The ABC's of Spray Equipment

A Working Guide to the Selection and Use of Spray Finishing Equipment

1. Introduction

While this book examines the spray finishing operation and its equipment from many viewpoints, there is still much more to be learned to become truly proficient at spray finishing.

The best way to become proficient at spray finishing is to just do it! Many Technical Colleges and Colleges of Further Education have courses involving spray finishing, a great way to improve your skills. We have our own Training facilities at Milperra and regularly conduct training courses there.

The "art" of the professional spray finisher involves an in-depth knowledge of the paints and coatings in use. The manufacturers publish comprehensive sales and technical literature on their products. These publications are available from the material distributors and the manufacturers themselves, and will provide you with considerable detail. Many of these publications also contain information on techniques for surface preparation and applications.

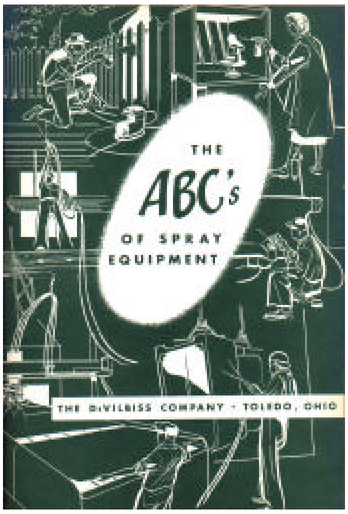
Another important source of information, particularly on equipment use and selection is your local DeVilbiss spray finishing equipment distributor. No book could ever completely cover a specialist's in-depth knowledge of equipment, techniques, maintenance and troubleshooting.

Information is available from many resources on the subject of spray finishing. It is our hope that this book will provide you with a start toward perfecting your finishing skills.

A recent addition to resources available to the spray finisher is the World Wide Web. Many manufactures are represented and question and answer forums are available. Please visit our website at **http//www.itwfinishing.com.au**

2. About this book

This book has been totally updated from "The ABC's of Spray Equipment," originally published by The DeVilbiss Company in 1954. It focuses on equipment and techniques for spray finishing.



The format of the original book was question-and-answer. We have retained that format in this edition.

This book has now been significantly revised to take into account the most recent product developments and to reflect the equipment range available in our market. It is organised around the major components of a spray shop - compressors, air control equipment, hose, respirators, spray guns, material containers, pumps and spray booths. The various gun types – Conventional, HVLP and Compliant, are all covered. A thorough understanding of the material in this book - plus a lot of actual spray painting practice -should enable you to handle most spray painting situations.

Although we have made an effort to make this book as detailed and as complete as possible, be aware that the equipment and product systems used to illustrate points are normally based on DeVilbiss technology. This manufacturer forms part of the the Worlds largest supplier of spray equipment as part of the ITW Finishing Systems Group and has the equipment and knowledge available to meet every spray finishing requirement.

3. Table of Contents

4. Surface Preparation

Without going into detail about the specialist chemical preparation and treatment of certain substrate types, it should go without saying that the surface to be coated must be in a suitable condition ready to accept the sprayed material. This will normally require the absence of all loose particles, dust and scale.

In the most common cases this will involve the 'dusting down' of the surface with a compressed air gun. More stubborn contamination may need the use of a bristle or wire brush while the worst situation may need the application of acid etching or particle blasting.

Dust or loose particle contamination will block the sprayed material from keying and adhering to the surface, producing peeling and a displeasing visual appearance. Likewise, any liquid or chemical contamination could also produce the same poor results (plus a few more).

In many production spray shops the preparation sequence will be:

1) lightly abrade surface to aid adhesion of sprayed coating and remove surface contamination
2) thoroughly blow down with compressed air gun to remove loose dust and particulate contamination
3) Wipe with solvent dampened, lint free cloth to loosen and remove liquid contamination
4) Allow to fully dry before coating

Remember that moisture and water will also act as a block and contaminant and therefore compressed air filters and separators should be checked and drained regularly to prevent contamination being sprayed onto the surface with the coating.

Plastic parts may present additional problems, namely mould release agent and static. Mould release agent will normally be removed by a single or multiple solvent wipe. In the worst case a high pressure detergent wash may be necessary. Due to the charging properties of most plastic materials the act of wiping or blowing the surface will generate static electricity that will attract particles of dust and dirt. Therefore use of an anti-static cleaning liquid and/or de-ionising air gun will be necessary.

If in any doubt about the correct preparation prior to spraying, consult the Product Data Sheet or contact the coatings manufacturers Technical Support Department.

"The topcoat is only as good its substrate" - no amount of primer or paint will cover up a badly prepared surface.

5. Paint Preparation

Today's finishes are extremely complex chemical formulations. They include both solvent and waterborne types as well as more specialised formulations for special applications. Some only require the addition of solvents to give the proper spraying viscosity while others require the addition of a second component at a prescribed ratio to obtain sprayable consistency. Many modern coatings have hardeners or other chemicals, added to them to insure correct colour match, gloss, hardness, drying time or other characteristics necessary to produce a first class finish. Make sure you are familiar with the specific Product Data Sheets accompanying each material. Do not mix materials from various manufacturers. Read and follow directions carefully.

All finish materials must also be supplied with a Material Safety Data Sheet (MSDS). This data provides information on proper handling and disposal of materials. Health and Safety laws require that MSDS be kept on file by the user for immediate reference when necessary.

Always follow the manufacturer's instructions for preparing the coating exactly. If you have any doubts about how to proceed, don't guess! Contact the supplier for help. Improperly prepared coating will never produce a good result.

The chief characteristic that determines the sprayablility of paint and how much film may be applied is its viscosity or consistency. For professional results with most general purpose coatings, use a viscosity cup. It is a simple but very accurate way to measure the thickness of paint. With the cup, you can thin or reduce the paint to the precise consistency required by the manufacturer.

Always prepare paint in a clean, dust-free environment. Paint has a remarkable ability to pick up dirt. Use clean containers to mix the paint in and always filter the liquid while pouring it into the gun, pump or tank. Dirty paint will not only clog your spray gun, but it will also ruin your paint job. Paint is never as clean as it looks.

6. Health and Safety

The spray shop is a dangerous place. Every day we work with lung clogging dusts, poisonous and carcinogenic chemicals, highly flammable liquids and high pressure fluids and gasses. In order to maintain our health it is essential that correct procedures are followed and that the correct protective clothing and equipment is used.

A strong pair of work boots and good overalls are the basic equipment to which the appropriate extras need to be added -

Lint free, disposable paper overalls that can be thrown away if they become heavily soiled with paint

Gloves, nitrile or latex to avoid solvent and paint coming into contact with the hands

A suitable mask for the paint type being sprayed or the sanding operation being carried out.

Safety glasses or Goggles to protect you eyes from chemical splashes and flying debris

Ear plugs or defenders to prevent damage to your hearing by loud or continuous noise.

Don't forget that other operations in the wokshop can carry just as much hazard – masks, gloves and goggles are not only necessary for spraying and flatting.

It should go without saying that eating and drinking in an area full of chemicals and dusts is not advised and smoking should never take place in any area containing flammable liquids such as paint and solvents.

Disposal of waste paints and soiled cloths is now a specialised process that needs planning and monitoring.

Consult your local area authority for details on the exact safety requirements for your process and paint shop.

7. Air Compressors

Introduction

All air tools, spray guns, sanders, etc, must be supplied with air which is elevated to higher pressures and delivered in sufficient volume. The air compressor compresses air for use in this equipment and is a major component of a spray painting system. This chapter will examine the various types available.

Compressed air is measured on the basis of volume supplied per unit of time (cubic feet per minute or cfm) at a given pressure per square inch or psi), referred to as delivery. This is the actual air output of the compressor after its efficiency is taken into account. Displacement is the output of air by a compressor at zero pressure, or Free Air Delivery. This is the theoretical air output of the compressor before its efficiency is taken into account.

1. What is an air compressor?

An air compressor is a machine designed to raise the pressure of air from normal atmospheric pressure to some higher pressure, as measured in pounds per square inch (psi). While normal atmospheric pressure is about 14.7 pounds per square inch, standard compressors will typically deliver air at pressures up to 150 psi.

> **Rule of thumb**
> The cubic feet per minute delivered by an electrically powered 2 stage piston industrial air compressor is approximately 3 to 4 times the motor's horsepower rating. (CFM = 3 to 4 xHP)

2. What types of compressors are most common in spray finishing operations?

There are two common types; the piston-type design and the rotary screw design.

Most commercial spray finishing operations consume large quantities of compressed air at relatively high pressures. the piston type compressor has traditionally been the more commonly used due to its robustness, simplicity and lower cost. However, the rotary screw is increasing in popularity with its quiet operation and high efficiency.

3. How does a piston-type compressor work?

This design elevates air pressure through the action of a reciprocating piston. As the piston moves down, air is drawn in through an intake valve. As the piston travels upward, that air is compressed. Then, the now-compressed air is discharged through an exhaust valve into the air tank or regulator.

Piston type compressors are available with single or multiple cylinders in one or two-stage models, depending on the volume and pressure required.

Figure 1 - Piston Type Air Compressor

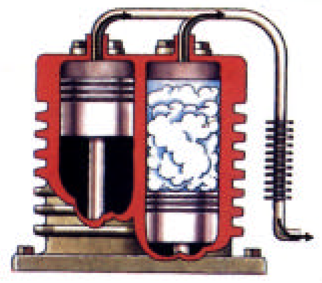


Figure 2 - Sectioned Single stage compressor

4. How does a rotary screw compressor work?

Rotary screw compressors utilise two intermeshing helical rotors in a twin bore case. Air is compressed between one convex and one concave rotor. Trapped volume of air is decreased and the pressure is increased.

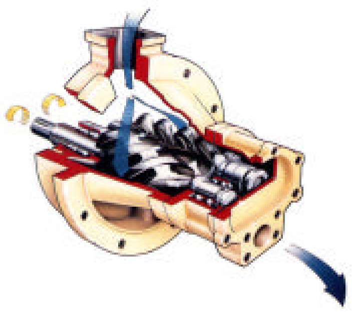


Figure 3. - Rotary Screw Air Compressor

Figure 4. - Sectioned Rotary Screw Air Compressor

5. What is a single stage compressor?

This is a piston-type compressor with one or more cylinders, in which air is drawn from the atmosphere and compressed to its final pressure with a single stroke.

All pistons are the same size, and they can produce typically up to 125 psi.

6. Where are single stage compressors used?

The application of this compressor is usually limited to a maximum pressure of 125 psi. It can be used above 125 psi, but above this pressure, two stage compressors are more efficient.

7. What is a two-stage compressor?

A compressor with two or more cylinders of unequal size in which air is compressed in two separate steps.

The first (the largest) cylinder compresses the air to an intermediate pressure. It then exhausts it into a connecting tube called an intercooler.

From there, the intermediate pressurised air enters the smaller cylinder, is compressed even more and is delivered to a storage tank or to the main air line.

Two-stage compressors can deliver air to over 175 psi.

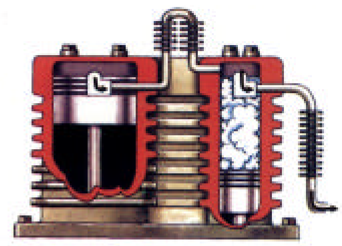


Figure 5. - Sectioned 2 Stage Compressor

They are normally found in operations requiring compressed air of 125 psi or greater.

8. What are the benefits of two-stage compressors?

Two-stage compressors are usually more efficient. They run cooler and deliver more air for the power consumed, particularly in the over 100 psi pressure range.

8. Air Control Equipment

Introduction

The control of volume, pressure and cleanliness of the air entering a spray gun are of critical importance to the performance of the system.

Following some key installation principles will help decrease the risk of contaminants. For example, it's important to use the right size air compressor for your application. An overworked air compressor can produce a significant amount of dirt and oil. Additionally, proper piping layout is very important to help prevent condensation from forming within the line and contaminating the air supply.

This chapter examines the various types of equipment available to perform these control functions.

1. What is air control equipment?

Any piece of equipment installed between the air source and the point of use that modifies the nature of the air.

This modification could be a change in pressure, in volume, in cleanliness, or some combination of them.

2. Why is air control equipment necessary?

Raw air, piped directly from an air source to a spray gun, is of little use in spray finishing. Raw air contains small, but harmful, quantities of water, oil, dirt and other contaminants that will alter the quality of the sprayed finish. Raw air will likely vary in pressure and volume during the duration of the spraying operation.

There will probably be a need for multiple compressed air outlets to run various pieces of equipment.

Any device, installed in the airline

which performs one or more of these functions, is considered to be air control equipment.

3. What are the types of air control equipment?

Air control equipment comes in a wide variety of types, but it basically all performs one or more of the following functions; air filtering and cleaning, air pressure regulation and measuring of pressure and air distribution through multiple outlets.

Some typical devices to perform these functions are called air transformers, air regulators, air filters, air coalescers, air dryers and in some circumstances, air lubricators. All of these types will be covered below.

4. How does an air filter work?

It filters out water, oil, dust and dirt before they get on your paint job. Air entering the filter is swirled to remove moisture and other contaminants that collect in the baffled quiet zone at the base of the filter.

Smaller impurities are filtered out by a filter. Accumulated liquid is carried away through either a manual or automatic drain.

