GUIDANCE MATERIAL

GM-06

AIRCRAFT PAINTING

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1. Aircraft Painting Requirements for Aircraft Requiring a CAR 145 Certificate of Release to Service

Aircraft Painting is considered a maintenance activity and when doing so instructions provided by the TC holder must be followed. The owner/operator or its Continuing Airworthiness Management Organisation must ensure that the aircraft is placed under the control of an approved maintenance organisation as appropriate for the aircraft. This organization will be responsible for the painting process and any associated maintenance, ensuring the task is completed in accordance with approved data and subsequently to issue the Certificate of Release to Service.

In addition, painting a complete aircraft requires that different maintenance tasks need to be performed in addition to painting the aircraft (towing & preparation, placing the aircraft in the right configuration for the painting operation like protection of the pitot probes, jacking, paint-stripping, removal of flight surfaces, balancing, reinstallation, weighing, which are maintenance activities). This type of activities requires a base maintenance environment and an appropriate type rated certifying staff qualified as category C in accordance with CAR-66 and 145.35 would be needed.

- The task of painting an aircraft or making a change to its surface finish, such as paint removal and subsequent polishing, is a maintenance task and consequently a Certificate of Release to Service must be issued, by an appropriately approved CAR 145 organisation, on completion of the process.
- Careful control has to be exercised over the painting of aircraft exterior surfaces, the removal and application of paint is only part of the process.
- Type Certificate holder’s instructions for surface finish changes also include maintenance requirements. These could include panel/component removal and refitting, structural inspections, function checks and aircraft weighing.
- The term painting embraces the associated processes of stripping and such terms as refinishing and refurbishing, as well as preparation, inspection and return to service.
- Painting requires the use of the correct equipment and careful control over the environment where painting is performed.
- Simple paintwork repairs and paint touch up of small areas may be accomplished in a Line Maintenance environment, if conditions are suitable. All other tasks must be carried out in a Base Maintenance environment.

Options for the Continuing Airworthiness Management Organisation.

- Contract a CAR 145 “A” rated Base Maintenance organization, with an in-house paint facility, that is approved to work on the specific aircraft type. The organization must have appropriate facilities, sufficient competent personnel, tooling and equipment and processes and procedures defined in the exposition to ensure the task can be completed satisfactorily.

alternatively;

- Contract a CAR 145 "A" rated Base Maintenance organization that is approved on the specific aircraft type but does not have an in-house paint facility. The contracted maintenance organization will need to sub-contract the paint task to an aircraft paint facility in accordance with approved procedures. The CAR 145 retains responsibility for all work performed. During the period when the approved organization is sub-contracting work, it must extend its quality system to the paint facility, taking responsibility for the facilities, tooling, equipment, data and the competence of staff involved in accomplishing and overseeing the paint task.
- In all cases it is the responsibility of the maintenance organization to ensure that all work is completed in accordance with the Type Certificate holder's instructions and to issue the Certificate of Release to Service on completion of the task. They are also responsible for ensuring the paint facility meets all the relevant requirements.
- Specialist painting organisations are not entitled to issue any certification in respect of the airworthiness status of an aircraft following painting, unless the organization also holds the appropriate "A" rated maintenance organization approval.
- Approved maintenance organisations with in-house painting facilities must ensure that the process and procedures for painting aircraft are included in their exposition and associated procedures.

2. Competence of paint shop personnel

A comprehensive competence assessment of paint shop personnel should be undertaken, including but not limited to, knowledge and experience of Tasks Common to Aviation Painters;

The tasks listed below were made as generic as possible to accommodate the largest amount of work environments and equipment / tools but do not necessarily cover all tasks individuals should be assessed on.

- **Block A — Safety**
  Task 1 – Demonstrates Safe Working Practices and Techniques
- **Block B — Planning**
  Task 2 – Estimates / Scopes Work
  Task 3 – Orders / Selects Materials
  Task 4 – Organizes Staff / Work Schedules
  Task 5 – Prepares Work Area for Job
  Task 6 – Prepares Ground Support Equipment such as Stands, Scissor Lifts, Scaffolding, Ladders and Dollies
- **Block C — Preparation of Surface**
  Task 7 – Cleans Aircraft, Parts and Components for Inspection
  Task 8 – Strips Surface of Aircraft, Parts and Components
  Task 9 – Sands Surface of Aircraft, Parts and Components
  Task 10 – Detail Strips and Cleans Aircraft, Parts and Components
  Task 11 – Removes Minor Surface Corrosion on Aircraft, Parts and Components
  Task 12 – Fills Dents in Aircraft, Parts and Components
  Task 13 – Blends Out Scratches on Aircraft, Parts and Components
  Task 14 – Applies Sealer to Seams and Joints
  Task 15 – Etches Metal and Applies Chemical Conversion Coatings
- **Block D — Application of Coatings**
  Task 16 – Masks Aircraft, Parts and Components for Application of Coatings
  Task 17 – Prepares Coating Materials
  Task 18 – Blows and Tacks Surface to Remove Dusts Prior to Coating
  Task 19 – Applies Coatings
- **Block E — Equipment Maintenance**
  Task 20 – Maintains and Repairs Coating Application Equipment
  Task 21 – Verifies Operation of Ground Support Equipment
  Task 22 – Verifies Operation of Ventilation Equipment
  Task 23 – Verifies Operation of Compressed Air Source
  Task 24 – Maintains Personal Protective Equipment
  Task 25 – Verifies Operation of Fresh Air Breathing System
- **Block F — Test Panel Production**
  Task 26 – Identifies Test Panel Requirements
- **Block G — Quality Control**
  Task 27 – Records Coating Documentation of Preparation and Application
  Task 28 – Evaluates Finished Product and Completed Job According to Customer Specifications

In the absence of formal qualification for aircraft painters, it is incumbent on the Quality System of the organization responsible for the release to service of the aircraft, following painting, to ensure the competence of involved personnel is established and controlled to a standard that ensures all TC holder's requirements are met and consequently allows the organisation's Certifying Staff to be satisfied that the painting tasks have been carried out to the required standard prior to issue of the CRS.

3. Important aspects to consider before commencing the painting work

This document provides basic guidance on the processes of paint removal, surface preparation and paint application for the interior or exterior of the aircraft.

First, the organisation needs to have access or purchase the following:

- an inventory of the materials needed.
- the technical data sheets that explain how the materials are used and the conditions of use. The technical data sheets for the materials are designed to be used together. Both need to be read and followed to obtain optimal results.
- Facilities are available and suitable
- Staff are trained, competent and sufficient for the work scope.

When it comes to painting activities, safety should be the number one concern. So, it is highly recommended that, prior to application, everyone one who uses the required PPEs as mentioned in the Safety Data Sheet (SDS) that should be available for each product. The SDS provides instructions on the appropriate safety equipment to use and what to do in case of an accident or an emergency. It is also recommended that a copy of the SDS be kept at the location where the materials are being used so if there is an emergency, "First Responders" know exactly what they are dealing with.

It is important to appreciate and understand that a coating does more than just make the surface of an aircraft aesthetically pleasing. It protects the aircraft from the damaging effects of the extreme environment in which aircraft must function. **PROTECTION** and **BEAUTIFICATION** are essential criteria for any aircraft coating system.

3.1 Painting Sequence for Single and Twin Engine Aircraft

Generally, the paint process includes these steps regardless of aircraft size:

1. The aircraft is washed and moved into a stable clean environment.
2. At-risk components and flight controls are covered or removed.
3. A nonacidic, environmentally friendly chemical stripper is applied.
4. The aircraft is inspected, flaws are removed, corrosion is treated, and necessary repairs made.
5. The aircraft is washed with an alkaline soap.
6. All aluminum surfaces are etched.
7. All aluminum surfaces are treated with alodine.
8. An epoxy chromate primer is applied.
9. An epoxy surfacer can be applied.
10. A polyurethane basecoat is applied.
11. The paint scheme is laid out.
12. The colors are applied.

13. The colors are topped with a clear coat.
14. Touch ups are made and the aircraft is buffed out.
15. The aircraft is weighed if required.
16. Over the years painting materials have certainly improved. It also appears that air carriers are contracting out their aircraft painting to MROs that specialize in painting and have facilities that can accommodate both narrow and wide-body aircraft.

When spraying an aircraft or any surface, using a cross spray technique is recommended to achieve consistent and complete coverage. Cross spraying is when each coat sprayed in a direction perpendicular to the previous. Apply the primer coat followed by spraying a tack coat and subsequent topcoats with a cross spray technique, one coat vertical followed by a horizontal coat.

Start spraying the corners and gaps around fixed and control surfaces. Then paint the leading edge and trailing edge of every surface. If applicable, spray the landing gear and wheel wells followed by the belly of the fuselage and up the sides to the horizontal break. Paint the underside of the horizontal stabilizer, the vertical stabilizer and rudder. Once complete paint the topside of the horizontal stabilizer. Spray the top and the sides of the fuselage down to the horizontal break overlapping the spray from the underside. Finally, spray the underside of the wings followed by the top of the wings.

Although, painting a small aircraft is very possible with one experienced applicator It is recommended having 2 painters working simultaneously. A challenge that applicators face when working by themselves is controlling the overspray and keeping the applied paint wet in order to have a consistent smooth finish over the entire aircraft as various sections are painted.

4. Safety

4.1 PPE (Personal Protection Equipment)

Because painting, stripping, sanding, refinishing, touching up and blasting exposes aircraft painters to chemicals, vapors, mist, dust or airborne debris and other materials that may be hazardous, it is important and necessary to use Personal Protection Equipment (PPE). Standard PPE includes chemical resistant gloves, goggles and clothing – a Tyvek suit – as well as a charcoal filtered respirator. In tight spaces a helmet might be necessary.

