Measurement of Resistance of Amalgam Mixes to Condensation

H. OGURA, F. HADAVI[+#], and K. ASGAR[+]

Nippon Dental University, Niigata 951, Japan, and [+]The University of Michigan, School of Dentistry, Ann Arbor, Michigan 48109

A method was designed to evaluate the resistance of amalgam mixes to condensation forces. For the purpose of classification with respect to the plasticity of amalgam, the optimum test conditon was to apply 40 or 50 lb. of static load at 30 sec after trituration.

J Dent Res 62(8):930-932, August 1983

Introduction.

The plasticity of an amalgam mix has been characterized by the practitioner's feeling of its resistance to condensation. It is classified qualitatively either as soft and offering little resistance to condensation forces, or as hard and offering considerable resistance to condensation forces.

This phenomenon is different from the setting or hardening of amalgam, which has been studied in the past by several investigators.[1-4] In 1967, Mahler[5] published results of his study on the plasticity of amalgam mixes. Even though Mahler's method is capable of determining the plasticity of an amalgamated mass, it does not quantify resistance to condensation forces.

Recently, different types of high-copper alloys have been introduced to the dental profession. These alloys have various resistances to condensation. From a practical point of view, it is important to know the resistance to condensation forces, since the choice of condenser, as well as the magnitude of the force applied during condensation, is determined by the resistance that the amalgamated mass offers.

In this study, a device was developed which quantitatively measures the resistance to condensation forces, as well as the effects of some variables on plasticity of an amalgamated mix.

Materials and methods.

A special die was machined from stainless steel (Fig. 1). An amalgam mix was placed in the mold cavity 15 sec after trituration by means of a plunger, and a 12.7 Kg (28 lb) pre-condensation load was applied to the mix (Fig. 2). This load had been pre-determined to produce a flat surface and not to squeeze any mercury from the specimen. Within five sec, the pre-condensation load was removed from the specimen. A thinner plunger with a guide cap was substituted for the former plunger. A heavier static load was then applied to the prepared surface through the thinner plunger to generate the plastic deformation of the amalgam mix. This caused the extrusion of the amalgam mix into the space created between the split mold and the thinner plunger (Fig. 3). After the load had been applied for one min, the specimen was removed from the mold, and the height of the deformed amalgam, shaped like a crown, was measured. By means of a caliper, the height of each specimen was measured in three different parts of the cylinder, and those values were averaged to represent its resistance to condensation forces.

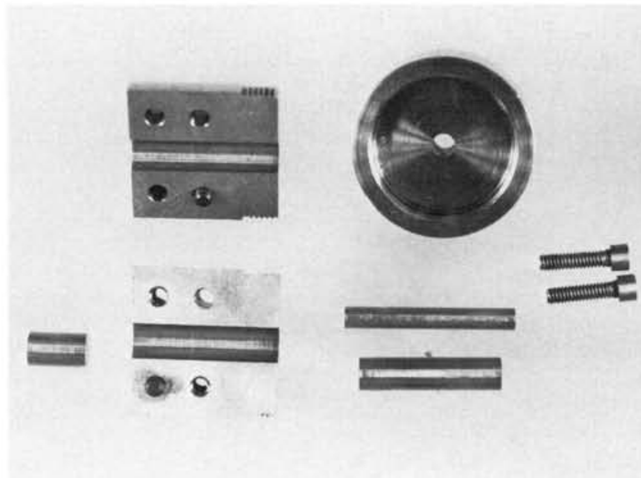

Fig. 1 – Stainless steel die.

