the NPL scale described above. The samples were returned to NPL between participants and were checked for changes by visual inspection and by measuring the diffuse reflectance at a number of wavelengths. At the end of the intercomparison the samples were remeasured to determine if any change in their reflectance had occurred over the course of the study.

Participants were asked to measure the centre of each sample at 50 nm intervals across the wavelength range 800 nm - 2500 nm or as much of this range as was possible on their instrumentation. They were asked to use the method they would normally apply to such measurements and to provide details of the white reference used to set the 100% level for the measurements. Instructions were also supplied on the method of reporting the results to NPL. Details of the participants, instruments used and sample sets are contained in appendices 1-3. Six different manufacturers equipment and eight different models of instrument were used in the intercomparison. All except one of these were monochromator based scanning spectrophotometers and most models were capable of making measurements across the entire 800 nm to 2500 nm wavelength range. The data returned by the participants was used to calculate differences from the NPL values for sample reflectances. The participant data was also renormalised to the NPL scale using the white spectralon values.

3 RESULTS AND DISCUSSION

3.1 Raw Data

Results were received from 12 of the 14 participants. Two participants were unable to make the measurements as planned due to other commitments. Participants are identified by a randomly designated laboratory number known only to NPL and to each individual participant. Two participants (one in the sphere geometries and one in the 0/45 geometry) made measurements on two different instruments and returned two sets of results - these have been treated separately resulting in a total of 14 data sets reported here. Ten data sets are reported for the sphere geometries and eight of these include both the specular included and the specular excluded geometries - one participant measured the specular included only and one measured the specular excluded only. Four data sets are reported for the 0/45 geometry. Tables 1-3 in appendix 4 give the differences in reflectance values as measured by each participant from the NPL values for each sample. The differences are given as participant value minus NPL value. Tables 1 and 2 give the differences for the specular included and excluded geometries respectively (results from sets GW96 and GY96 have been combined) and table 3 gives the differences for the 0/45 geometry. The difference values are shown for each participant and for each sample. No difference values are shown for the parts of the wavelength range not measured by participants. The same results are also presented in graph form in figs 1a - 17b. (Note: the scales on the figures vary.) There are two graphs per sample, one showing participant measured reflectance values and the other showing differences from the NPL values for each sample. In addition, the NPL values are shown on the reflectance plots and the NPL uncertainties are shown on the difference plots.

For reference the uncertainties on the NPL values for the samples are given in tables 7a and 7b in appendix 4. These range from 0.30% for the black spectralon (0/45, 800 nm - 2000 nm range) to 2.75% for white spectralon (0/45, 2010 nm - 2500 nm range). Uncertainties of this level are quoted on NPL near infrared transfer standards. This compares with uncertainties of approximately 0.6% for a white sample in the visible region. The near infrared uncertainties are dominated by the type B contribution associated with the scale itself. The uncertainty in the scale takes into account knowledge of detector noise in near infrared measurements, differences in the Morren and NPL scales in the 800 nm - 900 nm region, and the Morren¹ uncertainties. For the range 800 nm - 1800 nm Morren quotes that 'an accuracy greater than 1% is not claimed' and no assessment of uncertainty is provided for wavelengths above 1800 nm. The uncertainty in the NPL near infrared scale must be sufficiently large to cover all these factors. Any industrial measurements based on the NPL

scale will inevitably have uncertainties greater than those quoted for the NPL transfer standards used to disseminate the scale.

Differences between the participant diffuse reflectance values and the NPL values (in percent reflectance) ranged from 0.00% to 41.74% for the sphere geometry measurements and from 0.10% to 88.28% for the 0/45 geometry measurements. The highest difference values were for a sample of white spectralon in both cases.

A detailed description of the results is given below. The sphere geometries and the 0/45 geometry are considered separately. For the sphere geometries the results are separated into the measurements on the diffuse samples (the four spectralon samples and the white tile) and on the mirror. For most participants, on the diffuse samples, the largest difference from NPL values was for the white spectralon with the differences for samples of lower reflectance smaller in proportion to their reflectance. Where this was not so, the largest difference was for the light grey sample. It is the largest difference that is considered below.

Measurements in the Sphere Geometries - Diffuse Samples:

- The differences between participant values and the NPL values range from 0.00% to 41.74%. The 41.74% value was lower than the NPL value and was for the specular excluded geometry.
- The two data sets received from lab nos. 6 and 16 had differences from the NPL values of less than 2% reflectance. Both sets were made by the same participant and the values are all higher than NPL values for the white spectralon and white tile, but are both higher and lower for the other samples in the set. The measurements were made on two different high quality scanning spectrophotometers and NPL calibrated transfer standards were used to set the scale on both instruments.
- The data from lab. no. 2 had differences from the NPL values of up to 4%. In general the participant values are higher than the NPL values but not in all cases. This participant used a NIST calibrated transfer standard and on a high quality scanning instrument. The measurement results agree to the NPL values to within 2% below 1800 nm, with the larger differences occurring above 1800 nm.
- The data from lab nos. 3, 10 and 13 had differences from the NPL values of up to 10%. Two of these participants used high quality scanning instruments with a piece of white spectralon to set the 100% level. The other participant used a diode array instrument (measurements up to 1100 nm only) calibrated with white tile, believed to be traceable to NIST, and supplied with the instrument. Apart from the black sample, all participant values were higher than the NPL values.
- The data from lab nos. 5, 8 and 14 had differences from the NPL values of up to 30%. All used high quality scanning instruments with the 100% level set using barium sulphate. Two of the data sets agree with the NPL values to within 2.5% below 1300 nm, with the differences increasing towards the longer wavelengths. All participant values were higher than the NPL values.
- The data from lab no. 11 had differences from the NPL values of up to 42%. No information was supplied as to the method used to set the 100% level. These values were

all lower than the NPL values except for measurements on the white tile in the range 1250 nm to 1900 nm.

Measurements in the Sphere Geometries - Mirror:

- Differences from NPL for the mirror measurements in the specular included geometry range from 1.03% to 29.48%. NPL values in this geometry range from 82% to 97% depending on wavelength.
- Differences from NPL for the mirror measurements in the specular excluded geometry range from 1.75% to 22.90%. NPL values in this geometry range from 0% to 3.5% depending on wavelength.
- The data sets with high and low difference values for the mirror measurements do not necessarily correspond to those having low or high difference values for the diffuse samples. One data set, lab. no. 16, with good agreement for the diffuse samples (in the 2% range) has the worst disagreement for the mirror values in the specular excluded geometry.

Measurements in the 0/45 Geometry:

- The differences between participant values and the NPL values range from 0.10% to 88.28% for the 0/45 geometry measurements.
- The data set from lab. no. 4 had differences from the NPL values of less than 8.82% reflectance. In most cases the values are lower than the NPL values. A white ceramic tile was used to set the 100% level.
- Three of the data sets, lab. nos. 7, 12 and 15, have maximum differences from the NPL values of 37.08%, 49.13% and 88.28% respectively on the white spectralon. All values are higher than the NPL values and all participants used a white tile to set the 100% level.

The results described above show differences from the NPL values corresponding to the method of setting the 100% level. The best agreement to NPL values was found for those measurements made against a scale traceable to the NPL scale (via NPL calibrated transfer standards). This is followed in order of increasing difference from the NPL values by those using white spectralon, barium sulphate and white ceramic tile to set the 100% level. Those using a white material 'as is' to set the 100% level assume that the material actually has 100% reflectance across the entire wavelength range. Therefore the closer the reflectance of the white material to 100% the better the agreement to the NPL values. Figure 35, appendix 5, shows the diffuse reflectance values, measured against the NPL scale, of three different white materials, spectralon, barium sulphate and ceramic tile, across the wavelength range 800 nm to 2500 nm. Spectralon has the highest reflectance and the flattest spectral profile with a reflectance of the order of 99% at 800 nm decreasing to 97% at 2500 nm. Barium sulphate has a similar reflectance to spectralon between 800 nm and 1300 nm but decreases from that point until at 2500 nm the reflectance is only 88%. The white ceramic tile has approximately 84% reflectance from 800 nm to 2200 nm, thereafter decreasing to 74% at 2500 nm.

High reflectance values for the mirror for the specular excluded geometry indicate the existence of a gloss trap error. This is caused when the specular beam is not aligned correctly

to the gloss trap and therefore not all of the specular light leaves the sphere. The results show that instruments with good agreement to the NPL values do not necessarily have good agreement for the mirror reflectance values. This demonstrates that sphere errors can be present even when care is taken in calibrating the reflectance scale. Conversely, instruments measuring against an inappropriate scale may not have sphere errors.

3.2 Renormalisation to NPL Scale

To determine to what extent the variation in measurement results was due to the use of different methods to set the 100% level of the instrument, the data for each participant was renormalised to the NPL scale. This was carried out for the data for each participant by dividing the data for each sample in the set by the white spectralon data (as measured by the participant) and multiplying by the NPL values for that white spectralon sample. The differences from NPL values after renormalisation are shown in tables 4 to 6, again as participant data minus NPL data. Plots of the renormalised reflectance values and renormalised differences from NPL are shown for each participant in figures 18a to 34b. The results are described below.

Measurements in the Sphere Geometries - Diffuse Samples:

- After renormalisation the data for nine of the ten data sets (all except lab. no. 11) had differences from the NPL values of 5% or less.
- There was no significant improvement in the results for the measurements made against the NPL scale.
- One data set, lab. no. 11, had differences of less than 2% for the spectralon samples but had differences of up to 49% for the white tile. This was a result of an anomaly prior to renormalisation whereby white tile had reasonable reflectance values but the white spectralon had lower reflectance values than for the tile. The darker spectralon samples had correspondingly low values.

Measurements in the Sphere Geometries - Mirror:

- The mirror difference values were not significantly improved by renormalisation and, in fact, some increased.

Measurements in the 0/45 Geometry:

- After renormalisation the data for three of the data sets (lab. nos. 4, 7 and 15) had differences from the NPL values of 5% or less for all samples. The other data set, lab. no. 12, had differences below 5% for all samples except the white tile.
- After renormalisation the participant values were lower than the NPL values for all samples except the white tile.

The results above indicate that renormalisation to the NPL scale improved the reflectance values for most diffuse samples. Therefore traceability to the NPL scale for near infrared diffuse reflectance would improve measurement agreement across industry. The high mirror reflectance values indicate the presence of sphere errors in many of the instruments used.

At the end of the intercomparison the samples were remeasured at NPL to determine if there had been any changes to the reflectance values over the course of the study. The two integrating sphere sets showed no changes greater than 0.5% for all samples except the dark grey spectralon (across the entire wavelength range) and the mirror (in the range 2100 nm to 2500 nm). In the specular excluded geometry the dark grey spectralon sample in set GW96 had reflectances of up to 0.8% higher at the end of the study. There was no similar difference in the specular included measurements. The dark grey spectralon sample in set GY96 showed an increase in reflectance of up to 1.2% in both geometries. In both sets the mirror showed a decrease in reflectance between 2100 nm and 2500 nm of up to 2.7%. Set GX96 has not yet been returned for remeasurement.

4 SUMMARY

The raw data results show significant variations in the value of diffuse reflectance measured across industry on the same samples. This will often lead to disagreements between suppliers and purchasers of products through either the incorrect acceptance of out of specification items or, conversely, the incorrect rejection of items within specification. This may occur at any point in the supply chain.

The use of a similar reflectance white material across industry would decrease the variation in results. However, this solution alone is not enough - white standards made of the same material are not identical and may change with time and usage, and as no material is 100% reflecting anomalous results of greater than 100% are possible on some samples.

In this intercomparison, not surprisingly, the lowest discrepancies from the NPL values are found when an NPL calibrated transfer standard was used to determine the scale. Renormalising the other results to the NPL scale greatly decreased the variability in the measurements bringing agreement to within 5% for most participants. The incidence of sphere errors was high. The use of available methods to determine different classes of sphere errors would make their correction possible.

As stated earlier the NPL scale is based on measurements made over 25 years ago in Belgium and the uncertainties are large. It is intended that an absolute scale for near infrared diffuse reflectance based on the National reference Reflectometer at NPL will lead to reduced uncertainties and thereby the opportunity for further improvements in measurement agreement.

5 BIBLIOGRAPHY

1. *A study of the reflection factor of usual photometric standards in the near infrared*, L Morren et al, Lighting Research and Technology, Vol 4 No 4, 1972
2. *Reference instruments for spectrophotometry at NPL*, G H C Freeman, Spectrophotometry, Luminescence and Colour, C Burgess and D G Jones (eds.), 1995 Elsevier Science

6 APPENDICES

APPENDIX 1 - Participants

Organisations that participated in the intercomparison:

Bran & Luebbe Ltd
 Bridport Aviation Products
 Campden and Chorleywood Food Research Association
 Defence Clothing and Textiles Agency, Colchester
 Defence Evaluation and Research Agency, Farnborough
 Infrared Engineering Ltd
 Kodak Ltd
 Pfizer Central Research
 Rohm GmbH
 SmithKline Beecham
 University of York, Department of Chemistry
 Unilever Research, Port Sunlight
 Varian Ltd
 VitapruF

APPENDIX 2 - Instrumentation

Instrumentation used to make measurements in the intercomparison:

Bran and Luebbe 500
 Cary 500
 Cary 5E
 Hitachi U3400
 Hunterlab Ultrascan XE
 NIR Systems 6500
 Perkin Elmer Lambda 9
 Perkin Elmer Lambda 19

APPENDIX 3 - Samples

Sets GW96 and GY96:

White spectralon disc (50 mm in diameter)
 Light grey spectralon disc
 Dark grey spectralon disc
 Black spectralon disc
 White ceramic tile (102 mm square)
 Front surface mirror (50 mm square)

Set GX96:

White spectralon disc (50 mm in diameter)
 Light grey spectralon disc
 Dark grey spectralon disc
 Black spectralon disc
 White ceramic tile (102 mm square)

APPENDIX 4 - Tables

Table 1. Specular Included Geometry.
% Reflectance differences from NPL values.

Sample	White Spectralon									Light Grey Spectralon								
Lab No.	10	14	13	3	5	8	6	16	2	10	14	13	3	5	8	6	16	2
Wavelength																		
800	0.79	12.92	0.15	1.04	1.13	1.13	-0.35	0.42	0.45	2.37	6.36	0.69	0.42	0.73	-2.16	-0.61	0.32	-0.03
850	0.69	13.07	0.52	1.38	1.07	1.61	-0.17	-0.80	-0.50	1.87	5.62	0.43	0.16	-1.16	-2.49	-0.75	-0.63	-0.65
900	0.45	13.18	0.65	1.51	1.20	1.70	-0.07	0.92	1.10	2.12	6.50	1.34	0.85	0.89	-1.94	-0.21	1.45	0.16
950	-0.24	11.82	-0.08	0.66	0.84	0.82	0.20	0.22	0.77	1.60	6.15	1.13	0.45	0.13	-2.23	-0.26	0.22	0.00
1000	-0.22	12.91	0.01	0.70	0.68	1.39	-0.11	0.50	0.70	1.57	6.45	1.63	0.53	-0.03	-2.57	-0.90	0.18	-0.18
1050	-0.07	12.29	0.21	0.92	0.79	1.05	0.20	0.62	0.62	1.75	6.82	2.26	0.79	-0.01	-2.22	-0.85	0.18	-0.05
1100	0.08	11.70	0.18	1.00	1.32	1.42	0.63	0.75	0.93	1.81	6.65	2.50	0.91	0.13	-2.31	-1.46	0.07	-0.12
1150	0.61	13.30		1.50	1.50	1.62	0.71	0.76	0.80	1.52	6.86		0.56	0.12	-2.43	-1.38	-0.06	-0.36
1200	0.77	13.47		1.58	1.98	2.22	0.47	0.67	1.34	2.39	7.44		1.29	0.88	-1.79	-1.01	0.22	0.41
1250	0.76	14.13		1.85	2.00	2.15	0.40	0.44	1.19	2.29	7.79		1.32	0.77	-1.79	-1.16	-0.01	0.25
1300	1.32	13.83		2.25	2.48	2.19	0.64	0.93	1.38	2.50	7.87		1.51	1.02	-1.71	-0.86	0.08	0.29
1350	1.50	14.88		2.54	3.69	3.46	0.68	0.88	1.82	2.45	8.46		1.48	1.86	-0.91	-0.63	0.25	0.81
1400	1.77	15.45		2.42	5.97	4.68	0.43	0.32	1.87	2.88	8.40		1.61	3.22	0.11	-0.57	-0.07	0.75
1450	0.12	14.56		0.95	7.15	4.73	0.41	0.27	-0.04	1.45	7.91		0.42	3.62	-0.41	-0.98	-0.30	-0.89
1500	1.11	16.09		2.16	7.59	5.20	0.76	1.08	1.10	2.24	8.89		1.25	4.02	0.15	-0.19	0.39	0.29
1550	0.87	15.86		1.90	6.68	4.52			1.55	2.35	9.17		1.44	3.56	-0.16			0.41
1600	0.77	14.99		1.66	6.07	3.96			1.06	2.66	9.31		1.56	3.46	-0.46			0.34
1650	0.89	16.03		2.04	6.24	4.01			0.82	2.48	9.31		1.55	3.49	-0.13			0.13
1700	1.01	15.66		2.12	6.57	4.26			0.85	2.31	8.81		1.41	3.58	-0.18			-0.19
1750	0.63	16.05		1.68	7.88	5.14			0.64	2.22	9.15		1.22	4.31	0.32			-0.02
1800	1.08	17.33		2.49	9.57	6.85			1.88	2.86	10.44		1.96	5.42	1.14			0.39
1850	3.08	19.11		4.15	11.55	8.04			2.69	3.70	10.68		2.70	7.03	2.09			0.67
1900	1.03	19.82		2.23	16.45	11.54			0.56	2.91	11.49		1.60	10.97	4.10			-0.52
1950	-1.13	19.47		0.06	20.69	12.90			-2.63	1.04	11.66		0.03	13.05	5.07			-0.92
2000	1.42	19.53		2.97	18.94	11.95			0.15	2.78	11.72		1.80	11.75	4.61			-0.50
2050	2.84	20.03		4.61	17.48	10.84			0.93	3.91	12.71		3.09	10.95	4.30			0.33
2100	3.16	19.79		5.28	15.42	10.15			1.75	4.34	12.16		3.60	10.43	3.54			-0.44
2150	4.26	20.51		6.28	15.57	9.91			2.83	5.25	12.99		4.39	11.36	4.42			1.00
2200	2.05	19.97		3.88	15.98	9.97			-0.28	3.35	12.38		2.46	10.73	4.42			0.66
2250	1.91	21.22		3.59	16.11	11.38			0.22	3.34	12.59		2.11	10.72	4.35			-0.80
2300	1.62	22.40		3.21	15.96	10.63			-1.84	3.31	13.34		2.25	11.44	4.27			-2.92
2350	3.06	22.51		4.89	17.54	10.45			1.72	4.47	13.88		3.62	12.37	4.38			0.55
2400	3.09	23.50		5.12	20.82	15.29			-0.17	4.29	14.69		3.31	13.72	6.71			-1.56
2450	4.14	26.15		5.88	25.19	17.89			-3.60	3.96	15.28		2.91	15.95	7.85			-3.79
2500	4.19	27.98		5.78	28.10	18.39			0.44	5.64	17.97		4.27	19.15	12.17			-3.97

Lab No. 2 measured in the Specular Included geometry only.

Table 1. Specular Included Geometry.
% Reflectance differences from NPL values,

Sample Lab No.	Dark Grey Spectralon										Black Spectralon									
	10	14	13	3	5	8	6	16	2		10	14	13	3	5	8	6	16	2	
Wavelength																				
800	1.08	2.19	0.98	0.79	1.01	-0.32	0.61	0.74	0.40		-0.19	0.34	0.02	0.29	0.09	0.46	0.03	-0.19	0.10	
850	0.94	2.01	1.02	0.91	0.75	-0.66	0.66	0.90	0.12		-0.09	0.43	0.11	0.45	0.09	0.28	0.08	-0.24	0.18	
900	1.17	2.65	1.44	1.20	1.49	-0.20	1.21	1.83	0.95		0.02	0.16	0.23	0.69	0.80	0.34	0.49	0.12	1.04	
950	1.09	2.58	1.69	1.37	0.69	-0.55	0.65	0.72	0.40		0.17	0.08	0.36	0.87	0.04	0.15	0.13	-0.38	0.19	
1000	0.99	2.70	1.99	1.40	0.96	-0.65	0.60	1.10	0.81		0.10	0.10	0.20	0.70	0.33	0.20	0.19	-0.29	0.33	
1050	1.37	2.67	2.50	1.63	1.12	-0.38	0.76	1.32	0.84		0.19	0.54	0.45	0.97	0.33	0.36	0.23	-0.31	0.29	
1100	1.08	2.47	2.26	1.39	0.88	-0.67	0.20	0.83	0.54		0.08	0.86	0.32	0.82	0.24	0.26	0.10	-0.53	0.31	
1150	1.69	3.46		1.88	1.27	-0.07	0.49	1.06	0.87		-0.15	0.75		0.56	0.24	0.15	0.01	-0.53	0.33	
1200	1.14	3.04		1.49	1.03	-0.44	0.08	0.60	0.50		-0.27	-0.21		0.47	0.23	0.16	0.12	-0.51	0.31	
1250	1.19	3.01		1.41	1.19	-0.42	0.22	0.79	0.68		0.21	0.55		0.97	0.19	0.12	0.05	-0.81	0.32	
1300	1.61	3.35		1.86	1.46	-0.12	0.44	0.99	0.82		-0.39	-0.19		0.50	0.36	0.24	0.17	-0.59	0.41	
1350	1.69	3.47		1.89	1.61	0.08	0.68	0.66	0.93		0.10	0.49		0.91	0.10	-0.01	-0.13	-0.94	0.13	
1400	2.11	4.24		2.07	2.31	0.76	0.67	0.76	1.08		0.20	0.20		1.01	0.82	0.79	0.56	0.05	0.90	
1450	1.35	3.76		1.44	2.54	0.65	0.71	1.00	0.56		-0.37	0.42		0.46	0.20	0.05	-0.03	-0.53	0.30	
1500	1.68	3.93		1.81	2.25	0.41	0.55	0.95	0.45		-0.07	1.03		0.92	0.50	0.35	0.15	-0.28	0.57	
1550	1.66	3.67		1.61	2.14	0.24			0.63		0.13	0.74		1.00	0.37	0.21			0.38	
1600	1.56	4.20		1.66	2.21	0.35			0.62		-0.25	0.13		0.66	0.67	0.61			0.65	
1650	1.49	3.90		1.58	2.18	0.14			0.42		-0.16	0.32		0.78	0.29	0.09			0.27	
1700	1.88	4.17		1.75	2.37	0.45			0.40		0.03	0.99		0.91	0.41	0.19			0.34	
1750	1.81	4.48		1.82	2.44	0.58			0.46		0.01	0.70		0.96	0.31	0.12			0.35	
1800	1.56	4.67		1.58	2.72	0.42			0.24		0.25	0.30		1.09	0.65	0.54			0.28	
1850	1.72	4.41		1.91	3.74	1.33			0.66		0.12	0.38		1.05	0.96	0.60			0.37	
1900	1.86	5.48		1.84	5.56	1.62			0.02		0.30	0.65		1.15	1.91	0.57			0.43	
1950	0.94	5.15		1.08	6.34	2.15			0.42		0.59	0.86		1.39	1.89	0.73			1.34	
2000	1.86	5.53		1.89	5.85	2.21			0.31		0.16	0.77		1.13	1.32	0.14			0.44	
2050	2.22	5.58		2.38	5.57	1.69			0.63		0.07	0.15		1.01	1.34	0.94			0.21	
2100	1.95	5.52		1.95	5.23	1.86			0.63		0.25	0.83		1.21	1.75	0.88			-0.63	
2150	2.01	5.03		2.12	5.62	2.59			1.31		0.19	0.44		1.15	1.76	0.31			0.69	
2200	1.57	4.96		1.59	5.32	1.50			0.17		-0.32	0.44		0.62	1.54	-0.01			0.22	
2250	1.61	5.35		1.38	5.41	2.32			-0.35		0.08	0.98		0.92	1.75	0.46			-0.57	
2300	1.78	5.96		1.86	5.84	1.71			-1.06		0.48	1.33		1.41	2.24	0.71			0.32	
2350	2.23	5.74		2.37	6.36	2.62			0.35		0.36	1.31		1.55	1.60	0.57			1.35	
2400	2.68	7.10		2.63	7.36	2.18			0.97		0.96	2.76		1.94	2.88	1.11			0.49	
2450	2.94	8.45		2.67	8.94	5.31			0.30		0.66	2.37		1.24	2.52	3.21			0.83	
2500	2.02	8.11		1.26	8.54	3.02			-1.83		0.10	1.31		-0.01	2.17	-1.04			1.49	

Lab No. 2 measured in the Specular Included geometry only.