Respirators should provide a tight seal over the nose and mouth to prevent inhaling any dust from sanding and the vapors, fumes, mist and/or overspray from the application of paints.

Respirators have filters – cartridges or canisters – that remove contaminants from the air by passing the ambient air through the air-purifying element before it reaches the user. The user will know that it is time to change the filters when he/she experience breathing irritation in his/her nose or throat, if the user detects an odor inside the mask or if there is a change in breathing resistance. Even when using a respirator then the operator should still make sure that the working environment is well ventilated. If for any reason the user starts to feel nauseous or dizzy, he/she should immediately and carefully leave the area and relocate to an area where he/she can breathe fresh air.

Goggles should be splash and vapor resistant to protect the eyes from splatter, vapor and/or fumes. The goggles need to provide a tight seal and should be fog resistant. Wearing goggles, when cleaning the equipment, is also important, especially when cleaning with solvents. Face and eye protection especially when spraying any paint product is essential. Thousands of people a year are blinded from work-related eye injuries.

Rubber gloves should be worn whenever any strippers, etching compounds, solvents, paints or coatings are being used. When stripping paint with Methylene Chloride based paint strippers it is recommended that butyl or neoprene gloves be used. The standard solvent resistant gloves will not stand up to Methylene Chloride's aggressive chemical characteristics.

Forced air breathing systems should be used in place of charcoal filter respirators whenever spraying coatings that contain isocyanates or chromates. They should also be used when using chemical strippers that contain Methylene Chloride or when stripping using an abrasive blasting method. Forced air breathing systems provide constant fresh air from a high capacity electric air turbine. Most systems come with 200 feet of hose through which fresh air flows from the turbine air pump intake that is to be placed where fresh air can be accessed.

The organisation shall sure that all electrical equipment provided is explosion proof. Many of the materials used when painting, if not all, are flammable. Anything that causes a spark can ignite liquid and vapor chemicals. Keep all areas free of flames.

4.2 Material Storage

All chemicals and hazardous materials in general, must be kept in a cabinet intended for flammable material storage that protects them from sources of heat or flames. The products used to paint an aircraft are, more often than not, flammable in their liquid state. Check the SDS to note which materials are compatible to store in the same area. Avoid storing with incompatible or reactive materials. Also make sure that the area where the chemicals are kept is well ventilated and the ambient temperatures won't fall below freezing or exceed 95°F/35 °C. Most paints and paint components have a shelf life. Check the technical data or the label to view the shelf life for a particular product. It is important to note that the manufacturer may extend the shelf life if contacted before the material expires and are able to sample in order to ensure that the material is still usable. All materials that are liquid and/or are considered hazardous (except distilled water) that are being used and stored should be accompanied by an MSDS (Material Safety Data Sheet) that is to be kept in proximity to where the product is being used.

4.3 Hangar/Paint Shop Safety

Painting should be performed in a Hangar/booth that has an acceptable ventilation system. The ventilation must be capable of exhausting toxic air while pulling in sufficient fresh air. Furthermore, a proper Hangar/booth has a ventilation system where the flow of air reduces overspray and dust from collecting on the newly painted substrate. Hangar/Booths should be properly illuminated so that no shadowing occurs on the parts being painted and all lighting systems and bulbs should be covered and protected against breakage. Electric fans and motors must be explosion proof and properly grounded to eliminate sparks.

Regardless of whether the organisation has a properly ventilated Hangar/booth and/or the perfect paint shop conditions, Personal Protection Equipment (PPE) is still extremely important. In cases where highly toxic chemicals or solvent based coatings are being used, it is important to use forced/fresh air breathing systems in the painting process. All PPE is not just exclusive to the application process but also needs to be utilized when mixing or handling.

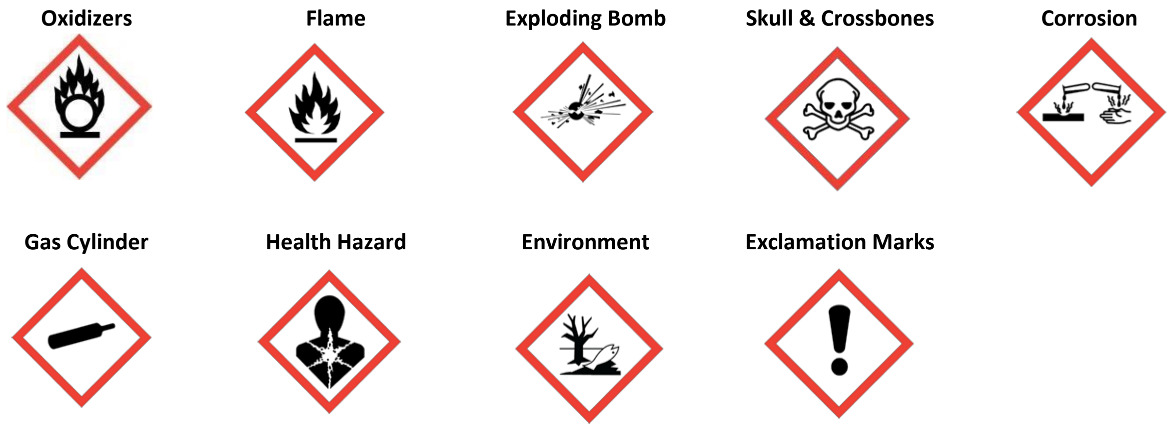
Given the type of materials being used the proper size and number of class C fire extinguishers need to be available in the area for spray operations. All extinguishers need to be certified as required to be sure that they work in case of an emergency. Usually a 6-month checkup by a certifying company is standard in the industry. Lidded containers that are fireproof need to be available for disposing of excess paint and solvent/paint soaked rags.

4.4 Label Requirements

The Global Harmonized System (GHS) and the Department of Transportation require that all chemical products have labels that include, but are not limited to, 6 pieces of information.

1. **Product identification/ingredient disclosure:** It is important to confirm that the product name on the label matches the product name in the SDS. The SDS will be covered in the next section.
2. **Signal word:** When required, signal word indicates the severity of the hazard of the chemical – "**Danger**" for severe and "**Warning**" for less severe.

3. **Hazard statement:** Standard phrases describe the nature and degree of the hazard. They will differ based on the type of product. i.e. **Flammable Liquid**, **Corrosive**, **Vapor** etc.
4. **Pictograms:** A black symbol on a white background with a red border which conveys information about the hazards of a chemical.



5. **Precautionary statement:** Standardized phrases that describe the recommended measures that should be taken to minimize or prevent adverse effects that result from exposure to the chemical, or from improper handling or storage.
6. **Supplier identification:** Name, address and telephone number of the chemical manufacturer, importer or other responsible party.

4.5 HSE Legal Requirements

The HSE legal regime in the UAE is principally derived from the following overriding laws and decisions:

a) Federal Law No (24) of 1999 for the protection and development of the environment Federal Law No. (8) of 1980 as amended – UAE Labour Law
b) Ministerial Decision No. (27/1) of 1981 concerning remote areas and locations
c) Ministerial Decision No. (32) of 1982 concerning preventive methods to protect employees
d) Ministerial Decision No. (37/2) of 1982 concerning standards of medical care provided for Employees
e) Ministerial Decision No. (4/1) of 1981 concerning hazardous works

Employers must also be aware of Local Legislation and Codes of Practice (Emirate or Free Zone) which may affect the HSE obligations, remembering that where the organisation is licensed, and where it does business, can impact upon which rules it is governed by.

Examples of HSE Local Legislation from the Dubai Municipality through the Rulers Court of Dubai:

a) Local Order (61) of 1991 concerning Environmental Protection Regulation in the Emirate of Dubai
b) Local Order (11) of 2003 concerning public Health and Community Safety in the Emirate of Dubai
c) Codes of Practice include the UAE Civil Defence Fire and Life Safety Code of 2017

For more information with regard to OSHA work place painting international standards regulations please see refer the below legislation:

a) OSHA work place painting regulations pleasesee regulation standard OSHA1915.35.

When contracting an organisation outside the UAE, Operators must also be aware of Local Legislation and Codes of Practice which may affect the HSE obligations, remembering that where the organisation is licensed, and where it does business, can impact upon which rules it is governed by.

4.6 Material Safety Data Sheets

The Safety Data Sheet (SDS) provides comprehensive information for chemical use and chemical management in the workplace. Employers and workers should use the SDS as a tool to identify hazards and safety precautions. Each SDS is product specific but not workplace specific. However, the SDS information enables the employer to develop an active program of worker protection measures, including training, which is specific to the workplace as well as measures that may be necessary to protect the environment. The SDS also provides a source of information for others that are involved in the transport of the material, emergency responders, poison centers and anyone else that comes in contact or stores the material

There are sixteen headings and that should be included on every SDS. Below are listed those headings. An SDS should be included and each heading needs to filled out.

1. Identification of the substance or mixture and the supplier
2. Hazard identification
3. Composition/information on ingredients
   - Substance
4. Mixture
5. First aid measures
6. Firefighting measures
7. Accidental release measures
8. Handling and storage
9. Exposure controls/personal protection
10. Physical and chemical properties
11. Stability and reactivity
12. Toxicological information
13. Ecological information
14. Disposal considerations
15. Transportation information
16. Regulatory information
17. Other information including information on preparation and revision of the SDS

For more specific information, refer 4.5 above

4.7 Volatile Organic Compounds (VOC)

Users of paint products must be mindful of the VOC content of those products. VOC is an acronym that stands for **Volatile Organic Compounds**. VOC's are organic chemical compounds that have high enough vapor pressures under normal conditions to significantly vaporize and enter the earth's atmosphere. Volatile organic compounds are numerous and varied. Government toxicologists have determined that most of them are considered harmful or toxic, particularly when sprayed. VOC's, or subsets of the VOCs, are often regulated. With that in mind, it is of maximum importance that the Organisation applies products according to state and/or local government regulations.

