This chapter explains the painting process and also will highlight the previous work.

3.1 Painting Definition:

1. An industrial coating defined by its protective rather than its aesthetics properties, although it can provide both the most common use of industrial coating is for corrosion control of steel structures such as offshore platforms, bridges and underground pipelines.
2. A synthetic polymer used in high performance latex or water-based paints.
3. Painting is the process of applying paints or coatings to a surface.

- The difference between painting and coating:
  Paint is a coat, but there are differences in purpose, environment, material, process and skills.
  There are two basic coating categories:
  1- Architectural Coating (house paint, drawing, pictures).
  2- Industrial coating.

3.1.1 Painting:
Defined by its esthetic value rather than protection value. although it can provide both

3.1.2 Coating:
Defined by its protection value rather than its esthetic value although it can provide both.[21]

3.2 Painting

Paint, or more specifically its overall color and application, is usually the first impression that is transmitted to someone when they look at an aircraft for the first time. Paint makes a statement about the aircraft and the person who owns or operates it. The paint scheme may reflect the owner’s ideas and color preferences for an amateur-built aircraft project, or it may be colors and identification for the recognition of a corporate or air carrier aircraft. Aircraft Painting and Finishing Paint is more than aesthetics; it affects the weight of the aircraft and protects the integrity of the airframe. The topcoat finish is applied to protect the
exposed surfaces from corrosion and deterioration. Also, a properly painted aircraft is easier to clean and maintain because the exposed surfaces are more resistant to corrosion and dirt, and oil does not adhere as readily to the surface. A wide variety of materials and finishes are used to protect and provide the desired appearance of the aircraft.

The term “paint” is used in a general sense and includes primers, enamels, lacquers, and the various multipart finishing formulas. Paint has three components:

1-Resin as coating,

2- Material, pigment for color, and

3- Solvents to reduce the mix to a workable viscosity.

Internal structure and unexposed components are finished to protect them from corrosion and deterioration. All exposed surfaces and components are finished to provide protection and to present a pleasing appearance. Decorative finishing includes trim striping, the addition of company logos and emblems, and the application of decals, identification numbers, and letters.

3.3 Finishing Materials

A wide variety of materials are used in aircraft finishing. Some of the more common materials and their uses are described in the following paragraphs.

3.3.1 Acetone

Acetone is a fast-evaporating colorless solvent. It is used as an ingredient in paint, nail polish, and varnish removers. It is a strong solvent for most plastics and is ideal for thinning fiberglass resin, polyester resins, vinyl, and adhesives. It is also used as a superglue remover. Acetone is a heavy-duty degreaser suitable for metal preparation and removing grease from fabric covering prior to doping. It should not be used as a thinner in dope because of its rapid evaporation, which causes the doped area to cool and collect moisture. This absorbed moisture prevents uniform drying and results in blushing of the dope and a flat no-gloss finish.
3.3.2 Alcohol

Butanol, or butyl alcohol, is a slow-drying solvent that can be mixed with aircraft dope to retard drying of the dope film on humid days, thus preventing blushing. A mixture of dope solvent containing 5 to 10 percent of butyl alcohol is usually sufficient for this purpose. Butanol and ethanol alcohol are mixed together in ratios ranging from 1:1 to 1:3 to use to dilute wash coat primer for spray applications because the butyl alcohol retards the evaporation rate. Ethanol or denatured alcohol is used to thin shellac for spraying and as a constituent of paint and varnish remover. It can also be used as a cleaner and degreaser prior to painting. Isopropyl, or rubbing alcohol, can be used as a disinfectant. It is used in the formulation of oxygen system cleaning solutions. It can be used to remove grease pencil and permanent marker from smooth surfaces, or to wipe hand or fingerprint oil from a surface before painting.

3.3.3 Benzene

Benzene is a highly flammable, colorless liquid with a sweet odor. It is a product used in some paint and varnish removers. It is an industrial solvent that is regulated by the Environmental Protection Agency (EPA) because it is an extremely toxic chemical compound when inhaled or absorbed through the skin. It has been identified as a Class A carcinogen known to cause various forms of cancer. It should be avoided for use as a common cleaning solvent for paint equipment and spray guns.

3.3.4 Methyl Ethyl Ketone (MEK)

Methyl ethyl Ketone (MEK), also referred to as 2-Butanone, is a highly flammable, liquid solvent used in paint and varnish removers, paint and primer thinners, in surface coatings, adhesives, printing inks, as a catalyst for polyester resin hardening, and as an extraction medium for fats, oils, waxes, and resins. Because of its effectiveness as a quickly evaporating solvent, MEK is used in formulating high solids coatings that help to reduce emissions from coating operations. Persons using MEK should use protective gloves and have adequate ventilation to avoid the possible irritation effects of skin contact and breathing of the vapors.
3.3.5 Methylene Chloride

Methylene Chloride is a colorless, volatile liquid completely miscible with a variety of other solvents. It is widely used in paint strippers and as a cleaning agent/degreaser for metal parts. It has no flash point under normal use conditions and can be used to reduce the flammability of other substances.

3.3.6 Toluene

Referred to as Toulon or methylbenzene, toluene is a clear, water-insoluble liquid with a distinct odor similar to that of benzene. It is a common solvent used in paints, paint thinners, lacquers, and adhesives. It has been used as a paint remover in softening fluorescent-finish, clear-topcoat sealing materials. It is also an acceptable thinner for zinc chromate primer. It has been used as an anti knocking additive in gasoline. Prolonged exposure to toluene vapors should be avoided because it may be linked to brain damage.

3.3.7 Turpentine

Turpentine is obtained by distillation of wood from certain pine trees. It is a flammable, water-insoluble liquid solvent used as a thinner and quick-drier for varnishes, enamels, and other oil-based paints. Turpentine can be used to clean paint equipment and paint brushes used with oil-based paints.

