Copy One and Nova D 1200

Figure 1: Reprographic setup with 2 Copy One

Figure 2: Copy One and a Nova D 1200 power pack

Measurement setup

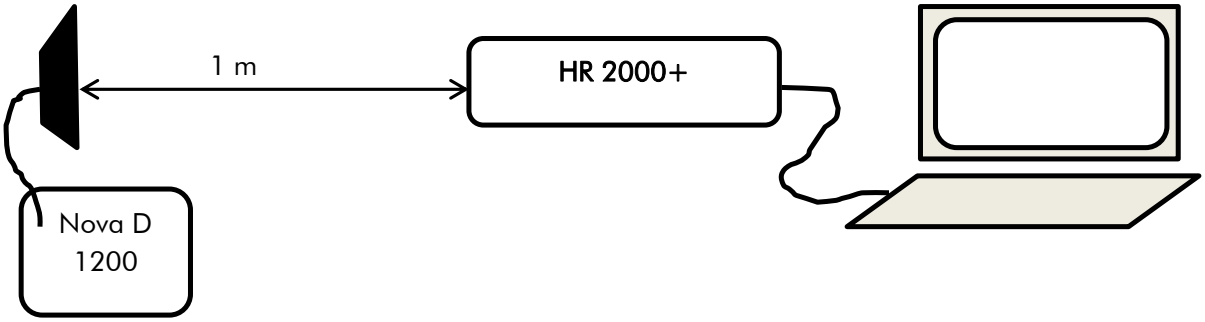


Figure 3: Measurement setup

For different power settings the spectral distribution of the flash system consisting of a Copy One and a Nova D 1200 power pack was measured and evaluated with a spectrometer HR2000+ from Ocean Optics. The wavelength was recorded from 200 to approx. 1,100 nm. The spectrometer is calibrated against a traceable standard and the errors are in the range of 15%. If possible the measurements were carried out at a distance of 1 m, or corrected for this distance.

