

PAINT TESTING MANUAL

**Physical and Chemical Examination of
Paints, Varnishes, Lacquers, and Colors**

Gardner/Sward

THIRTEENTH EDITION • 1972

STP 500



AMERICAN SOCIETY FOR TESTING AND MATERIALS

PAINT TESTING MANUAL

Physical and Chemical Examination of
Paints, Varnishes, Lacquers, and Colors

G. G. Sward, editor

Thirteenth Edition—1972

ASTM SPECIAL TECHNICAL PUBLICATION 500

List price \$27.50

04-50000-14



AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race Street, Philadelphia, Pa. 19103

© by American Society for Testing and Materials 1972
Library of Congress Catalog Card Number: 75-186850

NOTE

The Society is not responsible, as a body,
for the statements and opinions
advanced in this publication.

Printed in Lutherville-Timonium, Md.
June 1972



To

Dr. Henry A. Gardner

*whose vision and interest in developing
and sharing knowledge of paint materials
has endured for more than a half century*

Preface to the Thirteenth Edition

When the twelfth edition of this book came off the press in 1962, its authors believed that their work was done. Others would henceforth take over—new faces, a new generation, new approaches.

But Dr. John C. Weaver had the idea that the work started by Dr. Henry A. Gardner should live on and grow. All it needed was a permanent sponsor. And this sponsor, he thought, should be the American Society for Testing and Materials, in which Dr. Gardner had been very active. The Society agreed, and in a brief but historic ceremony at the January 1967 meeting of Committee D-1 in Washington, D.C., ownership of the Gardner-Sward Handbook was transferred from the Gardner Laboratory to the American Society for Testing and Materials.

In accepting the gift, the Society assumed responsibility for revising, editing, and publishing future editions of this time-honored work. The project was assigned to Committee D-1 on Paint, Varnish, Lacquer, and Related Materials, who created a permanent subcommittee (Subcommittee 19 on the Gardner-Sward Handbook) to guide the policy and preparation of future editions. A. Gene Roberts was appointed chairman of this working committee which included Harold M. Werner and Mark W. Westgate, with the three officers of Committee D-1, J. C. Moore, J. C. Weaver, and W. A. Gloger, as ex-officio members. George G. Sward who had coauthored most of the previous editions, was selected to be the editor. The thirteenth edition attests to the dedication with which this subcommittee and the contributing authors accomplished their task.

The scope of this book is in keeping with the stated scope of Subcommittee 19: "To provide technical, editorial, and general policy guidance for preparation of the 13th and subsequent editions of the Gardner-Sward Handbook. The Handbook is intended to review for both new and experienced paint technologists the past, present, and foreseeable trends in all kinds of testing within the scope of Committee D01. It supplements, but does not replace, the pertinent parts (currently parts 20 and 21) of the ASTM Book of Standards. It describes briefly and critically all test methods believed to have significance in the world of paint technology, whether or not these tests have been adopted officially by the Society."

As a general policy, in accordance with the above scope, standard methods that are described in detail in the ASTM Book of Standards are reviewed here only in sufficient detail to indicate the principle of operation, basic techniques and apparatus, area of usefulness, and a critique where appropriate. Test methods of particular merit and importance other than ASTM standard methods are described in greater detail.

Methods of limited usefulness or of largely historical interest are described only briefly. References to original or detailed sources of information are given wherever possible. The overall treatment, while not exhaustive, is sufficiently comprehensive to provide the paint technologist with a broad and critical guide to the selection of appropriate test methods.

A special debt of gratitude is due the authors who, without remuneration and often at a great sacrifice of personal time, contributed the material that made this work possible. Thanks are due also to those organizations that allowed authors to use company time for some of the writing, to contributors of photographs or drawings, and to the reviewers. The editor and the chairman appreciate the helpful interest of the ASTM publications staff.

G. G. Sward
Editor

A. G. Roberts
Chairman Subcommittee 19
ASTM Committee D01

Biographical Profiles



Leonard C. Afremow, M.S. University of Wisconsin. Chapter 10.10, Nuclear Magnetic Resonance Spectroscopy. Manager, Industrial Research, DeSoto, Inc., which he joined in 1961. Fields of interest include infrared analysis, nuclear magnetic resonance spectroscopy, gas chromatography, and chemical functional group analysis. Member of American Chemical Society, Society of Applied Spectroscopy, and Chicago Society for Paint Technology.



