GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. E-19-B08 (E-18-605)

GTRI/GIT — DATE 7/6/84

Project Director: Dr. M. J. Marek — School/Lab: ChE

Sponsor: DHHS/PHS/NIH/National Institute of Dental Research, Bethesda, MD

Type Agreement: Grant No. 2 R01DE03601-11A2

Award Period: From 7/1/84 To 6/30/85 (Performance) 9/30/85 (Reports)

Sponsor Amount:

	This Change	Total to Date
Estimated:	$ 86,701	$ 86,701
Funded:	$ 86,701	$ 86,701

Cost Sharing Amount: $ 4,332 — Cost Sharing No: E-19-315

Title: "Effect of Corrosion on Dental Amalgams"

ADMINISTRATIVE DATA

OCA Contact: Lynn Boyd x4820

1) Sponsor Technical Contact:

William E. Rogers, Jr, PhD
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Defense Priority Rating: n/a — Military Security Classification: n/a

(or) Company/Industrial Proprietary: n/a

RESTRICTIONS

See Attached NIH Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT.

COMMENTS:

JUL 1984 RECEIVED Research Reports

COPIES TO:

Sponsor I.D. #02.108.001.84.003

Project Director	Procurement/EES Supply Services	GTRI
Research Administrative Network	Research Security Services	Library
Research Property Management	Reports Coordinator (OCA)	Project File
Accounting	Research Communications (2)	Other Newton

FORM OCA 4:383

GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date January 24, 1986

Project No. E-18-605 (Formerly E-19-B08)

School/XXX ChE

Includes Subproject No.(s) N/A

Project Director(s) Dr. M.J. Marek XXXX / GIT

Sponsor DHHS/PHS/NIH/National Institute of Dental Research, Bethesda, MD

Title "Effect of Corrosion on Dental Amalgams"

Effective Completion Date: 6/30/85 (Performance) 9/30/85 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [ ] XXXXXXXXXX Final Fiscal Report
- [ ] Closing Documents
- [X] Final Report of Inventions Sent 568 to Project Director
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No.

Continued by Project No. E-18-611

COPIES TO:

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Project File
Other Heyser, Jones, Embry

FORM OCA 69.285

E-19-B08/Marek/Che

SECTION IV

PROGRESS REPORT SUMMARY

GRANT NUMBER	5R01DE03601-12
PRINCIPAL INVESTIGATOR OR PROGRAM DIRECTOR: MAREK, MIROSLAV I.	PERIOD COVERED BY THIS REPORT
NAME OF ORGANIZATION: Georgia Institute of Technology	FROM 07/01/84 THROUGH 06/30/85

TITLE *(Repeat title shown in item 1 on first page)*

EFFECT OF CORROSION ON DENTAL AMALGAMS

(SEE INSTRUCTIONS)

PUBLICATIONS

M. Marek: "Acceleration of Corrosion of Dental Amalgam by Abrasion." J. Dent. Res. 63:1010 (1984)

Presentations:

M. Marek: "Corrosion, Galvanic Cell Production, and Release of Metal Ions." Workshop on Biocompatibility of Metals in Dentistry, July 11-13, 1984, Chicago, IL. (Invited paper)

M. Marek: "Corrosion testing of Dental Materials: Methods, Interpretation, Fallacies." International Conference on Oral Metallic Interactions, October, 1984, Callaway Gardens, GA. (Invited paper)

"M. Marek: "Galvanic Corrosion of Restorations under Continuous and Intermittent Contacts." 63rd general Session of the IADR/Annual Session of the AADR, March 21-24, 1985, Las Vegas, NV.

REPORT

1. SCIENTIFIC GOALS

No change. The general scientific goal of the project remains the same, i.e., to determine the role of corrosion in the deterioration of dental amalgam restorations.

2. STUDIES AND RESULTS (1984/85 budget year)

A. Effects of Abrasion

Abrasion is one of the mechanical effects taking place on dental restorations in the mouth and affecting corrosion. A special abrasion/corrosion electrochemical test cell was designed and constructed that allowed the measurement of the corrosion behavior before, during, and after the application of abrasion by a rotating abrasion tool. Soft leather abrasion pads were used to simulate chewing of moderately hard food. Five commercial amalgams, representing the major types, were examined.
The abrasion caused substantial acceleration of corrosion in the potential regions where the amalgam is normally protected by a passive film. Both low and high copper amalgams were affected, but low copper amalgams more severly, apparently because of the presence of the soft and corrosion susceptible Sn-Hg phase. The potential above which breakdown of passivity occurs was not, however, affected. Current and potential transients when abrasion ceased showed a relatively slow repassivation, with a time constant of several seconds.

