Tables and Templates

A collection of useful look-up and conversion tables, and some templates to support your work

A considerable amount of scientific work and care has gone into the preparation of this book. All authors made an effort to take nothing for granted and challenged many photographic myths. To prove out these challenges, numerous tests were conducted, evaluated and archived. However, some material and processing conditions and their combinations are either not predictable, or depend entirely on the individual setup and material choices. Consequently, you may wish to conduct your own tests, which allows for individual calibration and provides you with confidence and knowledge about your own materials and techniques. Testing should be kept to a minimum; after all, the main purpose of our efforts is to create beautiful images and get them ready for display. Nevertheless, a few basic tests save time, material and frustration in the long run, while improving and assuring quality results and making our photography more enjoyable.

The tables and templates in this chapter are prepared to help you run a few experiments using your own photographic papers and films. Feel free to copy the individual pages from the book for your own test records and evaluations, but take care not to damage the book. Some templates are used as overlays and must be the same scale as the data sheets evaluated. If possible, copy overlays onto transparent material. Otherwise, use them in combination with the data sheets on a light table or against a window.

To obtain accurate and repeatable results, many tests rely on the availability of a reflection and transmission densitometer. We realize that such an instrument is a serious investment for any photographer, but its many uses will soon justify the purchase. Densitometers are often available from a friend or on the secondhand market. If all else fails, every 1-hour photo-lab has one to calibrate their systems, and the owner may be willing to take a few readings for you.

Standard Values for Negatives, Prints and Monitors

Zone	Negative	Print	Monitor
0	**0.00**	**2.10**	**100%**
•	0.03	2.09	
••	0.07	2.06	
I	**0.10**	**2.04**	**99**
•	0.14	2.00	98
••	0.19	1.95	97
II	**0.24**	**1.89**	**96**
•	0.28	1.81	95
••	0.33	1.72	93
III	**0.38**	**1.61**	**90**
•	0.43	1.48	86
••	0.49	1.34	82
IV	**0.54**	**1.19**	**77**
•	0.60	1.04	71
••	0.66	0.89	64
V	**0.72**	**0.75**	**56**
•	0.78	0.62	48
••	0.84	0.50	40
VI	**0.90**	**0.40**	**32**
•	0.97	0.32	25
••	1.03	0.25	19
VII	**1.10**	**0.19**	**14**
•	1.16	0.15	10
••	1.22	0.12	6
VIII	**1.29**	**0.09**	**4**
•	1.35	0.08	3
••	1.42	0.07	2
IX	**1.48**	**0.06**	**1**
•	1.55	0.05	0
••	1.61		
X	**1.67**		
•	1.73		
••	1.79		
XI	**1.85**		

fig.1 Standard, normal development, Zone System density values for relative negative transmission and absolute print reflection, as well as digitally representative grayscale values for computer monitors set to 2.2 gamma, are shown in 1/3-stop increments.

f/stop Timing Table [s]

dodging [f/stop] ←						base exposure	→ burning [f/stop]											
-1	-5/6	**-2/3**	-1/2	**-1/3**	-1/6		+1/6	**+1/3**	+1/2	**+2/3**	+5/6	**+1**	+1 1/3	+1 2/3	**+2**	+2 1/3	+2 2/3	**+3**
-4.0	-3.5	**-3.0**	-2.3	**-1.7**	-0.9	**8**	1.0	**2.1**	3.3	**4.7**	6.3	**8.0**	12.2	17.4	**24.0**	32.3	42.8	**56.0**
-4.2	-3.7	-3.1	-2.5	-1.7	-0.9	8.5	1.0	2.2	3.5	5.0	6.6	8.5	12.9	18.4	25.4	34.2	45.3	59.3
-4.5	-3.9	-3.3	-2.6	-1.9	-1.0	9.0	1.1	2.3	3.7	5.3	7.0	9.0	13.6	19.5	26.9	36.3	48.0	62.9
-4.8	-4.2	-3.5	-2.8	-2.0	-1.0	9.5	1.2	2.5	3.9	5.6	7.4	9.5	14.5	20.7	28.5	38.4	50.9	66.6
-5.0	-4.4	**-3.7**	-3.0	**-2.1**	-1.1	**10.1**	1.2	**2.6**	4.2	**5.9**	7.9	**10.1**	15.3	21.9	**30.2**	40.7	53.9	**70.6**
-5.3	-4.7	-4.0	-3.1	-2.2	-1.2	10.7	1.3	2.8	4.4	6.3	8.3	10.7	16.2	23.2	32.0	43.1	57.1	74.8
-5.7	-5.0	-4.2	-3.3	-2.3	-1.2	11.3	1.4	2.9	4.7	6.6	8.8	11.3	17.2	24.6	33.9	45.7	60.5	79.2
-6.0	-5.3	-4.4	-3.5	-2.5	-1.3	12.0	1.5	3.1	5.0	7.0	9.4	12.0	18.2	26.1	36.0	48.4	64.1	83.9
-6.3	-5.6	**-4.7**	-3.7	**-2.6**	-1.4	**12.7**	1.6	**3.3**	5.3	**7.5**	9.9	**12.7**	19.3	27.6	**38.1**	51.3	67.9	**88.9**
-6.7	-5.9	-5.0	-3.9	-2.8	-1.5	13.5	1.6	3.5	5.6	7.9	10.5	13.5	20.4	29.3	40.4	54.4	72.0	94.2
-7.1	-6.3	-5.3	-4.2	-2.9	-1.6	14.3	1.7	3.7	5.9	8.4	11.1	14.3	21.7	31.0	42.8	57.6	76.3	99.8
-7.6	-6.6	-5.6	-4.4	-3.1	-1.6	15.1	1.8	3.9	6.3	8.9	11.8	15.1	23.0	32.8	45.3	61.0	80.8	106
-8.0	-7.0	**-5.9**	-4.7	**-3.3**	-1.7	**16**	2.0	**4.2**	6.6	**9.4**	12.5	**16.0**	24.3	34.8	**48.0**	64.6	85.6	**112**
-8.5	-7.4	-6.3	-5.0	-3.5	-1.8	17.0	2.1	4.4	7.0	10.0	13.3	17.0	25.8	36.9	50.9	68.5	90.7	119
-9.0	-7.9	-6.6	-5.3	-3.7	-2.0	18.0	2.2	4.7	7.4	10.5	14.0	18.0	27.3	39.1	53.9	72.6	96.1	126
-9.5	-8.3	-7.0	-5.6	-3.9	-2.1	19.0	2.3	4.9	7.9	11.2	14.9	19.0	28.9	41.4	57.1	76.9	102	133
-10.1	-8.8	**-7.5**	-5.9	**-4.2**	-2.2	**20.2**	2.5	**5.2**	8.4	**11.8**	15.8	**20.2**	30.6	43.8	**60.5**	81.4	108	**141**
-10.7	-9.4	-7.9	-6.3	-4.4	-2.3	21.4	2.6	5.6	8.8	12.5	16.7	21.4	32.5	46.4	64.1	86.3	114	150
-11.3	-9.9	-8.4	-6.6	-4.7	-2.5	22.6	2.8	5.9	9.4	13.3	17.7	22.6	34.4	49.2	67.9	91.4	121	158
-12.0	-10.5	-8.9	-7.0	-4.9	-2.6	24.0	2.9	6.2	9.9	14.1	18.7	24.0	36.4	52.1	71.9	96.8	128	168
-12.7	-11.1	**-9.4**	-7.4	**-5.2**	-2.8	**25.4**	3.1	**6.6**	10.5	**14.9**	19.9	**25.4**	38.6	55.2	**76.2**	103	136	**178**
-13.5	-11.8	-10.0	-7.9	-5.6	-2.9	26.9	3.3	7.0	11.1	15.8	21.0	26.9	40.9	58.5	80.7	109	144	188
-14.3	-12.5	-10.5	-8.4	-5.9	-3.1	28.5	3.5	7.4	11.8	16.7	22.3	28.5	43.3	62.0	85.5	115	153	200
-15.1	-13.3	-11.2	-8.8	-6.2	-3.3	30.2	3.7	7.9	12.5	17.7	23.6	30.2	45.9	65.7	90.6	122	162	211
-16.0	-14.0	**-11.8**	-9.4	**-6.6**	-3.5	**32**	3.9	**8.3**	13.3	**18.8**	25.0	**32.0**	48.6	69.6	**96.0**	129	171	**224**
-17.0	-14.9	-12.5	-9.9	-7.0	-3.7	33.9	4.2	8.8	14.0	19.9	26.5	33.9	51.5	73.7	102	137	181	237
-18.0	-15.8	-13.3	-10.5	-7.4	-3.9	35.9	4.4	9.3	14.9	21.1	28.1	35.9	54.6	78.1	108	145	192	251
-19.0	-16.7	-14.1	-11.1	-7.9	-4.2	38.1	4.7	9.9	15.8	22.4	29.8	38.1	57.8	82.8	114	154	204	266
-20.2	-17.7	**-14.9**	-11.8	**-8.3**	-4.4	**40.3**	4.9	**10.5**	16.7	**23.7**	31.5	**40.3**	61.3	87.7	**121**	163	216	**282**
-21.4	-18.7	-15.8	-12.5	-8.8	-4.7	42.7	5.2	11.1	17.7	25.1	33.4	42.7	64.9	92.9	128	173	229	299
-22.6	-19.9	-16.7	-13.3	-9.3	-4.9	45.3	5.5	11.8	18.7	26.6	35.4	45.3	68.8	98.4	136	183	242	317
-24.0	-21.0	-17.7	-14.0	-9.9	-5.2	47.9	5.9	12.5	19.9	28.2	37.5	47.9	72.9	104	144	194	256	336
-25.4	-22.3	**-18.8**	-14.9	**-10.5**	-5.5	**50.8**	6.2	**13.2**	21.0	**29.8**	39.7	**50.8**	77.2	110	**152**	205	272	**356**
-26.9	-23.6	-19.9	-15.8	-11.1	-5.9	53.8	6.6	14.0	22.3	31.6	42.1	53.8	81.8	117	161	217	288	377
-28.5	-25.0	-21.1	-16.7	-11.8	-6.2	57.0	7.0	14.8	23.6	33.5	44.6	57.0	86.7	124	171	230	305	399
-30.2	-26.5	-22.4	-17.7	-12.5	-6.6	60.4	7.4	15.7	25.0	35.5	47.2	60.4	91.8	131	181	244	323	423
-32.0	-28.1	**-23.7**	-18.7	**-13.2**	-7.0	**64**	7.8	**16.6**	26.5	**37.6**	50.0	**64.0**	97.3	139	**192**	259	342	**448**

fig.2

critical viewing conditions

Minimum Visual Angles

	arc sec	degrees	rad	
detectable point	0.05	13.889E-06	242.407E-09	stars against black sky
detectable line	1	277.778E-06	4.848E-06	thin wire against a bright sky
perceptible	10	2.778E-03	48.481E-06	limit of actuance
distinguishable	20	5.556E-03	96.963E-06	critical minimum visual angle
separable	60	16.667E-03	290.888E-06	standard minimum visual angle
	120	33.333E-03	581.776E-06	relaxed minimum visual angle
chosen	20	5.556E-3	9.696E-5	