James A. Boylan. Chapter 6.2, Chemical Resistance. Manager, retired, Customer Service Laboratory, Oxy-Metal Finishing Group, Parker Co. For over forty years active in corrosion testing and surface treatment of metals. Member of American Society for Testing and Materials Committee D01 (honorary) and Detroit Society for Paint Technology.



Herbert Barry, B.S. Queens College. Chapter 8.9, Paint for Marine Environment. Group Leader, Maintenance and Marine Coatings Laboratory, Mobil Chemical Co. For eleven years engaged in development and evaluation of coatings for use in marine environments. Member of National Association of Corrosion Engineers and New York Society for Paint Technology.



George E. F. Brewer, Ph.D. University of Vienna. Chapter 8.10, Paint for Electrocoating. Staff Scientist, Manufacturing Center, Ford Motor Co. Initiated development of Ford electrocoating process and has published over 20 papers in this field. For these and other "outstanding contributions to automotive chemistry" awarded the 1969 Midgely Medal by the Detroit Section of the American Chemical Society.



Harvey W. Berger, B.S. City College of New York. Chapters 10.7, Polarography; 10.8, Constant-Current Coulometry; and 10.9, Differential Thermal Analysis. Chemist, National Bureau of Standards, engaged in the development of test methods and analytical procedures for paint. Currently, Manager, HUD/NBS Project on Detection and Elimination of Lead Poisoning Hazard to Children. Other assignments have included flammability of fabrics and effects of pollutants on building materials.



Harry Burrell, Ch.E. Newark College of Engineering. Section on Solubility Parameter Systems in Chapter 2.7, Solvents. Technical Director, Building and Industrial Products, Inmont Corp. Fields of interest include entropy, solubility parameters, and high polymers. Recipient of first prize, Room Foundation Competition (twice), George B. Heckel Award, and first recipient of American Chemical Society Award in the chemistry of plastics. Member of New York Society for Paint Technology, Paint Research Institute, and Gordon Research Conference on Organic Coatings.



Richard A. Bieneman, B.S. University of Michigan. Seamless Floors in Chapter 8.6, Tile-Like Coatings and Seamless Floor Testing. Manager, Chemical Products Department, Spencer Kellogg Division, Textron, Inc. Fields of interest include sealants, seamless flooring systems, and urethane elastoplastics. Has published papers on vegetable oils, universal tinting vehicles, and water-thinned paint. Member of American Society for Testing and Materials Committee D01, Society of the Plastics Industry, and Western New York Society for Paint Technology.



Edward M. Corcoran, M.Ch.E. College of City of New York. Chapters 5.1, Hardness and Related Properties; and 5.3, Adhesion. Associate Member, Technical Staff, Bell Telephone Laboratories, responsible for formulation, development, and testing of organic coating systems. Chairman of Group 14 on Hardness, Abrasion, and Mar Resistance of American Society for Testing and Materials Committee D01.23.



Ellsworth R. Blosser, B.A. Goshen College. Chapter 10.6, Mass Spectrometry. Associate Chief, Environmental and Materials Characterization Division, Battelle Memorial Institute. Twenty years developing techniques for trace detection in inorganic research materials, and application of optical emission spectrography, mass spectrometry, and spark-source mass spectrography to varied problems. Present interest, ion microanalysis.



James K. Duffer, M.S. Illinois Institute of Technology. Chapter 10.5, Atomic Absorption and Flame Emission Spectroscopy. Senior Chemist, Research Service Department, DeSoto, Inc. Currently engaged in applying techniques of atomic absorption and flame emission spectroscopy to problems in the paint industry.



William H. Ellis, B.S. Stanford University. Chapter 2.7, Solvents. Supervisor, Solvents Research and Technical Service, Chevron Research Co. Author of many papers and patents in petroleum and related fields. Member of American Chemical Society, American Association for the Advancement of Science, and Los Angeles Society for Paint Technology (President 1971-1972).



George G. Esposito, B.S. Loyola College of Baltimore. Chapter 10.2, Chromatography. Research Chemist, Aberdeen Proving Ground. Main interest is research in and development of analytical procedures for military paint specifications, specializing in chromatography. Has published over 20 papers on chromatography.