Table 1. Specular Included Geometry.
% Reflectance differences from NPL values,

Sample Lab No.	White Tile										Mirror									
	10	14	13	3	5	8	6	16	2		10	14	13	3	5	8	6	16	2	
Wavelength																				
800	3.91	10.00	0.56	1.10	0.86	-0.13	0.36	-0.08	0.92		3.79	6.56	-0.66	-0.44	-4.19	19.30	0.63	0.69	1.16	
850	4.02	10.00	0.76	1.24	-0.29	0.73	0.02	-0.41	0.98		2.88	6.44	-1.03	-0.73	-4.90	24.43	-0.10	0.80	0.68	
900	0.60	10.45	1.00	1.54	0.41	0.68	0.63	0.76	1.15		-0.24	6.76	-0.85	-0.58	-5.46	25.00	-1.37	-4.63	1.38	
950	-0.15	9.64	0.66	0.99	0.33	0.36	0.51	0.57	1.12		-1.08	6.86	-0.91	-0.87	-6.13	25.99	-0.52	-3.36	1.45	
1000	-0.05	10.34	1.08	1.22	0.24	-0.06	0.16	0.46	0.98		-1.26	6.88	-0.93	-1.04	-6.70	25.70	-1.13	-3.73	1.37	
1050	0.00	10.15	1.17	1.21	0.58	0.05	0.39	0.77	1.12		-0.86	7.29	-0.55	-0.70	-6.85	25.65	-1.34	-4.15	0.88	
1100	-0.02	9.94	1.11	1.21	0.68	0.29	0.27	0.63	1.13		-1.11	7.12	-1.00	-0.83	-6.68	25.64	-1.56	-4.13	1.14	
1150	0.43	10.31		1.54	0.79	0.26	0.32	0.57	0.88		-0.76	6.89		-0.77	-6.70	26.70	-1.55	-4.06	1.21	
1200	0.78	10.85		1.82	1.18	1.02	0.11	0.44	1.31		-0.93	7.22		-0.87	-6.76	27.11	-1.92	-4.82	1.51	
1250	0.52	11.59		1.84	1.54	0.90	0.47	0.60	1.61		-1.07	7.75		-0.86	-6.84	25.29	-2.13	-4.99	1.32	
1300	0.72	11.06		1.75	1.48	0.77	0.28	0.47	1.20		-1.32	7.75		-0.91	-7.03	24.96	-2.33	-4.92	1.13	
1350	1.33	12.31		2.65	2.81	1.88	0.39	0.37	1.66		-1.16	7.90		-0.85	-6.90	25.98	-3.13	-6.11	0.77	
1400	1.49	12.15		2.51	4.91	3.39	0.49	0.56	1.92		-0.92	7.73		-1.13	-5.42	29.62	-3.29	-7.39	1.08	
1450	0.14	11.77		1.19	6.32	3.83	0.66	0.82	0.59		-1.11	7.12		-0.86	-3.87	28.66	-1.41	-6.41	1.25	
1500	0.78	12.88		2.14	6.38	3.88	0.81	0.71	1.75		-1.01	7.47		-0.66	-4.40	27.59	-2.42	-7.21	1.51	
1550	0.69	12.61		1.94	5.87	3.36			1.93		-1.42	7.73		-0.95	-5.01	27.95			1.25	
1600	0.63	12.57		1.95	5.16	2.85			1.31		-1.20	7.69		-0.72	-5.48	26.36			1.09	
1650	0.77	12.58		2.07	5.06	2.79			1.08		-1.05	8.48		-0.63	-5.00	27.45			1.34	
1700	0.92	13.20		2.25	5.53	3.26			1.45		-1.09	7.83		-0.83	-5.10	29.14			1.45	
1750	0.94	13.41		2.27	6.35	3.70			1.22		-1.01	8.01		-0.69	-4.67	29.48			1.08	
1800	0.97	14.07		2.54	7.85	4.81			1.76		-1.23	8.18		-0.79	-4.04	28.03			1.31	
1850	2.46	15.00		3.90	9.77	6.41			2.90		-1.35	7.89		-1.46	-3.56	27.99			0.07	
1900	0.31	15.41		1.98	13.97	8.67			1.35		-0.98	6.88		-0.97	-1.14	28.35			0.49	
1950	-1.15	15.57		0.21	17.62	9.95			-1.19		-0.92	6.61		-0.67	1.97	26.97			1.33	
2000	0.99	16.27		2.63	16.27	9.57			0.35		-1.04	6.92		-0.97	0.63	26.56			-0.59	
2050	2.16	16.53		4.09	14.81	8.60			0.73		-1.26	7.53		-1.78	-1.02	26.67			-1.60	
2100	2.55	16.35		4.56	13.02	7.59			0.77		-0.92	7.38		-1.84	-2.08	26.12			-2.12	
2150	3.44	16.86		5.65	13.12	8.04			1.49		-0.96	8.22		-2.25	-1.76	26.20			-2.28	
2200	1.57	15.55		3.64	12.82	7.88			0.05		-1.31	8.03		-1.51	-1.80	26.25			-1.99	
2250	0.97	15.75		2.85	12.91	7.99			0.20		-0.78	8.21		-1.35	-0.93	24.65			-1.96	
2300	0.82	16.68		2.70	12.71	8.54			-3.00		-0.96	8.52		-1.68	-2.88	23.13			-3.49	
2350	2.12	17.00		4.10	14.22	10.07			-2.67		-0.56	8.81		-1.78	-2.11	20.46			-5.25	
2400	2.24	17.42		4.53	16.21	9.48			-3.53		-1.10	8.42		-2.35	-1.24	21.20			-8.65	
2450	2.22	18.25		4.31	20.00	13.35			-1.12		-0.75	8.01		-2.09	0.19	18.47			-3.62	
2500	1.87	18.32		3.86	21.96	10.11			-2.43		-0.69	8.21		-2.09	1.84	18.06			3.90	

Lab No. 2 measured in the Specular Included geometry only.

Table 2. Specular Excluded Geometry.
% Reflectance differences from NPL values.

Sample Lab No.	White Spectralon										Light Grey Spectralon									
	10	14	13	3	5	8	6	16	11	10	14	13	3	5	8	6	16	11	10	14
Wavelength																				
800	0.64	13.05	3.65	1.02	1.28	1.30	-0.24	-0.72	-40.94	2.24	6.97	5.27	0.48	1.22	1.43	-0.77	-0.40	-25.70	2.24	6.97
850	1.17	13.70	3.78	1.21	1.85	2.21	-0.09	0.51	-41.74	2.65	7.66	5.66	0.83	2.01	1.27	-0.46	0.11	-26.26	2.65	7.66
900	0.70	12.97	3.50	0.99	-0.45	0.98	-0.51	-0.01	-40.47	2.40	7.16	5.88	0.72	0.16	0.93	-0.76	-1.20	-25.48	2.40	7.16
950	0.91	12.68	3.52	1.02	-0.41	0.96	-0.11	-0.31	-37.94	2.43	6.93	6.16	0.89	-0.51	0.87	-0.65	-0.48	-24.03	2.43	6.93
1000	1.30	13.43	3.85	1.41	0.45	1.66	0.38	-0.45	-35.92	2.21	7.21	6.43	0.83	-0.23	1.10	-1.11	-0.05	-23.09	2.21	7.21
1050	0.67	12.33	3.19	0.85	-0.45	0.65	-0.17	-1.02	-34.85	2.15	6.77	6.78	0.81	-0.38	0.87	-1.17	-0.56	-22.13	2.15	6.77
1100	1.04	13.59	3.48	1.38	0.21	1.17	0.23	-0.32	-32.86	2.22	7.24	7.00	1.06	0.08	1.28	-1.43	-0.43	-20.94	2.22	7.24
1150	1.09	13.11		1.24	0.52	1.38	-0.06	-0.81	-31.70	2.22	7.41		0.97	0.08	1.22	-1.66	-0.62	-20.24	2.22	7.41
1200	1.60	13.76		1.61	1.17	2.05	0.53	-0.16	-30.14	2.72	7.70		1.32	0.31	1.68	-1.49	-0.52	-19.10	2.72	7.70
1250	1.49	14.46		1.71	1.31	2.15	0.47	-0.15	-29.01	2.65	7.83		1.24	0.59	1.79	-1.23	-0.27	-18.52	2.65	7.83
1300	1.49	14.21		1.53	1.45	2.19	0.68	-0.29	-28.32	2.95	7.92		1.38	0.44	1.68	-1.30	-0.41	-17.82	2.95	7.92
1350	2.99	15.82		2.90	3.14	3.69	0.33	-0.62	-26.36	3.36	8.84		1.87	1.74	2.79	-1.05	-0.85	-16.95	3.36	8.84
1400	2.18	15.13		2.32	5.06	4.93	0.18	-0.71	-27.57	3.40	8.78		1.75	3.00	3.64	-1.07	-0.71	-17.40	3.40	8.78
1450	0.35	13.56		0.50	6.63	5.01	0.80	-0.64	-27.82	2.13	8.19		0.71	3.74	3.57	-0.85	-0.58	-17.51	2.13	8.19
1500	1.67	15.18		1.51	6.34	4.95	0.35	-0.40	-26.65	2.93	8.74		1.24	3.49	3.51	-1.45	-0.37	-16.88	2.93	8.74
1550	2.02	16.36		2.24	5.92	4.92			-25.90	3.12	9.41		1.62	3.27	3.61			-16.48	3.12	9.41
1600	1.81	16.24		1.87	5.26	4.12			-26.39	2.99	9.84		1.49	3.16	3.34			-16.70	2.99	9.84
1650	1.68	16.01		1.84	5.62	4.33			-26.68	3.02	9.31		1.52	3.01	3.22			-16.86	3.02	9.31
1700	2.00	16.98		2.27	6.07	4.58			-26.63	2.50	9.43		1.00	3.25	3.18			-17.65	2.50	9.43
1750	1.86	16.89		2.11	6.94	5.12			-27.05	3.08	9.98		1.52	3.82	3.71			-17.25	3.08	9.98
1800	1.53	17.16		1.95	7.89	6.10			-27.57	3.13	10.51		1.59	5.00	4.52			-17.43	3.13	10.51
1850	3.90	19.03		3.93	10.19	7.80			-26.14	4.33	10.98		2.81	7.01	5.85			-16.80	4.33	10.98
1900	1.55	19.90		2.08	16.12	11.44			-28.50	2.98	12.29		1.47	11.32	7.80			-18.36	2.98	12.29
1950	-0.23	19.42		0.22	20.41	12.68			-30.89	1.94	11.73		0.34	13.27	8.58			-19.90	1.94	11.73
2000	2.65	20.80		3.16	18.53	11.98			-28.94	3.40	12.55		1.95	11.91	8.31			-19.03	3.40	12.55
2050	3.58	19.93		4.47	16.32	10.36			-29.08	4.17	12.06		2.65	10.57	7.41			-19.42	4.17	12.06
2100	4.39	20.35		5.61	15.48	10.84			-28.96	4.91	12.74		3.58	10.75	7.58			-19.31	4.91	12.74
2150	4.61	20.22		5.85	15.55	10.39			-29.83	5.33	12.57		3.87	10.93	7.00			-19.82	5.33	12.57
2200	2.91	20.90		3.76	15.75	10.84			-31.78	4.24	12.74		2.54	11.00	7.35			-20.75	4.24	12.74
2250	2.36	20.73		2.95	15.54	10.42			-34.04	4.14	13.30		2.17	11.63	7.63			-21.91	4.14	13.30
2300	3.29	22.78		3.77	15.90	10.17			-34.26	4.64	13.86		2.54	11.68	8.17			-22.57	4.64	13.86
2350	3.57	23.10		4.58	17.53	12.43			-34.09	5.30	15.31		3.66	12.67	9.10			-22.21	5.30	15.31
2400	3.99	23.15		4.90	20.21	13.97			-34.39	4.70	14.41		3.17	13.51	9.47			-23.17	4.70	14.41
2450	5.76	27.35		6.64	26.71	16.89			-33.83	6.13	17.20		4.19	18.15	12.95			-22.70	6.13	17.20
2500	5.16	27.66		5.60	25.15	18.90			-35.97	6.37	18.88		4.14	22.39	16.36			-23.49	6.37	18.88

Lab No. 11 measured in the Specular Excluded geometry only.

Table 2. Specular Excluded Geometry.
% Reflectance differences from NPL values.

Sample Lab No.	Dark Grey Spectralon							Black Spectralon										
	10	14	13	3	5	8	6	16	11	10	14	13	3	5	8	6	16	11
Wavelength																		
800	0.95	2.43	3.71	0.59	0.93	1.48	0.59	0.51	-9.88	-0.37	0.37	0.24	0.24	0.14	0.43	0.07	-0.18	-0.06
850	0.90	2.30	3.95	0.78	0.51	0.76	0.69	0.56	-10.16	-0.25	0.44	0.25	0.46	-0.01	0.49	0.12	-0.14	-0.04
900	1.25	2.92	4.60	1.21	1.24	1.51	0.89	1.26	-9.57	-0.23	0.44	0.22	0.47	1.01	0.46	0.12	0.84	-0.11
950	1.18	3.07	4.76	1.27	0.50	1.46	1.05	1.21	-9.15	-0.13	0.47	0.31	0.61	0.19	0.39	0.08	-0.39	0.02
1000	1.16	3.10	5.11	1.33	0.36	1.08	0.34	0.47	-8.82	-0.27	0.74	0.46	0.74	0.42	0.62	0.32	-0.13	0.10
1050	0.99	3.40	5.40	1.22	0.45	1.14	0.47	0.64	-8.58	0.00	-0.01	0.51	0.79	0.38	0.44	0.27	-0.34	0.10
1100	1.22	2.98	5.69	1.35	0.52	1.23	0.20	0.63	-8.17	-0.48	0.05	0.15	0.45	0.16	0.27	0.05	-0.53	-0.30
1150	1.59	3.57		1.76	0.80	1.41	0.27	0.71	-7.50	0.08	0.55		0.90	0.35	0.40	0.13	-0.60	0.09
1200	1.44	3.51		1.63	0.83	1.49	0.33	0.81	-7.35	0.02	0.21		0.76	-0.22	-0.10	-0.39	-0.99	-0.11
1250	1.50	3.74		1.60	0.92	1.61	0.44	0.72	-7.17	0.15	1.08		1.01	0.35	0.48	0.15	-0.61	0.10
1300	1.51	3.77		1.64	0.76	1.38	0.19	0.36	-6.94	-0.19	0.74		0.75	0.23	0.31	0.05	-0.90	-0.22
1350	1.89	4.46		1.95	1.18	1.77	0.42	0.24	-6.50	0.08	0.64		0.91	0.15	0.30	-0.01	-0.92	-0.08
1400	1.97	4.33		1.82	1.80	2.17	0.59	0.63	-6.73	0.33	0.78		1.17	0.29	0.49	0.14	-0.27	0.14
1450	1.33	3.62		1.45	2.10	2.29	0.64	0.89	-6.86	0.43	0.87		1.41	0.63	0.75	0.34	-0.48	0.31
1500	1.23	4.16		1.39	1.96	2.04	0.42	0.32	-6.89	-0.32	0.09		0.60	0.45	0.50	0.05	-0.53	
1550	2.02	4.71		2.06	1.89	2.15			-6.23	0.04	0.42		1.00	0.52	0.52		-0.19	
1600	1.52	4.32		1.47	1.76	1.96			-6.88	-0.11	0.22		0.80	0.25	0.40		-0.45	
1650	1.94	4.56		1.92	1.96	2.09			-6.52	-0.09	-0.21		0.86	0.35	0.48		-0.44	
1700	1.81	4.49		1.78	1.80	1.88			-6.82	-0.16	-0.06		0.91	0.24	0.40		-0.47	
1750	1.23	4.51		1.28	1.98	2.13			-7.37	0.01	0.55		1.04	0.41	0.51		-0.40	
1800	1.44	4.98		1.39	2.36	2.33			-7.35	-0.10	0.34		0.87	0.40	0.41		-0.65	
1850	2.32	5.16		2.21	3.43	2.68			-6.83	-0.44	-0.02		0.65	1.14	0.49		-0.92	
1900	1.61	5.39		1.39	5.65	3.41			-7.70	0.02	1.01		1.13	1.59	0.53		-0.40	
1950	1.07	4.94		0.91	6.42	4.25			-8.31	0.07	0.56		1.04	1.91	1.09		-0.51	
2000	1.82	6.19		1.90	5.36	3.54			-7.66	0.26	1.03		1.28	1.91	1.37		-0.31	
2050	2.06	5.55		1.99	5.06	3.52			-8.03	0.13	1.20		1.16	1.33	0.61		-0.48	
2100	2.31	6.01		2.11	5.27	3.51			-8.22	-0.19	0.41		0.95	1.50	0.29		-0.77	
2150	2.62	5.31		2.20	5.58	3.52			-8.39	0.16	0.69		1.11	2.05	0.75		-0.63	
2200	2.34	5.92		1.88	5.42	3.53			-8.63	-0.25	0.44		0.96	1.92	0.84		-0.78	
2250	1.90	5.30		1.24	5.53	3.34			-9.44	0.27	0.63		1.17	2.14	1.28		-0.44	
2300	2.49	6.42		1.79	5.78	3.17			-9.58	0.82	1.92		1.81	2.52	1.99		-0.20	
2350	2.51	6.56		2.26	6.41	4.11			-9.54	0.64	2.08		1.78	2.53	1.77		-0.27	
2400	2.27	6.62		1.99	6.73	4.07			-9.92	1.18	2.89		2.26	3.09	2.15		0.25	
2450	2.83	8.16		2.26	8.03	4.97			-9.77	1.10	2.59		1.72	3.32	2.90		0.03	
2500	2.94	8.53		1.98	9.56	5.74			-10.14	-1.61	0.73		-1.44	2.60	1.45		-2.91	

Lab No. 11 measured in the Specular Excluded geometry only.

Table 2. Specular Excluded Geometry.
% Reflectance differences from NPL values.

Sample Lab No.	White Tile									Mirror								
	10	14	13	3	5	8	6	16	11	10	14	13	3	5	8	6	16	11
Wavelength																		
800	4.35	10.95	5.49	1.45	0.84	1.55	0.48	0.89	-7.41	-0.35	1.00	2.50	5.25	0.24	0.60	1.83	19.57	3.22
850	4.19	10.74	5.32	1.22	0.90	1.85	0.46	0.90	-8.95	-0.56	1.09	2.46	5.24	0.66	0.34	1.68	18.71	3.35
900	1.41	10.46	5.61	1.44	-0.86	1.35	0.07	1.38	-7.68	-0.01	0.53	2.85	5.75	0.76	0.45	1.87	16.72	4.04
950	0.43	9.88	5.68	1.44	-1.37	1.23	0.64	0.20	-5.93	-0.50	0.17	2.59	5.48	-0.06	0.20	1.24	18.60	3.87
1000	0.52	11.02	5.88	1.52	-1.27	1.67	0.20	0.73	-4.31	-0.51	0.09	2.68	5.34	-0.09	0.23	1.20	19.62	3.99
1050	0.85	10.80	6.18	1.73	-1.01	1.74	0.55	1.39	-2.73	-0.50	0.03	2.56	5.07	-0.07	0.20	1.04	20.81	3.76
1100	0.58	11.13	5.92	1.61	-1.00	1.65	0.22	0.61	-1.66	-0.52	-0.05	2.75	5.08	0.06	0.33	1.00	21.26	3.69
1150	0.80	11.07		1.62	-0.44	2.23	0.17	0.61	-0.46	-0.20	-0.10		5.19	0.09	0.38	0.96	21.51	3.68
1200	1.31	11.70		2.01	-0.09	2.73	0.78	1.27	0.98	-0.58	-0.38		4.25	0.24	0.50	1.01	21.66	2.92
1250	1.03	11.68		1.93	-0.22	2.50	0.48	0.91	1.76	-0.41	0.01		4.40	-0.14	0.19	0.49	21.51	2.85
1300	1.54	12.07		2.38	-0.08	2.56	0.79	0.72	2.89	-0.22	0.09		4.59	0.16	0.66	0.77	21.70	2.76
1350	2.12	12.89		2.96	1.44	3.84	0.19	0.48	4.04	-0.60	-0.12		4.55	-0.26	0.16	0.18	22.90	2.19
1400	1.75	12.65		2.57	3.10	4.80	0.26	0.50	4.43	-0.38	-0.15		4.51	-0.07	0.42	0.30	21.90	2.18
1450	0.33	11.91		1.28	4.82	5.06	0.58	0.46	2.35	-0.52	-0.12		4.19	-0.08	0.28	0.20	21.71	1.61
1500	1.04	13.02		1.86	4.46	5.12	0.08	1.10	3.48	-0.14	0.55		4.59	0.10	0.56	0.34	21.44	1.87
1550	1.84	13.83		2.67	4.32	5.06			4.45	-0.10	0.30		4.61	0.13	0.56			1.71
1600	1.47	13.61		2.35	3.69	4.39			4.08	-0.51	0.26		4.42	0.06	0.50			1.35
1650	1.23	13.25		2.18	3.70	4.50			3.67	-0.41	-0.26		4.53	-0.23	0.28			1.28
1700	1.39	14.13		2.37	4.59	4.90			3.39	-0.47	0.09		4.66	-0.11	0.44			1.15
1750	1.21	14.22		2.21	5.35	5.45			3.02	-0.31	0.34		4.87	0.08	0.61			1.29
1800	1.57	14.49		2.65	6.41	6.33			3.24	-0.21	-0.03		5.18	0.09	0.76			1.26
1850	2.87	15.70		3.80	8.20	7.35			3.93	-0.29	0.06		4.92	0.23	0.09			1.00
1900	0.60	15.71		2.08	13.13	10.27			1.48	-0.40	0.36		5.30	1.15	0.45			1.18
1950	-0.71	16.21		0.33	17.28	11.36			-0.58	-0.32	0.06		4.74	0.70	0.07			1.13
2000	1.83	17.44		3.08	16.07	11.27			1.08	-0.60	-0.68		4.81	0.37	0.29			1.00
2050	2.77	16.70		4.32	13.89	9.98			0.74	-0.45	0.35		4.97	0.27	-0.13			1.32
2100	3.33	16.33		5.00	13.04	9.87			0.16	-0.44	-0.12		4.61	1.09	0.60			1.16
2150	3.89	16.77		5.66	12.51	9.27			-0.29	-0.78	-0.38		4.22	0.73	0.24			1.09
2200	1.90	16.02		3.66	12.87	9.13			-2.23	-1.22	-0.55		4.43	0.62	-0.67			0.82
2250	2.03	16.76		3.15	12.95	9.69			-4.29	-1.16	0.01		3.65	0.40	-0.04			0.74
2300	2.10	17.67		3.12	13.31	9.45			-5.79	-3.33	-1.57		1.16	-1.81	-2.58			-1.51
2350	2.96	18.73		4.52	14.56	10.06			-4.95	-3.20	-1.75		1.40	-1.95	-1.60			-1.50
2400	2.46	17.14		3.95	15.47	11.99			-5.90	-3.36	0.13		1.42	-1.61	-2.71			-1.38
2450	3.34	19.10		4.57	19.91	13.71			-6.25	-2.31	0.75		2.05	-0.93	-2.41			-0.52
2500	6.31	20.47		4.88	23.79	18.60			-7.07	-2.87	0.00		0.82	-1.78	-0.99			-1.04

Lab No. 11 measured in the Specular Excluded geometry only.

Table 3. 0°/45° Geometry.
% Radiance Factor differences from NPL values.

