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UNINTENDED HYGROSCOPIC EXPANSION OF DENTAL STONE AND INVESTMENT

by

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It is well known that the setting expansion of gypsum materials is increased when the setting takes place under water. This additional expansion is called hygroscopic expansion[1]). The purpose of the present study was to investigate whether hygroscopic expansion occurs when a sample of setting gypsum material is brought into contact with a freshly mixed sample, as it is in practice when a base is cast on a stone or plaster model, and in double investment technique. As far as is known, this question has not been investigated so far.

METHODS

The arrangement used for measuring the expansion is shown diagrammatically in Fig. 1. The measuring instrument was a dial gauge[2]) attached to a rigid frame. The test specimen was placed in a flat-bottomed glass dish standing on the plate on the frame base. The lower end of the vertically movable dial gauge rod was provided with a brass plate, which was parallel to the flat plate on the frame base. The brass plate was 20 mm in diameter. The

[1]) Regarding hygroscopic expansion the reader is referred to *Knud Dreyer Jørgensen*, 1960: The Hygroscopic Setting Expansion of Gypsum. Acta odont. scand. *18:* 461—477.

[2]) Made by Carl Mahr, Germany.

pressure of the dial gauge was 75 ± 5 grams. A complete turn of the dial gauge pointer corresponded to a vertical movement of the rod of 1.000 mm. The circular scale on the dial was divided into 100 intervals, so that the distance between two graduation marks corresponded to a movement of 0.01 mm. As the marks were

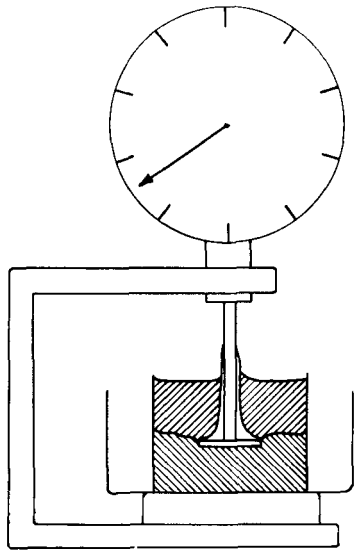

Fig. 1. Diagram of experimental arrangement for measuring setting expansion.

widely spaced as compared to the width of the pointer, it was possible to read movements of 0.002 mm with certainty, and movements of 0.001 mm with approximate accuracy. According to the manufacturer the measuring accuracy was greater than the reading accuracy.

All the experiments were carried out at temperatures of 23°—26° C, and the procedure was as follows: The upper part of the brass plate and the lower part of the dial gauge rod were carefully coated with vaseline. Fifty grams of dental stone or investment were mixed with the proper proportion of distilled water. After 60 seconds' spatulation the mixture was poured into a cylinder of thin, only slightly hygroscopic paper, standing in the flat-bottomed glass dish. The paper cylinder, which was 4 cm high and 4.6 cm in diameter, was now about half filled. The glass

dish was then placed on the plate on the dial gauge frame. The dial gauge was lowered until the brass plate was in close contact with the surface of the mix. As soon as the setting mass was barely able to support the dial gauge pressure, the dial gauge was moved some way farther down. Thereby the vertical rod was lifted, and the pointer travelled forward on the scale. A deflection of about one turn was intended. By means of a screw the dial gauge was held in this position, and the movement of the pointer was observed. During the first 30—60 seconds the pointer moved slightly backward, indicating penetration of the brass plate into the mass. Then it stopped for a moment, after which it moved forward — the expansion had started. Readings were now taken at regular intervals during the two hours of the experiment.

At a predetermined time during the experiment a freshly mixed sample of stone or investment, of the same size as the initial mixture, was gently vibrated down on top of the first sample with a spatula, so that the upper half of the paper cylinder became filled up. At the end of the experiment the test specimen

Table 1

Expansion of EPI Dental Stone® (W/P ratio 17 g/50 g).

