# NATIONAL BUREAU OF STANDARDS REPORT

4585

Progress Report

on

A PROPOSED SPECIFICATION FOR
DENTAL CHROMIUM-COBALT CASTING ALLOYS

by

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W. T. Sweeney


U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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# NATIONAL BUREAU OF STANDARDS REPORT

**NBS PROJECT** **NBS REPORT**

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Progress Report

## A PROPOSED SPECIFICATION FOR DENTAL CHROMIUM-COBALT CASTING ALLOYS

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NBS

**U. S. DEPARTMENT OF COMMERCE**
**NATIONAL BUREAU OF STANDARDS**

# A PROPOSED SPECIFICATION FOR DENTAL CHROMIUM-COBALT CASTING ALLOYS


## Abstract

The widespread use of chromium-cobalt casting alloys in the construction of partial dentures has presented a need for a specification for alloys of this type. The major requirements of the specification proposed herein are a composition of not less than 85% chromium, cobalt and nickel, yield strength of 60,000 psi, tensile strength of 90,000 psi, elongation of 1.5%, and hardness of 50 (Rockwell 30N). The alloys are divided into two types, one with a minimum fusion temperature of 2400°F and one with a maximum fusion temperature of 2400°F.


Chromium-cobalt base alloys were introduced for dental use in 1929 [1], and since that time have shown gradual and steady gains in popularity. While the desirable physical properties of these materials and their relatively low cost have promoted their use, the necessity of using specialized equipment and techniques has restricted their application almost entirely to commercial dental laboratories. In recent years, as dentists have come to rely more upon the services of commercial laboratories and of auxiliary personnel in general, the chrome-cobalt alloys have nearly preempted the partial denture field.

The increasing popularity of these materials has prompted the appearance on the market of many new products of this type which exhibit wide variations in their suitability for dental use. As the number of available products has multiplied, a growing need has been felt by the dental profession and the laboratories for a standard or specification as an aid in the selection of a material. The interest of the Federal dental services has been particularly pronounced since such a specification would facilitate their purchase of these alloys.

Much of the research on the properties of these materials has been directed toward properties which are of interest for their industrial use, such as creep resistance, but which have little pertinence for their dental application. Several groups of investigators have worked with the dental alloys in the last twenty years, but few results have found their way into the literature, and as yet there is no accepted standard for these materials.

The accompanying specification is submitted as representing an initial approach to this problem, and has been approved by the Specifications Committee of the Dental Materials Group of the International Association for Dental Research. The values proposed in this specification are based upon the work done by Paffenbarger, Caul, and Dickson [1], and more recently by Taylor, Leibfritz, and Adler [2] at the National Bureau of Standards, and upon that done at the University of Michigan by Bush, Ingersoll, Mahler and Peyton [3]. The tensile test specimen design and spruing arrangement recommended are essentially those developed

by the Michigan group.

As far as possible the following principles were observed in drafting this specification:

1. The values specified should be selected to eliminate materials having properties inferior to those readily obtainable in currently available products, without at the same time excluding products of known clinical acceptability.
2. The specification should limit the variation in composition and properties to types within which acceptable products may be used interchangeably without major alterations in equipment or technique.
3. The specification should parallel as far as possible the existing specifications for other materials used for the same purpose [4].
4. The test methods specified should be selected to simplify testing and reduce the required interpretation of the observations as far as possible without sacrificing accuracy or thoroughness.

Certain of the individual requirements of the specification made on this basis would seem to merit further discussion.

This specification divides the chromium-cobalt base dental casting alloys into two types on the basis of their liquidus temperatures. The dividing temperature has been taken as 2400°F on the basis of advice from the manufacturers of investments for these materials that alloys melting above 2400°F cannot be cast with routine success into gypsum-bonded investments. Since the techniques required for the water-mixed, gypsum-bonded investments

differ greatly from those employed for materials utilizing ethyl silicate or some other high temperature binder, this seemed to constitute a logical basis for a division into separate types.

The composition requirement that the alloy contain no less than 85% by weight of chromium, cobalt, and nickel serves two purposes. It defines the general group of alloys considered by the specification somewhat more closely than does the title, and at the same time it is an attempt to compensate for the lack of a satisfactory test for corrosion resistance under oral conditions. In the absence of such a test it is felt that this composition requirement gives some assurance of corrosion resistance without unduly imposing penalties in the form of reduced mechanical properties. All widely used, clinically successful alloys meet this requirement without difficulty.

The specimen design used for the determination of tensile properties was selected as approximating dental dimensions, and, on the basis of the results of Bush et al, as showing greater uniformity of properties and freedom from casting failure than other designs. The chrome-cobalt alloys are particularly hard to cast in the rod form used for testing dental golds.

