Micro-fading report

www.microfading.com

Object:	Not In My Name placard
Maker:	
Accession No:	[redacted]
Materials and media	Coreflute, marker pens.
Collection:	[redacted]
Year of production	March 2014
Test Date:	15-11-17
Operator:	Bruce Ford
Requested by:	Ashley Tenison

Summary

The least lightfast marker pen is red (3) which faded at least three times faster than BW1 (CIE_{00}) under the test conditions (Endnotes 1 & 2). This is at the extreme fugitive end of the range of lightfastness (BW1 or worse to BW3) for colourants described in the CIE standard for museum lighting as having “high responsivity to light” for museum purposes (CIE 2004).

It should be noted that rather than the more usual pattern of the fading rate declining as fading proceeds, the response of the red and yellow inks accelerate. It is an estimate, but the lightfastness of the red ink is probably equivalent to something like 50,000 lux hours (0.05 Mlux h) where one year’s display is about 0.15 - 0.2 Mlux h depending on light intensity and hours of opening. 2-3 years of continuous display during opening hours (at 50 lux UV free) would be sufficient to fade red colour to a faint brown (30 JNDs), and it would look badly faded within a year (~10JNDs, Endnote 4).

According to the current National Museum of Australia lighting guidelines, it would be considered suitable for display from a fading perspective for less than a month/decade at 50 lux, and even so it would sustain more light damage than considered acceptable (Endnote 4).

Figure 1 Test positions

	CIE76			CIE2000							
Colour	**BW Range**	**BW Equivalent**	**ΔE76**	**BW Range**	**BW Equivalent**	**ΔE2000**	**ΔL***	**Δa***	**Δb***	**ΔC**	**Δh**
BW1			12.4			4.5	3.8	-4.4	11.0	-10.5	8.8
BW2			7.4			2.6	2.3	-2.0	6.7	-6.4	3.9
BW3			2.6			0.6	0.4	-1.1	2.3	-2.5	0.5
BW4			1.1				-0.2	1.0	0.6	-0.7	-1.7
1 purple marker	BW3-BW2	2.7	4.2	BW3-BW2	2.3	2.0	1.1	-0.5	4.0	-3.1	-2.4
2 black marker	>BW4	>BW4	0.2	>BW3	>BW3	0.2	0.1	0.1	0.2	-0.2	-0.7
3 red	<BW1	<BW1	12.6	<<BW1	<<BW1	8.5	8.0	-9.5	1.7	-7.2	6.3
4 red-orange	BW3	3.9	1.3	BW3	2.8	1.0	1.0	-0.7	-0.2	-0.7	0.3
5 yellow	<BW1	<BW1	12.7	<<BW1	<<BW1	4.4	0.8	0.0	-12.7	-12.5	2.9
6 green	BW3	3.1	2.4	BW3-BW2	2.7	1.3	1.1	1.9	-1.0	-2.0	0.5

Table 1. Colour change summary. See last page for CIELAB diagram and Endnote 2 for a discussion of CIE76 vs CIE2000 results.

