

รายการอ้างอิง



1. Jeanne M. Anglin. " Engineered materials handbook composites volume 1 " USA :
ASM International, 1988.
2. R. W. Cahan, P. Haasen and E. J. Kramer. " Material science and technology :
a comprehensive treatment " Weinheim : VCH Verlagsgesellschaft mbH, 1992.
3. P. K. Vallittu and V. P. Lassils. " Reinforcement of acrylic resin denture base material with
metal or fiber strengtheners " J. oral rehabil, 1992 ; 19 (3) : 225-230.
4. P. K. Vallittu. " A review of fiber-reinforced denture base resin " J. prosthodont, 1996 ;
5 (4) : 270-276.
5. T.E. Donovan, R. G. Hurst and W. V. Campagni." Physical properties of acrylic resin
polymerized by four different technics" J Prosthet Dent , 1985; 54 : 522-528
6. G. A. V. M. Geerts nad C. H. Jooste. " A comparison of the bond strengths of
Microwave and water bath cured denture materials " J Prosthet Dent , 1993 ; 70
: 406-409
7. G. S. Solnit. " The effect of MMA reinforcement with silane treated and untreated
glass fiber " J Prosthet Dent , 1991 ; 66 : 310-314
8. A. Samadzadch, G. Kugel, E. Hurley and A. Aboushala. " Fracture strengtyh of provisional
restorations reinforced with plasma-treated woven polyethylene fiber " J Prosthet Dent ,
1997 ; 78 : 477-450
9. V. Ramos, D. A. Runyan and L. C. Christensen. " The effect of plasma treated PE fiber on
the fracture strength of PMMA " J Prosthet Dent , 1996 ; 76 : 94-96

10. P. K. Vallittu . “ Curing of a silane coupling agent and its effects on the transverse Strength of autopolymerizing PMMA – glass fiber composite ” J oral Rehabil 1997 ; 24 : 124-130
11. T. R. Manley, A. J. Bowman and M. Cook. “ Denture bases reinforced with carbon fiber ” British Dent. J. 1979 ; 2 : 25-26
12. S.Y. Chen. "Improvement of Denture Base Resin Reinforced by Incorporating Various Fibers" school of dentistry China Medical College Taiwan,ROC.
13. J. M. Berrong, R. M. Weed and J. M. Young. “Fracture resistance of kevlar reinforced PMMA resins : A Preliminary study.” The international J. Prosthodontics , 1990 ; 34 : 391-395
14. W. R. Larson, D. L. Dixon, S. A. Aquilino and J. M. Clancy. “ The effect of carbon graphite fiber reinforcement on the strength of provisional crown and fixed partial denture resin ” J Prosthet Dent , 1991 ; 66 : 816-820
15. D. D. Wright, E. P. Lautenschlager and J. L. Gilbert. “Bending and fracture toughness of woven self reinforced composite PMMA ” Woven SRC-PMMA , 1997 ; 040441-13
16. S. R. Shukla, M. R. Mathur and V. B. Hedao. “Alkaline weight reduction of polyester fibers” American Dyestuff Reporter, 1997.
17. S. R. Shukla, V. B. Hedao and A. N. Saligram. “ Alkaline weight reduction of polyester fibers using ethylenediamine ”American Dyestuff Reporter, 1995.
18. เจน รัตนไพศาล “ ทันตวัสดุศาสตร์ ”, พิมพ์ครั้งที่สอง, บริษัทโรงพิมพ์ไทยวัฒนาพานิช จำกัด, พ.ศ. 2533
19. R. G. Craig and M. L. Ward. “ Restorative Dental Materials “ USA : Mosby, 1997.

20. Charles A. Harper "Handbook of Plastics, Elastomers and Composites". 2nd edition, McGraw – Hill, Inc., 1992
21. F. L. Matthews and R. D. Rawlings "Composite Materials : Engineering and Science". 1st edition, Chapman & Hill, London, 1994
22. I. Goodman and J. A. Rhys "Polyesters Volume1 Saturated Polymers". American Elsevier Publishing Company Inc., New York, 1965
23. Lawrence E. Nielson and Robert F. Landel "Mechanical Properties and Composites". 2nd edition, Revised and expanded, Marcel Dekker, Inc., New York, 1994
24. Witold Brostow and Roger D. Comeliussen "Failure of Plastics". Hanser Publisher, New York, 1986
25. John Scheirs "Compositional and Failure Analysis of Polymers", John Wiley & Sons, Ltd., England, 1999
26. Peter C. Powell "Engineering with Fibre - Polymer Laminates ", 1st edition, Chapman & Hall, London, 1994
27. F. W. Billmeyer. "Textbook of polymer science" 3rd ed. USA : John Wiley & Sons, 1984.

ภาคผนวก

ภาคผนวก

ภาคผนวก ก. ข้อมูลดิบผลการทดสอบความต้านทานแรงกระแทก

ตารางที่ ก-1 ค่าความต้านทานแรงกระแทกของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 5 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่ \ ปริมาณเส้นใย	ค่าความต้านทานแรงกระแทก (J/m)			
	Pure PMMA	1 %	2 %	3 %
1	55.62	76.89	106.87	133.26
2	58.32	78.95	128.75	142.25
3	63.92	90.81	104.08	130.11
4	52.10	95.58	121.32	124.88
5	56.90	86.00	131.10	116.02

ตารางที่ ก-2 ค่าความต้านทานแรงกระแทกของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 10 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่ \ ปริมาณเส้นใย	ค่าความต้านทานแรงกระแทก (J/m)			
	Pure PMMA	1 %	2 %	3 %
1	55.62	105.23	119.49	164.16
2	58.32	115.56	116.31	132.55
3	63.92	93.27	134.91	143.94
4	52.10	102.28	142.38	156.18
5	56.90	87.50	139.92	123.82

ตารางที่ ก-3 ค่าความต้านทานแรงกระแทกของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 15 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่ / ปริมาณเส้นใย	ค่าความต้านทานแรงกระแทก (J/m)			
	Pure PMMA	1 %	2 %	3 %
1	55.62	102.90	147.25	127.60
2	58.32	136.85	127.87	168.14
3	63.92	101.57	130.68	175.46
4	52.10	115.96	119.11	146.02
5	56.90	106.37	152.80	137.66

ตารางที่ ก-4 ค่าความต้านทานแรงกระแทกของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยยาวที่ทิศทางและปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่ / ปริมาณเส้นใย	ค่าความต้านทานแรงกระแทก (J/m)				
	Pure PMMA	1 แนว 1 ชั้น	1 แนว 2 ชั้น	2 แนว 1 ชั้น	2 แนว 2 ชั้น
1	55.62	91.74	103.69	80.57	101.77
2	58.32	73.27	125.53	76.41	110.02
3	63.92	69.39	108.36	83.28	92.93
4	52.10	77.39	97.38	74.66	117.85
5	56.90	85.79	98.91	68.74	113.13

ภาคผนวก ข. ข้อมูลดิบผลการทดสอบการทนการดัดโค้ง

ตารางที่ ข-1 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 5 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่	ปริมาณเส้นใย	ค่าความต้านทานการดัดโค้ง (MPa)			
		Pure PMMA	1 %	2 %	3 %
1		97.9	82.5	78.2	79.6
2		92.1	83.8	86.5	75.0
3		93.8	82.3	87.0	79.7
4		97.2	81.3	78.5	82.3
5		99.7	86.5	80.6	79.2
6		90.9	82.6	79.9	82.1
7		91.1	89.7	80.5	80.7

