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DOPES AND THEIR APPLICATION
(MATERIALS AND FACTORY SECTIONS REPORT)

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[Signatures and seals]
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DOPES

Dope is essentially a colloidal solution of cellulose acetate or cellulose nitrate, together with sufficient softness to give a smooth, homogeneous, flexible film when dry, produce tautness, and thus increase the strength of the fabric.

A fabric-covered surface without the addition of a protective film would be very susceptible to humidity changes, becoming slack or taut with every increase or decrease of atmospheric moisture. It would also lose its strength quite rapidly and could not give any protection to the interior wing structure. Coating the fabric-covered surfaces renders them weatherproof, tightens the surface to conform to the wing section, and produces a more nearly rigid airfoil.

CLEAR Dope

The essential constituents of clear dope are five in number:

a. The film-base compound.

b. The softeners or flexilizers for producing a flexible film.

c. The solvents for the film-base material.

d. The diluents for thinning the solution.

e. The high-boiling compounds for controlling evaporation and preventing blushing—that is, provided ventilation is properly controlled.

The film-base compounds are cellulose acetate or cellulose nitrate. Cellulose acetate is the more expensive compound owing to the cost of the raw materials required to prepare it and to its more complicated process of production. It is, however, much less flammable than cellulose nitrate, and for this reason is used almost entirely for clear dope.

Softeners or flexilizers are required to produce a flexible film, as the cellulose acetate or nitrate alone would be too brittle. Triphenyl phosphate and triacetin are commonly used softeners for cellulose acetate dopes, while castor oil is a common softener for cellulose nitrate.

The solvents are the liquids which are used to dissolve the cellulose base materials. Acetone, methyl acetone, and methyl acetate are the most commonly used for cellulose acetate. Amyl acetate, butyl acetate, and ethyl acetate are the most commonly used for cellulose nitrate.

The diluents or thinners are liquids which have no appreciable solvent power by themselves, but are added to the solution to keep down the expense of the dope mixture. They evaporate completely with the volatile solvents. Common diluents for both cellulose acetate and nitrate dopes are benzol, ethyl alcohol, and methyl alcohol.

The high boilers help to prevent whitening or blushing of the dope while it is drying. They tend to hold the cellulose acetate in solution when it is dried under conditions of relatively high humidity and in the presence of the water that forms on the surface owing to the chilling caused by evaporation of the highly volatile solvents.

PIGMENTED Dope

Besides producing, when dry, a tautness of the fabric that is not greatly affected by changes in atmospheric moisture, dope should act as a protective coating to prevent rapid deterioration from weathering. A clear film of either cellulose acetate or cellulose nitrate dope is transparent to sunlight, and sunlight is the greatest factor in the deterioration of dopes and fabrics.

To prevent excessive deterioration, an opaque protective coating on top of the clear dope film is of the utmost importance. This opaque protective coating is a dope similar to the clear dopes already mentioned, but with the addition of an inert opaque pigment that cuts out the actinic rays of sunlight from the clear dope and fabric. A clear dope will only withstand a few months' constant exposure to the weather, while the same finish protected by an opaque pigmented dope will last for several years.

APPROVAL

All airplane dopes authorized for purchase by the Air Service or used by contractors of airplanes on Air Service contract have been thoroughly tested by the Engineering Division. Any new brand or formula must undergo chemical, physical, and exposure tests as outlined in Air Service specifications. When found suitable for Air Service use, it is placed upon an approved list, from which all purchases must be made.

Each separate product is assigned a code number which identifies the product while in storage and when used.

All clear acetate dope is supplied in 110-gallon steel drums provided with two bungs, one in the head and the other in the side to facilitate drawing dope from the drum.

Pigmented dope is supplied in 1-gallon and 5-gallon large-opening cans. The cans are made with an opening large enough to permit ready mixing of any settled pigment.

STORAGE

Dope should be stored in dry warehouses where it is not subjected to direct sunlight and heat in the summer months. The drums may be painted to prevent rusting, but care must be taken to see that the information stenciled on the drum is not effaced.
COVERING POWER

In practice it has been found that, applying four coats, the average covering power of clear dope is 1 gallon to 28 square feet of surface; applying 2 coats, the average covering power of pigmented dope is 1 gallon to 90 square feet.

APPLYING DOPE WITH A BRUSH

The first two coats of clear dope should be applied with a 4-inch bristle brush. By that time the lint is fastened to the warp and woof of the fabric and can not be pulled out by using the DeVilbiss spray gun.

Occasionally grease spots may get onto the fabric before it is doped. They should be rubbed gently with a piece of clean waste soaked in benzol and allowed to dry thoroughly. If oil spots are not removed, bubbles or blisters form.