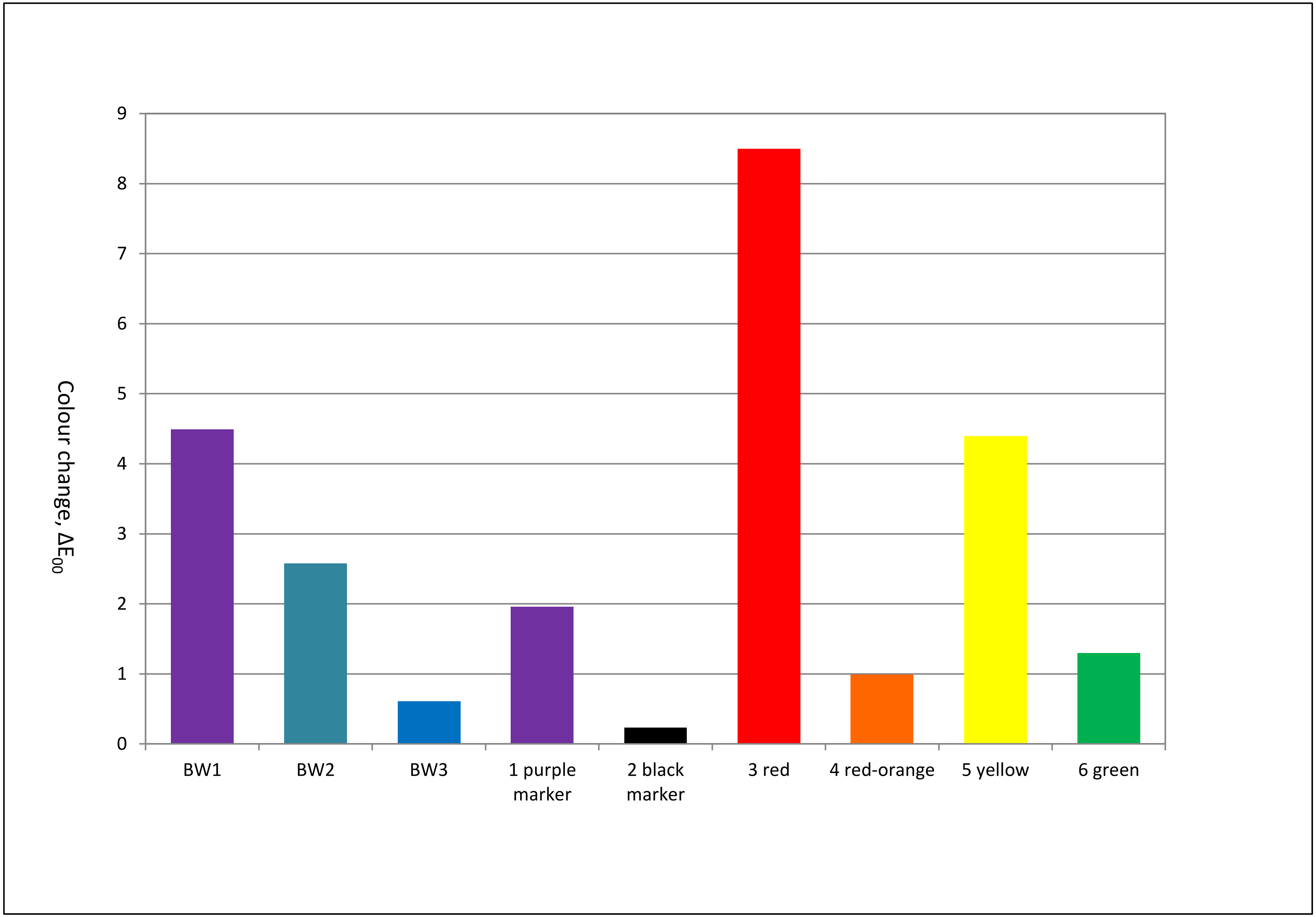


Figure 2. Relative colour change rates , CIE2000

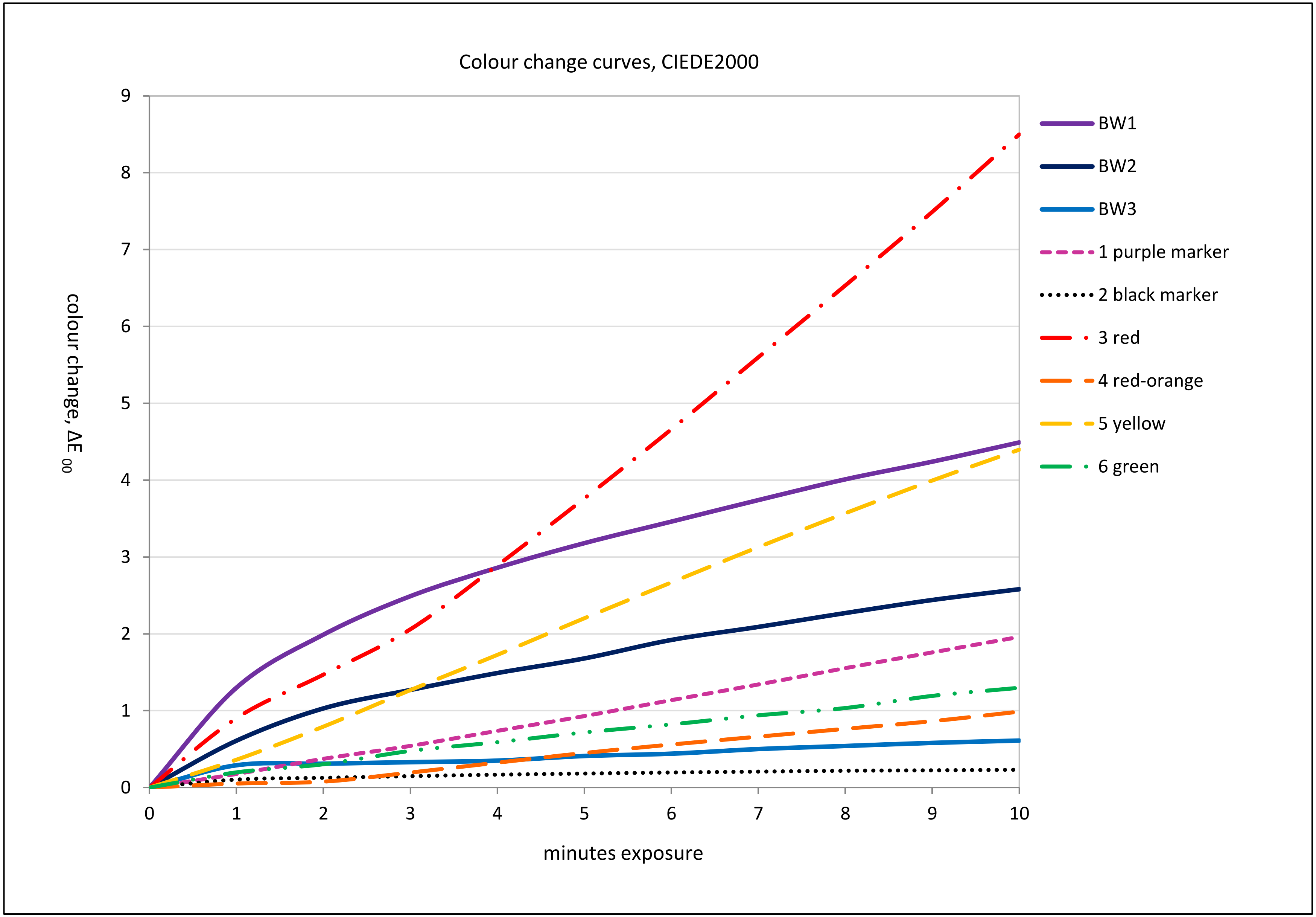


Figure 3. Colour change curves, CIE2000

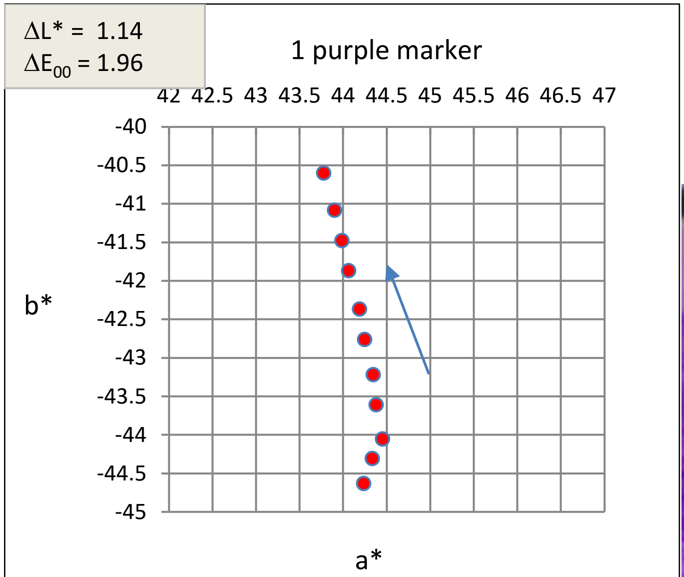
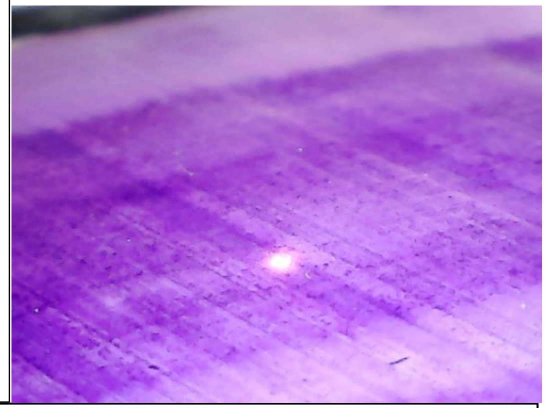