3.3.8 Mineral Spirits

Sometimes referred to as white spirit, Stoddard solvent, or petroleum spirits, mineral spirits is a petroleum distillate used as a paint thinner and mild solvent. The reference to the name Stoddard came from a dry cleaner which helped to develop it in the 1920s as a less volatile dry cleaning solvent and as an alternative to the more volatile petroleum solvents that were being used for cleaning clothes. It is the most widely used solvent in the paint industry, used in aerosols, paints, wood preservatives, lacquers, and varnishes. It is also commonly used to clean paint brushes and paint equipment. Mineral spirits are used in industry for cleaning and degreasing machine tools and parts because it is
very effective in removing oils and greases from metal. It has low odor, is less flammable, and less toxic than turpentine.

**3.3.9 Naphtha**

Naphtha is one of a wide variety of volatile hydrocarbon mixtures that is sometimes processed from coal tar but more often derived from petroleum. Naphtha is used as a solvent for various organic substances, such as fats and rubber, and in the making of varnish. It is used as a cleaning fluid and is incorporated into some laundry soaps. Naphtha has a low flashpoint and is used as a fuel in portable stoves and lanterns. It is sold under different names around the world and is known as white gas, or Coleman fuel, in North America.

**3.3.10 Linseed Oil**

Linseed oil is the most commonly used carrier in oil paint. It makes the paint more fluid, transparent, and glossy. It is used to reduce semi paste oil colors, such as dull black stenciling paint and insignia colors, to a brushing consistency. Linseed oil is also used as a protective coating on the interior of metal tubing. Linseed oil is derived from pressing the dried ripe flax seeds of the flax plant to obtain the oil and then using a process called solvent extraction. Oil obtained without the solvent extraction process is marketed as flaxseed oil. The term “boiled linseed oil” indicates that it was processed with additives to shorten its drying time. A note of caution is usually added to packaging of linseed oil with the statement, “Risk of Fire from Spontaneous Combustion Exists with this Product.” Linseed oil generates heat as it dries. Oily materials and rags must be properly disposed after use to eliminate the possible cause of spontaneous ignition and fire.

**3.3.11 Thinners**

Thinners include a plethora of solvents used to reduce the viscosity of any one of the numerous types of primers, subcoats, and topcoats.
3.3.12 Varnish

Varnish is a transparent protective finish primarily used for finishing wood. It is available in interior and exterior grades. The exterior grade does not dry as hard as the interior grade, allowing it to expand and contract with the temperature changes of the material being finished. Varnish is traditionally a combination of a drying oil, a resin, and a thinner or solvent. It has little or no color, is transparent, and has no added pigment. Varnish dries slower than most other finishes. Resin varnishes dry and harden when the solvents in them evaporate. Polyurethane and epoxy varnishes remain liquid after the evaporation of the solvent but quickly begin to cure through chemical reactions of the varnish components.

3.3.13 Primers

The importance of primers in finishing and protection is generally misunderstood and underestimated because it is invisible after the topcoat finish is applied. A primer is the foundation of the finish. Its role is to bond to the surface, inhibit corrosion of metal, and provide an anchor point for the finish coats. It is important that the primer pigments be either anodic to the metal surface or passivate the surface should moisture be present. The binder must be compatible with the finish coats. Primers on nonmetallic surfaces do not require sacrificial or passivating pigments. Some of the various primer types are discussed below.

3.3.14 Wash Primers

Wash primers are water-thin coatings of phosphoric acid in solutions of vinyl butyral resin, alcohol, and other ingredients. They are very low in solids with almost no filling qualities. Their functions are to passivate the surface, temporarily provide corrosion resistance, and provide an adhesive base for the next coating, such as a urethane or epoxy primer. Wash primers do not require sanding and have high corrosion protection qualities. Some have a very small recoat time frame that must be considered when painting larger aircraft. The manufacturers’ instructions must be followed for satisfactory results.
3.3.15 Red Iron Oxide

Red oxide primer is an alkyd resin-based coating that was developed for use over iron and steel located in mild environmental conditions. It can be applied over rust that is free of loose particles, oil, and grease. It has limited use in the aviation industry.

3.3.16 Gray Enamel Undercoat

This is a single component, non sanding primer compatible with a wide variety of topcoats. It fills minor imperfections, dries fast without shrinkage, and has high corrosion resistance. It is a good primer for composite substrates.

3.3.17 Urethane

This is a term that is misused or interchanged by painters and manufacturers alike. It is typically a two-part product that uses a chemical activator to cure by linking molecules together to form a whole new compound. Polyurethane is commonly used when referring to urethane, but not when the product being referred to is acrylic urethane. Urethane primer, like the urethane paint, is also a two-part product that uses a chemical activator to cure. It is easy to sand and fills well. The proper film thickness must be observed, because it can shrink when applied too heavily. It is typically applied over a wash primer for best results. Special precautions must be taken by persons spraying because the activators contain isocyanides (discussed further in the Protective Equipment section at the end of this chapter).

3.3.18 Epoxy

Epoxy is a synthetic, thermosetting resin that produces tough, hard, chemical-resistant coatings and adhesives. It uses a catalyst to chemically activate the product, but it is not classified as hazardous because it contains no isocyanides. Epoxy can be used as a no sanding primer/sealer over bare metal and it is softer than urethane, so it has good chip resistance. It is recommended for use on steel tube frame aircraft prior to installing fabric covering.
3.3.19 Zinc Chromate

Zinc chromate is a corrosion-resistant pigment that can be added to primers made of different resin types, such as epoxy, polyurethane, and alkyd. Older type zinc chromate is distinguishable by its bright yellow color when compared to the light green color of some of the current brand primers. Moisture in the air causes the zinc chromate to react with the metal surface, and it forms a passive layer that prevents corrosion. Zinc chromate primer was, at one time, the standard primer for aircraft painting. Environmental concerns and new formula primers have all but replaced it.

