SECTION 2. APPLICATION OF DOPE

2-20. GENERAL. Nitrate dope and butyrate dope are manufactured by treating cellulose, derived from wood pulp or cotton linter with select acids, then dissolving in a blend of solvents and adding plasticizers for flexibility. After a brush or spray application on fabric, the film develops tension and strength as the solvents evaporate. The tension and strength will increase in proportion to the total film thickness. The fabric functions as a film former and carries no load until a crack develops in the dope film. An excessively-thick dope film will develop too much tension and may warp or damage a light airframe.

a. Viscosity adjustments for brush or spray applications may also vary between brands. When the viscosity adjustment ratio is not provided or is unclear, the product manufacturer should be contacted for detailed instructions. If instructions cannot be obtained or the source of the dope is unknown, the dope should be considered suspect and its use is not advised.

b. Dope, which has been stored for an extended period of time or under adverse conditions, should be suspected of becoming acidic and should be tested before being used on cotton or linen fabric. In some cases, fresh production dope has also been found to have a high acid content and will begin to deteriorate cotton or linen in a period of a few months. The acid content of nitrate or butyrate dope should not exceed 0.06 percent, calculated as acidic acid. An acidity test can be performed by most testing laboratories if high acid content is suspected.

c. Butyrate dope is superior to nitrate dope in weather exposure tests. However, nitrate dope provides better adhesion to natural fiber than butyrate dope. The adhesion of butyrate dope to natural fibers is adequate; it is not necessary to use nitrate dope for the first application and butyrate dope for all other applications. The presence of naphtha in nitrate dope, manufactured in accordance with canceled Mil Specs formulas, causes nitrate dope to be incompatible with butyrate dope; therefore, nitrate dope should not be applied over butyrate dope for repairs or refinishing; however, butyrate dope may be applied over nitrate dope.

> **NOTE: Nitrate or butyrate dope thinners and retarders should not be substituted for each other, nor should automotive coating-type thinners be used.**

d. Clear dope produces the most tension and strength. Aluminum-pigmented dope will weigh slightly more than clear dope and develop less tension and strength for the same film thickness. Pigmented color finishes will produce the least tension and strength due to the higher ratio of plasticizers.

e. During the coating-buildup procedure, solvents released from each succeeding coat will penetrate and be absorbed into the previous dope film, temporarily releasing the tension and increasing the drying time between coats as the dope film becomes thicker. If elapsed time between coats exceeds several weeks at temperatures above 70 F, it is recommended that several spray coats of an appropriate dope thinner or dope with retarder and/or rejuvenator added be applied to the lightly-sanded, dried dope film to open the surface and provide cohesion for the next coat. This will reduce the possibility of surface cracks caused by dissimilar tension between the old and new dope film.

f. All dope coats through the final finish may be applied with a brush; however, brush

marks will be noticeable in the finish. With increasing environmental concerns, high pressure airless and high-volume low-pressure (HVLP) paint spray equipment is recommended over conventional siphon and pressure pot spraying equipment. High pressure airless and HVLP paint spraying equipment will greatly reduce paint over-spray and fogging. A spray gun, single coat is applied by overlapping each consecutive pass 50 percent of the fan width. A double coat is applied by repeating the coating application in the same direction, or at a 90°€angle to the first coat (cross coat) before the first coat has flashed off or dried dust free. For safety and helpful tips for doping, see tables 2-3 and 2-4.

TABLE 2-3. Safety tips for dope/paint.

SAFETY TIPS.
Always ground the aircraft structure while sanding and painting.
Do not use an electric drill as a dope/paint mixer.
Wear leather-soled shoes in the dope/painting area.
Have an adequate, approved ventilation system.
Wear cotton clothes when doping or painting.
Wear an approved face mask or respirator when spraying.
Follow all the manufacturer's instructions.

TABLE 2-4. Tips for doping**.**

HELPFUL TIPS FOR DOPING.
Limits for optimum application of dope: relative humidity 20 to 60%; temperature range 65° to 75 °F.
Drying time will vary with temperature, humidity, amount of thinner used, and whether or not retarder was added to the mixture.
Do not recoat until the surface is completely dry and all active solvents have left the dope film.
Spray all coats except the first three or four clear coats, to avoid brush marks.
Over thinning is preferred to under thinning.
Addition of retarder will produce a smoother coat, but drying time between coats will be extended.
To get a clean line for the trim colors, apply a light coat of clear dope directly on the masking tape prior to painting. This will help eliminate the trim color from running under the masking tape.
Remember to always bring the dope to room temperature before using.
Rubbing compound and wax polish may be applied after all solvents have escaped (usually 2 weeks, depending upon the weather).