Figure 4.Purple marker pen (1): lighter, chroma loss (less purple).



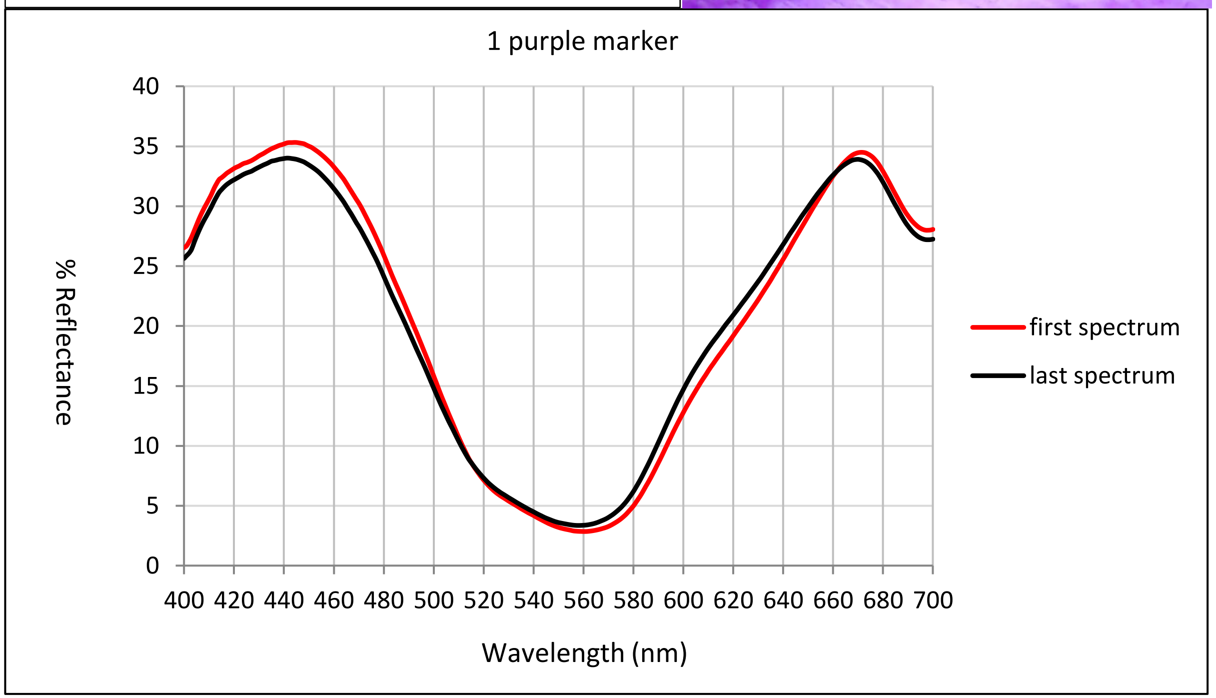
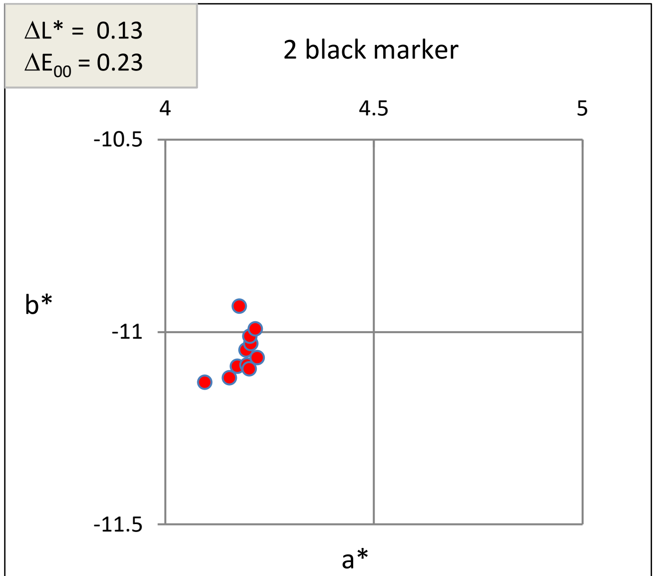
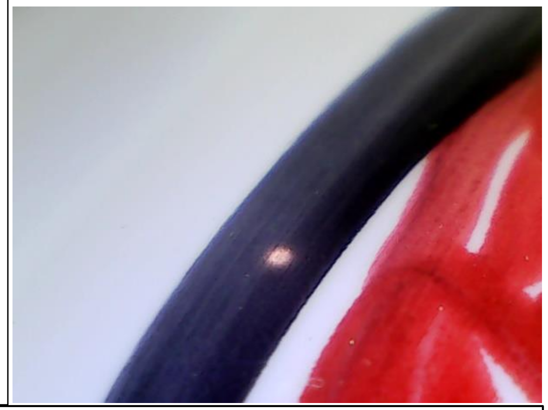


Figure 5. Black marker (2): little if any response.