The Measure of Man
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and
On the Psychophysical Function
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Print Details Size	Diagonal [mm]	Min Viewing Distance [mm]	Eye Resolution [lp/mm]	Enlarged Circle of Confusion [mm]
5x7	218	250	20.6	0.048
8x10	325	325	15.9	0.063
9.5x12	389	389	13.3	0.075
11x14	452	452	11.4	0.088
12x16	508	508	10.2	0.099
16x20	651	651	7.9	0.126

Negative Details Size	Diagonal full [mm]	Diagonal 4x5 [mm]	Enlargement 5x7	8x10	9.5x12	11x14	12x16	16x20	Circle of Confusion [mm]	Resolution required [lp/mm]
16x24	28.8	25.6	8.5	12.7	15.2	17.7	19.8	25.4	0.005	201
24x36	43.3	38.4	5.7	8.5	10.1	11.8	13.2	16.9	0.007	134
6x4.5	69.7	66.4	3.3	4.9	5.9	6.8	7.6	9.8	0.013	78
6x6	79.2	71.7	3.0	4.5	5.4	6.3	7.1	9.1	0.014	72
6x7	88.9	83.2	2.6	3.9	4.7	5.4	6.1	7.8	0.016	62
6x9	99.8	89.6	2.4	3.6	4.3	5.0	5.7	7.3	0.017	58
4x5	153.7	153.7	1.4	2.1	2.5	2.9	3.3	4.2	0.030	34
5x7	206.5	192.1	1.1	1.7	2.0	2.4	2.6	3.4	0.037	27
8x10	307.3	307.3	0.7	1.1	1.3	1.5	1.7	2.1	0.060	17
11x14	434.2	432.6	0.5	0.8	0.9	1.0	1.2	1.5	0.084	12

standard viewing conditions

Minimum Visual Angles

	arc sec	degrees	rad	
detectable point	0.05	13.889E-06	242.407E-09	stars against black sky
detectable line	1	277.778E-06	4.848E-06	thin wire against a bright sky
perceptible	10	2.778E-03	48.481E-06	limit of actuance
distinguishable	20	5.556E-03	96.963E-06	critical minimum visual angle
separable	60	16.667E-03	290.888E-06	standard minimum visual angle
	120	33.333E-03	581.776E-06	relaxed minimum visual angle
chosen	60	1.667E-2	2.909E-4	

Print Details Size	Diagonal [mm]	Min Viewing Distance [mm]	Eye Resolution [lp/mm]	Enlarged Circle of Confusion [mm]
5x7	218	250	6.9	0.145
8x10	325	325	5.3	0.189
9.5x12	389	389	4.4	0.226
11x14	452	452	3.8	0.263
12x16	508	508	3.4	0.296
16x20	651	651	2.6	0.378

Negative Details Size	Diagonal full [mm]	Diagonal 4x5 [mm]	Enlargement 5x7	8x10	9.5x12	11x14	12x16	16x20	Circle of Confusion [mm]	Resolution required [lp/mm]
16x24	28.8	25.6	8.5	12.7	15.2	17.7	19.8	25.4	0.015	67
24x36	43.3	38.4	5.7	8.5	10.1	11.8	13.2	16.9	0.022	45
6x4.5	69.7	66.4	3.3	4.9	5.9	6.8	7.6	9.8	0.039	26
6x6	79.2	71.7	3.0	4.5	5.4	6.3	7.1	9.1	0.042	24
6x7	88.9	83.2	2.6	3.9	4.7	5.4	6.1	7.8	0.048	21
6x9	99.8	89.6	2.4	3.6	4.3	5.0	5.7	7.3	0.052	19
4x5	153.7	153.7	1.4	2.1	2.5	2.9	3.3	4.2	0.089	11
5x7	206.5	192.1	1.1	1.7	2.0	2.4	2.6	3.4	0.112	9
8x10	307.3	307.3	0.7	1.1	1.3	1.5	1.7	2.1	0.179	6
11x14	434.2	432.6	0.5	0.8	0.9	1.0	1.2	1.5	0.252	4

fig.3 Throughout the book, we make several references to standard and critical viewing conditions, the minimum circle of confusion, typical print enlargements and the lens, film or sensor resolutions required. The data compiled in these two tables are the foundation of our references.

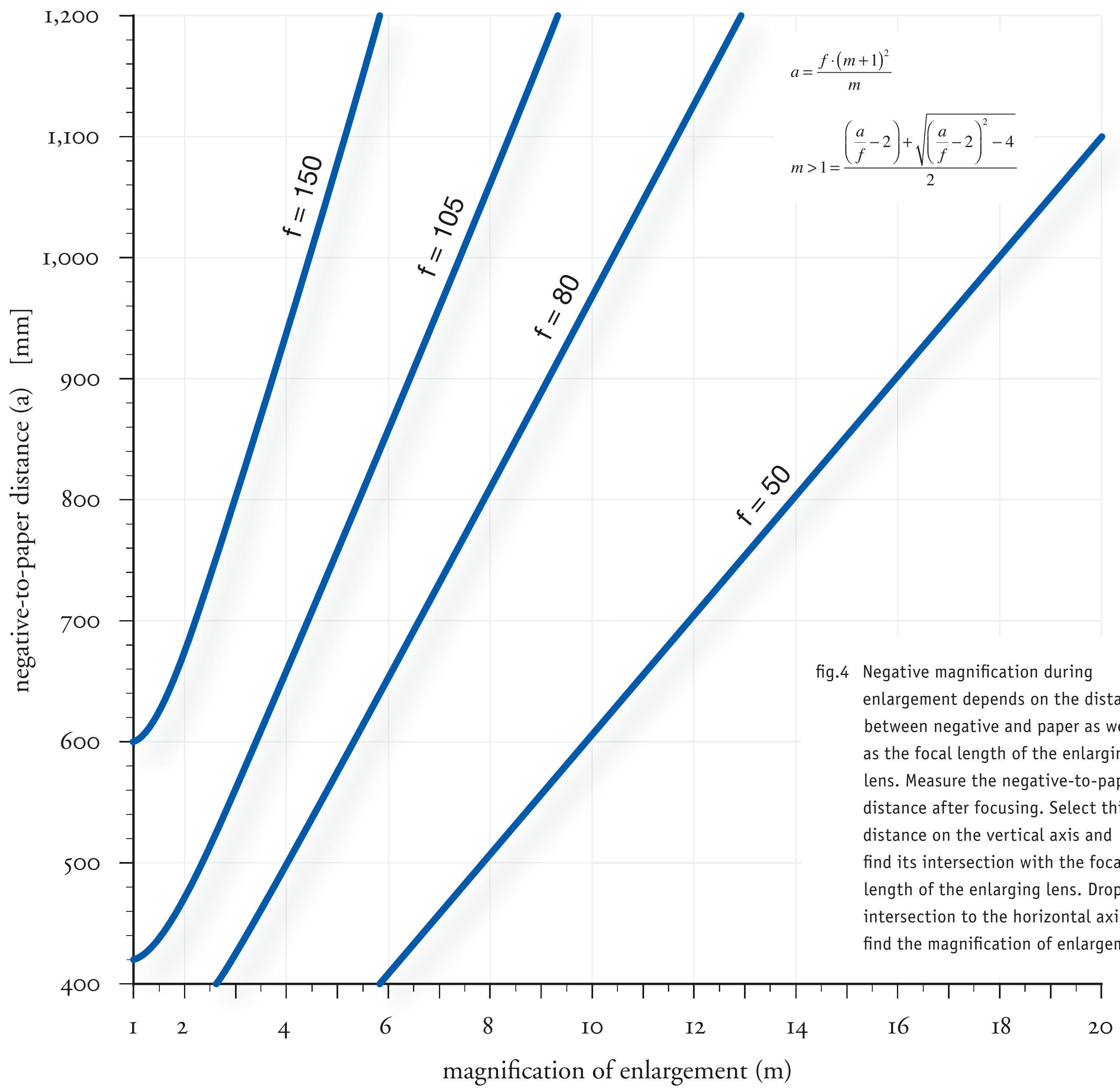


fig.4 Negative magnification during enlargement depends on the distance between negative and paper as well as the focal length of the enlarging lens. Measure the negative-to-paper distance after focusing. Select this distance on the vertical axis and find its intersection with the focal length of the enlarging lens. Drop the intersection to the horizontal axis to find the magnification of enlargement.