Hensel-Visit GmbH & Co. KG, Dipl.-Phys. Andreas Stöhr, 2018 July

UV Filter with the Filterglass

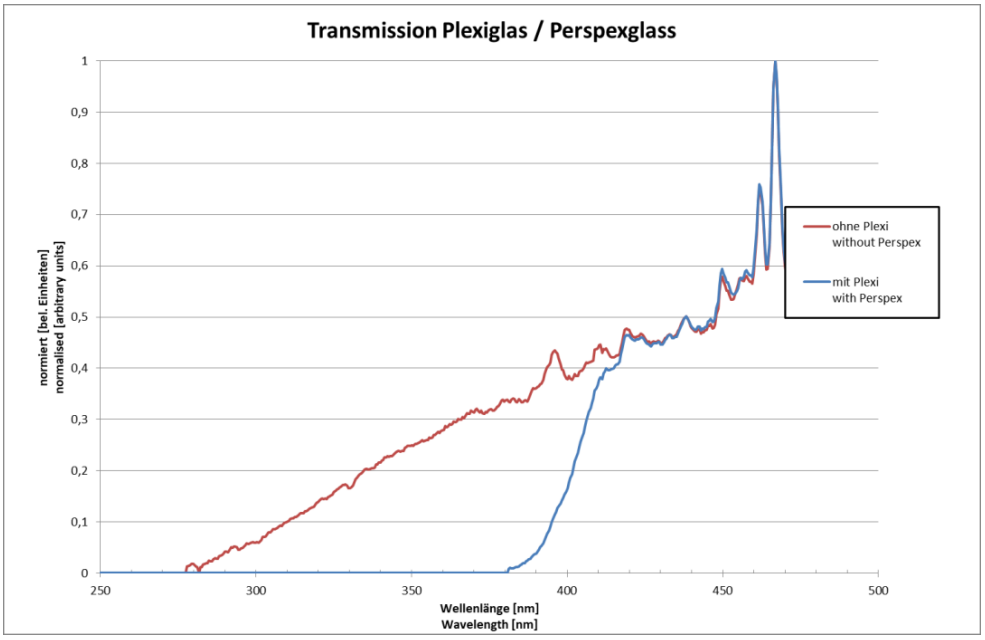


Figure 4: Transmission of the diffusor

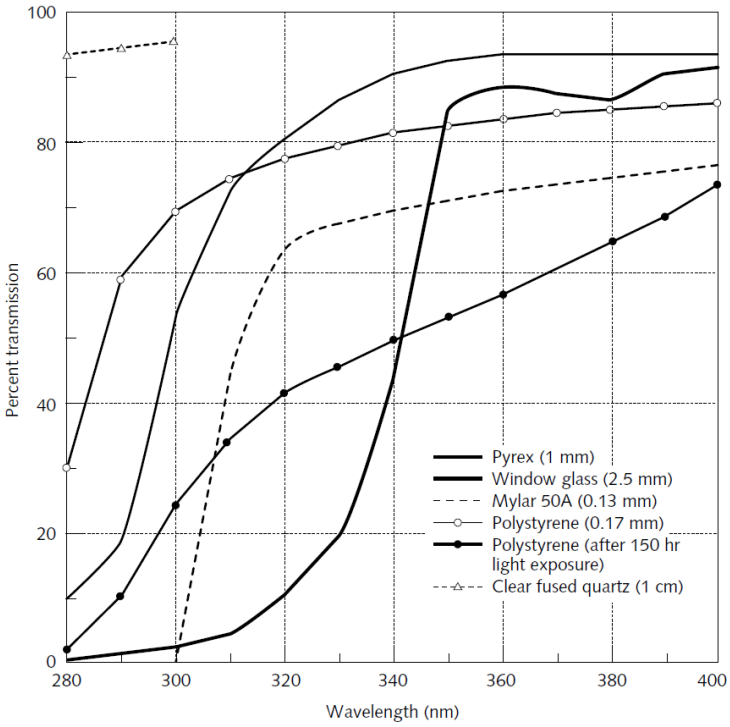


Figure 5: Transmission of Pyrex, (Schaeffer, 2001)

To show the transmission characteristic of the front diffusor a measurement at maximum flash power of 1,200 J with and without the diffusor was made. Figure 4 shows the reduction of the UV by the diffusor made of Perspex. The flash tube is made out of Pyrex and therefore no radiation below 250 nm is generated and transmitted, see Figure 5.

UV Portion of the Radiation

The UV irradiance can be calculated based on the measured spectral irradiance $E(\lambda)$

$$E_{UV} = \int_{200\ nm}^{400\ nm} E(\lambda) d\lambda$$

The UV radiant exposure H_{UV} can be calculated by multiplication with the flash duration t_{Blitz}

$$H_{UV} = E_{UV} * t_{Blitz}$$

The illuminance E_v is derived from the spectral irradiance $E(\lambda)$ by multiplication with the sensitivity curve of the human eye for photopic vision $V(\lambda)$, according to

$$E_v = K_m \int_{380\ nm}^{780\ nm} V(\lambda) * E(\lambda)\ d\lambda$$

With the photometric radiation equivalent $K_m = 683\ lm/W$.

Power setting	Flash energy [Ws]	E_{UV}/E_v [µW/lm]	E_{UV}[1] [W/m²]	E_v[2] [lx]	Number of flashes[3]
4.0	18.75	26	0.03	1,310	45,000
5.0	37.5	26	0.10	3,613	13,500
6.0	75	28	0.22	7,846	6,750
7.0	150	26	0.94	36,142	1,500
8.0	300	30	2.95	97,255	450
8.1	322	30	3.42	114,171	379
8.2	345	31	3.77	123,319	355
8.3	369	29	3.86	134,566	346
8.4	396	34	5.63	149,698	241
8.5	424	31	5.63	179,058	241
10.0	1,200	31	18.06	590,852	74

Table 1: Results of Copy One at Nova D 1200 power pack

For conservators and curators the relationship between the UV irradiance and the illuminance is an important number for choosing the right illumination or reprographic light. This number is almost constant at 30 µW/lm over the whole range of possible power settings for the Copy One.