The numerical values required for the tensile properties correspond approximately to those of Federal Specification QQ-G-540 for dental casting golds, type IV. The requirements for yield strength and elongation are set slightly lower than those for golds since some base metal alloys of known clinical suitability are unable to meet those requirements. The hardness test

requirement is in terms of a Rockwell superficial hardness scale (30N), rather than the Brinell test employed for golds, because the diamond indenter used in the Rockwell test is not subject to the deformation that occurs in the ball indenter of the Brinell tester when used on these hard materials.

## BIBLIOGRAPHY

1. Paffenbarger, George C., Caul, H. J. and Dickson, George. Base metal alloys for oral restorations. J.A.D.A. 30, 852-862 June 1943.
2. Taylor, Duane F., Leibfritz, Walter A., and Adler, Alfred G. Physical properties of chromium cobalt dental alloys. (In preparation).
3. Bush, S. H., Ingersoll, C. E, and Peyton, F. A. Navy contract N6-Onr-232 Progress Reports, School of Dentistry, University of Michigan.
4. Federal Specification QQ-G-540 for Gold; Casting, Inlay, Dental.

# PROPOSED SPECIFICATION FOR DENTAL CHROMIUM-COBALT CASTING ALLOYS

## 1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers chromium-cobalt casting alloys of the type used in removable partial denture prostheses.

1.2 Types. The chromium-cobalt alloys covered by this specification shall be of the following types:

Type I. High fusing.

Type II. Low fusing.

## 2. APPLICABLE SPECIFICATIONS

2.1 Specification. There are no other specifications applicable to this specification.

## 3. REQUIREMENTS

3.1 Color. The color of the alloy shall be the color specified by the purchaser.

3.2 Composition. The alloy shall contain a total of not less than 85% by weight of chromium, cobalt and nickel.

3.3 Physical properties. The requirements for physical properties for each type are listed in Table 1.

Table 1

REQUIREMENTS FOR PHYSICAL PROPERTIES

| Type | Fusion temperature | Yield strength | Tensile strength | Elongation (one inch gage length) | Hardness Rockwell 30N |
|---|---|---|---|---|---|
| | °F | psi | psi | % | |
| | | min. | min. | min. | min. |
| I | 2400 (min.) | 60,000 | 90,000 | 1.5 | 50 |
| II | 2400 (max.) | 60,000 | 90,000 | 1.5 | 50 |

3.4 Manufacturer's directions. Instructions for use shall accompany each package. The instructions shall include casting temperature of the alloy, burnout temperature for the investment, a description of necessary auxiliary materials and equipment, and any special precautions for satisfactory use.

4. SAMPLING, INSPECTION, AND TEST PROCEDURES

4.1 Sampling. The manufacturer shall provide a set of six specimens of the type described in 4.4.1, cast from each of the lots or batches of alloy included in the delivery. The specimens shall be submitted in the "as cast" condition and with sprues and buttons attached. An additional six ounces of material shall be chosen at random from each lot or batch of material included in the delivery.

4.2 Inspection. Compliance with the requirements outlined in 3.1, 3.4 and 5, shall be determined by inspection.

4.3 Test procedures.

4.3.1 Composition. At the option of the purchaser, certification by the manufacturer that the alloy contains not less than 85% of chromium, cobalt, and nickel may be considered to satisfy the composition requirement. Otherwise the composition shall be determined by wet analysis.* The determined values for metallic constituents shall be recorded as the nearest 0.5 percent. When a determined value falls midway between a half and a whole number, the whole number shall be recorded.

* Analyses for chromium, nickel and cobalt shall be made by procedures given in J. Research NBS 53,353 (1954), ASTM Methods of Chemical Analysis of Metals (1950) Chemical Analysis of Iron and Steel, by Lundell, Hoffman and Bright, or by methods demonstrated to be of equal accuracy.

4.3.2 Fusion temperature. The fusion temperature shall be the liquidus temperature as determined by cooling curves. The manufacturer shall determine and certify the fusion temperature. The purchaser may, at his option, accept such certification as satisfying the fusion temperature requirement.

4.3.3 Physical properties.

4.3.3.1 Preparation of specimens. Physical properties other than fusion temperature shall be determined on cast specimens tested in the "as cast" condition without subsequent heat treatment. The specimens shall be of the type and dimensions indicated in Figure 1. They shall be cast in accordance with the manufacturer's directions for partial dentures except that where those directions conflict with the provisions of this specification, the specification shall be followed. It is suggested that two, three or four such patterns be symetrically arranged around a central sprue, and be provided with gates, risers, and vents in a manner similar to that indicated in Figure 2. If so desired, a continuous ring of adequate cross-section may be substituted for individual risers.