Enlarger-Height Exposure Compensation

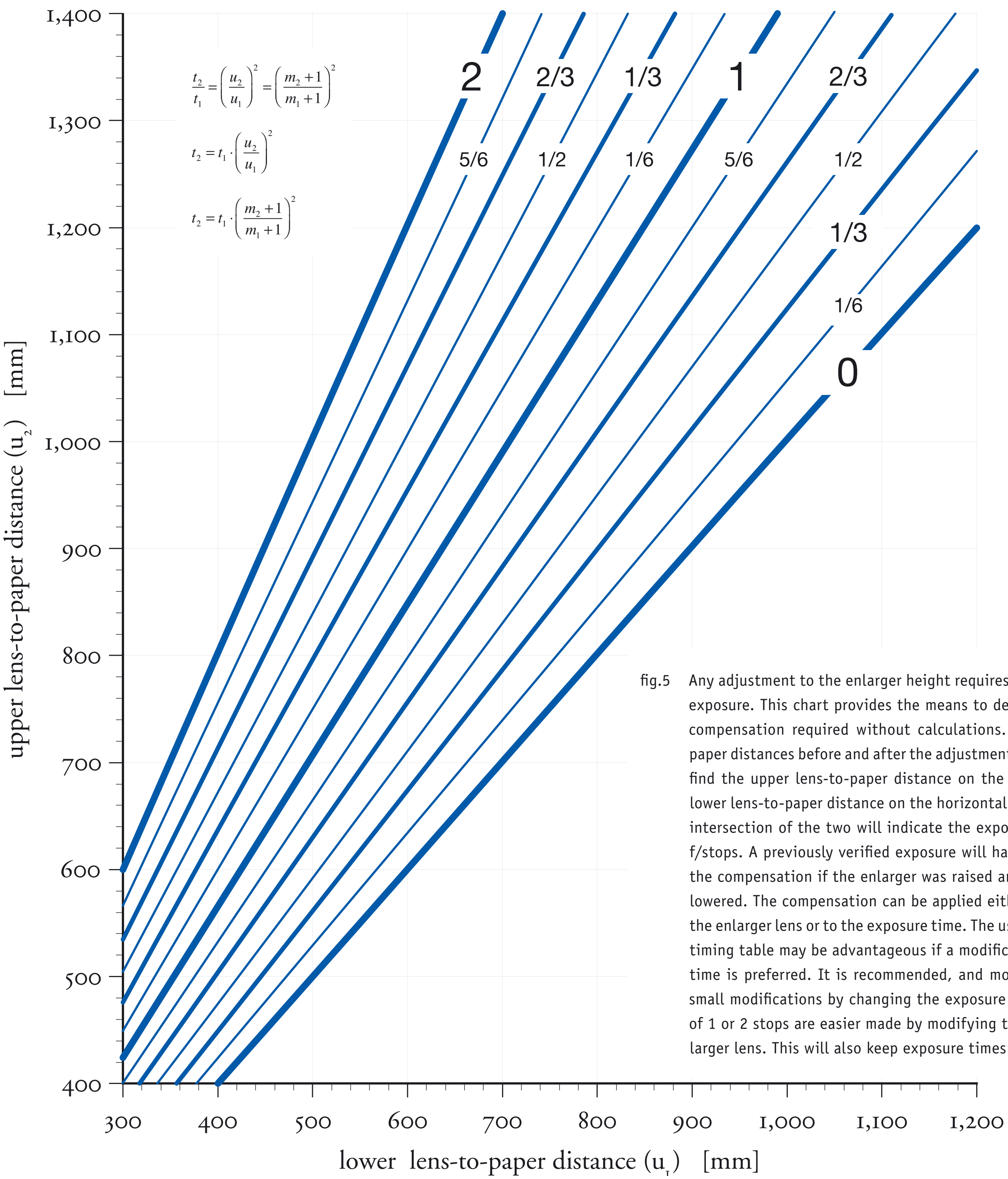


fig.5 Any adjustment to the enlarger height requires a change in the print exposure. This chart provides the means to determine the exposure compensation required without calculations. Measure the lens-to-paper distances before and after the adjustment to the enlarger. Then, find the upper lens-to-paper distance on the vertical axis and the lower lens-to-paper distance on the horizontal axis of the chart. The intersection of the two will indicate the exposure compensation in f/stops. A previously verified exposure will have to be increased by the compensation if the enlarger was raised and decreased if it was lowered. The compensation can be applied either to the aperture of the enlarger lens or to the exposure time. The use of a separate f/stop timing table may be advantageous if a modification of the exposure time is preferred. It is recommended, and more practical, to make small modifications by changing the exposure time. Larger changes, of 1 or 2 stops are easier made by modifying the aperture of the enlarger lens. This will also keep exposure times at manageable levels.

Temperature Conversion

°C	°F	°F	°C
10	50.0	**50**	10.0
11	51.8	**52**	11.1
12	53.6	**54**	12.2
13	55.4	**56**	13.3
14	57.2	**58**	14.4
15	59.0	**60**	15.6
16	60.8	**62**	16.7
17	62.6	**64**	17.8
18	64.4	**66**	18.9
19	66.2	**68**	20.0
20	68.0	**70**	21.1
21	69.8	**71**	21.7
22	71.6	**72**	22.2
23	73.4	**73**	22.8
24	75.2	**74**	23.3
25	77.0	**75**	23.9
26	78.8	**76**	24.4
27	80.6	**78**	25.6
28	82.4	**80**	26.7
29	84.2	**82**	27.8
30	86.0	**84**	28.9
31	87.8	**86**	30.0
32	89.6	**88**	31.1
33	91.4	**90**	32.2
34	93.2	**92**	33.3
35	95.0	**94**	34.4
36	96.8	**96**	35.6
37	98.6	**98**	36.7
38	100.4	**100**	37.8
39	102.2	**102**	38.9
40	104.0	**104**	40.0

$$°F = °C \cdot \frac{9}{5} + 32$$

$$°C = (°F - 32) \cdot \frac{5}{9}$$

fig.6 Celsius is a temperature scale named after the Swedish astronomer Anders Celsius (1701–1744), who developed it two years before his death. The Fahrenheit scale is named after the physicist Daniel Gabriel Fahrenheit (1686–1736) who proposed his scale in 1724. On the Celsius scale, 0 and 100°C are defined as the freezing and boiling points of water, both measured at standard atmospheric pressure. The Celsius scale has replaced Fahrenheit in most countries, with the exception of the USA and a few other nations, where most people are still accustomed to measuring temperatures in Fahrenheit.

Film Development Temperature Compensation

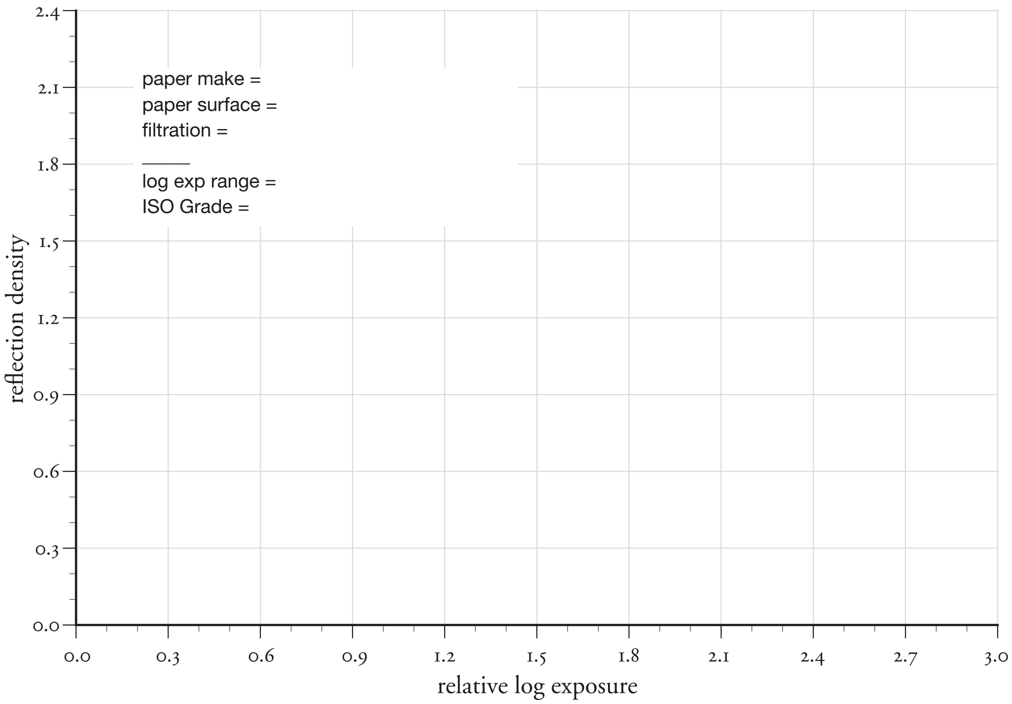
development temperature substitutes										
18°C 64°F	19°C 66°F	20°C 68°F	21°C 70°F	22°C 72°F	23°C 73°F	24°C 75°F	25°C 77°F	26°C 79°F	27°C 81°F	28°C 82°F
4:50	4:20	4:00	-	-	-	-	-	-	-	-
5:20	5:00	4:30	4:10	-	-	-	-	-	-	-
6:00	5:30	5:00	4:30	4:10	-	-	-	-	-	-
6:40	6:00	5:30	5:00	4:40	4:10	-	-	-	-	-
7:10	6:40	6:00	5:30	5:00	4:30	4:10	-	-	-	-
7:50	7:10	6:30	6:00	5:30	5:00	4:30	4:10	-	-	-
8:20	7:40	7:00	6:20	5:50	5:20	4:50	4:30	4:00	-	-
9:00	8:10	7:30	6:50	6:20	5:40	5:10	4:50	4:20	-	-
9:40	8:50	8:00	7:20	6:40	6:10	5:30	5:00	4:40	4:10	-
10:10	9:20	8:30	7:50	7:10	6:30	5:50	5:20	4:50	4:30	4:10
10:50	9:50	9:00	8:10	7:30	6:50	6:10	5:40	5:10	4:40	4:20
11:30	10:30	9:30	8:40	8:00	7:10	6:40	6:00	5:30	5:00	4:30
12:00	11:00	10:00	9:10	8:20	7:40	7:00	6:20	5:50	5:20	4:50
13:10	12:00	11:00	10:00	9:10	8:20	7:40	7:00	6:20	5:50	5:20
14:30	13:10	12:00	11:00	10:00	9:10	8:20	7:40	7:00	6:20	5:50
15:40	14:20	13:00	11:50	10:50	9:50	9:00	8:10	7:30	6:50	6:20
16:50	15:20	14:00	12:50	11:40	10:40	9:40	8:50	8:10	7:20	6:40
18:00	16:30	15:00	13:40	12:30	11:20	10:20	9:30	8:40	7:50	7:10
19:10	17:30	16:00	14:40	13:20	12:10	11:10	10:10	9:10	8:30	7:40
20:30	18:40	17:00	15:30	14:10	13:00	11:50	10:50	9:50	9:00	8:10
21:40	19:40	18:00	16:30	15:00	13:40	12:30	11:20	10:20	9:30	8:40
22:50	20:50	19:00	17:20	15:50	14:30	13:10	12:00	11:00	10:00	9:10
24:00	22:00	20:00	18:20	16:40	15:10	13:50	12:40	11:30	10:30	9:40
25:10	23:00	21:00	19:10	17:30	16:00	14:30	13:20	12:10	11:00	10:10
26:30	24:10	22:00	20:00	18:20	16:40	15:20	14:00	12:40	11:40	10:30

$$\log c = \frac{(\log t_2 - \log t_1) \cdot 10}{T_1 - T_2}$$

$$t_2 = t_1 \cdot c^{\frac{T_1 - T_2}{10}}$$

fig.7 To achieve consistent film development at different temperatures, a temperature coefficient (c) is used to calculate a new development time (t_2) for a new temperature (T_2) from an old development time (t_1) and an old temperature (T_1). For the table shown here, a coefficient of 2.5 was used to account for the temperature effect on D-23, D-76 and ID-11.
In the column with your standard development temperature, find the row with your target development time. Follow that row, left or right, until you reach the column with the actual processing temperature and find the new development time. For example, if 10 minutes at 20°C is your standard film development process, you need to reduce the development time to 6 minutes and 20 seconds if the processing temperature changes to 25°C.