Dope cans should not contain more than a 30 to 45 minute supply, because otherwise evaporation of the solvents, resulting in a change in viscosity and a loss of material, might be serious.

When dope cans are set on the wings while doping, care should be taken that they are supported by a wing rib and not by the fabric alone. (See fig. 1.)

To keep brushes clean, let them stand, when not in use, in an acetone solution and in a covered can.

Ventilation should be controlled as described in the part on spraying dope with the DeVilbiss system, except that it is not necessary to run the fumexer fans.

REQUIREMENTS FOR SPRAYING DOPE WITH THE DeVILBISS SYSTEM

The DeVilbiss aeron system has proved very satisfactory for spraying the fabric parts of airplanes with dope. Only at first was difficulty experienced, and that was in operating the guns. Two separate container types of guns are in use by the Engineering Division; namely, Types J and A. Type J has given satisfactory service for six years, while Type A was only recently installed. The latter has given equally good results and has, moreover, the advantage of being lighter in weight and more compact. Type A is shown in Figure 2.

One attached-cup type, Type D aeron with VB spray head, is used for spraying insignia. Other DeVilbiss equipment in use as follows: The 13-gallon tank equipped with pressure gauges, air-adjusting diaphragms, and hose for use with the Types J and A aerons; fluid hose cleaner; air compressor; air receiver; air transformer; Type P fumexer, used without the housing; and 30 by 40 inch covered containers. Mixing tanks of 100 gallons capacity are used instead of those manufactured by the DeVilbiss company. Other special equipment is described in the text or illustrations following. Requirements for good results in using the spray system are as follows:

SKILLFUL USE OF THE GUN

Two projections on the cone of the gun, one for release of air and the other for release of dope, are set at such an angle to each other that the two streams, air and dope, unite about 1 inch from the end of the nozzle. For longitudinal or transverse spraying, the nozzle can be turned to obtain a fan-shaped spray.

Six coats of dope are usually applied, four of clear and two pigmented. As previously mentioned, the first two coats of clear dope are always applied with a 4-inch bristle brush, because using the spray gun at first would pull out the lint. After the tape and fitting patches are applied, the other two coats of clear and the two coats of pigmented dope are applied with the DeVilbiss aeron system. Figure 3 shows the correct method of holding the gun. One coat of the pigmented dope can be used successfully, but two thin coats, in any case, are better than one heavy coat, because it lessens the probability of runs. First attempts at using only one coat were entirely unsatisfactory, because of unfamiliarity with the gun. An arm movement allowing free forward and backward strokes across the wing, that is, from leading edge to trailing edge, and the knack of decreasing the pressure on the trigger at the edges of the airfoil to keep the dope from getting too heavy and running in channels or lumps had to be acquired. To keep the dope from piling up, the gun should be moved rather rapidly, and the gun nozzle should be held at least 8 inches from the surface being covered. Held at this distance, the spray is 12 inches wide. When spraying pigmented dope, to prevent white streaks on the fabric after the dope dries, the sprayed strips should overlap each other about 2 inches. Cover the upper side of a wing first, then the lower, and then the edges. If the gun nozzle is held at the proper distance, this method of procedure prevents the dope from piling up and running. If the dope deposit is a little heavy, it is better to leave it than to try removing it, for it will not be noticed when dry. Drying heavily applied dope with the gun is a trick that the men have learned to use successfully. To do this, the U-shaped needle holder on the back of the gun is raised, thus allowing the air to flow, but shutting off the dope. Then the gun is moved up and down on the wing to dry the surplus liquid.

A CLEAN GUN

When through using the spray gun, submerge it in a can of acetone and keep a cover on the can. When the thickened dope is dissolved, remove and dry the gun and store it in a clean locker. (See fig. 4.)

When the gun is in use, if the projections on the cone become clogged with thickened dope, thus breaking the fan-shaped spray, spraying should be stopped and the dope removed.

CLEAN HOSE FOR DOPE

Hose must be clean and free from kinks so that the dope can flow freely. When work for the day is completed, attach the hose to a hose cleaner (De-Vilbiss fluid hose cleaner H. D. No. 501) and shoot at least a quart of acetone through it under air pressure to remove all dope, placing the free end of the hose in a covered bucket to prevent splashing. (See fig. 5.) Coil the hose and hang it on a peg of at least 16 inches diameter to prevent permanent kinks and breaking the fabric plies.
DOPE OF PROPER CONSISTENCY

Instead of using the agitators supplied by the De-Vilbiss company, the Engineering Division mixes dope in a 100-gallon tank manufactured by the Columbia Manufacturing & Metal Products Co., of Dayton, Ohio. (See fig. 6.) This tank is equipped with motor-driven paddle wheels and has a faucet at the bottom, so that the dope can easily be drawn for filling the 13-gallon containers used in spraying. Figures 7, 8, and 9 show the 13-gallon container. Figure 10 shows the stand constructed at the Engineering Division for moving dope barrels.