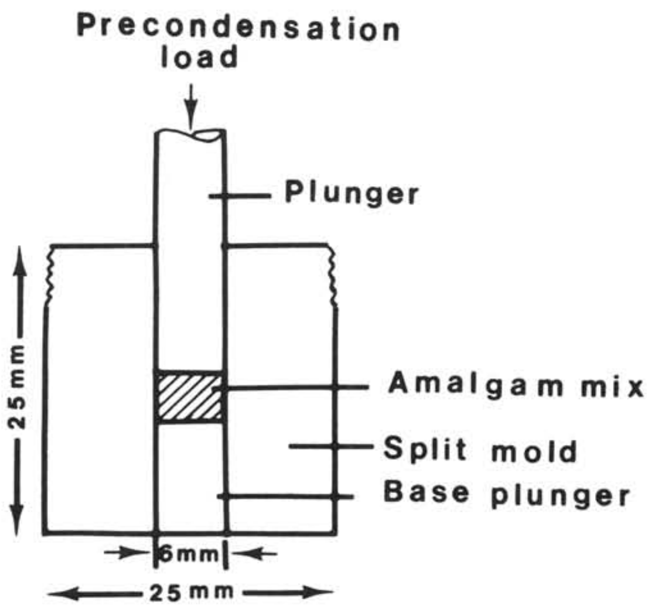

Fig. 2 – Application of pre-condensation load.

In order to investigate the effects of the load and the time at which the load is applied, three magnitudes of load –13.6, 18.2 and 22.7 Kg (30, 40, and 50 lb) – were used 30, 60, and 90 sec after trituration.

Three kinds of amalgam alloys*, which produced a soft, a medium, and a hard mix, respectively, were chosen from 12 commercial alloys by means of the feeling of

Received for publication November 5, 1982

Accepted for publication April 25, 1983

#Present address: The University of Saskatchewan, College of Dentistry, Saskatoon, Saskatchewan, Canada S7N 0W0

Request reprints from Dr. Asgar.

This investigation was presented at the 58th General Session of the International Association for Dental Research in Osaka, Japan, June, 1980.

*Tytin, S.S. White Company, Philadelphia, PA 19406

Dispersalloy, Johnson & Johnson Dental Products Company, East Windsor, NJ 08520

Velvalloy, S.S. White Company, Philadelphia, PA 19406

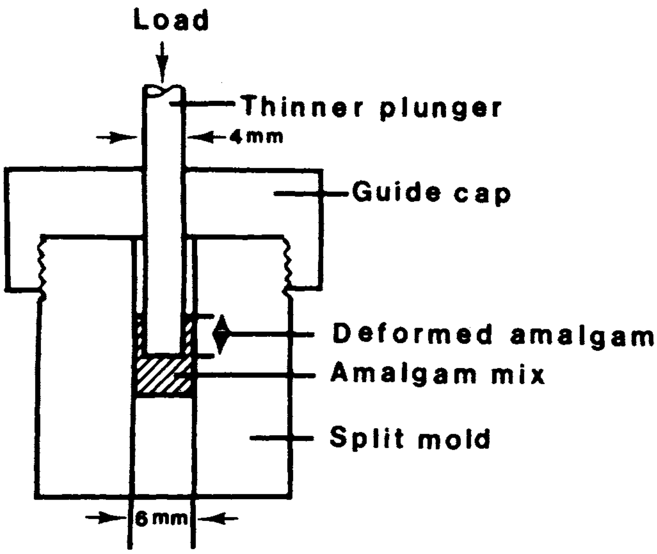

Fig. 3 – Plastic deformation of an amalgam mix.

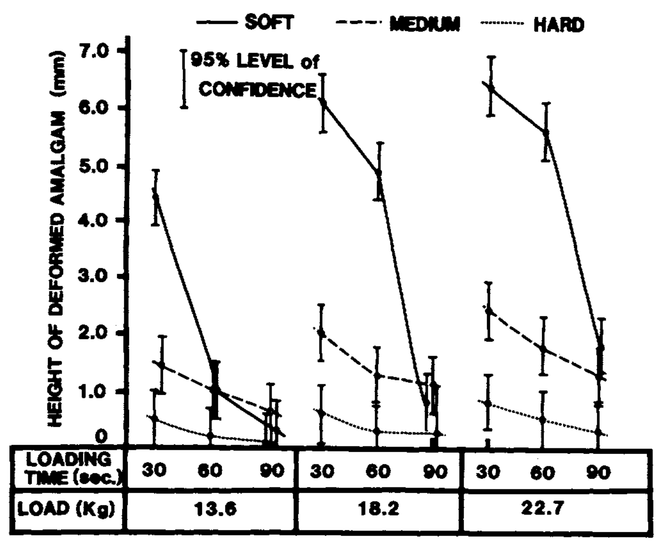

Fig. 4 – The change of plastic deformation with load and time for three amalgams.