Measurement No.	1	2	3	4	Average
	%	%	%	%	%
Setting expansion in air	0.48	0.45	0.48	0.43	0.46
Maximum hygroscopic expansion	1.27	1.23	1.43		1.31
Addition of 2nd sample after min.					
5	0.91	0.87	0.88		0.89
6	1.05	0.96	1.01		1.01
7	0.98	1.01	0.98		0.99
8	0.85	0.91	0.90		0.89
9	0.85	0.93	0.90		0.89
10	0.87	0.77			0.82
12	0.67	0.71			0.69
14	0.61	0.60	0.65		0.62
16	0.56	0.57	0.58		0.57
18	0.56	0.55			0.56
20	0.60	0.52			0.56
28	0.56	0.57			0.56

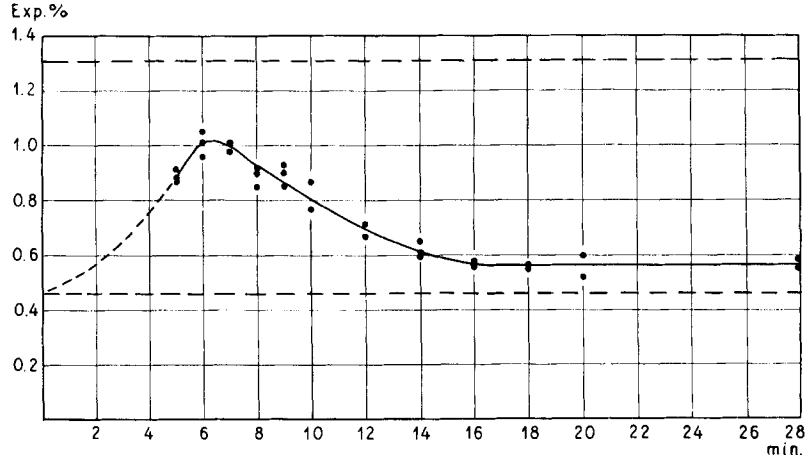

Fig. 2. Setting expansion versus time. The abscissa values give the number of minutes elapsed from start of mixing the first sample of stone to the addition of the freshly mixed stone. The lower dotted line shows the setting expansion in air, the upper dotted line shows the maximum hygroscopic expansion.

was removed from the dial gauge by unscrewing the brass plate embedded in the gypsum mass. By means of a hammer and a sharp knife the two gypsum layers were separated. The length (L_e) of the test specimen, i.e. the distance from the bottom to the impression of the brass plate, was measured with a sliding caliper after the raised rim of gypsum had been cut off. The original length (L_0) of the test specimen was found by subtracting the expansion from L_e, and the expansion was calculated in per cent of L_0.

RESULTS

Expansion tests made on EPI Dental Stone ®

First the setting expansion in air and the maximum hygroscopic expansion were determined. Then three experiments followed, in which the freshly mixed stone was added 5 minutes after start of mixing the first sample. In supplementary experiments the fresh mix was added after 6 min., 7 min., etc. The results appear in Table I and in Fig. 2.

The findings show that in all the cases addition of freshly mixed stone gave a higher expansion than setting in air. The effect of the added stone was greatest for addition 6—7 minutes after start of mixing the first sample. This time is approximately coinciding with the stage at which the first sample was beginning to imbibe water. Obviously, the expansion value for addition at the time zero (0) must be equal to the setting expansion in air. As the curve slope in the interval 5—6 minutes is known too, it must be warrantable to plot the curve segment from 0—5 minutes, as shown in Fig. 2.

It was then examined whether the expansion would become still greater if the second mixture was twice the amount of the first one. Such was not the case. The percentage expansion in these tests was the same as found in the first experimental series for addition at the same time. If, on the other hand, the added sample was only half as large as the initial mixture, a slight decrease in the total setting expansion was observed (Table II).

Table II

Expansion of EPI® with varying ratio between the first and the second samples.

Ratio	first sample, 35 g sec. sample, 65 g	first sample, 65 g sec. sample, 35 g
Expansion	0.97 % 1.00 %	0.76 % 0.75 %

Test made on Duroterm Investment®.