Paper Characteristic Curves



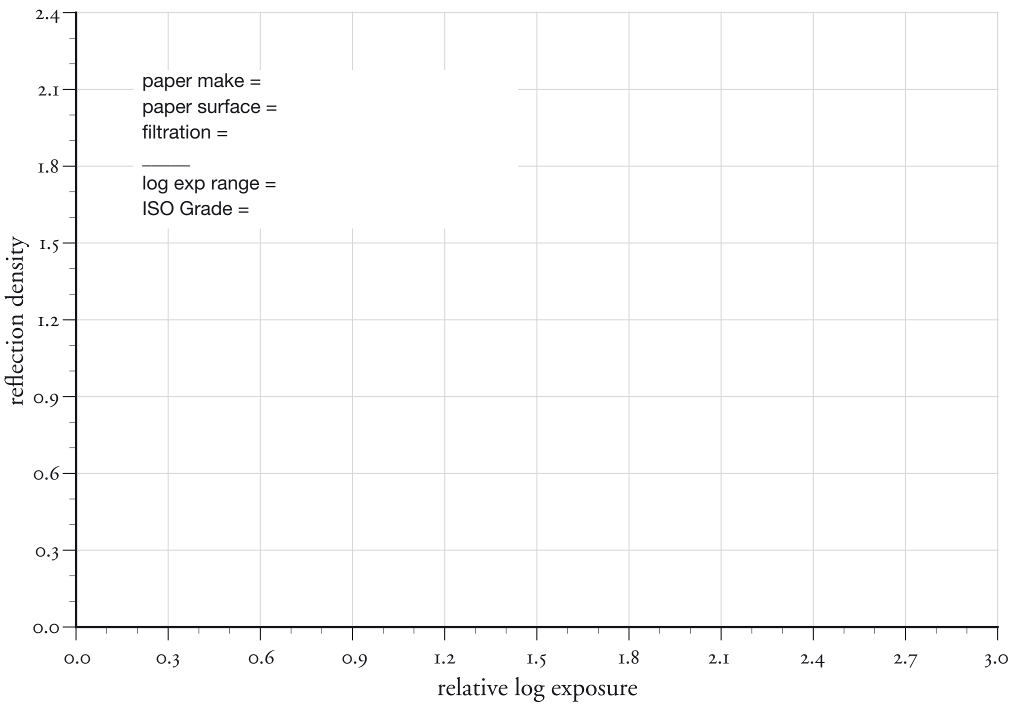


fig.8 This template is used to chart paper characteristic curves. First, record the paper specifications and contrast-filtration method. Then, conduct the test as described in 'Measuring Paper Contrast' and chart the data on one of these sheets. Use the template in fig.12 as an overlay to measure the log exposure range and the table in fig.9 to determine the corresponding ISO grade.
(do not change the scale of this template)

Paper Log Exposure Range / Standard ISO Paper Grade

log ER	ISO	log ER	ISO	log ER	ISO
0.50	5.52	0.90	2.85	1.30	0.87
0.51	5.45	0.91	2.79	1.31	0.83
0.52	5.38	0.92	2.73	1.32	0.80
0.53	5.32	0.93	2.67	1.33	0.76
0.54	5.25	0.94	2.61	1.34	0.72
0.55	5.18	0.95	2.55	1.35	0.68
0.56	5.11	0.96	2.49	1.36	0.65
0.57	5.04	0.97	2.44	1.37	0.61
0.58	4.97	0.98	2.38	1.38	0.58
0.59	4.90	0.99	2.32	1.39	0.54
0.60	4.83	1.00	2.27	1.40	0.51
0.61	4.76	1.01	2.21	1.41	0.47
0.62	4.69	1.02	2.16	1.42	0.44
0.63	4.63	1.03	2.10	1.43	0.40
0.64	4.56	1.04	2.05	1.44	0.37
0.65	4.49	1.05	2.00	1.45	0.34
0.66	4.42	1.06	1.95	1.46	0.30
0.67	4.35	1.07	1.90	1.47	0.27
0.68	4.28	1.08	1.85	1.48	0.24
0.69	4.21	1.09	1.80	1.49	0.20
0.70	4.14	1.10	1.75	1.50	0.17
0.71	4.08	1.11	1.70	1.51	0.14
0.72	4.01	1.12	1.65	1.52	0.10
0.73	3.94	1.13	1.60	1.53	0.07
0.74	3.87	1.14	1.55	1.54	0.04
0.75	3.81	1.15	1.51	1.55	0.01
0.76	3.74	1.16	1.46	1.56	-0.03
0.77	3.67	1.17	1.41	1.57	-0.06
0.78	3.61	1.18	1.37	1.58	-0.09
0.79	3.54	1.19	1.33	1.59	-0.12
0.80	3.48	1.20	1.28	1.60	-0.16
0.81	3.41	1.21	1.24	1.61	-0.19
0.82	3.35	1.22	1.20	1.62	-0.22
0.83	3.28	1.23	1.15	1.63	-0.26
0.84	3.22	1.24	1.11	1.64	-0.29
0.85	3.16	1.25	1.07	1.65	-0.33
0.86	3.09	1.26	1.03	1.66	-0.36
0.87	3.03	1.27	0.99	1.67	-0.40
0.88	2.97	1.28	0.95	1.68	-0.43
0.89	2.91	1.29	0.91	1.69	-0.47
0.90	2.85	1.30	0.87	1.70	-0.50

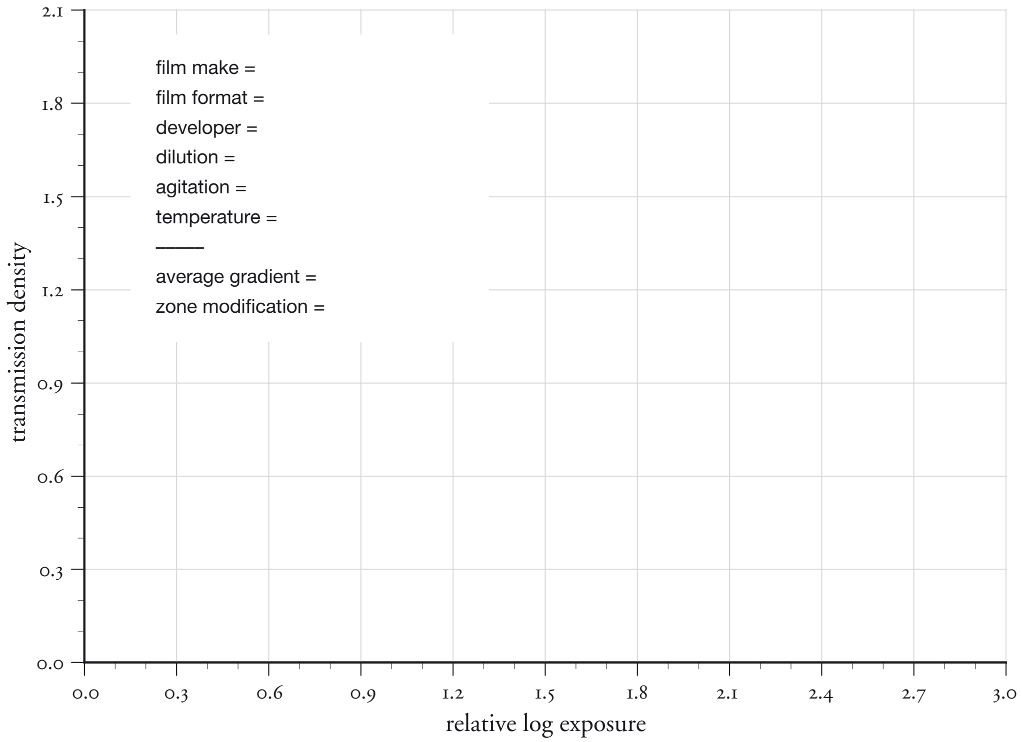
ISO	log ER
0.000	1.54
0.125	1.51
0.250	1.47
0.375	1.43
0.500	1.40
0.625	1.37
0.750	1.33
0.875	1.30
1.000	1.27
1.125	1.24
1.250	1.21
1.375	1.18
1.500	1.16
1.625	1.13
1.750	1.10
1.875	1.08
2.000	1.05
2.125	1.03
2.250	1.00
2.375	0.98
2.500	0.96
2.625	0.94
2.750	0.92
2.875	0.89
3.000	0.87
3.125	0.85
3.250	0.83
3.375	0.81
3.500	0.79
3.625	0.78
3.750	0.76
3.875	0.74
4.000	0.72
4.125	0.70
4.250	0.68
4.375	0.67
4.500	0.65
4.625	0.63
4.750	0.61
4.875	0.59
5.000	0.58

$$ISO = 9.21 - 7.80 \cdot (LER) + 0.421 \cdot (LER)^2 + 0.486 \cdot (LER)^3$$

$$LER = 1.55 - 0.306 \cdot (ISO) + 0.0349 \cdot (ISO)^2 - 0.00250 \cdot (ISO)^3$$

fig.9 There is a numerical relationship between standard ISO paper grades (ISO) and the paper's log exposure range (log ER or LER).

Film Characteristic Curves



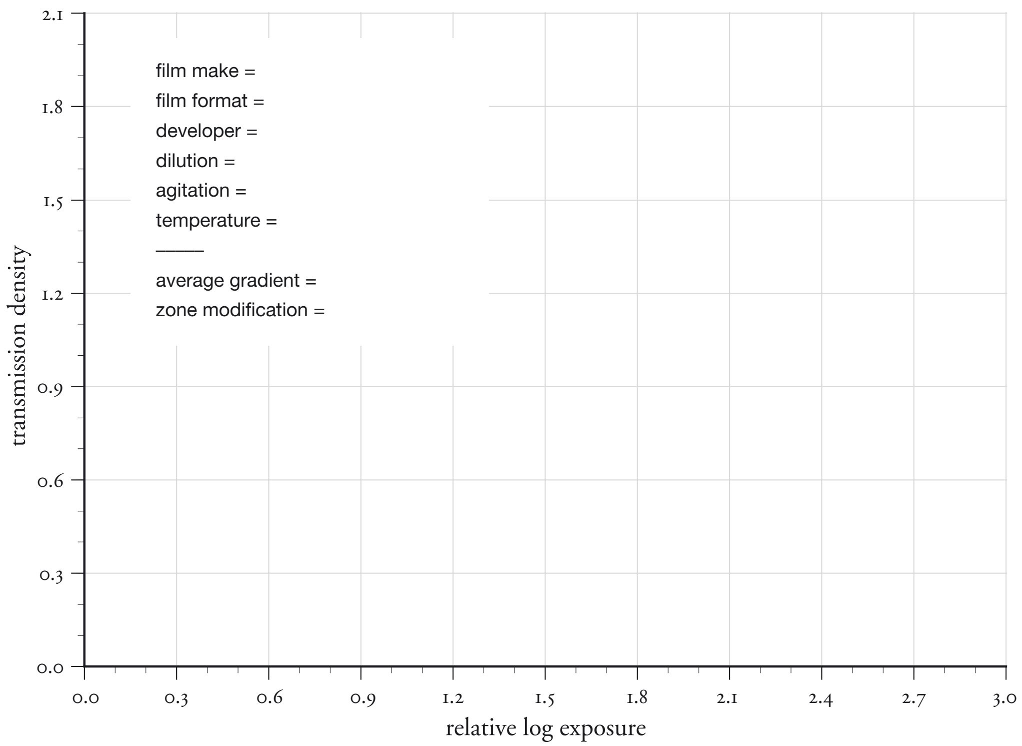


fig.10 This template is used to chart film characteristic curves. First, record the film and development specifications. Then, conduct the test as described in 'Customizing Film Speed and Development' and chart the data on one of these sheets. Use the template in fig.13 as an overlay to measure the average gradient and the table in fig.11 to determine the corresponding zone modification.
(do not change the scale of this template)