Sample Lab No.	White Spectralon					Light Grey Spectralon					Dark Grey Spectralon				
	12	7	4	15	9	12	7	4	15	9	12	7	4	15	9
Wavelength															
800	49.13	28.16	1.15			25.35	13.57	-0.96			7.64	4.57	-1.79		
850	48.11	27.36	1.06			24.18	12.50	-1.71			7.82	4.75	-1.50		
900	47.31	26.98	1.64			23.84	12.23	-1.36			7.68	4.53	-1.44		
950	46.25	26.23	2.08			23.38	11.80	-1.03			7.64	4.30	-1.25		
1000	45.15	25.76	2.46			22.82	11.61	-0.81			7.88	4.67	-0.72		
1050	44.50	26.21	2.95			22.45	11.84	-0.66			7.43	4.45	-0.96		
1100	40.67	25.43	3.05	82.01		21.01	12.07	0.43	46.65		7.99	5.28	0.57	18.68	
1150	40.48	25.88	2.60	82.19		20.73	11.87	-0.15	46.56		7.58	4.81	-0.01	18.34	
1200	39.84	25.98	1.57	82.02		20.85	12.39	-0.29	46.98		7.75	4.91	0.07	18.66	
1250	38.68	25.17	0.17	81.22		20.29	12.03	-1.11	46.58		7.45	4.83	-0.35	18.44	
1300	38.31	25.21	-0.48	81.34		20.11	12.11	-1.60	46.60		7.37	4.72	-0.58	18.43	
1350	39.47	26.70	0.20	83.08		20.54	12.84	-1.55	47.22		7.71	5.03	-0.42	18.80	
1400	39.80	26.60	-0.83	83.76		20.98	13.45	-2.09	47.60		7.77	4.92	-0.77	18.79	
1450	38.65	26.29	-2.77	82.26		19.67	12.20	-3.91	45.94		7.33	4.69	-1.42	18.20	
1500	39.06	27.07	-2.76	82.56		20.38	13.24	-3.51	46.44		7.63	5.07	-1.26	18.43	
1550	40.33	28.93	-2.03	84.32		20.76	13.88	-3.50	46.99		7.63	5.16	-1.41	18.46	
1600	40.32	28.97	-2.95	83.98		21.12	14.24	-3.75	47.25		7.65	5.10	-1.66	18.47	
1650	41.43	30.06	-2.60	84.32		21.59	14.88	-3.89	47.21		8.23	5.59	-1.35	18.85	
1700	42.45	31.32	-2.44	85.50		22.60	16.54	-3.64	48.16		8.52	5.81	-1.43	19.08	
1750	43.08	32.68	-2.69	85.56		22.98	17.08	-3.86	48.08		8.54	6.15	-1.67	18.93	
1800	44.25	34.60	-2.23	85.27		23.06	16.81	-4.17	47.28		8.61	6.36	-1.75	18.67	
1850	46.38	36.91	-0.56	87.34		24.97	18.96	-2.75	49.13		9.36	6.91	-1.21	19.39	
1900	45.66	35.59	-2.80	85.84		23.88	17.46	-4.88	47.44		8.73	6.10	-2.27	18.51	
1950	44.73	33.95	-5.39	84.45		23.63	16.97	-6.28	46.75		8.68	5.81	-2.81	18.25	
2000	45.61	38.01	-3.67	85.43		24.43	18.04	-5.32	47.80		9.06	6.62	-2.39	18.72	
2050	44.25	37.82	-4.03	83.89		24.59	18.37	-5.01	48.15		8.97	6.58	-2.46	18.70	
2100	43.56	36.43	-4.33	83.24		24.14	17.97	-5.56	47.89		8.79	6.38	-2.69	18.61	
2150	43.58	35.31	-5.01	83.31		25.24	18.92	-5.24	49.05		9.28	6.60	-2.54	19.11	
2200	45.38	32.37	-5.64	86.78		25.30	18.99	-6.03	49.50		9.29	6.54	-2.86	19.26	
2250	44.03	35.61	-7.09	87.04		24.68	18.79	-6.76	49.72		9.22	6.72	-3.00	19.50	
2300	42.64	36.15	-8.18	87.53		24.54	19.31	-7.22	50.93		9.30	6.79	-3.14	20.12	
2350	41.83	36.71	-8.82	85.87		25.42	19.28	-6.62	51.69		9.45	7.27	-3.11	20.26	
2400	43.47	34.91	-8.04	87.48		24.37	18.32	-8.43	50.60		9.80	6.98	-3.08	20.59	
2450	44.65	35.34	-8.27	88.28		25.81	19.47	-7.91	51.70		10.46	7.56	-2.80	21.10	
2500	46.41	37.08				28.08	21.54				11.31	8.35			

Table 3. 0°/45° Geometry.
% Radiance Factor differences from NPL values.

Sample Lab No.	Black Spectralon					White Tile				
	12	7	4	15	9	12	7	4	15	9
Wavelength										
800	1.12	0.54	0.04			18.94	23.24			
850	1.07	0.53	0.00			17.87	22.19			
900	1.12	0.55	0.03			17.92	22.32			
950	0.77	0.10	-0.34			16.97	21.57			
1000	1.41	0.77	0.31			16.62	21.48			
1050	1.05	0.44	-0.07			16.86	22.10			
1100	1.08	0.56	-0.06	2.38		17.98	21.27		70.40	
1150	1.36	0.78	0.18	2.57		17.78	21.20		70.65	
1200	0.98	0.38	-0.24	2.11		17.50	21.67		70.71	
1250	1.21	0.62	-0.05	2.28		16.94	21.53		70.29	
1300	0.95	0.34	-0.35	1.95		16.45	21.26		70.11	
1350	1.08	0.45	-0.29	2.01		16.95	22.07		70.99	
1400	0.93	0.27	-0.51	1.78		17.18	22.98		70.48	
1450	1.16	0.50	-0.35	1.95		16.29	21.39		69.67	
1500	1.21	0.56	-0.34	1.97		16.44	22.85		69.67	
1550	1.27	0.65	-0.36	1.94		17.23	22.57		71.28	
1600	1.19	0.52	-0.52	1.74		17.47	23.80		71.24	
1650	1.50	0.74	-0.29	2.00		18.38	24.87		71.47	
1700	1.38	0.57	-0.50	1.82		18.70	25.54		72.10	
1750	1.28	0.47	-0.68	1.68		19.72	27.81		72.58	
1800	1.36	0.54	-0.66	1.72		20.35	28.92		71.84	
1850	1.42	0.56	-0.66	1.75		22.23	30.63		73.84	
1900	1.42	0.51	-0.76	1.69		20.42	31.21		69.94	
1950	1.74	0.78	-0.54	1.96		20.31	26.64		70.22	
2000	1.47	0.53	-0.85	1.68		21.66	30.67		71.89	
2050	1.61	0.65	-0.75	1.81		21.93	31.42		72.40	
2100	1.69	0.72	-0.70	1.89		20.94	30.85		71.25	
2150	1.52	0.49	-0.96	1.69		21.29	31.78		69.98	
2200	1.51	0.46	-1.03	1.67		20.89	31.70		68.10	
2250	2.18	1.13	-0.40	2.36		20.00	29.33		68.87	
2300	2.33	1.25	-0.32	2.51		19.41	29.07		71.27	
2350	1.66	0.62	-1.02	1.86		19.86	31.34		70.94	
2400	2.21	1.06	-0.54	2.39		19.31	31.19		67.76	
2450	2.38	1.20	-0.45	2.54		19.42	30.16		65.70	
2500	2.77	1.57				20.82	30.77			

Table 4. Specular Included Geometry.
% Reflectance differences from NPL values after renormalisation.

Sample Lab No.	White Spectralon					Light Grey Spectralon				
	10	14	13	3	5	8	6	16	2	
Wavelength										
800	0	0	0	0	0	0	0	0	-0.30	
850	0	0	0	0	0	0	0	0	-0.35	
900	0	0	0	0	0	0	0	0	-0.51	
950	0	0	0	0	0	0	0	0	-0.47	
1000	0	0	0	0	0	0	0	0	-0.61	
1050	0	0	0	0	0	0	0	0	-0.43	
1100	0	0	0	0	0	0	0	0	-0.70	
1150	0	0	0	0	0	0	0	0	-0.86	
1200	0	0	0	0	0	0	0	0	-0.42	
1250	0	0	0	0	0	0	0	0	-0.49	
1300	0	0	0	0	0	0	0	0	-0.57	
1350	0	0	0	0	0	0	0	0	-0.33	
1400	0	0	0	0	0	0	0	0	-0.42	
1450	0	0	0	0	0	0	0	0	-0.86	
1500	0	0	0	0	0	0	0	0	-0.40	
1550	0	0	0	0	0	0	0	0	-0.56	
1600	0	0	0	0	0	0	0	0	-0.33	
1650	0	0	0	0	0	0	0	0	-0.39	
1700	0	0	0	0	0	0	0	0	-0.72	
1750	0	0	0	0	0	0	0	0	-0.43	
1800	0	0	0	0	0	0	0	0	-0.80	
1850	0	0	0	0	0	0	0	0	-1.02	
1900	0	0	0	0	0	0	0	0	-0.87	
1950	0	0	0	0	0	0	0	0	0.79	
2000	0	0	0	0	0	0	0	0	-0.59	
2050	0	0	0	0	0	0	0	0	-0.28	
2100	0	0	0	0	0	0	0	0	-1.57	
2150	0	0	0	0	0	0	0	0	-0.83	
2200	0	0	0	0	0	0	0	0	0.85	
2250	0	0	0	0	0	0	0	0	-0.94	
2300	0	0	0	0	0	0	0	0	-1.75	
2350	0	0	0	0	0	0	0	0	-0.57	
2400	0	0	0	0	0	0	0	0	-1.45	
2450	0	0	0	0	0	0	0	0	-1.41	
2500	0	0	0	0	0	0	0	0	-4.24	

Lab No. 2 measured in the Specular Included geometry only.

Table 4. Specular Included Geometry.
% Reflectance differences from NPL values after renormalisation.

Sample Lab No.	Dark Grey Spectralon										Black Spectralon									
	10	14	13	3	5	8	6	16	2		10	14	13	3	5	8	6	16	2	
Wavelength																				
800	-0.18	-0.69	0.94	0.54	0.74	-0.57	0.70	0.64	0.30		-0.20	0.17	0.02	0.28	0.08	0.44	0.04	-0.19	0.10	
850	-0.16	-0.92	0.89	0.58	0.50	-1.01	0.70	1.09	0.23		-0.10	0.25	0.10	0.43	0.08	0.26	0.08	-0.24	0.19	
900	-0.11	-0.38	1.28	0.83	1.20	-0.58	1.23	1.60	0.69		0.01	0.02	0.22	0.66	0.78	0.32	0.49	0.11	1.02	
950	0.06	-0.16	1.71	1.21	0.49	-0.73	0.60	0.67	0.22		0.18	-0.03	0.36	0.85	0.03	0.14	0.13	-0.38	0.18	
1000	0.05	-0.31	1.99	1.23	0.80	-0.96	0.62	0.98	0.64		0.10	-0.04	0.20	0.69	0.32	0.18	0.19	-0.29	0.32	
1050	0.02	-0.21	2.45	1.40	0.93	-0.61	0.71	1.17	0.69		0.19	0.38	0.45	0.96	0.32	0.34	0.23	-0.31	0.28	
1100	-0.02	-0.31	2.21	1.13	0.56	-0.99	0.05	0.65	0.32		0.08	0.65	0.32	0.80	0.22	0.24	0.09	-0.54	0.29	
1150	-0.14	0.25		1.50	0.91	-0.44	0.32	0.88	0.68		-0.16	0.49		0.53	0.22	0.13	0.00	-0.53	0.32	
1200	-0.19	-0.22		1.09	0.55	-0.94	-0.03	0.44	0.19		-0.28	-0.38		0.44	0.20	0.13	0.12	-0.52	0.29	
1250	-0.19	-0.42		0.93	0.71	-0.90	0.12	0.68	0.39		0.20	0.33		0.93	0.16	0.09	0.04	-0.81	0.30	
1300	-0.32	-0.03		1.28	0.86	-0.62	0.29	0.77	0.49		-0.40	-0.38		0.45	0.32	0.21	0.16	-0.60	0.38	
1350	-0.36	-0.17		1.23	0.72	-0.70	0.51	0.45	0.50		0.08	0.25		0.85	0.04	-0.07	-0.14	-0.94	0.10	
1400	-0.43	0.39		1.44	0.87	-0.31	0.57	0.68	0.64		0.18	-0.01		0.95	0.72	0.71	0.55	0.05	0.87	
1450	-0.03	0.11		1.19	0.81	-0.43	0.61	0.93	0.57		-0.37	0.12		0.44	0.08	-0.03	-0.04	-0.54	0.30	
1500	-0.27	-0.08		1.24	0.42	-0.78	0.37	0.68	0.19		-0.09	0.67		0.87	0.36	0.26	0.13		0.55	
1550	-0.22	-0.28		1.11	0.52	-0.79	0.11		0.26		0.12	0.42		0.95	0.24	0.13			0.35	
1600	-0.19	0.37		1.23	0.74	-0.56	0.74		0.37		-0.26	-0.15		0.62	0.55	0.53			0.62	
1650	-0.22	-0.15		1.04	0.67	-0.77	1.04		0.23		-0.18	0.01		0.72	0.16	0.01			0.25	
1700	-0.25	0.16		1.18	0.78	-0.53	1.18		0.20		0.01	0.60		0.85	0.27	0.11			0.32	
1750	-0.16	0.36		1.37	0.54	-0.60	1.37		0.30		0.00	0.33		0.91	0.14	0.01			0.33	
1800	-0.28	0.17		0.92	0.40	-1.13	0.92		-0.20		0.23	-0.03		1.01	0.43	0.38			0.24	
1850	-0.78	-0.49		0.79	0.89	-0.53	0.79		0.02		0.06	-0.03		0.92	0.64	0.40			0.30	
1900	-0.26	0.33		1.24	1.42	-1.00	1.24		-0.11		0.27	0.21		1.08	1.37	0.31			0.42	
1950	0.30	0.08		1.07	1.19	-0.80	1.07		1.08		0.62	0.42		1.39	1.21	0.41			1.44	
2000	-0.37	0.35		1.08	1.14	-0.56	1.14		0.28		0.13	0.28		1.03	0.75	-0.11			0.44	
2050	-0.73	0.24		1.11	1.18	-0.81	1.11		0.41		0.00	-0.29		0.85	0.80	0.63			0.19	
2100	-0.83	0.11		0.48	1.26	-0.56	1.26		0.20		0.17	0.31		1.03	1.18	0.57			-0.66	
2150	-1.12	-0.50		0.37	1.58	0.16	1.58		0.60		0.08	-0.06		0.93	1.16	0.05			0.60	
2200	-0.54	-0.34		0.52	1.27	-0.81	1.27		0.24		-0.37	-0.14		0.48	0.93	-0.26			0.23	
2250	-0.50	-0.28		0.40	1.35	-0.35	1.35		-0.40		0.03	0.34		0.80	1.16	0.16			-0.58	
2300	-0.43	-0.04		0.97	1.78	-0.72	1.78		-0.64		0.43	0.64		1.29	1.59	0.41			0.38	
2350	-0.81	-0.31		0.99	1.85	0.12	1.85		-0.06		0.27	0.59		1.35	0.89	0.22			1.28	
2400	-0.81	0.62		1.18	2.02	-1.22	2.02		1.01		0.87	1.82		1.74	2.02	0.69			0.49	
2450	-1.07	1.10		1.02	2.47	1.00	2.47		1.18		0.53	1.32		1.02	1.43	2.27			0.97	
2500	-1.13	0.17		-0.35	1.34	-1.20	1.34		-1.93		-0.04	0.26		-0.20	0.95	-1.38			1.47	

Lab No. 2 measured in the Specular Included geometry only.

Table 4. Specular Included Geometry.
% Reflectance differences from NPL values after renormalisation.

Sample Lab No.	White Tile							Mirror										
	10	14	13	3	5	8	6	16	2	10	14	13	3	5	8	6	16	2
Wavelength																		
800	3.17	-1.58	0.42	0.15	-0.17	-1.15	0.68	-0.46	0.51	3.11	-3.68	-0.78	-1.29	-5.06	18.16	0.93	0.34	0.79
850	3.36	-1.71	0.28	-0.02	-1.25	-0.73	0.17	0.33	1.44	2.28	-4.05	-1.46	-1.87	-5.73	22.72	0.04	1.48	1.10
900	0.19	-1.36	0.41	0.16	-0.68	-0.85	0.70	-0.08	0.15	-0.64	-4.32	-1.42	-1.88	-6.44	23.11	-1.31	-5.40	0.40
950	0.07	-0.97	0.73	0.39	-0.43	-0.38	0.33	0.37	0.42	-0.86	-3.52	-0.84	-1.47	-6.84	24.94	-0.70	-3.56	0.75
1000	0.15	-1.22	1.07	0.58	-0.38	-1.31	0.26	0.00	0.34	-1.06	-4.62	-0.94	-1.69	-7.28	24.07	-1.03	-4.18	0.72
1050	0.06	-0.93	0.98	0.36	-0.14	-0.90	0.20	0.20	0.55	-0.79	-3.89	-0.75	-1.56	-7.54	24.39	-1.53	-4.72	0.29
1100	-0.09	-0.64	0.94	0.30	-0.52	-0.99	-0.30	-0.06	0.28	-1.18	-3.66	-1.17	-1.77	-7.84	23.93	-2.15	-4.81	0.24
1150	-0.13	-1.64		0.16	-0.58	-1.21	-0.33	-0.13	0.14	-1.35	-5.27		-2.19	-8.03	24.73	-2.22	-4.76	0.43
1200	0.07	-1.29		0.36	-0.63	-1.00	-0.32	-0.17	0.08	-1.67	-5.20		-2.37	-8.52	24.40	-2.36	-5.43	0.20
1250	-0.18	-1.18		0.14	-0.28	-1.04	0.10	0.20	0.51	-1.80	-5.34		-2.62	-8.62	22.69	-2.52	-5.40	0.15
1300	-0.48	-1.45		-0.31	-0.78	-1.22	-0.31	-0.38	-0.06	-2.59	-5.17		-3.06	-9.24	22.31	-2.94	-5.79	-0.22
1350	-0.04	-1.10		0.32	-0.55	-1.25	-0.23	-0.44	0.00	-2.60	-5.93		-3.28	-10.18	21.77	-3.78	-6.92	-1.02
1400	-0.10	-1.54		0.32	-0.47	-0.81	0.10	0.28	0.22	-2.63	-6.57		-3.45	-10.69	23.84	-3.70	-7.68	-0.76
1450	0.03	-1.24		0.33	-0.15	-0.44	0.29	0.58	0.63	-1.22	-6.23		-1.78	-10.12	22.95	-1.80	-6.65	1.30
1500	-0.22	-1.44		0.18	-0.45	-0.78	0.12	-0.27	0.74	-2.09	-7.28		-2.74	-11.06	21.31	-3.15	-8.19	0.42
1550	-0.09	-1.58		0.20	-0.20	-0.72			0.51	-2.26	-6.90		-2.78	-10.89	22.15			-0.28
1600	-0.07	-0.91		0.44	-0.35	-0.73			0.34	-1.94	-6.18		-2.33	-10.83	21.56			0.04
1650	-0.05	-1.73		0.21	-0.60	-0.84			0.33	-1.91	-6.37		-2.60	-10.51	22.56			0.52
1700	0.00	-0.91		0.31	-0.43	-0.60			0.67	-2.08	-6.68		-2.87	-10.89	23.88			0.61
1750	0.37	-0.95		0.74	-0.78	-0.94			0.63	-1.63	-6.78		-2.32	-11.58	23.15			0.44
1800	-0.01	-1.42		0.28	-0.82	-1.36			0.04	-2.28	-7.76		-3.20	-12.40	19.78			-0.56
1850	-0.33	-2.00		0.12	-0.70	-0.86			0.42	-4.35	-9.66		-5.46	-13.66	18.28			-2.59
1900	-0.61	-1.94		-0.02	-0.67	-1.50			0.85	-1.98	-10.70		-3.12	-15.04	15.05			-0.06
1950	-0.14	-1.66		0.15	-0.95	-1.55			1.23	0.18	-10.37		-0.73	-15.11	12.73			4.01
2000	-0.30	-1.29		-0.08	-0.93	-1.24			0.21	-2.43	-10.58		-3.84	-15.43	12.93			-0.74
2050	-0.45	-1.64		-0.17	-1.24	-1.34			-0.14	-4.05	-10.75		-6.21	-16.01	13.96			-2.53
2100	-0.38	-1.68		-0.33	-1.23	-1.74			-0.86	-4.04	-10.75		-6.89	-15.47	14.14			-3.85
2150	-0.43	-1.53		-0.08	-1.07	-1.00			-1.09	-5.16	-10.80		-8.24	-15.41	14.38			-5.06
2200	-0.21	-1.52		0.25	-1.18	-0.89			0.31	-3.32	-10.18		-5.24	-15.51	14.57			-1.71
2250	-0.69	-2.33		-0.28	-1.27	-1.95			0.01	-2.66	-10.89		-4.80	-14.77	11.74			-2.18
2300	-0.61	-2.63		-0.15	-1.44	-0.94			-1.37	-2.55	-11.49		-4.77	-16.37	11.12			-1.66
2350	-0.59	-2.49		-0.25	-1.30	-0.61			-4.14	-3.59	-11.55		-6.46	-17.03	8.74			-6.90
2400	-0.41	-2.25		0.12	-1.74	-3.43			-3.39	-4.15	-12.69		-7.25	-18.68	4.62			-8.49
2450	-1.22	-3.01		-0.62	-1.36	-1.74			2.07	-4.84	-15.02		-7.72	-20.56	-0.15			0.14
2500	-1.56	-3.83		-0.90	-1.34	-4.52			-2.79	-4.84	-16.12		-7.63	-21.12	-0.92			3.43

Lab No. 2 measured in the Specular Included geometry only.

Table 5. Specular Excluded Geometry.
% Reflectance differences from NPL values after renormalisation.

Sample Lab No.	White Spectralon								Light Grey Spectralon									
	10	14	13	3	5	8	6	16	11	10	14	13	3	5	8	6	16	11
Wavelength																		
800	0	0	0	0	0	0	0	0	0	1.84	-0.88	2.93	-0.14	0.43	0.62	-0.62	0.04	-1.24
850	0	0	0	0	0	0	0	0	0	1.91	-0.64	3.22	0.08	0.85	-0.09	-0.40	-0.21	-1.23
900	0	0	0	0	0	0	0	0	0	1.95	-0.71	3.60	0.11	0.44	0.32	-0.44	-1.20	-1.08
950	0	0	0	0	0	0	0	0	0	1.85	-0.78	3.85	0.25	-0.26	0.27	-0.58	-0.29	-1.05
1000	0	0	0	0	0	0	0	0	0	1.38	-1.00	3.89	-0.04	-0.51	0.06	-1.34	0.23	-1.22
1050	0	0	0	0	0	0	0	0	0	1.73	-0.78	4.65	0.28	-0.10	0.46	-1.06	0.08	-0.82
1100	0	0	0	0	0	0	0	0	0	1.56	-1.06	4.67	0.20	-0.05	0.55	-1.57	-0.24	-0.76
1150	0	0	0	0	0	0	0	0	0	1.52	-0.67		0.19	-0.24	0.35	-1.62	-0.11	-0.71
1200	0	0	0	0	0	0	0	0	0	1.70	-0.77		0.31	-0.42	0.39	-1.81	-0.42	-0.46
1250	0	0	0	0	0	0	0	0	0	1.69	-1.06		0.17	-0.23	0.43	-1.51	-0.18	-0.52
1300	0	0	0	0	0	0	0	0	0	1.99	-0.83		0.42	-0.47	0.29	-1.72	-0.23	-0.20
1350	0	0	0	0	0	0	0	0	0	1.44	-0.96		0.04	-0.23	0.45	-1.26	-0.46	-0.50
1400	0	0	0	0	0	0	0	0	0	1.99	-0.62		0.29	-0.18	0.51	-1.18	-0.26	-0.05
1450	0	0	0	0	0	0	0	0	0	1.90	-0.28		0.39	-0.42	0.38	-1.34	-0.17	-0.08
1500	0	0	0	0	0	0	0	0	0	1.85	-0.70		0.29	-0.50	0.35	-1.34	-0.17	-0.15
1550	0	0	0	0	0	0	0	0	0	1.81	-0.78		0.21	-0.46	0.47	-1.67	-0.12	-0.20
1600	0	0	0	0	0	0	0	0	0	1.82	-0.34		0.30	-0.16	0.71			-0.09
1650	0	0	0	0	0	0	0	0	0	1.92	-0.68		0.35	-0.54	0.44			-0.04
1700	0	0	0	0	0	0	0	0	0	1.19	-1.23		-0.44	-0.59	0.24			-0.81
1750	0	0	0	0	0	0	0	0	0	1.87	-0.61		0.18	-0.57	0.42			-0.16
1800	0	0	0	0	0	0	0	0	0	2.13	-0.29		0.35	-0.01	0.61			0.01
1850	0	0	0	0	0	0	0	0	0	1.77	-0.95		0.29	0.48	0.82			-0.21
1900	0	0	0	0	0	0	0	0	0	1.96	-0.34		0.14	0.86	0.42			-0.26
1950	0	0	0	0	0	0	0	0	0	2.10	-0.56		0.20	0.12	0.37			-0.25
2000	0	0	0	0	0	0	0	0	0	1.64	-0.73		-0.09	-0.09	0.48			-0.48
2050	0	0	0	0	0	0	0	0	0	1.76	-0.82		-0.26	-0.13	0.55			-0.55
2100	0	0	0	0	0	0	0	0	0	1.93	-0.54		-0.11	0.43	0.36			-0.36
2150	0	0	0	0	0	0	0	0	0	2.18	-0.64		0.01	0.51	0.08			-0.21
2200	0	0	0	0	0	0	0	0	0	2.28	-0.66		0.10	0.64	0.26			-0.25
2250	0	0	0	0	0	0	0	0	0	2.56	-0.04		0.26	1.36	0.81			0.02
2300	0	0	0	0	0	0	0	0	0	2.41	-0.80		0.08	1.11	1.38			-0.36
2350	0	0	0	0	0	0	0	0	0	2.86	0.16		0.63	0.90	0.77			0.15
2400	0	0	0	0	0	0	0	0	0	1.97	-0.76		-0.08	-0.03	0.09			-0.55
2450	0	0	0	0	0	0	0	0	0	2.18	-0.72		-0.20	0.19	1.38			-0.44
2500	0	0	0	0	0	0	0	0	0	2.83	0.55		0.43	4.75	3.38			0.24

Lab No. 11 measured in the Specular Excluded geometry only.