In this case too, the setting expansion and the maximum hygroscopic expansion were determined first. In subsequent experiments the freshly mixed investment was added 5 minutes after start of mixing the initial sample, then experiments were carried out with addition of the second sample after 6, 7 and 8 minutes, respectively. In this experimental series too, the expansion was considerably increased (Table III).

CONCLUSIONS

It must be considered established that EPI Dental Stone® as well as Duroterm Investment® may show a pronounced hygro-

Table III

Expansion of Duroterm Investment® (W/P ratio 18 g/50 g).

Measurement No.	1	2	3	Average
	%	%	%	%
Setting expansion in air	1.05	1.09	1.07	1.07
Maximum hygroscopic expansion	3.74	3.69	3.71	3.71
Addition of 2nd sample after min.				
5	1.85	1.82	1.91	1.86
6	1.97	2.15	2.03	2.05
7	2.15	2.02	2.12	2.10
8	1.91	1.88	1.84	1.88

scopic expansion when allowed to absorb water from freshly mixed stone or investment during the setting period. Although the experimental investigation was concerned with EPI® and Duroterm® only, it is reasonable to conclude that the less the difference between normal setting expansion and maximum hygroscopic expansion of a given gypsum product, the less significant will be the drawbacks involved.

SUMMARY

The purpose of this work was to investigate whether hygroscopic expansion occurs if two samples of gypsum material, one in the process of setting, the other freshly mixed, are brought into contact with each other. This question is of practical interest, e.g. when a base is cast on a stone model, and in double investment techniques. The experimental arrangement is shown in Fig. 1. The expansion of EPI Dental Stone® appears in Tables I—II and in Fig. 2. The results for Duroterm Investment® are given in Table III.

The findings show that a considerable increase in expansion occurred of the dental stone and investment tested in these experiments, and that this increase depends upon the time at which the freshly mixed sample is added.

RÉSUMÉ

EXPANSION HYGROSCOPIQUE ININTENTIONNELLE DANS LE PLÂTRE PIERRE ET LE REVÊTEMENT

Le but de ce travail est d'examiner s'il se produit une expansion hygroscopique lorsque, pendant la prise, du plâtre ou du revêtement entre en contact avec du plâtre frais gâché ou du revêtement fraîchement mélangé. Cette question présente un intérêt pratique lors de la coulée d'une base sur modèle de plâtre pierre ou dans la technique de mise en revêtement avec noyau central. La disposition de l'essai est montrée sur la figure 1. L'expansion trouvée pour le plâtre pierre EPI résulte des tables I et II et de la figure 2. Les résultats pour le revêtement Duroterm sont présentés sur la table III. On voit qu'il se produit une augmentation considérable de l'expansion et que cette expansion dépend du moment où le plâtre frais gâché ou la masse de revêtement nouvellement mélangé sont ajoutés.

ZUSAMMENFASSUNG

UNBEABSICHTIGTE HYGROSKOPISCHE EXPANSION VON GIPS UND EINBETTUNGSMASSE

Zweck dieser Arbeit war zu untersuchen ob hygroskopische Expansion vorkommt, wenn Gips oder Einbettungsmasse während des Abbindens in Verbindung mit frisch angerührtem Gips oder Einbettungsmasse kommen. Diese Frage hat praktisches Interesse beim Giessen von Gipsmodellen und in Gusstechnik nach der Kerneinbettungsmethode. Die Versuchsaufstellung ist in Abb. 1 gezeigt. Die gefundene Expansion des Modellgipses EP1 geht aus die Tabellen I und II und aus Abb. 2 hervor. Die Ergebnisse für die Einbettungsmasse Duroterm sind in der Tabelle III angegeben. Es geht von diesen Messungen hervor, dass eine erhebliche Vergrösserung der Abbindeexpansion hervorgerufen wird, und dass diese Vergrösserung von dem Zeitpunkt abhängt, wo der frisch angerührte Gips bzw. Einbettungsmasse in Verbindung mit dem abbindenden Material kommt.