The Air Service has a series of code numbers which they use in combination with the manufacturer's numbers to show the color, compounding, and consistency of the different dopes. Information concerning these codes and numbers may be obtained from the Engineering Division.

Keep all dope cans in covered containers when not in use. Size 30 by 40 inch containers with hinged covers are used. (See fig. 11.)

If dope has stood, for any reason, in an open container, it becomes too thick to flow through the hose freely. It should be thinned with acetone and stirred until it is of the proper consistency.

PROTECTION OF AIR PRESSURE GAUGES

To adjust the air pressure on the gun and fluid, there are two gauges on top of the 13-gallon fluid container, one to give proper air pressure for the gun spray and the other for sending the fluid from the tank to the gun. The air pressure to the gun should be not less than 70 or more than 80 pounds. The air pressure on the fluid should be 15 to 20 pounds, but this can be regulated by the operator as various guns and nozzles use various pressures.

Very often the diaphragms of the pressure gauges are broken in regulating the air pressure for both the air and dope. A buzzing sound will be noticed in the valve when this occurs. At least two dozen De-Vilbiss diaphragms should be kept on hand to replace broken ones.

To prevent injury of the air-adjusting diaphragms and pressure gauges of the 13-gallon container when pulled over the ground, the portable fixture shown in Figure 12 was constructed from steel tubing and airplane wheels. The casters provided by the De-Vilbiss company may be used on smooth floors.

RIVETED AIR TANK OF PROPER CAPACITY

The air container should have a capacity of at least 75 cubic feet for two guns, in order to keep the volume above the amount used. The capacity of the tank also depends on the bore and stroke of the air compressor; if the input is large, the container may be small, or vice versa. The container should have two safety valves to prevent explosions of the tank, as the valves occasionally become corroded. A welded tank should not be used for the air receiver, because welding is not of the same thickness throughout the joint. The least overinflation would cause trouble in such a tank. The only suitable tank is one made from a three-eighths-inch stock and with a lapped and riveted seam, using rivets of the same thickness as the material. Figure 13 shows the air compressor and air receiver installed in the Engineering Division dope room.

AIR FREE FROM PARTICLES OF DIRT, OIL, AND WATER AND AT 80 TO 90 POUNDS CONSTANT PRESSURE

The compressed air used in spraying must be kept free from particles which drop from the inside of the air container or tank. The air tank should have a removable manhole cover to permit cleaning. To insure an air supply free from scale and dirt, the tank should be cleaned at least every three months.

Oil used to lubricate the air compressor also works itself into the air stream and prevents proper drying of the dope. There should be a drain cock at the bottom of the tank for draining it of water and oil before beginning work.

To further insure a pure-air supply, the De-Vilbiss Manufacturing Co. provides a renovator, the air transformer set shown in Figure 14, which may be placed in the air line between the tank and the gun. This transformer set is used principally, however, with the cup gun, so that the air pressure may be regulated without attaching the hose connection to the diaphragm of the 13-gallon container.

The air should be kept at 80 to 90 pounds constant pressure, and should never exceed 100 pounds. The following sign should be painted on the tank:

NOTICE: OPERATING AIR PRESSURE NOT TO BE OVER 100 POUNDS

The air-pressure gauge should be placed in plain view of the operator. The safety valves should have a hand wire attached, so that the air may be released in an emergency or when work is completed.

GOOD VENTILATION

To ventilate the dope room, the Engineering Division uses a De-Vilbiss fumexer Type P, except that the housing is not used, the room being small enough to act as a housing. Only two wings can be sprayed at one time. The fumexer cone should come in contact with the floor, so that the suction created by the fans will draw the dope fumes from the floor as well as the ceiling. Figures 15, 16, and 17 show this fumexer installation in the Engineering Division dope room. When the 10 fans of the fumexer are running, such a suction is created in the room that a system of shutters is required. Holes were cut into the room wall and frames made into which the short obsolete DH-4B radiator shutters were fitted. To give ample ventilation in a room 25 by 40 feet, six of these shutters were installed, three at the ceiling and three at the floor, because the dope fumes first rise to the ceiling before they settle on the floor. Control cables of one-sixteenth inch were fastened to the shutter bell cranks and conducted to quadrant control levers, so that the air flow into the room can be regulated. The old shutter spring was left on and serves to close the shutter when the cable is released at the quadrant. Without these shutters, neither ventilation nor room temperature can be successfully controlled nor the doped surface kept...
from blushing. Without proper ventilation, the men become sick from headaches and heartburns.