resistance to condensation. Each amalgam mix was prepared according to the manufacturer's instructions. Since the mercury-to-alloy ratio differed with different alloys, various weights of mercury and alloy were employed to produce a 117 mm^3 amalgamated mass under the pre-condensation load (Table)

Three kinds of amalgam mixes (soft, medium, and hard) were tested in the aforementioned procedure with two variable factors – load and time at which the load was applied. Three replications were made for each combination of these test conditions. The data were collected and analyzed by means of a three-way analysis of variance[6], and the means were compared by Tukey's interval[7].

TABLE

Product	Type of Plasticity	Alloy, Hg (mg)
Tytin	Soft	665, 510
Dispersalloy	Medium	610, 610
Velvalloy	Hard	580, 580

Results.

This method enabled measurement to begin at less than 60 sec after trituration. It can easily be accomplished 30 sec after trituration.

The results of a three-way analysis of variance related to three factors – type of alloy, the magnitude of load, and the time of load application – showed that all factors and interactions were highly significant. Tukey's interval was calculated to be ±0.3 mm, using the mean square of the error obtained from the three-way analysis of variance.

The results are summarized in Fig. 4, which shows the change of plastic deformation of amalgam as influenced by the magnitude of the load and the time of load applications. As the load increased, or the time at which the load was applied decreased, the plastic deformation of the amalgam mass increased for each mix.

Significant differences among the three types of mixes were found for only five test conditions: 13.6 Kg-30 sec, 18.2 Kg-30 sec, 18.2 Kg-60 sec, 22.7 Kg-30 sec, and 22.7 Kg-60 sec. Using the method developed in this study, we determined that five test conditions were effective for the quantitative evaluation of plasticity.

Discussion.

A hand condenser is commonly used for clinical condensation of an amalgam mix. Condensation force is applied on a mix through the tip of the condenser. In response to force application, some amount of the mix flows toward the wall and the margin of a prepared cavity. The condenser penetrates the amalgam mix, causing extrusion of the mass around the condenser (Fig. 5). The device developed in this study simulated the mechanism of clinical condensation (Fig. 3). Therefore, the obtained results could reflect the practitioner's feeling of amalgam condensation.

A question may arise in a laboratory test, such as the one described, as to when the force should be applied and what its magnitude should be. Clinically, it has been considered that 3.5 min is the maximum desirable condensation time.[8] The greater portion of the condensation, however, is accomplished within 60 to 90 sec after trituration. For this reason the load was applied 30, 60, and 90 sec after trituration. The 30 sec could be appropriate to indicate the initial plasticity of an amalgam mix.

Since the diameter of a condenser tip ranges from 1.5 to 2.0 mm, a force of from 3.5 to 4.5 Kg has been thought to be sufficient for adequate condensation of an amalgam mix.[9] Such a force would produce a condensation pressure of 1.1, 1.43, 1.98, and 2.55 Kg/mm^2, depending on the diameter of the condenser and the force applied. Based on this pressure range, 13.6, 18.2, and 22.7 Kg of load were used with the 4-mm-diameter plunger to give condensation pressures of 1.08, 1.45, and 1.81 Kg/mm^2, respectively. Although, with all three loads 30 sec after trituration, the differences in the resistance to condensation of the three types of mixes could be distinguished, 18.2 Kg or 22.7 Kg would be better than 13.6 Kg for a clearer distinction. Therefore, the optimum measurement should be made 30 sec after trituration under 18.2 or 22.7 Kg of load for classification and comparison of different types of amalgams. Loads heavier than 22.7 Kg may be used with