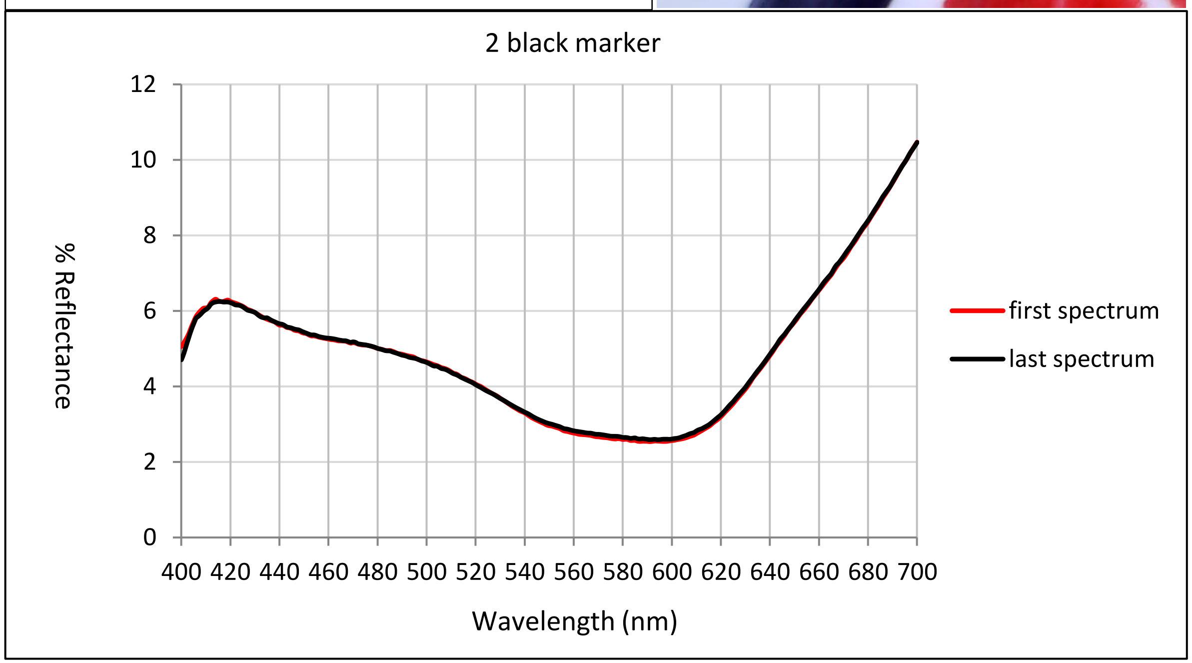
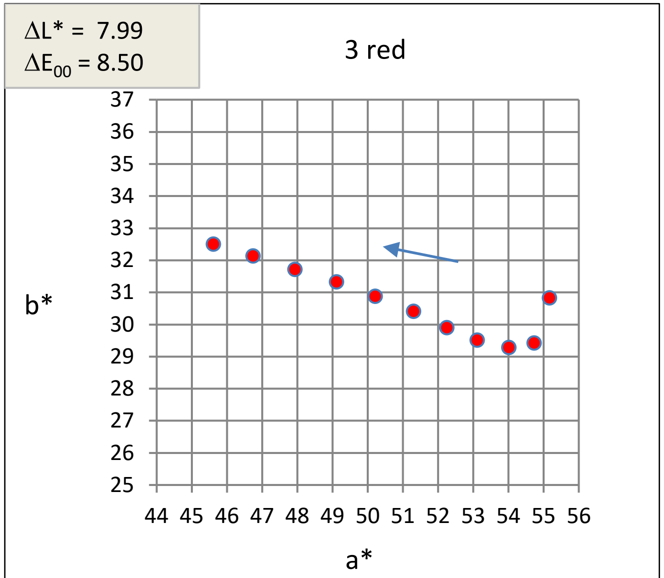
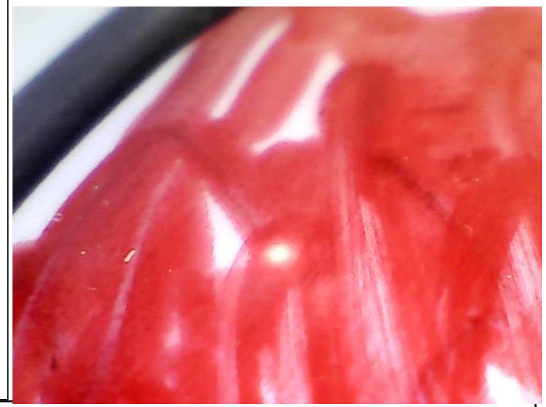
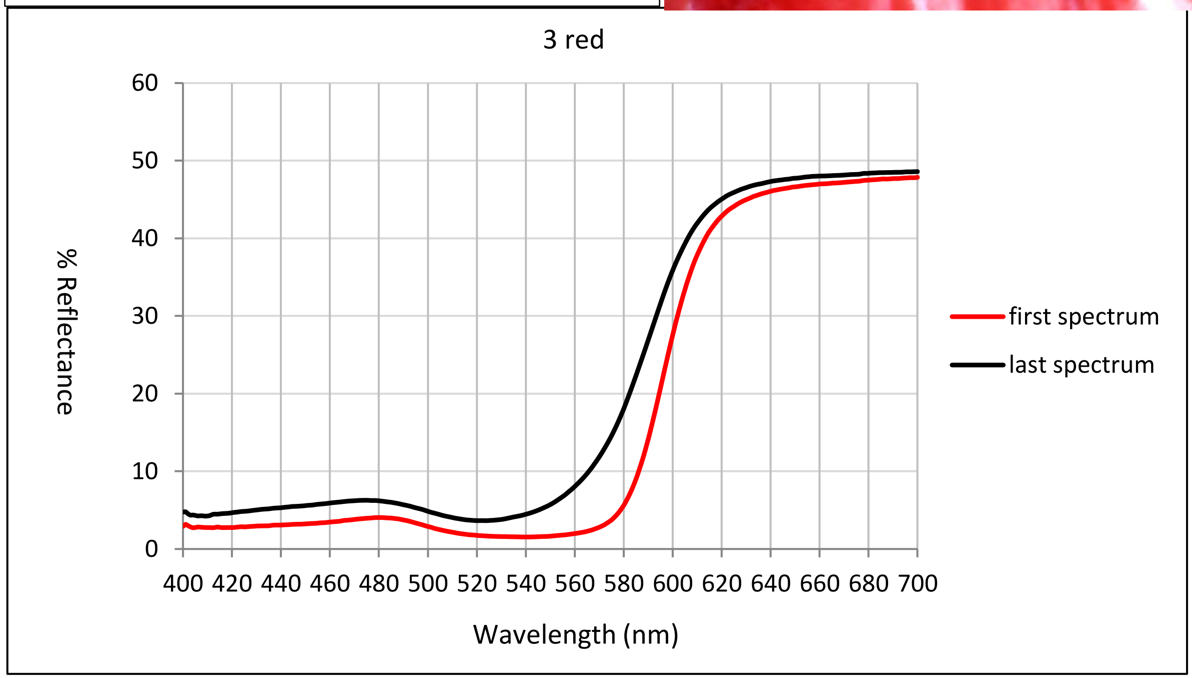