4.3.3.2 Compliance. An alloy shall be considered to meet the requirements for tensile properties and hardness when all of the recorded values for three or more of a set of six specimens meet the requirements of Table 1.

4.3.3.3 Yield Strength. The yield strength shall be determined using an averaging extensometer and a one-inch gage length. An initial load calculated to produce a stress of 5000 pounds per square inch shall be applied to the specimen and the strain gage read. The load shall then be increased to produce a stress of 60,000 pounds per square inch and a second reading taken. The load shall be applied at a rate of not less than 50 nor more than 100 pounds per minute. The maximum strain permitted between the limits specified shall be 0.0025 inch per inch. The determined value of strain shall be recorded to the nearest 0.0001 inch per inch. When the determined value falls midway between two numbers, the even number shall be recorded.

4.3.3.4 Tensile strength. After the loading for the yield strength (4.3.3.3) has been completed and the strain gages have been removed, additional load shall be applied to the specimen until rupture occurs. The determined value for tensile strength shall be recorded to the nearest 1000 poundsper square inch. When the determined value falls midway between two numbers, the even number shall be recorded.

4.3.3.5 Elongation. The elongation shall be determined on the specimens used in the tests for yield strength and tensile strength. Elongation shall be measured on a one-inch gage length. Castings that break outside of the gage marks shall not be repulled, but the elongation between the marks shall

be recorded if it equals or exceeds the minimum specified value. The determined value shall be recorded to the nearest 0.1 percent. When the determined value falls midway between two numbers the even number shall be recorded.

4.4.6 Hardness. The Rockwell 30 N number shall be determined on each tensile specimen. After fracture the tensile specimens shall have a flat surface wet ground on their rod portions. Five indentations shall be made on the flat surface of each specimen no nearer than one-eighth inch from the fractured end or from the tapered end. The high and the low readings shall be discarded and the remaining three shall be averaged. The average hardness number of each specimen shall be recorded to the nearest whole number. When the determined value falls midway between two numbers, the even number shall be recorded.

5. PREPARATION FOR DELIVERY

5.1 Packaging. The alloy shall be packaged in accordance with acceptable commercial practice.

5.2 Marking. Each package shall be marked with the name of the manufacturer or contractor, name of the material, type and minimum net weight of contents, together with a serial number or combination of letters and numbers which shall refer to the manufacturer's records for the particular lot or batch of alloy. The date of manufacture shall be indicated either as a part of the serial number or as a separate item.