3.4 Identification of Paints

3.4.1-Dope

When fabric-covered aircraft ruled the sky, dope was the standard finish used to protect and color the fabric. The dope imparted additional qualities of increased tensile strength, air tightness, weather-proofing, ultraviolet (UV) protection, and tautness to the fabric cover. Aircraft dope is essentially a colloidal solution of cellulose acetate or nitrate combined with plasticizers to produce a smooth, flexible, homogeneous film. Dope is still used on fabric covered aircraft as part of a covering process. However, the type of fabric being used to cover the aircraft has changed. Grade A cotton or linen was the standard covering used for years, and it still may be used if it meets the requirements of the Federal Aviation Administration (FAA), Technical Standard Order (TSO) C-15d/AMS 3806c. Polyester fabric coverings now dominate in the aviation industry. These new fabrics have been specifically developed for aircraft and are far superior to cotton and linen. The protective coating and topcoat finishes used with the Ceconite polyester fabric covering materials are part of a Supplemental Type Certificate (STC) and must be used as specified when covering any aircraft with a Standard Airworthiness Certificate. The Ceconite covering procedures use specific brand name, no tautening nitrate and butyrate dope as part of the STC. The Poly-Fiber system also uses a special polyester fabric covering as part of its STC, but it does not use dope. All the liquid products in the Poly-Fiber system are made from vinyl, not from cellulose dope. The vinyl coatings have several
real advantages over dope: they remain flexible, they do not shrink, they do not support combustion, and they are easily removed from the fabric with MEK, which simplifies most repairs.

3.4.2- Synthetic Enamel

Synthetic enamel is an oil-based single-stage paint (no clear coat) that provides durability and protection. It can be mixed with a hardener to increase the durability and shine while decreasing the drying time. It is one of the more economical types of finish.

3.4.3- Lacquers

The origin of lacquer dates back thousands of years to a resin obtained from trees indigenous to China. In the early 1920s, nitrocellulose lacquer was developed from a process using cotton and wood pulp. Nitrocellulose lacquers produce a hard, semi flexible finish that can be polished to a high sheen. The clear variety yellows as it ages, and it can shrink over time to a point that the surface crazes. It is easy to spot repair because each new coat of lacquer softens and blends into the previous coat. This was one of the first coatings used by the automotive industry in mass production, because it reduced finishing times from almost two weeks to two days. Acrylic lacquers were developed to eliminate the yellowing problems and crazing of the nitrocellulose lacquers. General Motors started using acrylic lacquer in the mid-1950s, and they used it into the 1960s on some of their premium model cars. Acrylics have the same working properties but dry to a less brittle and more flexible film than nitrocellulose lacquer. Lacquer is one of the easiest paints to spray, because it dries quickly and can be applied in thin coats. However, lacquer is not very durable; bird droppings, acid rain, and gasoline spills actually eat down into the paint. It still has limited use on collector and show automobiles because they are usually kept in a garage, protected from the environment. The current use of lacquer for an exterior coating on an aircraft is almost nonexistent because of durability and environmental concerns. Upwards of 85 percent of the volatile organic compounds (VOCs) in the spray gun ends up in the atmosphere, and some states have banned its use. There are some newly developed lacquers that use a catalyst, but they are used mostly in the woodworking and furniture industry. They have the ease of application of
nitrocellulose lacquer with much better water, chemical, and abrasion resistance. Additionally, catalyzed lacquers cure chemically, not solely through the evaporation of solvents, so there is a reduction of VOCs released into the atmosphere. It is activated when the catalyst is added to the base mixture.

3.4.4- Polyurethane

Polyurethane is at the top of the list when compared to other coatings for abrasion-, stain-, and chemical-resistant properties. Polyurethane was the coating that introduced the wet look. It has a high degree of natural resistance to the damaging effects of UV rays from the sun. Polyurethane is usually the first choice for coating and finishing the corporate and commercial aircraft in today’s aviation environment.

3.4.5- Urethane Coating

The term urethane applies to certain types of binders used for paints and clear coatings. (A binder is the component that holds the pigment together in a tough, continuous film and provides film integrity and adhesion.) Typically, urethane is a two-part coating that consists of a base and catalyst that, when mixed, produces a durable, high-gloss finish that is abrasion and chemical resistant.

3.4.6- Acrylic Urethanes

Acrylic simply means plastic. It dries to a harder surface but is not as resistant to harsh chemicals as polyurethane. Most acrylic urethanes need additional UV inhibitors added when subject to the UV rays of the sun.

3.5 Methods of Applying Finish

There are several methods of applying aircraft finish. Among the most common are dipping, brushing, and spraying.

3.5.1- Dipping

The application of finishes by dipping is generally confined to factories or large repair stations. The process consists of dipping the part to be finished in a tank filled with the finishing material. Primer coats are frequently applied in this manner.
3.5.2-Brushing

Brushing has long been a satisfactory method of applying finishes to all types of surfaces. Brushing is generally used for small repair work and on surfaces where it is not practicable to spray paint. The material to be applied should be thinned to the proper consistency for brushing. A material that is too thick has a tendency to pull or rope under the brush. If the materials are too thin, they are likely to run or not cover the surface adequately. Proper thinning and substrate temperature allows the finish to flow-out and eliminates the brush marks.

3.5.3- Spraying

Spraying is the preferred method for a quality finish. Spraying is used to cover large surfaces with a uniform layer of material, which results in the most cost effective method of application. All spray systems have several basic similarities. There must be an adequate source of compressed air, a reservoir or feed tank to hold a supply of the finishing material, and a device for controlling the combination of the air and finishing material ejected in an atomized cloud or spray against the surface to be coated.

A self-contained, pressurized spray can of paint meets the above requirements and satisfactory results can be obtained painting components and small areas of touchup. However, the aviation coating materials available in cans is limited, and this chapter addresses the application of mixed components through a spray gun.

There are two main types of spray equipment. A spray gun with an integral paint container is adequate for use when painting small areas. When large areas are painted, pressure feed equipment is more desirable since a large supply of finishing material can be applied without the interruption of having to stop and refill a paint container. An added bonus is the lighter overall weight of the spray gun and the flexibility of spraying in any direction with a constant pressure to the gun.
The air supply to the spray gun must be entirely free of water or oil in order to produce the optimum results in the finished product. Water traps, as well as suitable filters to remove any trace of oil, must be incorporated in the air pressure supply line. These filters and traps must be serviced on a regular basis.