ตารางที่ ข-2 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 10 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่	ปริมาณเส้นใย	ค่าความต้านทานการดัดโค้ง (MPa)			
		Pure PMMA	1 %	2 %	3 %
1		97.9	79.8	84.4	79.0
2		92.1	84.0	81.2	77.4
3		93.8	79.2	82.6	86.1
4		97.2	86.9	83.2	80.0
5		99.7	79.6	82.2	79.0
6		90.9	83.7	86.7	83.1
7		91.1	90.4	84.6	81.1

ตารางที่ ข-3 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 15 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน

ตัวอย่างที่ / ปริมาณเส้นใย	ค่าความต้านทานการดัดโค้ง (MPa)			
	Pure PMMA	1 %	2 %	3 %
1	97.9	80.9	90.4	82.3
2	92.1	79.6	88.7	77.0
3	93.8	85.6	74.5	78.6
4	97.2	90.1	89.2	79.9
5	99.7	86.4	81.6	87.9
6	90.9	83.7	82.6	85.1
7	91.1	90.8	79.9	77.8

ตารางที่ ข-4 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 5 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน (ผ่านการแช่น้ำ 2 สัปดาห์)

ตัวอย่างที่ / ปริมาณเส้นใย	ค่าความต้านทานการดัดโค้ง (MPa)			
	Pure PMMA	1 %	2 %	3 %
1	85.3	77.8	76.5	76.3
2	86.1	88.4	82.9	68.3
3	87.4	86.7	71.7	73.7
4	86.7	89.5	73.5	69.6
5	87.9	80.6	85.7	72.8
6	87.0	74.6	85.4	74.8
7	86.6	74.6	81.1	76.5

ตารางที่ ข-5 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริลิตที่เสริมแรงด้วยเส้นใยขนาด 10 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน (ผ่านการแช่น้ำ 2 สัปดาห์)

ตัวอย่างที่ \ ปริมาณเส้นใย	ค่าความต้านทานการดัดโค้ง (MPa)			
	Pure PMMA	1 %	2 %	3 %
1	85.3	75.1	78.2	78.1
2	86.1	84.1	78.7	69.5
3	87.4	85.3	79.0	69.2
4	86.7	77.2	83.9	72.1
5	87.9	88.8	77.1	77.3
6	87.0	77.7	82.8	79.3
7	86.6	87.8	75.7	71.8

ตารางที่ ข-6 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริลิตที่เสริมแรงด้วยเส้นใยขนาด 15 มิลลิเมตร ที่ปริมาณเส้นใยต่าง ๆ กัน (ผ่านการแช่น้ำ 2 สัปดาห์)

ตัวอย่างที่ \ ปริมาณเส้นใย	ค่าความต้านทานการดัดโค้ง (MPa)			
	Pure PMMA	1 %	2 %	3 %
1	85.3	76.7	79.9	73.4
2	86.1	83.6	77.6	71.9
3	87.4	82.7	76.7	72.8
4	86.7	77.1	76.2	70.0
5	87.9	87.1	82.5	74.3
6	87.0	79.6	78.8	77.8
7	86.6	81.1	83.6	73.6

ตารางที่ ข-7 ค่าความต้านทานการตัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลตที่เสริมแรงด้วยเส้นใยขนาด 10 มิลลิเมตรปริมาณ 1 เปอร์เซ็นต์ โดยผ่านการปรับแต่งผิวที่เวลาต่างๆ กัน

ตัวอย่างที่	เวลา	ค่าความต้านทานการตัดโค้ง (MPa)		
		5 นาที	10 นาที	20 นาที
1		83.1	84.4	85.5
2		86.2	80.4	87.6
3		90.2	87.4	88.2
4		81.7	88.0	82.9
5		72.2	80.0	80.6
6		89.2	84.5	84.4
7		81.7	87.3	81.6

ตารางที่ ข-8 ค่าความต้านทานการตัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลตที่เสริมแรงด้วยเส้นใยขนาด 10 มิลลิเมตรปริมาณ 2 เปอร์เซ็นต์ โดยผ่านการปรับแต่งผิวที่เวลาต่างๆ กัน

ตัวอย่างที่	เวลา	ค่าความต้านทานการตัดโค้ง (MPa)		
		5 นาที	10 นาที	20 นาที
1		87.5	81.1	82.2
2		81.9	79.8	83.5
3		83.9	87.1	79.9
4		76.1	82.6	81.7
5		85.1	79.3	84.4
6		84.0	83.9	80.7
7		81.4	85.3	83.7

ตารางที่ ข-9 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลตที่เสริมแรงด้วยเส้นใยขนาด 10 มิลลิเมตรปริมาณ 3 เปอร์เซ็นต์ โดยผ่านการปรับแต่งผิวที่เวลาต่างๆ กัน

ตัวอย่างที่ \ เวลา	ค่าความต้านทานการดัดโค้ง (MPa)		
	5 นาที	10 นาที	20 นาที
1	80.6	82.3	78.0
2	82.6	79.9	77.6
3	80.4	78.7	85.4
4	75.2	81.2	81.5
5	83.5	79.4	81.2
6	79.3	83.6	79.9
7	81.2	82.7	83.3

ตารางที่ ข-10 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลตที่เสริมแรงด้วยเส้นใยขนาด 15 มิลลิเมตรปริมาณ 1 เปอร์เซ็นต์ โดยผ่านการปรับแต่งผิวที่เวลาต่างๆ กัน

ตัวอย่างที่ \ เวลา	ค่าความต้านทานการดัดโค้ง (MPa)		
	5 นาที	10 นาที	20 นาที
1	85.1	84.4	81.7
2	83.5	82.9	84.5
3	82.7	84.3	85.6
4	86.1	85.9	83.2
5	83.4	83.7	79.8
6	84.9	84.7	85.5
7	85.5	84.9	84.9

ตารางที่ ข-11 ค่าความต้านทานการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 15 มิลลิเมตรปริมาณ 2 เปอร์เซ็นต์ โดยผ่านการปรับแต่งผิวที่เวลาต่าง ๆ กัน

ตัวอย่างที่ \ เวลา	ค่าความต้านทานการดัดโค้ง (MPa)		
	5 นาที	10 นาที	20 นาที
1	81.9	81.1	80.7
2	79.7	76.8	85.6
3	85.3	78.7	79.7
4	80.4	83.4	83.2
5	84.2	83.7	83.8
6	83.2	84.5	85.3
7	79.3	82.3	84.8

ตารางที่ ข-12 ค่าความต้านทานต่อการดัดโค้งของผลิตภัณฑ์ประกอบแต่งพอลิเมทิลเมทาคริเลต ที่เสริมแรงด้วยเส้นใยขนาด 15 มิลลิเมตรปริมาณ 3 เปอร์เซ็นต์ โดยผ่านการปรับแต่งผิวที่เวลาต่าง ๆ กัน

ตัวอย่างที่ \ เวลา	ค่าความต้านทานการดัดโค้ง (MPa)		
	5 นาที	10 นาที	20 นาที
1	83.0	80.5	79.5
2	79.9	84.7	78.9
3	75.5	79.8	80.1
4	83.4	78.7	83.9
5	77.7	87.6	84.6
6	82.2	79.2	82.4
7	79.3	80.2	77.6

ภาคผนวก ค. องค์ประกอบของน้ำลายเทียม (Artificial Saliva, ภาควิชาเภสัชวิทยา,
คณะทันตแพทยศาสตร์, จุฬาลงกรณ์มหาวิทยาลัย)

Composition :