Section IV
PROGRESS REPORT SUMMARY (continued)

The results indicate that abrasion is an important factor in acceleration of corrosion of dental amalgam restorations. This observation explains why corrosion effects in vivo on occlusal surfaces are often more severe than those observed in the laboratories. The relatively slow repassivation kinetics indicate that during mastication the amalgam is continuously unprotected and subjected to accelerated corrosion.

B. Dimensional Changes due to Corrosion

Extrusion of dental amalgam restorations from the tooth cavity after a period of service is often observed, and may be a factor in the breakdown of restoration margins. One of the causes of extrusion may be the dimensional changes as a result of corrosion. A study was performed to determine the extent of dimensional changes as a function of various amounts of corrosion for different types of amalgam.

Two commercial amalgams were included in this study, representing the low and high copper types. Beam-type specimens were exposed to a simulated oral environment and corroded under galvanostatic conditions. Only one side of each specimen was exposed to the electrolyte. In a specimen of this type a dimensional change associated with corrosion results in the deflection of the specimen into a curved beam. Because of the creep of amalgam at the testing temperature ($37^{\circ}C$) most of the deformation is permanent. The amount of corrosion was controlled by measuring the total anodic charge, which is proportional to the corrosion damage.

The results showed that dimensional changes caused by corrosion occurred in the low copper amalgam, but not in the high copper amalgam. A calculation of the volumetric change associated with the conversion of the structural phases into corrosion products showed a substantial volumetric expansion associated with the corrosion of the Sn-Hg phase in a low copper amalgam, but no expansion associated with corrosion of the Cu-Sn phase that corrodes in high copper amalgams. In addition, corrosion of the Sn-Hg phase in low copper amalgams releases metallic mercury, that causes mercuroscopic expansion of the matrix, as reported by Jorgensen. Thus the experimental results are in agreement with the calculations. In this study it was not possible to separate the effects of nonmetallic corrosion products from the mercuroscopic expansion. This question will be examined in the follow-up studies. The results obtained in this study show that the observed better clinical performance of high copper amalgams as compared with the low copper types is due to several factors, the dimensional change being one of them.

C. Sulfide Tarnishing of Dental Amalgam

Reactions of dental amalgam with sulfides in the oral environment result in the formation of sulfide surface films, that are observed as tarnishing. In this study the interaction between sulfide reactions and

Section IV
PROGRESS REPORT SUMMARY (continued)

chloride corrosion was examined. Sulfide films were formed potentiostatically in a diluted sulfide solution, which was then replaced by synthetic saliva and the corrosion behavior was examined as a function of the amount of sulfur on the surface. One low copper and one high copper amalgam were examined.

The results showed different behavior of the two materials. For low copper amalgams the sulfide film provided some protection against the chloride attack, resulting in a shift of the breakdown potential to more positive values. For the high copper amalgam, however, the sulfide film increased the corrosion current density in chlorides. The results indicate that sulfide tarnishing is more serious for high copper amalgams than for low copper amalgams not only because of the effect on the appearance, but also as an accelerating factor in chloride corrosion.

SUMMARY: All the objectives of the project in the current year have been accomplished.

3. RESEARCH GOALS FOR THE COMING YEAR

In accord with the overall proposal the following studies are planned for the coming year:

a. Determination of the Effect of Mercury on the Stability of Phases in Dental Amalgam.

The effect of the presence of mercury on the corrosion stability of the major phases of dental amalgam structure that do not contain mercury (as a major element) will be examined. The phases will include the copper-tin reaction phase Cu_6Sn_5 (an extension of the previous study), the silver-tin phase Ag_3Sn, and the gold-tin reaction phase.

b. Determination of the Corrosion Depth as a Function of the Integrated Corrosion Current Density

The functional relationship between corrosion rate and the depth of the corrosion-affected layer will be examined. Specimens will be corroded under controlled conditions, and the corrosion current density will be integrated. Specimens will be sectioned and the depth of corrosion determined. The results for different types of amalgam will allow prediction of the corrosion depth and loss of strength for amalgams corroding at different rates.

c. Investigation of Sulfide Tarnishing of Dental Amalgam

To reach a better understanding of sulfide reactions on dental amalgam the basic kinetic data for the major phases in dental amalgams will be determined. The phases will be prepared metallurgically, and their electrode behavior in solutions containing sulfide will be examined by electrochemical techniques.