3.6 Finishing Equipment

3.6.1-Paint Booth

A paint booth may be a small room in which components of an aircraft are painted, or it can be an aircraft hangar big enough to house the largest aircraft. Whichever it is, the location must be able to protect the components or aircraft from the elements. Ideally, it would have temperature and humidity controls; but, in all cases, the booth or hangar must have good lighting, proper ventilation, and be dust free.

A simple paint booth can be constructed for a small aircraft by making a frame out of wood or polyvinyl chloride (PVC) pipe. It needs to be large enough to allow room to walk around and maneuver the spray gun. The top and sides can be covered with plastic sheeting stapled or taped to the frame. An exhaust fan can be added to one end with a large air-conditioning filter placed on the opposite end to filter incoming air. Lights should be large enough to be set up outside of the spray booth and shine through the sheeting or plastic windows. The ideal amount of light would be enough to produce a glare off of all the surfaces to be sprayed. This type of temporary booth can be set up in a hangar, a garage, or outside on a ramp, if the weather and temperature are favorable.

Figure 3-1 Standard air compressors.
Normally, Environmental Protection Agency (EPA) regulations do not apply to a person painting one airplane. However, anyone planning to paint an aircraft should be aware that local clean air regulations may be applicable to an airplane painting project. When planning to paint an aircraft at an airport, it would be a good idea to check with the local airport authority before starting.

3.6.2- Air Supply

The air supply for paint spraying using a conventional siphon feed spray gun should come from an air compressor with a storage tank big enough to provide an uninterrupted supply of air with at least 90 pounds per square inch (psi) providing 10 cubic feet per minute (CFM) of air to the spray gun. The compressor needs to be equipped with a regulator, water trap, air hose, and an adequate filter system to ensure that clean, dry, oil-free air is delivered to the spray gun. If using one of the newer high-volume low-pressure (HVLP) spray guns and using a conventional compressor, it is better to use a two stage compressor of at least a 5 horsepower (hp) that operates at 90 psi and provides 20 CFM to the gun. The key to the operation of the newer HVLP spray guns is the air volume, not the pressure.

If purchasing a new complete HVLP system, the air supply is from a turbine compressor. An HVLP turbine has a series of fans, or stages, that move a lot of air at low pressure. The more stages provide greater air output (rated in CFM) that means better atomization of the coating being sprayed. The intake air is also the cooling air for the motor. This air is filtered from dirt and dust particles prior to entering the turbine. Some turbines also have a second filter for the air supply to the spray gun. The turbine does not produce oil or water to contaminate the air supply, but the air supply from the turbine heats up, causing the paint to dry faster, so you may need an additional length of hose to reduce the air temperature at the spray gun.
3.7 Spray Equipment

3.7.1- Air Compressors

Piston-type compressors are available with one-stage and multiple-stage compressors, various size motors, and various size supply tanks. The main requirement for painting is to ensure the spray gun has a continuous supplied volume of air. Piston-type compressors compress air and deliver it to a storage tank. Most compressors provide over 100 psi, but only the larger ones provide the volume of air needed for an uninterrupted supply to the gun. The multistage compressor is a good choice for a shop when a large volume of air is needed for pneumatic tools. When in doubt about the size of the compressor, compare the manufacturer’s specifications and get the largest one possible.

3.7.2- Large Coating Containers

For large painting projects, such as spraying an entire aircraft, the quantity of mixed paint in a pressure tank provides many advantages. The setup allows a greater area to be covered without having to stop and fill the cup on a spray gun. The painter is able to keep a wet paint line, and more material is applied to the surface with less overspray. It provides the flexibility of maneuvering the spray gun in any position without the restriction and weight of an attached paint cup. Remote pressure tanks are available in sizes from 2 quarts to over 60 gallons.
The use of a piston-type air compressor for painting requires that the air supply lines include filters to remove water and oil. A typical filter assembly is shown in Figure 3-3.

Miscellaneous Painting Tools and Equipment

Some tools that are available to the painter include:

- Masking paper/tape dispenser that accommodates various widths of masking paper. It includes a masking tape dispenser that applies the tape to one edge of the paper as it is rolled off to facilitate one person applying the paper and tape in a single step.

- Electronic and magnetic paint thickness gauges to measure dry paint thickness.

- Wet film gauges to measure freshly applied wet paint.

- Infrared thermometers to measure coating and substrate surfaces to verify that they fall in the recommended temperature range prior to spraying.

![Air-line filter assembly](image)

**Figure 3-3 Air-line filter assembly**

### 3.7.3 Spray Guns

A top quality spray gun is a key component in producing a quality finish in any coating process. It is especially important when painting an aircraft because of the large area and varied surfaces that must be sprayed. When spray painting, it is of utmost importance to follow the manufacturer’s recommendations for correct sizing of the air cap, fluid
tip, and needle combinations. The right combination provides the best coverage and the highest quality finish in the shortest amount of time. All of the following examples of the various spray guns (except the airless) are of the air atomizing type. They are the most capable of providing the highest quality finish.

3.7.3.1-Siphon Feed Gun

The siphon feed gun is a conventional spray gun familiar to most people, with a one quart paint cup located below the gun. Regulated air passes through the gun and draws (siphons) the paint from the supply cup. This is an external mix gun, which means the air and fluid mix outside the air cap. This gun applies virtually any type coating and provides a high quality finish. [Figure 3-4]
3.7.3.2- Gravity-Feed Gun

A gravity-feed gun provides the same high-quality finish as a siphon-feed gun, but the paint supply is located in a cup on top of the gun and supplied by gravity. The operator can make fine adjustments between the atomizing pressure and fluid flow and utilize all material in the cup. This also is an external mix gun. [Figure 3-5] Gravity-Feed Gun

![Gravity Feed Gun](image)

