Base and fog densities of fresh Ektaspeed Plus dental X-ray films

Ib Paul Sewerin

Department of Radiology, School of Dentistry, Faculty of Health Sciences, University of Copenhagen, Copenhagen, Denmark

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Previous findings with regard to base and fog density of Ektaspeed Plus dental X-ray films have shown increased values compared with Ektaspeed and Ultra-Speed films, but the results are contradictory. The purpose of the present study was to measure base density, using 10 different fixing solutions, and fog density, using 10 different developing solutions at temperatures varying from 16 to 30 °C. The 10 developers tested were intended for manual (three), semiautomatic (three), and automatic (four) processing. Base densities were nearly identical for all fixing products (range, 0.190–0.192). One group of six developers showed quite stable fog values for all temperatures (range, 0.190–0.259), whereas another group (four developers) showed increased values at increasing temperatures (range, 0.395–0.438 at 30 °C). It is concluded that base density is within the limits of ISO standards for most fixing products but that some developers result in fog densities that are above ISO standard limits at high temperatures. □ *Radiography, dental; technology, radiologic; X-ray film*

Ib Sewerin, Department of Radiology, School of Dentistry, 20 Nørre Allé, DK-2200 Copenhagen, Denmark

The base and fog density of dental X-ray films influences image contrast. Several studies have shown that Ektaspeed film (Kodak, France), belonging to speed group E, which was introduced in the 1980s, had a higher base and fog density than its predecessor, Ultra-Speed film, belonging to speed group D (Table 1).

Ektaspeed Plus film, which was introduced in 1994 to replace Ektaspeed film, had an even higher base and fog density (Table 1). However, previous experiments were carried out at different processing temperatures, and different developing solutions were used, and the influence of these factors has not been considered.

The density values listed in Table 1 vary up to 0.10 for D-speed films and 0.12 for E-speed films. Not included in Table 1 are the findings of Nesbit et al. (12), as they did not present exact values in their article. However, from their figures it can be read that they found base and fog densities of approximately 0.26–0.29 for D-speed films and of approximately 0.31 for E-speed films; these values are higher than all other values in Table 1. Also not included are the results of Geist & Gleason (13), who compared automatic developing with rapid developing. From their Fig. 1 it can be deduced that they found fog and density values of only approximately 0.14 for D-speed film, which is an extremely low value.

The purpose of the present study was to measure the base densities of Ektaspeed Plus dental X-ray films, using different products of fixing agents, and the base and fog densities, using different processing solutions and various processing temperatures.

Materials and methods

The investigation comprised 10 samples of processing products (Table 2). Three developing solutions were intended for manual, three for semiautomatic, and four for automatic processing. The solutions were tested at 16, 18, 20, 22, 24, 26, 28, and 30 °C. The processing times used were those recommended by the manufacturers. For two of the solutions for manual processing (Scanfors Uniset and Kodak Manual) developing times were adjusted by 27.5 sec for each degree deviating from 20 °C. For Kodak Monobath the developing time was adjusted by 10 sec for deviations of 1° from 20 °C. Uniform developing temperatures were provided with a Hetofrig thermal bath CB 11 (Heto Lab Equipment A/S, Birkerød, Denmark).

Developing in solutions intended for semiautomatic and automatic machines was carried out manually. When developing in solutions intended for Procomat and Periomat machines actual developing times of 65 and 90 sec were used for each machine. In solutions for automatic machines a developing time of 65 sec was used, in accordance with the actual time spent in the solution in, for example, an AC-245 machine (Dürr Dental, Germany). For all films intermediate rinsing was performed for 20 sec. Fixing times for manual development were standard times recommended by the manufacturers, and fixing times for semiautomatic and automatic machines were the times actually used in the machine.