2-21. DOPE APPLICATION PROCEDURE (Natural Fabrics).

a. Step 1. After the cotton or linen fabric is installed in accordance with the procedures specified in paragraphs 2-7 and 2-8, the fabric is wetted with distilled water to remove wrinkles and fold creases, which will show in a gloss finish. Water may be applied by rubbing with a clean sponge or rag, or by using a paint spray gun. Do not use tap water. It may contain minerals which will contaminate the fabric.

(1) As water is absorbed by the fibers, the threads swell, resulting in temporary tauting of the fabric panel. The fabric should be allowed to dry before dope application, otherwise the water in the fibers will interfere with the dope penetration and adhesion.

(2) After the fabric has dried, the first coat of dope is applied, brushing in one direction to set the nap with a clean, non-shedding, 2-to 6-inch wide, semi-soft, long bristle paint brush.

(3) To offset the deteriorating effect of mildew or other fungus on natural fibers, especially in damp climates, it is recommended that a fungicide be added to the first coat of dope. The preferred fungicide is zinc dimethyldithiocarbamate powder, which should be prepared per the manufacturer's instructions. If no manufacturer's instructions are available the zinc powder may be stirred in at a ratio of 4 ounces, to one gallon of un-thinned nitrate or butyrate dope, after the powder is wetted to a paste with a 50/50 ratio of dope and thinner.

(4) Pre-mixed fungicidal dope, manufactured in accordance with the formula specified in MIL-D-7850, will have a transparent purple tint to indicate the fungicide additive. Dope manufactured with other colors to

identify the manufacturers' products sold under proprietary trade names may or may not have a fungicidal additive.

(5) The viscosity of the dope should be adjusted to uniformly wet the fabric, indicated by the fabric becoming translucent so that it penetrates through the fabric but does not drip or run down the opposite side. Any dope-runs or pooling on the opposite side will shrink and distort the fabric, and may be visible on the finished surface.

(6) The ideal temperature for application of dope or other coatings is 65 to 75 F and the humidity should be less than 65 percent. As a general rule, each 10 F increase or decrease in ambient temperature will increase or decrease drying time by 100 percent. Dope should be allowed to warm to room temperature prior to attempting to adjust the viscosity.

b. Step 2. Depending upon the quality of the dope and the ratio of thinning, the fabric should start to become taut after the first brushed coat of dope has dried approximately 1 hour at 70 °F. A second, heavier coat is applied by cross brushing at 90°F to the first coat. Viscosity should be adjusted only as necessary to brush out a heavy uniform coat. If the fabric is not taut, with all sag removed, after the second coat has dried approximately 2 hours, a third coat may be applied.

c. Step 3. After the fabric has become semi-taut and stabilized with the initial dope application, and the rib lacing and other fabric attachments are completed as detailed in paragraphs 2-9 through 2-12, it is ready for "dressing out" as described in paragraphs 2-13 and 2-14.

d. NOTE: "Dressing out" means applying all the finishing tapes, reinforcing patches, inspection access ports, and drain grommets, etc.

e. Step 4. After the covering is a dressed out, one or more coats of clear dope are brushed over all finishing tapes and fabric reinforcing patches. This will balance the thickness of the dope film with the previously coated areas of the fabric. It is very important that the porosity of the fabric be filled while brushing to avoid pinholes showing in the finish.

f. Step 5. After drying at least 2 hours at 70 °F, a third heavy coat of clear dope is applied over the entire surface, preferably with a paint spray gun if brush marks are to be avoided. After the third coat of dope has dried at least 2 hours at 70 °F, the fabric should be taut and the dope film should show a gloss, depending upon the dope quality and the ratio of thinner added. If not, a fourth coat of clear dope may be applied, in the same manner as the third coat.