Figure 3-5 Gravity feed gun

The HVLP production spray gun is an internal mix gun. The air and fluid is mixed inside the air cap. Because of the low pressure used in the paint application, it transfers at least 65 percent and upwards of 80 percent of the finish material to the surface. HVLP spray guns are available with a standard cup located underneath or in a gravity-feed model with the cup on top. The sample shown can be connected with hoses to a remote paint material container holding from 2 quarts to 60 gallons. [Figure 8-6] Because of more restrictive EPA regulations, and the fact that more paint is being transferred to the surface with less waste from overspray, a large segment of the paint and coating industry is switching to HVLP spray equipment.
Airless spraying does not directly use compressed air to atomize the coating material. A pump delivers paint to the spray gun under high hydraulic pressure (500 to 4,500 psi) to atomize the fluid. The fluid is then released through an orifice in the spray nozzle. This system increases transfer efficiency and production speed with less overspray than conventional air atomized spray systems. It is used for production work but does not provide the fine finish of air atomized systems.
3.8 Fresh Air Breathing Systems

Fresh air breathing systems should be used whenever coatings are being sprayed that contain isocyanides. This includes supplied air respirator system with all polyurethane coatings. The system incorporates a high capacity electric air turbine that provides a constant source of fresh air to the mask. The use of fresh air breathing systems is also highly recommended when spraying chromate primers and chemical stripping aircraft. The system provides cool filtered breathing air with up to 200 feet of hose, which allows the air pump intake to be placed in an area of fresh air, well outside of the spraying area.

A charcoal-filtered respirator should be used for all other spraying and sanding operations to protect the lungs and respiratory tract. The respirator should be a double-cartridge, organic vapor type that provides a tight seal around the nose and mouth. The cartridges can be changed separately, and should be changed when detecting odor or experiencing nose or throat irritation. The outer prefilters should be changed if experiencing increased resistance to breathing.
3.9 Viscosity Measuring Cup

This is a small cup with a long handle and a calibrated orifice in the bottom that allows the liquid in the cup to drain out at a specific timed rate. Coating manufacturers recommend spraying their product at a specific pressure and viscosity. That viscosity is determined by measuring the efflux (drain) time of the liquid coating through the cup orifice. The time (in seconds) is listed on most paint manufacturers’ product/technical data pages. The measurement determines if the mixed coating meets the recommended viscosity for spraying. There are different manufacturers of the viscosity measuring devices, but the most common one listed and used for spray painting is known as a Zahn cup. The orifice number must correspond to the one listed on the product/technical data sheet. For most primers and topcoats, the #2 or #3 Zahn cup is the one recommended.

![Figure 3-10: A Zahn cup viscosity measuring cup](image)

To perform an accurate viscosity measurement, it is very important that the temperature of the sample material be within the recommended range of 73.5 °F ± 3.5 °F (23 ºC ± 2 ºC), and then proceed as follows:

1. Thoroughly mix the sample with minimum bubbles.
2. Dip the Zahn cup vertically into the sample being tested, totally immersing the cup below the surface.
3. With a stopwatch in one hand, briskly lift the cup out of the sample. As the top edge of the cup breaks the surface, start the stopwatch.

4. Stop the stopwatch when the first break in the flow of the liquid is observed at the orifice exit. The number in seconds is referred to as the efflux time.

5. Record the time on the stopwatch and compare it to the coating manufacturer’s recommendation. Adjust the viscosity, if necessary, but be aware not to thin the coating below recommendations that could result in the release of VOCs into the atmosphere above the regulated limitations.

3.10 Mixing Equipment

Use a paint shaker for all coatings within 5 days of application to ensure the material is thoroughly mixed. Use a mechanical paint stirrer to mix larger quantities of material. If a mechanical stirrer is driven by a drill, the drill should be pneumatic, instead of electric. The sparks from an electric drill can cause an explosion from the paint vapors.

3.11 Surfaces preparation

The most important part of any painting project is the preparation of the substrate surface. It takes the most work and time, but with the surface properly prepared, the results are a long-lasting, corrosion-free finish. Repainting an older aircraft requires more preparation time than a new paint job because of the additional steps required to strip the old paint, and then clean the surface and crevices of paint remover. Paint stripping is discussed in another section of this chapter.

It is recommended that all the following procedures be performed using protective clothing, rubber gloves, and goggles, in a well-ventilated area, at temperatures between 68 °F and 100 °F.

Aluminum surfaces are the most common on a typical aircraft. The surface should be scrubbed with Scotch-Brite® pads using an alkaline aviation cleaner. The work area should be kept wet and rinsed with clean water until the surface is water break free. This means that there are no
beads or breaks in the water surface as it flows over the aluminum surface.

The next step is to apply an acid etch solution to the surface. Following manufacturers’ suggestions, this is applied like a wash using a new sponge and covering a small area while keeping it wet and allowing it to contact the surface for between 1 and 2 minutes. It is then rinsed with clean water without allowing the solution to dry on the surface. Continue this process until all the aluminum surfaces are washed and rinsed. Extra care must be taken to thoroughly rinse this solution from all the hidden areas that it may penetrate. It provides a source for corrosion to form if not completely removed.

When the surfaces are completely dry from the previous process, the next step is to apply Alodine® or another type of an aluminum conversion coating. This coating is also applied like a wash, allowing the coating to contact the surface and keeping it wet for 2 to 5 minutes without letting it dry. It then must be thoroughly rinsed with clean water to remove all chemical salts from the surface. Depending on the brand, the conversion coating may color the aluminum a light gold or green, but some brands are colorless. When the surface is thoroughly dry, the primer should be applied as soon as possible as recommended by the manufacturer.

The primer should be one that is compatible with the topcoat finish. Two-part epoxy primers provide excellent corrosion resistance and adhesion for most epoxy and urethane surfaces and polyurethane topcoats. Zinc chromate should not be used under polyurethane paints.

Composite surfaces that need to be primed may include the entire aircraft if it is constructed from those materials, or they may only be components of the aircraft, such as fairings, radomes, antennas, and the tips of the control surfaces.

Epoxy sanding primers have been developed that provide an excellent base over composites and can be finish sanded with 320 grit using a dual action orbital sander. They are compatible with two-part epoxy primers and polyurethane topcoats.
Topcoats must be applied over primers within the recommended time window, or the primer may have to be scuff sanded before the finish coat is applied. Always follow the recommendations of the coating manufacturer.