5. Facility Requirements and Painting Conditions

- The evaporation of solvents and the presence of spray dust necessitate current -free ventilation in paint shops.
- The temperature should, generally, be maintained between 15 degrees Celsius and 25 degrees Celsius, with a relative humidity below 75%, however some paints require closer or more specific control of the temperature and humidity levels, necessitating approved technical data be closely adhered to. Temperature and humidity should be checked at frequent intervals
- Ventilation may be provided by extractor fans and filtered air inlets, but the most satisfactory method of maintaining the required conditions is by filtering and cooling the incoming air to a sufficiently low temperature to remove excess moisture, then re-heating the air before passing it into the paint shop.
- The air conditioning system should be capable of changing the air in the paint shop continuously and it is recommended that the paint shop should be maintained at a slight positive pressure in order to prevent dust and draughts from entering through doors and windows.
- Consequently, and especially during the painting process, access to the facility should be controlled. This may include signage prohibiting the opening of entrance doors during the time actual painting is being undertaken.
- Cleanliness is essential to a good standard of paint finishing. Paint shop floors should be sealed to prevent “dusting” and should be swept at frequent intervals to ensure the air is largely free from dust. Dried paint and spray dust presents a serious fire hazard and these should be removed frequently.
- When the paint shop is also used for pre-treatment, stripping and flatting, drainage should also be provided, so that rinsing water can be quickly removed and the floor dried before commencement of painting.
- The surface to be painted must be adequately illuminated hence portable flame proof lamps may be necessary when painting the under surfaces of wings and fuselage. The provision of suitable scaffolding or working platforms will be necessary with large aircraft to ensure the correct application of paint.
- Precautions must also be taken to prevent the possibility of fire by removing naked lights and arcing electrical equipment; suitable fire-fighting equipment must be readily available.

5.1 Air Distribution System Configurations for Paint Hangar Bays

The following four basic configurations of air flow were considered in this study for use in large aircraft hangar bays:

1. **Horizontal or laminar flow:** Horizontal flow systems employ full face wall air supply with return either in full face wall or in floor trenches. When full face wall return is used, the flow is termed "laminar”

Advantages:

- Horizontal airflow over aircraft from nose to tail most closely follows airflow around the aircraft when in flight and makes use of the aerodynamics of the surfaces to move air along the point of paint application.

- A horizontal flow system requires a total air volume that is less than any other system to provide a given air velocity through the hangar bay.
- A horizontal flow system is best suited to low velocity return through dry-type paint arrestors in a full face wall configuration.

Disadvantages:

- Horizontal airflow causes problems when one paint crew must work downstream from another paint crew.
- Horizontal airflow causes problems due to the aerodynamics of airflow over surfaces such as wing flaps. During the painting operation, the aircraft's flaps and high-lift devices are extended, which causes overspray to be diverted to the floor and separated from the airflow by the inertia of the particles. Those particles form a buildup on the floor with a resulting fire hazard unless provision is made for a constant removal of overspray particles from the floor.
- Horizontal airflow requires more complex layout in order to achieve the desired nose-to-tail airflow pattern. It is necessary to provide either air supply or return through a movable plenum made up of two sets of hangar doors or to provide a complex system of tracks and trolleys or turntables in order to position the aircraft for airflow between supply outlets and return inlets on two fixed walls.

2. **Vertical laminar flow:** Vertical laminar flow systems employ full ceiling air supply and full floor return.

Advantages:

- The vertical airflow pattern allows paint crews to work side by side without exposure of the second crew when the first crew is painting.
- The vertical airflow pattern carries overspray downward, where it is captured by high-velocity airstreams through floor grates over trenches that connect· through underfloor tunnel or duct systems into an air filtration system. This minimizes the buildup of overspray particles on the floor and the resulting fire hazard. ·

Disadvantages:

- A vertical laminar flow system requires the largest total air volume of any system in order to provide 100 fpm air velocity over the hangar bay.
- Airflow in a vertical laminar flow system does not follow the patterns ·of the aircraft when in flight and. causes turbulent airflow under the planform of the aircraft.
- Vertical laminar airflow causes exposure problems when one paint crew must work below another paint crew.
- Vertical laminar airflow is not suited to row velocity return through dry-type paint arrestors in a full face wall configuration.

3. Downdraft flow: Downdraft flow systems employ ceiling air supply with return through floor trenches or low wall returns or a combination of the two methods. The primary air supply may be concentrated in slots over the planform of the aircraft, with a secondary "entrained air" supply through the remaining celling area to prevent overspray reaching the ceiling, where it would be entrained with the primary air supply and delivered to newly processed surfaces.

Advantages:

- Downdraft flow system airflow allows paint crews to work side by side without exposure of the second crew when the first crew is painting.
- Total. air volume in a downdraft flow system is less than for a laminar flow system or hybrid system in order to provide a 100 fpm air velocity over the areas of paint application, provided the overall hangar bay is not required to have a 100 fpm minimum velocity.
- Downdraft flow system airflow carries overspray downward, where it Is captured by high-velocity airstreams into floor grates on trenches connecting underfloor to an air filtration system. This minimizes the fire hazard from buildup of overspray particles on the floor.

Disadvantages:

- A downdraft flow system does not allow airflow to follow the airflow patterns of the aircraft when it is in flight and causes turbulent airflow under the planform of the aircraft.
- Downdraft airflow causes exposure problems when one paint crew must work below another paint crew.
- Downdraft airflow is not suited to low-velocity return through dry-type paint arrestors in a full face wall configuration
- A downdraft flow system requires an underfloor tunnel system to conduct airflow to an air filtration system.
- In a downdraft flow system in facilities used for both stripping and painting, floor trenches must carry waste from water washdown during the stripping cycle requiring greater maintenance than for wall return systems
- Downdraft airflow does not allow the desired nose-to-tail airflow pattern.
- In a downdraft flow system; the primary air supply through high-velocity air outlets along the aircraft planform causes a secondary flow of room air containing overspray particles toward the ceiling: Unless an "entrained air" system is used, when the air velocity is reduced at the ceiling, the heavier overspray particles separate out of the airflow by gravity and fall on newly prepared or painted surfaces below. The remaining overspray particles are induced into the supply airstream and delivered to the point of paint applies

4. Mixed flow or hybrid systems: Mixed flow, or hybrid. systems employ a downdraft flow system over fuselage, wing, and tail. with an additional horizontal air supply introduced along the leading edges of wings. Return air may be taken through either floor trenches or low wall returns or a combination of the two methods. Entrained air supply from areas of the ceiling not over the aircraft planform may be employed in conjunction with the primary air supply.

6. Paint Removal – Metal and Composite Surfaces

Before stripping a plane and regardless of the coating method it is necessary to first consult the airport authorities to see what they allow. Also, to preserve the surrounding environment in case of spills, it is crucial to contain stripped paint and other chemicals from running off into drains. Therefore, at a minimum, ground containment should be set up.

- ***Tip –*** For smaller aircraft, the organisation can roll the plane onto thick gage plastic that stretches past the ends of the wings, nose and tail of the aircraft. A sandbag dam should be set up under the edges of the plastic when using chemical strippers to prevent runoff. Laying down plastic, especially with a dam, contains contaminants very well and provides an easy method of clean up and disposal.
- ***Tip –*** Larger aircraft should always be stripped in an approved facility where they are set up to safely and legally handle hazardous waste generated from the operation.

There are 3 traditional methods to remove paint from an aircraft –

a) sanding,
b) plastic bead blasting and
c) chemical stripping.

The most time consuming method is to sand down the painted surface until the metal substrate is reached. This method is labor intensive, time consuming, expensive, dusty and generally not recommended. The sanding method is usually employed when the painter is trying to remove the top coat, enable adhesion between old and new paint or where the primer has failed and is no longer adhering to the metal substrate. Using this method requires that the primer have good adhesion over the majority of the aircraft. Where adhesion has failed it is important to sand the lifting or cracked primer and expose the metal.

- ***Tip –*** *As a general rule, the area where the primer is lifting plus 20% on all sides should be sanded until only primer is seen with good adhesion and clean metal. Once that is done, the areas can prime-d where metal is exposed before applying the polyurethane topcoat.*

Sanding to prepare the surface for painting is common for composite surfaces as well. It shall Begin with 100 grit sand paper. The operator shall take all measures not to scratch the composite substrate when sanding off all the paint and primer. Once the top coat has been sanded away and the primer is visible, the operator should switch to a finer grit of sand paper to prevent damage – 240 grit or 320 grit.

Plastic media blasting is quick but requires expensive equipment and containment to prevent environmental contamination due to paint chips and dust flying through the air. Commonly, plastic media blasting is performed by a professional with the proper equipment in a debris containment facility. This method is effective on most surfaces and has been shown to produce less visual damage on composite surfaces than sanding.

Chemical stripping is the third de-painting method. Chemical Stripping demands proper masking to prevent damage to components sensitive to abrasive chemicals. Substances such as: rubber, silicone, glue, adhesive, plastic, composites and electronic or avionic components like radar equipment and antennas need to be protected. Standard masking tape and paper will not suffice.

- ***Tip –** use **<u>only</u>** tape and masking material that is intended for use with chemical strippers or media blasting.*

For aircraft, protective masking materials are applied to the windows, windshield frame, composites, vents, static ports, rubber seals, tires and applicable flight controls. All openings are sealed. A similar procedure should be followed with other equipment. Once stripped, the substrate should be cleaned and rinsed with fresh water. Masking materials are then removed while the paint is fresh or tacky.