- Potassium Chloride BP 37.5 mg.
- Magnesium Chloride BP 30528 mg.
- Calcium Chloride BP 90972 mg.
- Dipotassium Hydrogen Phosphate USP 48.23 mg.
- Potassiumdihydrogen Phosphate NF mg.
- Sodium Fluoride BP 0.258 mg.
- Sodium Carboxymethylcellulose BP 0.38 g.
- Sorbitol BP 1.8 g.
- Sodium Benzoate 0.12 g.
- Carmoisine Water

ภาคผนวก ง. สมบัติเชิงกลของ Denture Base Plastic [19]

ตาราง ง-1 สมบัติเชิงกลของ Denture Base Plastic (PMMA)

Properties	Poly(methyl methacrylate)
Tensile Strength (MPa)	48.3 – 62.1
Compressive Strength (MPa)	75.9
Elongation (%)	1-2
Elastic Modulus (GPa)	3.8
Proportional Limit (MPa)	26.2
Impact Strength, Izod (kg m/cm notch)	0.011
Transverse Deflection (mm)	
At 3,500 g	2.0
At 5,000 g	4.0
Fatigue Strength (cycles at 17.2 MPa)	1.5×10^6
Recovery After Indentation (%)	
Dry	89
Wet	88
KHN (kg/mm^2)	
Dry	17
Wet	15

ภาคผนวก จ. คุณสมบัติของเส้นใยพอลิเอสเตอร์ [27]

ตาราง จ-1 คุณสมบัติของเส้นใยพอลิเอสเตอร์ชนิดต่าง ๆ

Properties	Polyester		
	Continuous		Staple
	Regular Tenacity	High Tenacity	
Tenacity, dry (g/denier)	2.8-5.6	6.8-9.5	2.4-7.0
Tenacity, wet (g/denier)	2.8-5.6	6.8-9.5	2.4-7.0
Tensile Strength (Thousands psi)	50-90	106-168	39-106
Elongation (% at break)	24-42	12-25	12-55
Elastic Recovery (% from elongation)	76/3	88/3	81/3
Stiffness (g/denier)	10-30	30	12/17
Toughness (g-cm)	0.4-1.1	0.5-0.7	0.2-1.1
Specific Gravity (g/cm ³)	1.38	1.39	1.38
Moisture Regain (%, 70°F, 65% RH)	0.4	0.4	0.4
Melting Temperature (°C)	250	250	250
Chemical Resistance	Good	Good	Good
Bleach Resistance	Resistance	Resistance	Resistance
Solvent Resistance	Excellent	Excellent	Excellent
Sunlight Resistance	Good	Good	Good
Abrasion Resistance	Excellent	Excellent	Excellent

ภาคผนวก ฉ. ค่ามาตรฐานของวัสดุฐานฟันปลอม

**AMERICAN NATIONAL STANDARD/
AMERICAN DENTAL ASSOCIATION
SPECIFICATION NO. 12**

DENTURE BASE POLYMERS

**Council on Scientific Affairs
American Dental Association
211 E. Chicago Avenue
Chicago, IL 60611**

REVISED AMERICAN NATIONAL STANDARD/AMERICAN DENTAL ASSOCIATION SPECIFICATION NO. 12 DENTURE BASE POLYMERS

Foreword

The Council on Scientific Affairs of the American Dental Association has reaffirmed this revision of American Dental Association Specification No. 12 for denture base polymers. This and other specifications for dental materials, instruments and equipment are being formulated by working groups of the Accredited Standards Committee MD156 for Dental Materials, Instruments and Equipment. The Council acts as the administrative sponsor of that committee, which has representation from all interests in the United States in the standardization of materials, instruments, and equipment in dentistry. The Council has adopted the specifications, showing professional recognition of their usefulness in dentistry, and has forwarded them to the American National Standards Institute with a recommendation that the specifications be approved as American National Standards. The American National Standards Institute granted approval of Revised ADA Specification No. 12 as an American National Standard in 1975 and subsequently reaffirmed on April 23, 1999.

The Council acknowledges, with thanks, the work of the working group members and their affiliations at the time the specification was developed: Gerhard Brauer (chairman), Dental Research Section, National Bureau of Standards, Washington, DC; George Cowperthwaite, Esschem Co., Essington, PA; Emery Dougherty, L.D. Caulk Co., Milford DE; Eugene Huget, Walter Reed Army Medical Research Institute, Washington, DC; Andrew Koran, School of Dentistry, University of Michigan, Ann Arbor; Robert McConnell, American Dental Association, Chicago, IL; E. Severn Olsen, Spooner, WI; William Sweeney, School of Dentistry, University of Alabama, Birmingham; Julian B. Woelfel, College of Dentistry, Ohio State University, Columbus; and Sheldon Winkler (secretary), School of Dentistry, State University of New York at Buffalo, Buffalo.

The major differences between the following revision and the previous specification are the inclusion of the pour resins; changes in the test for discoloration, packing plasticity test, and preparation of sorption-solubility specimens; and an added requirement for warnings.

**REVISED AMERICAN NATIONAL STANDARD/AMERICAN
DENTAL ASSOCIATION SPECIFICATION NO. 12
DENTURE BASE POLYMERS**

1. SCOPE AND CLASSIFICATION

1.1 Scope.

This specification is for denture base polymer of any of the following:

- a) poly(acrylic acid esters);
- b) poly(substituted acrylic acid esters);
- c) poly(vinyl esters);
- d) polystyrene;
- e) copolymers or mixtures of the foregoing.

1.2 Types and Classes.

Denture base polymer covered by this specification shall be of the following types, classes, and colors and specified:

- a) Type I polymer formed by external heating of monomer-polymer mixtures (heat-processed polymers);
- b) Class 1 powder and liquid including pour resins;
- c) Class 2 plastic cake;
- d) Type II polymers formed without external heating of the monomer-polymer mixtures (autopolymerized polymers);
- e) Class 1 powder and liquid;
- f) Type III thermoplastic resins to form the complete denture base.

2. APPLICABLE SPECIFICATIONS.

2.1 SPECIFICATIONS.

There are no other specifications applicable to this specification. (Copies of American Dental Association specifications may be obtained on application to the American Dental Association, 211 E. Chicago Avenue, Chicago, IL 60611).

3. REQUIREMENTS

3.1. Liquid

3.1.1 The liquids of Types I and II shall be clear and free of deposits or sediment.

3.1.2 Thermal Stability.

Liquids of Types I and II (1.2) shall not discolor or increase in viscosity by more than 10% when heated in the dark in a closed container at $60 \pm 2\text{C}$ for 48 hours.

3.2 Solid Components.

In all types and classes (1.2), the solid or semisolid components shall be free of extraneous material such as dirt or lint that could adversely affect the appearance or properties of the processed resin.

3.3 Monomer-polymer Mixture.

3.3.1 Preparation for Packing.

All types of resin shall be proportioned and mixed or prepared for packing according to the instructions accompanying the package (3.4.3) except when otherwise specified in this specification.

3.3.2 Packaging Plasticity.

Type I, II, and II, when subjected to the test described in 4.3.1.2, shall intrude into not less than two holes of the die to a depth of not less than 0.5 mm.

3.4. Processed denture Base Polymer.

3.4.1 Toxicity.

The manufacturer shall submit at the time of certification to the American Dental Association a statement that the denture base, produced according to the instructions accompanying the material, has no known toxic effect on the normal, healthy person, and that the ad-interim recommended standard practices for toxicity tests on dental materials Type II, class 7 (Guide to Dental Materials and Devices, ed 7, Chicago, American Dental Association, 1974, p 161) have been conducted. The instructions shall also include a caution against prolonged handling of the uncured mixture with bare hands and against inhalation of monomer vapor.

