

COMMERCIAL STANDARD CS274-66

**TFE-Fluorocarbon (Polytetra-
fluoroethylene) Resin Sintered Thin
Coatings for Dry Film Lubrication**

A recorded
voluntary standard of the
trade published by
the U.S. Department
of Commerce



U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
Office of Product Standards

EFFECTIVE DATE

Having been passed through the regular procedures of the Office of Commodity Standards (now Office of Product Standards, National Bureau of Standards) and approved by the acceptors hereinafter listed, this Commercial Standard is issued by the U.S. Department of Commerce, effective January 20, 1966.

JOHN T. CONNOR, *Secretary.*

COMMERCIAL STANDARDS

Commercial Standards are developed by manufacturers, distributors, and users in cooperation with the Office of Product Standards of the National Bureau of Standards. Their purpose is to establish quality criteria, standard methods of test, rating, certification, and labeling of manufactured commodities, and to provide uniform basis for fair competition.

The adoption and use of a Commercial Standard is voluntary. However, when reference to a Commercial Standard is made in contracts, labels, invoices, or advertising literature, the provisions of the standard are enforceable through usual legal channels as a part of the sales contract.

Commercial Standards originate with the proponent industry. The sponsors may be manufacturers, distributors, or users of the specific product. One of these three elements of industry submits to the Office of Product Standards the necessary data to be used as the basis for developing a standard of practice. The Office by means of assembled conferences or letter referenda, or both, assists the sponsor group in arriving at a tentative standard of practice and thereafter refers it to the other elements of the same industry for approval or for constructive criticism that will be helpful in making any necessary adjustments. The regular procedure of the Office assures continuous servicing of each Commercial Standard through review and revision whenever, in the opinion of the industry, changing conditions warrant such action.

SIMPLIFIED PRACTICE RECOMMENDATIONS

Under a similar procedure the Office of Product Standards cooperates with industries in the establishment of Simplified Practice Recommendations. Their purpose is to eliminate avoidable waste through the establishment of standards of practice for sizes, dimensions, varieties, or other characteristics of specific products; to simplify packaging practices; and to establish simplified methods of performing specific tasks.

The initial printing of Commercial Standard CS274-66 was made possible through the cooperation of The Society of the Plastics Industry, Inc., in securing copies for its members.

TFE-FLUOROCARBON (POLYTETRAFLUOROETHYLENE) RESIN SINTERED THIN COATINGS FOR DRY FILM LUBRICATION

(Effective January 20, 1966)

1. PURPOSE

1.1 The purpose of this Commercial Standard is to establish a national standard of quality for the information and guidance of producers, distributors, and users; to promote understanding between buyers and sellers; to provide a basis for fair competition among producers; to give the consumer confidence in the quality of the product, and to provide means for identifying coatings of polytetrafluoroethylene (referred to herein as TFE-fluorocarbon resin coatings) produced in conformance with this standard.

2. SCOPE

2.1 This standard establishes the requirements and methods of test for the material, thickness, workmanship, and properties of TFE-fluorocarbon resin coatings 0.001 inch or less in thickness for the purpose of dry film lubrication. Methods of marking and indicating compliance with this standard are included.

2.2 Coatings complying with this standard will have an inherent coefficient of kinetic friction of less than 0.1 when applied to sufficiently hard substrates and sintered at a temperature in excess of 630° F. (See Appendix A1.5)

3. REQUIREMENTS

3.1 **Material.**—The TFE-fluorocarbon coating shall be composed of materials suitable for producing a finish to meet the requirements of this standard. The substrate, prior to the application of the coating shall be free from burrs, pits, fins, and other surface defects detrimental to the operation of the coating system as a dry film lubricant.

3.2 **Workmanship.**—The coating shall be uniform, free from cracks, sags, runs, heavy edges, and incomplete coverage, and shall be completely heat fused. The surface of the coating shall be free of foreign inclusions or entrapped debris.

3.3 **Thickness.**—The coating shall have a maximum thickness of 0.001 inch when measured in accordance with 4.3.1.

3.4 **Roughness.**—The coating roughness shall not exceed 90 micro-inches when measured in accordance with 4.3.2.

3.5 **Adhesion.**—The coating adhesion to the substrate shall be satisfactory as determined by the method described in 4.3.3.

3.6 **Interfacial tension.**—The minimum acceptable contact angles shall be greater than 90° for water, 81° for methylene iodide, and 35° for n-hexadecane. (Pure smooth TFE exhibits 108°, 88°, and 46° re-

spectively for these fluids.) Coatings failing to meet either of the above requirements shall be removed and replaced. No corrective coating shall be applied. The interfacial tension of the coating shall be determined by the method described in 4.3.4.