7. Environmental Effects on Unpainted Surfaces

Environmental conditions can pose a variety of problems for metals and composite materials that are not properly coated or are left uncoated. Those problems differ depending on the material used. The three major materials used are steel, aluminum and composite substrates.

- The safety of pilots and passengers may be compromised due to corrosion of metals, rusting of steel, the degradation of polymers in composites and the rotting of wood when used as a structural member in fabric planes. Geography obviously affects the potential for the degradation of the materials. For example, the salt air in Southern California, the extreme heat of the Mojave Desert or the humidity in the Gulf States may cause the materials used to construct the plane to degrade at a faster rate than a warm dry climate. This makes coating the plane one of the most important parts of preserving its structural integrity. Below are listed the effects to various substrates when exposed to the elements.

7.1 Alloys (Aluminum & Steel)

Corrosion is the disintegration of an engineered material into its constituent atoms due to chemical reactions with its surroundings. Many structural alloys corrode merely from exposure to moisture, salts and other chemicals/minerals in the air or surrounding environment. Corrosion, most often referred to simply as "rust," can be concentrated locally to form rust, a pit or eventually a crack. Or, it can extend across a wide area more or less uniformly corroding the surface.

- Aluminum is an alloy that has proven to be extremely resistant to corrosion. Aluminum is actually a very active metal, meaning that its nature is to oxidize very quickly forming a protective film. While a weakness for most metals, this quality is actually the key to its ability to resist corrosion. When oxygen is present (in the air, soil, or water), aluminum instantly reacts to form aluminum oxide. This aluminum oxide layer (protective film) is chemically bound to the surface, is impervious to oxygen, and it seals the core aluminum from any further reaction. Aluminum's oxide film is tenacious, hard, and instantly self-renewing. According to the US Army Corps of Engineers, "Aluminum has excellent corrosion resistance in a wide range of water and soil conditions because of the tough oxide film that forms on its surface. Therefore, it is an outstanding material for aircraft. When corrosion does affect the integrity of aluminum it usually occurs in the form of pits. This is how to determine whether there's a corrosion problem. The conditions most likely to cause corrosion commonly occur in environments where UV light, salt and moisture are prevalent. Paints and other coatings are critical to the prevention of corrosion and to preserving the integrity of the structural members of whatever is being coated. For these reasons a system of coatings which allows materials such as metal to maintain their strength and properly perform to their intended specifications needs to be developed.

7.2 Composite Degradation

Corrosion is not limited to metals. Corrosion can occur in ceramics or polymers, although in this context, the term degradation is more commonly used. Owners of composite aircraft should be careful to avoid what is called composite degradation. Composite or Polymer degradation is present where there is a change in the properties of the composite – changes in tensile strength, color or shape are the most common. Degradation occurs due to the influence of one or more environmental factors such as heat, light or chemicals such as acids, alkalis and some salts. These changes include cracking and depolymerisation of products which will lower the molecular weight of a polymer. The changes in properties are often termed "ageing". Polymeric molecules are very large (on the molecular scale), and their unique and useful properties are mainly a result of their size. Any loss in chain length lowers tensile strength and is a primary cause of premature cracking. This cracking often occurs during use and over a period of time can lead to a lack of integrity in the composite. This process severely increases the chance of substrate failure.

8. Surface Preparation

Surface preparation is by far the most important and time consuming phase of the painting process.

- ***Tip –*** *PPE such as gloves, goggles, protective clothing and a mask be used to minimize exposure to chemicals, dust and the impact from debris. From this point forward, all safety equipment should be worn especially the gloves to prevent surface contamination and the transfer of skin oils or other area contamination and to prevent chemical exposure.*

All dust should be removed from the surface being painted, from the floor and surrounding area immediately before and after performing any work on the aircraft surface. The following functions should be performed in a clean well ventilated area with temperatures ranging from 60° to 100°F/15.5 to 37.7°C. For metals all rust and/or corrosion should be completely removed. Section "5.2" discusses the various methods of accomplishing rust and corrosion removal.

8.1 Composite Filling, Sanding and Surface Preparation

The process to prepare the composite substrate is a two stage process that is always affected by the quality of the molds used to create the structure and also by the percent solids of the resin. The first step is to insure the shape and contour of the surface with filler. Next, perfect and sand smooth the surface for paint. After a smooth surface has been created, the surface will be ready to start priming. For more information with regard to the use and application for the sandable Epoxy Primer refer to section 10 of this manual and to technical data. Most composite surfaces need to be repaired prior to sanding and painting.

- ***Tip –*** *DON'T look for the low spots in the substrate individually. Trying to find them all and fill them, then sand, then recheck and refill again and again and again is time consuming and will not produce the desired result. INSTEAD: fill the entire surface. For example, when filling and sanding a fuselage. Start by filling the entire surface all at once by applying a fairly thick coat of the filler primer. After this is accomplished, begin sanding. The amount of filler to sand off may seem overwhelming but when using the right techniques and equipment this task is essentially effortless. Now, instead of looking for the low spots to fill, just sand until the high spots show through the filler.*

For composite planes with deep depressions where spars or deep joints are located, fill those areas prior to the previous step. This first fill must stay below the surface of the substrate.

- ***Tip –*** *prior to filling the depression, paint the depression and some of the flat surface around the depression with a high quality dark paint (the paint needs to be high quality to prevent peeling later on). After painting the substrate, fill in dents and depressions with glazing putty. Then coat with a thin coat (.6mm) of the sandable, epoxy filler primer and sand when ready. When the paint on the flat surface around the depression begins to show, stop sanding. The surface should be smooth and consistent – no noticeable dents or depressions. Since glazing putty can leave pinholes which may need require an additional coat of filler primer and sand again.*

Once filling is complete, the sanding process can begin. Here, as with so many projects, the correct tools are imperative. There are two fundamental steps to achieving a perfectly smooth composite surface. First, right size and shape sanding tools for the job are a must. An orbital sander is ideal. If sanding is done by hand, multiple types of tools will be needed. Different shaped surfaces require long and short boards, blocks and tubes. Sanding with paper and bare hand will not produce the desired results

Second, the proper technique must be used. Ensure to sand at 45 degree angles and use the longest strokes possible, within reason. The sand paper grade needed for most of the job is 36 grit. Followed by the 80 grit to remove deep scratches. Finish with 120 or 240 grit to smooth the surface in preparation for the sandable primer application.

Once completed the sanding process it is important to remove all the dust from the surface, floor and surrounding area. Start by thoroughly rinsing the surface with an approved purpose aircraft cleaner. The purpose of this step is to remove large debris and to remove oils and other surface contaminants that might undermine the adhesion of the primer to the substrate. the use of a solvent (where permitted) such as Acetone or IPA (Isopropyl Alcohol 99%) is recommended to wipe down the plane, to insure that all oils, greases, adhesives and contaminant films are removed. For the wipe, low lint wipes are recommended for smooth surfaces and abrasive surfaces.

When the surface is fully dry, a tack rag or cheese cloth can be used to remove the small dust and debris particles. When the cloth is removed from the packaging, it must be unfolded completely, fluffed and very lightly crumpled into a very loose ball and gently graze the surface of the substrate to clean the surface. Making the cloth into a loose ball makes the rag easy to hold without pressing it or dragging it against the surfaces. Pressing the cloth to the surface will leave adhesives behind, which will undermine adhesion.

8.2 Rust and Corrosion Removal for Metal Surfaces

For steel, aluminum, magnesium and most other metals it is important to remove all rust or corrosion from the surface. There are several ways to do this.

Chemical cleaners that are intended to remove rust and corrosion are popular. Usually, these products are either sprayed or wiped on the surface and then scrubbed off.
When scrubbing the metal surface, it is suggested an abrasive material such as scotch brite pads is used. This not only helps to remove rust and corrosion from affected areas, it also scuffs the surface. The scuffed surface helps promote adhesion when treating and then priming the surface.

Sanding is another method used to prepare the surface. Sand the surface with aluminum oxide sandpaper (3M or other manufacturers). For light to moderate rust, sandpaper with 80 or 100 grit should be used. Once the rust has been removed, the area should be sanded down with 240 or 320 grit sand paper to smooth the area. Excessive rust may require the use of a chemical process to remove the corrosion/rust before sanding. Particularly difficult corrosion may require additional cycles of chemical cleaning and sanding until a clean metal surface is achieved. Also, this is the best method for removing excessive rust on thinner metals.

Finally, blasting the surface with some sort of media can be an efficient way to rid the metal surface of rust and corrosion. When this method is used, instructions must be followed with regard to the type of media and the equipment. Beware of blasting through thin metal. Even without excessive rust, it is possible to blast through the substrate. Blasting through the substrate can occur if the blast nozzle is pointed at one area for too long a period of time and/or using excessive pressure or is held too close to the metal.

8.3 Metal Surface Preparation

Whether starting with new, clean, metal or refinishing old metal, where all the corrosion and/or rust have already been removed, it is important to thoroughly wash the surface with an approved cleaner. The purpose of this step is to remove large debris, dried films, oils and other surface contaminants that undermine the adhesion between the substrate and the primer. After washing and drying the surface, wipe down the surface (where permitted) with **MEK** (Methyl Ethyl Ketone), **Acetone** or **IPA** (Isopropyl Alcohol 99%) to ensure that all oils, greases, adhesives and other contaminant films are removed. The use of low lint wipes is suggested for smooth and abrasive surfaces.

When the surface is fully dry it is the right time to remove the small dust and debris particles with a tack rag or cheese cloth. Remove the cloth from the packaging, unfold it completely. Fluff it and very lightly bunch it into a very loose ball. This makes the rag easy to hold without pressing it or dragging it against the surfaces. Gently graze the surface. Pressing the cloth to the surface will leave adhesives behind, which will undermine adhesion. When this step is completed. It is time to start the “Metal Pretreatment”.