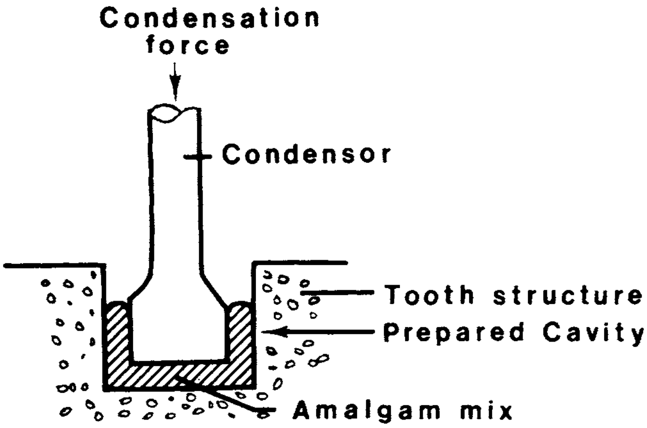

Fig. 5 – Schematic figure of plastic deformation on clinical condensation.

hard mixes, whereas loads lighter than 18.2 Kg could be used with soft amalgam mixes.

The results of the analysis of variance showed that the type of alloy, the magnitude of load, and its time of application had a significant effect on the plasticity. It should be recognized that the purpose of the present study was to determine the plasticity of different types of amalgam at early stages of condensation. The plasticity of the amalgam mass, however, can be measured at any time 30 sec after trituration. By means of this procedure, it seems that relative condensing time of amalgams can also be assessed.

In employing the abovementioned method for determining plasticity of different amalgams, one could use a more elaborate instrument than a simple caliper (used here) for measuring the height of the amalgam test specimens. It was felt that any more precise measurement of specimen height than that offered by a caliper (within 0.1 mm) is unnecessary, since the differences in the height of specimens prepared from different types of amalgam alloys were from 40 to 50 times greater than the accuracy of readings provided by a caliper. It should be mentioned that the object was to develop a fast, dependable, and reproducible test method, one that easily differentiates plasticity of different amalgams using simple equipment. Because of the simplicity of this test procedure, it is hoped that the method will be used by manufacturers and researchers, and finally that it might be included in amalgam specifications for classifying different types of amalgams for plasticity of their mixes.

Conclusions.

A method was designed to evaluate the resistance to condensation forces of amalgam mixes. In order to investigate its validity and determine optimum test conditions, the height of deformed amalgams was measured under 13.6, 18.2, and 22.7 Kg of static load 30, 60, and 90 sec after trituration, using three types of amalgam mixes (soft, medium, and hard).

It was found that the method was effective enough to detect differences in resistance to condensation forces for three amalgams. For the purpose of classification of amalgams, optimum test conditions were to apply 18.2 or 22.7 Kg of load 30 sec after trituration.

REFERENCES

1. EAMES, W.B. and SKINNER, E.W.: A Possible Test for Working Time of Dental Amalgam, IADR *Progr & Abst* 43:No. 94, 1965.
2. DAVIDSON, C.L.; ARENDS, J.; and HARKEL, E.T.: An Ultrasonic Investigation into the Working Time of Amalgam, *J Oral Rehabil* 1:99-106, 1974.
3. OHASHI, M.; WARE, A.L.; and DOCKING, A.R.: A Comparison of Methods for Determining Setting Rate of Amalgam, *Aust Dent J* 20:176-182, 1975.
4. EAMES, W.B.; AJMO, C.T.; and PALMERTREE, C.O., Jr.: A Proposed Working Time Test for Dental Amalgam, IADR *Progr & Abst* 58:No. 424, 1979.
5. MAHLER, D.B.: Plasticity of Amalgam Mixes, *J Dent Res* 46: 708-713, 1967.
6. DALBY, J. (programer): BMD8V – Analysis of Variance, Ann Arbor, MI: Statistical Research Laboratory, University of Michigan, 1968, 4 pp.
7. GUENTHER, W.C.: **Analysis of Variance**, Englewood Cliffs, NJ: Prentice-Hall, 1964, p. 199.
8. PHILLIPS, R.W.: **Skinner's Science of Dental Materials,** 7th ed., Philadelphia: W.B. Saunders Co., 1973, p. 343.
9. CRAIG, R.G.; O'BRIEN, W.J.; and POWERS, J.M.: **Dental Materials – Properties and Manipulation,** 2nd ed., St. Louis: C.V. Mosby Company, 1979, p. 85.