NOTE: Three to four clear coats of dope film showing a uniform gloss combined with the aluminum-pigmented coats and finish coats is considered satisfactory for light aircraft up to 9 lb. per square foot wing loading. Five to eight clear coats, depending upon the quality of the dope and resulting film thickness, are recommended for higher wing loading aircraft to assure the covering does not stretch and lose tension.

g. Step 6. After the clear coats are found to be satisfactory, two heavy cross-coats of aluminum-pigmented dope are applied with a spray gun to provide protection from ultraviolet (UV) rays. Tests have shown that UV radiation will deteriorate cotton, linen, and polyester fabric; however, polyester fabric deteriorates at a rate half that of cotton or linen under identical exposure conditions. UV radiation

does not deteriorate glass fabric. Aluminum-pigmented dope blocks UV radiation and provides a sanding base. A gauge of ultraviolet protection in the field is to block all visible light from penetrating through the fabric. Drying time between the two coats should be at least 1 hour at 70 °F.

(1) An option to premixed aluminum dope is to use aluminum-pigment paste. Aluminum paste should be prepared per the manufacturer's instructions. If no manufacturer's instructions are available, mix 3 ounces (by weight), of 325-mesh aluminum-pigment paste, to 1 gallon of unthinned, clear dope. The aluminum paste should first be mixed to a cream consistency with a 50/50 ratio of dope and thinner before mixing into the unthinned clear dope. A higher ratio of aluminum-pigment added to the dope may cause a loss of primer-coat and finish-coat adhesion, and peeling may occur especially when high tack tape is used to mask for the trim colors and registration numbers.

(2) The viscosity of the mixed aluminum-pigmented dope should be adjusted for satisfactory spray gun application.

h. Step 7. After two coats of aluminum-pigmented dope have dried at least 4 hours at 70 °F, the surface may be wet sanded with # 280 grit (or finer) waterproof sandpaper. The aluminum-pigmented dope should be sanded only to develop a smooth surface, not sanded completely off to the clear dope undercoats. Do not sand over screwheads, rib lacing, or any structural sharp edges that will quickly cut through fabric and require patching. Additional coats of aluminum-pigmented dope may be applied and sanded, depending on the final finish desired. The last coat should not be sanded to assure ultraviolet protection along the edges of the finishing tapes and reinforcing patches is maintained.

i. Step 8. Three coats of pigmented color finish are applied with a paint spray gun, allowing adequate drying time between coats. The color finish may be wet sanded between coats, if desired, with a fine grit waterproof sandpaper. Adding blush retarder to the final dope finish will improve the gloss. After drying several weeks, a rubbing compound may be used to buff the finish and increase the gloss. A periodic application of a wax polish will help protect the finish from the weather and environmental pollution.

NOTE: Drain holes should be opened soon after all finishing is complete to insure drainage and to aid ventilation of the structure.

(1) When exposed to the sun, dark colors absorb more sun energy and convert that energy to heat more easily than light colors. High temperatures dry out wood structures and deteriorate organic materials in an aircraft structure. Preferably the lighter color shades are applied first and then overcoated with darker trim and registration number colors.

(2) Only high-quality, solvent-resistant crepe paper or polypropylene masking tape should be used to avoid finish bleed under the tape edge. Newspaper printing ink may transfer to a fresh finish and should not be used for masking paper. Plastic sheeting should not be used as a dust cover on a fresh finish due to possible bonding and damage.

2-22. COVERING OVER PLYWOOD.

Exposed, stressed plywood surfaces, such as wings, must be protected from weather

deterioration with fabric at least equal to that used by the original manufacturer. If the quality is not known, intermediate-grade fabric, meeting TSO-C14b specification, is acceptable. Fabric may be installed in sections with a 1/2 inch edge overlap without covering the overlap with finishing tape. Fabric may also be installed with the edges butted together, and the seam covered with a minimum 1-inch wide finishing tape. The seams may be oriented in any direction, in reference to the line of flight. However, overlapped seams, not covered with a finishing tape, should be oriented rearward. Fabric should be wrapped completely around a wing's leading and trailing edges and other components, where possible, to provide fabric-to-fabric continuity around all edges to avoid a poorly-bonded fabric edge from peeling from the plywood surface causing serious aerodynamic consequences.

a. After the plywood surface is prepared, and the two pre-coats of clear dope have dried as recommended in paragraph 2-6 g, the fabric is pulled snug and bonded with clear dope around the perimeter of the fabric section. The fabric is then wetted with distilled water to remove fold creases, in the same manner described for fabric panel areas. After the water has evaporated, a heavy coat of low-viscosity clear dope is brushed firmly through the fabric to soften the underlying dope pre-coat, insuring a good bond. Brushing techniques should be accomplished by moving the brush from one side across to the opposite side to remove all air bubbles and thoroughly saturate the fabric. This is indicated by the plywood grain being easily visible through the translucent fabric. Except for very small imperfections or small dents in the plywood surface, voids are not permissible between the fabric and plywood surfaces. Voids may allow the fabric to balloon from the plywood surface, creating adverse handling characteristics.