5.3 Instructions for use. Instructions for use shall accompany each package (3.4).

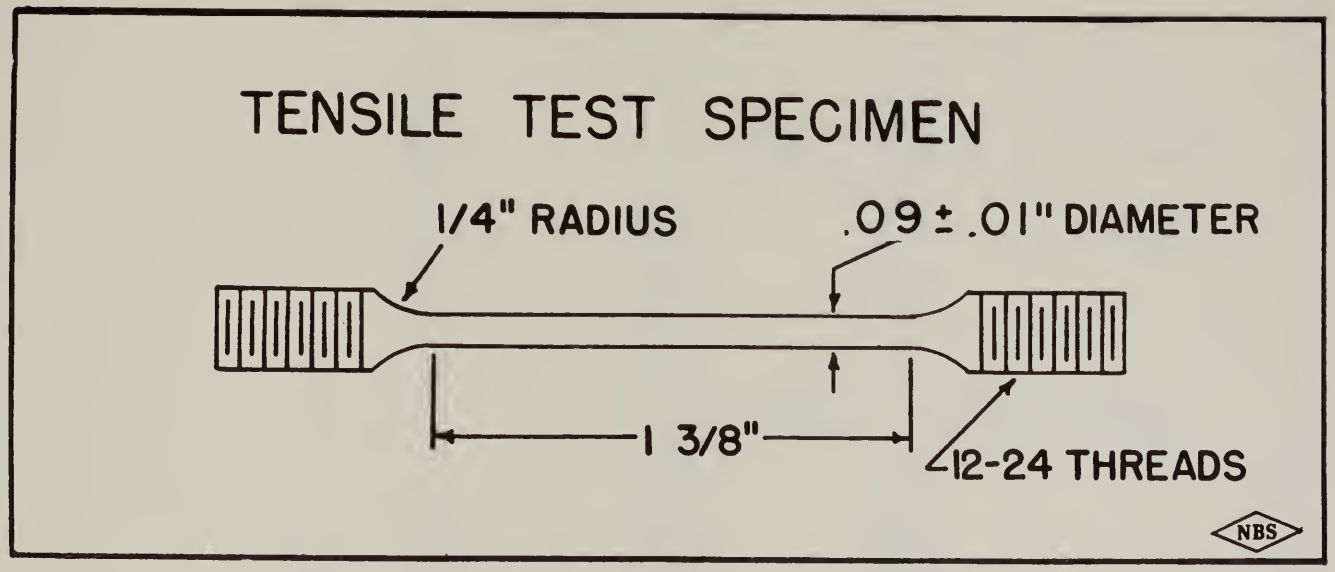
TENSILE TEST SPECIMEN
1/4" RADIUS
.09 ± .01" DIAMETER
1 3/8"
12-24 THREADS
NBS

FIGURE 1

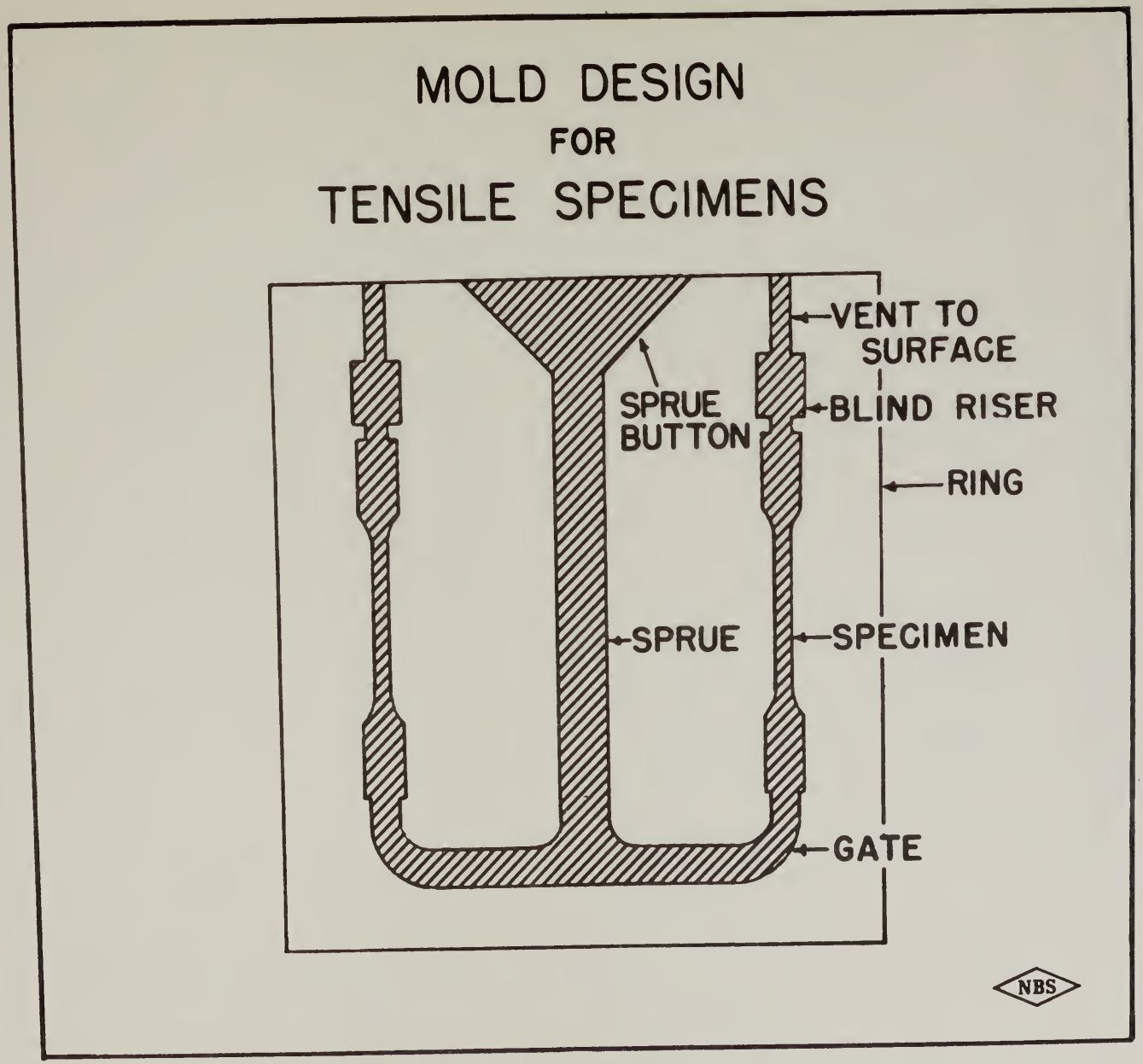
MOLD DESIGN
FOR
TENSILE SPECIMENS
VENT TO SURFACE
SPRUE BUTTON
BLIND RISER
RING
SPRUE
SPECIMEN
GATE
NBS

FIGURE 2

## THE NATIONAL BUREAU OF STANDARDS

### Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

### Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.


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