9. Masking

When painting the bulk of the aircraft surface with one color (usually white) very little masking is needed initially. However, it is necessary to mask the cockpit, windows, window trim, wheels, vents, openings, lights antennas and anything else not requiring painting.

- ***Tip –*** *If a seam, opening or an area that doesn't require painting is identified and not sure whether it should be masked, mask it to keep overspray off of it. It is recommended masking with good quality solvent resistant masking tape that is at least 1inch wide and use good quality masking paper when covering larger areas such as windows, wheels, propellers, cock pits, etc. Do not use newspaper to mask or low quality tape which will buckle and leak. For large openings or gaps it is helpful to stuff them full of crumpled up paper prior to masking.*

Newspaper will transfer ink to the surface and low quality tape will leave adhesive residue behind when the tape is removed. When applying the tape to the surfaces, ensure that a good seal is achieved by pressing down the edges. When wrapping items with paper, make sure to seal every possible opening with tape. With spray paints of any type they tend to find the tiniest breaks or wrinkles in the tape or paper that get overlooked and leak through, causing more work to have to be done.

9.1 Masking for Trim

At this point in the painting process the aircraft has been painted with a base color over the entire surface.

- ***Tip – Carefully remove all masking paper and tape from the painted surfaces.***

Now start prepping to mask for trim paint application. Before applying any tape make sure to refer to the technical data sheet in order to confirm that the paint is dry and cured enough to reapply tape to the surface.

- ***Tip –*** *For the Polyurethane, wait a minimum of 24 hours, 36 hours is optimum. If tape is applied to the area any sooner, there's a risk of pulling up the previously coated area.*

Do not wait for more than 72 hours otherwise the areas that are to be painted will need to be scuffed. Trim designs can be elaborate with multiple color schemes and designs or they can be simple with just 2 or 3 colors. Either way the masking should be done the same basic way.

Making a personally designed paint scheme is an option. In which case the design shall be drawn on a silhouette drawing of the aircraft that is as close to scale as possible.

- ***Tip –*** *The masking materials to be used for the trim lines should be 3M Fine Line tape. This tape is solvent resistant and is available in widths that range from 1/8 to 1 inch and give a good clean edge when applied properly.*

Quality masking tapes such as the product from 3M and masking paper should be used to cover the areas that need to trimmed to avoid the paper lifting and over spraying the basecoat.

- ***Tip –*** *To start the masking first set a point on the aircraft from which to initiate the trim lines using the 3M 1/8 or ¼ inch Fine Line tape. If the lines that generate from this point have a large radius or are straight use the ¾ inch or 1-inch tape and keep it pulled tight with one hand will pressing the edge with the other. I have found that it is much easier to control wider tape when masking a radius that does not turn too sharply as well as straight lines. Sharp and short radius curves require the 1/8 inch or ¼ inch tape to avoid crinkles in the tape.*

Really, the key is to use the widest tape possible that lays down flat around a radius. On one side of the plane finish masking the fuselage, wings, vertical fin, rear stabilizer, rudder and the engine nacelles. At this point, any adjustments that need to be made should be made, so examine the lines very carefully. After one side of the aircraft has been completed, trace the entire design on paper and transfer the design to the other side of the aircraft. Ensure to pick the same stating point picked on the other side. Also, to ensure that the angle is the same, pick a few points on the side of the aircraft that are already masked and use them as points of reference to make sure that the lines and points are even. Of course different methods can be used to transfer the placement of the trim design. Another method is to use the initial starting point and apply trim tape using the rivets or metal frames to measure and position the tape correctly. After both sides are done being masked, take a picture and inspect for differences. Make corrections where needed.

- ***Tip – Now that the taping is complete, it is recommended that a sealing strip of ¾ inch tape is applied in order to cover half the Fine line tape extending over the outside edge. Applying a wider tape gives a larger area to tape the masking paper to with 1 inch tape. Ensure to place half the masking tape to half the width of the tape that has already been applied and the other half to the masking paper.***

Now that all the trim masking is complete, it is important to mask around that area to prevent any overspray from landing on the base color coat. To ensure that paint does not drift under the masking paper or tape, check the seams and double check the edges by pressing them to the substrate.

10. Coatings

10.1 Primers

All components should be mixed thoroughly before applying. This will ensure that all pigments and solids that have settled to the bottom of the can will be brought into suspension and distributed evenly throughout the paint. For this task, the can should be placed on a mechanical shaker for a minimum of 15 minutes. Once shaken, open the can and with a stir stick scrape the bottom of the can to make sure that all the solids are fully dispersed. If there is still material on the bottom continue to stir the paint and scrape the settled material from the bottom of the can. Place material back on the mechanical shaker for another 10 minutes and recheck.

Metal Pretreatment/Acid Etching Vinyl Wash Primer:

When applied as a thin film, it etches the metal and promotes adhesion for the Epoxy Primer. This thin film also provides minimal corrosion protection. This primer is most commonly used on aluminum, but can also be applied to steel and magnesium.

Zinc Chromate Primer:

The Zinc Chromate is a non-sanding primer that is compatible single component top coats such as enamels, lacquers, waterborne polyurethane and waterborne acrylic lacquer. It is intended for use over metals that are bare, scuffed, sanded, lightly rusted, media blasted and previously painted surfaces. It is an excellent adhesion promoting primer with superior anti-corrosion properties. The Zinc Chromate works by forming a passive layer that prevents corrosion when moisture in the air causes the Zinc Chromate to react with the metal.

Zinc Phosphate Primer:

Zinc Phosphate primer is an Alkyd based, single component, general purpose primer. It is a less hazardous alternative to the Zinc Chromate primer. This primer has many of the same beneficial characteristics as the Zinc Chromate: it is a non-sanding, rust inhibiting and displays excellent adhesion properties.

Water Reducible Epoxy Primer:

This primer exhibits excellent adhesion and inhibits corrosion on plated and unplated metals but can also be applied to most any material.

Epoxy Primer:

This primer has some of the same properties as urethanes with much stronger adhesion characteristics. It provides the ultimate protection and gives a high quality finished appearance to metal, wood, composites and most other materials able to be coated. The Epoxy Primer is able to be applied direct to composite and metal surfaces that have been prepared and cleaned properly. However, when applying to a metal surface, using the Acid Etching Primer to promote long lasting adhesion is recommended.

Sandable Epoxy Primer:

The Sandable Epoxy Primer is a high build primer commonly used as a filler primer specifically for composite aircraft. It has the same protective and adhesion promoting qualities as the Epoxy Primer.

10.2 Top Coats

Before top coat application, it is important to thoroughly shake and then mix all components. Performing this task properly will ensure that all pigments and solids that have settled to the bottom of the can will be brought into suspension and distributed evenly throughout the paint. For this task it is recommended placing the can on a mechanical shaker for a minimum of 15 minutes. Next, open the can. With a stir stick scrape the bottom of the can to make sure that all the solids are fully dispersed. If there is still material on the bottom continue to stir the paint and scrape the settled material from the bottom of the can. Place the material back on the mechanical shaker for another 10 minutes. Check again before using.

Waterborne Polyurethane:

As with most waterborne coatings, proper application and an awareness of the environmental conditions in which the coating is being applied are extremely important. It is recommended applying this coating in temperatures no lower than 60°F and no higher than 95°F. Do not spray when humidity exceeds 85 percent. Additional moisture can over-thin the paint after it has been applied to the substrate.

Enamel:

Enamel top coats are high performance single component paint. Enamels can be used for interior and exterior application and are excellent when used as touch up coatings.

Interior Epoxy:

Although this paint is intended for interior applications, the specification that the product meets does have weathering and UV requirements, making it the most durable and impact resistant coating, that will resist yellowing, to be used in the cockpit.

Polyurethane:

Polyurethane top coat is a unique formulation of high molecular weight urethane resins which produce an extremely hard impervious film which will not yellow or chalk and retains gloss even when exposed to most solvents, chemicals, fumes and sun light. This coating can be applied to most any surface and is a new age high solids polyurethane system which has an average of 79% of solid material per admixed gallon.

11. Application Methods

11.1 Dipping

Dip application is a process that is commonly performed when there are a large number of small parts to coat. This is a process that requires a tank that allows to fully submerge the part in the coating. Once the part has been removed from the dip tank it is recommended to hang the dipped part from racks with tie wire until the coating dries hard. This application is most popular with primer type coatings but can also be performed with topcoats.

11.2 Brushing

Brushing is most commonly used as a method of application for painting small touch up areas or when applying paint in confined and enclosed spaces. Before applying confirm that the brush is compatible with the paint being applied. For example, if a solvent or oil based paint is applied, be sure that the brush is not intended for water based or water borne coatings. after confirming that correct brush is used, review the technical data sheet. Specifically, look for reducing instructions with respect to brushing. A good way to identify if the material is too thick or thin is to first brush the paint on a small test panel. If the paint is too thick the material will either pull or rope under the brush. This means that lines will form and ridges from the brush on the surface of the paint. If the paint is too thin the material is likely to not cover well, and will run and/or drip. Proper viscosity and substrate temperature (75°F ± 5°F) allows the material to flow out and eliminates marks left by the brush.

11.3 Spraying

Spraying is the most common and most preferred method to achieve the best finished product over large and small areas efficiently. All spray systems have the same basic characteristic. There must be a sufficient amount of air from the compressor to spray the volume of paint needed. Next, a pressure pot, tank, reservoir or cup to house and supply the paint material is needed. Finally, use a gun or device that properly applies the paint to the substrate allowing the user to control the air flow and the volume of paint leaving the gun so that the paint is atomized into a consistent spray or cloud so that a smooth finish can be achieved. Conventional spray systems need water traps and oil filters incorporated in the air supply line to remove moisture and contaminants. Traps and filters must be maintained to work efficiently.

