Václav Bumba

The results of measuring optical transfer functions of photographic films by edge spread function

Acta Universitatis Palackianae Olomucensis. Facultas Rerum Naturalium. Mathematica-Physica-Chemica, Vol. 10 (1969), No. 1, 55--62

Persistent URL: http://dml.cz/dmlcz/119925

1969 — ACTA UNIVERSITATIS PALACKIANAE OLOMUCENSIS — TOM 30
FACULTAS RERUM NATURALIUM

Department of experimental physics and methodology of physics
The chairman of the department: Prof. Paed. Dr. Josef Fuka

THE RESULTS OF MEASURING OPTICAL TRANSFER FUNCTIONS OF PHOTOGRAPHIC FILMS BY EDGE SPREAD FUNCTION

VÁCLAV BUMBA

Received 3. 5. 1968

We have suggested the method of measuring optical transfer functions (OFF) of photographic films by means of edge spread function in work [1]. Apparatus for exposure is shown in fig. 1. where *Ž* is a milk bulb, *F* . . . an interference filter, *Z* . . . a shutter, *E* . . . an observed photographic film. For this apparatus we used suitably adapted enlarger. We did not use any optical member purposely because if the case beeing so we should need the values of OTF of this member and OTF photographic layer could be obtained from OTF of photographic layer + optical member. But in this case the error of determination of OTF would increase because this calculation is not exact for higher spacing frequencies.

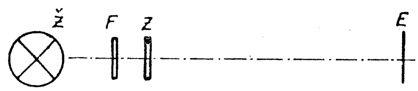

Fig. 1

The edge was obtained by bobbed blade contactly pressed to the layer.

The Exposure Conditions

To realize the edge spread function it was necessary to determine the optical density which ought to be obtained by exposure. Entering the layer the light is diffused and reflected [2]. This diffusion and reflection in the layer causes that the images will not be the same though exposures were different. The lower the enlightening time the lower the diffusion and the reflection of the light in the sensitive layer and the material then has a steeper edge spread curve and vice versa. So the determination of optical density which ought to be obtained by exposure is a very important question. This exposure should approach the real conditions of enlightening as much as possible. Let's consider this: a given object which should be photographed has certain distribution of light and dark spots from the lowest to the highest ones. If the photographic material is to give us the most exact image of given object, the optical densities of the middle linear part of characteristic curve should correspond the average enlightening of given object.

That is why we at first determined characteristic curves of given photographic materials. We developed the films in the developer recommended by the factory in the way which was also determined by the factory. On the curves we had obtained, we determined optical densities D_s which corresponded with the middle points of their linear parts (Fig. 2).

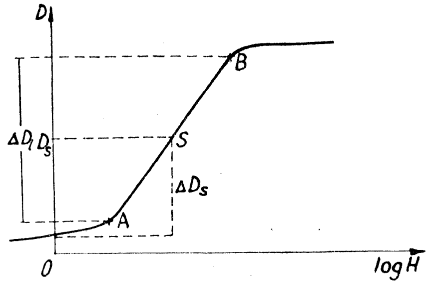

Fig. 2

Though we exposure into the middle part of characteristic curve of given photographic material we always work with the lower part of it too. The edge spread function shows a slight asymmetry. This can be explained by the fact that we also work with the unlinear part of characteristic curve. F. Perrin [3] however thinks that the asymmetry of the edge spread function is caused by the light diffraction on the edge and by the possibility of light reflection from the edge. Because of this asymmetry we choose such a way of calculation of OTF. We determined both the real and the imaginary part of OTF without suggesting the symmetry of edge spread function.

The Determination of the Edge Spread Function

The samples obtained by means of the above described method were measured by Zeiss microphotometer. The steps among individual measurings were 5 μm, the scanning slit was 30 μm broad and by enlarging 15 $\times$ we scanned the area of 2 μm. The samples were always carefully focused and the control of focusing and the zero position of galvanometer were determined for each individual measuring. We determined the microphotometrical course from five individual measurings and we converted it into the course of optical densities from which we obtained the effective exposures and the whole course was standardized to the unit. From this course of the edge spread function only the increases $\Delta H(\mathrm{v})$ had been calculated because their values are sufficient for our calculation [1].

In the image of the edge the Eberhard's effect could be observed in some cases according to the used developer. We can register it microphotometrically and so we obtain the course shown in fig. 3. That is why we could obtain the course of OTF in limits of low spacing frequencies about $\nu \doteq 5$ line/mm higher than the unit. But we cannot think this will effect the course of OTF for higher spacing frequencies. As we deal with typical unlinear effect we did not register the hatched part in fig. 3 by microphotometer.