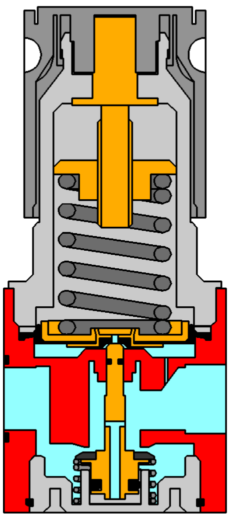


Figure 6.- Sectioned Air Regulator

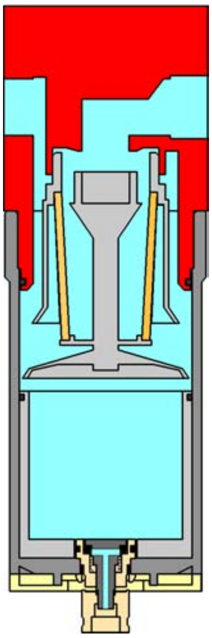


Figure 7. - Air Filter

5. What is an air regulator?

This is a device for reducing the main line air pressure as it comes from the compressor. Once set, it maintains the required air pressure with minimum fluctuations.
Regulators should be used in lines already equipped with an air filtration device.

Air regulators are available in a wide range of cfm and psi capacities, with and without pressure gauges and in different degrees of sensitivity and accuracy.

6. What is an air transformer?

This is another name for a combined filter/regulator unit.

7. How is an air filter/regulator installed?

The unit needs to be securely fixed to the wall near to the operators position. Do not put it in direct line of the spray guns spraying or it will rapidly become contaminated in paint and overspray. This location makes it convenient to read the gauges and operate the valves.

It is recommended on smaller systems to install the unit at least 25 ft from the compressor to aid elimination of pulsation from the compressor and to allow the air to cool before use.

Figure 8. - Filter Regulator

The take-off elbow from the main supply pipe should be installed as shown below to prevent liquid gravity draining into the filter/reg unit.

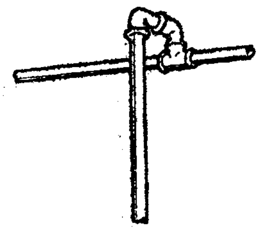


Figure 9. Take-off elbow

The main supply piping should slope back toward the compressor, and a drain leg should be installed at the end of each branch, to drain moisture from the main airline.

The main supply ring main piping should be of sufficient I.D. for the volume of air being passed, and the length of pipe being used. (see figure 10)

As a rule of thumb, the drop leg to the filter/reg unit should be of a minimum of ½” BSP size.

Piping should be as direct as possible. If a large number of fittings are used, larger I.D. pipe should be installed to help overcome excessive pressure drop.

Minimum Pipe Size Recommendations – Main ring main			
Compressor		Main Air Line	
HP	CFM	Length	Size
1½-2	6-9	50' +	¾"
3-5	12-20	< 200'	¾"
		200' +	1"
5-10	20-40	< 100'	¾"
		100'-200'	1"
		200' +	1 ¼"
10-15	40-60	< 100'	1"
		100'-200'	1 ¼"
		200' +	1 ½"

Figure 10. - Pipe Sizes

8. How often should the filter/regulator be drained of accumulated moisture and dirt?

It depends largely on the level of system use, the type of filtration in the air system, and the amount of humidity in the air.

For average use, once-a-day drainage is probably sufficient.

For heavily used systems, or in high humidity, drainage should occur several times daily.

Some units drain automatically when moisture reaches a predetermined level.

9. What steps should be taken if moisture passes through the filter/regulator?

Since moisture in the spray gun atomisation air will ruin a paint job, it must be removed from the air supply.

When the compressed air temperature is above its dew point temperature, water vapour will not condense out into liquid droplets.

Check the following:

a) Drain transformer, air receiver and airline of accumulated moisture.

b) Be sure the transformer is located at least 25 feet from the air source.
c) Main airline should not run adjacent to steam or hot water piping
d) Compressor air intake should not be located near steam outlets or other moisture-producing areas.
e) Air outlet on the air receiver should be near the top of the tank.
f) Check for damaged cylinder head or leaking head gasket, if the air compressor is water-cooled.
g) Intake air should be as cool as possible.

If the problem persists or is excessive then the fitting and use of a compressed air drier should be investigated.

10. What causes excessive pressure drop on the main line gauge of the filter/regulator?

a) The compressor is too small to deliver the required air volume and pressure for all tools in use.
b) The compressor is not functioning properly.
c) There is leakage in the airline or fittings.
d) Valves are only partially opened.
e) The airline, or piping system, is too small for the volume of air required.

11. What is an air Lubricator?

Certain types of air operated equipment such as grinders, hammers, chippers, pumps, etc, require a very small amount of oil mixed in the air supply which powers them. An air line lubricator supplies this small but necessary bit of oil to the system. Lubricators are often combined with air filters and regulators in a single unit.

Figure 11 shows a lubricator unit with a built-in sight glass for determining reserve oil level.

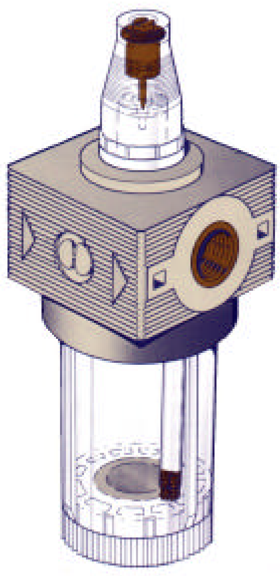


Figure 11. - Lubricator unit

Any oil in spraying air will cause unacceptable contamination and paint defects. Lubricators should only be used for certain compressed air tools and not spray guns.

12. What is a Coalescer?

This is another type of filter. However it is a specialist type that has the capability of removing particles and liquid droplets down to a very small particle size, typically 0.01 micron!

This very fine filtration is particularly required for air that is to be used for breathing. British Standards and legislation require this in the UK

A special filter such as a coalescer is required to be fitted to achieve this extreme filtration.

13. What is an air Restrictor?

This is sometimes called a needle valve. It can be used to control the pressure of flowing air, but cannot control static air supplies.

This type of valve is often fitted into or onto a spray gun handle and is called a 'cheater' valve.

14. What is an Air dryer?

Air filters and Coalescers are

capable of removing water droplets but cannot remove water vapour.

If, due to ambient conditions or expansion of the air as it leaves the air cap, the air drops in temperature water droplets or mist can be created which will adversely affect finish quality.

Therefore the vapour must be removed by a specialised air dryer.

There are two main types of drier, the refrigerated dryer and the absorption drier.

15. How does a Refrigerated Air Dryer work?

In this unit the air temperature is dropped to below its dew temperature and the moisture precipitates out to be collected and drained off.

Figure 12. -Refrigerated drier

16. How does an Absorption Air Dryer work?

In this unit the water vapour is removed by an absorption medium such as silica gel.

In simple units the gel must be replaced when it is saturated, while the more expensive units have a built-in recycling system.

Figure 13. - Absorption Air Drier

17. What is a Whirlwind Filter?

This is a small gun mounted disposable filter that normally screws onto the gun air inlet. It removes dirt and most contamination from the compressed air stream during use but because it is sealed the accumulated liquid cannot be drained away – hence periodic replacement is necessary.

Figure 14.- Whirlwind Air Filter

9. Masks and Respirators

Introduction

Consult with the appropriate safety personnel or equipment supplier if in doubt as to the suitability of a particular respirator before using it. Respirators may not provide protection against eye and skin absorption of chemicals.

Spray finishing creates a certain amount of overspray, hazardous vapours and toxic fumes. This is true, even under ideal conditions. Anyone near a spray finishing operation should use some type of respirator, or breathing apparatus. This chapter covers various types of equipment for this use.

1. What is a respirator?

A respirator is a mask that is worn over the mouth and nose to prevent the inhalation of spray fog, dust, fumes or vapours.

2 Why is a respirator necessary?

For two reasons:

First, some type of respiratory protection is required by Health & Safety regulations.

Second, even if it wasn’t a requirement, common sense tells you that inhaling particles of sprayed material is not healthy.

Spray fog contains toxic particles of paint pigment, harmful dust and, in some cases, vapour fumes which can be harmful to your health.

Depending on design, a respirator can remove some, or all, of these dangerous elements from the air around a spray finishing operator.

Always read the manufacturers data carefully before use to ensure suitability.

3. What types of respirators are used by spray finishing operators?

There are three primary types; the dust respirator, the organic vapour respirator and the air-supplied respirator,

4. What is a dust respirator and where is it used?

Dust respirators are sometimes used in spray finishing but, in <u>all</u> applications, they are unsatisfactory due to their inability to block solvent vapours. (see

Figure 1).

Figure 1. - Dust Respirator

These respirators are equipped with cartridges or filters that remove only solid particles from the air.

In their simplest form they are a pressed formed fibre mask that covers the nose and moth and is held in place by an elasticated strap.

They are effective, however, in abrasive operations such as sanding, grinding and buffing.

5. What is an organic vapour respirator and where is it used?

This type of respirator, which again covers the nose and mouth is equipped with cartridges that remove organic vapours by chemical absorption.

Some are designed with pre-filters to remove solid particles from the air before it passes through the chemical cartridge.

The organic vapour respirator is normally used in finishing operations with standard materials. This type of mask is not suitable for paints containing isocyanates.

Figure 2. - Organic Vapour Respirator

6. What is an air-supplied respirator?

This mask type is connected to an independent air supply such as an air cylinder or the main factory compressed air so that the sprayer is not breathing air from the booth that is contaminated.

Air-supplied respirators for spraying operations use filtered air from a compressor to work.

Two types are available – the full face visor and the half mask.

These type of masks are the only type that are approved for use with isocyanate based materials by Health and Safety Legislation.

7. What is a Full Face visor?

This type of mask fully covers the face and eyes and is pressurised by compressed air to keep hazardous fumes and contamination away from the mouth, nose and eyes.

It is normal for a belt mounted carbon filter to be used to act as a final odour remover before the lungs. This carbon filter needs to be replaced periodically.

Figure 3. - Full face air supplied mask.

8. What is a Half mask?

This is also a supplied air mask. However it only covers the mouth and nose – some people call it a pilots mask.

It also uses a belt mounted carbon pack as a final odour remover.

Goggles must be worn with this type of mask to give protection to the eyes.

Figure 4. - Positive Pressure Half Mask Respirator

9. How much air do supplied air masks use?

The full face visor requires approximately 7-10 cfm while the Half mask, which covers less of the face, uses between 6 and 7 cfm.

10. How clean must breathing air be?

Australian Standard AS/NZS1715/1716 states that the delivered air supply should satisfy the following criteria:

Carbon dioxide: at or below 800ppm (by volume)
Oil mist: at or less than 1.0 mg per cubic metre of air.
Particles size range must be less than 0.2210um
Water: not more than 100mg per cubic metre.
Carbon monoxide: at or below 10 ppm (by volume)
Air temperature should be a comfortable 15-25^{o}C
Oxygen levels to be in the region of 18-21% (by volume)

The air should have no nauseous or objectionable odours or taste.

11. How do I test for breathing air quality?

By using a suitable test kit that will measure the levels of these contaminants.

The compressed air is passed, at a known flow rate, through tubes containing crystals impregnated with certain chemicals. The various 'contaminants' listed in 10 react with the chemicals to produce a colour change allowing the level of contamination to be seen and measured. A different tube is used for each of the four main contaminants.

Figure 5. - Breathsafe Test Kit

NOTE: Before using any respirator, carefully read the manufacturer's Safety Precautions, Warnings and Instructions. Many respirators are not suitable for use with isocyanates, chromates and 2-component paints.

10. Hoses & Connections

Introduction

The various types of hose used to carry compressed air and fluid material to the spray gun are important parts of the system. Improperly selected or maintained hose can create a number of problems. This chapter will review the different kinds of hose and fittings in use, provide guidance in selecting the proper types for the job and cover the maintenance of hose.

1. What types of hose are used in spray painting?

There are two types: air hose (usually red in colour) used to transfer compressed air from the air regulator to the gun, and fluid hose (usually black in colour) used in pressure feed systems to transfer the material from its source to the spray gun.

2. How is each type identified?

Air hose in professional spraying systems is usually coloured red although cheaper hose may be natural black rubber colour.

Fluid hose is traditionally black.

Recent guidelines have recommended that dedicated 'food quality' breathing air hoses be blue although this grade hose is also available in red.

However, be aware that hose colours do vary greatly between different manufacturers. Check on their precise specification before use.

All hoses have their maximum working pressure printed on the cover exterior. Hose part number and size is normally also shown.

NOTE: Air hose is not to be used for solvents or liquids except water.

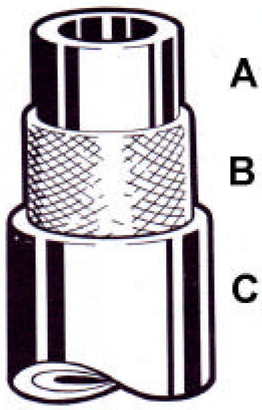


Figure 1. - Basic Hose Construction

3. How is hose constructed?

Air and Fluid hose is a performance designed combination of three main components: Tube (A), Reinforcement (B) and Cover (C).

The tube is the interior flexible artery that carries air or fluid material from one end of the hose to the other.

The reinforcement adds strength to the hose. It is located between the tube and cover, and it can be many combinations of materials and reinforcement design. Its design determines pressure rating, flexibility, kink and stretch resistance and coupling retention in high pressure fluid hose this is normally steel wire mesh.