J. G. Neevel calculated in his study (Neevel, 1995) the possible number of flashes based on an one hour illuminance of an object with an incandescent lamp with 50 lx. The incandescent lamp generates an UV irradiance of 3.75 mW/m². The corresponding number of flashes can

[1] < 400 nm
[2] Flash duration 10 ms
[3] Number of possible flashes compared to an one hour illumination of an incandescent lamp with an illuminance of 50 lx (UV irradiance 3,75 mW/m²).

be found in row 6 of Table 1. A reprographic exposure with flash light will not cause any damage since the number of flashes will normally be less than 10 flashes.

(Saunders, 1995) examined, if two photon processes can be induced by the intense radiation of flash light, as they have been proposed by (Neevel, 1995). He couldn't find any evidence and suggests that the reciprocity law also applies to intense flash light. According to this law, the effects of an one hour illumination with a 1,000 lx lighting source is equivalent to ten hours at a level of 100 lx.

A Metz Mecablitz 45 CT-1 was used for this study, the same model which (Neevel, 1995) used. The gathered data of the Copy One can be compared to the results of this photo flash.

Power setting	Flash energy [Ws]	E_{UV}/E_v [µW/lm]	E_{UV}[4] [W/m²]	H_{UV}[5] [mJ/m²]	Number of flashes[6]
4.0	18.75	26	0.03	0.3	45,000
5.0	37.5	26	0.10	1	13,500
6.0	75	28	0.22	2	6,750
7.0	150	26	0.94	9	1,500
8.0	300	30	2.95	30	450
8.1	322	30	3.42	34	379
8.2	345	31	3.77	38	355
8.3	369	29	3.86	39	346
8.4	396	31	5.63	56	241
8.5	424	31	5.63	56	241
10.0	1,200	31	18.06	181	74
Metz Mecablitz 45 CT-1		**280**	**18.67**	**560**	**24**

Table 2: Comparison of a Copy One at a Nova D 1200 power pack and a Mecablitz 45 CT-1

Saunders, (Sandro-Arroyo & Rioux, 2004) and (Schaeffer, 2001) recommend flash units as an illumination source for reprography, as the light exposure for reprography is very short compared with continuous light sources. This argument applies even more for the Copy One, as the UV irradiance for a typical exposure is less by a factor of 10, compared to the Metz photo flash.

With continuous light sources more time is needed to achieve a good exposure and even during setup the museum objects are exposed to unnecessary radiation which is not needed for the actual reprography. Typical values of the relationship E_{UV}/E_v for different light sources can be found in table 1.1 in (CIE 157, 2004):

[4] < 400 nm
[5] Flash duration 10 ms
[6] Number of possible flashes compared to an one hour illumination of an incandescent lamp with an illuminance of 50 lx (UV irradiance 3,75 mW/m²).

Light source	UV content [µW/lm]
Daylight	400 – 1500
Tungsten incandescent	70 – 80
Tungsten halogen*	40 – 470
Fluorescent lamps	30 – 100
Metal halide	160 – 700
Light emitting diode (LED)**	< 5

*Includes „UV Stop" lamps.
**These lamps are not of suitable high colour quality for museum use at present, but have future potential as very low UV power sources.
Data provided by Dr. David Sanders, Scientific Department, The National Gallery, London, UK

The flash system Copy One and Nova D power pack is very well suited for the reprography of highly sensitive museum objects, as the exposure to radiation lasts only 10 ms and the UV radiation level is lower compared to other light sources.