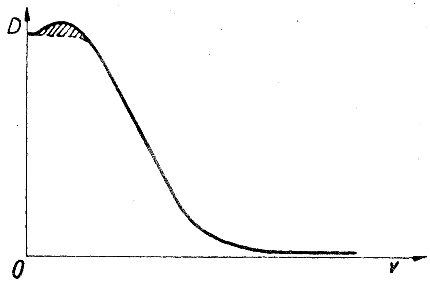

Fig. 3

The Standardization of Measuring

The characteristic curves were obtained by means of Eder-Hecht's wedge when the wedge constant $k = 0{,}4$. The wedge was photometrically measured to eliminate all errors caused by production, by ageing, etc. Optical densities of individual samples were kept to dimensions $\Delta D = \pm 0{,}05$.

The exposures were provided by interference filtres $\lambda_1 = 596$ nm, $\lambda_2 = 503$ nm, $\lambda_3 = 407$ nm for three wave length which corresponded with red, green and blue part of the visible spectrum.

The exposured image of the edge on photographic film can be influenced by various components of developer, the purity and temperature of developer, developing time, movement of film in the developer. All these influences were not observed. We suppose that factories producing photographic materials determine also how should the films be developed to receive the best results. Most of the factories now produce developers in packing in which they are sold so we needn't worry about the purity of chemical compounds. That is why all the films were developed by developers and in the way recommended by producers.

The temperatures of developers were kept to limits $\pm$ 0,1 °C and developing times $\pm$ 10 sec. We tried to move the films in developing tanks for 20 sec per minute.The developers were riping for about 12 hours and in the interval of the next 30 hours the observed films were developed. But only a small part of the developing capacity was used.

The Results of Measurings

Eight kinds of films were evaluated and were divided into three groups according to their sensitivity (Tab. 1).

Table 1:

Fig. number			Sensitivity °DIN	Emulsion number	Develop before	Size
I.	Fomapan 17	4–6	17	3443	XI. 1967	24×36
	ORWO NP 18	4–6	18	251 6867	V. 1968	6×9
	Fortepan 27	4–6	17	8937	XII. 1967	6×9
II.	Fomapan 21	7–9	21	3515	III. 1968	24×36
	ORWO NP 22	7–9	22	252 4175	II. 1968	6×9
III.	Fomapan 24	10–12	24	3630	IX. 1967	6×9
	ORWO NP 27	10–12	27	2495	III. 1968	24×36

Films produced in national enterprise Fotochema were developed in developer Fomadon, films ORWO in developer ORWO A 49 and film from the factory FORTE in developer Fenofort. There were some objections against the suitability of phenidon developer Fomadon for the film Fomapan 17. This film was developed also in developer ORWO A 49 but it was found that this developer has a very low value pH (Kieser's defect). If the developer is fresh and no films were developed in it this defect can't be observed.

An example of calculation is given in tab. 2.

Table 2:

v	$E(v)$	$D(v)$	log H	$H(v)$	$\Delta H(v)$	ν	$T(\nu)$
0,000	10,8	1,08	1,62	1,0000	0,0000	5	0,956
0,005	12,1	1,03	1,57	0,8859	0,1141	10	0,845
0,010	17,9	0,86	1,41	0,5967	0,2893	15	0,706
0,015	30,5	0,63	1,18	0,3296	0,2670	20	0,589
0,020	47,9	0,43	0,95	0,1724	0,1572	25	0,519
0,025	62,3	0,32	0,84	0,1220	0,0504	30	0,471
0,030	70,6	0,26	0,74	0,0861	0,0360	35	0,415
0,035	76,5	0,23	0,59	0,0455	0,0406	40	0,341
0,040	78,7	0,22	0,47	0,0218	0,0237	45	0,260
0,045	80,4	0,21	0,33	0,0012	0,0205	50	0,190
0,050	80,9	0,20	0,32	0,0000	0,0012	55	0,144
0,055	80,9	0,20	0,32	0,0000	0,0000	60	0,119
						65	0,114

The example of calculation for film ORWO NP 18, $\lambda = 407$ nm is given in table 2 (Fig. 6). The middle point of characteristic curve $D_s = 1{,}07$.