Film Average Gradient, Zone System and Subject Brightness Range

avg gradient	N	SBR	avg gradient	N	SBR
0.400	-3.0	10.0	0.571	0.0	7.0
0.404	-2.9	9.9	0.580	0.1	6.9
0.408	-2.8	9.8	0.588	0.2	6.8
0.412	-2.7	9.7	0.597	0.3	6.7
0.417	-2.6	9.6	0.606	0.4	6.6
0.421	-2.5	9.5	0.615	0.5	6.5
0.426	-2.4	9.4	0.625	0.6	6.4
0.430	-2.3	9.3	0.635	0.7	6.3
0.435	-2.2	9.2	0.645	0.8	6.2
0.440	-2.1	9.1	0.656	0.9	6.1
0.444	-2.0	9.0	0.667	1.0	6.0
0.449	-1.9	8.9	0.678	1.1	5.9
0.455	-1.8	8.8	0.690	1.2	5.8
0.460	-1.7	8.7	0.702	1.3	5.7
0.465	-1.6	8.6	0.714	1.4	5.6
0.471	-1.5	8.5	0.727	1.5	5.5
0.476	-1.4	8.4	0.741	1.6	5.4
0.482	-1.3	8.3	0.755	1.7	5.3
0.488	-1.2	8.2	0.769	1.8	5.2
0.494	-1.1	8.1	0.784	1.9	5.1
0.500	-1.0	8.0	0.800	2.0	5.0
0.506	-0.9	7.9	0.816	2.1	4.9
0.513	-0.8	7.8	0.833	2.2	4.8
0.519	-0.7	7.7	0.851	2.3	4.7
0.526	-0.6	7.6	0.870	2.4	4.6
0.533	-0.5	7.5	0.889	2.5	4.5
0.541	-0.4	7.4	0.909	2.6	4.4
0.548	-0.3	7.3	0.930	2.7	4.3
0.556	-0.2	7.2	0.952	2.8	4.2
0.563	-0.1	7.1	0.976	2.9	4.1
0.571	0.0	7.0	1.000	3.0	4.0

$$\gamma = \frac{1.2}{2.1-(N \cdot 0.3)}$$

$$N = \frac{2.1-\frac{1.2}{\gamma}}{0.3}$$

$$SBR = 7 - N$$

fig.11 There is a numerical relationship between the average gradient, the zone modification (N) and the potential subject brightness range (SBR).

Paper Range and Grade Meter

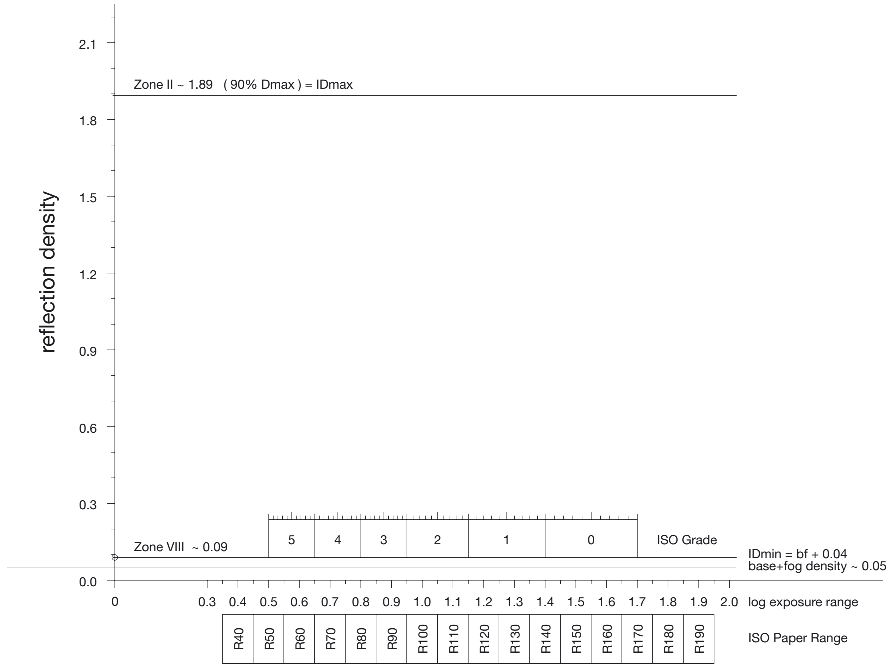
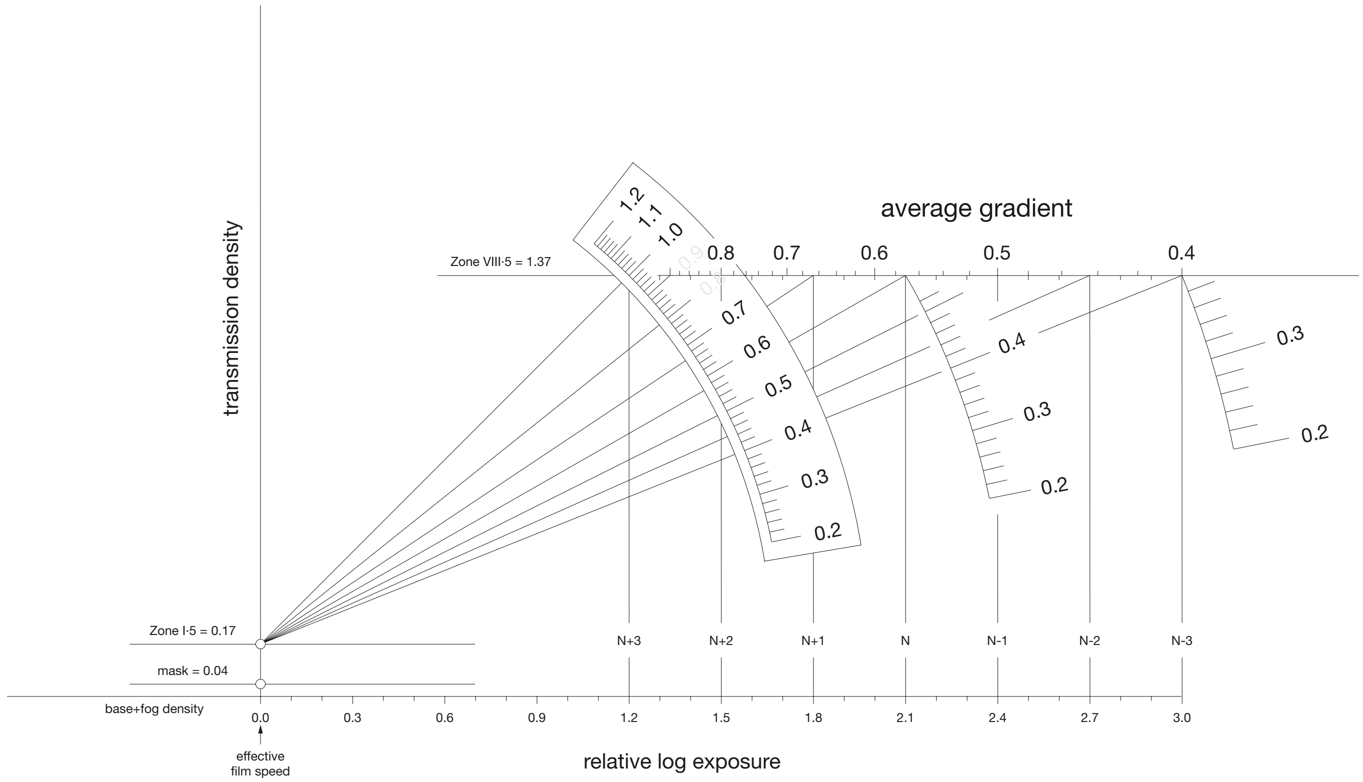


fig.12 (left) This template is used as an overlay to measure a paper's log exposure range in combination with fig.8.
(copy onto transparent material but do not change the scale of this template)

fig.13 (below) This template is used as an overlay to measure a film's average gradient in combination with fig.10.
(copy onto transparent material but do not change the scale of this template)

Film Average Gradient Meter



Film Test Summary

SBR	Zone	γ
10	N-3	0.40
9	N-2	0.44
8	N-1	0.50
7	N	0.57
6	N+1	0.67
5	N+2	0.80
4	N+3	1.00

pictorial range :
Zone I·5 = 0.17 – Zone VIII·5 = 1.37
textural range :
Zone II = 0.24 – Zone VIII = 1.29
negative density range (I·5 – VIII·5) = 1.2
normal subject brightness range = 2.1
speed point = 0.17

film make =
film format =
developer =
dilution =
agitation =
temperature =
date =

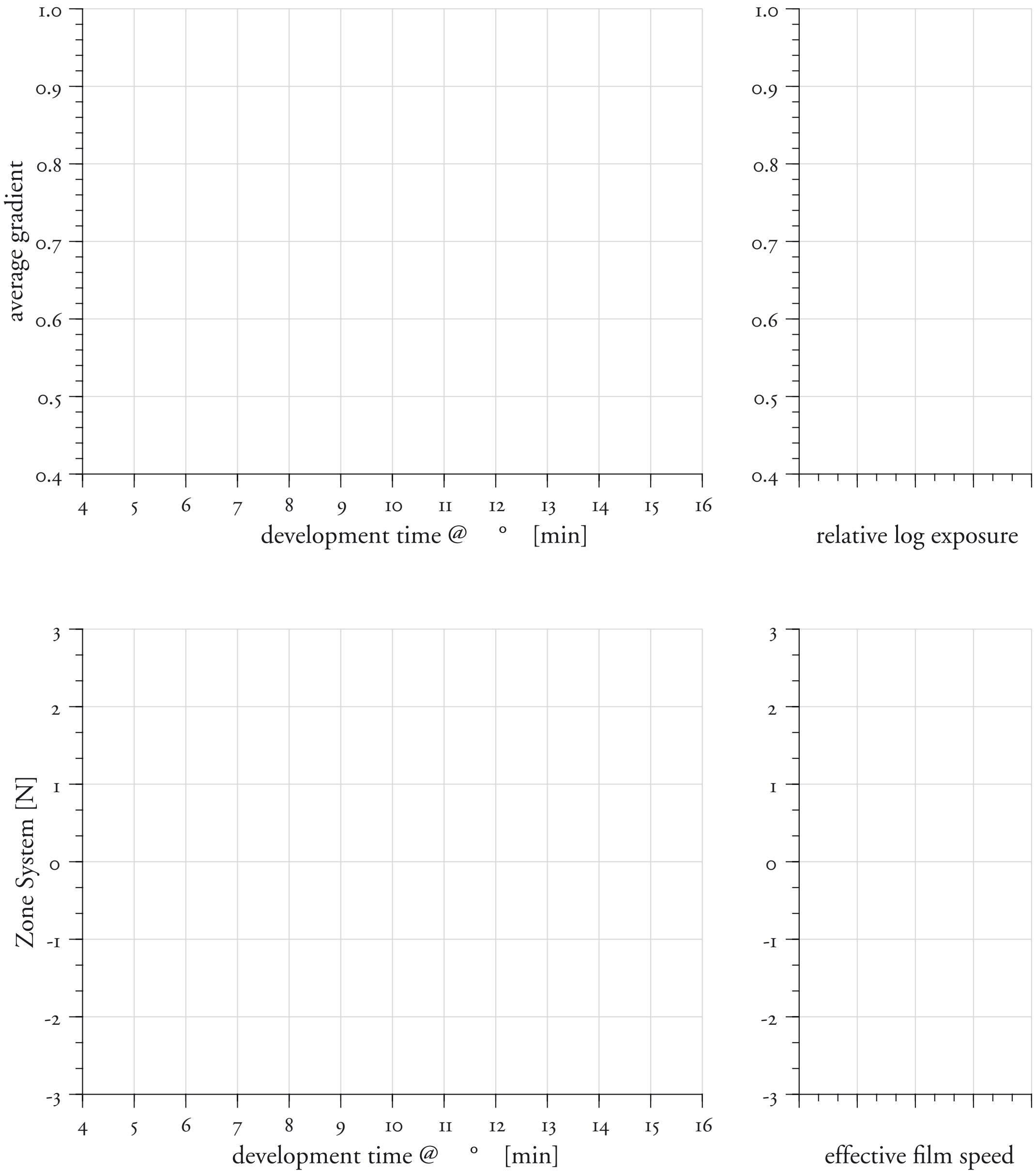
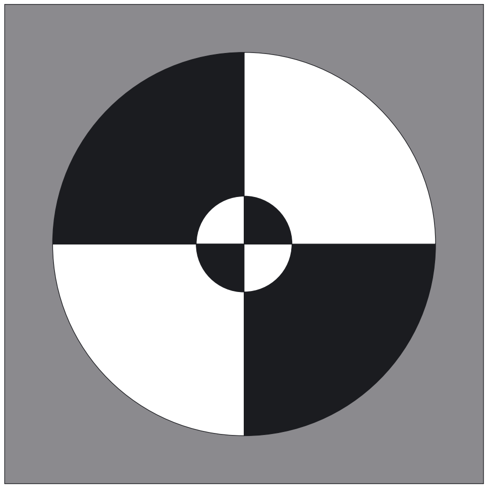