3.7 **Continuity.**—The continuity of the coating shall be determined by the method described in 4.3.5. Cracks visible at a magnification of 20 x shall be cause for rejection.

4. METHODS OF TEST

4.1 **Sampling.**—Samples shall be taken at random from each lot of TFE-coated items to determine its conformance with this standard. The tests described in 4.3 are nondestructive when performed on satisfactory TFE-coatings.

4.2 **Inspection.**—The TFE-coated items shall be visually inspected to verify their compliance with the requirements specified in 3.2 of this standard.

4.3 Tests.—

4.3.1 **Thickness.**—The coating thickness when applied to flat magnetic substrates shall be determined in several locations on the coated specimen in accordance with the requirements of Method 6181 of Federal Test Method Standard No. 141.¹ For nonmagnetic substrates a gage such as the "Dermatron"² or equivalent, may be used.³

4.3.2 **Roughness.**—The maximum surface roughness of the coated items shall be determined by visual comparison with comparison roughness specimens⁴ or with a Profilometer, Brush Surfindicator or equivalent, using three specimens. Failure of any specimen to meet the requirement of 90 microinches maximum shall be cause for rejection of the lot.

4.3.3 **Adhesion.**—The adhesion of the coating to the substrate shall be determined on three specimens using a Shore Durometer Tester Type A instrument. The tester shall be placed on the coating of the substrate and pressed down firmly to force the spring-loaded flattened conical probe inward to the maximum load. The tester shall then be slid over the coating in the direction of the longer dimensions of the instrument. Visible ploughing or detachment of the coating from any specimen shall be cause for rejection of the lot.

NOTE: Care should be exercised to avoid scratching the specimen. All feather edges on the probe of the instrument should be carefully removed, if present.

¹ Copies of Federal Test Method Standard No. 141, Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling and Testing, may be obtained from the General Services Administration Region 3, Federal Supply Service, Buying Division, General Services Regional Office Building, Washington, D.C., at \$3 per copy.

² Available from Unit Process Assemblies, Inc., Woodside, L.I., N.Y.

³ When these methods are not applicable, Federal Test Method Standard No. 151a, Methods 520 and 522.1; A.S.T.M. Standard D1186; or A.S.T.M. Standard A219, may be used whichever is suitable. If none of these is suitable, then any method that is demonstrated to have an accuracy of better than ± 0.1 mil may be used.

Method 6181 of Federal Test Method No. 141 and Method 522.1 of Federal Test Method No. 151a, both describe the Magne-gage method of measuring thickness. It should be noted that the substrate of the specimen must have essentially the same magnetic properties as the steel substrate of the standards used to calibrate the instrument. The uncoated steel should give a "zero" reading when tested with a suitably calibrated Magne-gage.

The inside surfaces of cylindrical surfaces are often inaccessible to conventional gages. Some gage manufacturers do provide special probes or instruments for measuring inside tubes.

⁴ Roughness height and the preparation of comparison roughness specimens are covered by American Standard B48.1-1962, Surface Texture, available from the American Standards Association, Inc., 10 East 40th Street, New York, N.Y., 10016, at \$2.50 per copy.

4.3.4 Interfacial tension.—The surface tension of the coating shall be determined by the use of one of the fluids specified in 3.6 in contact with the TFE surface. The contact angles exhibited by sessile drops of water, methylene iodide or n-hexadecane shall be observed in profile. A low-power telescope fitted with a goniometer eyepiece is a suitable instrument for determining the contact angle requirements. Another suitable method would be a protractor measurement of the contact angle as shown on a photomicrograph.

4.3.5 Continuity.—The film continuity of the coating shall be determined by visual examination using a microscope with a 20 x magnification. Observation of the film under the microscope will normally show cracks which have been healed during the fusing operation, and the coating should not be rejected on this account. Open cracks or lack of film continuity shall not be permitted.

5. IDENTIFICATION

5.1 Labels and Literature.—In order that purchasers may be assured that the TFE-fluorocarbon coating actually complies with all requirements of the Commercial Standard, manufacturers choosing to comply with the voluntary standard may include the following statement in conjunction with their name and address on labels, invoices, sales literature, etc.:

This TFE-fluorocarbon coating complies with Commercial Standard CS274-66, as developed under the procedure of the Office of Product Standards, and published by the U.S. Department of Commerce.