Robert M. Evans, Ph.D. Case Western Reserve University. Chapter 8.6, Tile-Like Coatings and Seamless Floor Testing. Vice-President for Research and Engineering, Mameco International; President, Isonetics, Inc. Fields of interest include organic coatings, adhesives, sealants, and floor materials. Author of many papers and patents. Chairman of American Society for Testing and Materials Committee D01.48 on Tile-Like Coatings and member of Cleveland Society for Paint Technology.



Edwin C. Gallagher, B.Sc. Cornell University. Chapter 2.1, Drying Oils. Production Manager, and Director of Development and Research Laboratories, NL Industries, which he joined in 1931. Chairman of American Society for Testing and Materials Committee D01.2 on Drying Oils and member of Philadelphia Society for Paint Technology.



David M. Gans, Ph.D. University of Chicago. Chapter 3.3, Surface Energetics. Director, Coatings Research Group, Inc., a nonprofit organization of medium-size paint manufacturers. Fields of interest have included nuclear disintegration, surface chemistry, coatings, and allied areas. Member of American Society for Testing and Materials, American Institute of Chemists, Cleveland Society for Paint Technology, and other scientific and technical societies.



Neil B. Garlock, M.S. University of Texas. Chapters 7.1, Natural Weathering; and 7.2, Artificial Weathering. Chemist, Naval Ship Engineering Center. Field of interest includes specifications for paint and related products. For many years Chairman of American Society for Testing and Materials Committee D01.27 on Accelerated Weathering; and member of American Chemical Society, National Association of Corrosion Engineers, and Baltimore Society for Paint Technology.



Charles Grenko, B.S. Northwestern University. Chapter 4.1, Preparation of Films for Test. Western Electric Co., Hawthorne Works. His work has included design and installation of organic finishing systems, test methods, formulation, materials engineering, specifications, and electroplating. Currently installing a powdered resin coating system. Chairman of Group 11 on Film Thickness of American Society for Testing and Materials Committee D01.23; and member of American Chemical Society and American Electroplaters Society.



George W. Grossman, B.S. in Engineering Administration, Case Institute of Technology. Chapter 6.1, Resistance to Water Vapor and Liquid in the Atmosphere. President, Q-Panel Co. Principal fields of interest include influence of steel surfaces on paint performance, and destructiveness of water and ultraviolet radiation on paint. Chairman of Group 11 on Water Tests of American Society for Testing and Materials Committee D01.27; and member of National Association of Corrosion Engineers and Cleveland Society for Paint Technology.



Russel D. Hamilton, B.S. Northwest Missouri State College. Chapter 8.10, Paint for Electrocoating. Project Engineer, retired, in charge of Paint Development and Testing Laboratory, Manufacturing Center, Ford Motor Co. Member of American Society for Testing and Materials Committee D01 and past chairman of several subcommittees.



Harry K. Hammond, III, B.S. Lehigh University. Chapters 1.1, Color and Light; and, 1.2 Gloss. Chief, Product Appearance Laboratory, National Bureau of Standards, which he joined in 1939. Chairman of American Society for Testing and Materials Committee D01.26 on Optical Properties from 1957 to 1970; currently chairman of Committee E-12 on Appearance of Materials; and member of Optical Society of America, Illuminating Engineering Society, and U.S. National Commission of International Commission on Illumination (CIE).



Arthur E. Jacobsen, M.S. Polytechnic Institute of Brooklyn. Chapter 3.4, Particle Size Measurement. Research Chemist, retired, Titanium Division, NL Industries. Presently, Consultant. Principal fields of interest have included physical chemistry of paints and pigments, embracing hiding power, tinting strength, particle size, dispersion, weathering, photochemical reactivity, and chalking. Member of American Society for Testing and Materials Committee D01 (honorary), American Chemical Society, and Optical Society of America.



Thomas J. Keane, studied architecture and physics at Catholic University of America. Chapter 1.1, Color and Light. Manager, Manufacturing, Gardner Laboratory, Inc. Prime interest is development of instruments for measuring color, gloss, and the like.