The cover is the outer skin of the hose. It protects the reinforcement from contact with oils, moisture, solvents and abrasive objects. The cover protects the reinforcement, but does not contribute to hose performance.

4. What type of tube is used in fluid hose?

Since the solvents in coatings would readily attack and destroy ordinary rubber compounds, fluid hose is lined with special solvent-resistant nylon and PTFE materials that are impervious to common solvents.

5. What sizes of fluid hose are recommended?

Type	Length ft	Size in ID
General Purpose	0 – 20	¼"
	10 – 35	⅜"
	35 – 100	½"
	100 – 200	¾"

Figure 2. - Recommended fluid hose sizes

6. What sizes of air hose are recommended?

Hose feeding only a Pressure feed tank may be ¼" ID due to its low air consumption.
The hose from the regulator to a gun should be a minimum of 5/16" ID. Tools requiring more air may need 3/8" I.D. hose or larger.

Type	Length	Size
General Purpose	0’-10’	¼” ID
	10’-20’	5/16” ID
	20’-50’	3/8” ID
	50’-100’	½” ID
HVLP	0-20’	5/16” ID
	20’-50’	3/8” ID
	50’-100’	½” ID

Figure 3. - Recommended air hose sizes

7. What happens if the hose is too small?

The spray gun or tool is "starved" for air or fluid due to excessive pressure drop in the hose. This will result in the equipment being unable to function correctly.

8. What is pressure drop?

This is the loss of pressure due to friction (caused by flow) between the source and the point of use. As the material travels through the hose or pipe, it rubs against the walls. It loses energy and pressure as it goes.

9. How can air pressure drop be determined?

While there are mathematical formula for accurately determining pressure loss these are time consuming and every component of the system has to be individually calculated. Therefore it is easier to use an approximate rule of thumb when requiring this information.
At low volumes, with short lengths of hose, pressure drop is not particularly significant. As the volume per minute flow increases, and hose is lengthened, the pressure rapidly drops and must be adjusted.

All air hose is subject to pressure loss or drop. For example, ¼” pressure drop is approx. 1 psi per foot and 5/16” is approx. ½ psi per foot. This pressure loss may result in poor atomisation being seen at the gun.

Too often, a tool is blamed for malfunctioning, when the real cause is an inadequate supply of compressed air due to an undersized I.D. hose.

For optimum spray gun results, the following is recommended: up to 20 ft - 5/16” I.D., over 20 ft - 3/8” I.D.

	15 cfm	18 cfm	20 cfm	25 cfm
1/4" x 20'	20 psi	26 psi	28 psi	34 psi
5/16" x 20'	7 psi	10 psi	12 psi	20 psi
3/8" x 20'	2.8 psi	4.0 psi	4.8 psi	7.0 psi

Figure 4.- Pressure loss in different hoses

10. Do fluid supply systems suffer from pressure loss as well?

Yes, the numbers are different (higher viscosities than air) but the effects are still seen.

There are no easy ways to determine pressure loss in these hoses.

11. How are hoses maintained?

Hoses will last a long time if they are properly maintained.

Be careful when dragging hose across the floor. It should never be pulled around sharp objects, run over by vehicles, kinked or otherwise abused. Hose that ruptures in the middle of a job can ruin or delay the work but is also highly dangerous.

The outside of both air and fluid hose should be occasionally wiped down with a solvent dampened rag and then immediately wiped dry, never immersed in solvent. At the end of every job, they should be stored by hanging up in coils.

12. What kinds of hose fittings are available?

Permanent, crimp type or reusable fittings are used to connect hoses to air sources or to spray equipment.

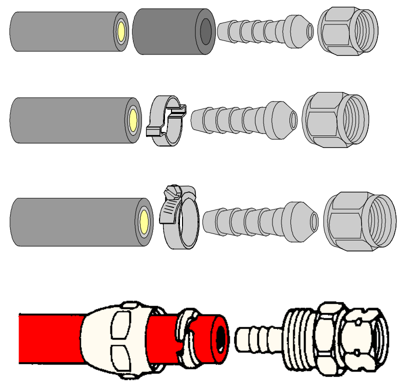


Figure 5. - Hose fittings and connections

13. What kinds of hose connections are available?

Although there are many different styles, the two most common are the threaded and the quick-disconnect types.

Remember that elements added to any hose, such as elbows, connectors, extra lengths of hose, etc., will cause a pressure drop.

On all spray guns, particularly HVLP systems, quick-disconnects must have larger, ported openings (high flow) to deliver proper pressure for atomisation. Because of normal pressure drop in these devices, many are not recommended for use with HVLP.

14. What is a threaded- type connection?

This is a common swivel-fitting type that is tightened with a spanner. (see figure 4).

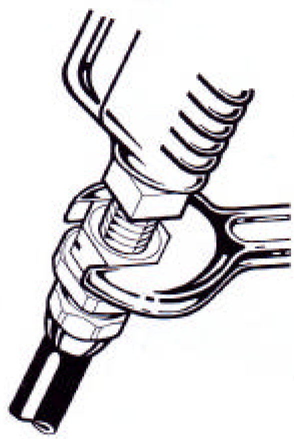


Figure 6. - Threaded-Type Connection

15. What is a quick-disconnect type connection?

This is a spring-loaded, male/ female connection system that readily attaches and detaches by hand. No tools are required (see figure 6).

Figure 7. - Ouick-Disconnect Type Connection

Care should be taken when selecting a quick-disconnect air connection. Due to design, most Q.D. connections result in significant pressure drop. This can adversely effect spray guns with higher consumption air caps such as HVLP.

16. How does High pressure fluid hose differ from the Low pressure variety.

While the basic materials of tube and cover are the same as for low pressure hose, a woven steel mesh is used for reinforcement against the high pressure fluid.

High pressure hoses are made in several different pressure ratings so it important that it is checked before use on your high pressure pump for adequate rating.

The steel mesh also serves as a conductive anti-static line to ground out any electrical charges generated by the friction of the fluid passing along the hose.

17. What hose connections are used on High pressure fluid hose?

Special H.P. crimped fittings are used. These are factory fitted and cannot be remade or reused by the operator.

H.P. fluid hoses are sold in pre-cut lengths with the connectors already fitted and tested.

11. Air Atomising Spray Guns

INTRODUCTION

The spray gun is the key component in a finishing system and is a precision engineered and manufactured instrument. Each gun type and size is specifically designed to perform a certain, defined range of tasks.

As in most other areas of finishing work, having the right tool for the job goes a long way toward getting professional results.

This chapter will help you know which is the proper gun by reviewing the Conventional Air, High Volume/Low Pressure and Compliant spray gun designs commonly used in finishing - Suction feed, Gravity feed and Pressure feed. It will also review the different types of guns and components within each design.

A thorough understanding of the differences between systems will allow you to select the right gun, to use it properly to produce a high quality finish and to contribute toward a profitable finishing operation.

SPRAY GUN TYPES

1. What is an Air Atomising spray gun?

An air atomising spray gun is a tool which uses compressed air to atomise paint, or other sprayable material, and to apply it to a surface.

Air and material enter the gun through separate passages and are mixed at the air cap in a controlled pattern.

2. What are the types of Air Atomising guns?

Air atomising spray guns may be classified in various ways. One way is by the location of the material container:

Figure 1 shows a Suction Feed gun with a cup attached below it.

Figure 3 shows a Gravity Feed gun with a cup attached above it.

Figure 4 shows a Pressure Feed gun that is fed from a pressurised paint source such as a tank or pump.

Guns may also be classified as either external or internal mix depending upon the type of air cap.

3. What is a Suction Feed gun?

A spray gun design in which a stream of compressed air creates a low pressure area at the air cap, providing a siphoning action. Atmospheric pressure on the material in the suction cup forces it up the suction tube, into the gun and out the fluid tip, where it is atomised by the air cap. The vent holes in the cup lid must be open. This type gun is usually limited to a 1 Litre, or smaller, capacity container and low to medium viscosity materials

Figure 1.- Suction Feed Gun with attached cup

A Suction feed Conventional Gun is easily identified by the fluid tip extending slightly beyond the face of the air cap, see figure 2.

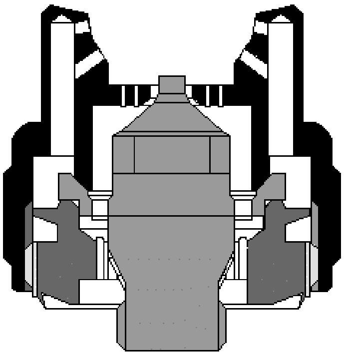


Figure 2. - Suction Feed Air Cap

Suction feed guns are suited to many colour changes and to small amounts of material, such as in touch-up or lower production operations.

4. What is a gravity feed gun?

This design uses gravity to flow the material from the cup, which is mounted above the gun, into the gun for spraying. No fluid pickup tube is used, since the fluid outlet is at the bottom of the cup.

This cup has a vent hole at the top of the cup that must remain open. The cup is normally limited to approximately 600 cc capacity due to weight and balance.

Gravity feed guns are ideal for small applications such as spot repair, detail finishing or for finishing in a limited space. They can utilise smaller quantities of material and feed more viscous liquids than suction guns.

Figure 3. - Gravity Feed Gun with attached cup

5. What is a Pressure feed gun?

In this design, the conventional gun fluid tip is flush with the face of the air cap (see Figure 5). The material is pressurised in a separate cup, tank or pump. The pressure forces the material through the fluid tip and to the air cap for atomisation.

Figure 4. - Pressure Feed Gun for use with remote pressure pot or pump

This system is normally used when large quantities of material are to be applied, when the material is too heavy to be siphoned from a container or when fast application is required. Production spraying in a manufacturing plant is a typical use of a pressure feed system

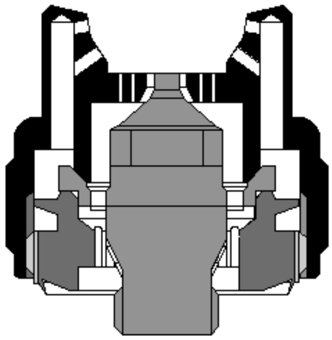


Figure 5. - Pressure Feed Air Cap

Fluid Feed Type	Viscosity Din 4 sec	Fluid Flow cc/min	Air Cap psi
Suction	< 25	< 300	20-50
Gravity	< 40	< 350	20-50
Press.	< 60	< 800	20-70

Figure 6. - Typical fluid flows

Sprayers Tip:
When switching from a suction feed gun to a gravity, downsize the fluid tip one size. If the suction system calls for a 1.8mm (0.070"), use a 1.4mm (0.055") or 1.8mm (0.063")

6. What is a Bleeder type Gun?

A bleeder type spray gun is designed without an air valve. Air passes through the gun at all times, the trigger only controls the flow of fluid. It is usually used with small compressors of limited capacity and pressure which have no pressure-controlling device. It is also used in some HVLP systems to allow the hot air generated by the turbine to escape. This prevents heat build-up that would lead to bearing failure.

This type of gun is normally found with small Diaphragm type compressors and turbine HVLP units sold for the DIY markets.

7. What is a Non-bleeder type Gun?

This type of gun is equipped with an air valve to shut off the flow of air when the trigger is released; the trigger controls both air and fluid flow. It is used with compressors having some type of pressure control device, and is the more common type of gun

8. What is an external mix air cap set-up?

This air cap and fluid tip combination mixes and atomises air and fluid outside the air cap. It can be used for almost all types of materials, and it is the most common type of set-up fitted to air atomising guns. This type gives particularly good atomisation and is used when a high quality finish is desired.

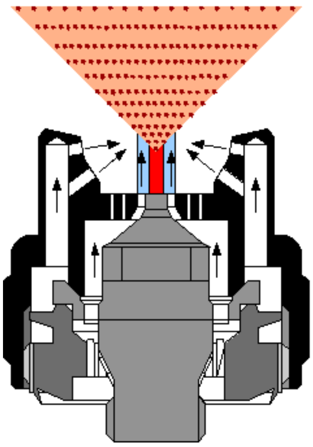


Figure 7. - External Mix set-up

9. What is an internal mix cap?

This cap mixes air and material inside the air cap, before expelling them.

It is normally used where low air pressures and volumes are available or specialist mastic or decorative coatings are being sprayed.

Typical examples are spraying emulsions or multi-fleck paints onto walls, or external house coatings, with a small compressor.

Figure 8. - Gun fitted with internal mix cap

Internal mix caps are rarely used for finishing with factory compressed air systems, or when a high quality finish is required.

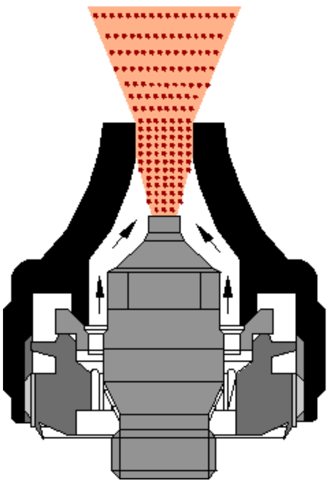


Figure 9. - Internal Mix Air cap

10. What is an Airbrush?

This is a very small, lightweight spray gun used for painting very fine detail. It normally has a maximum paint capacity of 15 to 30 cc and the pattern is adjustable up to about the size of a 5p piece. It is mainly used for technical Illustrations and artwork, although industrial applications include adhesive application and the decoration of ceramics.