Figure 6. Red (3): lighter, chroma loss.
Accelerating fading rate, extremely fugitive.







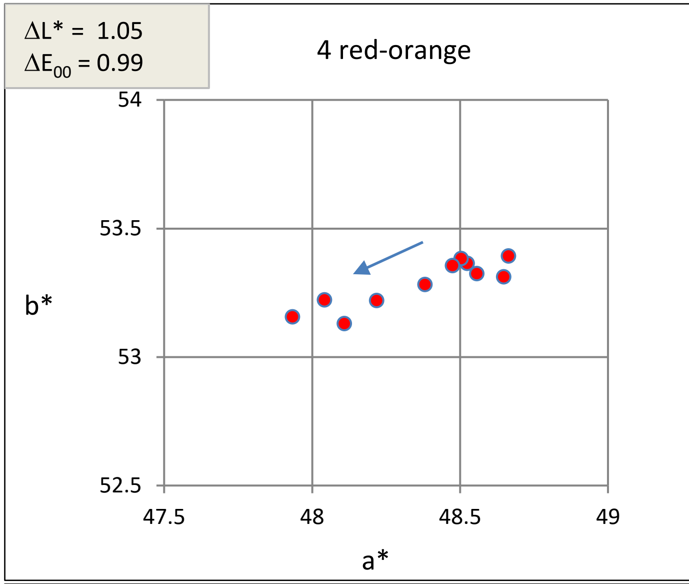
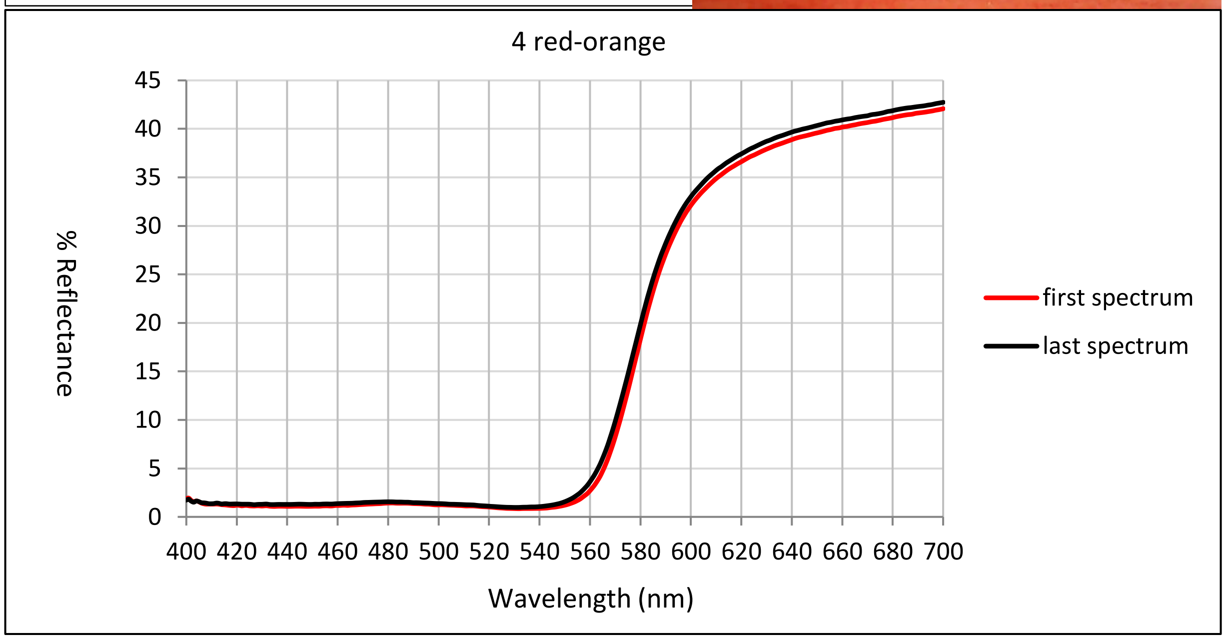


Figure 7.Red-orange (4): lighter, slight loss of chroma.