W. T. Lewis, M.S. University of Georgia. Chapters 10.3, Ultraviolet Spectroscopy; and 10.4, Infrared Spectroscopy. Research and Development Laboratory, Mobil Chemical Co. Sixteen years industrial experience in spectroanalytical techniques, primarily in the area of polymers and coatings.



Wesley K. Lind, M.S. University of New Hampshire. Chapter 10.1, Microscopy. Teacher, Chicago High School System. Experience includes paint formulating and microscopical work as Senior Research Chemist with W. C. McCrone Associates. Member of Microscopical Society of Illinois and educational societies.



Robert F. Lohr, B.A. Rutgers University. Chapter 8.9, Paint for Marine Environment. Technical Director, Maintenance and Marine Coatings Department, Mobil Chemical Co. For 14 years associated with development of heavy duty industrial and marine coatings. Member of American Society for Testing and Materials, National Association of Corrosion Engineers, and New York Society for Paint Technology.



Howell H. McCowen, B.A. University of Cincinnati, Chapter 8.7, Bituminous Coatings. Senior Research Chemist, Standard Oil Co. (Ohio). Thirty three years in asphalt and petroleum technology, research, and service. Member of American Society for Testing and Materials Committee D-8 on Bituminous and Other Organic Materials for Roofing, Waterproofing, and Related Building or Industrial Uses; Association of Asphalt Technologists; and Roof Coating Committee of National Paint, Varnish, and Lacquer Association.



James D. McGinness, B.A. University of Evansville. Chapter 9.1, Sampling, Separations, and Identification of Binder and Solvent. Manager, Reliability for Coatings Group, Sherwin-Williams Co. Chairman of Group 4 on Analysis of Whole Paint of American Society for Testing and Materials Committee D01.21; and member of Society for Applied Spectroscopy and Cleveland Society for Paint Technology.



John P. McGuigan, B.S. New York University. Chapter 3.2, Viscosity and Consistency. Senior Technologist, Industrial Chemical Division, Shell Chemical Co. Chairman (1957-1968) of American Society for Testing and Materials Committee D01.23 on Physical Properties of Liquid Paint; and member of Houston Society for Paint Technology and Washington Paint Technical Group.



Parker B. Mitton, B.S. Newark College of Engineering. Chapters 1.3, Hiding Power; and 1.4, Mass Color and Tinting Strength. Associate, Research and Development Laboratory, Titanium Pigment Division, NL Industries, in charge of tests on titanium pigments. Joined company in 1948. Member of American Society for Testing and Materials Committee D01.



L. G. Montague, B.S. George Washington University. Chapter 8.1, Tests on Varnish. Chemist, Quality Control Laboratory, Gardner Laboratory, Inc. Thirty years in varnish formulation, processing, and control, ten years in development of instruments and methods of test for paints and related materials. Author of chapter on varnish in *Characterization of Coatings* by Myers and Long.



M. B. Neher, Ph.D. Purdue University. Chapter 10.6, Mass Spectrometry. Technical Representative, Organic Chemistry Division, Battelle Memorial Institute. Twenty years in organic chemical research. Past ten years have been concentrated in gas chromatography and mass spectrometry, and application of computer technique to organic analytical problems.



Thomas E. Nevins, M.S. Northwestern University. Chapter 8.3, Cement-Base Paint and the Painting of Masonry. Manager, Paint and Coatings Research, United States Gypsum Company Research Center. In active research in water-thinned coatings since 1953. Active in many subcommittees of American Society for Testing and Materials Committee D01 and member of Chicago Society for Paint Technology.



Charles T. Ray, B.S. Berry College. Chapter 8.11, Printing Ink. Technical Director, U.S. Government Printing Office, which he joined in 1948. Member of American Society for Testing and Materials Committee E-12, American Chemical Society, Technical Association of Graphic Arts, Technical Association of Pulp and Paper Industry, and other scientific societies.



Horace E. Riley, B.S. Marietta College. Chapter 2.6, Plasticizers. Staff Chemist, retired, Union Carbide Corp., Chemical and Plastics Operation Division. Member of American Society for Testing and Materials Committees D01 and D-16 (honorary), American Chemical Society (emeritus), and American Institute of Chemists (fellow emeritus).