Figure 10. - Airbrush

11. What is Transfer Efficiency?

This is a measure of how much paint sprayed by the gun actually reaches and lands on the surface being coated. To accurately measure this efficiency requires specialised equipment in a laboratory and so the test cannot be easily carried out in a customers spray shop. The test method usually ignores the quantity of VOC (Volatile Organic Compound) in the coating and is based upon its Solids Content. This is because a large percentage of the VOC will evaporate between the gun and object and otherwise give misleading results.

12. What is a Conventional Air Atomising Gun?

This is the standard type of gun that has been available for many years. It uses high velocity air jets to break up the paint. A high quality atomisation and finish normally results. However, the high air speed also results in a high bounce-back and a relatively low transfer efficiency.

The DeVilbiss JGA and GFG guns are of this type.

Figure 11. – Conventional Air Atomising Guns

13. What is an HVLP Gun?

HVLP, or High-Volume Low Pressure, uses a high volume of air delivered at low pressure to atomise paint into a low-velocity pattern of particles. By definition, HVLP equipment has an atomisation pressure of 10 psi (0.7 bar) or less.

This type of gun is required to be used in many market sectors by the 1990 UK Environmental Protection Act. Other similar legislation has driven the introduction of such equipment in other countries.

As a result of the low velocity, less material is lost in bounceback than with conventional equipment and there is a higher Transfer Efficiency from gun to object.

Air cap design is similar to that of a standard spray gun, with a variety of air jets directing the atomising air into the fluid stream, atomising it as it leaves the tip.

HVLP is growing in popularity and can be used with a wide variety of paints and coatings.

14. What is a Turbine HVLP spray gun?

In this equipment, the air supply comes from an electrically powered air turbine. This generates the high volumes of air (30-40 cfm) at low pressure (3-5 psi).

The gun is of a fairly simple construction and does not have an air valve. The turbine generates hot air that must be bled off or damage could occur to the turbine.

Figure 12. - Turbine HVLP equipment

While highly efficient, this type of equipment does not usually give a fine atomisation and therefore is not suitable for most high production, high quality work.

This type of equipment was the original HVLP system. It is still widely used, particularly in the decorative contractor market, where low bounce-back in enclosed rooms is necessary and the emulsions and textured coatings used do not require fine atomisation.

15. What is a Venturi HVLP spray gun

As an alternative to Turbine guns these were introduced, powered by standard factory compressed air systems.

In this gun type a high air input pressure at the handle passes through a venturi which sucks in additional volume of air through a filter mounted at the handle base.

Figure 13. - Venturi HVLP gun

Again, air cap pressure was only relatively low at 5-6 psi while the boosted volume is typically between 20-30 cfm.

16. What are 'hybrid' HVLP guns?

Turbine and Venturi HVLP equipment do not have the power of atomisation and quality of finish required by many spray finishers.

Therefore development was accelerated by DeVilbiss in 1990, and HVLP guns that were a hybrid with conventional guns were conceived.

The full 10 psi potential at the air cap was now used to achieve superior atomisation and finishes.

Figure 14. - JGHV 'hybrid' HVLP Suction Gun

The guns are visually much more like conventional guns with air caps and handle input pressures of between 20 and 50 psi.

Better atomisation and finish quality was now available, allowing the equipment to be widely sold and used in the spray finishing industry.

17. What is a Compliant Gun?

This type is another option to HVLP guns in some Environmental Legislation. The requirement to atomise at 10 psi or less is replaced by the need to have a minimum of 65% Transfer Efficiency. It is felt that this gives even better atomisation potential while still reducing emissions and material use.

Figure 15. - GTI Compliant guns

This type of gun is the current top of the range gun available from DeVilbiss.

18. How do I recognise a Suction feed Compliant or HVLP gun?

On DeVilbiss UK guns the suction fluid tip has an external profile similar to that of a conventional gun. However in addition
a) the part number stamped on the outer rim of the tip will start with the code letters JGHV or GTI and
b) when the appropriate air cap is in place the tip will protrude in front of the cap.

Figure 16. - Suction HVLP and Compliant fluid tip

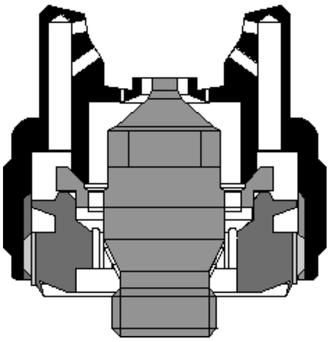


Figure 17. - Suction HVLP and Compliant set-up

19. How do I recognise a Pressure feed Compliant or HVLP gun?

On DeVilbiss UK guns the pressure fluid tip has a unique ‘ski-ramp’ profile unlike any other tip style. In addition
a) the part number stamped on the outer rim of the tip will start with the code letters JGHV or GTI and
b) when the appropriate air cap is in place the tip will protrude in front of the cap.

Figure 18. - Pressure HVLP and Compliant fluid tip

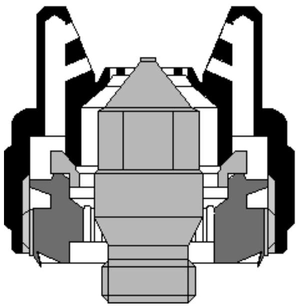


Figure 19. - Pressure HVLP and Compliant set-up

> ***Sprayers Tip:***
> *Don’t forget that a suction air cap, fluid tip and needle can be used on a pressure feed fluid system as well as a suction/gravity one. However a pressure set-up cannot be used visa versa.*

20. What is an Automatic Spray gun?

This gun is designed for use on automatic machinery and robotic spraying installations.

It has no handle or external trigger because it needs to be controlled by remote operation via control panels and/or solenoid valves.

The fluid tips and air caps are exactly the same items as used on manual guns and, if set up correctly, will give exactly the same performance.

Automatic guns are available in Conventional, HVLP and Compliant types.

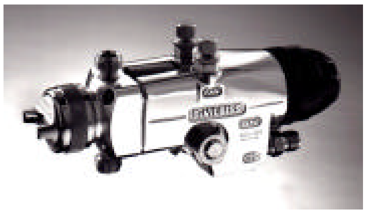


Figure 20. - Automatic Spray gun

PART IDENTIFICATION & FUNCTION

21. What are the principal parts of a spray gun?

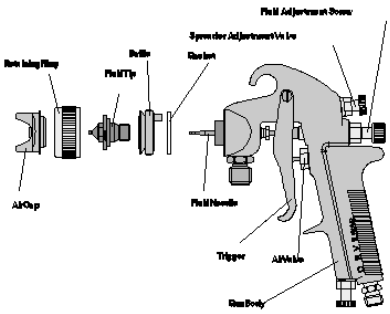


Figure 21. - Spray Gun Anatomy

22. What happens when the trigger is pulled?

The trigger operates in two stages - Initial trigger movement opens the air valve, allowing air to flow through the gun.

Further movement of the trigger pulls the fluid needle from its seat at the fluid tip, allowing fluid material to flow. When the trigger is released, the fluid flow stops before the airflow.

This lead/lag time in the trigger operation assures atomisation air when the fluid flow starts. It also assures atomisation until the fluid flow stops, so there is no spitting of unatomised fluid.

23. What is the function of the air cap?

The air cap (see figure 23) directs compressed air into the fluid stream to atomise it and form the spray pattern. (see Figure 27)

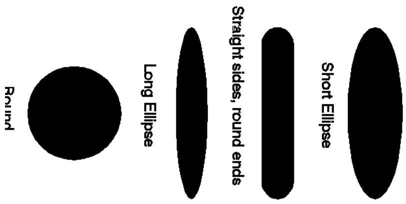


Figure 22. - Types of Spray Patterns

There are various styles of caps to produce different sizes and shapes of patterns for many applications.

24. What are the advantages of the external mix air cap?

This cap design provides better atomisation of more viscous materials and is the standard type of cap used on air atomisation guns.
It allows higher atomisation pressures to be used on more viscous materials and provides greater uniformity and control of pattern shape.

It also provides better atomisation for materials that can be sprayed with lower pressures.

Figure 23. - External Mix Air Cap

25. How should an air cap be selected?

The following factors must be considered:

a) volume and pressure of air available at the handle of the gun.
b) material feed system used (pressure, suction or gravity)
c) material type, viscosity and volume of material to be sprayed
d) shape of pattern required (see figure 22)
e) size of fluid tip to be used (most air caps work best with certain fluid tip/needle combinations)
f) size and nature of object, or surface to be sprayed.

Remember - multiple, or larger, orifices increase the ability to atomise more material for faster painting of large objects but also increase the air consumption of the air cap.

See the DeVilbiss spray gun literature for information on cap air consumption and suggested applications.

26. What is the function of the fluid tip and needle?

They restrict and direct the flow of material from the gun into the air stream. The fluid tip includes an internal seat for the tapered fluid needle, which reduces the flow of material as it closes. (see Figure 26).

The amount of material that leaves the front of the gun depends upon the viscosity of the material, the material fluid pressure and the size of the fluid tip opening provided when the needle is unseated from the tip.

Fluid tips are available in a variety of sizes to properly handle materials of various types, flow rates and viscosity.

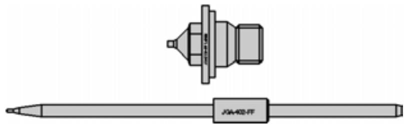


Figure 24. - The Fluid Tip and Needle

27. What is the air cap & tip combination?

In practice, the air cap, fluid tip and needle are selected as a set, since they all work together to produce the quality of the spray pattern and finish. These three items, as a unit, are referred to as the nozzle combination, the gun set-up or air cap and tip combination.

Figure 25. - Cap tip & needle set-up

28. Why do some fluid needles have different end profiles?

This is for two reasons
a) as the hole in the fluid tip becomes smaller the needle end profile has to still sit on and seal against the tip internal profile so the end angle also becomes less, and
b) fluid needles that are normally matched with tips used for pressure feed applications have a short parallel section on their end to push out and paint residue from the tip internal profile when the gun trigger is released. For this reason they are called 'Cleaner-tip' profiles.

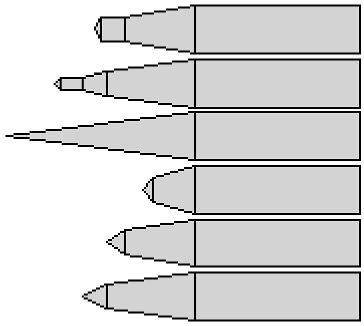


Figure 26. - Different Fluid Needle Profiles

29. What are typical fluid tip sizes and flow rates?

The typical sizes, corresponding fluid tip opening dimensions and flow rates are shown below in the tables. Note that only a small part of the tip range available is shown.

DeVilbiss Fluid Tip Size Code	Orifice Size	Typical Flow Rate
Pressure Feed System		
G	0.7 mm	< 100 cc/min
FX	1.1 mm	< 200 cc/min
FZ	1.2 mm	< 300 cc/min
FF	1.4 mm	< 400 cc/min
FW	1.6 mm	< 500 cc/min
EX	1.8 mm	< 600 cc/min
Suction Feed System		
FF	1.4 mm	< 200 cc/min
FW	1.6 mm	< 250 cc/min
EX	1.8 mm	< 300 cc/min
Gravity Feed System		
FF	1.4 mm	< 250 cc/min
FW	1.6 mm	< 300 cc/min
EX	1.8 mm	< 350 cc/min

Figure 27. Typical Fluid Flows

Sprayers Tip
HVLP and Compliant type Suction and Gravity guns generally generate less venturi effect than their conventional counterparts and therefore give lower fluid flow rates. Therefore it is usual to increase the fluid tip size by one or two sizes. However, remember that HVLP and Compliant guns have a greater transfer Efficiency than conventional guns and therefore a slightly lower fluid flow is not necessarily a problem.

30. How are fluid tip and needle sizes identified?

DeVilbiss fluid tips and needles have traditionally been identified by code letters stamped on the tip and the needle. This is still true for the conventional JGA/GFG guns and the JGHV/GFHV series. In addition the size in millimetres and 1000's of an inch is marked. However on all new guns introduced since 1998 we have dropped the code letter designation in favour of the hole size – it makes it easier to identify.

Different ranges of tips are available for different gun types, check the appropriate literature for the exact range available for your gun.

31. What fluid tip and needle combination sizes are most common?

E, EX, FW, FF and FX are the most commonly used tip & needle combinations.

The EX 1.8mm and FW 1.6mm combinations are used for suction feed.

The EX 1.8mm and FF 1.4mm are used for gravity Feed.

For pressure feed the most common tips are FX 1.1mm, FF 1.4mm and E 1.8mm.

32. How are air cap, fluid tip and needle combinations selected?

Five basic considerations are involved in selecting the cap, tip and needle combination:

(1) The type and model of the gun (different guns = different range available
(2) Available air supply
(3) The type and viscosity of the material being sprayed.
(4) The physical size of the object to be painted. As a general rule, use the largest possible spray pattern consistent with the object size. Remember that different air caps deliver various pattern characteristics. This can reduce both spraying time and the number of gun passes.
(5) The speed with which the finish will be applied and the desired level of quality.

For speed and coverage, choose a combination which produces a pattern as wide as possible.

When quality is the deciding factor, choose a combination which produces fine atomisation and a smaller pattern size, thereby giving greater application control.