3.4.2 Denture Base Characteristics.

When processed according to 4.3.1.1, the denture base polymer shall possess the following characteristics:

3.4.2.1 Surface Characteristics.

When cured according to manufacturer's instructions, the material shall be nonporous and free from surface defects.

3.4.2.2 Polish.

The polymer shall present a smooth surface having a high gloss when polished by the conventional dental methods.

3.4.2.3 Color

Clear material shall be colorless. The specimen plate of clear polymer, formed as described in 4.3.5, shall be sufficiently transparent to read clearly this paragraph through the plate. Colored resin shall be evenly colored or mottled. The color and general appearance of the resin processed in an alginate tinfoil substitute lined mold and polished by conventional dental methods shall not differ from that of the resin processed in a tinfoil-lined mold and polished in a similar manner.

3.4.2.4 Translucency.

The specimen plate formed as described in 4.3.5, shall have a degree of translucency that will permit the shadow of an opaque object such as a metal disk of 10 mm diameter to be visible through it when the object and the specimen plate are placed at a distance of 50 cm from frosted electric light bulb (40 w).

3.4.2.5 Porosity.

The specimen plate cut as described in 4.3.5, shall show no bubbles or voids when viewed without magnification.

3.4.2.6 Sorption

The increase in weight of the polymer shall not be more than 0.8 mg/cm^2 of surface after immersion in water for seven days at $37 \pm 1\text{C}$, as described in 4.3.3.

3.4.2.7 Solubility.

The loss of weight of the polymer shall not be more than 0.04 mg/cm^2 of surface when tested as directed in 4.3.4.

3.4.2.8 Transverse Deflection.

The deflection of at least three of the five specimens, prepared as outlined in 4.3.5, shall comply with the requirements in Table 1 when tested in distilled water at $37 \pm 1\text{C}$.

3.4.2.9 Color Stability.

The polymer shall not show more than a slight change in color when tested as described in 4.3.6.

3.4.2.10 Working Qualities.

The polymer, when processed according to instructions furnished by the manufacturer (3.4.3), shall yield a satisfactory denture.

3.4.3 Manufacturer's Instructions.

Adequate and accurate instructions for storing, preparing, and processing the resin shall be provided.

These instructions shall accompany each package and shall be such that denture base molding can be carried out with the equipment generally available to the dental laboratory of the general practitioner. These instructions shall include as applicable: recommended condition of storage where shelf life is limited, power-liquid ratio, the time and procedure required to mix the material properly, time required for the material to reach the proper packing plasticity at $23 \pm 1\text{C}$, working time during which packing may proceed, the material used to prepare the mold (for example, gypsum or hydrocolloid), temperature of flask when the polymer is packed, the proper curing temperature, time to bring the flask to recommended curing temperature(s), time to hold at curing temperature, method of cooling flask, and time at which the denture may be deflasked. For Type III materials, the instructions shall include: the temperature of the resin preform prior to thermoforming, the thermoforming or molding temperature, the temperature of the mold, the materials used to prepare the mold (for example, gypsum), any separating materials or separating processes that are to be used, and other details significant for producing a satisfactory denture. Temperatures given shall be attainable with the equipment prescribed. The manufacturer's instructions shall conform to those specified in 4.3.2 for Type 1 polymer except for Type pour resins. In addition to the instructions given in 4.3.2 for Type I materials, the manufacturer may provide alternate techniques. If alternate techniques are given, data shall be submitted by the manufacturer at the time of certification showing that the polymer will meet the requirement of this specification when it is processed according to each of the alternate methods as well as according to the prescribed methods. The instructions for Type III materials may be in manual form available to the user on request. The manufacturer's instructions shall include a method for repairing the processed material.

4. SAMPLING, INSPECTION, AND TESTING PROCEDURES.

4.1 Sampling.

Sufficient material to make no less than ten dentures (ten units) be procured at retail by a member of the American Dental Association. This sample shall be forwarded in the original unopened package or packages to the American Dental Association, Council on Scientific Affairs, 211 E. Chicago Avenue, Chicago, IL 60611.

4.2. Inspection.

Visual inspection shall be used in determining compliance with the requirements outlined in 3.1, 3.2, 3.4.2.1, 3.4.2.2, 3.4.2.3, 3.4.2.4, 3.4.2.5, 3.4.2.9, 3.4.3, 5.1. and 5.2.

4.3 Physical Tests.

All equipment shall be conditioned and all tests shall be conducted at $23\pm 2C$ unless specified otherwise.

4.3.1 Mixing and Packing Characteristics.

4.3.1.1 Mixing

Type I, class 1 and Type II, class 1 polymers shall be mixed as directed in the instructions accompanying the package except that the mixing temperature shall be $23\pm 2C$. Unless otherwise specified in the instructions, the polymer separates cleanly from the walls of the glass mixing jar.

4.3.1.2 Packing Test.

The perforated brass die and glass plate approximately 5 mm thick and 60 mm² shall be conditioned to the packing temperature specified in the manufacturer's instructions (3.4.3) and held within $\pm 2.5C$ until the intrusion measurement is begun.

The packing test for Type I and Type II class 1 polymers excepting pour resins shall be started five minutes after the material reaches proper plasticity as specified in 4.3.2.1. An 8 to 10 g sample of resin shall be prepared in accordance with the manufacturer's instructions. At the recommended initial packing time, it shall be shaped to a thickness of approximately 5 mm and shall be placed on the die conditioned to the specified packing temperature in the environment prescribed by the manufacturer. The resin shall be covered with a sheet of polyethylene and immediately the glass plate and a 5-kg mass placed on top. Then minutes later the load shall be removed and the depth of intrusion into each hole should be measured to a precision of 0.1 mm before the material is stripped from the die. For Type I, pour resins, Type I class 2, and Type III materials, the perforated die shall be covered with a wax pattern approximately 2 mm thick. This assembly shall be invested, boiled out, packed, and processed according to conventional denture construction procedures recommended by the manufacturer. A postprocessing measurement shall be taken to determine whether two or more holes have been penetrated to the required depth.

4.3.2 Preparation of Test Specimens of Cured Polymer for Sorption, Solubility, Transverse Deflection, and Color Stability Tests.

For Type I and Type II resins packed in rigid molds, the flask shall be immersed in boiling water and then successively flushed with a biodegradable detergent solution and clear boiling water. After the mold has cooled until it can be held comfortably in the bare hand, it shall be painted with one or more coatings of undiluted alginate compound tinfoil substitute. Flasks for materials not requiring higher packaging temperatures will be conditioned one hour at a temperature of $23\pm 2^{\circ}\text{C}$ prior to packing. Preparing of molds for resins requiring warm or heated molds will be conducted according to the manufacturer's instructions. Specimens of Type I polymers shall be processed in accordance with the following schedule. Ten minutes after the proper plasticity as specified in 4.3.1.1 has been reached, the flaked specimen held in a flask clamp, shall be submerged in water $73\pm 1^{\circ}\text{C}$ for $1\frac{1}{2}$ hours and followed by immersion for 30 minutes in boiling water. When the heating schedule has been completed, the flask in the clamp shall be cooled in air at $23\pm 10^{\circ}\text{C}$ for 30 minutes or more and then immersed in water at $23\pm 10^{\circ}\text{C}$ for 15 minutes. Preparation of molds for the pour-type resins is according to the manufacturer's instructions. For Type II and Type III polymers, the manufacturer's instructions shall be followed.