A. Gene Roberts, B.S. University of Richmond. Chapter 5.2, Abrasion Resistance. Physical Scientist, National Highway Traffic Safety Administration, in charge of Test Method Development. Twenty years in research and development of organic coatings at National Bureau of Standards. Inventor of Jet Abrader and Adherometer-Integrator. Awarded Bronze Medal of Department of Commerce for the book *Organic Coatings—Their Properties, Selection, and Uses*. Member of American Society for Testing and Materials and American Chemical Society.



Richard T. Ross, Ph.D. University of Tennessee. Chapter 6.4, Biological Deterioration of Paints and Paint Films. Marketing Manager, Buckman Laboratories; previously, Research Manager. Principal research involved the biodeterioration of paint films and the development of microbiocides for paint. Chairman of American Society for Testing and Materials Committee D01.28 on Biodeterioration.



Garmond G. Schurr, B.S. North Dakota State University. Chapters 5.4, Flexibility; and 5.5, Tensile Strength and Elongation. Director, Paint Research, Sherwin-Williams Co., since 1966. Publications include papers on house paints, role of coatings in corrosion prevention, and diffusion of water in coating systems. Member of American Society for Testing and Materials, Gordon Research Conferences on Coatings, and Chicago Society for Paint Technology.



Francis Scofield, B.S. Lehigh University. Chapter 7.3, Atmospheric Pollutants. Consultant. Vice-President, Technical Affairs, retired, National Paint, Varnish, and Lacquer Association, which he joined in 1936. Author of numerous technical papers. Member of American Society for Testing and Materials Committee D01, Baltimore Society for Paint Technology, and other scientific and technical societies.



Willard F. Spengeman, Ph.D. University of Wisconsin. Chapter 2.8, Pigments. Director, Technical Service Laboratory, Pigments Department, duPont Co. Author of numerous papers on the role of pigments in the weathering of exterior architectural paints. Active in American Society for Testing and Materials Committee D01.



Melvin H. Swann, B.A. Asbury College. Chapter 2.4, Synthetic Resins. Chief, Analytical Section, U.S. Army Coating and Chemical Laboratory, Aberdeen Proving Ground. Responsible for research and development in the analysis and application of paints and related materials, including metal conditioners and phosphate coatings. Has published over 50 papers in these fields. Member of American Society for Testing and Materials Committee D01.



G. G. Sward, M.S. University of Iowa. Chapters 2.2, Driers and Metallic Soaps; 2.3, Natural Resins; 2.5, Cellulosics; 3.1, Density, Specific Gravity, and Bulking Values; 3.4, Particle Size Measurement; 3.5, Oil Absorption of Pigments; 4.3, Drying Time; 7.2, Artificial Weathering; 8.2, Architectural Paints; 8.4, Waxes and Polishes; 8.5, Putty, Glazing Compounds, Caulking Compounds, and Sealants; 8.8, Traffic Paint; 11.1, Sources of Specifications. Director, retired, Scientific Section, National Paint, Varnish, and Lacquer Association. Consultant, Gardner Laboratory, Inc. Coauthor of recent editions of this book. Member of American Society for Testing and Materials Committee D01 (honorary), American Chemical Society (emeritus), and American Institute of Chemists (fellow emeritus).



Arthur W. Van Heuckeroth, B.S. George Washington University. Chapter 6.3, Fire Retardance and Flame Resistance. Chief, retired, Materials Division, U.S.A. Engineers Research and Development Laboratories, which he joined in 1941.



John C. Weaver, Ph.D. University of Cincinnati. Chapter 11.1, Sources of Specifications. Director, Research in Paint, Varnish, and Lacquer, Sherwin-Williams Co., Cleveland. Vice-chairman of American Society for Testing and Materials Committee D01; received Award of Merit in 1968. Member of Cleveland Society for Paint Technology. Technical editor of *Journal of Paint Technology*. Awarded George Baugh Heckel Award in 1969.