For a suction feed gun, there are several nozzle types available which are suitable for finishing operations. These nozzles have fluid tip openings ranging from 1.6mm (0.062") to 1.8mm (0.070"), and are designed to handle viscosities up to 30 seconds in a Din 4 Viscosity Cup

For a pressure feed gun, the amount of material discharged depends upon material viscosity, inside diameter of the fluid tip, length and size of hose, and particularly the pressure on the material container or pump.
If the fluid tip opening is too small, the material stream velocity will be too high. If the fluid tip opening is too large, you will lose control over the material discharging from the gun.

Pressure feed air caps consume between 7.0 and 25.0 CFM, depending on design. If your air supply is limited, because of an undersize compressor, or many other air tools are in use at once, the gun will be starved for air, producing incomplete atomisation and a poor finish.

> ***Rule of thumb***
> *The lower the viscosity of the material, the smaller the I.D. of the fluid tip.*

NOTE: Viscosity conversion charts are available to convert one viscosity cup reading to another from many material or equipment suppliers.

33. What are the criteria for selecting a pressure feed fluid tip?

The fluid discharge in cc/min from a suction feed gun is relatively stable (largely because it is determined by atmospheric pressure and it utilises only a short fluid column). However the fluid discharge from a pressure feed gun is affected by far more variables. These include the size of the inside diameter of the fluid tip and the pressure on the paint container or pump. The larger the opening, the more fluid is discharged at a given pressure.

If the fluid tip ID is too small for the amount of material flowing from the gun, the discharge velocity will be too high. The air, coming from the air cap, will not be able to atomise it properly causing a centre-heavy or poorly atomised pattern.

If the fluid tip opening is too large, material discharge control will be lost.

The fluid tip/air cap combination must be matched to each other and to the job at hand. Spray gun catalogues and service literature include charts to help you match them properly.

34. Of what metals are fluid tips made?

Traditionally fluid tips have been made of several different metals including Mild Steel, Low and High Grade Stainless Steel, Nitralloy and Tungsten Carbide. However, over several years we have standardised on three metal types:

High Grade 303 Stainless Steel used for Foods, Pharmaceutical and all solvent based and waterbased material types

Hardened Nitralloy for abrasive, but not corrosive, applications

Tungsten Carbide for extremely abrasive, non corrosive, materials and coatings.

In addition a small range of tips containing a plastic insert have been introduced. These have better needle/tip sealing characteristics for use in some applications and will eliminate the need for Lapped Tip and Needle sets.

35. What is the spreader adjustment valve?

Also known as the fan or Horn air control valve. A valve for controlling the air to the horn holes which regulates the spray pattern from maximum width down to a narrow or round pattern (see figure 28).

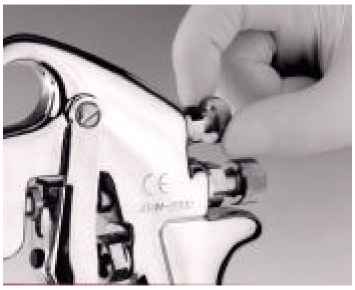


Figure 28.- Spreader adjustment valve

36. What is the fluid needle adjustment?

This controls the distance the fluid needle is allowed to retract from its seat in the fluid tip, which allows more or less material through the fluid tip (see figure 29).

With pressure feed systems, the fluid delivery rate should be adjusted by varying the fluid pressure at the pressure pot. Use the fluid adjustment knob for minor and/or temporary flow control. This will extend the life of the fluid needle and tip.

Figure 29.- Fluid Adjustment Screw

37. What is an Air Flow Control Valve?

Also known as a Cheater valve, this controls the quantity of air flowing through the gun. This will effect atomisation and bounce-back. The valve can either be fitted into the gun body or attached to the gun handle air inlet.

Figure 30.- Cheater Valves

38. What is the "Ball and Cone" principle?

A feature (Fig. 31) which assures perfect alignment between the air cap and fluid tip. A precision machined conical surface on the tip provides a seat for the precision machined ball segment of the cap.

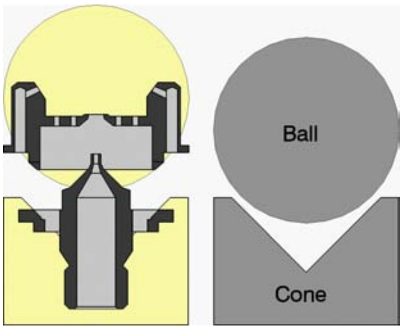


Figure 31.- Ball and Cone Seating

39. What is a Removable Spray head and what are its advantages?

A feature on the old DeVilbiss MBC spray gun which allowed the spray head (an assembly consisting of the air cap, fluid tip, fluid needle and spray head body) to be quickly removed as a unit from the spray gun body.

Its advantages were:
a) Ability to change spray head and combination to specialised assemblies for certain materials e.g. sound deadener, veiling etc
b) Ease of cleaning.
c) In case of damage to the spray head, a new gun body is not required.
d) An extra spray head can be substituted for one being repaired or cleaned.

The MBC gun is now no longer a current gun in the DeVilbiss range, but some other manufacturers guns, designed for painters and decorators, still have similar features.

Figure 32.- Removable Spray head

40. What are the components of suction and gravity feed systems?

Typical suction and gravity feed systems consist of: a suction feed or gravity feed spray gun with cup, an air compressor (not shown), a combination filter/air regulator and air hoses (see figure 33).

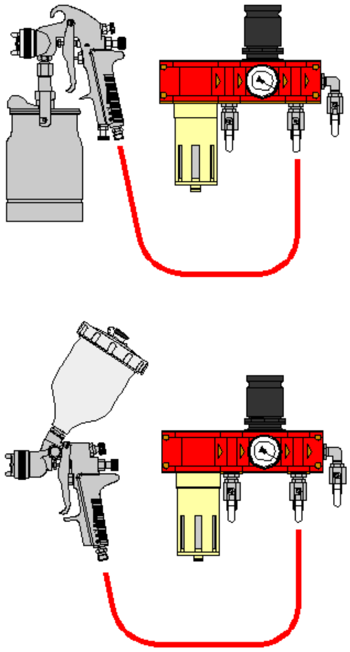


Figure 33.- Suction Feed and Gravity Feed System Components

OPERATION

41. How is suction and gravity feed equipment hooked up for operation?

a) Connect the air supply from the compressor outlet to the filter/air regulator inlet.

b) Connect the air supply hose from the air regulator outlet to the air inlet on the spray gun.

c) After the material has been re-duced to proper consistency, thoroughly mixed and strained into the cup, attach the gun to the cup (suction feed) or pour material into attached cup (gravity feed).

42. How are suction and gravity feed systems initially adjusted and balanced for spraying?

a) For maximum pattern size open wide the spreader adjusting valve on the gun. Turn counter-clockwise until it stops.

b) For maximum fluid delivery back out the fluid adjusting screw to a wide-open position. (Wide-open position is reached when the first thread of the screw is visible).

c) Open the air outlet valve on the air regulator and adjust the atomisation air to approximately 30 psi at the gun handle.

d) Spray a static vertical spray pattern to check size and shape of fan. Any deformation problems need to be corrected before continuing (see Troubleshooting section).

Figure 34.- Vertical Test Pattern

e) Make a few test passes with the gun on some clean paper. If there is major variation in particle sizes - some specks and/or large globs - the paint is not atomising properly (see figure 35). Increase the air pressure slightly and make another test pass. Continue this sequence until the paint particle size is relatively uniform.

Figure 35.- Quick pass sprayout

f) Spray a horizontal test pattern, holding the trigger open until the paint begins to run. There should be even distribution of paint across the full width of the pattern (see figure 36). If there is not, there is a problem with either the air cap or the fluid tip which must be corrected. Refer to the Troubleshooting section for examples of faulty patterns to help diagnose your problem.

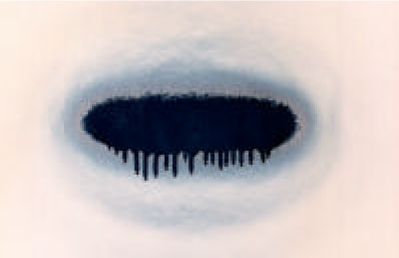


Figure 36. - Horizontal Test Runout

g) If the pattern produced by the above test appears normal, begin spraying.

h) If the pattern seems starved for material, and the fluid adjustment screw allows full needle travel, the fluid tip may be too small or the material may be too heavy. Recheck the viscosity or increase the size of the fluid tip and needle.

i) If the material is spraying too heavily and sagging, reduce the material flow by turning in the fluid adjusting screw (clockwise) or reducing the fluid tip size.

j) If using HVLP, using an "Air Cap Test kit', verify that the air cap pressure is not above 10 psi.

Remember, proper set-up utilises no more fluid and air pressure than is needed to produce the required quality and a flow rate that will meet production requirements.

43. What are the components of a pressure feed system?

A pressure feed system consists of: a pressure feed spray gun, a pressure feed tank, cup or pump, an air filter/regulator, appropriate air and fluid hoses, and an air compressor (see figure 37).

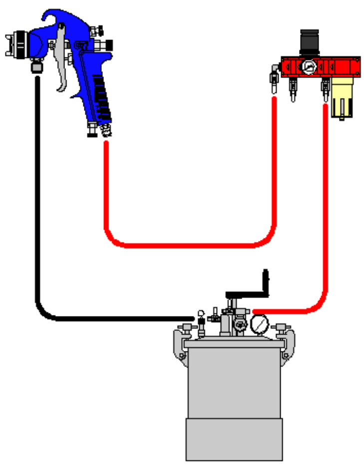


Figure 37.- Pressure Feed System Components

44. How is equipment hooked up for pressure feed spraying?

Connect the air hose from the air regulator to the air inlet on the gun.

Connect the mainline air hose to the air inlet on the tank. CAUTION: Do not exceed the container's maximum working pressure.

Connect the fluid hose from the fluid outlet on the tank to the fluid inlet on the gun.

45. How is the pressure feed gun adjusted for spraying?

Open spreader adjustment valve for maximum pattern size (see figure 28).

Open fluid adjustment screw until the first thread is visible (see figure 29).

46. How is the pressure feed gun balanced for spraying?

a) Check that the preliminary gun adjustments described above in 45 have been performed: the spreader adjustment control should be backed out to the wide-open position and the first thread should be visible on the fluid adjusting control.

b) Shut off the atomisation air to the gun. Set the fluid flow rate by adjusting the air pressure in the paint container. Use about 6 psi for a remote cup and about 15 psi for a 2-gallon or larger container as a start pressure.

c) Remove the air cap, aim the gun into a clean container and pull the trigger for 10 seconds. Measure the amount of material which flowed in that time and multiply by six (or 30 seconds and multiply by two). This is the fluid flow rate in cc per minute. For normal spraying operations it should be between 250 to 300 cc per minute. If the flow rate is less than this, increase the air pressure in the container and repeat. If it is faster than this, decrease the pressure slightly. When the flow rate is correct, reinstall the air cap.

d) Turn the atomisation air on and adjust to about 40 psi at the gun handle. Spray a static vertical spray pattern to check size and shape of fan. Any deformation problems need to be corrected before continuing (see Troubleshooting section).

e) Make a few passes on a piece of paper or cardboard. From that test pattern, determine if the particle size is small enough and relatively uniform throughout the pattern to achieve the required finish quality (see figure 35). If particle size is too large or is giving too much texture in the finish, turn the atomisation pressure up in 5 psi increments until particle size and texture of finish is acceptable.

f) Spray a horizontal test pattern holding the trigger open until the material begins to run. Paint distribution across the full width of the pattern should be the same. If it is not, there is a problem with either the air cap or fluid tip which must be corrected. Refer to the Troubleshooting section.

g) If the horizontal pattern appears normal, the pressure feed system is ready to spray.

Figure 38.- Air regulator adjustment

h) Spray a component with these settings. If you are not able to keep up with the production rate required or if the finish is starved for material, increase the fluid pressure with the fluid regulator control knob in 2 to 4 psi increments until required wet coverage is accomplished. Note: A larger capacity fluid tip may be required.

i) Remember, as you turn up the fluid pressure the particle size will increase. Once the coverage required is obtained, it may be necessary to re-adjust the atomisation pressure in 3 to 5 psi increments to insure required particle size and finish texture is achieved.

j) If using HVLP, using an "Air Cap Test kit', verify that the air cap pressure is not above 10 psi.

Figure 39.- Air Cap Test Kit

After establishing the operating pressures required for production and finish quality, develop a Process Control program for your finish process to follow.

47. What is a Process Control Program?

After establishing air and fluid pressures that meet required quality and production, record the data to be used for that application for future reference. (see figure 40)

Process Control Record
No. 12

Finishing Process:	Topcoat
Booth:	A
Material Sprayed:	Blue 2-pack Polyurethane
Mix Ratio:	2:1:1
Spray Viscosity:	22 sec Din4
Booth Temperature:	23°C
Booth R.H:	70%
Spray Gun:	DeVilbiss JGA
Air Cap:	765
Fluid Tip:	FF 1.4mm
Fluid Needle:	FF 1.4mm
Air Pressure:	55psi at handle
Fluid Flow:	320 cc/min
Tank pressure:	42 psi
Notes:	Check viscosity every breaktime

Figure 40.- Typical Process Control Record

48. How should the spray gun be held?

It should be held so the pattern is perpendicular to the surface at all times.
Keep the gun tip 8-10 inches (conventional spray guns) or 6-8 inches (HVLP guns) from the surface being sprayed. A simple way of determining the correct distance is shown in figure 41.