The solutions were used in quanta of 500 ml, and they were kept in plastic boxes with tightly fitting locks (14). At the beginning of the experiments fresh solutions were prepared, and all experiments were completed within 8 days. Three test films were developed in each solution and at each temperature, so that the total number of films developed in each solution was 24. The experiments were carried out in March 1996. Films with identical batch numbers were used. Expiry month

Table 1. Base and fog densities (D-values) for Kodak Ultra-Speed, Ektaspeed, and Ektaspeed Plus films found in previous studies. For each set of values the processing method and the processing temperature are indicated

Author	Film type			Method	Temperature, °C
	Ultra-Speed	Ektaspeed	Ektaspeed Plus		
Diehl et al., 1986 (1)	0.18–0.20	0.25–0.28	—	Autom + Manual	
Serman et al., 1987 (2)	0.12–0.17	0.21–0.26	—	Autom.	?
Petersson et al., 1987 (3)	0.18	0.21	—	Manual	20
Hashimoto et al., 1991 (4)	0.19	0.23	—	Manual	21
Svenson & Petersson, 1993 (5)	0.15	0.20	—	Autom.	?
Svenson et al., 1993 (6)	0.22	0.26	—	Autom.	26
Price, 1995 (7)	0.18	0.20	0.24	Autom.	28
Conover et al., 1995 (8)	0.15	0.16	0.20	Autom.	32
Ludlow & Platin, 1995 (9)	0.19	0.22	0.25	Autom.	28
Thunthy & Weinberg, 1995 (10)	0.19	0.20	0.22	Autom.	28
Helmrot, 1996 (11)	0.19	0.22	—	Autom.	26

was December 1997; that is, at the time of the experiments films were 21 months from expiry time.

Before the experiments the darkroom light was tested with the 'coin test'. Five films were left unwrapped for 2 and 4 min, respectively, in the darkroom and thereafter developed. In no case did the densities in uncovered areas surpass those of the central, covered area.

D-values were measured with a Macbeth TD 502 densitometer with a reading area of 3 mm. Five measurements were made on each film, in the upper and lower, right and left corners and in the central part. As three films were developed at each temperature and in each solution, D-values were calculated as the average of 15 measurements.

Results

D-values for undeveloped films—that is, base density—were nearly identical irrespective of fixing solution used and varied between 0.190 and 0.192.

Fig. 1 shows the D-values for base and fog after developing in the three solutions for manual processing at temperatures from 16 to 30 °C. The values for Scanfors Uniset and Kodak Manual only varied between 0.210 and 0.222. For Kodak Monobath slightly increased values were found at 16–22 °C, but at temperatures above 22 °C density increased, and at 30 °C a maximum D-value of 0.405 was reached.

Densities for solutions for semiautomatic machines are shown in Fig. 2. The lowest values and the most stable densities throughout the whole temperature scale were found for Adefo Procomat (range, 0.190–0.221). Dürr Periomat showed slightly increased values at lower temperatures, and at 30 °C a maximum value of 0.259 was seen. For Scanfors Procomat increased values at 26–30 °C, with a maximum value of 0.395 at 30 °C, were observed.

In the group of solutions intended for automatic processing (Fig. 3) very stable D-values were found for Kodak Readymatic and Dürr XR-24 solutions. For Dürr XR-24 the values varied between 0.205 and 0.231. However, for Adefo Polvoroll and Fuji RD-90 solutions increased values were observed already at temperatures of 22 and 24 °C, and at 30 °C they amounted to 0.387 and 0.438, respectively.

Discussion

The base densities were nearly identical for all products, but the base density of modern Kodak Ektaspeed Plus film seems to be higher than in previous types. In 1970 Smith (15) measured a base density of only 0.09 for Kodak Morlite (fast) films.

Table 2. List of the processing products studied and developing and fixing times used for each product

Product	Developing time	Fixing time
Manual developing		
Uniset 140 developer 302 (Scanfors, Denmark)	300 sec	300 sec
Dental Manual developer (Kodak, France)	300 sec	300 sec
Dental Monobath (Kodak, France)	240 sec	—
Semiautomatic developing		
Procomat developer 322 (Scanfors, Denmark)	65 sec	85 sec
Periomat developer (Dürr Dental, Germany)	90 sec	85 sec
Procomat developer (Adefo-Chemie, Germany	65 sec	85 sec
Automatic developing		
Readymatic (Kodak, France)	65 sec	90 sec
XR-24 (Dürr Dental, Germany)	65 sec	90 sec
Polvoroll (Adefo-Chemie, Germany)	65 sec	90 sec
RD-90 (Fuji Photo Film, Japan)	65 sec	90 sec