If you compare the UV radiation level of the Copy One with the exposure limit for highly sensitive materials of 15,000 lx h/year, see table 3.4 in (CIE 157, 2004), the possible number of flashes are shown in the following table:

Power setting	Flash energy [Ws]	Light exposure [lx s]	Number of flashes[7]
4.0	18.75	13	4,153,846
5.0	37.5	36	1,500,000
6.0	75	78	692,307
7.0	150	361	149,584
8.0	300	973	55,498
8.1	322	1,142	42,285
8.2	345	1,233	43,795
8.3	369	1,346	40,119
8.4	396	1,497	36,072
8.5	424	1,791	30,150
10.0	1,200	5,909	9,138

Table 3: Comparison with the exposure limit for the illumination of highly sensitive museum objects.

[7] Number of possible flashes until the illumination limit for highly sensitive artefacts of 15,000 lx h/year is reached.

IR Portion of the Radiation

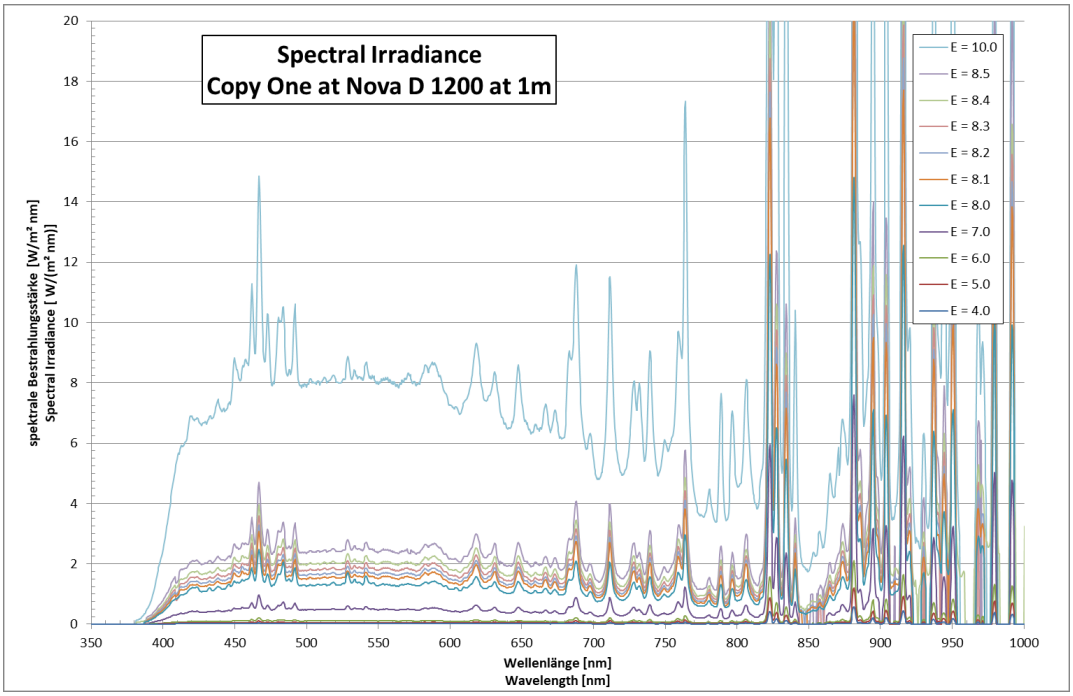


Figure 6: Spectral radiation distribution of Copy One at Nova D 1200

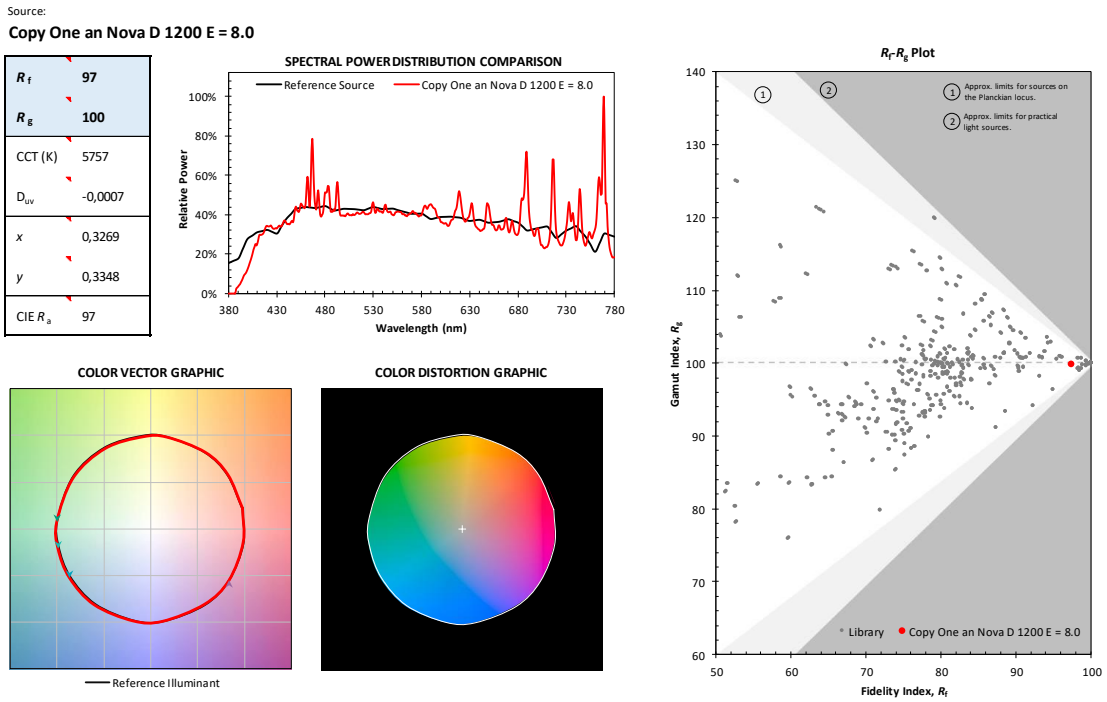
The spectral distribution of radiation of a Copy One at a Nova D 1200 power pack is shown in Figure 6. The strong peaks in the near IR can be neglected, since the intensity is to low start photochemical reactions, and the flash duration is too short, typically 10 ms, to heat the photographed objects significantly, see (Schaeffer, 2001).

Color Rendering