Table 5. Specular Excluded Geometry.
% Reflectance differences from NPL values after renormalisation.

Sample Lab No.	Dark Grey Spectralon					Black Spectralon				
	10	14	13	3	5	8	6	11	16	11
Wavelength										
800	0.80	-0.50	2.77	0.35	0.63	1.17	0.65	0.68	-0.81	-0.38
850	0.63	-0.77	2.96	0.49	0.08	0.25	0.71	0.43	-0.81	-0.26
900	1.08	-0.06	3.66	0.97	1.35	1.27	1.01	1.27	-0.40	-0.23
950	0.96	0.09	3.80	1.02	0.60	1.23	1.08	1.28	-0.44	-0.14
1000	0.84	-0.07	4.04	0.98	0.25	0.68	0.25	0.57	-0.48	-0.28
1050	0.82	0.41	4.49	1.01	0.56	0.98	0.51	0.89	-0.40	-0.01
1100	0.96	-0.26	4.69	1.00	0.47	0.95	0.14	0.70	-0.40	-0.49
1150	1.31	0.40		1.44	0.68	1.08	0.28	0.91	0.06	0.06
1200	1.04	0.16		1.22	0.55	0.99	0.20	0.85	-0.10	-0.01
1250	1.12	0.19		1.16	0.61	1.09	0.33	0.76	-0.14	0.13
1300	1.13	0.26		1.25	0.41	0.85	0.03	0.43	-0.03	-0.21
1350	1.12	0.49		1.20	0.43	0.87	0.34	0.39	-0.02	0.04
1400	1.39	0.51		1.21	0.59	0.97	0.55	0.80	0.15	0.29
1450	1.24	0.23		1.32	0.51	1.06	0.45	1.05	0.05	0.42
1500	0.80	0.29		0.99	0.44	0.83	0.33	0.42	-0.24	-0.35
1550	1.49	0.56		1.47	0.47	0.95	0.95	0.14	0.01	0.01
1600	1.04	0.17		0.97	0.50	0.95	0.26	0.14	-0.07	-0.14
1650	1.49	0.47		1.44	0.61	1.03	0.81	0.23	-0.44	-0.12
1700	1.27	0.14		1.17	0.34	0.76	-0.19	0.85	-0.34	-0.19
1750	0.73	0.11		0.72	0.32	0.87	-0.02	0.98	0.19	-0.02
1800	1.03	0.47		0.87	0.46	0.83	-0.13	0.81	-0.03	-0.13
1850	1.26	0.22		1.15	0.91	0.77	-0.52	0.53	-0.42	-0.52
1900	1.19	0.16		0.83	1.58	0.63	-0.01	1.06	0.50	-0.01
1950	1.13	-0.11		0.85	1.33	1.12	0.08	1.03	0.11	0.20
2000	1.10	0.62		1.04	0.76	0.59	0.20	1.18	0.49	0.49
2050	1.06	0.18		0.75	0.97	0.93	0.05	1.01	0.61	0.05
2100	1.07	0.39		0.56	1.27	0.77	-0.29	0.76	-0.11	-0.29
2150	1.30	-0.17		0.57	1.55	0.90	0.04	0.90	0.14	0.04
2200	1.52	0.30		0.84	1.42	0.85	-0.32	0.82	-0.10	-0.32
2250	1.24	-0.21		0.44	1.58	0.78	0.21	1.07	0.12	0.21
2300	1.55	0.22		0.74	1.72	0.68	-0.51	1.67	1.17	0.73
2350	1.48	0.21		0.97	1.89	1.02	-0.39	1.60	1.26	0.54
2400	1.12	0.18		0.60	1.50	0.59	-0.65	2.07	2.00	1.06
2450	1.17	0.46		0.39	1.23	0.76	-0.64	1.48	1.57	0.93
2500	1.44	0.71		0.41	2.91	1.10	-0.40	-1.63	-0.53	-1.78
								1.16	0.50	0.50
								0.41	0.46	0.41
								0.12	0.45	0.12
								0.08	0.38	0.08
								0.32	0.59	0.32
								0.27	0.43	0.27
								0.05	0.25	0.05
								0.13	0.38	0.13
								-0.40	-0.13	-0.40
								0.14	0.44	0.14
								0.04	0.27	0.04
								-0.02	0.23	-0.02
								0.14	0.40	0.14
								0.33	0.65	0.33
								0.05	0.40	0.05
								0.42	0.41	0.42
								0.15	0.31	0.15
								0.24	0.38	0.24
								0.11	0.29	0.11
								0.26	0.39	0.26
								0.22	0.27	0.22
								0.83	0.30	0.83
								1.04	0.24	1.04
								1.23	0.73	1.23
								1.33	1.03	1.33
								0.81	0.33	0.81
								-0.02	0.33	-0.02
								1.45	0.46	1.45
								1.30	0.50	1.30
								1.54	0.94	1.54
								1.88	1.61	1.88
								1.60	1.32	1.60
								2.25	1.65	2.25
								2.22	2.21	2.22
								1.16	0.50	1.16
								0.50	0.50	0.50
								0.46	0.46	0.46
								0.38	0.38	0.38
								0.44	0.44	0.44
								0.27	0.27	0.27
								0.23	0.23	0.23
								0.21	0.21	0.21
								1.12	1.12	1.12
								1.40	1.40	1.40
								0.56	0.56	0.56
								0.95	0.95	0.95
								0.75	0.75	0.75
								0.81	0.81	0.81
								0.85	0.85	0.85
								0.19	0.19	0.19
								0.02	0.02	0.02
								0.81	0.81	0.81
								0.53	0.53	0.53
								1.06	1.06	1.06
								1.03	1.03	1.03
								1.18	1.18	1.18
								1.01	1.01	1.01
								0.76	0.76	0.76
								0.90	0.90	0.90
								1.45	1.45	1.45
								1.30	1.30	1.30
								1.54	1.54	1.54
								1.88	1.88	1.88
								1.60	1.60	1.60
								2.07	2.07	2.07
								1.48	1.48	1.48
								2.22	2.22	2.22
								1.16	1.16	1.16
								0.50	0.50	0.50
								0.46	0.46	0.46
								0.38	0.38	0.38
								0.44	0.44	0.44
								0.27	0.27	0.27
								0.23	0.23	0.23
								0.21	0.21	0.21
								1.12	1.12	1.12
								1.40	1.40	1.40
								0.56	0.56	0.56
								0.95	0.95	0.95
								0.75	0.75	0.75
								0.81	0.81	0.81
								0.85	0.85	0.85
								0.19	0.19	0.19
								0.02	0.02	0.02
								0.81	0.81	0.81
								0.53	0.53	0.53
								1.06	1.06	1.06
								1.03	1.03	1.03
								1.18	1.18	1.18
								1.01	1.01	1.01
								0.76	0.76	0.76
								0.90	0.90	0.90
								1.45	1.45	1.45
								1.30	1.30	1.30
								1.54	1.54	1.54
								1.88	1.88	1.88
								1.60	1.60	1.60
								2.07	2.07	2.07
								1.48	1.48	1.48
								2.22	2.22	2.22
								1.16	1.16	1.16
								0.50	0.50	0.50
								0.46	0.46	0.46
								0.38	0.38	0.38
								0.44	0.44	0.44
								0.27	0.27	0.27
								0.23	0.23	0.23
								0.21	0.21	0.21
								1.12	1.12	1.12
								1.40	1.40	1.40
								0.56	0.56	0.56
								0.95	0.95	0.95
								0.75	0.75	0.75
								0.81	0.81	0.81
								0.85	0.85	0.85
								0.19	0.19	0.19
								0.02	0.02	0.02
								0.81	0.81	0.81
								0.53	0.53	0.53
								1.06	1.06	1.06
								1.03	1.03	1.03
								1.18	1.18	1.18
								1.01	1.01	1.01
								0.76	0.76	0.76
								0.90	0.90	0.90
								1.45	1.45	1.45
								1.30	1.30	1.30
								1.54	1.54	1.54
								1.88	1.88	1.88
								1.60	1.60	1.60
								2.07	2.07	2.07
								1.48	1.48	1.48
								2.22	2.22	

Table 5. Specular Excluded Geometry.
% Reflectance differences from NPL values after renormalisation.

Sample Lab No.	White Tile										Mirror									
	10	14	13	3	5	8	6	16	11	10	14	13	3	5	8	6	16	11		
Wavelength																				
800	3.77	-0.36	2.23	0.56	-0.27	0.41	0.69	1.53	48.13	-0.35	0.87	2.41	5.21	0.24	0.59	1.83	19.72	5.57		
850	3.14	-1.08	1.94	0.16	-0.71	-0.09	0.55	0.45	47.64	-0.55	0.94	2.36	5.18	0.65	0.33	1.68	18.61	5.90		
900	0.80	-0.70	2.49	0.57	-0.47	0.49	0.52	1.39	46.39	-0.01	0.48	2.75	5.70	0.76	0.44	1.88	16.72	6.80		
950	-0.35	-0.99	2.54	0.55	-1.02	0.39	0.73	0.48	43.76	-0.50	0.11	2.49	5.42	-0.06	0.19	1.24	18.66	6.49		
1000	-0.61	-0.62	2.43	0.29	-1.66	0.21	-0.13	1.12	42.53	-0.50	0.04	2.57	5.26	-0.09	0.22	1.20	19.71	6.47		
1050	0.26	0.09	3.31	0.98	-0.62	1.17	0.69	2.29	42.43	-0.50	-0.03	2.46	5.02	-0.07	0.20	1.04	21.03	6.07		
1100	-0.32	-0.65	2.78	0.40	-1.18	0.62	0.02	0.89	40.53	-0.52	-0.09	2.64	5.00	0.06	0.32	0.99	21.32	5.73		
1150	-0.15	-0.35		0.53	-0.89	1.01	0.22	1.33	40.15	-0.20	-0.11		5.13	0.09	0.37	0.96	21.69	5.52		
1200	-0.09	-0.29		0.59	-1.10	0.92	0.31	1.41	39.39	-0.59	-0.42		4.17	0.24	0.49	1.00	21.70	4.51		
1250	-0.27	-0.86		0.42	-1.35	0.60	0.07	1.05	38.55	-0.41	-0.05		4.32	-0.14	0.18	0.49	21.55	4.24		
1300	0.25	-0.25		1.03	-1.33	0.63	0.19	0.98	38.63	-0.22	0.05		4.52	0.16	0.64	0.76	21.76	3.98		
1350	-0.48	-0.83		0.40	-1.28	0.58	-0.10	1.03	37.22	-0.60	-0.18		4.40	-0.27	0.13	0.17	23.05	3.22		
1400	-0.14	-0.36		0.55	-1.24	0.49	0.11	1.13	39.51	-0.38	-0.18		4.40	-0.09	0.38	0.30	22.06	3.19		
1450	0.03	0.16		0.84	-0.89	0.66	-0.12	1.03	36.65	-0.52	-0.18		4.17	-0.11	0.24	0.19	21.85	2.48		
1500	-0.40	-0.09		0.54	-0.98	0.79	-0.22	1.46	36.35	-0.14	0.44		4.52	0.08	0.52	0.34	21.53	2.65		
1550	0.08	-0.34		0.71	-0.79	0.73			36.69	-0.11	0.22		4.50	0.11	0.52			2.43		
1600	-0.10	-0.44		0.71	-0.86	0.76			36.97	-0.51	0.15		4.33	0.04	0.47			2.04		
1650	-0.23	-0.60		0.56	-1.15	0.68			36.95	-0.41	-0.30		4.44	-0.25	0.24			1.95		
1700	-0.35	-0.61		0.38	-0.67	0.86			36.65	-0.47	-0.01		4.54	-0.14	0.40			1.79		
1750	-0.41	-0.44		0.36	-0.65	0.94			36.77	-0.31	0.23		4.76	0.05	0.56			1.93		
1800	0.24	-0.32		0.94	-0.42	0.96			37.72	-0.21	-0.08		5.07	0.06	0.70			1.91		
1850	-0.52	-0.77		0.36	-0.66	0.48			36.77	-0.30	-0.05		4.70	0.14	0.03			1.61		
1900	-0.73	-1.13		0.29	-0.69	0.34			36.55	-0.40	0.22		5.18	0.35	0.35			1.85		
1950	-0.51	-0.54		0.14	-0.41	0.28			37.96	-0.32	-0.03		4.73	0.45	-0.03			1.87		
2000	-0.47	-0.62		0.31	-0.12	0.70			37.61	-0.60	-0.69		4.63	0.21	0.19			1.72		
2050	-0.38	-0.78		0.35	-0.53	0.69			38.03	-0.45	0.21		4.72	0.13	-0.19			2.09		
2100	-0.56	-1.51		-0.01	-0.73	0.13			37.51	-0.44	-0.21		4.31	0.85	0.48			1.97		
2150	-0.13	-0.73		0.52	-1.12	0.03			37.64	-0.77	-0.45		3.93	0.50	0.13			1.93		
2200	-0.51	-1.18		0.50	-0.41	-0.05			36.26	-1.22	-0.63		4.22	0.40	-0.70			1.72		
2250	0.06	-0.42		0.68	-0.23	0.75			37.06	-1.15	-0.18		3.51	0.19	-0.15			1.73		
2300	-0.69	-1.46		-0.10	-0.32	0.63			36.44	-3.33	-1.91		0.99	-2.04	-2.66			-0.51		
2350	-0.07	-0.74		0.60	-0.47	-0.58			37.38	-3.21	-2.07		1.18	-2.19	-1.82			-0.46		
2400	-0.81	-1.67		-0.11	-1.37	0.13			35.42	-3.35	-0.54		1.19	-1.88	-2.77			-0.29		
2450	-1.27	-2.44		-0.78	-1.66	-0.19			33.31	-2.32	0.03		1.75	-1.31	-2.45			0.58		
2500	2.15	-0.94		0.46	2.98	2.97			34.06	-2.87	-0.67		0.61	-2.06	-1.35			0.14		

Lab No. 11 measured in the Specular Excluded geometry only.

Table 6. 0°/45° Geometry.
% Radiance Factor differences from NPL values after renormalisation.

Sample Lab No.	White Spectralon					Light Grey Spectralon					Dark Grey Spectralon				
	12	7	4	15	9	12	7	4	15	9	12	7	4	15	9
Wavelength															
800	0	0	0			-2.94	-2.71	-1.64			-2.63	-1.60	-2.04		
850	0	0	0			-3.62	-3.38	-2.34			-2.33	-1.30	-1.73		
900	0	0	0			-3.60	-3.46	-2.33			-2.37	-1.45	-1.80		
950	0	0	0			-3.50	-3.45	-2.26			-2.23	-1.50	-1.71		
1000	0	0	0			-3.49	-3.42	-2.27			-1.82	-1.06	-1.26		
1050	0	0	0			-3.54	-3.48	-2.42			-2.18	-1.42	-1.61		
1100	0	0	0	0		-3.09	-3.02	-1.42	-2.46		-1.14	-0.57	-0.15	-0.37	
1150	0	0	0	0		-3.32	-3.43	-1.74	-2.75		-1.57	-1.16	-0.62	-0.84	
1200	0	0	0	0		-2.89	-2.85	-1.25	-2.34		-1.31	-0.81	-0.30	-0.60	
1250	0	0	0	0		-2.81	-2.89	-1.21	-2.32		-1.40	-0.99	-0.39	-0.71	
1300	0	0	0	0		-2.81	-2.97	-1.30	-2.41		-1.44	-1.10	-0.47	-0.81	
1350	0	0	0	0		-3.12	-3.28	-1.67	-2.84		-1.42	-1.11	-0.47	-0.87	
1400	0	0	0	0		-2.95	-3.18	-1.58	-2.85		-1.49	-1.22	-0.56	-1.06	
1450	0	0	0	0		-3.58	-3.84	-2.20	-3.57		-1.69	-1.44	-0.75	-1.31	
1500	0	0	0	0		-3.13	-3.44	-1.81	-3.20		-1.51	-1.28	-0.59	-1.17	
1550	0	0	0	0		-3.55	-3.87	-2.25	-3.70		-1.83	-1.63	-0.91	-1.56	
1600	0	0	0	0		-3.23	-3.49	-1.93	-3.36		-1.85	-1.66	-0.93	-1.57	
1650	0	0	0	0		-3.51	-3.76	-2.28	-3.71		-1.59	-1.43	-0.71	-1.35	
1700	0	0	0	0		-3.25	-3.54	-2.13	-3.60		-1.63	-1.52	-0.83	-1.49	
1750	0	0	0	0		-3.25	-3.63	-2.19	-3.67		-1.78	-1.73	-1.00	-1.67	
1800	0	0	0	0		-3.87	-4.24	-2.79	-4.28		-2.00	-1.97	-1.19	-1.87	
1850	0	0	0	0		-3.39	-3.81	-2.40	-3.85		-1.83	-1.87	-1.07	-1.75	
1900	0	0	0	0		-4.11	-4.57	-3.13	-4.68		-2.33	-2.41	-1.57	-2.31	
1950	0	0	0	0		-3.86	-4.41	-2.92	-4.55		-2.20	-2.34	-1.46	-2.25	
2000	0	0	0	0		-3.87	-4.40	-3.01	-4.58		-2.16	-2.33	-1.46	-2.23	
2050	0	0	0	0		-3.25	-3.72	-2.44	-3.99		-2.10	-2.26	-1.42	-2.20	
2100	0	0	0	0		-3.54	-4.01	-2.77	-4.31		-2.24	-2.40	-1.57	-2.36	
2150	0	0	0	0		-2.67	-3.15	-2.00	-3.54		-1.87	-2.04	-1.23	-2.05	
2200	0	0	0	0		-3.16	-3.74	-2.46	-4.09		-2.06	-2.30	-1.42	-2.27	
2250	0	0	0	0		-2.93	-3.52	-2.27	-3.96		-1.82	-2.07	-1.17	-2.08	
2300	0	0	0	0		-2.50	-3.16	-1.99	-3.60		-1.55	-1.86	-1.01	-1.87	
2350	0	0	0	0		-1.42	-2.00	-0.91	-2.47		-1.34	-1.64	-0.79	-1.63	
2400	0	0	0	0		-3.64	-4.23	-3.21	-4.75		-1.47	-1.79	-0.95	-1.80	
2450	0	0	0	0		-2.98	-3.55	-2.54	-4.14		-1.13	-1.45	-0.60	-1.49	
2500	0	0	0	0		-1.92	-2.51				-0.78	-1.11			

Table 6. 0°/45° Geometry.
% Radiance Factor differences from NPL values after renormalisation.

Sample Lab No.	Black Spectralon					White Tile				
	12	7	4	15	9	12	7	4	15	9
Wavelength										
800	0.31	0.12	0.02			-16.81	-1.59			
850	0.26	0.11	-0.01			-17.11	-1.89			
900	0.31	0.13	0.01			-16.43	-1.36			
950	-0.02	-0.28	-0.37			-16.61	-1.46			
1000	0.62	0.38	0.28			-16.29	-1.17			
1050	0.25	0.03	-0.11			-15.76	-1.00			
1100	0.32	0.13	-0.10	0.61		-13.00	-1.13		-1.51	
1150	0.58	0.37	0.14	0.81		-13.16	-1.30		-1.68	
1200	0.19	-0.01	-0.26	0.36		-13.00	-1.15		-1.56	
1250	0.43	0.22	-0.05	0.54		-12.66	-0.84		-1.22	
1300	0.15	-0.06	-0.35	0.21		-12.86	-1.09		-1.47	
1350	0.23	0.01	-0.29	0.22		-13.21	-1.61		-2.02	
1400	0.04	-0.18	-0.50	-0.03		-12.93	-1.38		-2.11	
1450	0.27	0.04	-0.30	0.16		-13.05	-1.31		-1.94	
1500	0.29	0.10	-0.29	0.14		-13.03	-1.47		-1.89	
1550	0.29	0.06	-0.32	0.07		-13.45	-1.89		-2.37	
1600	0.18	-0.10	-0.46	-0.11		-13.22	-1.49		-2.12	
1650	0.43	0.13	-0.24	0.10		-13.18	-1.49		-2.19	
1700	0.24	-0.08	-0.45	-0.14		-13.66	-1.88		-2.67	
1750	0.09	-0.24	-0.62	-0.32		-13.04	-1.24		-2.05	
1800	0.11	-0.24	-0.61	-0.32		-13.30	-1.63		-2.44	
1850	0.07	-0.29	-0.65	-0.38		-13.10	-1.58		-2.43	
1900	0.05	-0.33	-0.70	-0.44		-13.59	-2.03		-3.16	
1950	0.37	-0.04	-0.41	-0.17		-13.47	-1.53		-2.67	
2000	0.02	-0.40	-0.76	-0.54		-13.22	-1.49		-2.69	
2050	0.15	-0.29	-0.65	-0.44		-12.45	-0.66		-1.97	
2100	0.21	-0.23	-0.59	-0.40		-13.13	-1.38		-2.86	
2150	-0.01	-0.47	-0.82	-0.66		-12.51	-0.95		-3.02	
2200	-0.07	-0.55	-0.88	-0.74		-12.68	-1.44		-3.95	
2250	0.62	0.12	-0.21	-0.09		-12.55	-1.21		-3.52	
2300	0.77	0.24	-0.09	0.00		-12.44	-0.81		-2.79	
2350	0.09	-0.45	-0.77	-0.68		-11.57	-0.17		-2.04	
2400	0.54	0.00	-0.31	-0.24		-12.42	-1.53		-3.92	
2450	0.65	0.09	-0.20	-0.15		-12.34	-1.78		-4.44	
2500	0.94	0.38				-11.53	-1.36			

Tables 7a and 7b - Uncertainties on the NPL Measurements of Near Infrared Diffuse Reflectance on the Intercomparison Samples

The uncertainties below are at quoted at the 95% confidence level.

Table 7a: Uncertainties for Sets GW96 and GY96 - Sphere Geometries

Note: Values are the same for both specular included and excluded except for the mirror

Sphere geometries	Approx reflectance	800 - 2000 nm (% reflectance)	2010 - 2500 nm (% reflectance)
white spectralon	98%	1.58	2.08
light grey spectralon	60%	1.06	1.48
dark grey spectralon	23%	0.54	0.88
black spectralon	2%	0.31	0.61
white tile	90%	1.45	1.93
mirror - spec inc	95%	1.58	2.08
mirror - spec exc	0.5%	0.31	0.61

Table 7b: Uncertainties for Set GX96 - 0/45 Geometry

0/45 geometry	Approx reflectance	800 - 2000 nm (% reflectance)	2010 - 2500 nm (% reflectance)
white spectralon	98%	2.25	2.75
light grey spectralon	60%	1.45	1.91
dark grey spectralon	23%	0.65	1.07
black spectralon	2%	0.29	0.69
white tile	90%	2.05	2.54

APPENDIX 5 - Figures

Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).
 Specular Included Geometry.

Fig. 1a: White Spectralon - Reflectance values.