The Evaluation of Given Groups of Films:

I. $\lambda = 596$ nm (Fig. 4): Film Fomapan 17 shows an improved course of OTF being developed by developer ORWO A 49. Film Fortepan 27 is under this course and in general we can say that its quality in this part is lower than that one of Fomapan 17 which was developed in Fomadon. Film ORWO NP 18 shows the best course.

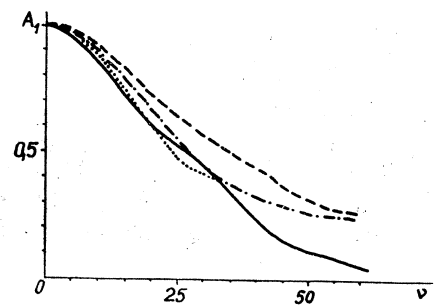

Fig. 4: OTF of films – Fomapan 17, --- ORWO NP 18, ... Fortepan 27, -.-.-. Fomapan 17, developer ORWO A 49, $\lambda = 596$ nm.

$\lambda = 503$ nm (Fig. 5): Film Fomapan 17 developed in developer ORWO A 49 shows much better course of OTF than the same film developed in Fomadon. Practically in the whole part it is better than the film ORWO NP 18 and in this part it shows the best course. As the film Fomapan 17 developed in Fomadon shows better course of OTF for lower spacing frequencies than Fortepan 27 for this wave length both films proved to be of the same quality.

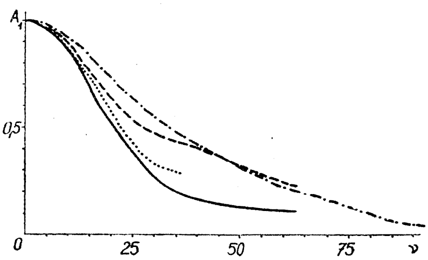

Fig. 5: OTF like in fig. 4., $\lambda = 503$ nm.

$\lambda = 407$ nm (Fig. 6): The lowest quality in this part has Fortepan 27. ORWO NP 18 shows higher quality of the course of OTF only for middle spacing frequencies which can't be shown by Hungarian film. Both kinds of film Fomapan 17 show much better course and Fomapan 17 developed in ORWO A 49 shows a little bit better course for higher spacing frequencies.

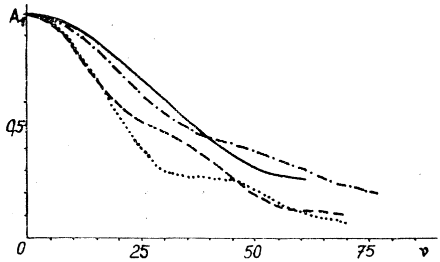

Fig. 6: OTF like in fig. 4., $\lambda = 407$ nm.

General Evaluation of the First Group:

From these three materials Fomapan 17 developed in developer ORWO A 49 is the best from the point of view of OTF. Our supposition that developer Fomadon is not the best one for this kind of film proved to be right. But the developer ORWO A 49 is not suitable either and Fotochema should try to find some other developer for this film. More important is the fact that Czechoslovak film has thicker emulsion layer than foreign films. The lower quality has ORWO NP 18 and Fortepan 27 is approximately of the same quality as Fomapan 17 developed in Fomadon. But we can say the quality of both these films is much lower than the quality of ORWO NP 18.

The second group (Fig. 7—9):

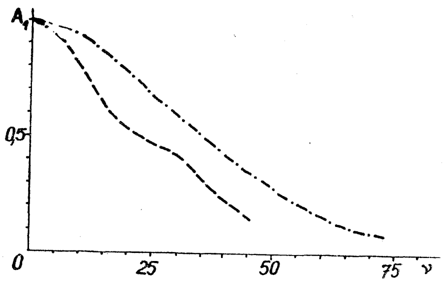

Fig. 7: OTF of films -.-.-. Fomapan 21,
--- ORWO NP 22, $\lambda = 596$ nm.

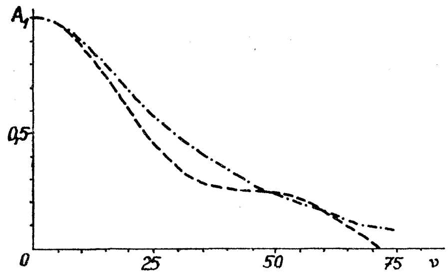

Fig. 8: OTF like in fig. 7, $\lambda = 503$ nm.