4.3.3 Water Sorption.

The water sorption test shall be made in duplicate on disks 50 ± 1 mm in diameter and 0.5 ± 0.05 mm thick. These specimens shall be formed in a stainless steel-gypsum mold or a gypsum-duplicating material mold as may be appropriate. The gypsum cover surface for the mold shall be formed against a flat glass or metal surface for the mold shall be formed against a flat glass or metal surface to obtain a smooth, plain surface. The resin shall be introduced into the mold as prescribed by the manufacturer except that there shall be no trial packing which will be approximately 0.88 mm thick. Each specimen will then be reduced to tolerance by removing at least 0.15 mm from each surface by accepted metallographic hand or machine grinding procedures employing abrasive papers in successive grits of 120, 240, 400, and 600. An assembly for reducing the specimen thickness is shown in Figure 5. The abrasive papers shall be flooded with water during the grinding procedures. All surfaces of the disk shall be smooth, and the top and bottom shall be flat. The disks shall be dried in a desiccator containing thoroughly dry anhydrous calcium sulfate (CaSO_4) or silica gel (freshly dried at 130°C) at $37\pm 2^{\circ}\text{C}$ for 24 hours, removed to a similar desiccator at room temperature for one hour, then weighed with a precision of 0.2 mg. This cycle shall be repeated until the weight loss of each disk is not more than 0.5 mg in any 24- hour period. The disks shall then be immersed in distilled water at $37\pm 1^{\circ}\text{C}$ for seven days, after which time the disks shall be removed from the water with tweezers, wiped with a clean, dry hand towel until free from visible moisture, waved in the air for 15 seconds, and weighed one minute after removal from the water. The value for water sorption shall be calculated as follows for each disk: $[\text{mass after immersion (mg)} - \text{conditioned mass (mg)}] / \text{surface area (cm}^2\text{)}$.

The average of the determined values for the two disks shall be recorded to the

nearest 0.01 mg/cm². The final value (average of two determinations) shall be rounded to the nearest 0.1 mg.cm². If the final value falls midway between two numbers, the even number shall be recorded.

4.3.4 Solubility.

After the final weighing (4.3.3), the disks shall be reconditioned to constant weight in the desiccator at 37±2C as was done in 4.3.3.

The value for solubility shall be calculated as follows for each disk: [conditioned mass (mg) (4.3.3) - reconditioned mass (mg) (4.3.4)]/surface area (cm²) = solubility (mg/cm²).

The final value (average of two determinations) shall be rounded to the nearest 0.01 mg/cm². If the final value falls midway between two numbers, the even number shall be recorded.

4.3.5 Transverse Deflection Tests.

A specimen plate of polymer shall be processed in a gypsum mold as described in 4.3.2 or in a gypsum-duplicating mold. Specimens for the transverse test shall be machined from this plate to the dimensions shown be machined from this plate to the dimensions. The plate shall be sawed lengthwise into five equal strips with a bandsaw operated at a speed of approximately 100 M-min (328 feet/min). For Type II polymers the plate shall be not less than two days old prior to sawing. The strips may then be sanded slightly on the molded surfaces, if necessary, to remove imperfections. All subsequent strips shall be machined on both molded surfaces and the edges so that the dimensions are slightly oversize. Care should be taken to avoid overheating the specimen.

One preferred technique is to use a 50-mm diameter flycutter, operating at a spindle speed of approximately 1,800 rpm and at a table feed of about 15 cm/min. As an alternative, a slab mill or an end mill may be used. Rough cuts shall be approximately 0.08 mm deep, and finish cuts shall be 0.03 mm deep. The strips shall be mounted side by side in a vise and the edges machined parallel in order to remove all bandsaw marks.

The strips at this point shall be oversize in width. One or more strips shall be mounted in a vise and the faces milled to the required thickness (2.50±0.03 mm). All five strips shall then be clamped face to face in a vise and the edges milled to the required width (10.00±0.03 mm).

The specimens shall be stored in distilled water at 37±1C for 50±2 hours immediately before testing.

The specimen shall be mounted in an appropriate calibrated instruments capable of a

uniform loading rate and equipped with a device for measuring deflection within 0.01 mm at the center of the specimen. The loading nose and the two supports shall have highly polished cylindrical surfaces 3.2 mm in diameter and shall be parallel to within 0.1 mm over a 10-mm length. The distance between the centers of the supports shall be 50 ± 0.025 mm.

Time		Load		Dial Reading
Min	Sec	N	g	mm
0	00	14.71	1,500	A
0	30	14.71	1,500	
1	00	19.61	2,000	
1	30	19.61	2,000	
2	00	24.52	2,500	
2	30	24.52	2,500	
3	00	29.42	3,000	
3	30	29.42	3,000	
4	00	34.32	3,500	B
4	30	34.32	3,500	
5	00	39.22	4,000	
5	30	39.22	4,000	
6	00	44.13	4,500	
6	30	44.13	4,500	
7	00	49.03	5,000	C
7	30	49.03	5,000	
Deflection at 34.32N=B-A.				
Deflection at 49.03N=C-A.				

*Readings shall be made to the nearest 0.01 mm.

The loading nose shall be midway between the supports to within 0.025 mm. Means should be provided to prevent misalignment of the specimen on the supports.

The specimen shall be immersed in water during testing. An initial load, consisting of the free-moving parts of the apparatus plus sufficient lead shot to make a load of 14.71 N, shall be placed on the specimen. Each 4.90-N increment of shot shall be added at a uniform rate during the last 30 seconds of each minute. The schedule shown in Table 2 shall be used in applying the loads and in making the observations. The differences between the deflections at the initial load and at specified loads shall be taken as the deflections of the specimen. The recorded deflections shall be reported to the nearest 0.1 mm. The value for transverse deflection shall be reported as the average of three or more specimens from a lot of five. If the determined value falls midway between two successive numbers, the even number shall be recorded.

4.3.6 Color Stability.

The color stability test shall be made on a disk 50 ± 1 mm in diameter and 0.5 ± 0.05 mm thick. The specimens used in the water sorption and solubility tests 4.3.3 and 4.3.4 shall be employed. The disks shall be cut in halves. One half shall be exposed to the radiation of a lamp with an S-1 bulb (6.2) which has been in use not less than 50 nor more than 400 hours. This light source (S-1 bulb), rated at 400 w, shall be a combination tungsten-filament mercury arc enclosed in glass which filters out ultraviolet light below 280 nm. The specimen shall be carried on an aluminum disk which shall be centered under the S-1 bulb resting on a turntable operating at 33 rpm. The specimen shall be held by screws approximately 5 mm above the disk and

12.7 cm from the center and shall be maintained between 60 and 65C. The plane of the top surface of the specimen shall be 17.8 cm from the bottom of the S-1 bulb. After exposure for 24 hours, the exposed specimen half, compared with the unexposed specimen half, shall not show more than a slight change in color (perceptible with difficulty). The comparison shall be made by visual inspection in north sky daylight.

5. PREPARATION FOR DELIVERY.

5.1. Packaging.

The material shall be supplied in properly sealed containers made of materials which shall not contaminate or permit contamination of the contents.

5.2 Markings.

5.2.1 Lot Numbers.

Each immediate container of material shall be marked with a serial number or a combination of letters and numbers that shall refer to the manufacturer's records for that particular lot or batch.

5.2.2 Date of Manufacture

The date or dates of manufacture (year and month) shall be given on the unit package either as a separate item or as a part of the lot number(s) (5.2.1). If no unit package is used, the date of manufacture will be given on the immediate container(s).

5.2.3 Net Weight and Volume.

The minimum weight in grams of powder and the minimum net volume in milliliters of liquid shall be given in legible type on the container. When the term "unit" is used as a designation, it shall represent not less than 21 g of powder and a sufficient volume of liquid to combine with the powder when mixed according to the manufacturer's instructions.