Primer and Paint

Purchase aircraft paint for the aviation painting project. Paint manufacturers use different formulas for aircraft and automobiles because of the environments they operate in. The aviation coatings are formulated to have more flexibility and chemical resistance than the automotive paint.

It is also highly recommended that compatible paints of the same brand are used for the entire project. The complete system (of a particular brand) from etching to primers and reducers to the finish topcoat are formulated to work together. Mixing brands is a risk that may ruin the entire project.

When purchasing the coatings for a project, always request a manufacturer’s technical or material data and safety data sheets, for each component used. Before starting to spray, read the sheets. If the manufacturer’s recommendations are not followed, a less than satisfactory finish or a hazard to personal safety or the environment may result. It cannot be emphasized enough to follow the manufacturer’s recommendations. The finished result is well worth the effort.

Before primer or paint is used for any type application, it must be thoroughly mixed. This is done so that any pigment that may have settled to the bottom of the container is brought into suspension and distributed evenly throughout the paint. Coatings now have shelf lives listed in their specification sheets. If a previously opened container is found to have a skin or film formed over the primer or paint, the film must be completely removed before mixing. The material should not be used if it has exceeded its shelf life and/or has become thick or jelled.

Mechanical shaking is recommended for all coatings within 5 days of use. After opening, a test with a hand stirrer should be made to ensure that all the pigment has been brought into suspension. Mechanical stirring is recommended for all two part coatings. When mixing any two-
part paint, the catalyst/activator should always be added to the base or pigmented component. The technical or material data sheet of the coating manufacturer should be followed for recommended times of Induction (the time necessary for the catalyst to react with the base prior to application). Some coatings do not require any induction time after mixing, and others need 30 minutes of reaction time before being applied.

Thinning of the coating material should follow the recommendations of the manufacturer. The degree of thinning depends on the method of application. For spray application, the type of equipment, air pressure, and atmospheric conditions guide the selection and mixing ratios for the thinners. Because of the importance of accurate thinning to the finished product, use a viscosity measuring (flow) cup. Material thinned using this method is the correct viscosity for the best application results.

Thin all coating materials and mix in containers separate from the paint cup or pot. Then, filter the material through a paint strainer recommended for the type coating you are spraying as you pour it into the cup or supply pot.

3.12 Spray Gun Operation

Spray gun is a device used to spray paint on the surface.

3.12.1 Adjusting the Spray Pattern

To obtain the correct spray pattern, set the recommended air pressure on the gun, usually 40 to 50 psi for a conventional gun. Test the pattern of the gun by spraying a piece of masking paper taped to the wall. Hold the gun square to the wall approximately 8 to 10 inches from the surface. (With hand spread, it is the distance from the tip of the thumb to the tip of the little finger.) All spray guns (regardless of brand name) have the same type of adjustments. The upper control knob proportions the air flow, adjusting the spray pattern of the gun. [Figure 3-11]
The lower knob adjusts the fluid passing the needle, which in turn controls the amount or volume of paint being delivered through the gun.

Pull the trigger lever fully back. Move the gun across the paper, and alternately adjust between the two knobs to obtain a spray fan of paint that is wet from top to bottom (somewhat like the pattern at dial 10.) Turning in (to the right) on the lower, or fluid knob, reduces the amount of paint going through the gun. Turning out increases the volume of paint. Turning out (to the left) on the upper, or pattern control knob, widens the spray pattern. Turning in reduces it to a cone shape (as shown with dial set at 0).

Once the pattern is set on the gun, the next step is to follow the correct spraying technique for applying the coating to the surface.

### 3.12.2 Applying the Finish

If the painter has never used a spray gun to apply a finish coat of paint, and the aircraft has been completely prepared, cleaned, primed, and ready for the topcoat, he or she may need to pause for some practice. Reading a book or an instruction manual is a good start as it provides the basic knowledge about the movement of the spray gun across the surface. Also, if available, the opportunity to observe an aircraft being painted is well worth the time.

At this point in the project, the aircraft has already received its primer coats. The difference between the primer and the finish topcoat is that the primer is flat (no gloss) and the finish coat has a glossy surface.
(some more than others, depending on the paint). The flat finish of the primer is obtained by paying attention to the basics of trigger control distance from the surface and consistent speed of movement of the spray gun across the surface.

Primer is typically applied using a cross coat spray pattern. A cross coat is one pass of the gun from left to right, followed by another pass moving up and down. The starting direction does not matter as long as the spraying is accomplished in two perpendicular passes. The primer should be applied in light coats as cross-coating is the application of two coats of primer.

Primer does not tend to run because it is applied in light coats. The gloss finish requires a little more experience with the gun. A wetter application produces the gloss, but the movement of the gun, overlap of the spray pattern, and the distance from the surface all affect the final product. It is very easy to vary one or another, yielding runs or dry spots and a less than desirable finish. Practice not only provides some experience, but also provides the confidence needed to produce the desired finish.

Start the practice by spraying the finish coat material on a flat, horizontal panel. The spray pattern has been already adjusted by testing it on the masking paper taped to the wall. Hold the gun 8–10 inches away from and perpendicular to the surface. Pull the trigger enough for air to pass through the cap and start a pass with the gun moving across the panel. As it reaches the point to start painting, squeeze the trigger fully back and continue moving the gun about one foot per second across the panel until the end is reached. Then, release the trigger enough to stop the paint flow but not the air flow.
Chapter Three

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Figure 3-12: Proper spray application.

The constant air flow through the gun maintains a constant pressure, rather than a buildup of pressure each time that the trigger is released. This would cause a buildup of paint at the end of each pass, causing runs and sags in the finish. Repeat the sequence of the application, moving back in the opposite direction and overlapping the first pass by 50 percent. This is accomplished by aiming the center of the spray pattern at the outer edge of the first pass and continuing the overlap with each successive pass of the gun.