To prevent knocking, the accumulation of dope should be removed from the fans at least once a week. The fan motors should be kept properly oiled and the commutator head should be kept closed to keep out the dope fog and lessen the fire hazard.

ROOM TEMPERATURE OF 70° F

Room temperature should be maintained at 70° F to prevent blushing of doped surfaces. In the Engineering Division's dope room, to maintain this temperature on cold or foggy days, steam coils and radiators, controlled by steam globe valves, were installed; one set of coils on the floor, one set on the walls, and three radiators in remote sections of the room. (See figs. 16 and 17.)

The floor coil, consisting of 12 pipes, is 30 feet long and 30 inches wide. To induce quick drying, the wings are laid on horses over these coils. The wall coil, consisting of seven pipes, is 20 feet long and 20 inches wide. The pipes of both coils, floor and wall, are screwed into manifolds, on one end into the in manifold, on the other to the out manifold. On the in ends, globe valves are installed; on the out ends, traps are provided to drain the pipes of water. The out ends are an inch lower than the in ends, so that the condensed steam will flow into the water traps.

It has been found that, on cold days, better results can be obtained by using only 5 of the 10 fan exer fans, because, with the 10, so much air is drawn from the room that the room cools, thus bringing on blushing of the fabric. If blushing does occur, it can be removed by gently rubbing the affected sections of the surface with a rag saturated with acetone. If results are not satisfactory, the spots should be rubbed again. This is a slow process for production, but is helpful in an emergency.

LATTICED WALK FOR OPERATORS

To reduce leg strains for the men operating the spray guns, a latticed boarding is placed on the concrete floor where the men stand.

TEMPLATES AND SMALL CUP GUNS FOR SPRAYING INSIGNIA

For spraying insignia on the wings, sheet aluminum templates of sizes specified for various sizes of airfoils are used to separate the colors. The fabric is sprayed with two coats of white pigmented dope and allowed to dry until it loses tackiness. A sheet aluminum star cut to size from sheet metal is laid on this surface and the edges weighted down with three-eighth-inch cold-rolled-steel flat pieces about 3 inches long. This prevents the blue dope, which is next applied, from getting onto the white star. The blue is applied in one heavy coat, the star removed carefully, and the blue allowed to dry as directed for the white. A large circular template of the specified size and with a hole in the center which is of the size specified for the red or bull's-eye is then weighted down, and the red insignia is sprayed in. The dope used for the wing surface is then sprayed around the edges of the template to give a clean-cut edge to the insignia. Cup guns of 1-quart capacity are used for the colors, one for each color. This gun is illustrated in Figure 18 and is called Type D aeron with VB spray head. Cup holders are screwed to the wall to keep the cup from tipping and spilling the liquid.

SPECIAL BRONZING MEDIUM FOR WOOD AND METAL

To produce effects on wood and metal that harmonize with the color produced on fabric by the spray gun, Baer Bros.' Best English Bronzing Medium (offices at 438 and 448 West Thirty-seventh Street, New York City) is mixed until the proper color is obtained under the brush. The mixture is best applied with a soft camel's-hair brush.

PATCHING

Never patch over the pigmented protective covering. Both the pigmented protective covering and the dope film may be removed with either acetone or clear dope. After the dope film is softened it may be easily peeled or scraped off. A broad putty knife or painter's spatula is best to use for this purpose.

The hole or tear should be darned if it is a bad one and the patch, which should be of the same material if possible, frayed around the edges. Dope should be applied both under and over the patch, and the same kind of dope used as that originally applied. This is important, as otherwise poor adhesion may result. The usual number of coats are applied, four of clear and one or two of pigmented.
FIG. 1.—Supporting dope can on wing rib.

FIG. 2.—DeVilbis type A spray gun.
FIG. 3.—Right way to hold spray gun.

FIG. 4.—Dope room locker for tools.
FIG. 5.—Hose attached to hose cleaner.

FIG. 6.—100-gallon dope mixer.
FIG. 7.—13-gallon container open for filling.

FIG. 8.—Supporting gun on pressure gages.
Fig. 9.—Hose coiled about 12-gallon container when not in immediate use.

Fig. 10.—Stand for moving dope barrels.
FIG. 11.—Dope containers on portable trays.

FIG. 12.—Portable fixture used to prevent jarring the pressure gages.
Fig. 13.—Air compressor and air receiver installation.

Fig. 14.—Air transformer.
Fig. 15.—Exterior view of fumexer.

Fig. 16.—Dope room, showing fumexer, floor coils, and latticed wall.
Fig. 17.—Dope room, showing wing supported over steam coils.

Fig. 18.—Type D cup gun.