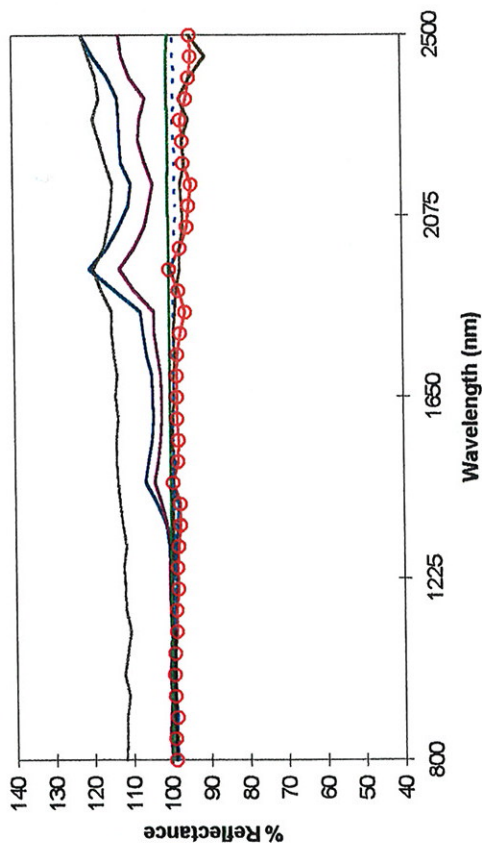


Fig. 1b: White Spectralon - Differences from NPL values.

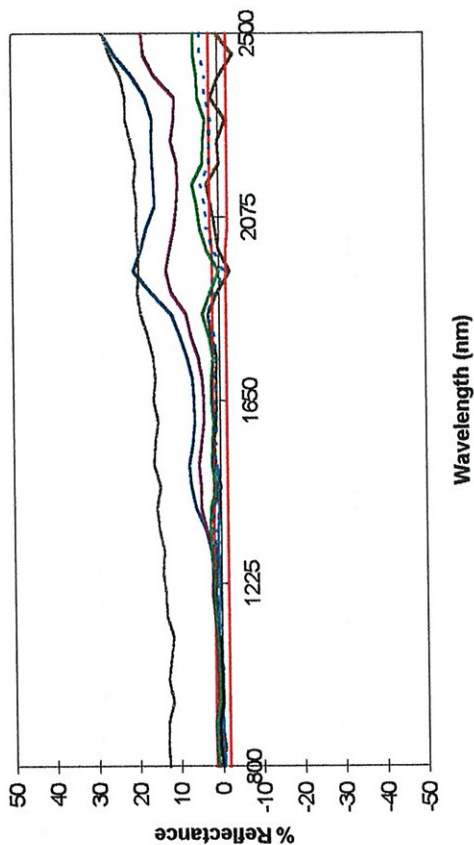


Fig. 2a: Light Grey Spectralon - Reflectance values.

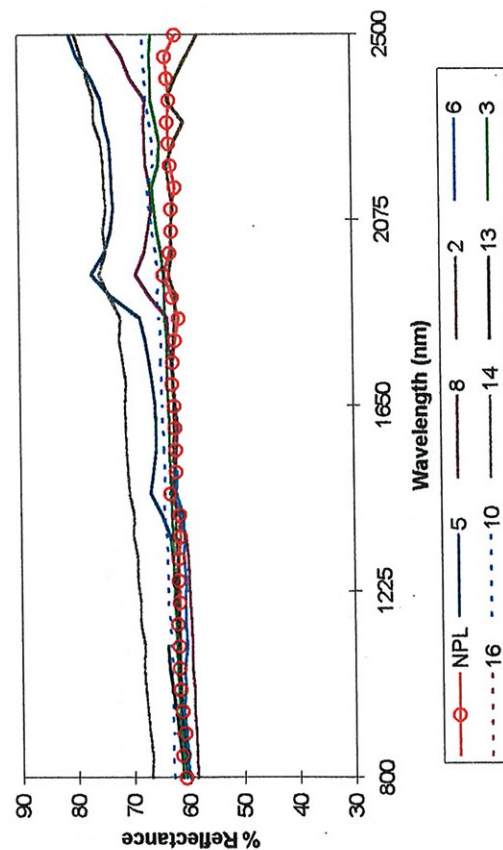
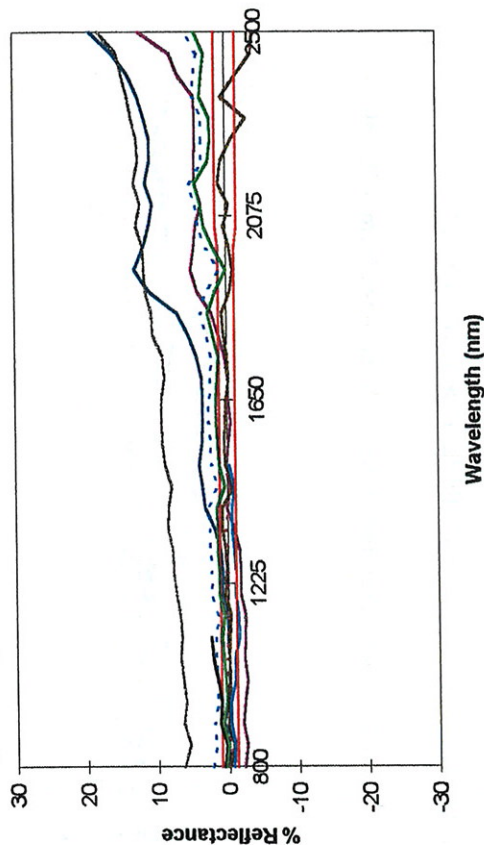


Fig. 2b: Light Grey Spectralon - Differences from NPL values.



Specular Included Geometry.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 3a: Dark Grey Spectralon - Reflectance Values.

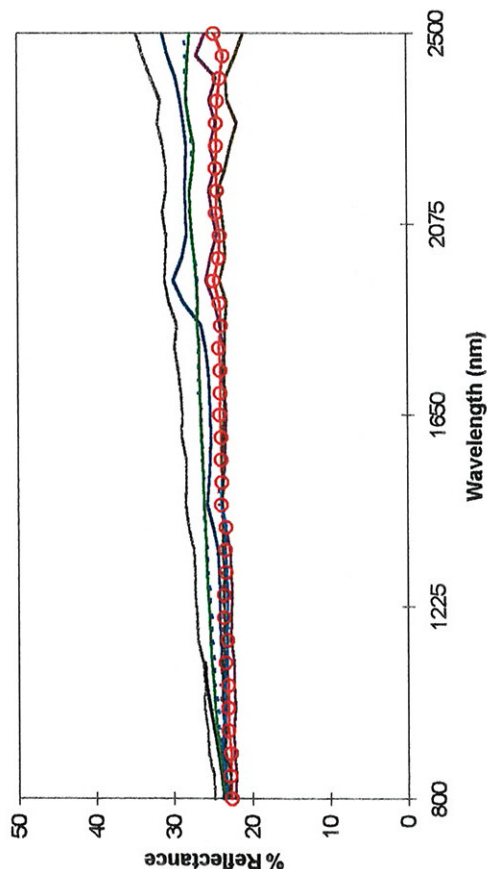


Fig. 3b: Dark Grey Spectralon - Differences from NPL values.

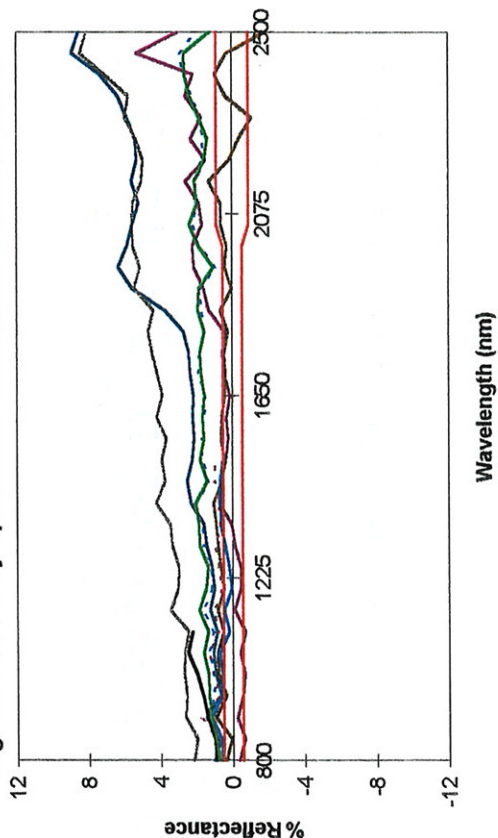


Fig. 4a: Black Spectralon - Reflectance values.

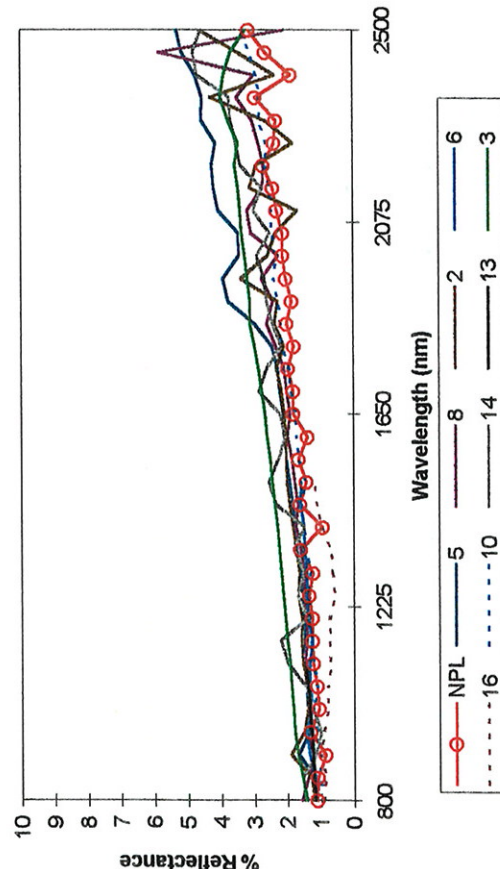
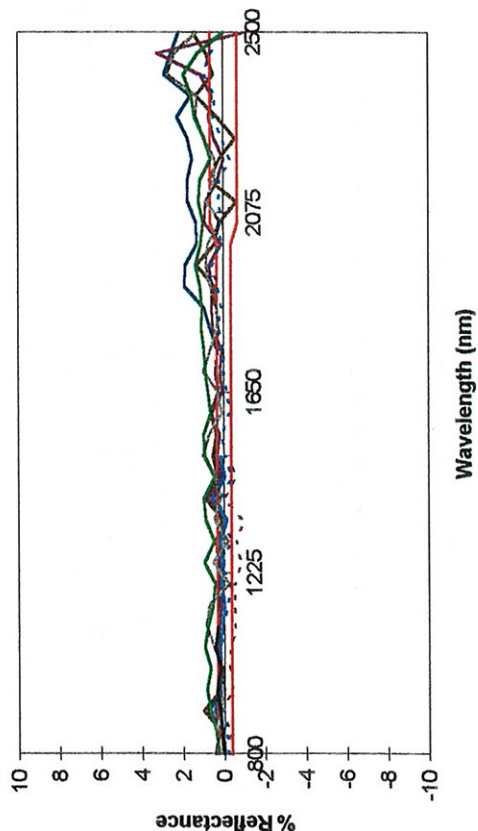


Fig. 4b: Black Spectralon - Differences from NPL values.



Specular Included Geometry.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 5a: White Tile - Reflectance values.

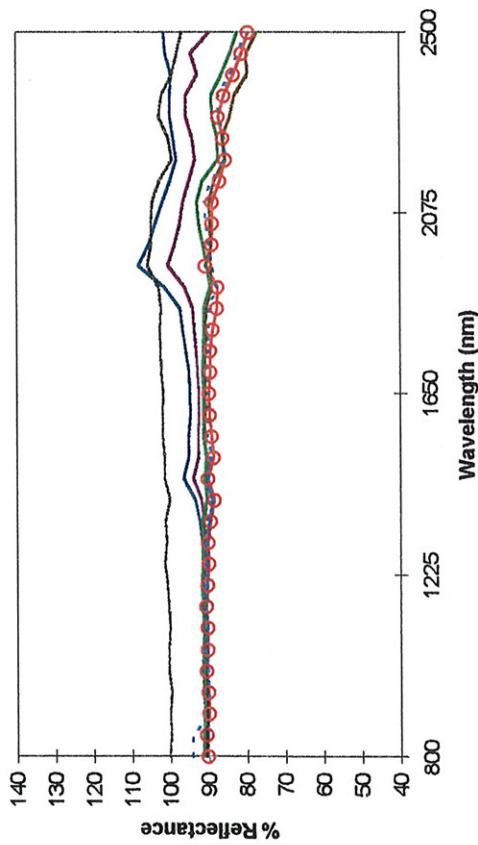


Fig. 5b: White Tile - Differences from NPL values.

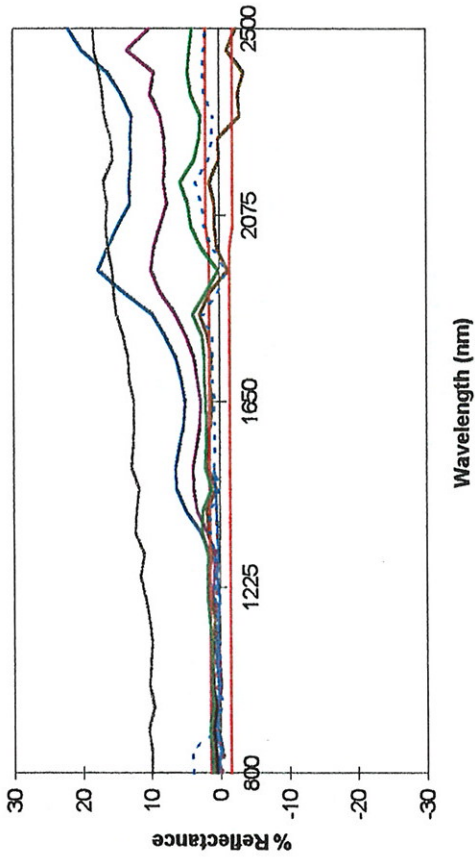


Fig. 6a: Mirror - Reflectance values.

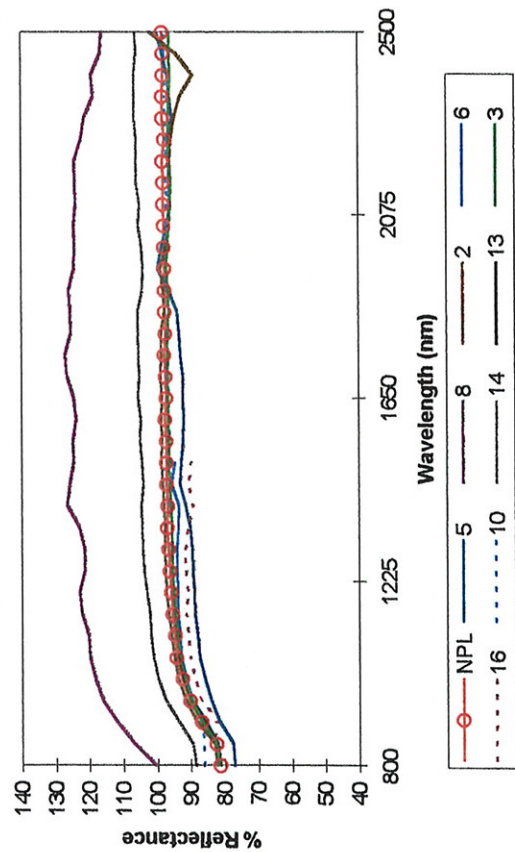
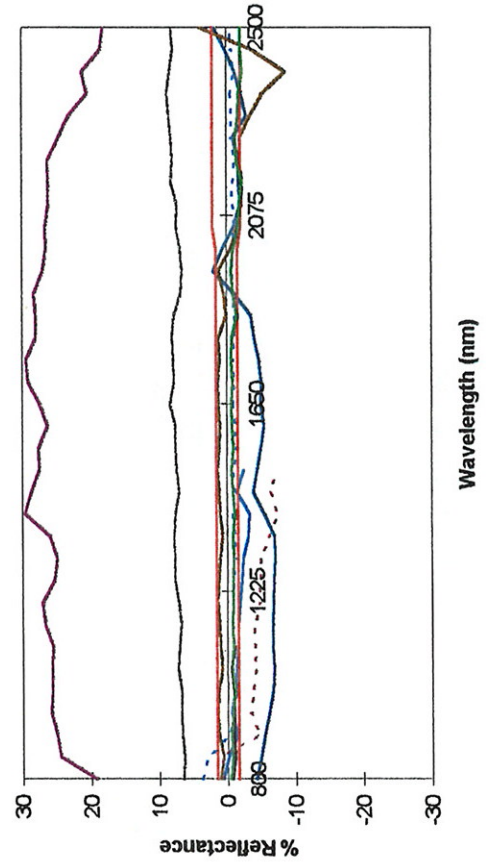


Fig. 6b: Mirror - Differences from NPL values.



Specular Excluded Geometry.
Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 7a: White Spectralon - Reflectance values.

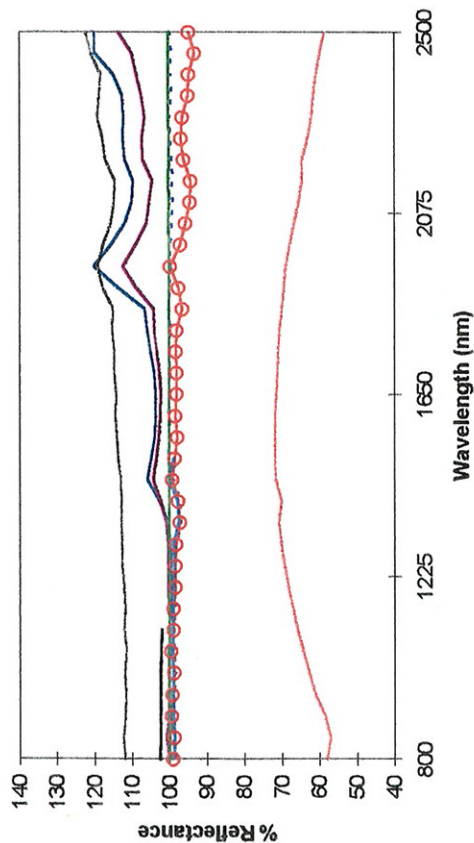


Fig. 7b: White Spectralon - Differences from NPL values.

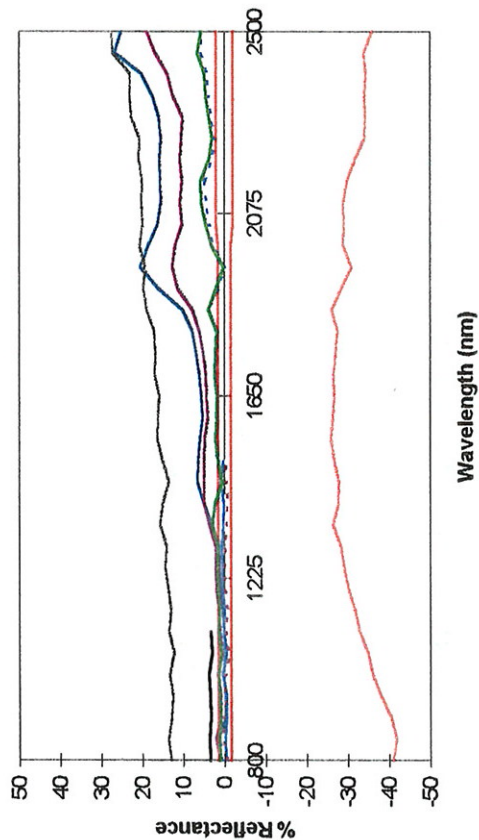


Fig. 8a: Light Grey Spectralon - Reflectance values.

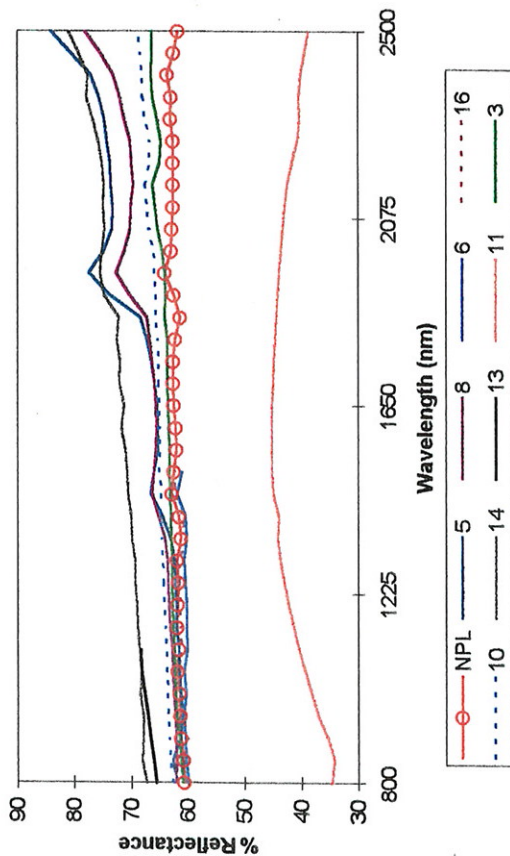
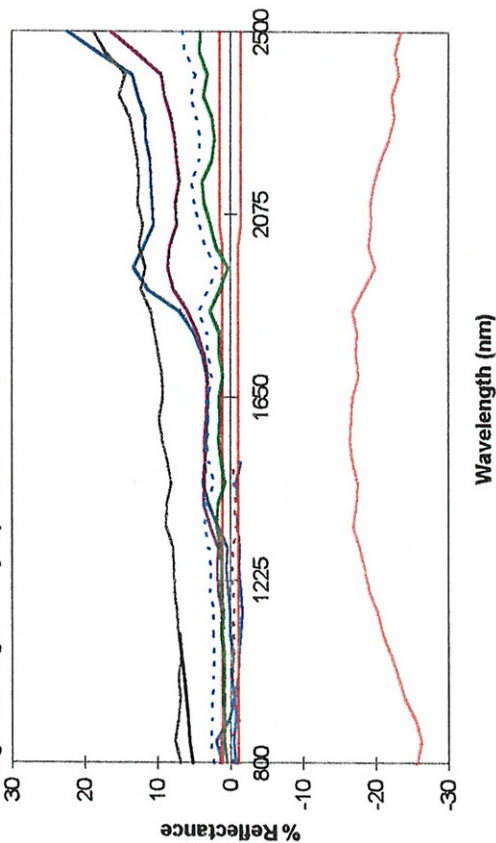


Fig. 8b: Light Grey Spectralon - Differences from NPL values.



Specular Excluded Geometry.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 9a: Dark Grey Spectralon - Reflectance values.

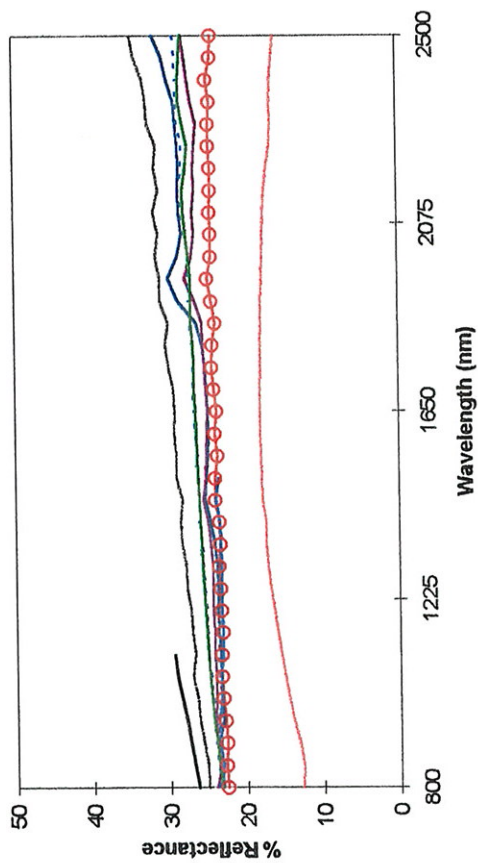


Fig. 9b: Dark Grey Spectralon - Differences from NPL values.