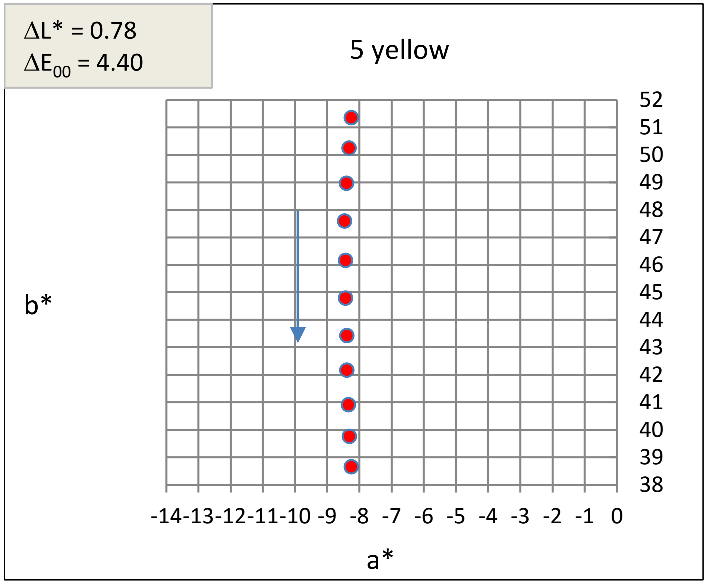
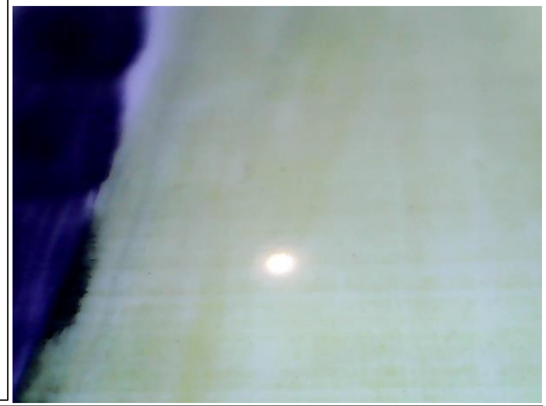
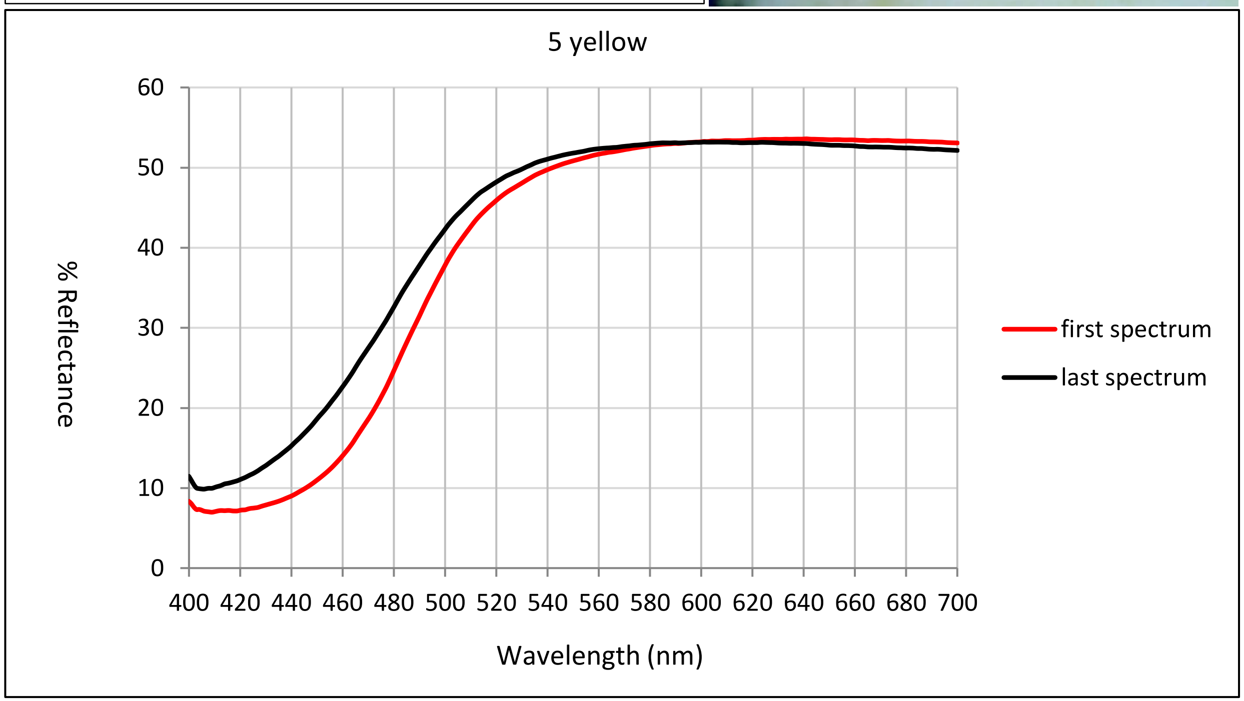


Figure 8. Yellow (5): lighter, chroma loss (less yellow).