11.4 Aerosols

Although this section is meant to mainly discuss conventional spray systems and HVLP, aerosol cans have all of the characteristics listed above. The propellant in the can is the air supply, the can itself is the reservoir and the valve and nozzle is the application device. However because of the small amount of paint that aerosol cans hold they are commonly used only on small parts and touchups. Aerosol cans are usually single component products such as lacquers, enamels, alkyds, etc. Painting an aircraft exterior with single component paint should be limited to touch up. It is possible to obtain two component materials in an aerosol can through 2 different methods:

First: i.e. epoxies and polyurethanes, in a can intended for two component material. These cans require to pop a valve on the bottom of the can to release the catalyst into the paint. These cans have a short shelf life, pot life and are very expensive for the amount of material inside the can. The second is a solution that for applying two component paints and coatings from an aerosol can. The aerosol cans come as a kit, with a plastic bottle and pump. The aerosol can contains the paint (component A) and the plastic bottle contains the catalyst (comp. B). shake the aerosol can thoroughly and should hear the bearing rattle inside the can. Next, screw the bottle of catalyst onto the hand pump, remove the nozzle from the top of the aerosol can and snap the pump to the top of the can. After the pump is securely attached pump the catalyst into the can. Once all the catalyst is in the can, detach the pump and reattach the nozzle and shake well for 5 – 10 minutes. Now the product is ready to be applied. Both methods for applying two component products from an aerosol can are limited to a single use since the coating will now turn solid inside the can and should be sprayed with in 4 to 8 hours of adding the catalyst to the paint, depending on the technical data sheet.

11.5 Conventional Spray System

Now back to the discussion on conventional spray systems There are a few types of equipment for this system: pressure feed, gravity feed and siphon feed. Conventional spray equipment is usually applied by using a compressor to supply air at 20 to 50 PSI depending on the gun. The size area that is going to be painted will determine what kind of material container and/or gun will be used. For small parts, small areas or trim, use a gravity-feed or siphon feed gun.

11.5.1 Gravity and siphon feed guns

have an integral paint container usually holding up to 1 quart or 32 ounces of material. The container can be mounted on top of the gun which is a gravity feed or underneath where the paint material is fed to the tip and nozzle of the gun with air pressure from the compressor or siphon feed. Gravity-feed guns, as stated earlier, have the paint supply cup mounted on the top of the gun. The operator can make fine adjustments between atomizing pressure and fluid flow and use all the material in the cup. The siphon feed gun is a conventional device that is familiar to most painters. Regulated air passes through the gun and draws the paint from the supply cup. The fluid and air mix outside of the air cap atomizing the material, which like the gravity-feed makes this an external mix gun. These options are usually reserved for small areas or when painting trim. For applying paint to large areas, use a pressure feed equipment with a large container or pressure pot (2 quarts to 60 gallons) that feeds material and air to the gun. Pressure feed is more desirable in this circumstance since a large amount of paint can be applied to the substrate without interruption of stopping and refilling the pressure pot. Also, without a container mounted on the top or bottom of the gun itself the applicator does not have to deal with as much weight and has the flexibility to spray in any direction with constant pressure through the gun.

11.6 HVLP Systems

The HVLP system is a newer technology which is becoming the preferred method of application due to more restrictive Environment regulations. The air supply can come from a high pressure convention type spray system which is a piston type compressor or the supply is provided through a series of turbine fans or stages that move a high volume of air at a low pressure. The more stages or fans available, provide a great volume of air output which is rated in CFM's (cubic feet per minute). Before entering the turbine fans the air is filtered to remove dirt, dust and debris. A second filter comes after the turbines on the air output side to supply the spray gun. Unlike the piston type compressor system, the HVLP does not produce water or oils that can possibly contaminate the air supply. The down side is that the turbine heats up, causing the paint to dry faster. To avoid this, get an extra length of hose to reduce the air temperature at the spray gun. Just like with the conventional spray system, use a gravity-feed and siphon feed spray guns and use a pressure pot or pressure equipment for large areas. However, HVLP guns are considered internal mixing guns. This means that the air and the paint are mixed inside the air cap. Also, HVLP systems have the advantage of low pressure in the paint application. The advantage is the amount of paint transfer to the substrate. HVLP spray guns can transfer 65 to 80 percent of the material to the surface. There are also HVLP guns that don't need the turbine system. They have HVLP stamped on the side of the gun. They have proven to the air quality management district that they can deliver more than 65% transfer efficiency with a regulated low air pressure.

12. Paint Compatibility

The use of a number of different paints and coatings along with different proprietary coatings makes repair of damaged or deteriorated areas a challenge. Not all paint systems are created equal or compatible. The following list is a general guideline of what not to do when it comes to repair or touch up. However, before ever performing a repair or touch up, please contact the manufacturer of the products intended to be used in order to verify compatibility.

- Old zinc chromate can always be used for touch ups directly to bare metal surfaces and on interior surfaces. If using on top coating the zinc chromate with a two component polyurethane or epoxy, check with the manufacture to make sure that the top coat will not lift the primer. Zinc chromate primers are usually top coated with single component acrylics, lacquers, enamels or alkyds. Use acid etching wash primers over zinc chromate primers.
- Modified zinc chromate primer must never be used on bare metals. If a modified version is used, first apply an acid etch wash primer to the bare metal. Furthermore, do not apply a modified zinc chromate primer over any acrylic nitrocellulose lacquer, as good adhesion will not be achieved.
- Nitrocellulose coatings and lacquers will adhere to acrylic finishes. However, some acrylics will not adhere to nitrocellulose coatings and lacquers.
- Acrylic nitrocellulose lacquers show poor adhesion when applied over nitrocellulose and epoxy coatings. To properly touch up areas with a lacquer or nitrocellulose lacquer, apply the material of successive coatings or an acid etch wash primer or zinc chromate primer that has been applied directly to bare metal. They can also be applied to an epoxy or epoxy primer that has been recently applied (dry hard less than 24 hours).
- Epoxy coatings adhere to most any two component paint system and some single component systems that are in good condition and show good adhesion. Epoxy coatings are very useful for general touchup on interior surfaces and some exterior surfaces and especially on baked enamels.
- Old wash primer can be over coated directly provided that the initial application shows no defects. Wash primer defects occur when the coating is too thick causing a failure in adhesion.
- When touching up old acrylic with new acrylic, first rewet the paint with acrylic nitrocellulose thinner.
- If damage to an epoxy surface occurs, fix it with an epoxy or polyurethane. In some scenarios, an air dry enamel can be used to touchup an epoxy surface, provided the edges of the damaged areas are abraded with fine sand paper (320 grit). Acrylics and nitrocellulose lacquers will usually not adhere to an epoxy surface.
- Polyurethane surfaces should be touched up with a two component polyurethane but can also be touched up with an air dry enamel, acrylic lacquer, nitrocellulose lacquer, waterborne lacquer
- (MIL-PRF-81352 TYI) or waterborne polyurethane (MIL-PRF-81352 TYIII). Before repairing an affected area, always abrade the surrounding surface with fine grade sand paper (320 grit).

12.1 Paint Touchup

Paint touchup to the substrate and the topcoat may be required for a number of reasons. Repair to a metal or composite substrate are the most substantial touchups that usually involve not only the top coat but the primer as well. Minor touchups usually involve repairing only the topcoat. Topcoat touchups include, but are not limited to, scratches, abrasions, permanent stains and fading. The first step to touch up is to identify what kind of coating is going to be touched up.

12.2 Identifying Paint Finishes

Finishes that are currently on the surface of the aircraft can be any number of different types of coatings, or a combination of two or more types, or even combinations of general paints with special proprietary coatings. Any of the previously discussed finishes may be present on the aircraft at any given time. Also repairs may have been made, utilizing a number of different coatings. With that in mind, it is important to identify each finish on the aircraft to ensure that the topcoat application will properly adhere and will not lift previously applied finishes. One common test is to apply a coat of engine or turbine oil that conforms to MIL-PRF-7808 to a small section of the aircraft. Old nitrocellulose type coatings will soften within a few minutes. Acrylic, polyurethane and epoxy finishes will show no defect. If the paint still cannot be identified, then soak a rag with MEK (Methyl Ethyl Ketone) and wipe the painted surface. A MEK wipe should pick up pigments from all coatings accept polyurethanes, epoxies, phenolic resins and baked on coatings. Just wipe the surface, do not excessively rub. Heavy rubbing can affect some bake, epoxy and polyurethane coatings. Do not use MEK on nitrocellulose coatings.

Nitrate	Nitrate Dope	Butyrate Dope	Nitrocellulose Lacquer	Acrylic Lacquer	Acrylic Enamel	Urethane Enamel	Epoxy Paint	Polyurethane Paint
IPA 99%	IS	IS	IS	S	IS	IS	IS	IS
Methanol	S	IS	IS	IS	PS	IS	IS	IS
MEK	S	S	S	S	ISW	IS	IS	IS
Methylene Chloride	SS	VS	S	S	ISW	ISW	ISW	ISW
Toluene	IS	IS	IS	S	ISW	IS	IS	IS

IS: Insoluble
ISW: Insoluble, film wrinkles
PS: Penetrate Film, Slight Softening Without Wrinkles.
S: Soluble
SS: Slightly Soluble
VS: Very Soluble

12.3 Preparing the Surface for Touchup

Now that the type of paint has been identified on the plane, the surface can now be prepared. Before any work is started, thoroughly clean the plane, removing all dust, debris, oils and dried films with an aircraft degreaser (PTC-2002 Aircraft Degreaser), especially if going to sand or abrade the area and apply paint over the existing primer. If going to repair a whole panel from seam to seam, strip the panel completely. Repairing an area from seam to seam eliminates the need to match and blend the topcoat to the existing color as closely as possible. After the area is completely stripped it should be completely redone with the wash primer, epoxy primer and polyurethane topcoat. The paint along the edges of the stripped area should be hand sanded wet and feathered with 320 grit sand paper.