b. After the first dope coat has dried at least 1 hour at 70 °F, a second heavy coat of clear dope is applied by brush to fill the fabric weave and prevent pinholes. The installation of finish tape around the perimeter of the plywood surfaces, leading edges, and other wear points, is optional but recommended for wear and chafe protection. The application of aluminum-pigmented dope coating, sanding, and finish coats will be the same as that specified for fabric panel areas. Reinforcement grommets are not required on drain holes through plywood surfaces.

2-23. COATING APPLICATION DEFECTS.

a. Blushing. The appearance of light shaded dull areas on the surface as dope dries is the result of moisture in the atmosphere condensing on a surface due to the cooling effect of the fast-evaporating components of dope thinner escaping from the coating. Blushing can occur at any temperature when the humidity is above 65 percent. There are several ways to remedy this problem. The drying time may be slowed by adding up to 1 quart of blush retarder to 1 gallon of dope or by increasing the temperature of the dope room and eliminating any cooling draft from blowing across the surface. Blushed surfaces may be reworked by spraying several, closely-timed coats of a 50/50 blend of blush retarder and dope thinner to soften and return the dope surface to the original liquid state. Blush retarder, mixed with dope, may delay the full drying time by several days, but will eventually escape from the dope film if the room temperature is maintained an average of 70 °F.

b. Pinholes. Voids between the fabric threads that are not filled with the first coats of dope are called pinholes. They may be caused by fabric contamination, such as oil or finger

prints, but are usually the result of improper dope application. Pinholes are usually found in a second layer of fabric such as finishing tapes and reinforcing patches or over underlying, non-porous structures; such as leading edges, turtle decks, and plywood surfaces. Any non-porous structure under fabric will act as a backstop and will resist complete dope penetration into the fabric. Microscopic cavities between the backstop and fabric collect escaping solvent vapors during the drying process and balloon up through the surface leaving pinholes, or become pinholes when the top of the balloon is sanded. Moisture, in the fabric or on the backstop surface, also interferes with complete dope penetration, resulting in pinholes. The remedy for pinholes, at any stage before the final finish coat, is to add blush retarder to low viscosity dope and carefully brush over the affected surfaces to penetrate into and fill the pinholes. Discontinue brushing after five or six strokes to avoid leaving brush marks.

c. Orange Peel. A rough spray gun-applied finish, similar to the texture of an orange peel, may be caused by one or more of the following conditions:

(1) Viscosity of material being sprayed is too high.

(2) Air temperature is too high.

(3) Spraying in direct sunlight, onto a hot surface or in a drafty/windy condition, which causes a fast solvent evaporation.

(4) Spray gun, tip, cap, and/or needle are not properly matched for the type material being sprayed.

(5) Volume of air available from the compressor not sufficient for spray gun.

(6) Wrong thinner used and drying too fast.

(7) Spray gun not properly adjusted. The spray gun should be adjusted to a uniform spray pattern with the material atomized to deposit fine, wet particles that merge and form a smooth film.

d. Blisters. One or more of the following conditions my cause blisters:

(1) Freshly coated surface placed in hot sunlight or high temperature area to accelerate drying time, causing the vapor from rapidly evaporating solvents to be trapped.

(2) Excessive high air pressure used to spray heavy coats which “blasts” air bubbles into the coating.

(3) Water or oil in air supply.

e. Runs, Sags, and Curtains. These defects may be caused by one or more of the following conditions:

(1) Viscosity of material being sprayed is too low.

(2) Coats applied too heavily.

(3) Insufficient drying time between coats.

(4) Spray gun held too close to work surface.

(5) Improperly adjusted spray gun.

f. Spray Gun Laps and Streaks. These defects may be caused by one or more of the following conditions:

(1) Spray gun not properly adjusted to spray a wet, smooth surface.

(2) Overspray on a partially-dried surface.

(3) Spray pattern not sufficiently overlapped on each pass.

(4) Viscosity of material being sprayed is too high.

(5) Metallic finishes sprayed too heavily allowing metallic pigments to move or flow after deposit, causing a marbled appearance.

2-24.—2-29. [RESERVED.]