Figure 41.- Gun to Target distance

49. What is the proper technique for spray gun stroke and triggering?

The stroke is made with a free arm motion, keeping the gun at a right angle to the surface at all points of the stroke.

Triggering should begin just before the edge of the surface to be sprayed. The trigger should be held fully depressed, and the gun moved in one continuous motion, until the other edge of the object is reached. The trigger is then released, shutting off the fluid flow, but the motion is continued for a few inches until it is reversed for the return stroke.

When the edge of the sprayed object is reached on the return stroke, the trigger is again fully depressed and the motion continued across the object.

Lap each stroke at least 50% over the preceding one. Less than 50% overlap will result in streaks on the finished surface. Move the gun at a constant speed while the trigger is pulled, since the material flows at a constant rate.

Another technique of triggering is referred to as "feathering." Feathering allows the operator to limit fluid flow by applying only partial trigger travel.

50. What happens when the gun is arced?

Arcing the stroke results in uneven application and excessive over-spray at each end of the stroke. When the tip is arced at an angle of 45 degrees from the surface (see figure 42), up to 65% of the sprayed material can be lost.

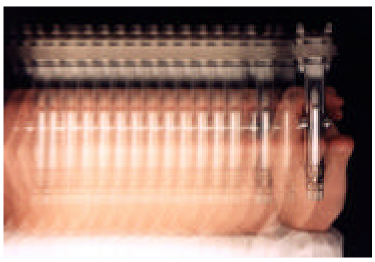


Figure 42.- Spray Techniques

51. What is the proper spraying sequence and technique for finishing applications?

Difficult areas, such as corners and edges, should normally be sprayed first. Aim directly at the area so that half of the spray covers each side of the edge or corner.

Hold the gun an inch or two closer than normal, or screw the spreader adjustment control in a few turns. Needle travel should be only partial by utilising the "feathering" technique. Either technique will reduce the pattern size.

If the gun is just held closer, the stroke will have to be faster to compensate for a normal amount of material being applied to smaller areas.

When spraying a curved surface, keep the gun at a right angle to that surface at all times. Follow the curve. While not always physically possible, this is the ideal technique to produce a better, more uniform, finish.

After the edges, flanges and corners have been sprayed, the flat, or nearly flat, surfaces should be sprayed.

Remember to overlap the previously sprayed areas by at least 50% to avoid streaking.

When painting very narrow surfaces, you can switch to a smaller gun, or cap with a smaller spray pattern, to avoid readjusting the full size gun. The smaller guns are usually easier to handle in restricted areas.

A full size gun could be used, however, by reducing the air pressure and fluid delivery and triggering properly.

MAINTENANCE

52. What causes fluid leakage from the fluid needle packing nut?

A loose packing nut, worn or dry fluid needle packing. Lubricate packing with a few drops of light oil. Tighten packing nut to prevent leakage but not so tight as to grip the fluid needle. It becomes necessary to replace the packing when it is worn. Tighten the packing nut until it grabs and holds the needle, then back off the packing nut until the needle is free to travel into the fluid tip.

53. What causes air leakage from the front of the gun? (See Fig. 43)

a) Foreign matter on valve or seat.
b) Worn or damaged valve or seat.
c) Broken air valve spring.
d) Sticking valve stem due to lack of lubrication.
e) Bent valve stem.
f) Packing nut too tight.
g) Gasket damaged or omitted.

Figure 43.- Air valve

54. How should the air cap be cleaned?

Remove the air cap from the gun and immerse it in clean solvent. If necessary, use a bristle brush to clean dried paint. Blow it dry with compressed air.

If the small holes become clogged, soak the cap in clean solvent. If reaming the holes is necessary, use a toothpick, a broom straw, or some other soft implement (see figure 44). Cleaning holes with a wire, a nail or a similar hard object could permanently damage the cap by enlarging the jets, resulting in a defective spray pattern.

Figure 44.- Cleaning the Air Cap

55. How should a suction gun be cleaned?

Turn off the air to the gun, loosen the cup lid and remove the fluid tube from the paint. Holding the tube over the cup, pull the trigger to allow the paint to drain back into the cup.

Empty the cup and wash it with clean solvent and a clean cloth. Partially fill it with clean solvent and spray it through the gun to flush out the fluid passages by directing stream into the back of the booth or a gun cleaner. Spray the minimum amount of solvent necessary to keep VOC emissions to a minimum.

In the UK and some other countries an enclosed gun cleaning machine must be used to comply with Environmental Legislation.

56. What is an enclosed gun cleaner?

Also known as a gun cleaning cabinet, these are machines that are used to wash and clean suction and gravity guns. They have been introduced to help prevent solvents being sprayed and evaporating to atmosphere during cleaning.

A gun cleaner is an enclosed box-like structure (vented) with an array of cleaning nozzles inside.

Figure 45.- Gun in solvent washing machine

Guns and cups are placed over the nozzles, the lid is closed, a valve is depressed, and the pneumatically powered pump sprays solvent through the nozzles to clean the equipment for a pre-set period of time. The closed lid keeps solvent evaporation to a minimum.

The solvent in the unit is recycled, and must be replaced periodically with fresh liquid.

After washing the guns should be removed, attached to an airline and any residual liquid in the air and fluid passageways blown out. Then wipe the gun exterior over with a clean cloth. It is also recommended that the gun be lubricated after cleaning (see Figure 47)

57. How should a pressure gun be cleaned?

To clean a pressure feed gun with remote cup or tank, turn off air supply to the cup or tank. Release material pressure from the system by opening relief valve.

Material in hoses may be blown back. The lid must be loose and fluid pressure off. Keep gun higher than container, loosen air cap two or three turns and trigger gun until atomising air forces most of the material back into the pressure vessel.

Clean the container and add solvent. Pressurise the system and run solvent until clean. (Note: atomisation air should be turned off during this procedure.)

Dry hose by again loosening the cap and container lid and forcing air back through the gun and hose. Clean air cap and fluid tip. Clean out tank and reassemble for future use.

Wipe off the gun with a solvent-soaked rag, or if necessary, brush the air cap and gun with a fibre brush using clean-up liquid or thinner.

58. What is a hose cleaner?

A device which incorporates a fluid mixer valve which forces a finely atomised mixture of solvent and compressed air through fluid hose and paint passages, ridding them of paint residue. A manual valve stops the flow of solvent and allows air to dry the equipment being cleaned. (See Fig. 46).

The cleaner can speed up equipment and hose cleaning and very efficiently purge all material from the internal surfaces. Care must be taken that both the hose cleaner and gun are properly grounded due to potential static charges being formed

Figure 46.- Using a Hose Cleaner

59. What parts of the gun require lubrication? (Figure 47)

The fluid needle packing (A), the air valve packing (B) and the trigger bearing screw (C) require regular lubrication with a non-silicone/non-petroleum gun lubrication oil.

The fluid needle spring (D) should be coated lightly with petroleum jelly or a non-silicone grease.

Lubricate each of these points after *every* cleaning in a gun washer!

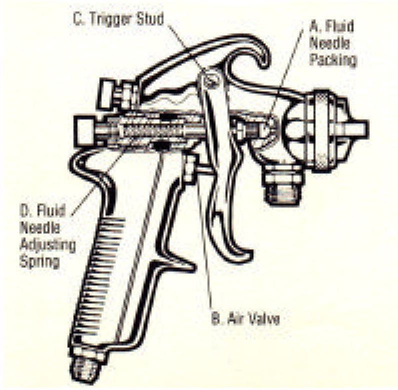
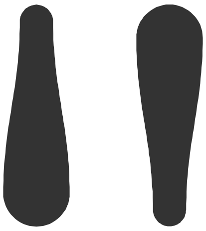
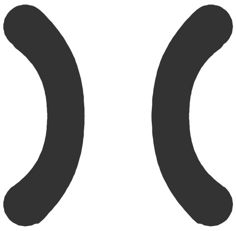


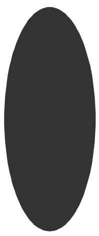
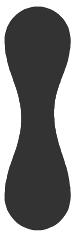
Figure 47.- Lubrication Points

TROUBLESHOOTING

Problem	Cause	Correction
Fluid leaking from packing nut	1. Packing nut loose 2. Packing worn or dry	1. Tighten, do not bind needle 2. Replace or lubricate
Air leaking from front of gun	1. Sticking air valve stem 2. Foreign matter on air valve or seat 3. Worn or damaged air valve or seat 4. Broken air valve spring 5. Bent valve stem 6. Air valve gasket missing damaged or missing	1. Lubricate 2. Clean Replace 4. Replace 5. Replace 6. Replace
Fluid leaking or dripping from front of pressure feed gun	1. Dry packing 2. Packing nut too tight 3. Fluid tip or needle worn or damaged 4. Foreign matter in tip 5. Fluid needle spring broken 6. Wrong size needle or tip	1. Lubricate 2. Adjust 3. Replace tip and needle with lapped set 4. Clean 5. Replace 6. Replace
Jerky, fluttering spray	**All Feed Systems** 1. Loose or damaged fluid tip/seat 2. Dry packing or loose fluid needle packing nut 3. Material level too low 4. Container tipped too far 5. Obstruction in fluid passage 6. Loose or broken fluid tube or fluid inlet nipple **Suction Feed Only** 7. Material too heavy 8. Air vent clogged 9. Loose, damaged or dirty lid 10. Fluid tube resting on cup bottom 11. Damaged gasket behind fluid tip	1. Tighten or replace 2. Lubricate packing or tighten packing nut 3. Refill 4. Hold more upright 5. Backflush with solvent 6. Tighten or replace 7. Thin or reduce 8. Clear vent passage 9. Tighten, replace or clean coupling nut 10. Tighten or shorten 11. Replace gasket

Problem		Cause		Correction
Top or bottom-heavy spray pattern 	1.	Horn holes plugged	1.	Clean, ream with non-metallic point (i.e. toothpick)
	2.	Obstruction on top or bottom of fluid tip	2.	Clean
	3.	Cap and/or tip seat dirty	3.	Clean
Right or left-heavy spray pattern 	1.	Horn holes plugged	1.	Clean, ream with non-metallic point (i.e. toothpick)
	2.	Dirt on left or right side of fluid lip	2.	Clean

***Remedies for the top, bottom, right, left heavy patterns are:**
1. Determine if the obstruction is on the air cap or fluid tip. Do this by making a static test spray pattern. Then, rotate the cap one-half turn and spray another pattern. If the defect is inverted, obstruction is on the air cap. Clean the air cap as previously instructed.
2. If the defect is not inverted, it is on the fluid tip. Check for damage or contamination on the edge of the fluid tip. Remove contamination or replace tip as necessary.
3. Check for dried paint just inside the opening. Remove paint by washing with solvent.

Problem		Cause		Correction
Centre-heavy spray pattern 	1.	Fluid pressure too high for atomisation air (pressure feed)	1.	Balance air and fluid pressure. Increase pattern width
	2.	Material flow exceeds air cap's capacity	2.	Thin or reduce fluid flow
	3.	Spreader adjustment valve set too low	3.	Adjust
	4.	Atomising pressure too low	4.	Increase pressure
	5.	Material too thick	5.	Thin to proper consistency
Split spray pattern 	1.	Fluid adjusting knob turned in too far	1.	Back out counter-clockwise to increase flow
	2.	Atomisation air pressure too high	2.	Reduce at regulator
	3.	Fluid pressure too low (pressure feed)	3.	Increase fluid pressure
	4.	Fluid tip too small	4.	Change to larger tip

Problem	Cause	Correction
Starved spray pattern	1. Inadequate material flow	1. Back fluid adjusting screw out to first thread or increase fluid pressure
	2. Low atomisation air pressure (suction feed)	2. Increase air pressure and rebalance gun
Unable to form round spray pattern	1. Fan adjustment stem not seating properly	1. Clean or replace
Dry spray	1. Air pressure too high	1. Lower air pressure
	2. Material not properly reduced (suction feed)	2. Reduce to proper consistency and temperature
	3. Gun too far from surface	3. Adjust to proper distance
	4. Gun motion too fast	4. Slow down
Excessive overspray	1. Too much atomisation air pressure	1. Reduce pressure
	2. Gun too far from surface	2. Use proper gun distance
	3. Improper technique (arcing, gun speed too fast)	3. Use moderate pace, keeping gun parallel to work surface
Excessive fog	1. Too much, or too fast drying thinner	1. Remix with proper reducer and temperature
	2. Too much atomisation air pressure	2. Reduce pressure
Will not spray	1. Pressure feed cap/tip used with suction feed	1. Use suction feed cap/tip
	2. No air pressure at gun	2. Check air lines
	3. Fluid needle not retracting	3. Open fluid adjusting screw
	4. Fluid too heavy (suction feed)	4. Lower fluid viscosity or change to pressure feed

12. Fluid Feed

INTRODUCTION

All spray Systems - from the smallest airbrush to the most sophisticated finishing system - must have containers to hold the material being applied and/or a method of feeding the material to the front of the gun.

Material container types and sizes vary considerably, depending on the kind of spraying system being used. Likewise the methods of feeding the liquid to the spray head can vary – diaphragm pumps, piston pumps or the more simple pressure feed tanks.

This chapter will discuss these methods, their particular applications, their construction, working and maintenance.

VISCOSITY

1. What is viscosity?

The viscosity of a liquid is its body or thickness, and it is a measure of its internal resistance to flow. Viscosity varies with the type and temperature of the liquid. Any reference to a specific viscosity measurement must be accompanied by a corresponding temperature specification.