When repairing small areas or performing spot repair which requires color matching of the new paint to the existing paint, plan on preparing an area three times the size of the damaged area. If the affected area has undermined the primer or its adhesion properties to the substrate, then sand the area with 320 grit aluminum oxide sandpaper on a double action (orbital) electronic sander. After which, wet sand the area using the same double action sander with 1500 grit wet sanding paper. Prior to applying the wash primer and epoxy primer to the area where the substrate is exposed, wipe down the area with Acetone or IPA following by a tack cloth. When spraying the primers use the cross spray method to achieve even coverage. For the Epoxy primer refer to the technical data sheet for dry times and recoat times. After the primer is dry sand the area with 1500 grit wet sand paper as well as the surrounding area, approximately three times the size of the repair. Clean and wipe the area with IPA or Acetone followed by wiping the area with a tack cloth. Mix the compatible top coat paint according to the technical data sheet. The first two coats that applied should be light. The second coat should extend slightly further than the first. Allow each coat to flash off to tack dry before applying the next. After the second coat has dried sufficiently apply a third coat that has been thinned 3 to 1 with the appropriate reducer. Spray the third coat so that the coating extends past the first two. After all the coats have been applied allow the coating to dry through but not fully cured and proceed with buffing and polishing the area.

If the primer has not been damaged complete all steps except for the ones that involve preparing for primer and primer application. Paint touchup as described in this section is usually the same for every type of product. However, before performing any of the said tasks, contact the manufacturer and confirm the process. The end result can be affected by a number of factors, including preparation, coating compatibility, color match, the proper thinner or reducer for the temperature and the experience of the applicator.

13. Spray Gun Operation

13.1 Gun Adjustments

When dialing in any gun the best place to start is to refer to the manufacturers specifications for the equipment to be used and identify the recommended air pressure to the gun. Next test the spray pattern by applying the paint to a large piece of masking paper that is taped to a vertical surface. When spraying it is important to hold the gun 10 to 12 inches from the surface. Regardless of the brand of gun being used, adjust the fluid volume and air flow on the gun itself. The upper control dial adjusts the air flow, which also adjusts the spray pattern. The lower dial regulates the amount of fluid that passes through the needle and controls the amount of paint that is transferred through the gun. When spraying, always pull the trigger all the way back. Still spraying the masking paper, move the gun across the paper horizontally while making adjustments between the two dials to achieve a spray pattern that is wet from top to bottom. To reduce the amount of fluid flowing past the needle turn the lower dial to the right. Turn it to the left to increase the fluid volume. Turning the top dial to the right not only decreases air flow but also reduces the size of the spray pattern. Turning the dial to the left increases the airflow and the size of the spray pattern. Once a good spray pattern has been achieved, apply the paint to the aircraft using the proper techniques that we will discuss in the following section.

13.2 Application

For inexperienced or first time finish applicators, some additional practice maybe needed before applying the finish coat. So after preparing, cleaning and primed the aircraft, pause for some practice.

At this point, the aircraft should already be primed and ready for the topcoat finish. There is one main difference between the primer and the topcoat which is that the primer appears flat and the topcoat is glossy. The flat finish of a primer is (1) due to the grind of the pigment and (2) obtained by trigger control and properly moving the gun across the surface at a consistent speed and distance from the surface. Typically, a primer should be applied using a cross coat spray pattern. The most common way to perform the cross coat technique is to spay one pass horizontally and a second pass moving vertically. Spray the first coat vertical and the next horizontal, so long as the first coat is perpendicular to the second. Ensure that the two coats applied are light.

If the primer is applied in light coats, runs and drips are not usually an issue. However, the finish coat requires a bit more experience with a spray gun. Wetter applications of the top coat help to produce a glossy finished product. Overlapping the spray pattern, proper as well as the consistent movement of the gun, and distance of the gun from the surface also can affect the final finish. It is easy to vary in any of the factors listed above which can lead to runs, drips or dry areas, so consistency is a must. Practicing the technique on the masking paper is necessary to gain the skills and confidence to achieve a smooth finish.

When practicing first start with a flat horizontal surface. Remember to hold the gun 10 to 12 inches above and perpendicular to the surface. Pull the trigger part way so that only air passes through the gun and begin to move the gun across the surface. Once close to the paint area, pull the trigger all the way back and release the material. Move the gun at approximately 1 foot per second until reaching the end. When reaching the end release the trigger enough to stop the flow of material but not enough to stop the air from passing through and then repeat in the opposite direction. Releasing the trigger only enough to stop the flow of material ensures that the pressure at the gun stays consistent and prevents pressure build up. Another consequence of pressure buildup is paint buildup at the end of each pass, which can lead to runs, drips and sags in the final product. Overlap each pass 50% of the previous pass. This can be easily accomplished by pointing the middle of the spray at the edge of the previous coat. Continue to overlap with each coat.

Once a good finish has been achieved on a horizontal surface practice on a vertical surface. Applying on vertical surfaces shows the usefulness of applying a tack coat. A tack coat is a very light coat that provides the foundation for the second coat and helps to prevent runs, drips and sags. Practicing spraying on a horizontal surface overlapping passes and then rotating the air cap 90 degrees to rotate the fan pattern for spraying the vertical surface with the same 50% overlap technique is very important. Practice the cross coat technique on a vertical surface until achieving a smooth, glossy finish with no runs, drips or sags. Once the technique is perfected, start the actual project.

13.3 Common Gun Issues

Before ever beginning to spray it is vital the spray pattern be double checked prior to application. This can be performed by just spraying the compatible thinner through the gun. This test indicates the correct spray pattern despite the fact that the thinner or reducer has a lower viscosity than the paint. The test will also verify that the lines are clean if the spray does not appear to have any remnants of previously sprayed paints. If the gun is not working properly, trouble shoot the problem utilizing the following steps:

- If the material being sprayed is pulsating or spitting it usually means that there is a loose nozzle, clogged vent hole on the supply cup or the packing around the needle may be leaking air.
- If the spray pattern is uneven or offset, there may be a clog in the air cap or the ports in the horns.
- IF the spray pattern is heavy on one side rotate the air cap 180°. If the pattern reverses the air cap is the issue. If the problem persists the needle in the gun may be damaged.
- Other problems with the gun may be the result of improper air pressure, improper reducing of the material or the wrong size spray nozzle.

14. Common Paint Issues

Painting is a skill. An experienced painter knows what environmental conditions (temperature, humidity and sometimes wind) to spray in and reads all the technical data for a product to avoid the issues that we will discuss in this next section. The biggest problem when troubles occur on any paint project is that they are particularly noticeable. The problems discussed in this section are adhesion and lifting, blushing, sags, runs, drips, orange peel, solvent pops or pinholes, fisheyes, sanding scratches, dings, dents, wrinkling and dry spray. Before ever pulling the trigger of the spray gun on the aircraft, first grab a piece of sheet metal or a metal panel and apply the paint to it. Use this opportunity to dial in the fluid volume, air supply, spray pattern and try to figure out the appropriate distance from the substrate (8-10 inches) and the speed at which the gun should move across the substrate.

14.1 Adhesion and Lifting

If the adhesion of a product fails it is usually due to poor or improper cleaning and preparation of the surface to be finished. Using the wrong primer for the substrate can also cause adhesion failure. Incompatibility of the topcoat with the primer can cause failure especially when the solvents in the topcoat undermine the primer and cause the primer to lift. If an improper thinning or reducing of the material occurs the paint can dry too quickly and lift. If the wrong thinner is used the performance and adhesion properties of the material could be compromised. When materials are mixed improperly, for example mixing an epoxy catalyst with a polyurethane base, adhesion will most certainly fail. Finally if the spray equipment or fluid and air lines are contaminated, then water, oils or other materials can affect the adhesion properties. Unfortunately, the only way to correct poor adhesion is to completely remove the finish. After which, evaluate what the cause was and correct the issue before entirely refinishing the affected area.