Contents

<i>Preface</i>	v
<i>Biographical Profiles</i>	vii
Part I Optical Properties	
1.1 Color and Light—H. K. HAMMOND, III AND T. J. DEAN	1
1.2 Gloss—H. K. HAMMOND, III	15
1.3 Hiding Power—P. B. MITTON	22
1.4 Mass Color and Tinting Strength—P. B. MITTON	41
Part 2 Raw Materials	
2.1 Drying Oils—E. C. GALLAGHER	53
2.2 Driers and Metallic Soaps—G. G. SWARD	71
2.3 Natural Resins—G. G. SWARD	76
2.4 Synthetic Resins—M. H. SWANN	92
2.5 Cellulosics—G. G. SWARD	119
2.6 Plasticizers—H. E. RILEY	124
2.7 Solvents—W. H. ELLIS	130
2.8 Pigments—W. F. SPENGE MAN	150
Part 3 Physical Properties	
3.1 Density, Specific Gravity, and Bulking Values—G. G. SWARD	165
3.2 Viscosity and Consistency—J. P. MCGUIGAN	181
3.3 Surface Energetics—D. M. GANS	213
3.4 Particle Size Measurement—G. G. SWARD AND A. E. JACOBSEN	218
3.5 Oil Absorption of Pigments—G. G. SWARD	239
Part 4 Films for Testing	
4.1 Preparation of Films for Test—CHARLES GRENKO	251
4.2 Measurement of Film Thickness—G. G. SWARD	260
4.3 Drying Time—G. G. SWARD	268
Part 5 Mechanical Properties of Films	
5.1 Hardness and Related Properties—E. M. CORCORAN	281
5.2 Abrasion Resistance—A. G. ROBERTS	301
5.3 Adhesion—E. M. CORCORAN	314
5.4 Flexibility—G. G. SCHURR	333
5.5 Tensile Strength and Elongation—G. G. SCHURR	338
Part 6 Chemical Properties of Films	
6.1 Resistance to Water Vapor and Liquid in the Atmosphere—G. W. GROSSMAN	341
6.2 Chemical Resistance—J. A. BOYLAN	351
6.3 Fire Retardance and Heat Resistance—A. W. VAN HEUCKEROTH	355
6.4 Biological Deterioration of Paints and Paint Films—R. T. ROSS	366
Part 7 Weathering Tests	
7.1 Natural Weathering—N. B. GARLOCK AND G. G. SWARD	371
7.2 Artificial Weathering—N. B. GARLOCK AND G. G. SWARD	405
7.3 Atmospheric Pollutants—FRANCIS SCOFIELD	413
Part 8 Specific Products	
8.1 Tests on Varnishes—L. G. MONTAGUE	415
8.2 Architectural Paint—G. G. SWARD	423
8.3 Cement-Base Paint and the Painting of Masonry—T. E. NEVINS	429
8.4 Waxes and Polishes—G. G. SWARD	436
8.5 Putty, Glazing Compounds, Caulking Compounds, and Sealants—G. G. SWARD	445
8.6 Tile-Like Coatings and Seamless Floor Testing—R. M. EVANS AND R. A. BIENEMAN	456
8.7 Bituminous Coatings—H. H. MCCOWEN	462
8.8 Traffic Paint—G. G. SWARD	468
8.9 Paint for Marine Environment—R. F. LOHR AND H. BARRY	478
8.10 Paint for Electrocoating—G. E. F. BREWER AND R. D. HAMILTON	486
8.11 Printing Ink—C. T. RAY	490

Part 9 Analysis of Whole Paint

- 9.1 Sampling, Separations, and Identification of Binder and Solvent—J. D. MCGINNESS 495
9.2 Chemical Analysis of Pigments—G. G. SWARD 500

Part 10 Instrumental Methods of Analysis

- 10.1 Microscopy—W. K. LIND 515
10.2 Chromatography—G. G. ESPOSITO 522
10.3 Ultraviolet Spectroscopy—W. T. LEWIS 545
10.4 Infrared Spectroscopy—W. T. LEWIS 547
10.5 Atomic Absorption and Flame Emission Spectroscopy—J. K. DUFFER 550
10.6 Mass Spectrometry—E. R. BLOSSER AND M. B. NEHER 553
10.7 Polarography—H. W. BERGER 556
10.8 Constant-Current Coulometry—H. W. BERGER 560
10.9 Differential Thermal Analysis—H. W. BERGER 562
10.10 Nuclear Magnetic Resonance Spectroscopy—L. C. AFREMOW 564

Part 11 Specifications

- 11.1 Sources of Specifications—G. G. SWARD AND J. C. WEAVER 583

Index 587