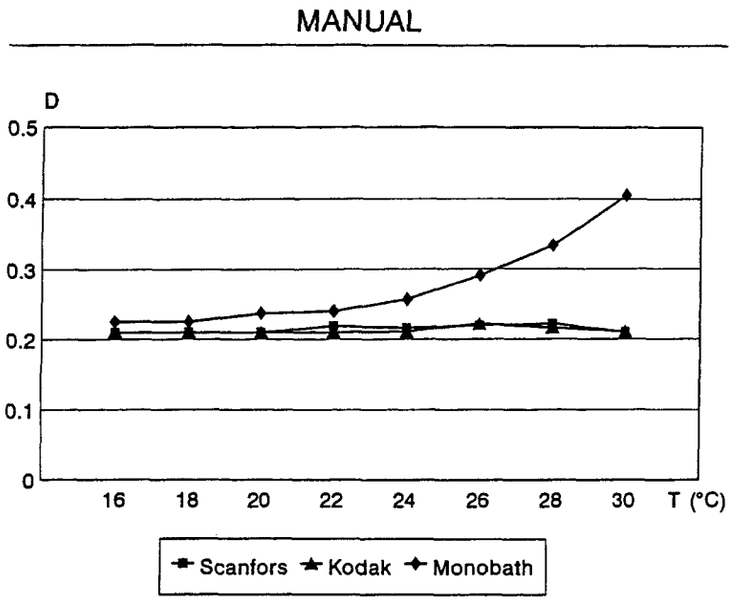

Fig. 1. Base and fog densities of Ektaspeed Plus dental X-ray films for three products intended for manual processing at temperatures from 16 to 30 °C. Scanfors = Scanfors Uniset (Scanfors, Denmark), Kodak = Kodak Manual (Kodak, France), and Monobath = Kodak Monobath (Kodak, France).

All developing solution products (except Monobath) showed very similar base and fog D-values at temperatures below 22 °C (range, 0.200–0.227 D). The difference between the average D-values for undeveloped films and the minimum and maximum values for developed films at 20 °C (= fog density) was only 0.008 and 0.036. At 30 °C, however, a much wider range was observed (0.211–0.438). One group of

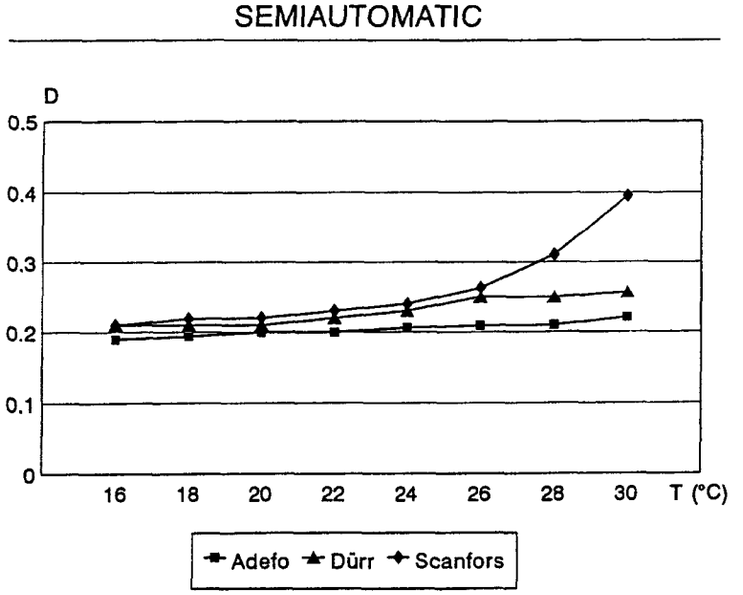

Fig. 2. Base and fog densities of Ektaspeed Plus dental X-ray films for three products intended for semiautomatic processing at temperatures from 16 to 30 °C. Adefo = Adefo Procomat (Adefo-Chemie, Germany), Dürr = Dürr Periomat (Dürr Dental, Germany), and Scanfors = Scanfors Procomat (Scanfors, Denmark).