14.2 Blushing

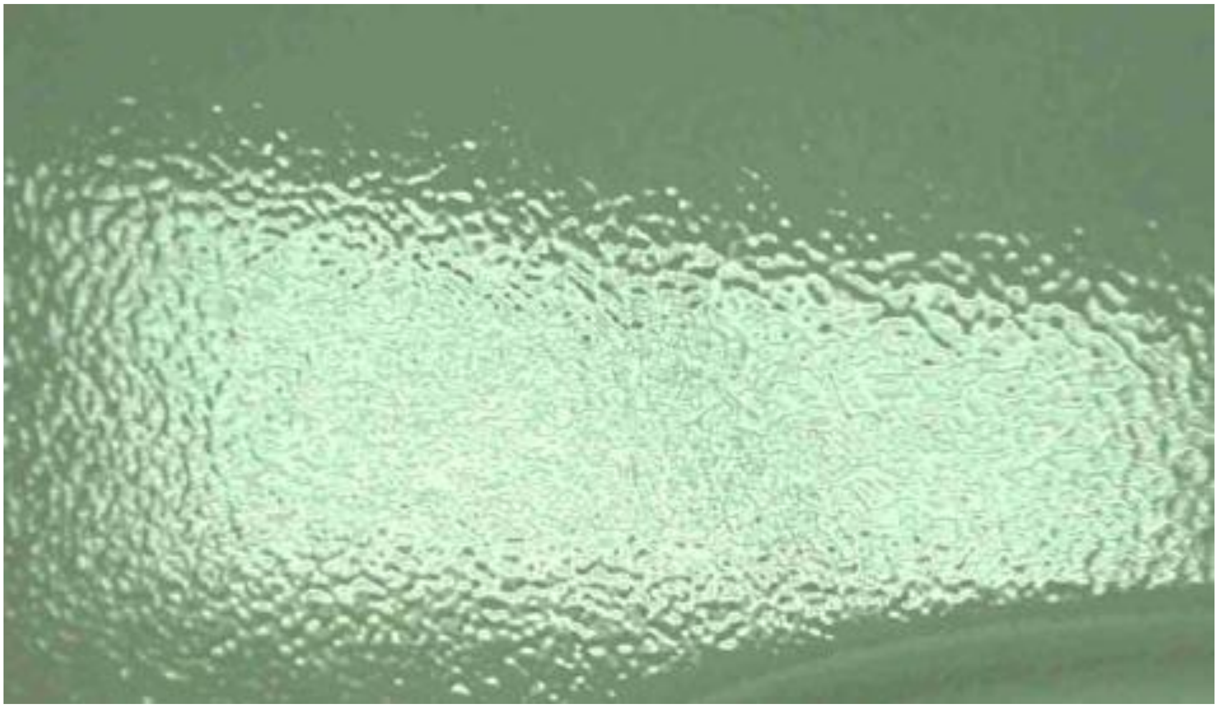
Blushing occurs when the paint finish appears dull, milky and hazy. This effect is usually caused when the wet or drying paint traps moisture. This occurs most often when humidity is at 80% or higher. The reason that blushing forms is because the solvents quickly evaporate from the applied coating, causing the temperature to drop enough to condense the water in the air. Other, causes for the blushing include spraying in temperatures that are below 60°F or above 95°F, using an incorrect thinner that causes the paint to dry too fast and/or excessively high air pressure at the spray gun. Sometimes blushing will be noticed while painting. If this is the case, add retarder or a compatible slow drying solvent to the paint mixture, and then repaint the area. If the paint is dry by the time the blushing is found, sand and repaint.

14.3 Sags, Runs and Drips

Sags, runs and drips are more often than not a function of applying too much paint to the substrate. This happens when the spray gun is held too close to the substrate or if the gun is moved across the surface too slowly. If the paint is not reduced correctly and is too thin the paint can sag and drip easily. Also, if the fluid volume setting on the gun is too high or the air supply is too low an excess of material can be applied to the substrate. Air to paint mixture settings on the gun can also cause spitting, which is when the paint is not being properly atomized into a spray or cloud. Read and follow the technical data sheet thoroughly and utilize the spray techniques which will be discussed in chapter 14 of this manual.

14.4 Orange Peel

Orange peel is when the painted surface appears bumpy much like the skin of an orange. The orange peel affect is the product of excessive surface tension or from the product drying too quickly and not being allowed the proper amount of time to flow out properly which can be cause by a number of different scenarios the first of which is not making the proper fluid to air adjustments on the spray gun. Not using enough reducer to thin the product may result in thicker coats that will develop orange peel. If material is not mixed thoroughly and uniformly the material may be compromised as it is being applied. Force dying a coating too soon after it is sprayed or force drying a coating too quickly can prevent the product from fully flowing out to create a smooth surface. Too little flash time between coats can also cause orange peel. Please refer to the technical data sheet for the material and read through the instructions with respect to recoat times. Finally, if the ambient or substrate temperature is too hot or too cold it can cause orange peel. If the orange peel is very light than it can be wet sanded and buff out the imperfect finish, paying attention to the technical data sheet. If the orange peel is heavy, sand the area smooth and repaint.



14.5 Solvent Pop and Pinholes

Pinholes or "solvent pop" visibly appears on the surface of finished paint due to trapped moisture or solvents. When the very top layer of paint dries quickly while underneath the paint stays wet or "skins over", moisture or solvents are trapped and form pockets that pop open when the fumes finally escape, creating pinholes or solvent pop. This effect can be caused by excessively hot temperatures or high winds that causes the surface of the paint to dry too fast. Contaminants in the paint or airlines can also contribute to the problem. Poor spraying techniques that allow excessively heavy or wet paint coats, which tend to trap moisture or solvents underneath the finish can also cause the problem. Lastly, using the wrong thinner or reducer, either too fast by quickly drying the surface and trapping solvents or too slow and trapping solvents in subsequent topcoats. If this issue is encountered, first identify what went wrong. Check the equipment to ensure that it is clean, evaluate the environment and double check the materials against the technical data sheet. Once the problem is identified and corrected, sand the area or areas smooth and repaint.

14.6 Fisheyes

Fish eyes appear in wet paint or paint that is being applied as small pin holes where the substrate or underlying surface can be seen. Most likely this has occurred because the surface being painted has not been prepared correctly. The only other reason would be because the lines are contaminated with water and/or oils. If this is found while spraying, immediately stop spraying. As stated earlier it is most likely due to surface contamination, usually the residue of cleaners, silicones, waxes or various oils have not been properly removed. Clean off all of the wet paint. Then, thoroughly clean the surface to remove all traces of silicone with a silicone wax or lubricant cleaner.

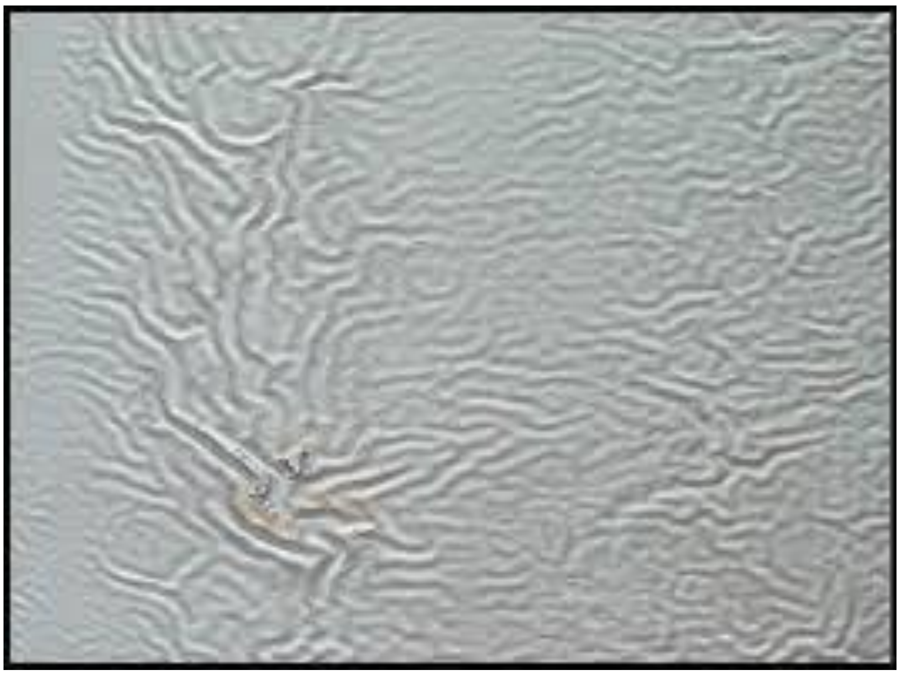
The only way to truly prevent fisheyes from ever occurring is to ensure that the surface to be painted is entirely free of ANY type of contamination as well as the equipment. The “water break test” is a very effective way to check for contaminants. Grab a hose and gently rinse or spray the surface to be painted. If areas where the water beads can be identified, instead of runs, then that surface is not clean. An unbroken film of water should flow down the substrate.

14.7 Sanding Scratches

If scratches or sharp lines are identified in the finish coat, then that is a good indication that the surfaces to be painted were not properly prepared prior to application. This particular issue is not indicative of metal surfaces. Rather, it most commonly occurs on non-metal surfaces such as composite, wood and plastic. In rare cases, scratches in the finish will be seen when an overly rapid or quick drying thinner is used. Sand and repaint until a smooth finish is achieved.

14.8 Wrinkling

Wrinkling is caused by unequal drying of the finish or trapped solvents from thick or heavy paint coats. Paint shrinks as it dries. If the surface dries faster than the wet paint below it, it causes the surface to glide over the wet paint into a wrinkle pattern. If fast evaporating solvents are present in the paint they can also cause wrinkling if the sprayed coat is not allowed to dry thoroughly. When thick coats or quick drying solvents are employed the top surface of the coating tends to dry before the coating is "dry through" trapping solvents underneath. If another coat is applied before the previous coat is dry, wrinkles may result. Furthermore, if a heavy coat is applied before the prior coat is dry enough the coating underneath may be lifted, with the same effect as a paint stripper. Rapid temperature changes in the surrounding environment, while applying the material, may result in the uneven release of solvents from the coating. This will cause the surface of the paint to dry unevenly, shrink and wrinkle. Making the error of using incompatible thinners or reducers can cause wrinkles among other problems as well. If the paint wrinkles, completely remove the paint either by sanding or stripping.



14.9 Dry Spray

Dry spray is a product of atomized spray particles from the paint gun flashing off or drying before being transferred to the substrate. Dry particles will not flow out, therefore leaving a dust-like material on the substrate. This effect is usually caused by too much air and not enough fluid volume flowing through the spray gun. The first step to be taken when dry spray is found, is to dial down the air pressure into the gun and adjust the spray pattern down. If that does not change the dry spray, then increase the fluid volume. Next should evaluate how far the gun is being held from the substrate, 8 to 10 inches is the preferred distance. Finally, if there's still an issue with dry spray, verify that the correct reducer is used. Fast evaporating reducers can easily cause dry spray.