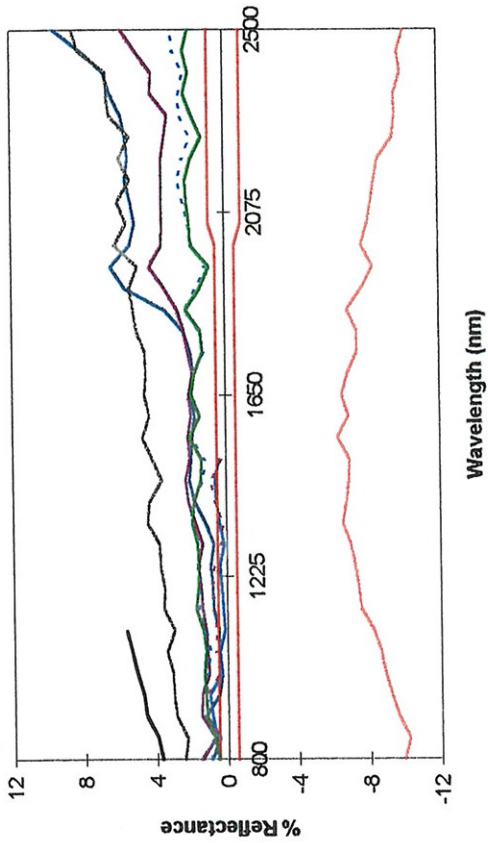


Fig. 10a: Black Spectralon - Reflectance values.

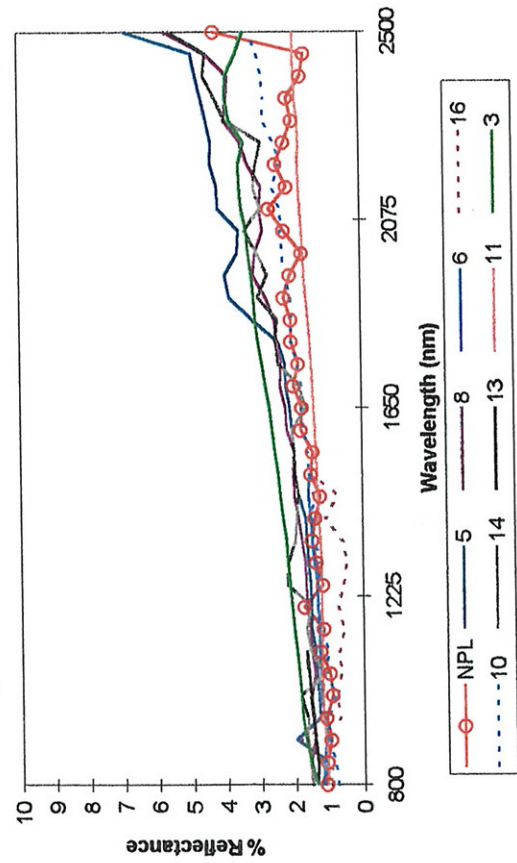
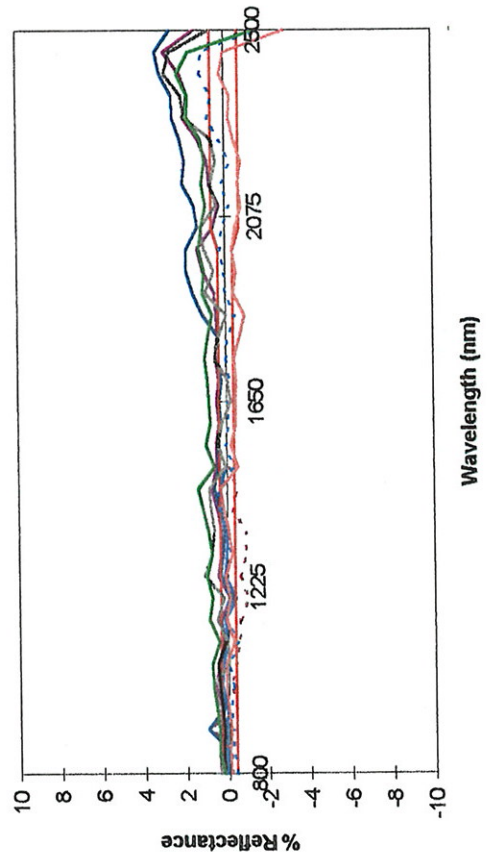


Fig. 10b: Black Spectralon - Differences from NPL values.



Specular Excluded Geometry.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 11a: White Tile - Reflectance values.

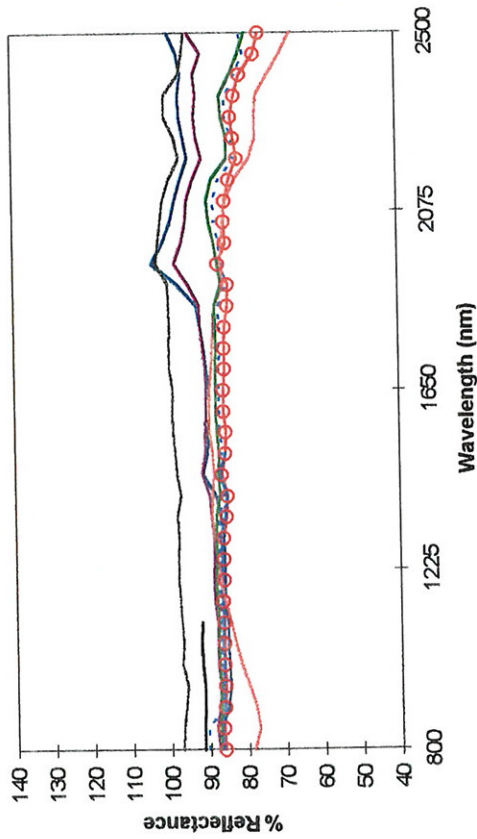


Fig. 11b: White Tile - Differences from NPL values.

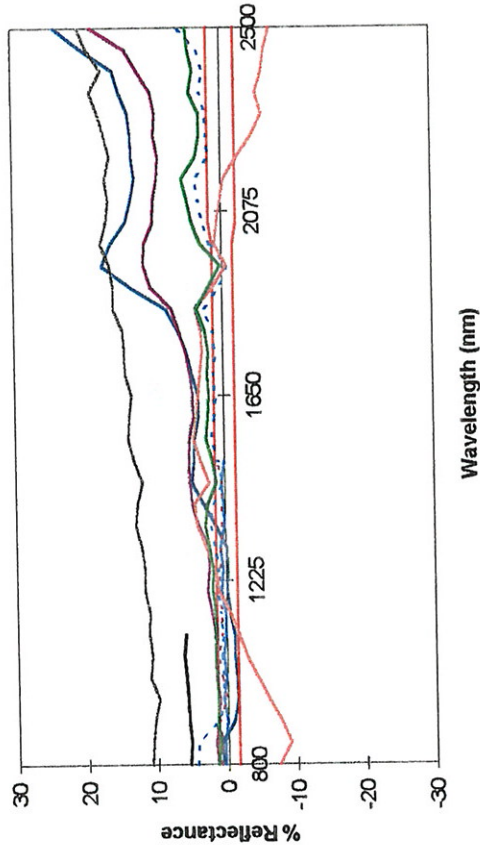


Fig. 12a: Mirror - Reflectance values.

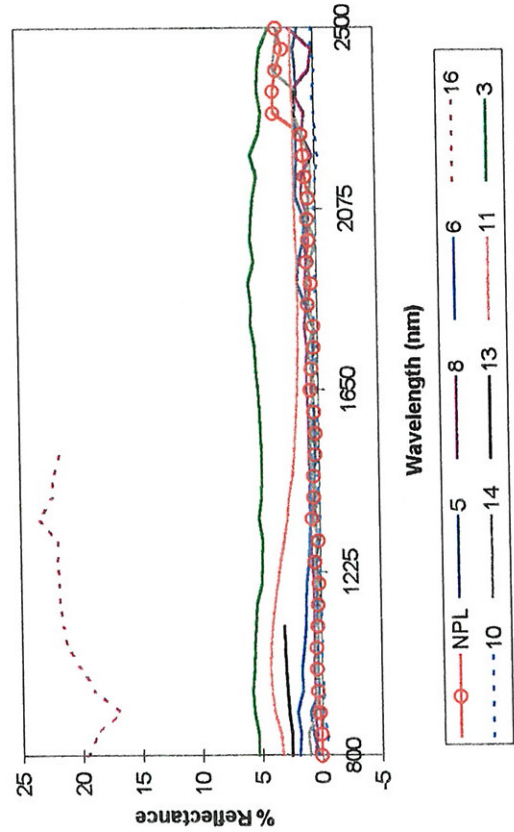
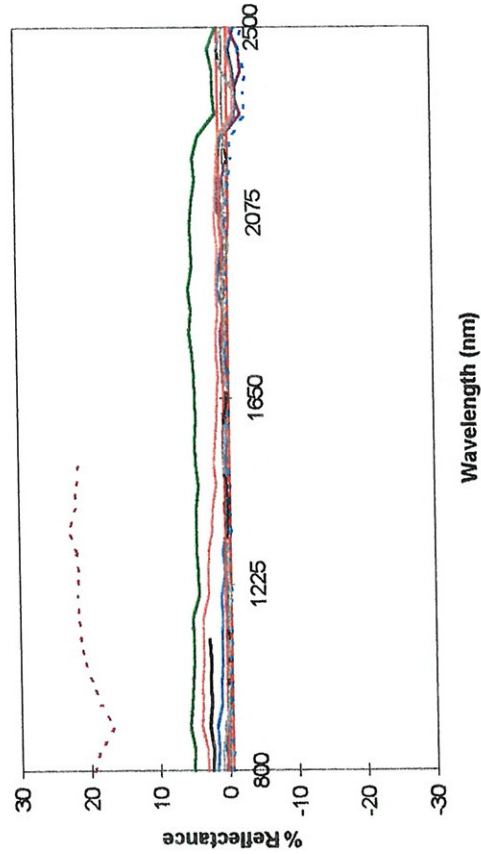


Fig. 12b: Mirror - Differences from NPL values.



0°/45° Geometry.
Radiance Factor values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 13a: White Spectralon - Radiance Factor values.

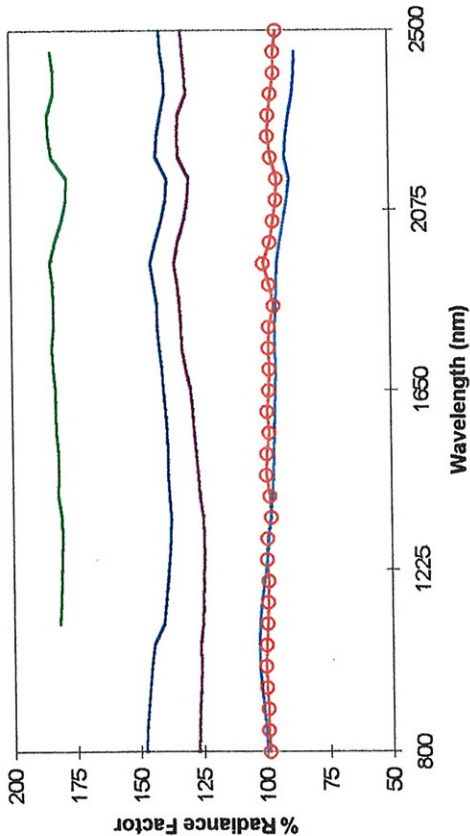


Fig. 13b: White Spectralon - Differences from NPL values.

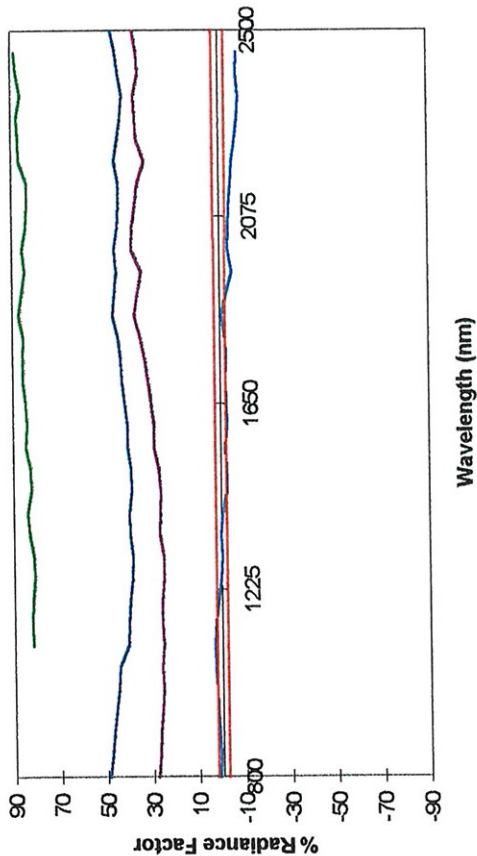


Fig. 14a: Light Grey Spectralon - Radiance Factor values.

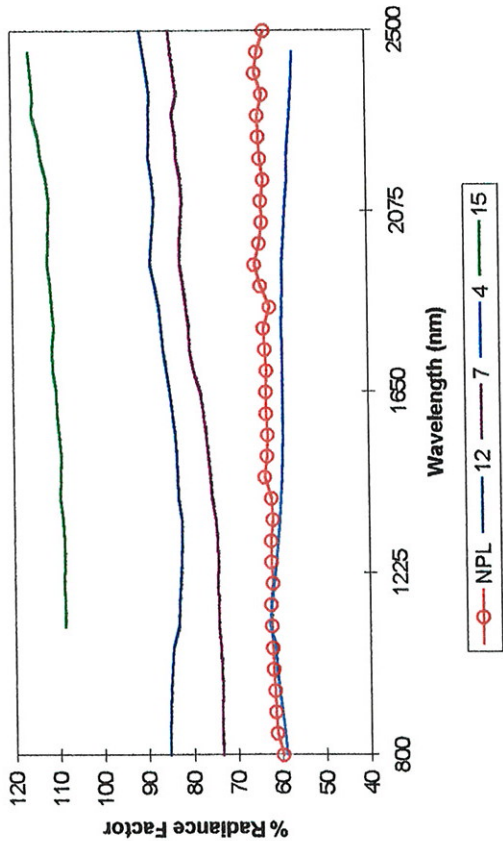
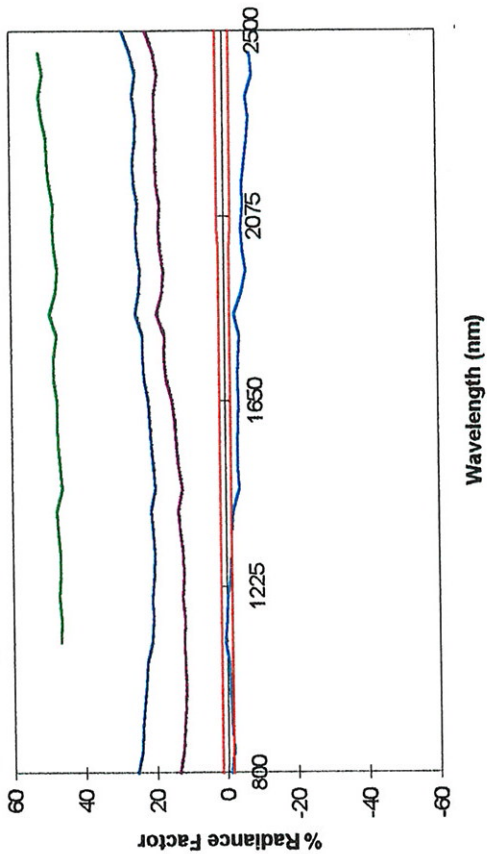


Fig. 14b: Light Grey Spectralon - Differences from NPL values.



0°/45° Geometry.
Radiance Factor values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 15a: Dark Grey Spectralon - Radiance Factor values.

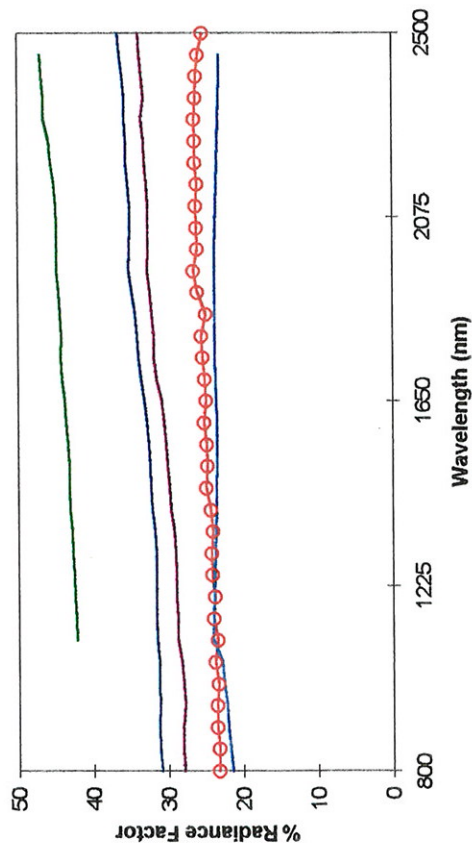


Fig. 15b: Dark Grey Spectralon - Differences from NPL values.

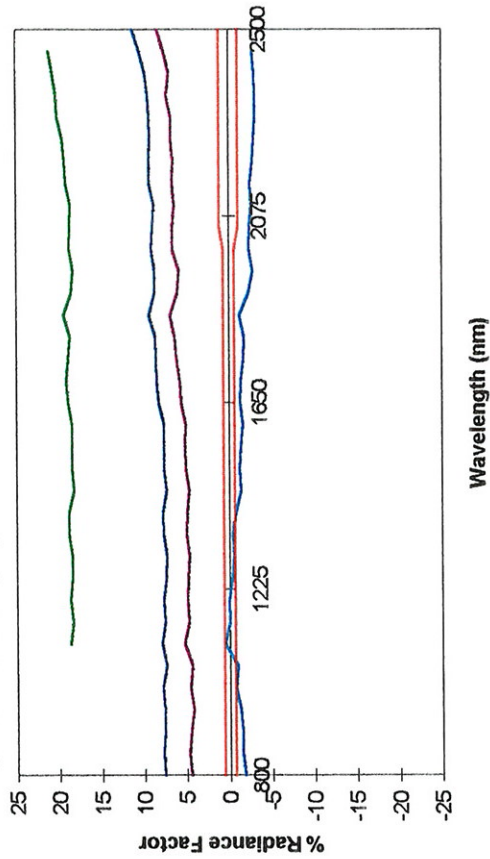


Fig. 16a: Black Spectralon - Radiance Factor values.

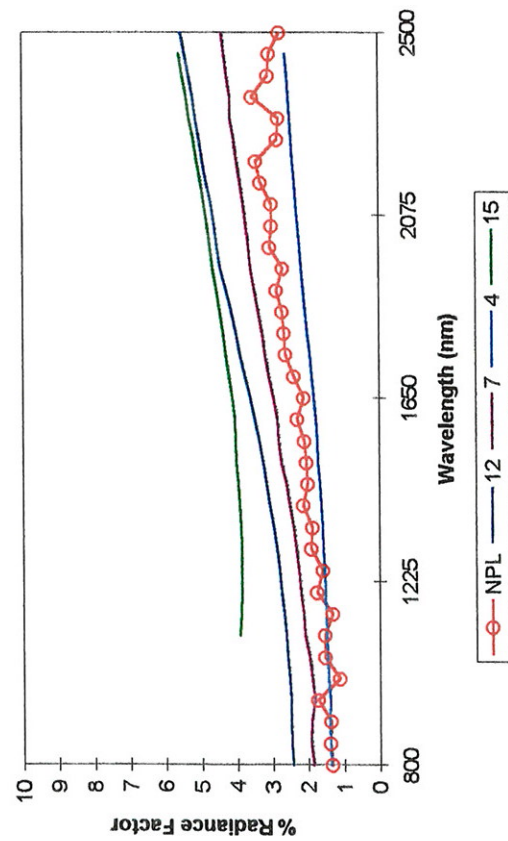
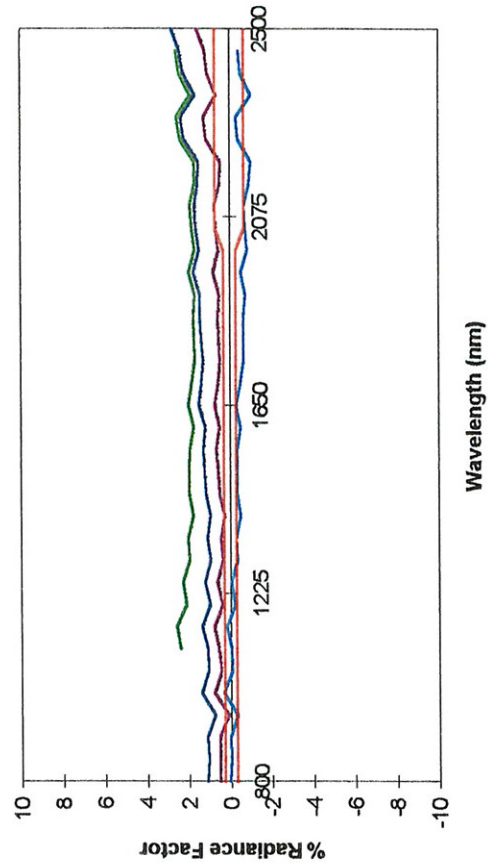


Fig. 16b: Black Spectralon - Differences from NPL values.



0°/45° Geometry.

Radiance Factor values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 17a: White Tile - Radiance Factor values.

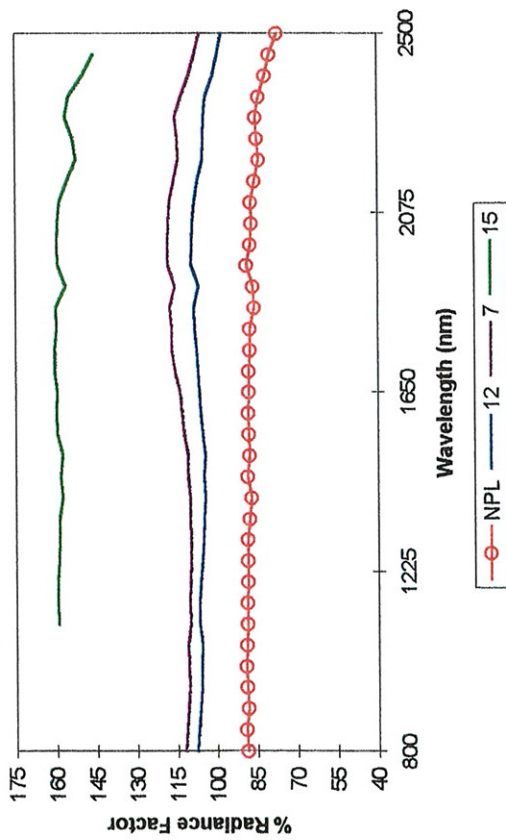
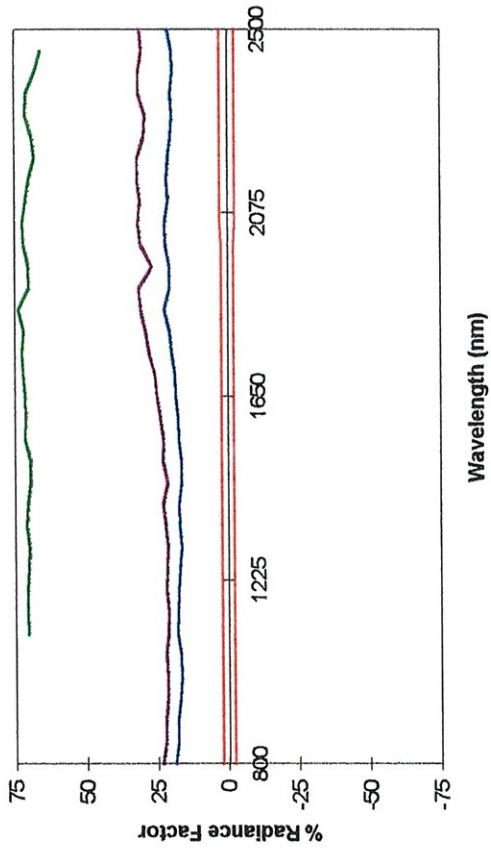


Fig. 17b: White Tile - Differences from NPL values.



Specular Included Geometry, after renormalisation.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 18a: White Spectralon - Reflectance values.

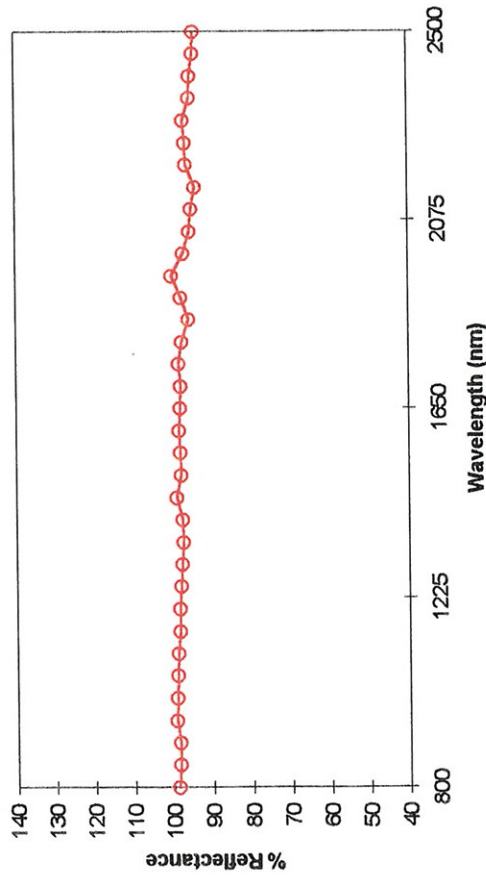


Fig. 18b: White Spectralon - Differences from NPL values.