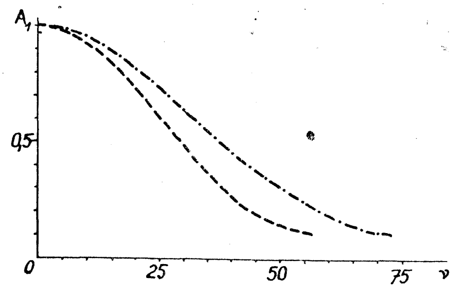

Fig. 9: OTF like in fig. 7., $\lambda = 407$ nm.

Film Fomapan 21 developed in Fomadon shows us much higher quality than ORWO NP 22.

The third group (Fig. 9—12): The quality of ORWO NP 27 for all three wave length is much higher than that one of Fomapan 24 which is not a good film. We must also realize that the sensitivity of Czechoslovak film is approximately twice lower.

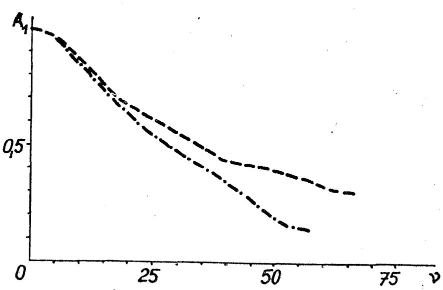

Fig. 10: OTF of films -.-.-. Fomapan 24, --- ORWO NP 27, $\lambda = 596$ nm.

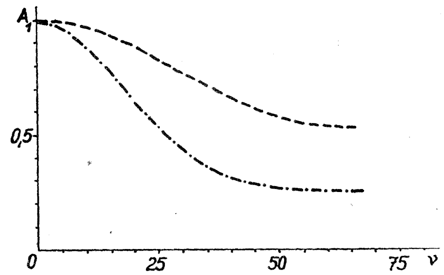

Fig. 11: OTF like in fig. 10, λ = 503 nm.

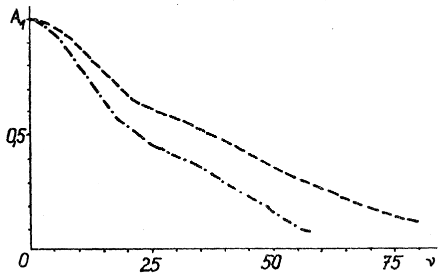

Fig. 12: OTF like in fig. 10, λ = 407 nm.

Conclusions

It is obvious from the results that this suggested method of measuring of OTF of photographic films is very suitable for determination and checking of quality of photographic films because it sensitively shows all interferes in such a complicated process like the production of films and their treatment. As far as we know only Kodak Corporation [4] uses OTF for this purpose. This function of photographic emulsion is obtained here from OTF of system lens + photographic layer.

I am grateful to Prof. Paed. Dr. Josef Fuka for his valuable help in preparing this edition.

BIBLIOGRAPHY

[1] *Bumba V.:* Acta Univ. Olomouc, Fac. Rerum Naturalium, Tom 30 (1969).
[2] *Frieser H.:* Phot. Korr. 1955, 69–77; 1956, 51–60.
[3] *Perrin F.:* JSMPTE *69*, 151 (1960).
[4] *Lamberts R. L.:* JSMPTE *71*, 635 (1962).
[5] *Lauschmann J.:* Rozbory ve fotografickém průmyslu, SNTL Praha 1955.

SHRNUTÍ

VÝSLEDKY MĚŘENÍ OPTICKÝCH PŘENOSOVÝCH FUNKCÍ FOTOGRAFICKÝCH FILMŮ ANALÝZOU OBRAZU HRANY

VÁCLAV BUMBA

Na základě vypracované metody měření optických přenosových funkcí fotografických filmů [1] byly změřeny přenosové funkce osmi druhů filmů pro tři vlnové délky viditelného spektra. Jsou popsány podmínky expozice a především standardizace měření.

ZUSAMMENFASSUNG

DIE ERGEBNISSE DER MESSUNGEN DER KONTRASTÜBERTRAGUNGSFUNKTIONEN DER PHOTOGRAPHISCHEN FILMEN MITTELS DER KANTENBILDANALYSE

VÁCLAV BUMBA

Auf Grund der ausgearbeiteten Methode der Kontrastübertragungsfunktionsmessung von photographischen Filmen [1] werden die Kontrastübetragungsfunktionen von acht Typen von Fotoemulsionen für drei Wellenlängen des Sichtbaren Spektrums ausgewertet. Es werden die Expositionsbedingungen und vor allem die Messungsnormen beschrieben.