5.2.4 Type, Class, and Color.

The type, class, and color (1.2) of polymer shall be indicated on all containers.

5.2.5 Caution

Toxic, hazardous, inflammable, or irritating characteristics associated with the handling of the components of the uncured mix shall be indicated on the container.

6. NOTES.

6.1 Specific Information.

Sources of testing equipment, information on certification submission for denture base polymers, and other details may be obtained from the Council on Dental Materials and Devices, American Dental Association, 211 E. Chicago Avenue, Chicago, IL 60611. Manufacturers of Type III and pour-type materials shall provide free of charge any special equipment on loan which may be required to test their products.

"Tinfoil substitute," whenever it appears in this specification, shall refer to a simple solution of sodium polyalginate in water. One percent of a bacterial stabilizer may be added.

6.2 Source of Ballast and Bulb for Color Stability Test (4.3.6).

Ballast, Catalog no 9T64Y4008 is available from General Electric Co., Fort Wayne, IN.

Gates S-1-400 Mercury Lamp Assembly includes aluminum oxidized reflector with upright and crossarm supports and connecting joint; autotransformer for S-1 sunlamp and S-1 Mercury Lamp (replacements for S-1 sunlight lamp bulb are also available). George W. Gates & Co., P.O. Box 216, Hempstead Turnpike and Lucille Avenue, Franklin Square, Long Island, NY 11010.

6.3 Conversion Factors.

25.4 mm = 1 inch

$(^{\circ}\text{C} \times 1.8) + 32 = ^{\circ}\text{F}$.

453.59 g = 1 lb.

1 N = 0.102 kgf = 0.225 lbf.

1 MN/m² = 10.2 kgf/cm² = 145 psi.

Table 1 Transverse deflection

Load increment		Deflection, mm	
N	G	Min	Max
14.7 – 34.3	1500 – 3500	---	2.5
14.7 – 49.0	1500 – 5000	2.0	5.5

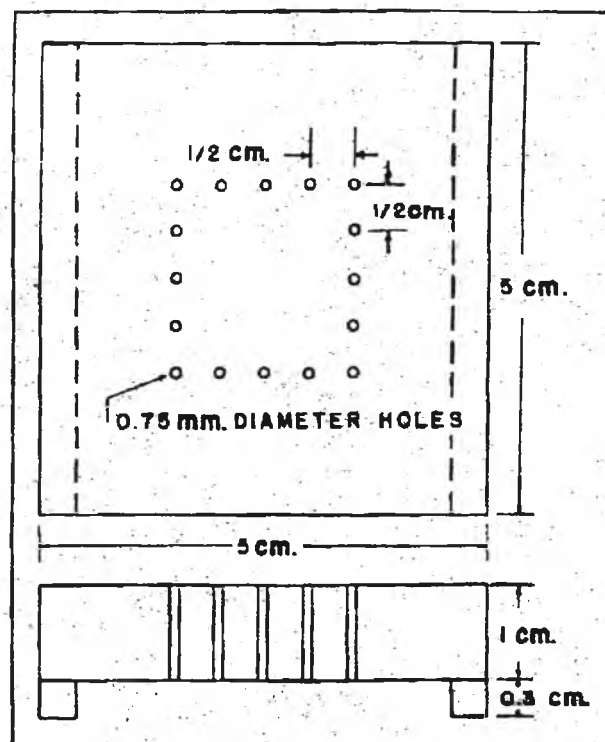


Fig 1 a. Brass die for packing test.

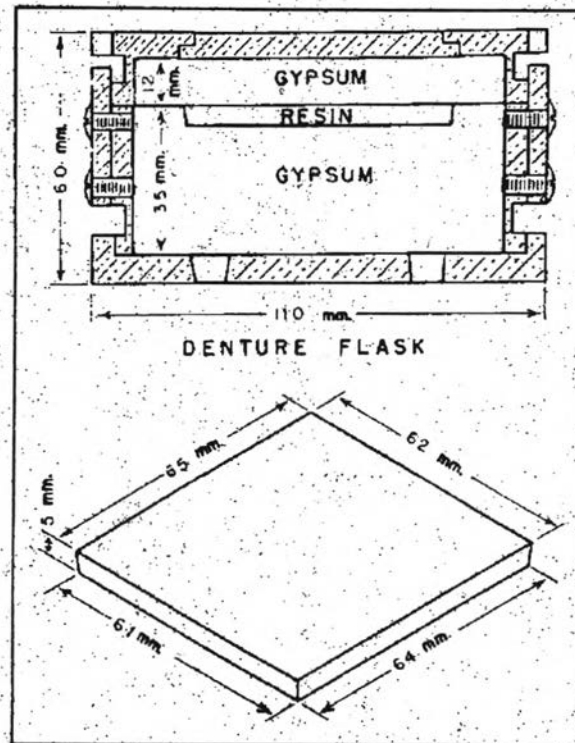


Fig 2 ■ Denture flask and specimen plate.