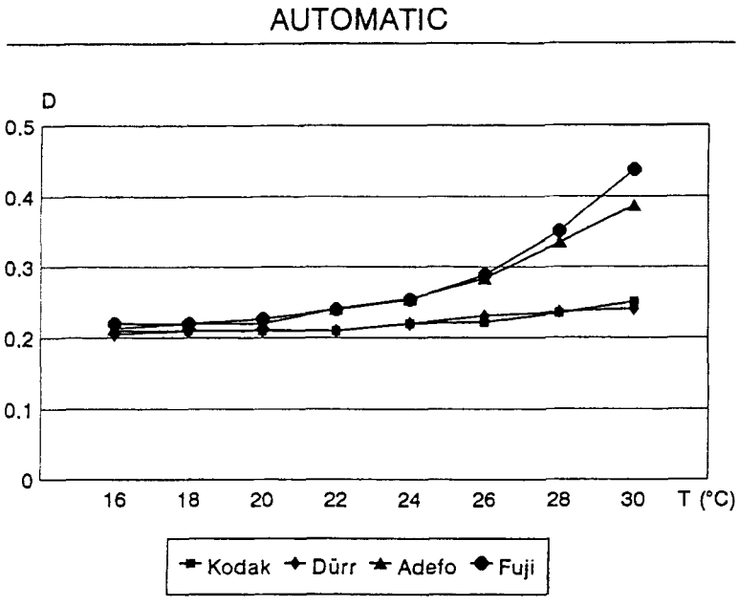

Fig. 3. Base and fog densities of Ektaspeed dental X-ray films for four products intended for automatic processing at temperatures from 16 to 30 °C. Kodak = Kodak Readymatic (Kodak, France), Dürr = Dürr XR-24 (Dürr Dental, Germany), Adefo = Adefo Polvoroll (Adefo-Chemie, Germany), and Fuji = Fuji RD-90 (Fuji Photo Film, Japan).

products (Scanfors Uniset, Kodak Manual, Adefo Procomat, Dürr Periomat, Kodak Readymatic, and Dürr XR-24) was very stable and only showed a moderate increase in density even at 30 °C. Another group (Kodak Monobath, Scanfors Procomat, Adefo Polvoroll, and Fuji RD-90) was highly sensitive to increased temperatures.

The fog densities at raised temperatures for the three solutions intended for manual processing may have been influenced by the reduced effect of the developer as developing times were shortened. However, it was found most appropriate to keep the actual developing times constant throughout the experiment.

When earlier findings (Table 1) are compared, base and fog densities vary considerably both for Ektaspeed Plus and for Ektaspeed and Ultra-Speed. It is not possible to see any correlation with developing temperatures. Conover et al. (8) measured a base and fog density of only 0.20 at 32 °C. However, it is well known that base and fog densities vary with different developer products (16, 17). Kaffe et al. (18) studied the base and fog densities of Kodak Ultra-Speed films after developing in five different solution products and found a variation from 0.16 to 0.24 even at 20 °C.

The different findings for the same film type in previous studies may also be explained by differences in the validity of the densitometers used. No previous authors have commented on this effect. The present measurements were carried out at the Danish State Institute of Radiation Protection, which takes care of all supervised workers in Denmark being exposed to ionizing radiation. The densitometer of the Institute is regularly calibrated and is expected to be very reliable.

According to ISO Standards (19), the base density of intraoral radiographic films should not exceed 0.20, and the fog density should not exceed 0.15 above base density. For the Ektaspeed Plus film base density was within this limit for all products tested in the present investigation, but fog densities were above the limit for four products tested. The present results were obtained for fresh films. As fogging increases gradually during storage, this limit may be reached for other products before expiration date.

The present investigation does not tell us anything about image density. The use of developing solutions intended for automatic processing will probably result in underdevelopment if used at temperatures below 26–28 °C. But certain products intended for manual processing will produce an increased fog density when used at high temperatures and should be avoided in hot periods. And certain products even result in unacceptable fog densities at normal working temperatures for automatic processing.

Still unanswered is the question, what are the diagnostic consequences of increased base and fog? Svenson et al. (20) studied the influence on the accuracy of approximal carious lesions and found no difference, even if base and fog density was as high as 0.6.

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