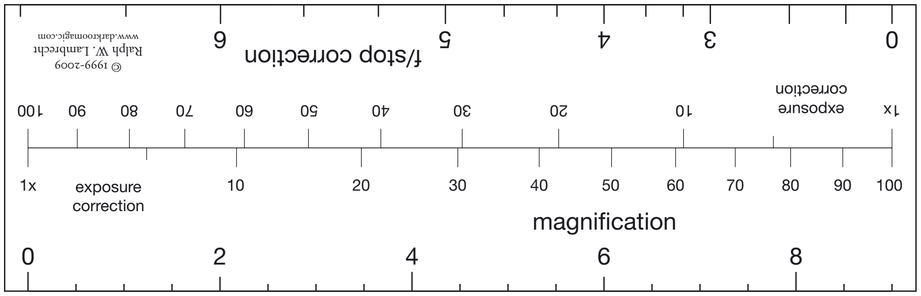
fig.14 Serious Zone System practitioners want to calibrate their favorite film/developer combinations to customized conditions. Once accomplished, most lighting conditions can be mastered with confidence and ease, rendering any negative a hassle-free printing assignment, while leaving paper grade latitude to imagination and providing maximum flexibility for creative interpretation. In 'Customizing Film Speed and Development', a detailed description of custom calibration was given, and figures 10, 11 and 13 provide the table and templates required to create the required information, so they can be summarized and completed here.

Bellows Target and Rulers



$$e = (m+1)^2$$

$$n = \frac{\log(m+1)\cdot 2}{\log 2}$$



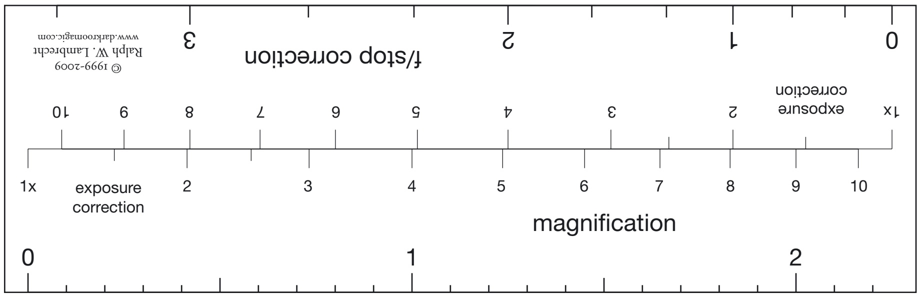
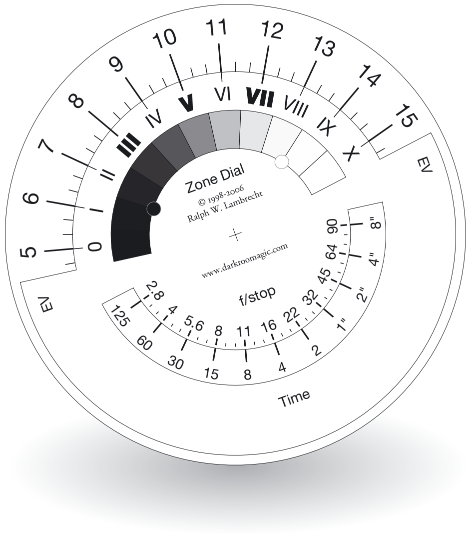


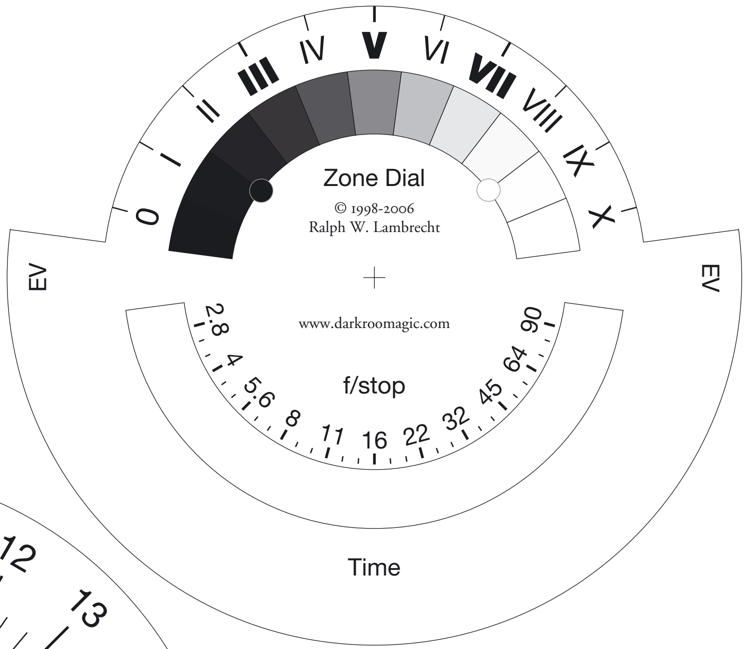
fig.15 View camera users copy the target (top) and the two rulers (below) onto separate pieces of heavy paper stock. Assemble the rulers back-to-back, and laminate each piece with clear tape to make a more durable tool. For close-up photography, place the target into the scene, and measure the diameter of the outer circle on the view screen with the bottom ruler. Determine subject magnification and f/stop correction to adjust exposure by opening lens aperture or extend shutter exposure. The inner circle, in combination with the top ruler, is provided for extreme close-up photography.

(do not change the scale of these templates)

The Zone Dial



Zone Dial assembled
(reduced view)



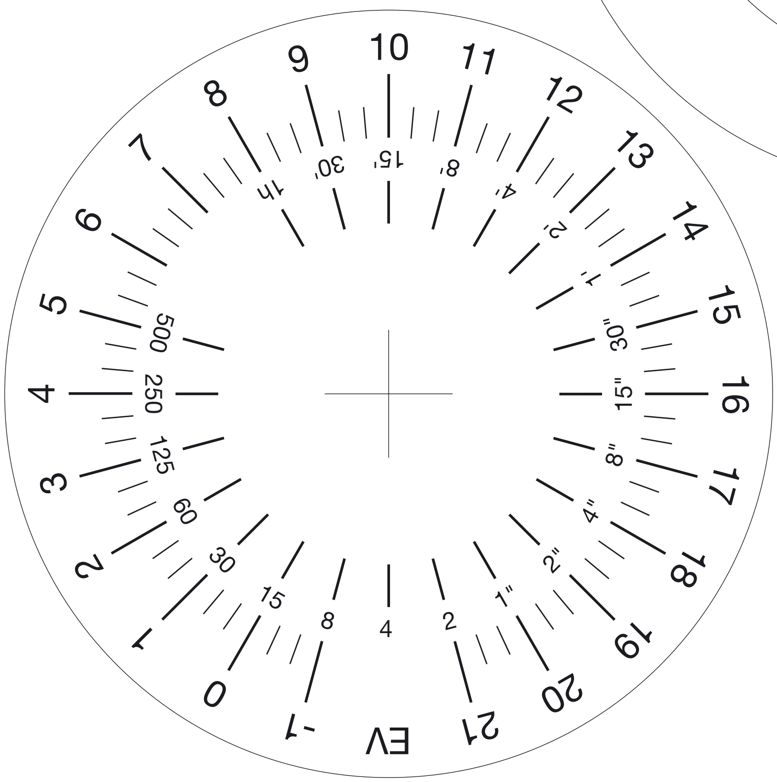


fig.16 The Zone Dial provides a visual reference to the way subject brightness will be represented in the final print. Zone III and VII are marked to place shadow and highlight details, and the tonality extremes of Zone I•5 and VIII•5 are identified as black and white points. All scales are in standard shutter speeds, f/stops and EVs. Meter the subject values in EVs, and correlate them to the intended Zones on the dial. This will give you an overview of the subject brightness range and several exposure recommendations. However, potential reciprocity failure has not been accounted for.