5.1.1 The following abbreviated statement is suggested when available space on labels is insufficient for the full statement:

Complies with CS274-66, published by the U.S. Department of Commerce.

HISTORY OF PROJECT

In a letter dated February 23, 1961, the Fluorocarbons Division of the Society of the Plastics Industry, Inc., requested the cooperation of the Commodity Standards Division, Office of Technical Services (now Office of Product Standards, National Bureau of Standards) in the establishment of a Commercial Standard for TFE-Fluorocarbon (Polytetrafluoroethylene) Resin Sintered Thin Coatings for Dry Film Lubrication, and submitted as a basis a tentative standard developed by the TFE-Coatings Section of that organization.

The Commodity Standards Division circulated copies of the proposed Commercial Standard to representative producers, distributors, users, laboratories, and Government agencies for constructive comment. All comments and suggestions received were carefully considered and adjustments were made to the proposal to satisfy the comment wherever practicable. The Recommended Commercial Standard, TS-5651C, was circulated to the trade on October 16, 1964.

On December 20, 1965, the Office of Product Standards announced that acceptances had been received representing a satisfactory majority of the industry and the Commercial Standard, to be designated CS274-66, would be considered effective beginning January 20, 1966.

Project Manager: D. R. Stevenson, Office of Product Standards,
National Bureau of Standards.

Technical Adviser: Dr. G. M. Kline, Consultant, National
Bureau of Standards.

STANDING COMMITTEE

The following individuals comprise the membership of the Standing Committee which is to review, prior to circulation for acceptance, revisions proposed to keep the standard abreast of progress. Comment concerning the standard and suggestions for revision may be addressed to any member of the committee or to the Office of Product Standards, National Bureau of Standards, U.S. Department of Commerce, which acts as secretary for the committee.

- ROBERT GOLDSMITH, General Plastics Corporation, 55 La France Avenue, Bloomfield, N.J. (Chairman)
- R. V. CURTIS, Industrial Coating Division, Ekco Products Company, 1949 North Cicero Avenue, Chicago, Ill., 60639
- VINCENT G. FITZSIMMONS, Chemistry Division, U.S. Naval Research Laboratory Washington, D.C., 20390
- HENRY FIELTIZ, Chemplast, Inc., 3 Central Avenue, East Newark, N.J., 07029
- K. C. HALLIDAY, The Bendix Corp., Eclipse-Pioneer Division, Teterboro, N.J., 07608
- DR. CHARLES L. HAMERMESH, Rocketdyne, A Division of North American Aviation, Inc., 6623 Canoga Avenue, Canoga Park, Calif., 91304
- ROBERT W. HANSEN, Boeing Associated Products, The Boeing Company, P.O. Box 3707, Seattle, Wash., 98124
- JOHN H. HENDRICK, American Durafilm Co., Inc., 2300 Washington St., Newton Lower Falls, Mass., 01262
- H. KATZ, Curtiss-Wright Corporation, Wright Aeronautical Division, Wood-Ridge, N.J., 07075
- L. K. OSDAL, E. I. du Pont de Nemours & Co., Marshall Laboratory, 3500 Grays Ferry Ave., Philadelphia, Pa., 19146
- H. E. RUSSELL, Industrial Coatings, Inc., 104 S. Hudson St., P.O. Box 1571, Greenville, S.C., 29602
- S. P. SOTIR, U.S. Army Materials Research Agency, Watertown, Mass., 02172

APPENDIX A

A1. The following information on TFE-fluorocarbon resin coatings is provided for general use and does not constitute a requirement of this Commercial Standard.

A1.1 **Thickness.**—TFE coatings have one of the lowest coefficients of friction of any solid provided that films of less than 1.0 mil are used. Because TFE resins are relatively soft and will cold flow it is necessary to provide very thin film to permit the substrate material to contribute to the load carrying capacity of the film. For example, TFE in bulk will cold flow or extrude at loads slightly above 1,000 psi while in thin films (less than 1.0 mil) the same material will support 50,000 psi. Thicker films not covered by this standard may be used to advantage where other requirements determine their usage.

A1.2 **Substrate materials.**—TFE coatings are heat fused (sintered) at 700–750° F.; therefore, the use of such coating is limited to substrate materials capable of withstanding such exposure. Low melting metals, solders and platings are all affected by the required thermal exposure. Copper and copper containing alloys are reactive at the required sintering temperature and therefore do not exhibit as good adhesion of TFE coatings as do ferrous metals. Also some metals may be degraded in mechanical properties by the metallurgical effects introduced by the thermal exposure.

A1.3 **Primer coatings.**—The use of primer coatings containing proprietary ingredients to improve adhesion and impede corrosion is optional. Such ingredients often react with contaminated substrate

materials to produce undesirable staining of the sintered finish. For example, fingerprints often produce brown staining of primer coats. However, under some conditions a random mottling of primer coatings may be associated with the interaction of the suspension and the substrate material with no other effect than that of appearance. Where color differences or staining of top coats occur there should be a presumption that either the finishing material has deteriorated or that the finish was applied to a contaminated surface.

A1.4 Surface roughness.—The surface roughness of thin TFE coatings is influenced by the roughness of the substrate and by the method of application. Surface roughness of the substrate has an effect on the adhesion of the TFE film, the durability of the film as a lubricant and on the coefficient of friction. It has been determined that optimum performance of lubricating TFE films is obtained through the application of such coatings to surfaces specially sand-blasted to a surface roughness not exceeding 90 microinches. The use of rougher finishes will decrease life expectancy of the lubricating film and the use of very smooth glossy finishes will increase the real area of contact with consequent increase friction.

A1.5 Bibliography.—

(a) FitzSimmons, V. G., and Zisman, W. A., Thin Films of Polytetrafluoroethylene Resin as Lubricants and Preservative Coatings for Metals. Naval Research Laboratory, Washington, D.C., Report No. 4753. Office of Technical Services Publication PB121161 (AD99304).⁵

(b) FitzSimmons, V. G., and Zisman, W. A., Thin Films of Polytetrafluoroethylene Resin as Lubricants and Preservative Coatings for Metals. Industrial Engineering Chemistry, Volume 50, No. 5, May 1958, P. 781.

ACCEPTORS

The manufacturers, distributors, users, and others listed below have individually indicated in writing their acceptance of this Commercial Standard prior to its publication. The acceptances indicate an intention to utilize the standard as far as practicable, but reserve the right to depart from it as may be deemed desirable. The list is published to show the extent of recorded public support for the standard and should not be construed as indicating that all products made by the acceptors actually comply with its requirements.

Products that meet all requirements of the standard may be identified as such by a certificate, grade mark, or label. Purchasers are encouraged to require such specific evidence of compliance, which may be given by the manufacturer whether or not he is an acceptor.

FIRMS

Aeromotive Product Specialties Corp., Detroit, Mich.
American Durafilm Co., Inc., Newton Lower Falls, Mass.
Amphenol Cable Division, Chicago, Ill.
Amphenol Controls Division, Amphenol-Borg Electronics Corp., Janesville, Wis.

⁵ Copies of PB121161 (AD99304) may be obtained from the Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Va., 22151, at \$3.60.

B & B Plastics Division, Metal-Cladding, Inc., Lockport, N.Y.
 Calumet & Hecla, Inc., Bartlett, Ill.
 Chase Company, The, Hayward, Calif.
 Chemplast, Inc., East Newark, N.J.
 Chicago Gasket Company, Chicago, Ill.
 Commercial Plastics & Supply Corp., New York, N.Y.
 Coronado Plastics Inc., Burbank, Calif.
 Detroit Testing Laboratory, Inc., Detroit, Mich.
 Dial Service & Manufacturing Inc., Cleveland, Ohio
 Dilectrix Corporation, Farmingdale, N.Y.
 Dixon Corporation, Bristol, R.I.
 Dodge Fibers Corporation, Hoosick Falls, N.Y.
 Dodge-Wasmund Manufacturing, Inc., Pico Rivera, Calif.
 Doré, John L., Co., Houston, Tex.
 du Pont, E. I., de Nemours & Co. Plastics Department, Wilmington, Del.
 Dynamic Division, Eaton Manufacturing Co., Kenosha, Wis.
 Eastern Industries Division, Laboratory for Electronics, Inc., Hamden, Conn.
 Edgerton, Germeshausen & Grier, Inc., Bedford, Mass.
 Enflo Corporation, Maple Shade, N.J.
 Ethylene Corporation, Murray Hill, N.J.
 Falls Hollow Staybolt Co., Metal Coating Division, Cuyahoga Falls, Ohio
 Fluoro-Plastics, Inc., Philadelphia, Pa.
 Fluorocarbon Company, The, Palo Alto, Calif.
 Froehling & Robertson, Inc., Richmond, Va.
 General Electric—Hanford Atomic Products Operation, Richland, Wash.
 General Plastics Corporation, Bloomfield, N.J.
 Gits Brothers Manufacturing Co., Chicago, Ill.
 Glaco Co. of Southern California, Subsidiary Ekco Products Co., Whittier, Calif.
 Halogen Insulator & Seal Corporation, Franklin Park, Ill.
 Haveg Industries, Inc., Wilmington, Del.
 Industrial Coatings Division, Ekco Products Co., Chicago, Ill.
 Industrial Coatings, Inc., Greenville, S.C.
 Kaiser Jeep Corporation, Toledo, Ohio
 Kurz-Kasch, Inc., Dayton, Ohio
 Lewis Engineering Co., The, Naugatuck, Conn. (General Support)
 Metal Products Division, Koppers Co., Inc., Baltimore, Md.
 Modern Industrial Plastics Division of The Duriron Co., Inc., Dayton, Ohio
 Molecular Dielectrics, Inc., Clifton, N.J.
 Ornamental Plastics Inc., Fluorocarbon Division, Sheboygan, Wis.
 Otis Elevator Company, Yonkers, N.Y.
 Pennsylvania Fluorocarbon Co., Inc., Clifton Heights, Pa. (General Support)
 Permacel, New Brunswick, N.J. (General Support)
 Philco Corporation, WDL Division, Palo Alto, Calif.
 Plastonics, Inc., Hartford, Conn.
 Polyflon Corp., Pelham Manor, N.Y.
 Radio Corporation of America, Camden, N.J.

ACCEPTANCE OF COMMERCIAL STANDARD

CS274-66

**TFE-Fluorocarbon (Polytetrafluoroethylene)
Resin Sintered Thin Coatings for Dry Film Lubrication**

If acceptance has not previously been filed, this sheet properly filled in, signed, and returned will provide for the recording of your organization as an acceptor of this Commercial Standard.

Date _____

Office of Product Standards
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C., 20234

Gentlemen:

We believe that this Commercial Standard constitutes a useful standard of practice, and we individually plan to utilize it as far as practicable in the production¹ distribution¹ purchase¹ testing¹ of this commodity.

We reserve the right to depart from the standard as we deem advisable.

We understand, of course, that only those articles which actually comply with the standard in all respects can be identified or labeled as conforming thereto.

Signature of authorized officer _____
(In ink)

(Kindly typewrite or print the following lines)

Name and title of above officer _____

Organization _____

Street Address _____
(Fill in exactly as it should be listed)

City, State, and Zip Code _____

¹ Underscore the applicable words. Please see that separate acceptances are filed for all subsidiary companies and affiliates which should be listed separately as acceptors. In the case of related interests, trade association, trade papers, etc., desiring to record their general support, the words "General Support" should be added after the signature.

(Out on this line)

TO THE ACCEPTOR

The following statements answer the usual questions arising in connection with the acceptance and its significance:

1. *Enforcement.*—Commercial Standards are commodity specifications voluntarily established by mutual consent of those concerned. They present a common basis of understanding between the producer, distributor, and consumer and should not be confused with any plan of governmental regulation or control. The United States Department of Commerce has no regulatory power in the enforcement of their provisions, but since they represent the will of the interested groups as a whole, their provisions through usage soon become established as trade customs, and are made effective through incorporation into sales contracts by means of labels, invoices, and the like.

2. *The acceptor's responsibility.*—The purpose of Commercial Standards is to establish, for specific commodities, nationally recognized grades or consumer criteria, and the benefits therefrom will be measurable in direct proportion to their general recognition and actual use. Instances will occur when it may be necessary to deviate from the standard and the signing of an acceptance does not preclude such departures; however, such signature indicates an intention to follow the standard, where practicable, in the production, distribution, or consumption of the article in question.

3. *The Department's responsibility.*—The major function, performed by the Department of Commerce in the voluntary establishment of Commercial Standards on a nationwide basis is fourfold: First, to act as an unbiased coordinator to bring all interested parties together for the mutually satisfactory adjustment of trade standards; second, to supply such assistance and advice as past experience with similar programs may suggest; third, to canvass and record the extent of acceptance and adherence to the standard on the part of producers, distributors, and users; and fourth, after acceptance, to publish the standard for the information and guidance of buyers and sellers of the commodity.

4. *Announcement.*—When the standard has been endorsed by a satisfactory majority of production or consumption in the absence of active, valid opposition, the success of the project is announced. If, however, in the opinion of the standing committee or of the Department of Commerce, the support of any standard is inadequate, the right is reserved to withhold publication.