Once the painter has mastered spraying a flat horizontal panel, practice next on a panel that is positioned vertically against a wall. This is the panel that shows the value of applying a light tack coat before spraying on the second coat. The tack coat holds the second coat from sagging and runs. Practice spraying this test panel both horizontally with overlapping passes and then rotate the air cap 90° on the gun and practice spraying vertically with the same 50 percent overlapping passes.

Practice cross-coating the paint for an even application. Apply two light spray passes horizontally, overlapping each by 50 percent, and allowing it to tack. Then, spray vertically with overlapping passes, covering the horizontal sprayed area. When practice results in a smooth, glossy, no-run application on the vertical test panel, you are ready to try your skill on the actual project.
3.13 Common Spray Gun Problems

A quick check of the spray pattern can be verified before using the gun by spraying some thinner or reducer, compatible with the finish used, through the gun. It is not of the same viscosity as the coating, but it indicates if the gun is working properly before the project is started.

If the gun is not working properly, use the following information to troubleshoot the problem:

• A pulsating, or spitting, fan pattern may be caused by a loose nozzle, clogged vent hole on the supply cup, or the packing may be leaking around the needle.

• If the spray pattern is offset to one side or the other, the air ports in the air cap or the ports in the horns may be plugged.

• If the spray pattern is heavy on the top or the bottom, rotate the air cap 180°. If the pattern reverses, the air cap is the problem. If it stays the same, the fluid tip or needle may be damaged.

• Other spray pattern problems may be a result of improper air pressure, improper reducing of the material, or wrong size spray nozzle.

3.14 Sequence for Painting a Single-Engine or Light Twin Airplane

As a general practice on any surface being painted,

- spray each application of coating in a different direction to facilitate even and complete coverage.

-After you apply the primer, apply the tack coat and subsequent top coats in opposite directions, one coat vertically and the next horizontally, as appropriate.

- Start by spraying all the corners and gaps between the control surfaces and fixed surfaces.

- Paint the leading and trailing edges of all surfaces.
- Spray the landing gear and wheel wells, if applicable, and paint the bottom of the fuselage up the sides to a horizontal break, such as a seam line. Paint the underside of the horizontal stabilizer.

- Paint the vertical stabilizer and the rudder, and then move to the top of the horizontal stabilizer.

- Spray the top and sides of the fuselage down to the point of the break from spraying the underside of the fuselage.

- Then, spray the underside of the wings. - Complete the job by spraying the top of the wings.

The biggest challenge is to control the overspray and keep the paint line wet. The ideal scenario would be to have another experienced painter with a second spray gun help with the painting. It is much easier to keep the paint wet and the job is completed in half the time.

3.15 Common Paint Troubles

Common problems that may occur during the painting of almost any project but are particularly noticeable and troublesome on the surfaces of an aircraft include poor adhesion, blushing, pinholes, sags and/or runs, “orange peel,” fisheyes, sanding scratches, wrinkling, and spray dust.

3.15.1 Poor Adhesion

- Improper cleaning and preparation of the surface to be finished.

- Application of the wrong primer.

- Incompatibility of the topcoat with the primer.

- Improper thinning of the coating material or selection of the wrong grade reducer.

- Improper mixing of materials.

- Contamination of the spray equipment and/or air supply.
Correction for poor adhesion requires a complete removal of the finish, a determination and correction of the cause, and a complete refinishing of the affected area.

![Figure 3-13: Example of poor adhesion](image)

### 3.5.2-Blushing

Blushing is the dull milky haze that appears in a paint finish. It occurs when moisture is trapped in the paint. Blushing forms when the solvents quickly evaporate from the sprayed coating, causing a drop in temperature that is enough to condense the water in the air. It usually forms when the humidity is above 80 percent. Other causes include:

- Incorrect temperature (below 60 °F or above 95 °F).
- Incorrect reducer (fast drying) being used.
- Excessively high air pressure at the spray gun.
If blushing is noticed during painting, a slow-drying reducer can sometimes be added to the paint mixture, and then the area re-sprayed. If blushing is found after the finish has dried, the area must be sanded down and repainted.

Figure 3-14: Example of blushing.

3.15.3-Pinholes

Pinholes are tiny holes, or groups of holes, that appear in the surface of the finish as a result of trapped solvents, air, or moisture. [Figure 3-18]Examples include:

- Contaminants in the paint or air lines.
- Poor spraying techniques that allow excessively heavy or wet paint coats, which tend to trap moisture or solvent under the finish.
- Use of the wrong thinner or reducer, either too fast by quick drying the surface and trapping solvents or too slow and trapping solvents by subsequent topcoats.
If pinholes occur during painting, the equipment and painting technique must be evaluated before continuing. When dry, sand the surface smooth and then repaint.

![Image of pinholes](image)

Figure 3-15: Example of pinholes.

### 3.15.4-Sags and Runs

Sags and runs are usually caused by applying too much paint to an area, by holding the spray gun too close to the surface, or moving the gun too slowly across the surface. [Figure 3-19] Other causes include:

- Too much reducer in the paint (too thin).
- Incorrect spray gun setting of air-paint mixture.

Sags and runs can be avoided by following the recommended thinning instructions for the coatings being applied and taking care to use the proper spray gun techniques, especially on vertical surfaces and projected edges. Dried sags and runs must be sanded out and the surface repainted.
3.15.5-Orange Peel

“Orange peel” refers to the appearance of a bumpy surface, much like the skin of an orange. [Figure 3-20] It can be the result of a number of factors with the first being the improper adjustment of the spray gun. Other causes include:

- Not enough reducer (too thick) or the wrong type reducer for the ambient temperature.
- Material not uniformly mixed.
- Forced drying method, either with fans or heat, is too quick.
- Too little flash time between coats.
- Spray painting when the ambient or substrate temperature is either too hot or too cold.

Light orange peel can be wet sanded or buffed out with polishing compound. In extreme cases, it has to be sanded smooth and re-sprayed.
3.15.6- Fisheyes

Fisheyes appear as small holes in the coating as it is being applied, which allows the underlying surface to be seen. [Figure 3-21] Usually, it is due to the surface not being cleaned of all traces of silicone wax. If numerous fisheyes appear when spraying a surface, stop spraying and clean off all the wet paint. Then, thoroughly clean the surface to remove all traces of silicone with a silicone wax remover.