Exposure, Development and Printing Record

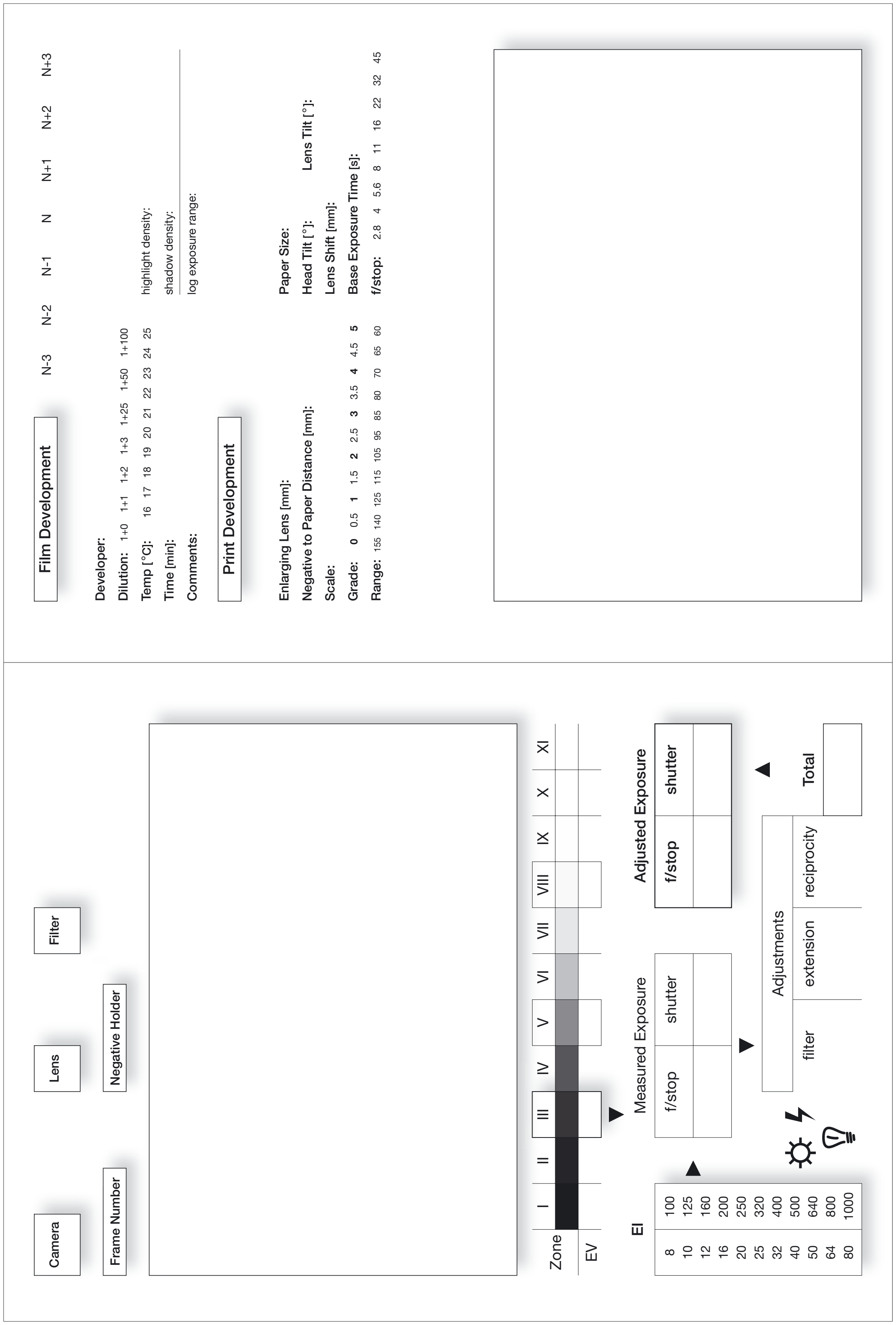
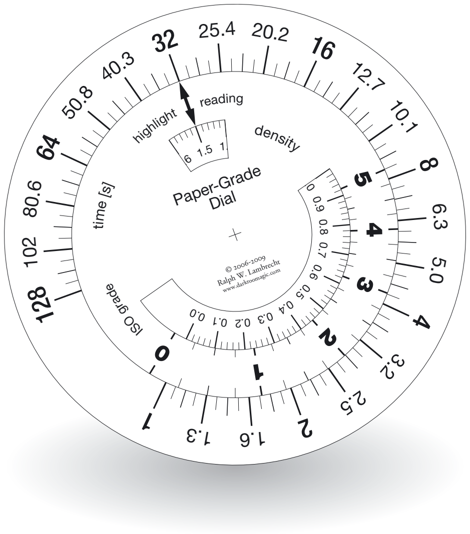
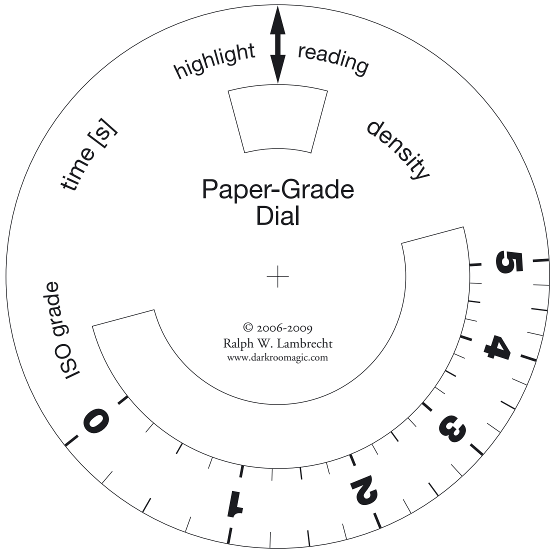


fig.17 Keeping accurate exposure and printing records are bureaucratic tasks many photographers avoid due to the initial workload required to obtain them. They do, however, provide significant clues to the 'things gone wrong' and allow for a certain repeatability of the overall photographic process. In 'Exposure, Development and Printing Records', we explained how to take them. This template provides the means to keep them.



Paper-Grade Dial assembled
(reduced view)



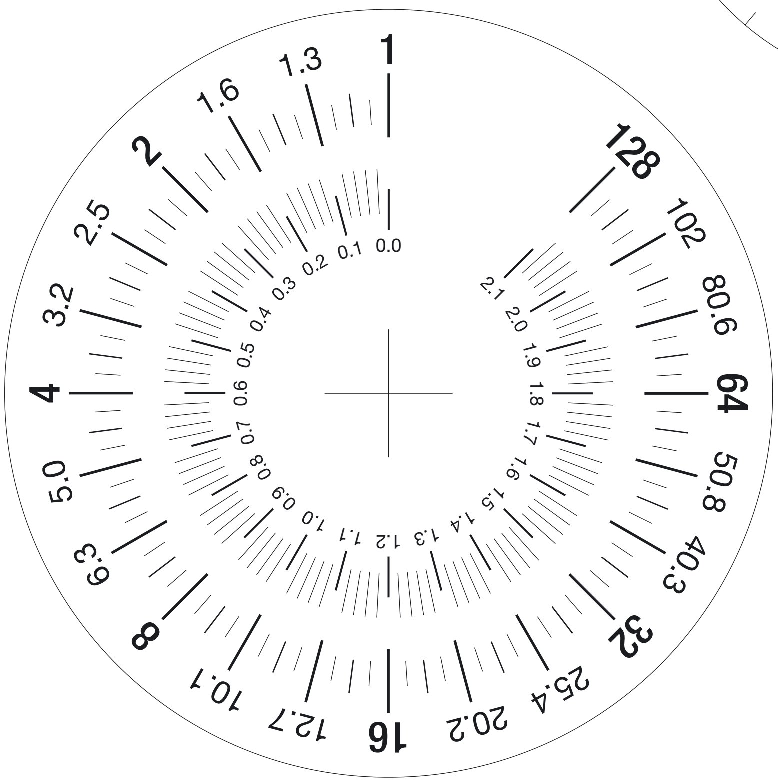
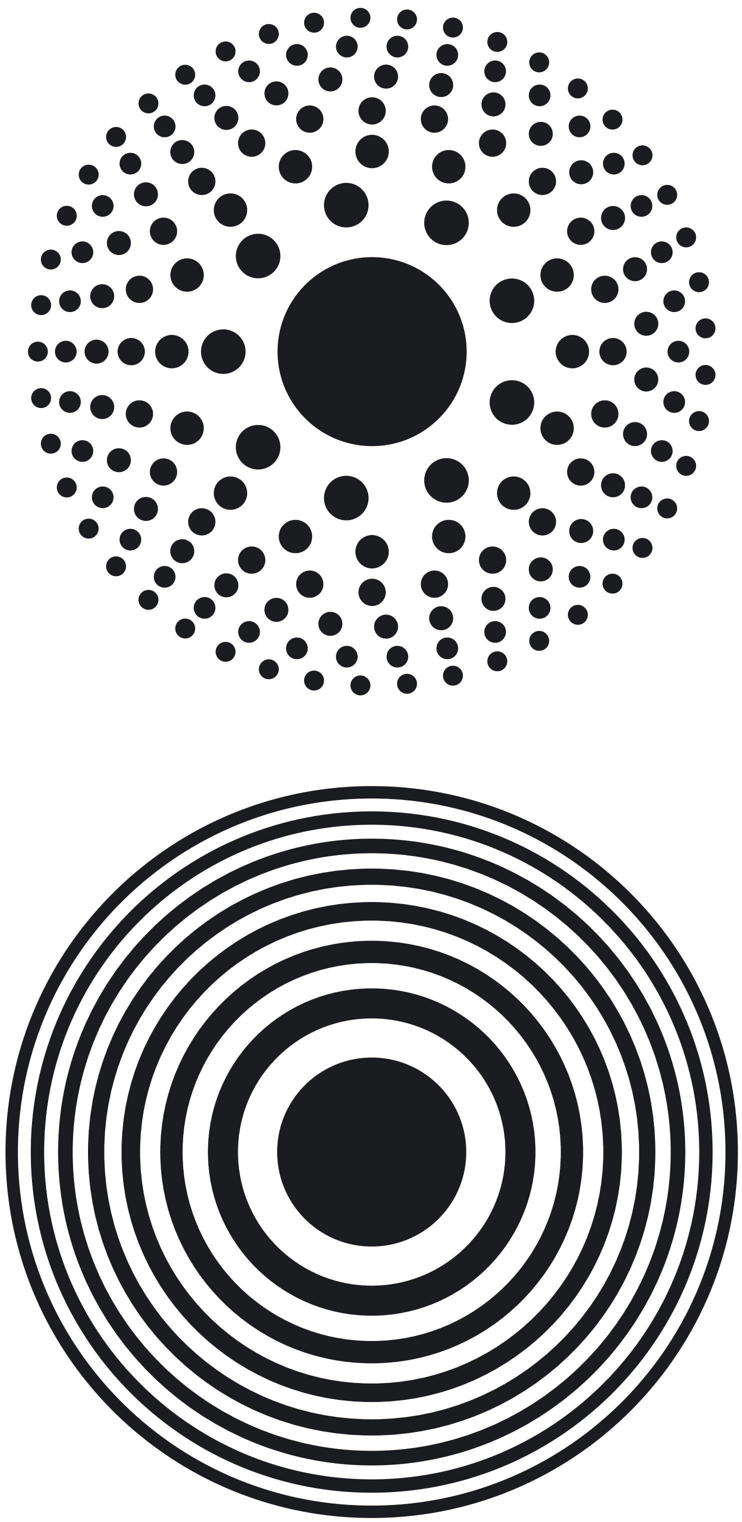


fig.18 The Paper-Grade Dial provides a simple method to calculate the overall paper contrast required to transfer the negative density range to the print density range. Using a densitometer or a simple enlarger meter, take a textural highlight reading and set the negative density or measured exposure time on the dial. Then, take a textural shadow reading, and next to its location on the dial, read off the required ISO paper grade to capture the entire textural negative density range on paper.