The most common measurement used to determine viscosity in finishing is flow rate (measured in seconds from a Ford, Din, BS or other viscosity cup).

Figure 1.- Viscosity cup

Different viscosity cup sizes are available. Each cup has a hole at the bottom, specified to an exact size. Use a viscosity cup that is designed to handle the time range of the materials in use. Viscosity control is an extremely important and effective method to maintain application efficiency and quality consistency. Always measure viscosity after each batch of material is mixed and make sure material temperature is the same, normally a nominal 20^{o}C (70 F).

Viscosity recommendations may also be given in poise and centipoise (1 poise=100 centipoise).

Viscosity conversion may be accomplished by consulting an appropriate viscosity conversion chart.

This type of measurement only works for Newtonian fluids i.e. fluids that have constant shear characteristics.

2. What other methods are there for measuring a liquids flow characteristics

Non-Newtonian fluids (such as many thixotropic waterbased paints) have to be measured in a different method.

When using a Rotometer a shaped paddle is rotated in a sample of the material. The torque or force needed to rotate the paddle is measured and used as a figure to compare it with other materials.

Figure 2.- Rotometer

When measuring the flow characteristics of Ceramic Glaze a slump meter can be used. An open-ended tube is placed upright on the centre of a horizontal target of concentric rings. The tube is filled with glaze and then lifted, allowing the material to flow over the target. The number of rings that the glaze covers is counted and used as a comparison with other materials.

These are only two of many other methods of measuring a materials characteristics.

CUPS

3. What different methods are used to feed fluid to the gun?

There are five main methods:

1) Suction feed
2) Gravity feed
3) Pressure Cup
4) Pressure Tank
5) Pump

4. What is a Suction Feed Cup and how does it work?

This is a small - usually 1 Litre or less - vented container attached to the gun. The vent hole allows atmospheric pressure to enter the cup. When the gun trigger is pulled and compressed air exits from the air cap of the gun, a vacuum is created at the tip end. Since the pressure in the container is now higher than that at the tip, material is forced up the delivery tube in the container, through the gun passages and out through the fluid tip, where the compressed air atomises it. This type container is commonly used where a small amount of relatively thin material (low viscosity) is being sprayed.

Figure 3.- Suction Cup

5. What capacities do Suction Feed Cups have?

Suction feed cups can range from quite small - about 20 cc for airbrushes - to about 1 Litre for a production gun. They are seldom any larger than a 1 Litre.

6. What is a Gravity Feed Cup and how does it work?

This are also a small - usually 600 cc or less - vented container attached to the top of the gun. The vent hole again allows atmospheric pressure to enter the cup. Gravity pulls the material down to the gun head. In addition, venturi is also generated which adds to the fluid flow.

This type container is commonly used where a small amounts of material is being sprayed. The combination of venturi and gravity allows heavier bodied material to be fed than is possible with suction feed.

Figure 4.- Gravity Cup

7. What is a Pressure Feed Cup and how does it work?

This type container which either attaches to the gun or attaches by short hoses so that the operator carries it. Is not vented and therefore does not depend on the development of a vacuum at the fluid tip to work. Instead, the material in the cup is pressurised by the atomising compressed air or via a small regulator, and this higher-than-atmospheric pressure forces the material out of the cup, through the gun passages and out the fluid tip, where compressed air atomises it as usual.
The pressure feed cup is typically used for materials which are too thick (high viscosity) for, or higher flow rates than suction feed equipment can supply.

It is really a small portable pressure feed tank.

8. What capacities do Pressure Feed Cups have?

Pressure feed cups normally have up to 2 Litre capacities.

Anything larger is considered a pressure feed tank and would be positioned some distance from the gun.

9. How are Pressure Feed Cups classified?

There are three kinds: non-regulator, regulator and remote types. The non-regulator type is not common in professional finishing systems, as it has no fluid pressure controlling device and is generally used with relatively small air compressing systems.

Figure 5.- Non-regulator Pressure Feed Cup

The regulator type cup has a built-in regulator which controls the fluid pressure independently of the atomisation air pressure, permitting better control of the cup pressure.

Figure 6.- Regulator Pressure Cup gun

The Remote cup is connected to the gun by short hoses (approx 1 metre) and has a a controlable regulator that can vary the internal pressure. It also includes other items that are fitted to a full size pressure tank such as a safety valve, pressure gauge and pressure release valve.

Figure 7.- KB 2 Remote Pressure Cup

TANKS

10. What are Pressure Feed tanks and how do they work?

Pressure feed tanks are closed containers, ranging in size from about 9 Litres (2 gall) to 45 Litres (10 gall). They provide a constant flow of material, under constant pressure, to the spray gun.

The tank is pressurised with clean, regulated, compressed air, which forces the fluid out of the tank through the fluid hose to the gun.

The rate of fluid flow is controlled by increasing or decreasing the air pressure in the tank.

A typical pressure feed tank consists of: the shell (A), clamp-on lid (B), fluid tube (C), fluid outlet (D), regulator (E), gauge (F), safety relief valve (G), and agitator (H) (see figure 8).

Pressure feed tanks are normally available with either top or bottom fluid outlets.

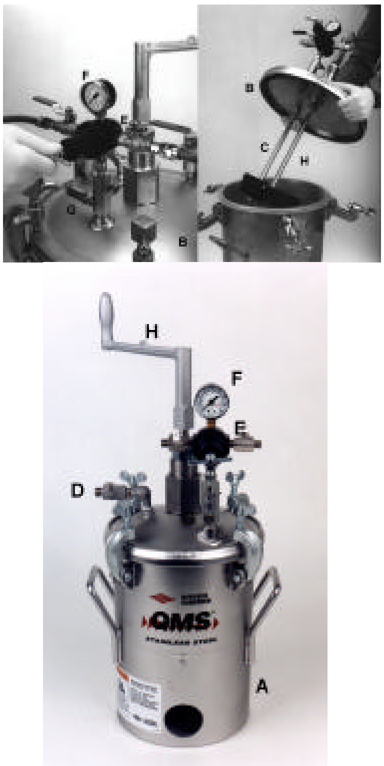


Figure 8.- Pressure Feed Tank

11. Where are pressure feed tanks recommended?

Pressure feed tanks provide a simple, practical, economical method of feeding material to the gun over extended periods of time.

They are mostly used in continuous production situations, because the material flow is positive, uniform and constant.

Tanks can be equipped with agitators (see Figure 3) that keep the material mixed and in suspension

12. When is an agitator used in a pressure feed tank?

When the liquid being used has a pigment or material that must be kept in motion to keep its particles in proper suspension. An agitator can be hand, air or electrically driven.

13. What is a single regulated tank?

This is a pressure feed tank with one air regulator mounted on the lid controlling only the pressure on the material in the tank (see figure 9). Most tanks used are designed this way

Figure 9.- Single Regulated Tanks

Some tanks are fitted with a second regulator to control atomisation pressure to the gun. These are normally called Double regulator tanks

14. To what standards are pressure tanks manufactured?

Pressure Feed Tanks have been constructed in the past to BS 1101 and ASME (American Society of Mechanical Engineers, a US standard).

From November 1999 the Pressure Equipment Directive 97/23/EC became law in the UK (although not manditary until May 2002), which sets the requirements for the design, manufacture, inspection and certification of PFT's.

Those that comply with the new standard will bear the 'CE' mark.

This harmonised standard means that equipment manufactured to the requirements of the PED, bearing the 'CE' mark, can be sold in any of the member states of the EU.

15. What materials are used to construct pressure feed tanks?

Heavy-duty, ASME-code and BS/PED tanks are made of galvanised mild steel plate or 304 series electropolished stainless steel. They also have zinc plated or stainless steel lids with forged steel clamps.

When abrasive or corrosive materials are being sprayed, the inside of the tank shell can sometimes be coated or lined with a special material such as Teflon or Vitreous Enamel, or a container insert or liner is used.

16. What are container liners and inserts?

Inserts are containers that are placed inside the tank to hold the material, keeping it from direct contact with the tank walls. They can be constructed from Tinplate or Stainless Steel.

Tank liners are thin plastic mouldings that fit inside the tank base and carry out the same function. They are made of disposable polyethylene.

Figure 10.- Tank liner and insert container

Using liners and inserts reduces tank cleaning time and makes colour changeover easier.

17. When would you use a bottom outlet tank?

1) When you are using very viscous materials.

2) When you wish to use all the material in the tank and you are not using an insert.

18. What would I use if I have difficulty accurately setting lower fluid pressures?

An extra-sensitive regulator may be available for use with lower fluid flow and/or lower viscosity materials where precise control is needed.

19. How often should a pressure tank be tested?

UK Insurance companies normally require pressure tanks of 2 gallons (9 Litres) capacity or greater to be pressure tested and certified every 18 months. However this duration may differ between different companies. Check with your own insurer.

PUMPS

20. What is a fluid pump?

This is a mechanical device for moving fluid under pressure from its storage container or reservoir to the point of use.

There are two main sources of power – compressed air and electricity. Due to the hazardous and inflammable nature of many of the liquids used in the finishing industry, compressed air is normally the favoured power source. Electric motors (flameproof) are usually only used in large paint circulating systems in Vehicle manufacturing plants and large industry.

All fluid pumps are designed to output a certain volume (cc/min) at a given pressure (psi). All pumps are rated by these two parameters.

Because electrically powered turbine pumps are a specialist subject, we will examine the more commonly used pump types.

21. What types of Fluid pumps are available?

Two main types are available – diaphragm and piston. Both are available in different fluid output and pressure ratings.

Diaphragm pumps can be vertical or horizontal and can be made from plastics, aluminium or stainless steel.

Figure 11.- Aluminium Double Diaphragm pumps

Piston pumps are normally made from stainless steel, Aluminium and mild steel.

Figure 12.- Piston pump

Always check that the materials of construction, ball material and packing type are compatible with the material to be pumped.

22. How are fluid pumps specified?

Performance of a pump is normally specified by three parameters

(1) fluid output in cc per stroke or cc per cycle

(2) Ratio of pump pressure – i.e. 1:1, 2:1,10:1 etc. This means that an air input pressure of 1 psi will result in a fluid output pressure of 1psi or 2 psi or 10 psi etc.

3) the maximum number of strokes or cycles per minute that the pump can function at without severely accelerating wear of the pump components.

Other information may be available but these three facts are the most important.

23. How does a Double Diaphragm pump work?

This type of pump uses two flexible diaphragms to apply pressure to the liquid in two chambers. They are linked together so that as liquid is pushed out of one chamber, fluid is drawn into the other. The pump fluid passageways incorporate several ball valves that ensure that fluid only flows in one direction when the diaphragms change stroke.

Figure 13.- Acetal Double Diaphragm pump

24. When do I use a diaphragm pump?

Diaphragm pumps can be used in most pumping applications. The range of pumps available has a wide range of fluid outputs from 20 cc/cycle up to 3000 cc/cycle.

Many pumps of this sort are used as an alternative to pressure feed tanks for small to medium finishing operations as well as small circulating systems.

The wide range of materials that the pumps can be constructed of allows many fluid to be pumped including lubrication oils, solvent and waterbased paints.

The squeezing action of a diaphragm pump makes it suitable for moving certain materials that the shearing action of piston pumps cannot. These include latex adhesives and ceramic glaze.

25. How does a piston Pump work?

This pump has two main sections – an upper air motor and a lower fluid section.

In a similar way to a diaphragm pump, an upper air piston reciprocates vertically and acts as the motive force for moving to a connected lower fluid piston.

Because the air and fluid pistons are totally divorced it is easy to design and manufacture pumps with ratios greater than 1:1. Low pressure pumps (2:1 up to 10:1) and high pressure pumps (10:1 up to 73:1) have the same basic construction except for the varied cross sectional area of the two pistons.

The fluid piston and pump incorporates one way valves to ensure the material only moves in one direction.

26. When do I use a Piston pump?

Due to the range of ratios available, these pumps can supply fluid at higher pressures than diaphragm pumps. Therefore they are primarily used where the material has higher viscosity or needs to be moved over longer distances.

While they have wide use in dead head systems for high pressure Airless and Air assisted Airless spraying systems, they are particularly suitable for use in large paint circulation systems.

27. What is a 'Dead Head' System?

This is any fluid supply system than runs from the source (pump or tank) to the gun with no return to the source.

It is the most common supply system for finishing.

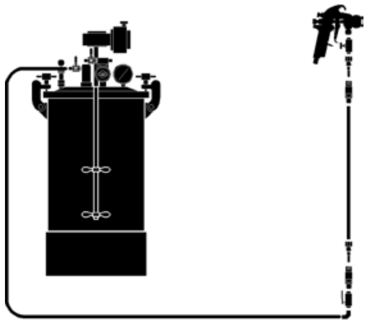


Figure 14.- Dead head Fluid Supply system

28. What is a Circulation System?

This fluid supply system moves fluid from its source to the gun and then has a return line running back to the source and its reservoir.

This system is used in higher production plants that utilise materials that need to be kept in constant suspension.

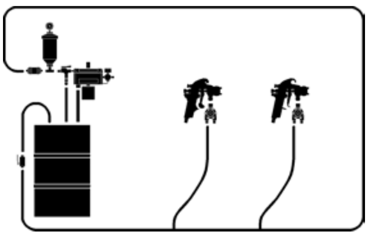


Figure 15.- Circulating Fluid Supply System

29. What is a Back Pressure Valve?

In a circulation system there must be some way to ensure that, when the gun trigger is pulled, fluid finds it easier to flow out of the fluid tip and not return to the reservoir. A back pressure valve is a method of adjusting the flow resistance in the return line to make sure the fluid finds it easier to exit the gun. The valve is adjustable and will automatically vary its orifice size in an attempt to maintain the preset fluid line pressure when the gun is fired.