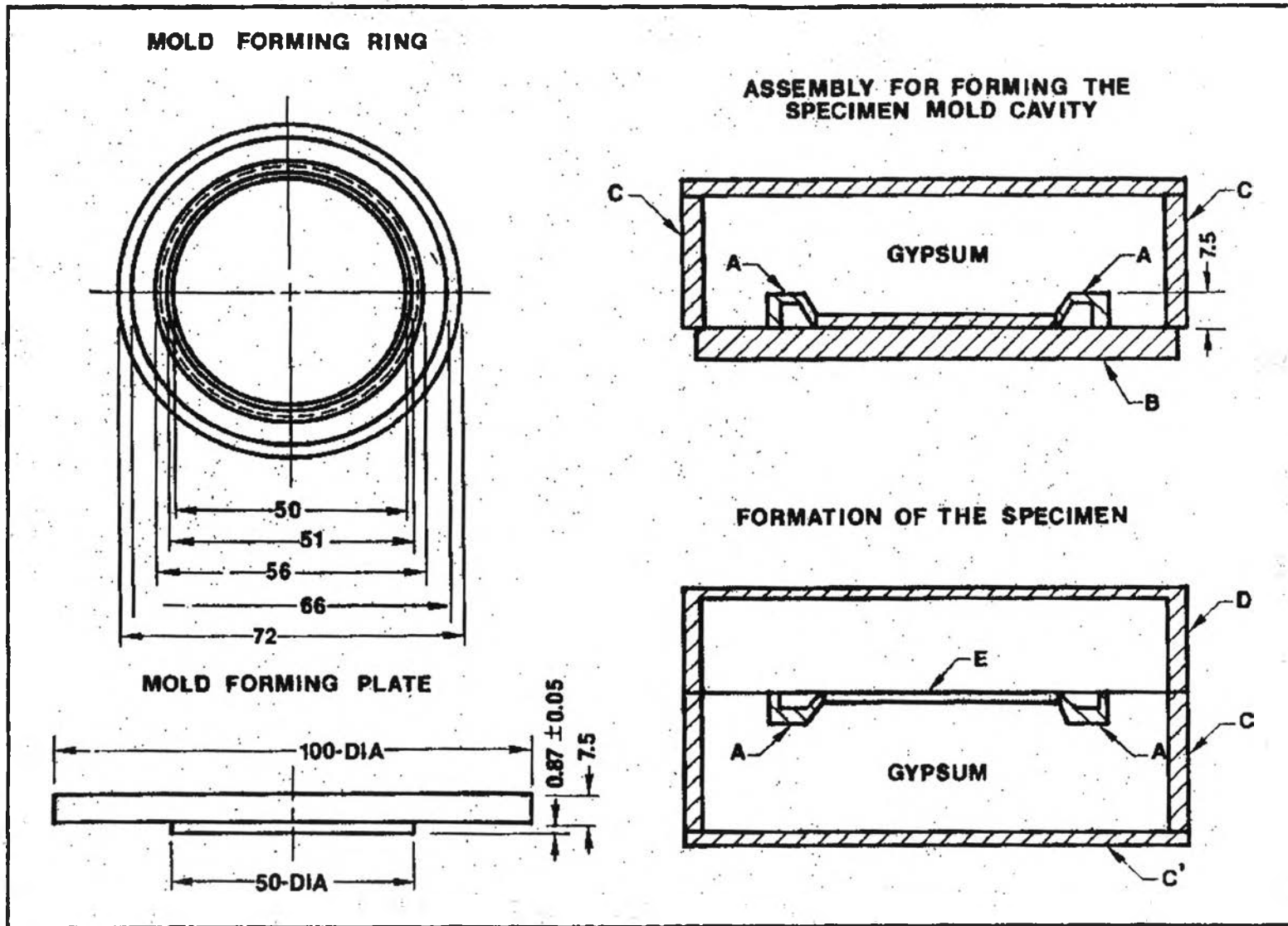


Fig 3 ■ System for forming sorption-solubility disks from heat-processed resins. A, mold forming ring; B, mold forming plate; C, upper half of denture flask; D, lower half of denture flask; E, specimen. Mold forming ring and plate of stainless steel. All dimensions in millimeters.

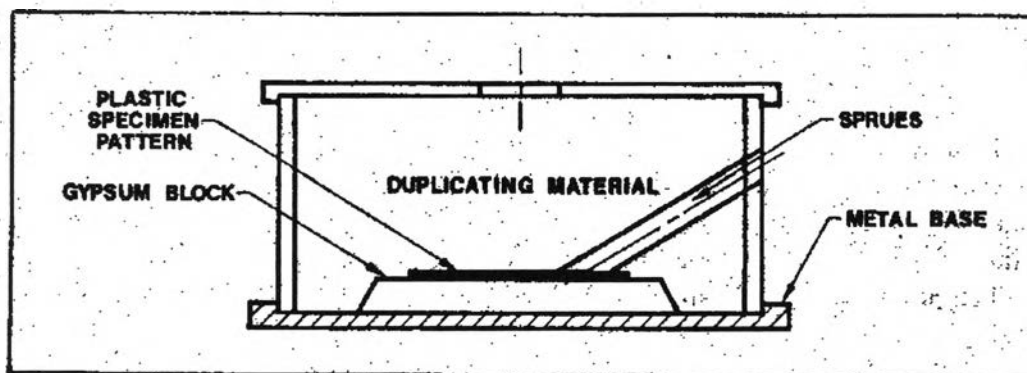


Fig 4 ■ System for forming sorption-solubility specimen disks (4.3.3) and transverse deflection specimen plates (4.3.5) from pour (fluid) resins in flexible molds.

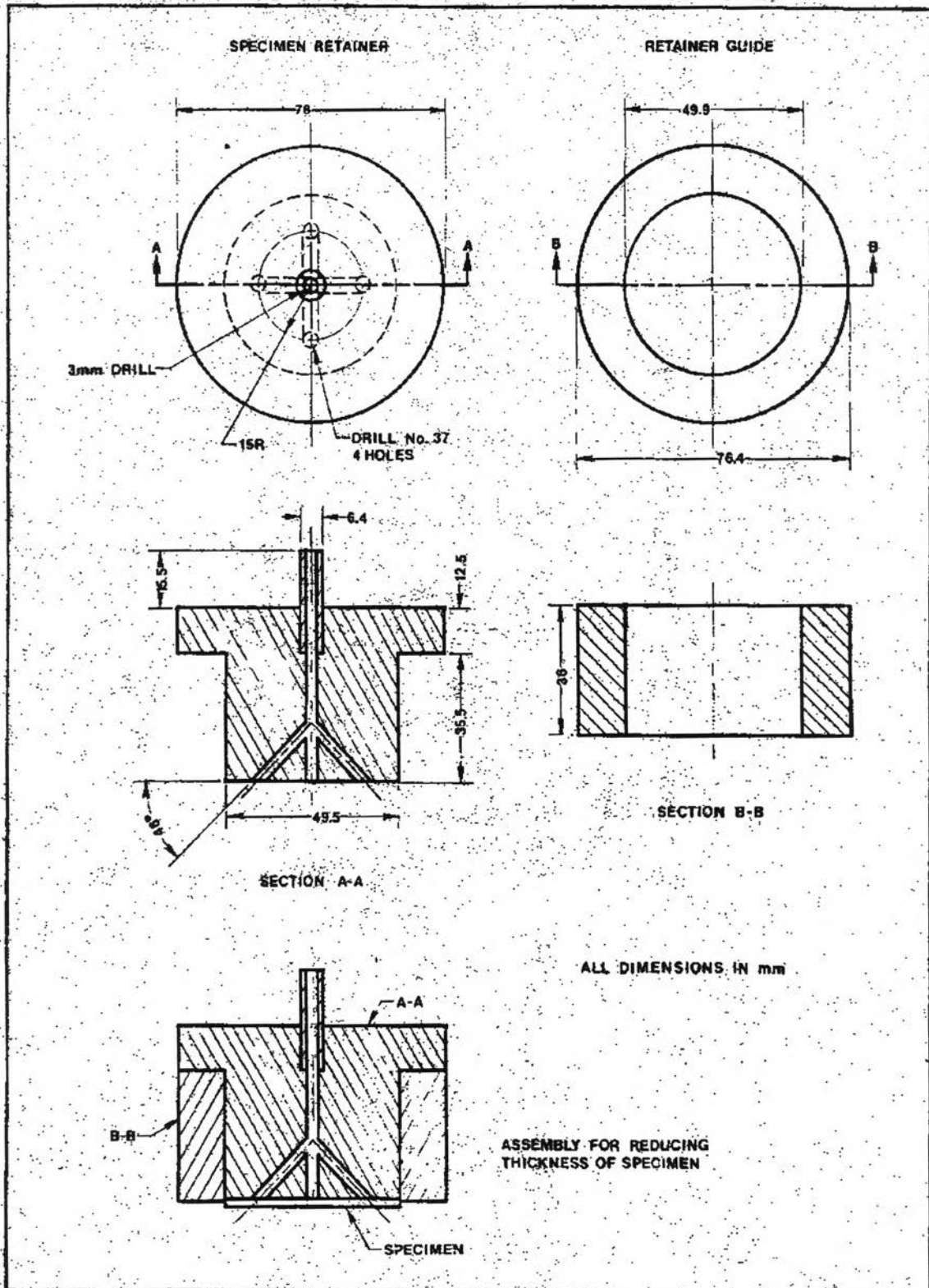


Figure 5. Assembly for holding specimen during deduction for thickness. Specimen retainer of brass. Retainer guide of stainless steel. All dimensions in millimeters.