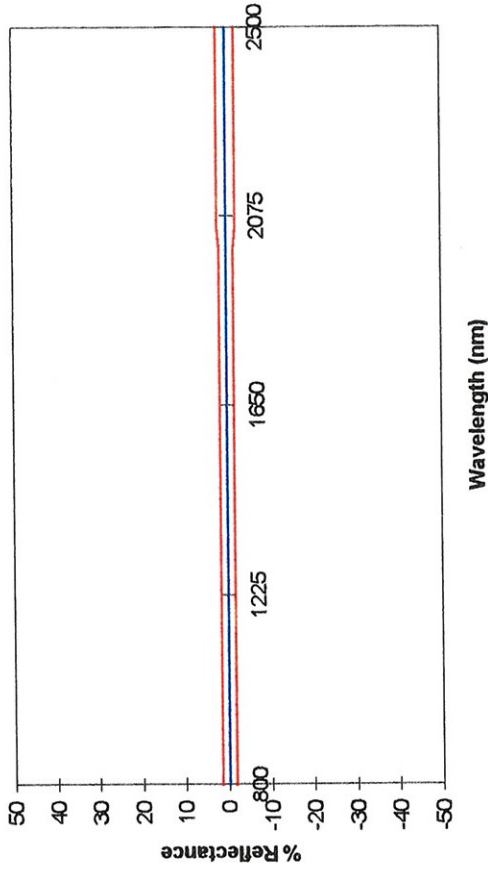


Fig. 19a: Light Grey Spectralon - Reflectance values.

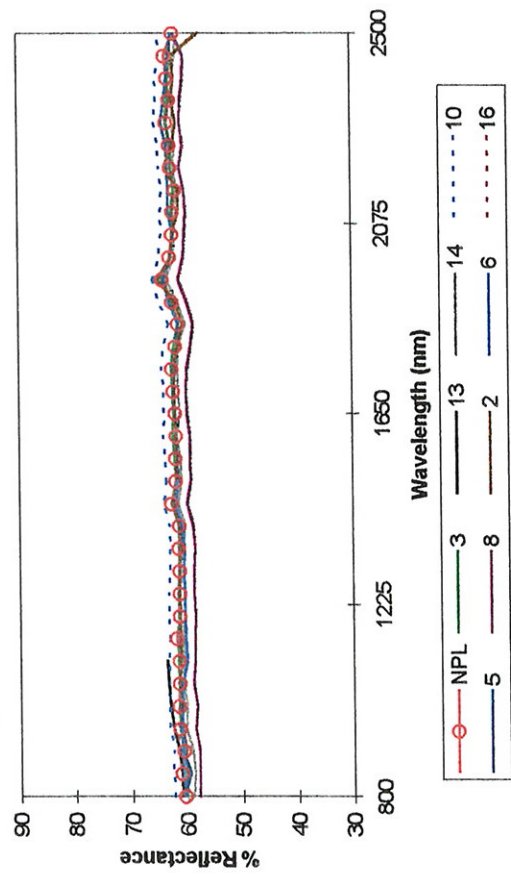
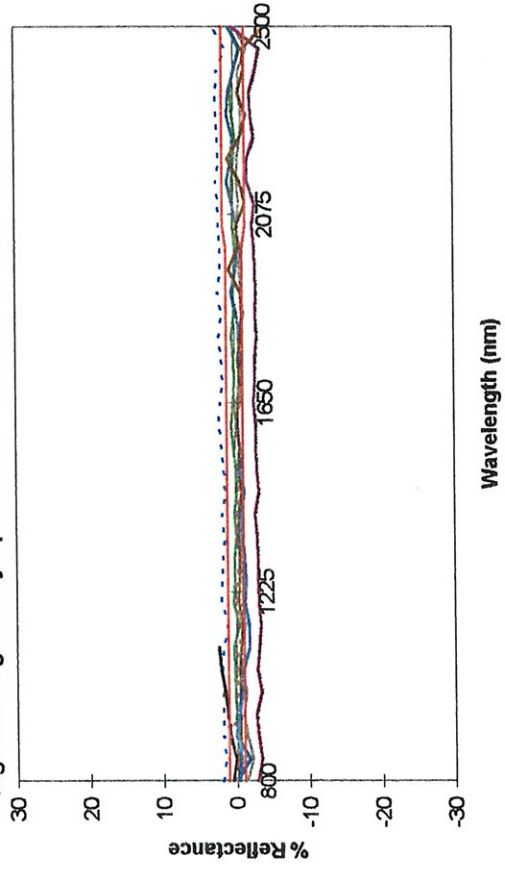


Fig. 19b: Light Grey Spectralon - Differences from NPL values.



Specular Included Geometry, after renormalisation.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 20a: Dark Grey Spectralon - Reflectance values.

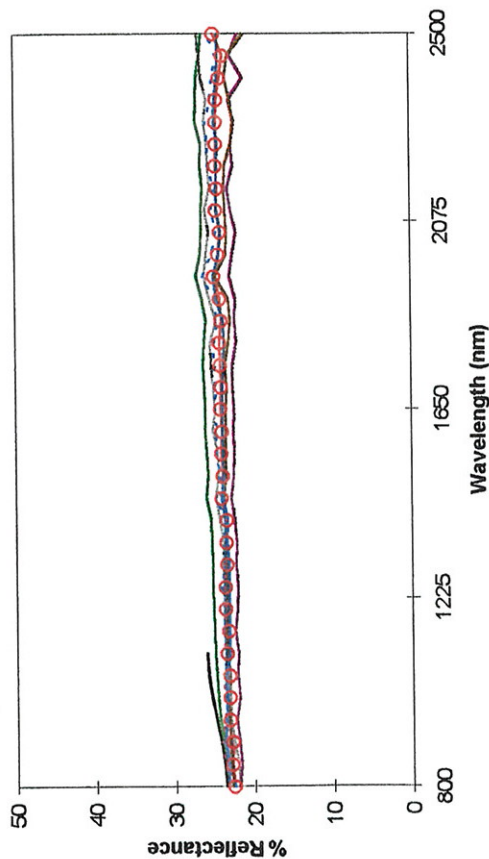


Fig. 20b: Dark Grey Spectralon - Differences from NPL values.

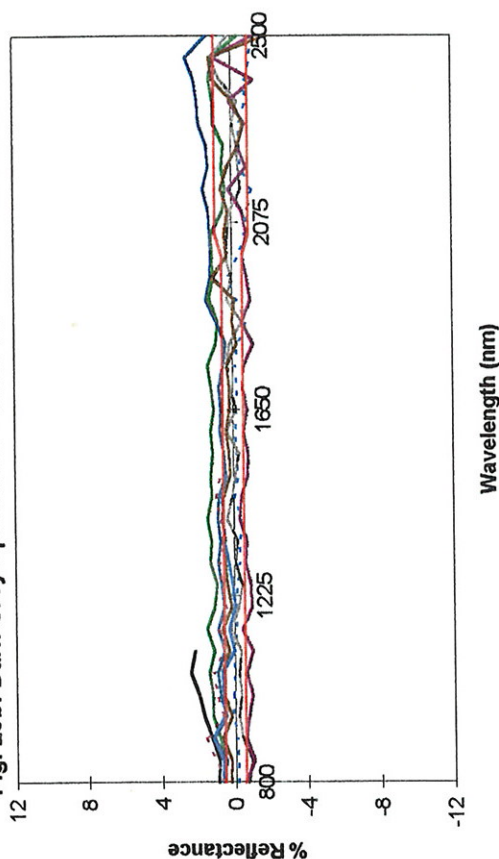


Fig. 21a: Black Spectralon - Reflectance values.

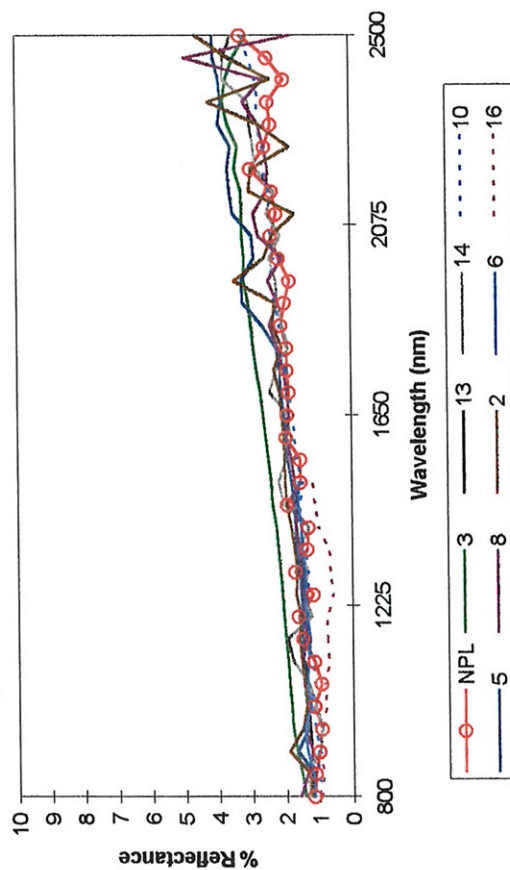
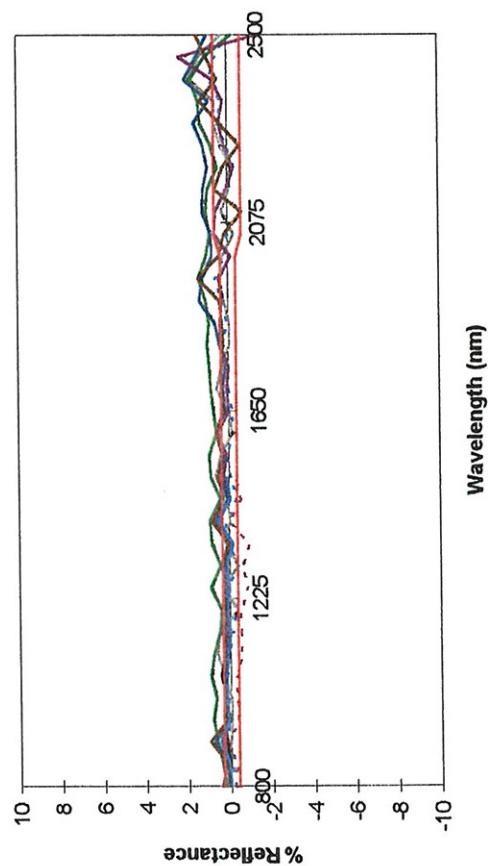


Fig. 21b: Black Spectralon - Differences from NPL values.



Specular Included Geometry, after renormalisation.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 22a: White Tile - Reflectance values.

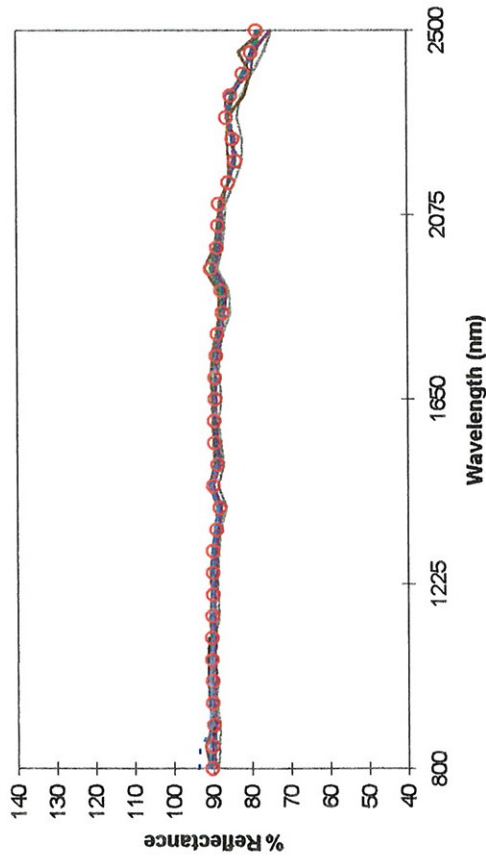


Fig. 22b: White Tile - Differences from NPL values.

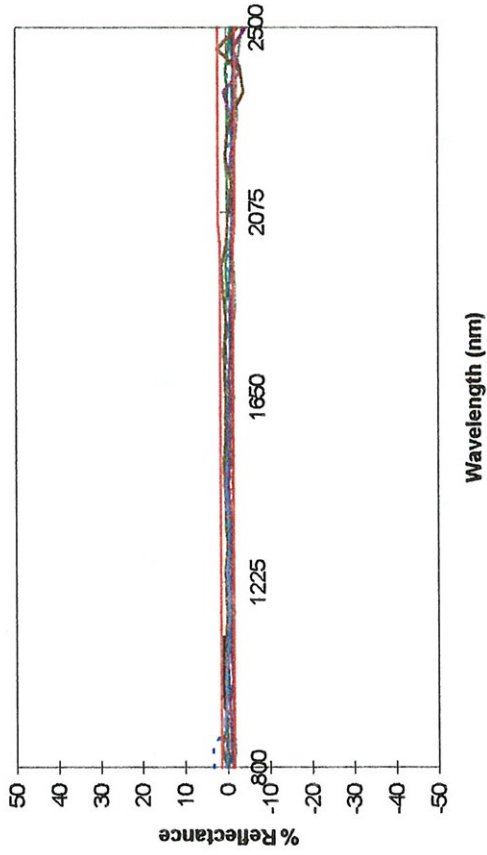


Fig. 23a: Mirror - Reflectance values.

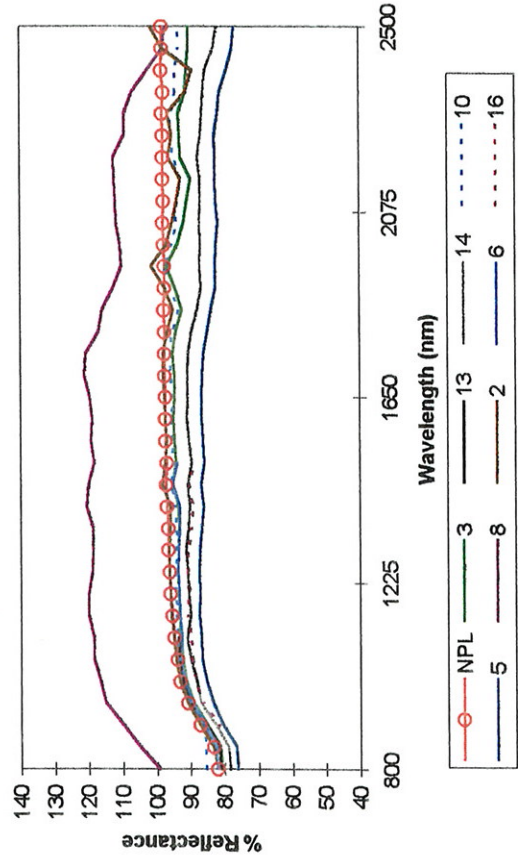
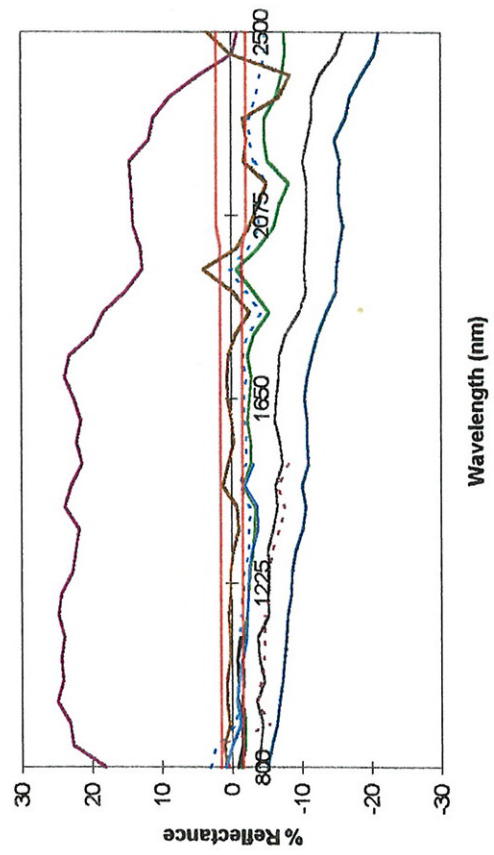


Fig. 23b: Mirror - Differences from NPL values.



Specular Excluded Geometry, after renormalisation.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 24a: White Spectralon - Reflectance values.

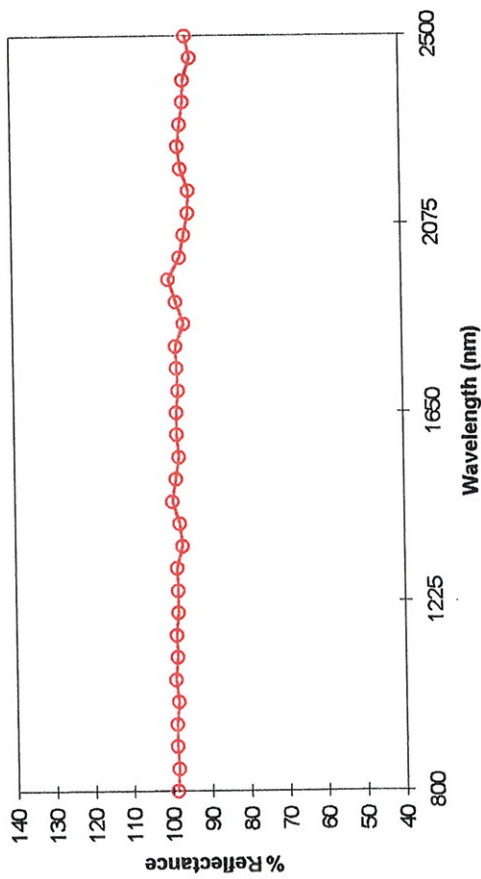


Fig. 24b: White Spectralon - Differences from NPL values.

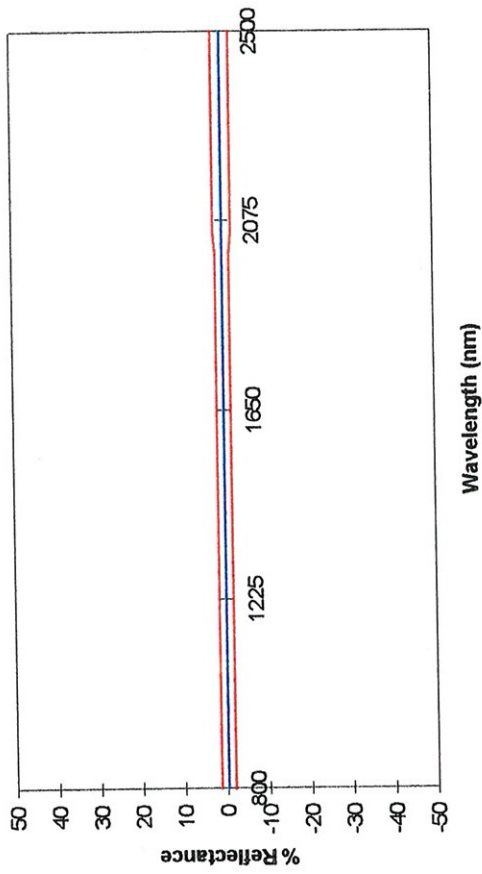


Fig. 25a: Light Grey Spectralon - Reflectance values.

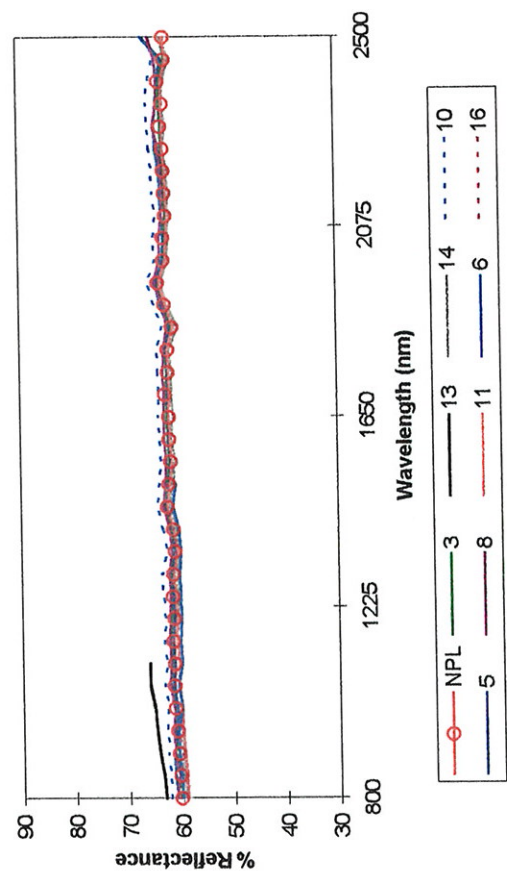
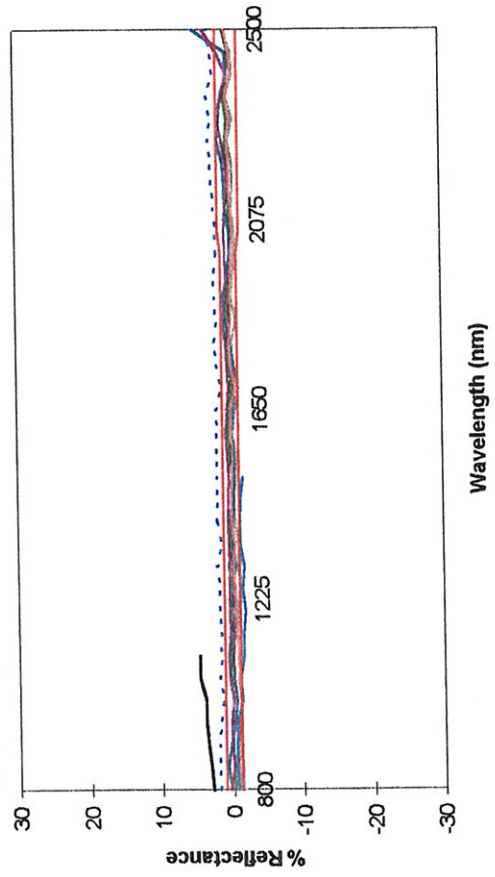


Fig. 25b: Light Grey Spectralon - Differences from NPL values.



Specular Excluded Geometry, after renormalisation.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 26a: Dark Grey Spectralon - Reflectance values.

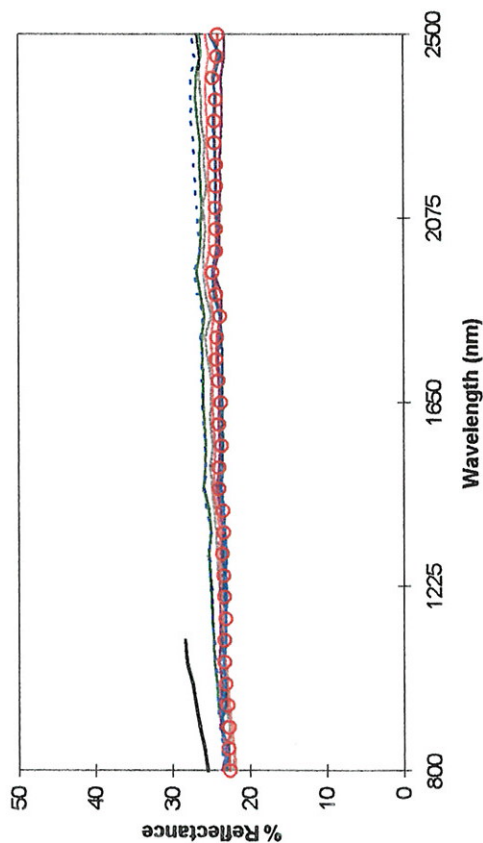


Fig. 26b: Dark Grey Spectralon - Differences from NPL values.