30. What is a Pulsation Chamber?

The cycling action of the diaphragm or piston produces high and low pressure pulses as the pump works. This is shown by surges in the fluid column exiting the fluid tip of the gun. This surges can create inconsistencies in the finish being achieved.

To help overcome these pulses a chamber can be fitted to the pump outlet. In its most simple form the fluid pressure is used to compress the air trapped in the top of the chamber. It then acts as a spring during the pulses and helps smooth out the surges.

31. What is a Fluid regulator?

This carries out the same function as an air regulator but it is fitted with components and a diaphragm that resist solvents and liquids.

Figure 16.- Fluid regulator

A fluid regulator will keep the fluid pressure to the gun constant while the pump pressure fluctuates (within specified parameters)

32. What is a Hot Spray system?

This is a fluid supply system that heats the fluid using a direct or indirect heater to a pre-set temperature for spraying.

Figure 17.- Hot Spray System

33. What are the advantages of using a Hot Spray system?

(1) Reduction of viscosity of solvent based materials without the addition of extra solvent.

(2) Supply of material at a constant temperature and viscosity so variations in ambient and booth temperature can be ignored.

(3) Reduction of atomising air pressure due to the reduction in viscosity

(4) Reduced possibility of blushing and blooming

(5) higer gloss levels

(6) increased rate of drying

34. What type of paint heater is used?

A direct heater where the material comes into direct contact with the heating element or an indirect heater where the material is heated by another medium, typically water, which has been heated by the elements.

Heating elements are normally electrically powered (flameproof).

Indirect heater units are not usually used in recent years due to their inferior efficiency when compared to direct units.

35. Where is a Hot Spray system used?

Such systems have extensive use in the Wood industry. However they are also used for adhesives and 2 component paints (with care!) Although waterbased materials do not have their viscosity reduced by this type of system, they are sometimes used to aid drying.

13. Spray Booths

Introduction

Containing the spray fog and keeping it out of the air and off other objects is an important consideration in a spray finishing operation. This chapter discusses various types of booths and details periodic maintenance.

1. What is a spray booth?

A compartment, room or enclosure of fireproof construction; built to confine and exhaust spray fog and fumes from the operator and finishing system.

There are various models available, designed for particular spray applications. Spray booths may be partially enclosed (figures 1 & 3) or totally enclosed (figure 4).

Consult your local authority for their requirements regarding the specifications of construction for spray booths in your area and country.

2. What are the benefits of a spray booth?

A well-designed and maintained spray booth provides important advantages:

It separates the spraying operation from other shop activities, making the spraying, as well as the other operations, cleaner and safer.

It reduces fire and health hazards by containing the spray fog.

It provides an area that contains residue, making it easier to keep clean. It also keeps both the operator and the object being sprayed cleaner.

In a booth equipped with adequate and approved lighting, it provides better control of the finish quality.

3. What types of spray booth filtration are there?

There are two, the dry filter type and the waterwash type.

4. What is a dry filter type spray booth?

This booth draws overspray - contaminated air through replaceable filters and vents the filtered air to the outside.
It is the most common type of booth for most industrial and automotive applications.
It is primarily used for low volume spraying operations.

Dry filter booths normally cost less as an initial purchase than water wash, but there are higher operation costs due to the need to regularly change the filter media.

Figure 1.- Dry Filter Type Booth

5. What type of filter media is used in a dry filter spray booth

Two main types are used
a) a glass fibre woven matting

b) a cardboard 'concertina'

The glass fibre media normally is built up in layers of woven matting that are stripped off during its working life as the filter becomes loaded with paint residue. This has the effect of increasing the working life of the media but gradually reducing its filtration efficiency.

The cardboard media is constructed in such a way that the paint laden air stream is forced to change direction several times causing it to throw out its contamination. It does not have the 'absorbency' of the glass fibre matting type but has a higher working efficiency throughout its life and is capable of being 'self-supporting' when mounted in its location frame in the spray booth.

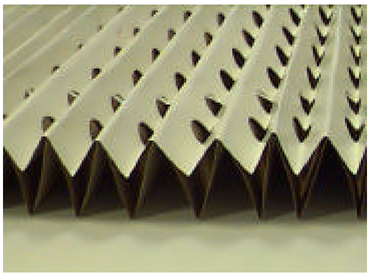


Figure 2.-Dry Filter Material Types

6. What is a waterwash type booth?

A waterwash booth actually washes the contaminated overspray air using a cascade of water, trapping the paint solids as the air-flows through it. If maintained correctly these booths are extremely efficient in their operation.

Waterwash booths are generally used when spraying high volumes of paint.

They are more expensive to purchase, but running costs can be lower due to their ability to work efficiently for long time between clean out.

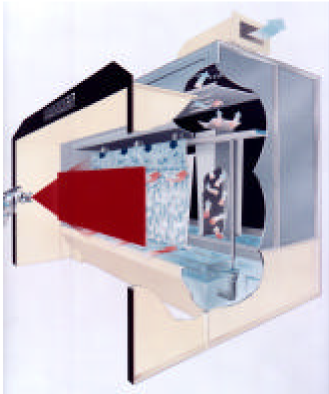


Figure 3.- Waterwash Industrial Type Spray Booth

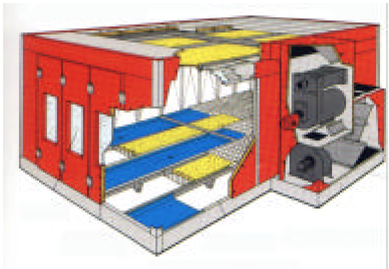


Figure 4.- Automotive Downdraft Dry Filter Booth

7. What is an axial flow exhaust fan?

A typical axial flow exhaust fan consists of a motor, a multiple blade fan, pulleys and belts. It removes overspray from the spray booth area (see figure 5).

The design of axial flow exhaust fans prevents overspray from coming into contact with the drive mechanism and electric motor.

Blades are made of non-sparking metal or plastic.

Figure 5.- Axial Flow Exhaust fan

8. What is a Centrifugal Fan?

This type of fan develops higher pressure and is used on larger spray booths that require more power and/or more air volume than is capable with axial flow fans.

Sometimes called a 'Snail shell' fan, the air is drawn into the centre of the fans rotating impellor and thrown out centrifugally through its vanes.

Figure 6.- Centrifugal Fan

9. What is air velocity?

Air velocity in a finishing operation is the term used to describe the speed of air moving through the spray booth - over and around the sprayer.

10. What effect does air velocity have on spray booth efficiency?

Air must move through the booth with sufficient velocity to carry away overspray.

Too low a velocity causes poor, even potentially dangerous working conditions, especially when the material contains toxic elements. It also increases maintenance costs.

Too high a velocity wastes power and the energy required to heat make-up air and can effect spray gun Transfer Efficiency and finish.

11. What Velocity is required in a spray booth?

Different designs of booth require different speeds but generally a minimum of 0.7 m/sec (137 ft/min) is used in an open fronted industrial type dry or water wash booth where general paint types are being applied. This is normally felt sufficient to contain the spray fog and prevent it escaping into the general workshop area.

However it is recommended that where Isocyanate paints are being used in an open fronted booth the air velocity is increased to 1.5m/sec (295 ft/min) due to the greater hazard these materials present.

Spraying inside an enclosed booth means that the spray fog is trapped inside the booth structure and therefore a velocity of 0.7 m/sec (137 ft/min) is again sufficient.

However, irrespective of the airflow velocity, safety equipment and suitable face masks must always be worn by operators during spraying operations.

Check with your local safety authority before purchasing a spray booth as regulations regarding the type of booths, their construction and air velocities can vary depending upon the country in which they are to be installed.

12. What is a manometer?

It is a type of pressure gauge that indicates when paint arrestor filters or intake filters are overloaded. (see figure 7)

The difference in pressure between the two sides of the filter is measured and gives an indication of the amount of contamination on them.

There are two main types – the simple inclined tube and the analogue dial type.

Figure 7.- Manometers

13. What does an air replacement unit do?

The volume of air exhausted from a spray booth is often equal to two or more complete air changes per minute.

Under such conditions, the temperature may become irregular and uncomfortable.

Excessive dust may also become a problem.

To prevent these conditions, sufficient "make-up' air must be introduced to compensate for the exhausted air.

The air replacement unit automatically supplies this "makeup" air - both filtered and heated - to eliminate the problems of air deficiency and airborne contaminants.

Figure 8.- Air Replacement Unit

14. What routine maintenance does a dry type spray booth require?

(a) The continuous flow of air through the booth eventually loads the filters with dirt and overspray. Periodically, visually inspect the filters and replace them if necessary with the correct filters, designed for spray booth use.

(b) Monitor the manometer reading daily, and know what a normal reading should be. This will indicate the condition of the filters and also can help diagnose problems with air replacement or exhaust fans.

(c) Periodically check the fan blades for spray dust build-up and clean if necessary.

(d) Check the fan belt tension and adjust when necessary.

15. What routine maintenance does a waterwash type booth require?

(a) Compounding of the water in this type unit is essential. Employ only booth treatment chemicals in accordance with suppliers' recommendations. The pH of the water should normally be between 8 and 9.

(b) Maintain the water level at the proper level per manufacturers' specifications. Check the water levelling device or ball valve periodically.

(c) check the tank for paint sludge build-up on the bottom, check the pump strainer (if fitted) to keep it clean and clear, check the air washer chamber and the nozzles in the header pipe (if fitted). If the nozzles are plugged, the overspray will encroach on the wash baffle section, fan and stack.

(d) Keep the booth interior and exhaust stack/fan blades free from overspray and dirt accumulation.

16. What checks can be used to assure good results from a spray booth?

(a) Keep the interior of the booth clean.

(b) Maintain and replace intake and exhaust filters when necessary.

(c) Caulk all seams and cracks where dirt might enter.

(d) Maintain and clean all equipment used in the booth.

(e) keep operators’ clothing clean and lint-free

(f) Perform routine maintenance above on a scheduled basis.

(g) Keep the booth free of dirt and dried paint dust. Floors and walls should be cleaned regularly. Pick up all tack rags, masking tape, wiping cloths, rags, etc.

(h) Coat the inside of the booth with a strippable, spray-on covering. When the overspray on it becomes too thick, strip and recoat.

(i) Periodically check the lighting inside the booth, and replace weak or burned out bulbs and fluorescent tubes. Improper lighting can prevent the operator seeing the component surface and affect finish quality.

14. Conversion tables

Air Volumetric Flow		
cfm	l/min	m^3/hr
1	28.3	1.7
2	56.6	3.4
4	113.3	6.8
6	169.9	10.2
8	226.5	13.6
10	283.2	17.0
12	339.8	20.4
14	396.4	24.8
16	453.1	27.2
18	509.7	30.6
20	566.3	34.0
22	622.9	37.4
24	679.6	40.8
26	736.2	44.2
28	792.9	47.6
30	849.5	51.0
35	991.1	59.4
40	1132.7	68.0
45	1274.3	76.5
50	1415.8	85.0
60	1699.0	102.0
70	1982.2	119.0
80	2265.3	136.0
90	2548.5	153.0
100	2831.7	170.0

Temperature	
^{o}C	^{o}F
-10	14
-5	23
0	32
5	41
10	50
15	59
20	68
25	77
30	86
40	104
50	122
60	140
70	158
80	176
90	194
100	212

Liquid Volume			
cm^3 ml	Litre	floz	Imp Gall
1	0.001	0.04	0.00022
10	0.01	0.35	0.0022
50	0.05	1.76	0.011
100	0.1	3.52	0.022
150	0.15	5.28	0.033
200	0.20	7.04	0.044
250	0.25	8.80	0.055
300	0.30	10.6	0.066
350	0.35	12.3	0.077
400	0.4	14.1	0.088
450	0.45	15.8	0.099
500	0.50	17.6	0.110
550	0.55	19.4	0.121
600	0.60	21.1	0.132
650	0.65	22.9	0.143
700	0.70	24.6	0.154
800	0.80	28.2	0.176
900	0.90	31.7	0.198
1000	1.0	35.2	0.220
1500	1.5	52.8	0.330
2000	2.0	70.4	0.440
2500	2.5	88.0	0.550
3000	3.0	105	0.660

1 Imp Gall = 1.2 US Gall

160 Imp floz = 8 Imp pints
160 Imp floz = 1 Imp gall

128 us floz = 1 US gall

Air Pressure	
psi	bar
5	0.34
10	0.69
20	1.38
30	2.07
40	2.76
50	3.45
60	4.14
70	4.83
80	5.52
90	6.21
100	6.70
150	10.3
200	13.8
400	27.6
600	41.4
800	55.2
1000	69.0
1250	86.2
1500	103
1750	121
2000	138
2250	155
2500	172
3000	207
3250	224
3500	241
3750	259
4000	276
4250	293
4500	310
4750	327
5000	345
5250	362
5500	379
5750	396
6000	414

1bar = 1.02 kPa
1bar = 0.98 atm

Miscellaneous		
1 Pound (lb)	=	0.453 kg
1 inch	=	25.4 mm
1 m/s	=	3.23 ft/sec

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