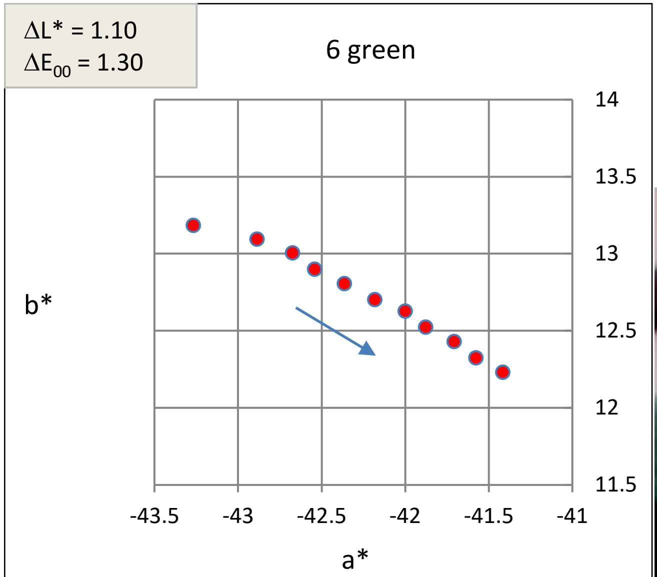
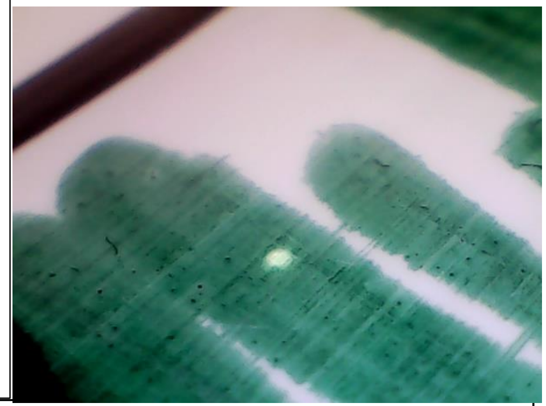
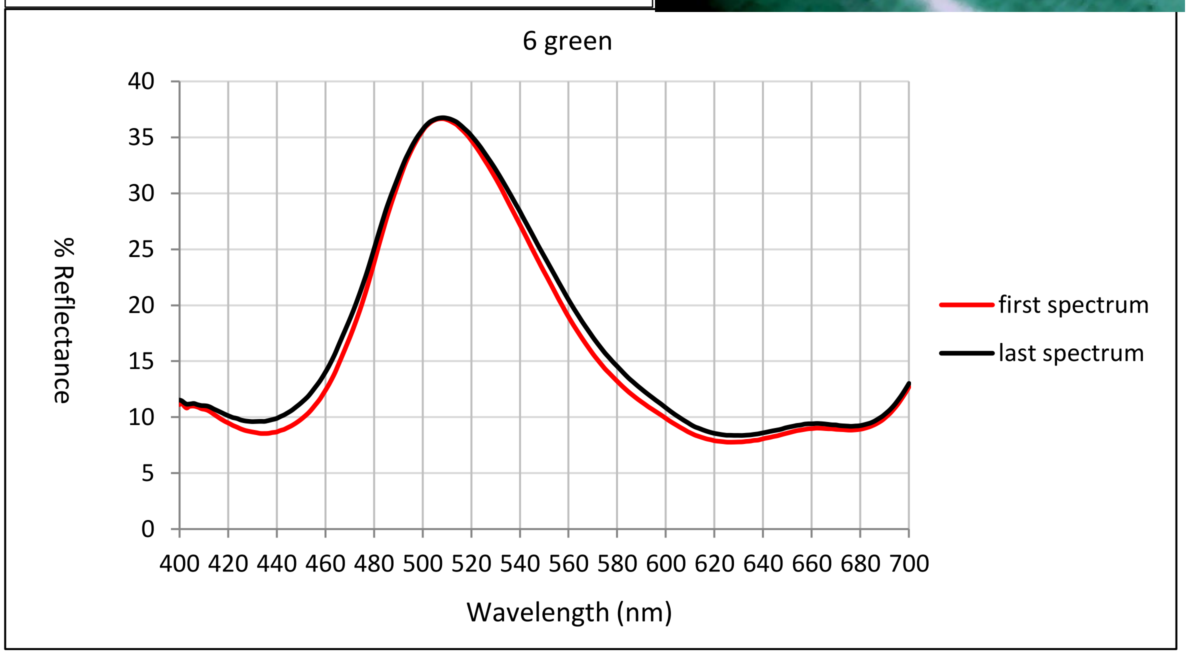


Figure 9. Green (6): lighter, chroma loss (less green).





Notes & References

Endnote 1

Microfade testing is an accelerated test method and there are uncertainties surrounding the correlation between what is observed at very high intensities and what is likely to occur on display and during subsequent storage (Whitmore et al 2000). It is a semi-quantitative risk assessment tool rather than necessarily predictive. The results in this case apply only to UV-free light.

Endnote 2

For the purposes of this report colour change (ΔE) has been calculated using the CIE's 2000 (CIEDE2000) colour difference formula which replaced the earlier and much simpler 1976 (CIE76 or CIELAB) equation. Relative fading rates using the latter calculation are also provided in Table 1 and Figures 10 & 11. While much of the accelerated and ambient fading instrumental data in the conservation literature has mostly been calculated using CIELAB, CIEDE2000 is likely to be more accurate (CIE 2001). The ability of an "average observer" to notice differences between blues was exaggerated by a factor of about two in CIELAB, and in CIEDE2000 the ISO Blue Wools (BWs) fade approximately twice as slowly as in CIELAB. This affects the relative fading rates of the ISO Blue Wools (BWs) used as internal standards and other colourants not affected by the revision to the same degree. There are many other colour difference equations all of which will give different results, for example CMC, S-CIELAB, and a proposed I* (I-star) metric for photographs (McCormick-Goodhart 2007).

Michalski's estimates of how much exposure (megalux hours, Mlux h) will result in a just noticeable fade or difference (JNF or JND) for each of the BWs (CIE 2004) are themselves approximations with a maximum error of ± 1 BW step (Michalski 2010). Therefore, absolute predictions of the response of a colourant to a particular exposure (mlx-h) are possibly uncertain to a similar extent. The most recent (unpublished) research by the CCI and GCI indicates that for BWs 2-5 Michalski's estimates are reasonable, but the lightfastness of BW1 is overestimated by as much as a factor of two or three.

Endnote 3

Microfading cannot predict the post-exposure colour of undyed and unpigmented fibres and paper because only the immediate photochemical response is measured and not the effect of concurrent and subsequent thermal (oxidative) yellowing reactions (Feller 1994). Light exposure accelerates subsequent yellowing via a mechanism involving residual photochemical reaction products. Thermal (dark) discolouration depends heavily on temperature, chemical processing of fibres, pH, exogenous and endogenous pollutants, prior conservation treatments and so on. To further complicate matters, ultraviolet directly yellows, rather than bleaches, groundwood paper and most natural fibres like wool. For example the rapid discolouration of newspaper in sunlight is the result of UV (<400nm) yellowing outpacing visible (>400nm) light bleaching.

Endnote 4

The NMA assumptions (Ford BL & N Smith 2009) are based on those of the V&A Museum (Ashley-Smith et al 2002): that is works should last for at least 500 years in a coloured form; a Just Noticeable Difference (JND) = 1.6ΔE and 10 JNDs signal the effective end of coloured life for an object. This may often be a conservative estimate because approximately 30ΔE represents complete fading, but for low chroma colours it seems reasonable. The absolute fading rates of the BWs are taken from CIE157 (2004), see Endnote 2. CIE157 recommends colourants less lightfast than BW3 be exposed only half as much as the V&A's 2 years/decade at 50lux recommendation.