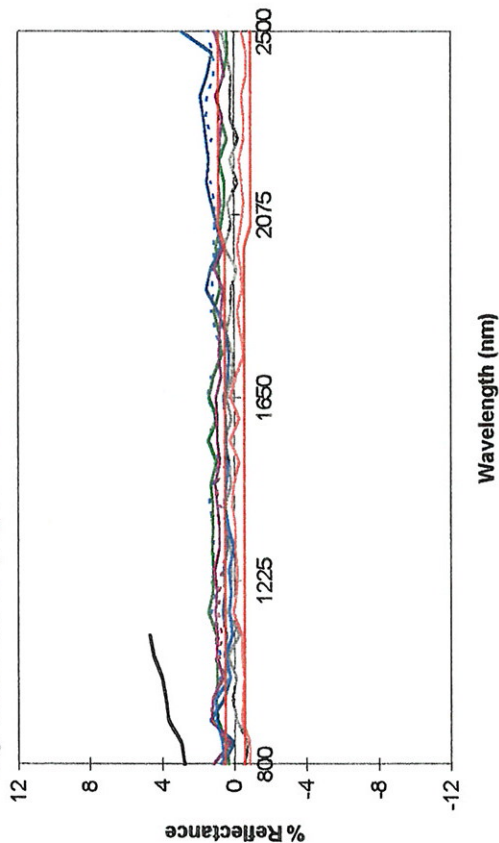


Fig. 27a: Black Spectralon - Reflectance values.

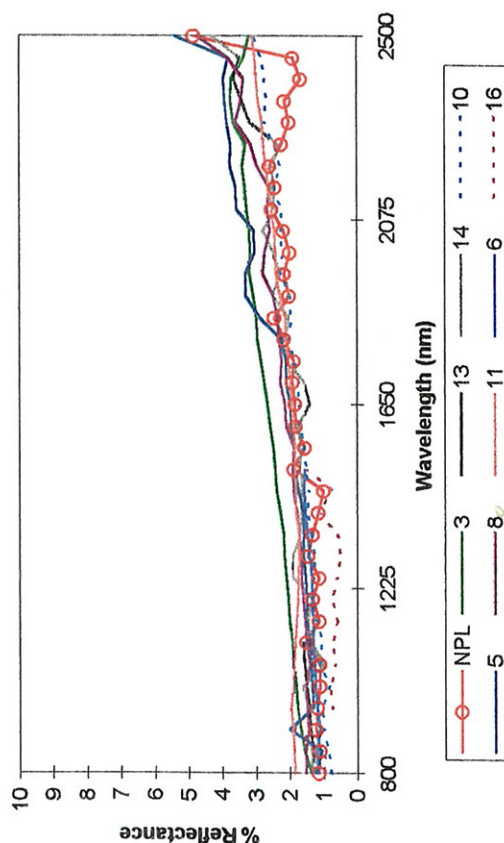
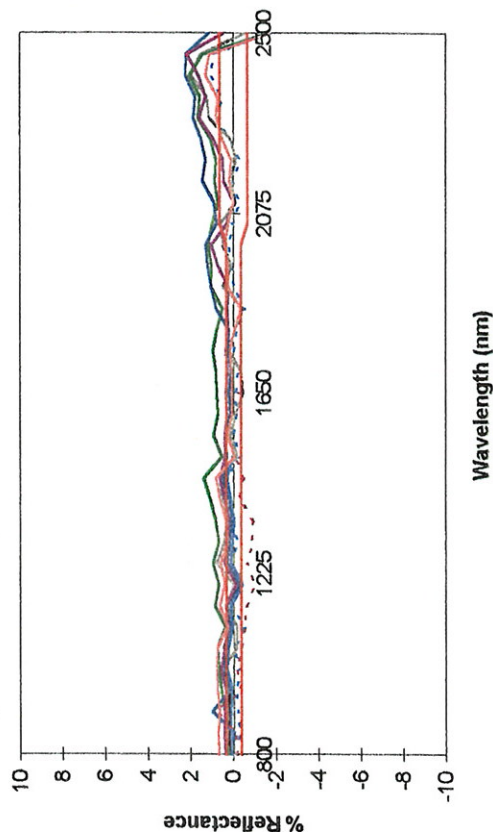


Fig. 27b: Black Spectralon - Differences from NPL values.



Specular Excluded Geometry, after renormalisation.
 Reflectance values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 28a: White Tile - Reflectance values.

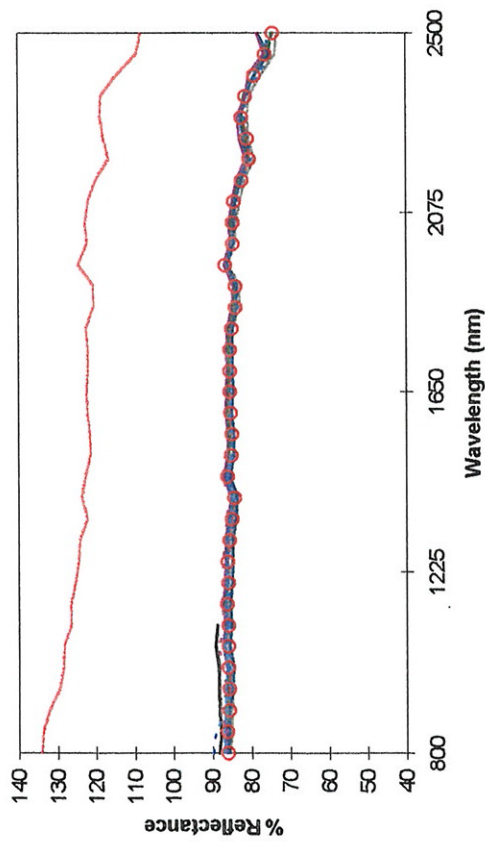


Fig. 28b: White Tile - Differences from NPL values.

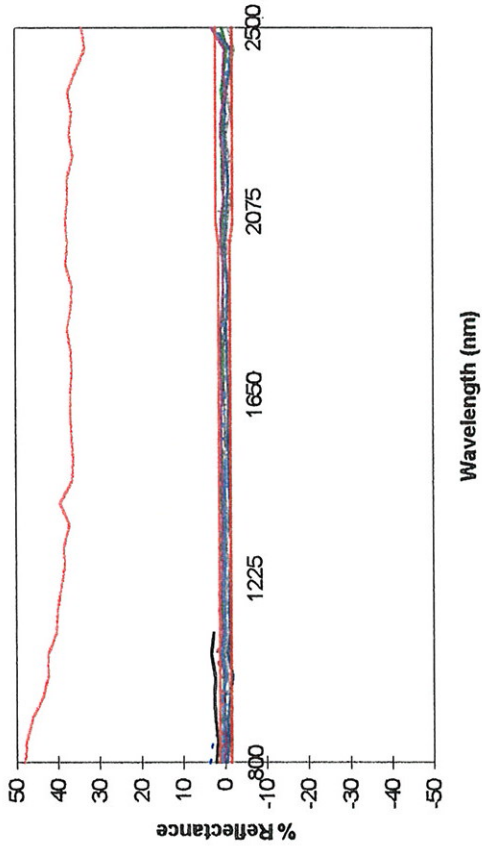


Fig. 29a: Mirror - Reflectance values.

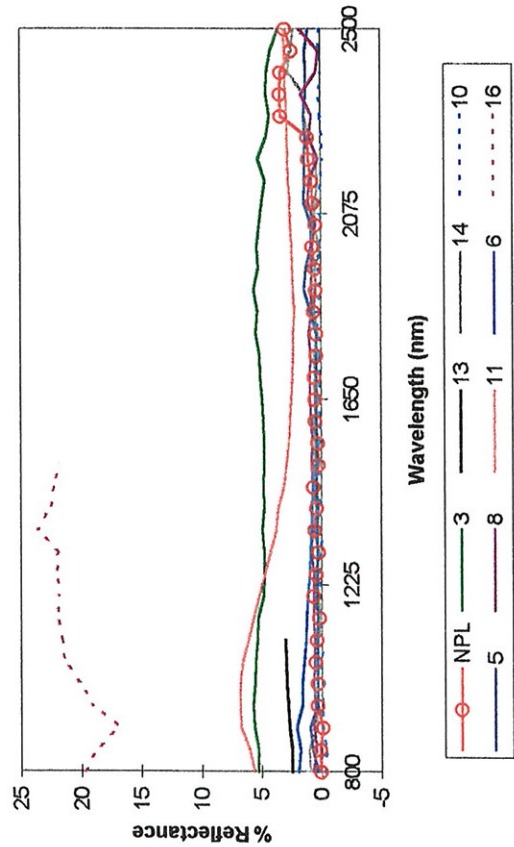
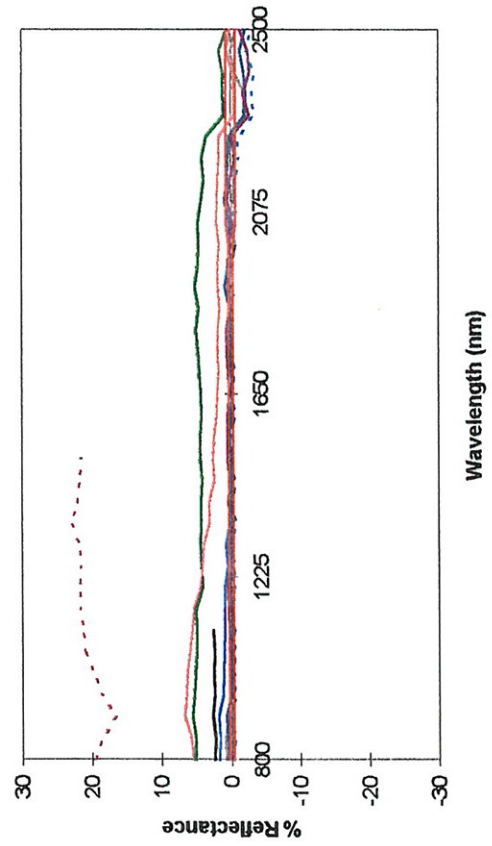


Fig. 29b: Mirror - Differences from NPL values.



0°/45° Geometry, after renormalisation.
Radiance Factor values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 30a: White Spectralon - Radiance Factor values.

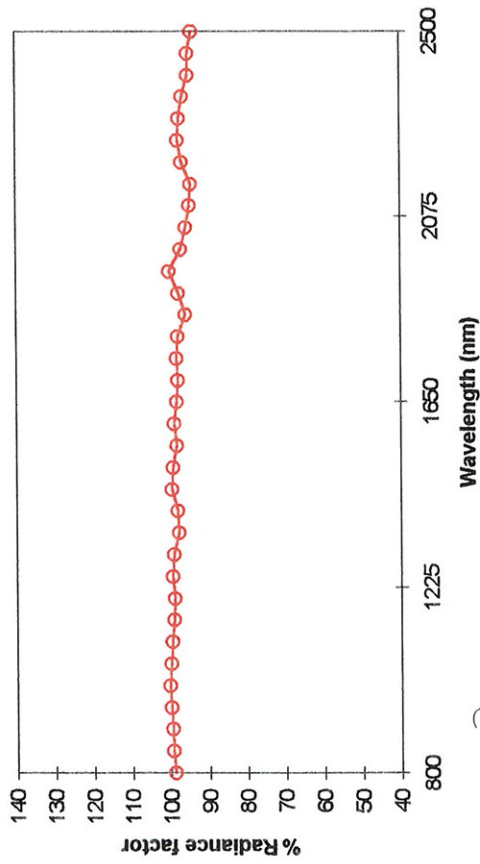


Fig. 30b: White Spectralon - Differences from NPL values.

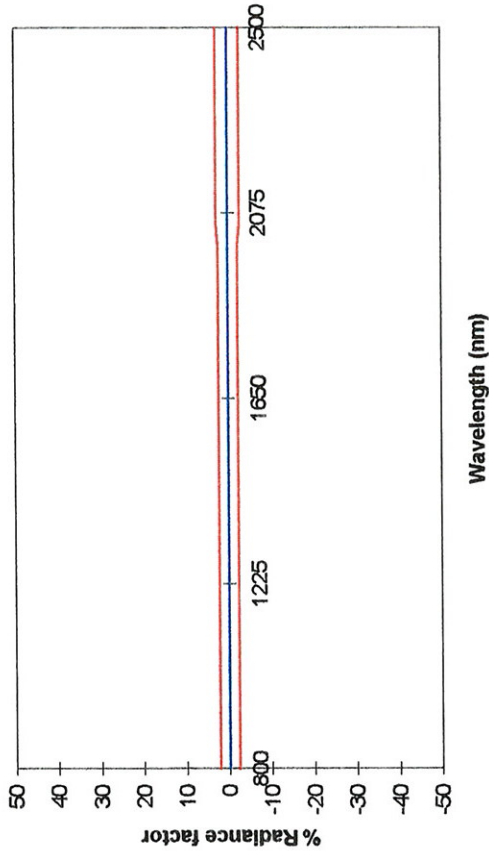


Fig. 31a: Light Grey Spectralon - Radiance Factor values.

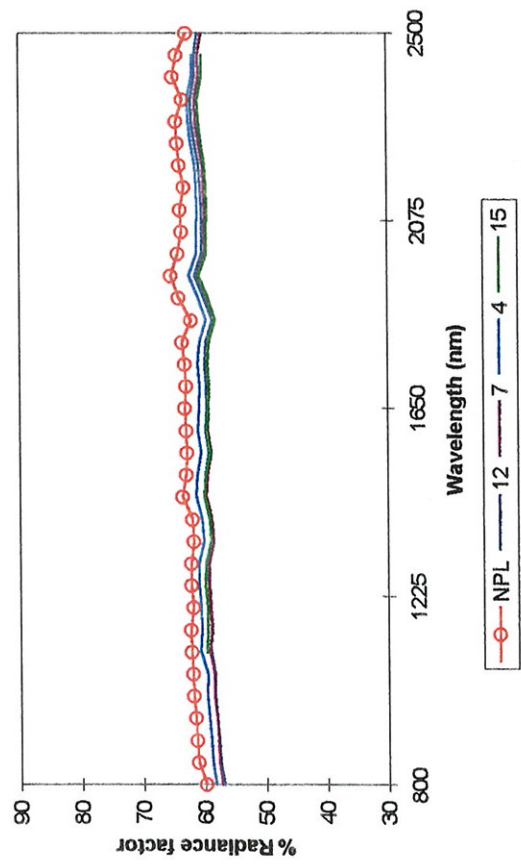
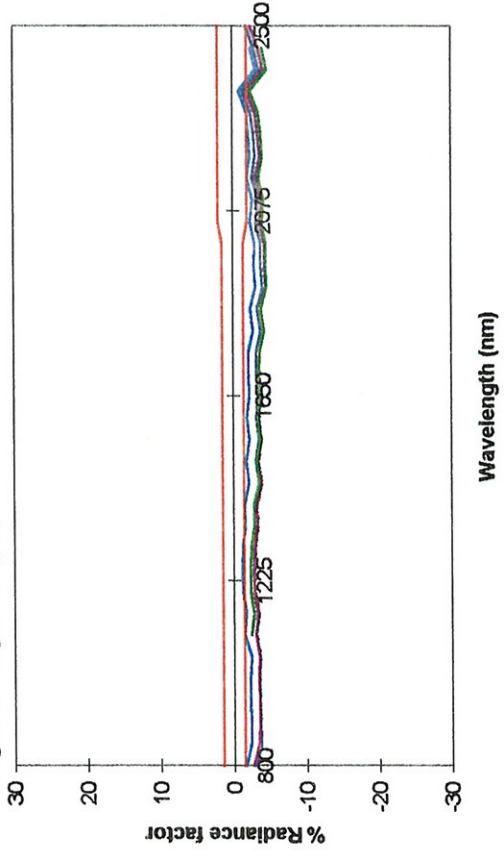


Fig. 31b: Light Grey Spectralon - Differences from NPL values.



0°/45° Geometry, after renormalisation.
Radiance Factor values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 32a: Dark Grey Spectralon - Radiance Factor values.

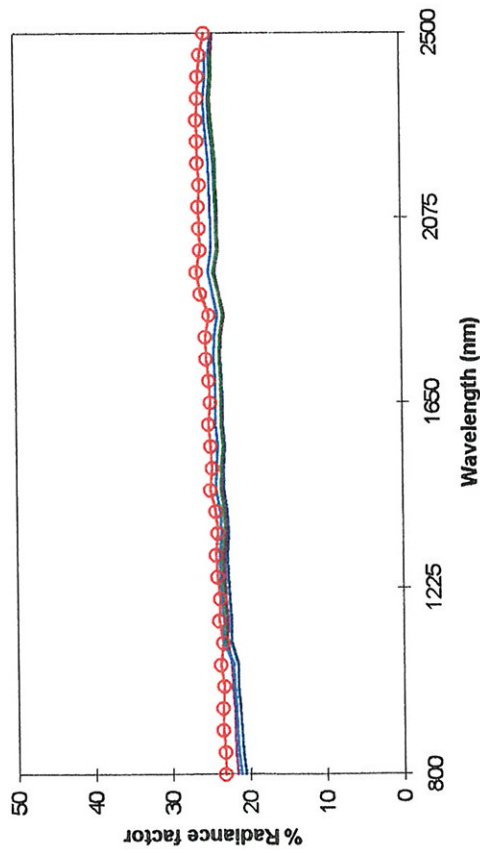


Fig. 32b: Dark Grey Spectralon - Differences from NPL values.

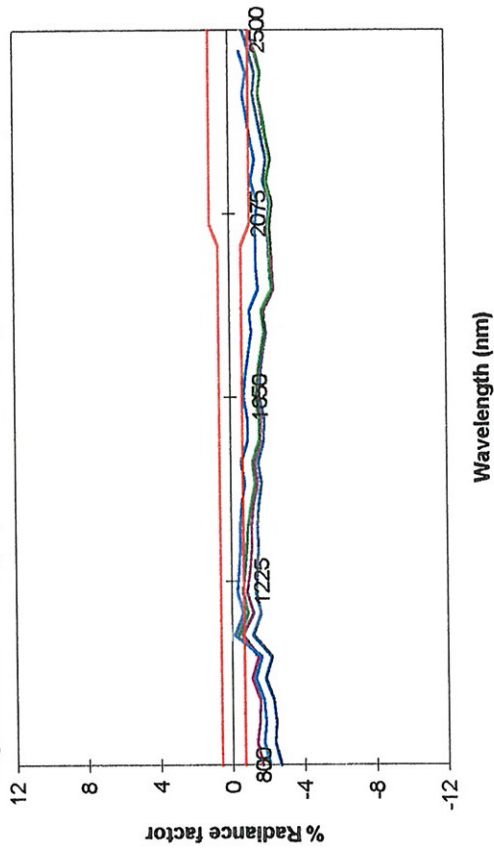


Fig. 33a: Black Spectralon - Radiance Factor values.

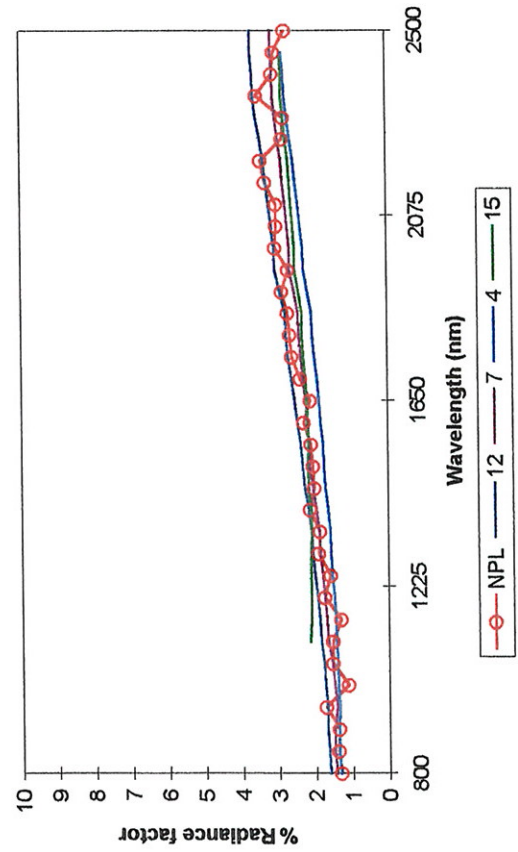
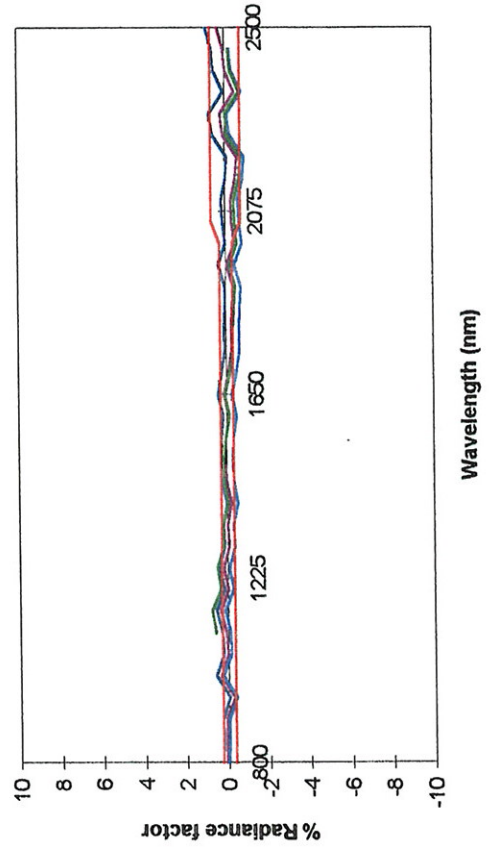


Fig. 33b: Black Spectralon - Differences from NPL values.



0°/45° Geometry, after renormalisation.
 Radiance Factor values on the left, identified by Lab No., and differences from NPL on the right (NPL uncertainties in red).

Fig. 34a: White Tile - Radiance Factor values.

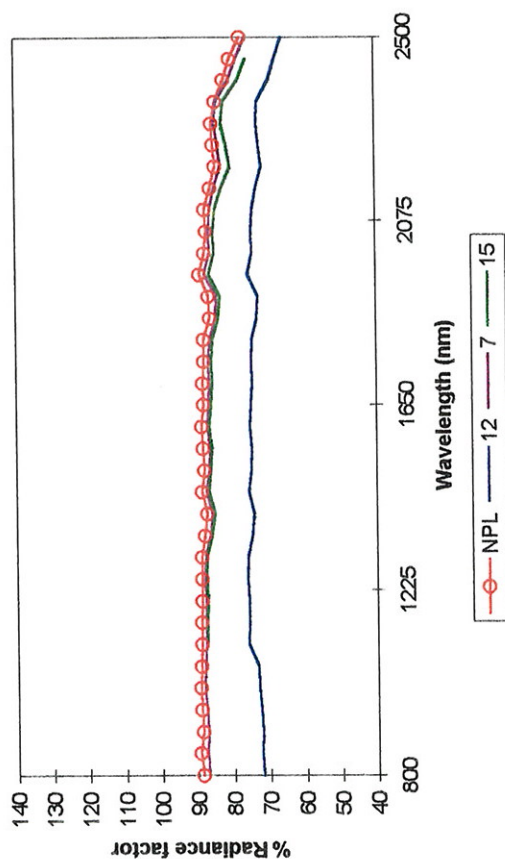


Fig. 34b: White Tile - Differences from NPL values.

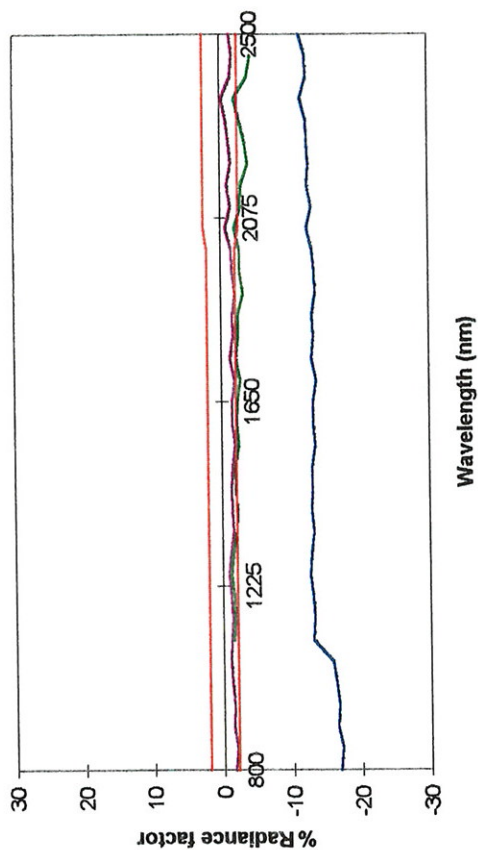


Fig 35: Absolute diffuse reflectance values for white samples of spectralon, barium sulphate and ceramic tile in the specular excluded geometry