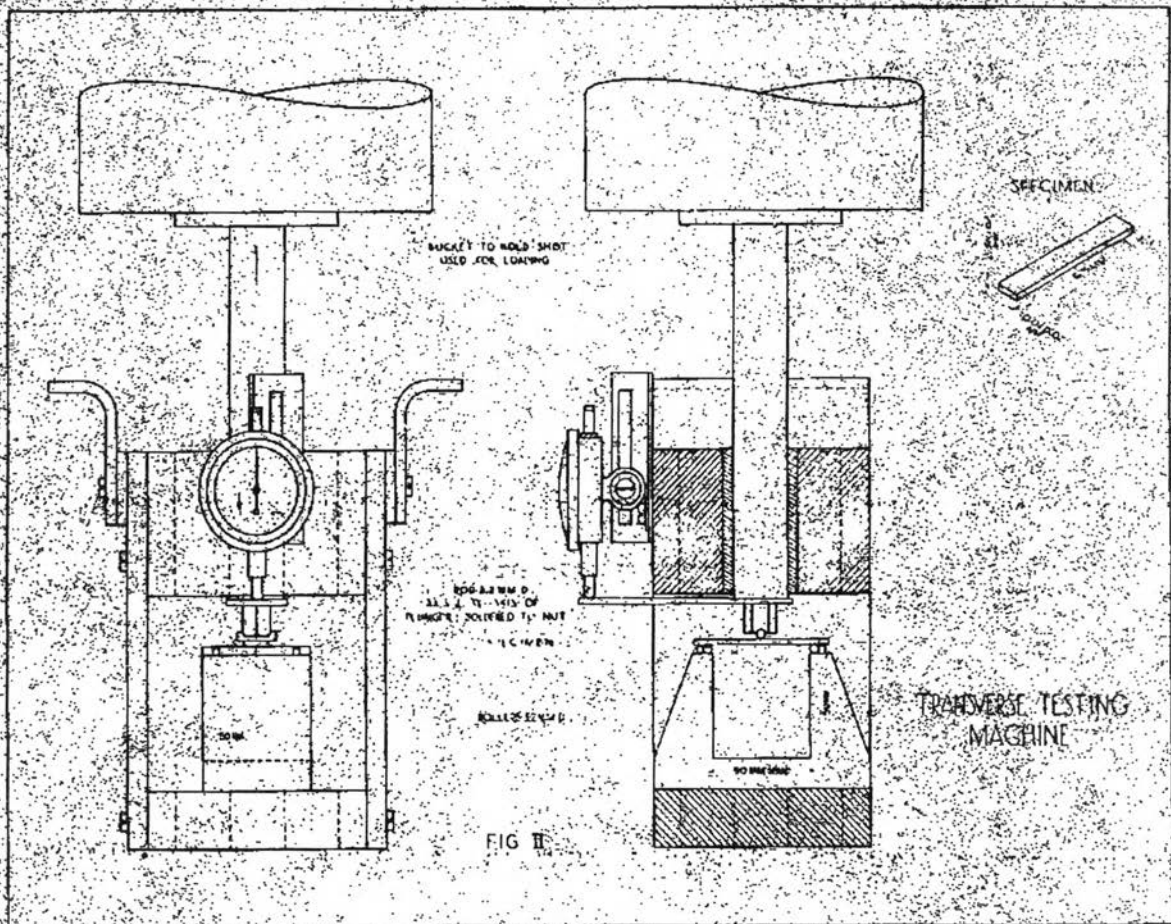


Fig 5 - Transverse testing machine.

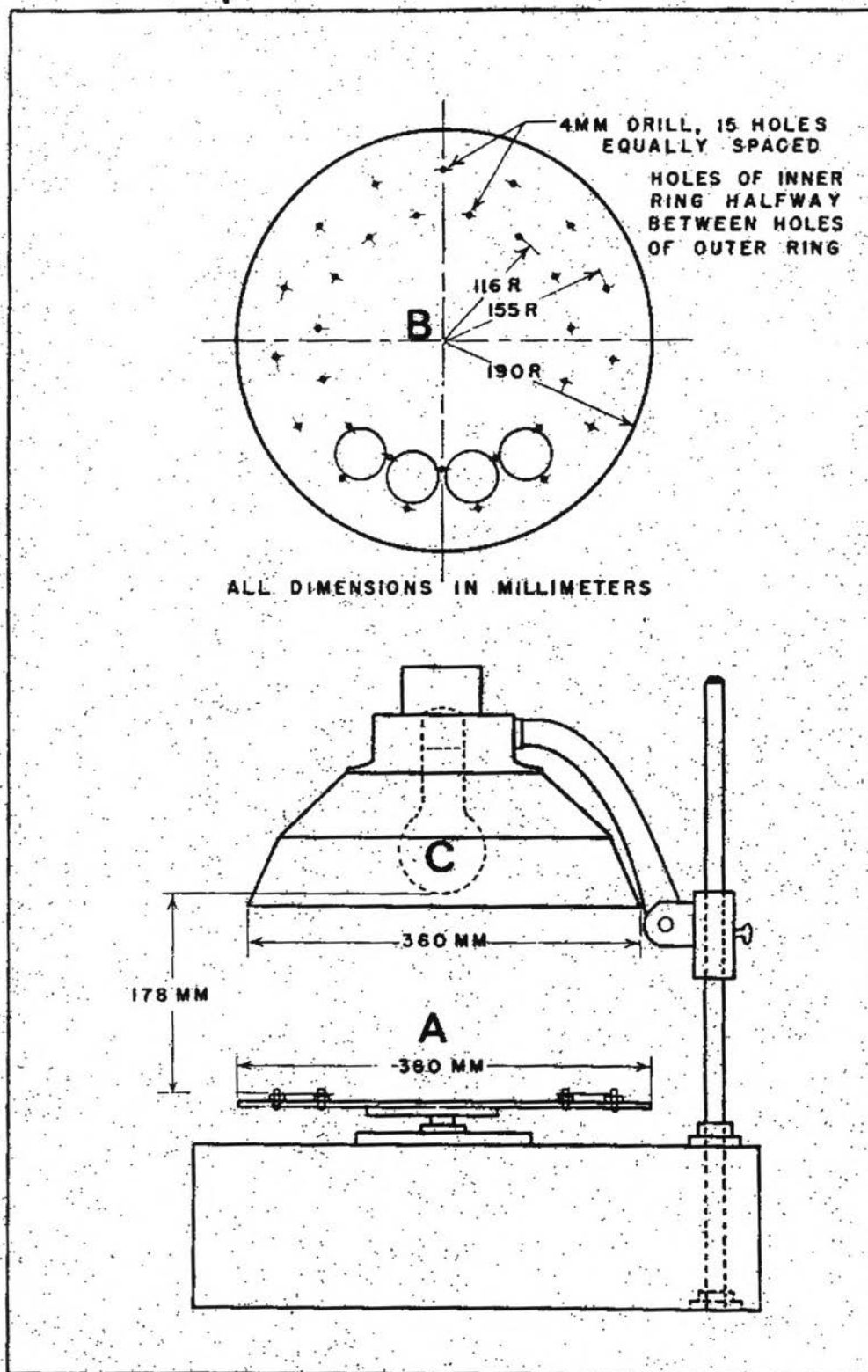


Fig 7 ■ Lamp to test for color stability. A, turntable; B, top view of turntable with specimens in place; C, S-1 bulb.

ประวัติผู้เขียน



ชื่อ นาย นิรุต ครามแสง

เกิด 28 กันยายน พ.ศ. 2514

การศึกษา

พ.ศ. 2534 : สำเร็จการศึกษาในระดับปริญญาตรี วิทยาศาสตร์บัณฑิต สาขา เคมี จากคณะวิทยาศาสตร์ สถาบันเทคโนโลยีพระจอมเกล้า ธนบุรี

พ. ศ. 2535 - 2536 ทำงานที่บริษัท ชุมพร เคมีคอล จำกัด

พ. ศ. 2536 - 2540 ทำงานที่บริษัท โกลู เคมีคอล จำกัด

พ. ศ. 2540 เข้าศึกษาในระดับปริญญาโท หลักสูตรวิศวกรรมศาสตรมหาบัณฑิต สาขาวิศวกรรมเคมี ภาควิชาวิศวกรรมเคมี คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย