Designation: D 823 – 95 (Reapproved 2001)

# Standard Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[1]

This standard is issued under the fixed designation D 823; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 Five practices are given for preparing films of uniform thickness of coatings on test panels. These practices are:
Practice A—Automatic Spray Machine Application
Practice B—Motor-Driven Dip Coater Application
Practice C—Motor-Driven Blade Film Application
Practice D—Hand-Held Spray Gun Application
Practice E—Hand-Held Blade Film Application

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products[2]

D 1005 Test Methods for Measurement of Dry Film Thickness of Organic Coatings Using Micrometers[2]

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[2]

D 1212 Test Methods for Measurement of Wet Film Thickness of Organic Coatings[2]

D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[2]

D 3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer and Related Materials[2]

## PRACTICE A—AUTOMATIC SPRAY MACHINE APPLICATION

## 3. Summary of Practices

3.1 A liquid material is applied to a test panel by means of an automatic spray machine consisting of a mounted spray gun and a panel holder. This machine can (*1*) move the panel holder, with test panel, at a uniform speed through the atomized spray produced by a fixed spray gun, or (*2*) it can move the gun, with atomized spray, at a uniform speed past the test panel mounted on a fixed panel holder. A machine equipped with a programmable system can index the spray gun vertically for multiple passes and for multiple coats with selective time delay.

3.2 The thickness of coating applied is controlled by the traverse speed of the panel or gun, the fluid delivery rate of the gun, the viscosity of the material, and the amount of nonvolatile matter in the material.

## 4. Significance and Use

4.1 These practices should be used for those coatings that are designed for spray applications of objects in the factory or in the field. It is particularly important that it be used in the evaluation of metallic coatings for appearance properties, such as gloss and color.

4.2 Coatings applied by this test method may exhibit a slight orange-peel or spray wave.

## 5. Apparatus

5.1 *Test Panels*, of any smooth, planar material of a size that can be accommodated by the panel holder of the automatic spray machine.

5.1.1 When steel panels are used, they should be prepared in accordance with the appropriate method in Practice D 609.

5.2 *Automatic Spray Machine,* equipped with a panel holder and a mounting for a spray gun. The machine shall be designed to move the panel holder at a uniform speed past the fixed gun mount, or designed to move the gun mount at a uniform speed

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[1] These practices are under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

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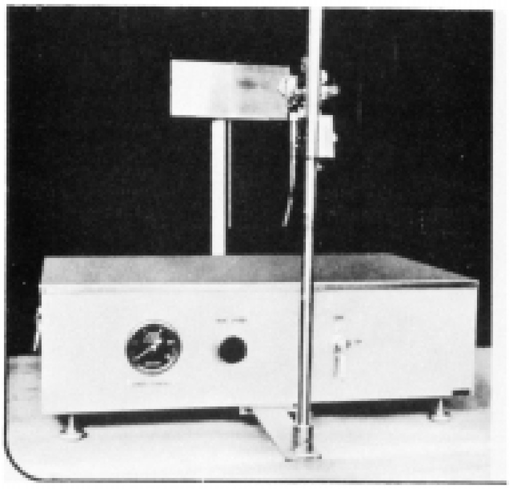
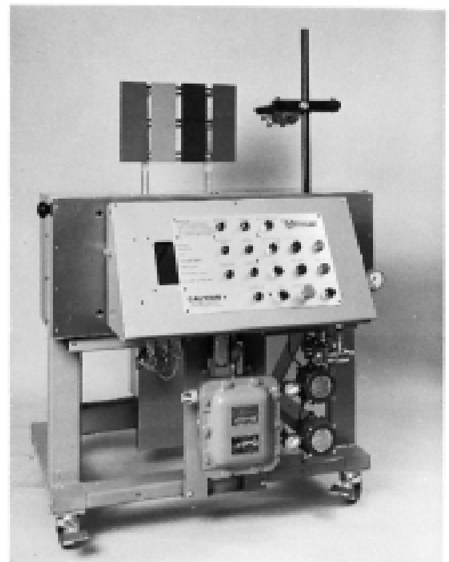
[2] *Annual Book of ASTM Standards*, Vol 06.01.

past the fixed panel holder. The panel holder or the gun mount traverse speed shall be adjustable from 7.5 to 30 m (25 to 100 ft)/min. Typical machines are shown in Fig. 1.

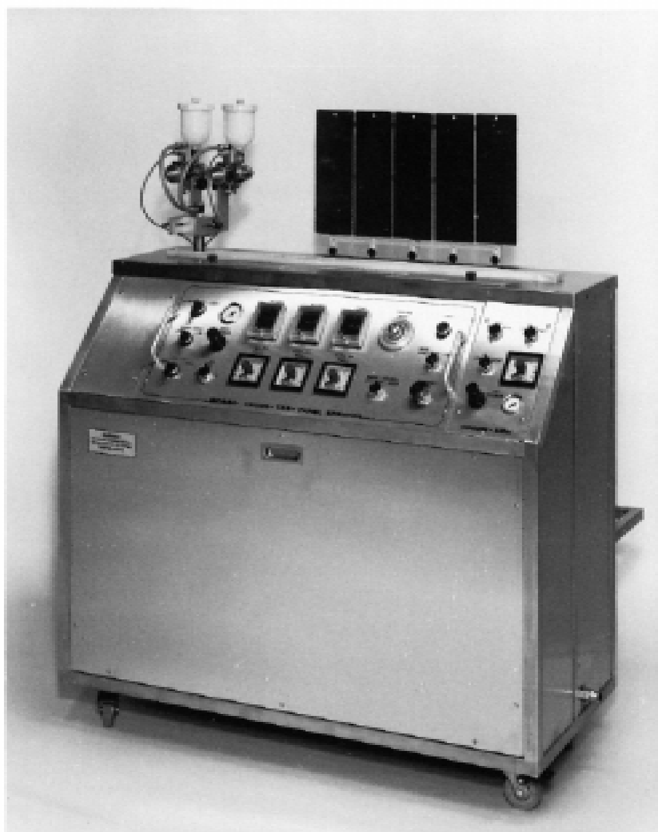
NOTE 1—Some automatic spray machines provide additional features that can improve the uniformity of film preparation. Some examples are: a z-bar panel holder; indexing of the panel holder at right angles to the gun



(*a*) Fixed Gun, Traveling Panel Machine



(*b*) Fixed Panel, Traveling Gun Machine



(*c*) Fixed Panel Programmable Indexing Traveling Gun Machine

**FIG. 1 Automatic Spray Machines, Practice A**

to provide uniform lapping; and automatic control of number of passes, time between passes, and lapping distance.

5.3 *Spray Gun*, any that will provide a uniform fan-type spray pattern at least 150 mm (6 in.) in width is satisfactory. The gun may be triggered manually or automatically.

5.4 *Pressure Gage*, covering the range of 0 to 690 kPa (0 to 100 psi).

5.5 *Air Pressure Regulator*.

5.6 *Air Supply*, oil-free, under pressure.

## 6. Preparation of Apparatus

6.1 Mount the spray gun on the automatic spray machine. Connect the air line hose from the regulator to the air pressure gage which in turn is connected to the air inlet of the spray gun.

6.2 Set the gun so that its tip is at the desired distance from the test panel surface, usually in the range from 200 to 300 mm ( 8 to 12 in.).

6.3 With the gun trigger fully open, adjust the air regulator to provide the desired reading on the air pressure gage.

NOTE 2—A suitable air pressure is usually from 275 to 520 kPa (40 to 75 psi).

6.4 Set the automatic spray machine controls to provide the desired traverse speed of the panel holder or the gun mount, whichever is pertinent to the type of machine being used.

NOTE 3—Suitable traverse speeds for automatic coatings usually range from 17.5 to 22.5 m/min (700 to 900 in./min ).

## 7. Procedure

7.1 Strain the material to be sprayed into the container to be used with the spray gun. Reduce the material to a viscosity suitable for spraying.

7.2 Connect the container to the gun and test the spray gun operation while stationary, for correct spray pattern and uniformity by allowing a momentary spray to be deposited on a piece of paper placed in the panel position. Adjust the air pressure material flow, and spray fan width controls until the desired pattern and uniformity are obtained. Further refinements may be made in the spray pattern by modifying the air pressure, the type of thinning agent, and the consistency of the material.

NOTE 4—The width of the spray pattern should be considerably wider than the width of the test panel to assure spray uniformity on the test panel.

7.3 Place a test panel on the panel holder and start the machine. Operate the spray gun so that it will begin spraying a few seconds before the test panel enters the spray pattern and continue spraying a few seconds after the test panel leaves the spray pattern.

7.4 Remove the coated panel and bake, force-dry, or air-dry it, in accordance with its type, in a vertical position in a dust-free atmosphere, as described in Specification D 3924.

7.5 Determine the thickness of the coating in accordance with Test Methods D 1005, D 1186, D 1212, or D 1400, whichever is appropriate.

## 8. Report

8.1 Report the following information:

8.1.1 Type of coating material,

8.1.2 Viscosity and percent of nonvolatile coating material,

8.1.3 Distance of test panel from gun tip,

8.1.4 Air pressure,

8.1.5 Number of spray passes,

8.1.6 Traverse speed,

8.1.7 Temperature and relative humidity at time of application, and

8.1.8 Film thickness values obtained for applied coating.

# PRACTICE B—MOTOR-DRIVEN DIP COATER APPLICATION

## 9. Summary of Practice

9.1 A motor-driven device is employed to withdraw the test panel from a container of the coating material at a desired uniform rate.

9.2 The thickness of coating applied is controlled by the speed of panel withdrawal, the viscosity of the material, and the percent of solids in the material.

## 10. Significance and Use

10.1 This test method is limited to those materials that flow out to smooth films when test panels are dipped into the material and withdrawn.

## 11. Apparatus

11.1 *Dip Coater*, consisting of a mechanism that will withdraw a panel from a container of the coating material at a predetermined rate. Suitable apparatus, is shown in Fig. 2(*a*) and 2(*b*):

11.1.1 The apparatus shown in Fig. 2(*a*) uses a cord wound around a step-cone pulley on the shaft of a motor to provide panel withdrawal rate of 50, 75, and 100-mm (2, 3, and 4-in. )/min. Prior to withdrawal, the panel, attached to the cord, is lowered by hand into the container holding the material.

11.1.2 The apparatus shown in Fig. 2(*b*) uses a cord driven by a variable-speed device that can provide panel immersion and withdrawal rates that are continuously variable from65 to 510 mm (2.5 to 20 in.)/min.

NOTE 5—Rectangular containers (F-style can with lid cut off) are useful because the smaller exposed surfaces of the liquid coating reduces volatile loss.

11.2 *Test Panels*, of any clean, smooth, rigid substrate of a size that can be accommodated by the dip coater and the container.

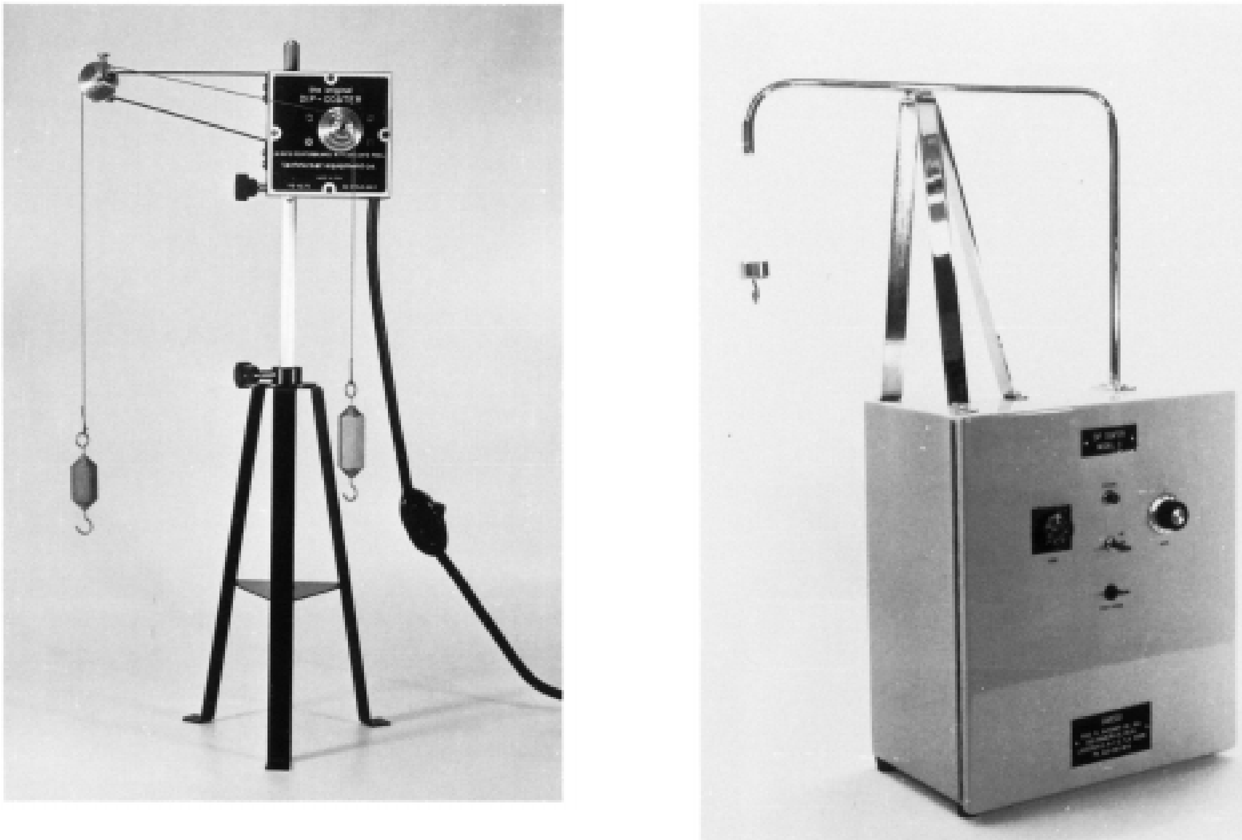
11.2.1 When steel panels are used they shall be prepared in accordance with the appropriate method in Methods D 609.

NOTE 6—The test panels should not exceed 300 mm (12 in.) in length, but the width may be varied up to 300 mm (12 in.) if a suitable counterweight is used and a dip tank of adequate size is provided. Use of a multiple hook will permit dipping several panels at one time.

## 12. Procedure

12.1 Adjust the coating material to the proper percentage of solids and viscosity. Measure the temperature of the material in the container at the time of application.

NOTE 7—The operating conditions (viscosity, percent of nonvolatile matter, and rate of withdrawal) are specific for a given coating material



(*a*) Dip-Coater With Motor-Driven Step-Cone Pulley (*b*) Dip-Coater With Continuously Variable Speed Drive

**FIG. 2 Dip-Coater, Practice B**

and film thickness and need to be determined by trial. Subsequent reproduction of the same operating conditions should give the same film thickness. Data are available[3] on a variety of materials and film thickness to indicate the range required. The viscosity range for normal film thickness of13 to 50 mm ( 0.5 to 2.0 mil ) has been shown to be 1 to 2.5 P.

12.2 Place the prepared test panel on the hook attached to the cord and lower it into the container holding the coating material. Wind the cord once completely around the pulley of the correct size to give the desired rate of withdrawal.

12.2.1 For the stepped-cone pulley apparatus, wind the cord once completely around the pulley of the correct size to give the desired weight of withdrawal.

12.2.2 For the continuously variable speed apparatus set the desired panel immersion and withdrawal rates on the control panel.

12.3 Start the motor and withdraw the panel at the desired rate, with a smooth movement entirely free of vibration. Bake, force-dry, or air-dry the coated panel, in accordance with its type, in a vertical position in a dust-free atmosphere in accordance with Specification D 3924.

12.4 Determine the thickness of the coating in accordance with Test Methods D 1005, D 1186, or D 1400, whichever is appropriate.

12.5 If the coating thickness is too low, coat another panel using a slower rate of panel withdrawal. If the coating thickness is too high, coat another panel using a faster rate of panel withdraw.

12.6 Continue in this manner until a test panel having the desired film thickness is produced. Measure thickness on at least three different areas of the test panel to determine coating uniformity.

NOTE 8—With the dip coater, non-uniform thickness on a panel is frequently obtained. Hence, if the film thickness is greater at the bottom than the top, the viscosity should be increased or the panel withdrawal speed should be reduced, or both.

## 13. Report

13.1 Report the following information:

13.1.1 Type of coating material,

13.1.2 Viscosity, temperature, and percent nonvolatile of coating material,

13.1.3 Rate of withdrawal,

13.1.4 Air temperature and relative humidity at time of application, and

13.1.5 Mean and range of dry film thickness values obtained.

[3] Information covering viscosity, percent of solids, rates of withdrawal and film thickness for a variety of finishing materials is given in the paper by Payne, H. F., "The Dip Coater, An Instrument For Making Uniform Films by the Dip Method," *Industrial and Engineering Chemistry*, Analytical Edition, Vol 15, 1943, p. 48.

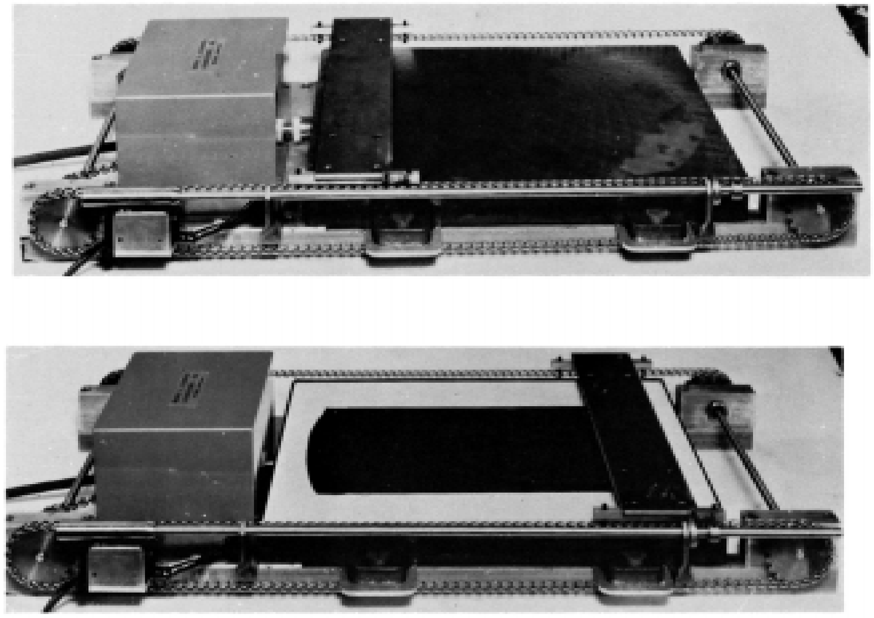


FIG. 3 Blade Film Applicator, Motor-Driven, Practice C

## PRACTICE C—MOTOR-DRIVEN BLADE FILM APPLICATION

### 14. Summary of Practice

14.1 A uniform film is produced by an applicator blade that is pushed across the test panel at a uniform speed by a motor-driven device.

14.2 The thickness of coating applied is controlled by the clearance of the applicator blade and the viscosity and percentage of solids of the material.

### 15. Significance and Use

15.1 This test method is applicable to substrates consisting of smooth rigid materials, such as metal or glass, and of non-rigid materials, such as paper charts. It is more reliable for producing uniform films than is the use of hand-held draw-down applicators.

### 16. Apparatus

16.1 *Motor-Driven Blade Film Applicator*,[4] consisting of a base plate, a bar for holding an applicator blade, and a driving mechanism. The base plate shall hold paper charts flat by means of a vacuum. The blade holder shall be designed to accommodate common types of applicator blades and to accept weights for loading the applicator blade. A mechanism shall be provided to stop the blade movement automatically at the end of the draw-down. A suitable apparatus is shown in Fig. 3.

16.2 *Vacuum Source*, a vacuum pump or a water aspirator.

16.3 *Applicator Blade*, any common type, either with adjustable or fixed clearances.

16.4 *Test Panels*, any clean, smooth, rigid substrate or may be paper charts or similar materials.

NOTE 9—Rigid panels shall be cleaned in an approved manner. Steel panels shall be prepared in accordance with the appropriate method in Practice D 609.

### 17. Procedure

17.1 Clean the base plate and place the test panel on it.

17.2 If a vacuum is needed to hold the test panel flat, connect the vacuum source to the base plate and turn it on.

NOTE 10—When films are being applied to paper charts or tin foil, a sheet of paper should first be placed on the vacuum plate to prevent formation of dimples at the plate perforations.

17.3 Select an applicator blade having a clearance that should provide a wet film thickness that will give the desired dry film thickness, or, if specified, the required wet film thickness. Insert the blade in the blade holder and load the holder with weights if needed.

17.4 Place a suitable amount of the coating material on the test panel in front of the blade. Start the motor-drive and coat the test panel.

17.5 Remove the coated panel and bake, force-dry, or air-dry the coating, in accordance with its type, in a horizontal position in a dust-free atmosphere in accordance with Specification D 3924.

NOTE 11—Paper charts should be taped down to prevent curling of the edges that causes the wet film to flow towards the center.

17.6 Clean the applicator blade.

17.7 Determine the thickness of the applied coating in accordance with Test Method D 1005, D 1186, or D 1400 whichever is appropriate.

17.8 If the coating thickness is too low, coat another panel using a larger blade clearance. If the coating thickness is too high, coat another panel using a smaller blade clearance.

[4] Suitable apparatus may be obtained from several suppliers of paint testing equipment.

17.9 Continue in this manner until a test panel having the desired dry film thickness is produced. Measure thickness on at least three different areas of the test panel to determine coating uniformity.

## 18. Report

18.1 Report the following information:

18.1.1 Type of coating material,

18.1.2 Viscosity and percentage of solids of coating material,

18.1.3 Clearance of applicator blade used,

18.1.4 Air temperature and relative humidity at time of application, and

18.1.5 Mean and range of the film thickness values obtained.

18.2 For most types of coatings, individual thickness readings taken over the surface of the applied coating can be expected to deviate no more than ±5 % from the mean.

18.3 *Bias*—Since there is no accepted reference material suitable for determining the bias for Test Method C in these test methods for producing films with uniform thickness using a motor-driven blade film applicator, bias has not been determined.

# PRACTICE D—HAND-HELD SPRAY GUN APPLICATION

## 19. Summary of Practice

19.1 A uniform film of a coating material is produced on a test panel by the means of a spray gun hand-held by a person skilled in its use.

19.2 The thickness of coating applied is controlled by the traverse speed of the gun, the number of passes of the gun, the fluid delivery rate of the gun, the viscosity of the material, and the amount of nonvolatile matter in the material.

## 20. Significance and Use

20.1 This test method is applicable to the coating of substrates consisting of smooth, rigid materials, such as metal or glass. It is usually less reliable for producing uniform films than is the automatic spray method. However, films sufficiently uniform for most physical property tests of materials can be produced by a hand-held spray gun operated by a person skilled in its use.

## 21. Apparatus

21.1 *Spray Gun*, any that will provide a uniform fan-type spray pattern at least 6 in. (150 mm) in width is satisfactory.

21.2 *Air Pressure Gage*, covering the range from 0 to 100 psi (0 to 690 kPa).

21.3 *Air Pressure Regulator*.

21.4 *Air Supply*, oil-free and under pressure.

21.5 *Panel Holder*.

## 22. Preparation of Apparatus

22.1 Connect the air line hose from the regulator to the air pressure gage which in turn is connected to the air inlet of the spray gun.

22.2 With the trigger fully open, adjust the air regulator to provide the desired reading on the air pressure gage.

NOTE 12—A suitable air pressure is usually from 275 to 520 kPa (40 to 75 psi).

## 23. Procedure

23.1 Strain the material to be sprayed into the container to be used with the spray gun. Reduce the material to a viscosity suitable for spraying.

23.2 Connect the container to the gun and test the spray gun operation for correct spray pattern and uniformity by allowing a momentary spray to be deposited on a piece of paper placed in the panel position. Adjust the air pressure, material flow, and spray width controls until the desired pattern and uniformity are obtained. Further refinements may be made in the spray pattern by modifying the air pressure, the type of thinning agent, and the consistency of the material.

NOTE 13—The width of the spray pattern should be considerably wider than the width of the test panel to assure spray uniformity on the test panel.

23.3 Place a test panel on the panel holder. Hold the spray gun tip 250 to 300 mm (10 to 12 in.) from the test panel surface and trigger the spray gun. Begin by aiming the gun at right angles to the panel so that the spray pattern is just beyond the edge of the panel. Gradually make the spray pattern move across the panel at a traverse speed of 250 to 400 mm (10 to 15 in. )/s.

23.4 Reverse the traverse direction of the spray gun and make the spray pattern move across the panel again.

23.5 Remove the panel from its holder and bake or air-dry the coating, in accordance with its type, in a horizontal position in a dust-free atmosphere in accordance with Specification D 3924.

23.6 Clean the spray gun with solvent.

23.7 Measure the film thickness of the dry applied coating in accordance with Test Methods D 1005, D 1186, or D 1400 whichever is appropriate.

23.8 If the coating thickness is too low, coat another panel using more passes of the spray pattern. If the coating thickness is too high, coat another panel with fewer passes of the spray pattern or, if this is not feasible, reduce the material further with thinner.

## 24. Report

24.1 Report the following information:

24.1.1 Type of coating material,

24.1.2 Viscosity and percent nonvolatile of coating material,

24.1.3 Temperature and relative humidity at time of application, and

24.1.4 Mean and range of dry film thickness values obtained.

# PRACTICE E—HAND-HELD BLADE FILM APPLICATION

## 25. Summary of Practice

25.1 A uniform film of a coating material is produced on a test panel by the means of a hand-held applicator blade.

25.2 The thickness of coating applied is controlled by the rate at which the applicator blade is drawn across the test panel, the viscosity of the material, the amount of nonvolatile matter in the material, and the clearance of the blade.

## 26. Significance and Use

26.1 This test method is applicable to the coating of substrates consisting of smooth, rigid materials such as metal or glass. It is applicable to the coating of smooth cardboard and paper charts if some means is used to assure that these substrates are held flat.

26.2 This test method is usually less reliable for producing uniform films than is the motor-driven applicator blade method. However, films sufficiently uniform for most physical property tests of materials can be produced by a hand-held applicator blade operated by a person skilled in its use.

## 27. Apparatus

27.1 *Film Applicator Blade*, any common type, either with adjustable or fixed clearances.

27.2 *Auxiliary Flattening Bar*, precision ground.

27.3 *Test Panels*, any clean, smooth, rigid substrates or may be paper charts or other similar materials.

## 28. Procedure

28.1 Select an applicator blade that has a clearance that will provide a wet film thickness that should result in the desired film thickness.

28.2 *For coating rigid substrates*:

28.2.1 Position the applicator blade near the edge of the panel and place a pool of the liquid material in front of it.

28.2.2 Grasp the sides of the applicator with the fingers and pull it across the panel at a speed of about 10 to 12 in. (250 to 300 mm)/s.

28.3 *For coating non-rigid substrates*:

28.3.1 Position the applicator blade near the edge of the panel and place a pool of the liquid material in front of it. Place the auxiliary bar in front of the pool of material (see Fig. 4).

28.3.2 Grasp the sides of the applicator with the fingers and pull it across the panel at a speed of about 10 to 20 in. (250 to 500 mm)/s. As the auxiliary bar is pushed by the applicator, it should press the substrate flat adjacent to the advancing edge of the applicator.

28.4 Bake or air-dry the applied coating, in accordance with its type in a horizontal position in a dust free atmosphere in accordance with Specification D 3924.

28.5 Clean the applicator bar with solvent.

28.6 Measure the film thickness of the dry-applied coating in accordance with Test Methods D 1005, D 1186, or D 1400 whichever is appropriate.

28.7 If the coating thickness is too low, select an applicator blade with a greater clearance and coat another panel. If the coating thickness is too high, select an applicator blade with a smaller clearance and coat another panel.

## 29. Report

29.1 Report the following information:

29.1.1 Type of coating material,

29.1.2 Viscosity and percent nonvolatile of coating material,

29.1.3 Clearance of applicator blade used,

29.1.4 Air temperature and relative humidity at time of application, and

29.1.5 Mean and range of the film thickness values obtained.

## 30. Keywords

30.1 automatic spray; blade applicator; dip coater; organic coatings

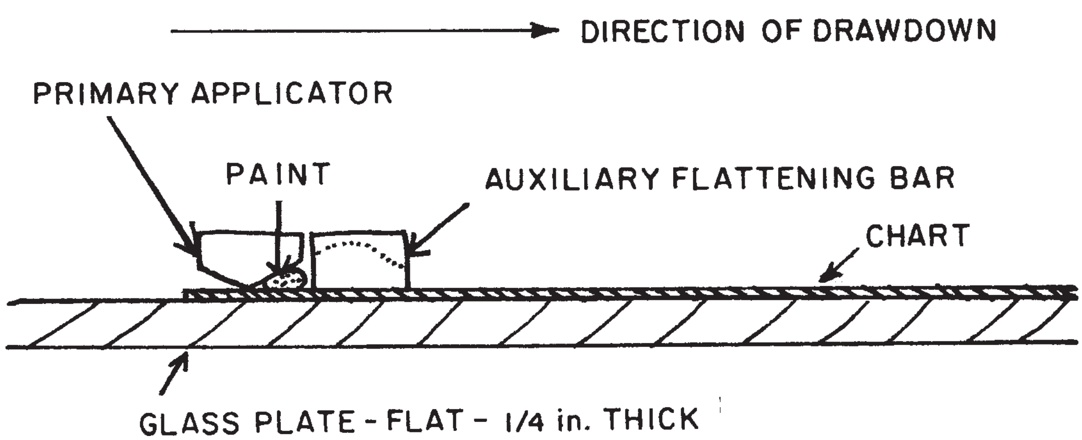



**FIG. 4 Use of Auxiliary Flattening Bar, Practices C and E**