According to the IES standard TM-30-15 the color rendering of a Copy One and a Nova D 1200 power pack was evaluated. Table 4 summarizes the results and indices, even those according to the color metric of CIE:

Copy One / Nova D 1200				
Power setting	R_f Fidelity Index	R_g Gamut Index	CIE R_a General index	CCT Color Temperature
4.0	97	100	96	5494
5.0	97	100	96	5613
6.0	97	100	97	5723
7.0	98	100	97	5833
8.0	98	100	98	5947
8.1	97	100	97	5757
8.2	97	100	97	5757
8.3	97	100	97	5770
8.4	98	100	97	5782
8.5	98	100	97	5808
10.0	98	100	97	5795

Table 4: Color rendering indices according to IES TM-30-15 and CIE



References

CIE 157. (2004). Control of Damage to Museum Objects by Optical Radiation. *CIE 157*.

Neevel, J. G. (1995). UV-Belastung durch Elektronenblitze und Kopiergeräte : Die Wirkung des Lichtes auf Papier und auf Textilobjekte. *Restauro (München), Vol. 101*.

Sandro-Arroyo, M., & Rioux, J.-P. (2004). Conditions d'usage des éclairs électroniques pour la photographie des oeuvres d'art. *Techné no. 4, Paris*.

Saunders, D. (1995). Photographic Flash: Threat or Nuisance? *National Gallery Technical Bulletin, Volume 16*.

Schaeffer, T. T. (2001). Effects of light on materials in collections: Data on photoflash and related sources. *The Getty Conservation Institute, Los Angeles*.