The most effective way to eliminate fisheyes is to ensure that the surface about to be painted is clean and free from any type of contamination. A simple and effective way to check this is referred to as a water break test. Using clean water, spray, pour, or gently hose down the surface to be painted. If the water beads up anywhere on the surface, it is not clean. The water should flatten out and cover the area with an unbroken film.

If the occasional fisheye appears when spraying, wait until the first coat sets up and then add a recommended amount of fisheye eliminator to the subsequent finish coats. Fisheyes may appear during touchup of a repair. A coat of sealer may help, but completed removal of the finish may be the only solution.
One last check before spraying is to ensure that the air compressor has been drained of water, the regulator cleaned, and the system filters are clean or have been replaced so that this source of contamination is eliminated.

Figure 3-18: Example of flash eye.

### 3.15.7-Sanding Scratches

Sanding scratches appear in the finish paint when the surface has not been properly sanded and/or sealed prior to spraying the finish coats. Nonmetal surfaces. Composite cowling, wood surfaces, and plastic fairings must be properly sanded and sealed before painting. The scratches may also appear if an overly rapid quick-drying thinner is used.
The only fix after the finish coat has set up is to sand down the affected areas using a finer grade of sandpaper, follow with a recommended sealer, and then repaint.

3.15.8-Wrinkling

Wrinkling is usually caused by trapped solvents and unequal drying of the paint finish due to excessively thick or solvent heavy paint coats. [Figure 3-23] Fast reducers can also contribute to wrinkling if the sprayed coat is not allowed to dry thoroughly.

Thick coatings and quick-drying reducers allow the top surface of the coating to dry, trapping the solvents underneath. If another heavy coat is applied before the first one dries, wrinkles may result. It may also have the effect of lifting the coating underneath, almost with the same result as a paint stripper.

Rapid changes in ambient temperatures while spraying may cause an uneven release of the solvents, causing the surface to dry, shrink, and wrinkle. Making the mistake of using an incompatible thinner, or reducer, when mixing the coating materials may cause not only wrinkles
but other problems as well. Wrinkled paint must be completely removed and the surface refinished.

![Figure 3-20: Example of wrinkling.](image)

### 3.15.9-Spray Dust

Spray dust is caused by the atomized spray particles from the gun becoming dry before reaching the surface being painted, thus failing to flow into a continuous film. This may be caused by:

- Incorrect spray gun setting of air pressure, paint flow, or spray pattern.
- Spray gun being held too far from the surface.
- Material being improperly thinned or the wrong reducers being used with the finish coats.

The affected area needs to be sanded and recoated.
3.16 Safety in the Paint Shop

All paint booths and shops must have adequate ventilation systems installed that not only remove the toxic air but, when properly operating, reduce and/or eliminate overspray and dust from collecting on the finish. All electric motors used in the fans and exhaust system should be grounded and enclosed to eliminate sparks. The lighting systems and all bulbs should be covered and protected against breakage.

Proper respirators and fresh-air breathing systems must be available to all personnel involved in the stripping and painting process. When mixing any paint or two-part coatings, eye protection and respirators should be worn.

An appropriate number and size of the proper class fire extinguishers should be available in the shop or hangar during all spraying operations. They should be weighed and certified, as required,
to ensure they work in the event they are needed. Fireproof containers should be available for the disposal of all paint and solvent soaked rags.

### 3.17 Storage of Finishing Materials

All chemical components that are used to paint an aircraft burn in their liquid state. They should be stored away from all sources of heat or flames. The ideal place would be in fireproof metal cabinets located in a well ventilated area. Some of the finishing components have a shelf life listed in the material or technical data sheet supplied by the coating manufacturer. Those materials should be marked on the container, with a date of purchase, in the event that they are not used immediately.

### 3.18 Protective Equipment for Personnel

The process of painting, stripping, or refinishing an aircraft requires the use of various coatings, chemicals, and procedures that may be hazardous if proper precautions are not utilized to protect personnel involved in their use. The most significant hazards are airborne chemicals inhaled either from the vapors of opened paint containers or atomized mist resulting from spraying applications. There are two types of devices available to protect against airborne hazards:

1. respirators and
2. forced-air breathing systems.

#### 3.18.1 Respirators

A respirator is a device worn over the nose and mouth to filter particles and organic vapors from the air being inhaled. The most common type incorporate double charcoal-filtered cartridges with replaceable dust filters that fits to the face over the nose and mouth with a tight seal. When properly used, this type of respirator provides protection against the inhalation of organic vapors, dust, mists of paints, lacquers, and enamels.

A respirator does not provide protection against paints and coatings containing isocyanides (polyurethane paint). A respirator must be used in an area of adequate ventilation. If breathing becomes difficult, there is a smell or taste the contaminant or an individual becomes dizzy or feel
nauseous, they should leave the area and seek fresh air and assistance as necessary. Carefully read the warnings furnished with each respirator describing the limits and materials for which they provide protection.

3.18.2 A forced-air breathing system

must be used when spraying any type of polyurethane or any coating that contains isocyanides. It is also recommended for all spraying and stripping of any type, whether chemical or media blasting. The system provides a constant source of fresh air for breathing, which is pumped into the mask through a hose from an electric turbine pump. Protective clothing should be worn that not only protects personnel from the paint but also help keep dust off the painted surfaces. Rubber gloves must be worn when any stripper, etching solution, conversion coatings, and solvent is used.

When solvents are used for cleaning paint equipment and spray guns, the area must be free of any open flame or other heat source. Solvent should not be randomly sprayed into the atmosphere when cleaning the guns. Solvents should not be used to wash or clean paint and other coatings from bare hands and arms. Use protective gloves and clothing during all spraying operations.

In most states, there are Occupational Safety Hazard Administration (OSHA) regulations in effect that may require personnel to be protected from vapors and other hazards while on the job. In any hangar or shop, personnel must be vigilant and provide and use protection for safety.[22]