The NMA further makes a judgement based on a significance test as to whether the object/collection is likely to be in strong demand for exhibition in the future (i.e. at higher risk of fading over time) and adjusts recommended exposures accordingly. Objects judged likely to be more in demand are treated more conservatively than objects which may rarely if ever displayed again (Ford BL & N Smith 2009) .

References

Ashley-Smith, J, Derbyshire, A & B Pretzel 2002, The continuing development of a practical lighting policy for works of art on paper and other object types at the Victoria and Albert Museum, *Preprints of the 13th triennial meeting of the ICOM Committee for Conservation in Rio de Janeiro*, vol.1, pp. 3-8.

CIE 2004, *CIE157-2004*, *control of damage to museum objects by optical radiation*, Vienna: Bureau Central de la Commission Internationale de l'Éclairage.

CIE. 2001. Improvement to industrial color difference evaluation, *CIE technical report 142-2001.* Vienna, CIE Central Bureau.

Druzik J.M., Getty Conservation Institute (GCI), personal communication, 18th November 2016

Feller, RL. 1994. *Accelerated ageing: photochemical and thermal aspects*. Research in Conservation No. 4, GCI. http://www.getty.edu/conservation/publications_resources/pdf_publications/accelerated_aging.html

Ford, B & N Smith, 2009, The development of a significance and risk based lighting framework at the National Museum of Australia, *AICCM Bulletin* vol. 32 pp. 80-86.

Michalski, S., Canadian Conservation Institute (CCI), personal communication, 10th October 2010.

Refs ctd.
McCormick-Goodhart, M. 2007. *An introduction to the I* Metric*. Aardenburg Imaging and Archives.

Whitmore, PM, Bailie, C & S Connors 2000, Micro-fading to predict the result of exhibition: progress and prospects, in *Tradition and Innovation: Advances in Conservation*, ed. A. Roy and P. Smith, pp. 200-205. London: IIC.

The Canadian Conservation Institute website has an excellent general introduction to light and museum collections: http://www.cci-icc.gc.ca/resources-ressources/agentsofdeterioration-agentsdedeterioration/chap08-eng.aspx

For a complete list of references to microfading and its applications see http://www.microfading.com/resources.html

Blue Wool categories	1	**2**	3	4	**5**	6	7	**8**	Over 8	
Mlx h[a] for noticeable fade[b] UV present[c]	0.22	**0.6**	1.5	3.5	**8**	20	50	**120**		
Probable Mlx h[a] for noticeable fade[b] if no UV[d]	0.3	**1**	3	10	**30**	100	300	**1000**		

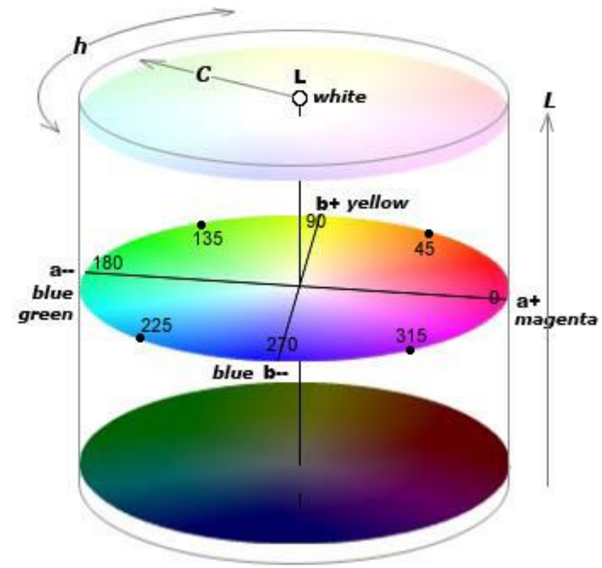
Explanatory notes to table:
The "Blue Wool categories" are the international standard (ISO) categories for specifying sensitivity to light, based on 8 blue dyes on wool, used as reference samples in most lightfastness tests.
a. Mlx h is the unit of light exposure, or dose. Megalux hours. It is light intensity (lux) multiplied by exposure time (hours)
b. A noticeable fade is defined here as Grey Scale 4 (GS4) , the step used in most lightfastness tests as noticeable. It is approximately equal to a colour difference of 1.6 CIELAB units. There are approximately thirty such steps in the transition from a bright colour to almost white.
c. UV rich refers to a spectrum similar to daylight through glass. This is the spectrum generally used for the lightfastness data used to derive this table. The exposures here are the best fit to data that varies about one Blue Wool step.
d. Exposures estimated for UV blocked light source are derived from a study on 400 dyes and the blue wool standards themselves. As such, it is only probable, and probably only for organic colorants. These estimates show minor benefit of UV filtration for low sensitivity colorants, but large improvements for high sensitivity colorants. For conservative estimates, use the UV rich scale.
f. "No sensitivity" to light does not mean guaranteed colour life. Many colorants in this group are sensitive to pollution. Many organic media will chalk or yellow or both if any UV is present.
g. The particular paint medium makes only small differences to fading rate, it is the colorant that matters in fading, not whether it is oil, or tempera, or watercolour, or acrylic. Media does, however, make large differences to rate of discoloration from pollutants such as ozone and hydrogen sulphide.

Michalski's BWFS estimates from *Running A Museum, a practical handbook* ICOM 2004. *http://portal.unesco.org/culture/en/ev.php-URL_ID=36646&URL_DO=DO_TOPIC&URL_SECTION=201.html More recent estimates of BW1 put it at about 0.1 Mlux h/JND (UV-free), far less lightfast than Michalski's estimate (Druzik 2016)*

Instrument Settings

Luminous flux (mlm)	~600
Spot lux (megalux)	~ 6-8
Spot diameter (mm)	0.4
Colour difference equations	ΔE_{76} & ΔE_{00}

Simplified L*a*b* colour space



L* a* b* and L C h are different ways of describing the same shift in CIELAB space

L* = Lightness
a* = red-green axis
b* = yellow-blue axis

C = vividness (chroma)
h = hue angle anticlockwise from red (0)