Pinhole and Zone Plate Pattern

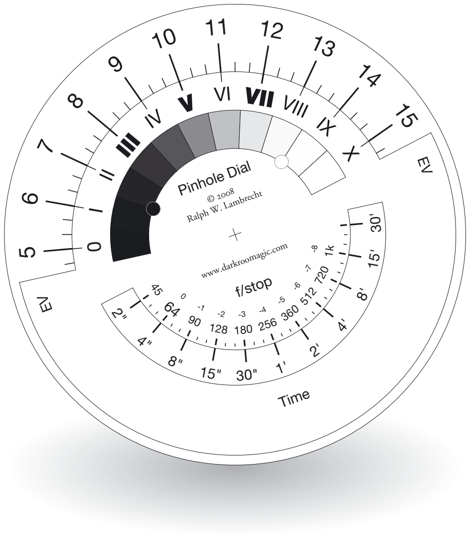


$$u = \frac{f}{m} + f$$

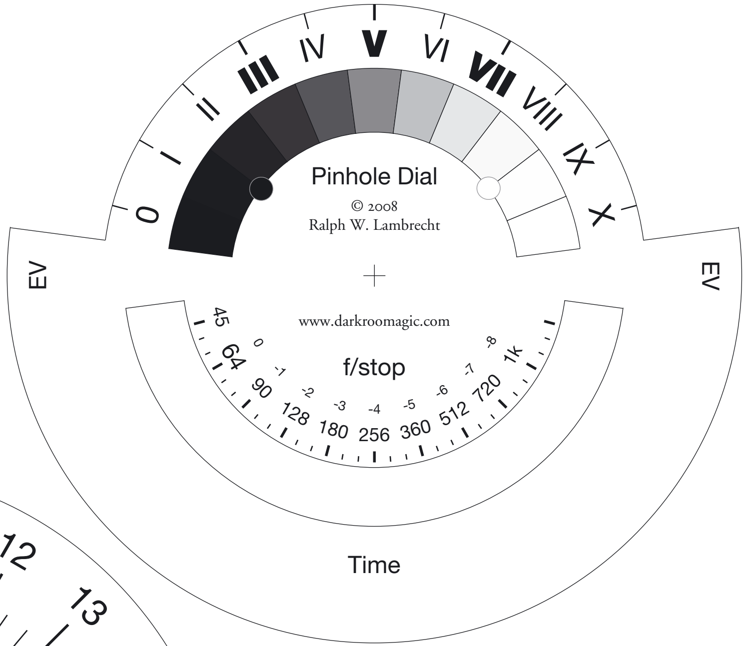
$$a = \frac{f \cdot (m+1)^2}{m}$$

fig.19 Photon sieves (top) and diffraction zone plates (bottom) are worthwhile alternatives to plain pinholes, but they cannot be cut or drilled like a simple hole. The best way of making them is to take an enlarged, tone-reversed design and photograph it onto high-contrast B&W film thus reducing it to the desired size. The two designs shown here have a center pinhole diameter of 25 mm. Using the equations above, photograph these designs with a focal length (f) from a lens-to-design distance (u), or a film-to-design distance (a), in order to reduce the patterns by a known magnification (m), and create the required size on transparent film.

The Pinhole Dial



Pinhole Dial assembled
(reduced view)



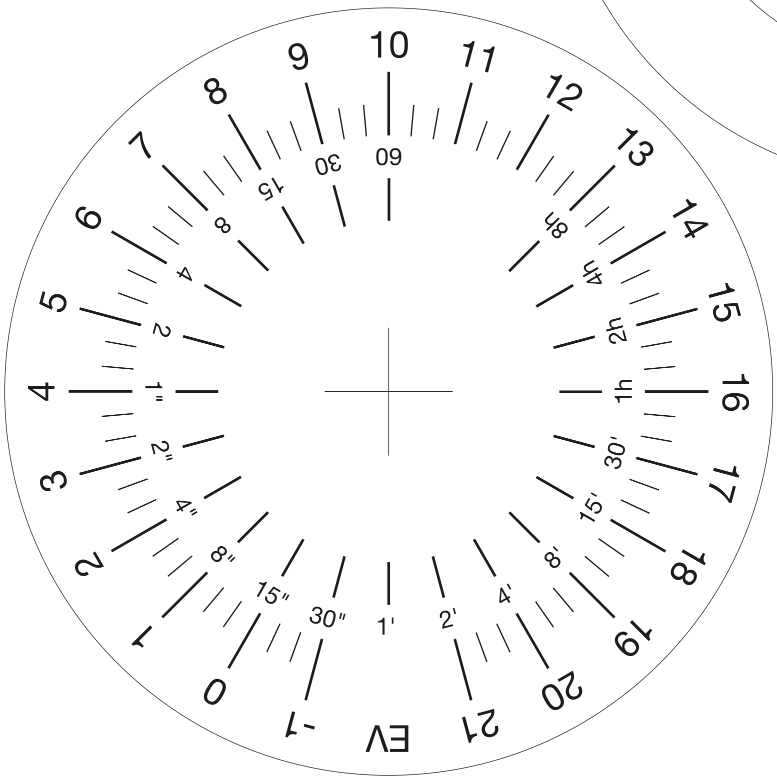


fig.20 The Pinhole Dial provides a visual reference to the way subject brightness will be represented in the pinhole print. Zone III and VII are marked to place shadow and highlight details, and the tonality extremes of Zone I•5 and VIII•5 are identified as black and white points. All scales are in standard shutter speeds, f/stops and EVs. Meter the subject values in EVs, and correlate them to the intended Zones on the dial. This will give you an overview of the subject brightness range and several exposure recommendations. However, potential reciprocity failure has not been accounted for.

Drawing for Laser-Jig Housing

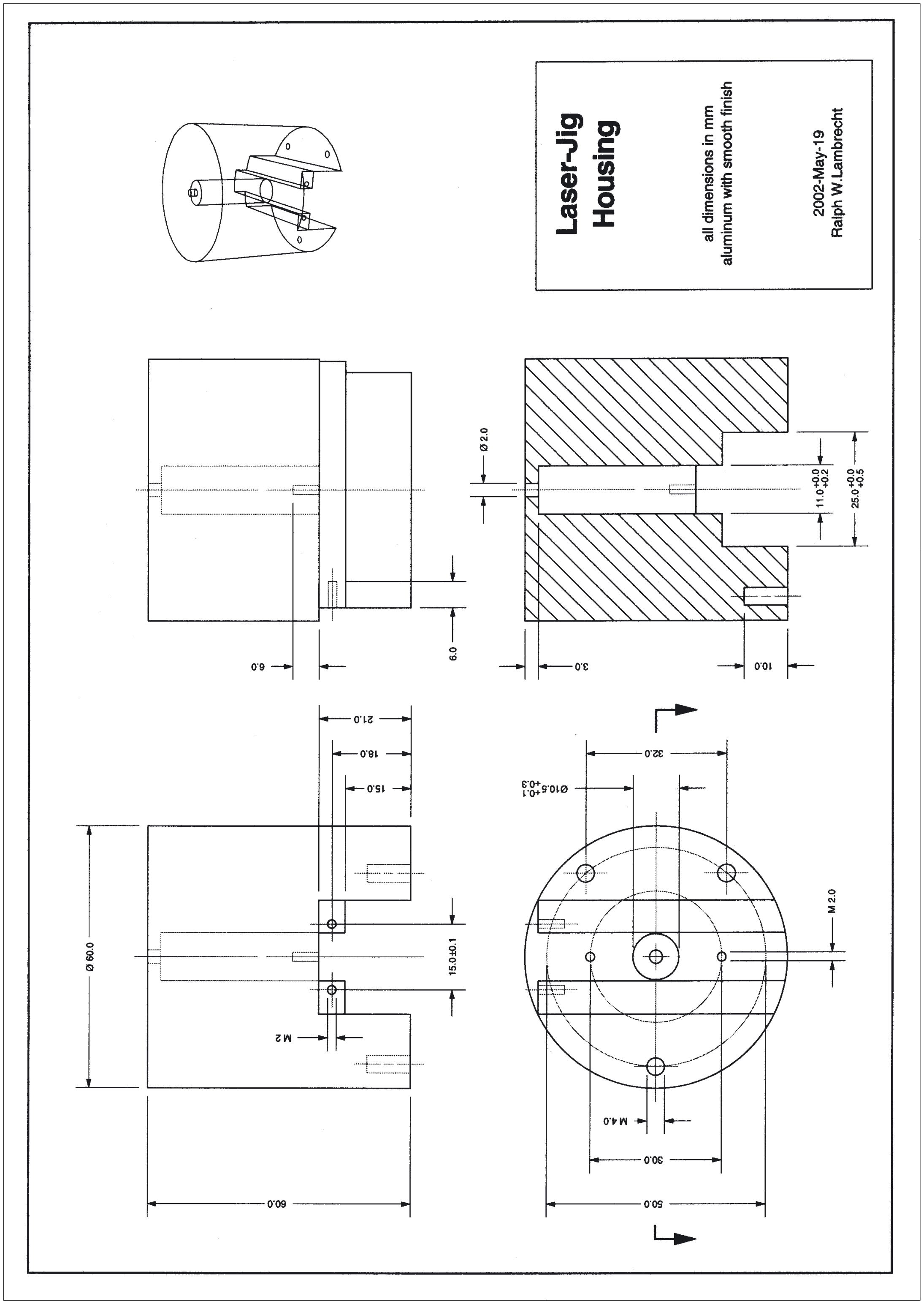


fig.21 With some ingenuity and help from a local machine shop, a do-it-yourself laser-alignment tool is brought from concept to reality. Three adjustable screws level the unit and align the laser module until it projects a perfectly vertical laser beam.

Transfer Functions

input	target density curve 'alt-a'	output at
0%	0.05	
5%	0.09	
10%	0.14	
20%	0.23	
30%	0.32	
40%	0.42	
50%	0.53	
60%	0.65	
70%	0.81	
80%	1.00	
85%	1.13	
90%	1.27	
95%	1.44	
98%	1.56	
100%	1.65	

input	target density curve '2.2a'	output at
0%	0.05	
5%	0.11	
10%	0.16	
20%	0.27	
30%	0.38	
40%	0.51	
50%	0.66	
60%	0.83	
70%	1.04	
80%	1.30	
85%	1.45	
90%	1.63	
95%	1.84	
98%	1.99	
100%	2.10	

input	target density curve '2.2c'	output at
0%	0.05	
5%	0.11	
10%	0.16	
20%	0.27	
30%	0.38	
40%	0.49	
50%	0.62	
60%	0.77	
70%	0.96	
80%	1.20	
85%	1.36	
90%	1.55	
95%	1.79	
98%	1.96	
100%	2.10	

fig.22 The purpose of a transfer function is to bring the subjective tone-reproduction cycle full circle, and as closely as possible match the final print to the on-screen image. To do so, a transfer function must correct for the differences between the actual and the desired process characteristics, thereby achieving a chosen rendering intent. Templates for three different rendering intents and their target density values are provided here. The first template makes use of a target density curve called 'alt-a' (top), which is a rendering intent designed for matte papers with a maximum density around 1.65. The other two templates are for papers with glossy or pearl surfaces and maximum densities of around 2.1. The target density curve '2.2a' (bottom left) is designed for normal processing with normal shadow detail, followed by moderate archival toning. Target density curve '2.2c' (bottom right) compensates for heavy toning or provides emphasized shadow detail. Once collected, the input and output values are entered into the 'Curves' adjustment dialog box of your photo editing software and saved as a transfer function for future use.