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PAINTS AND
COATINGS
SKILL COUNCIL

Participant Handbook

Sector
Paints and Coatings

Sub-Sector
Application

Occupation
Industrial Paint Application

Reference ID: **PCSC/Q5109, Version 2.0**
NSQF Level 4

Protective and Marine Painter

Published by

PAINTS AND
COATINGS
SKILL COUNCIL

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PAINTS AND COATINGS SKILL COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/ Qualification Pack: '**Protective and Marine Painter**' QP No. '**PCS/Q5109 NSQF Level 4**'

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Authorised Signatory
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Paints and Coatings Skill Council

About this book

This Participant Handbook is designed to train participants for the job Protective and Marine Painter a NSQF approved level 3 qualification covered by QP reference no. PCS/Q5109.

The individual at work assesses the environmental conditions which the substrate has to withstand, prepares its surface, and then applies protective as per company's standards or customer's requirements.

This QP consists of 6 NOS, each dealt under a separate unit as follows

1. PCS/N5110	Prepare to paint the surface.
2. PCS /N5111	Paint the surface.
3. PCS/N9901	Coordinate with colleagues and/or Customers.
4. PCS/N9902	Maintain standards of product/service quality.
5. PCS/N9903	Maintain Occupational, Health and Safety standards and follow environmental norms.
6. PCS/N9904	Maintain IPR of organisation and customers.

Symbols Used

Key Learning Outcomes	The key learning outcomes are listed at the beginning of each module. These outline the focus areas that the learners will cover in every module.
Tips	Wherever possible, tips are included in every module. They provide additional insight to learners on a particular topic being discussed.
Steps	These provide step-by-step instructions for a specific process.
Notes	Notes at the end of each module is a space for learners to list down their key points related to the topic.
Summarize	These provide the summary or the takeaways of the unit.
Unit Objectives	These are listed at the beginning of each unit under every module. They highlight the focus areas that the learners will cover in every unit.

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PAINTS AND
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1. Introduction

Scan the QR code for video

Key Learning Outcomes

At the end of this module, you will be able to:

1. Discuss the paints and coatings sector in India, and its sub-sectors
2. What is paint and how it is made?
3. Name different types of paints and their characteristics.
4. Mix and prepare the paint by mixing the base,hardner(if recommended) and thinner as recommended by the manufacturer.
5. Assist in estimating the time,material and equipment required.
6. Importance of colours and standards for colour.
7. Gain in-depth knowledge about finish and types of finish
8. Describe the role and responsibilities as an Protective and Marine Painter.
9. Demonstrate how to apply the paint on the prepared surface,using either brush/roller or spray.

UNIT 1.1 About Paints and Coatings Sector in India

Unit Objectives

At the end of this unit, you will be able to:

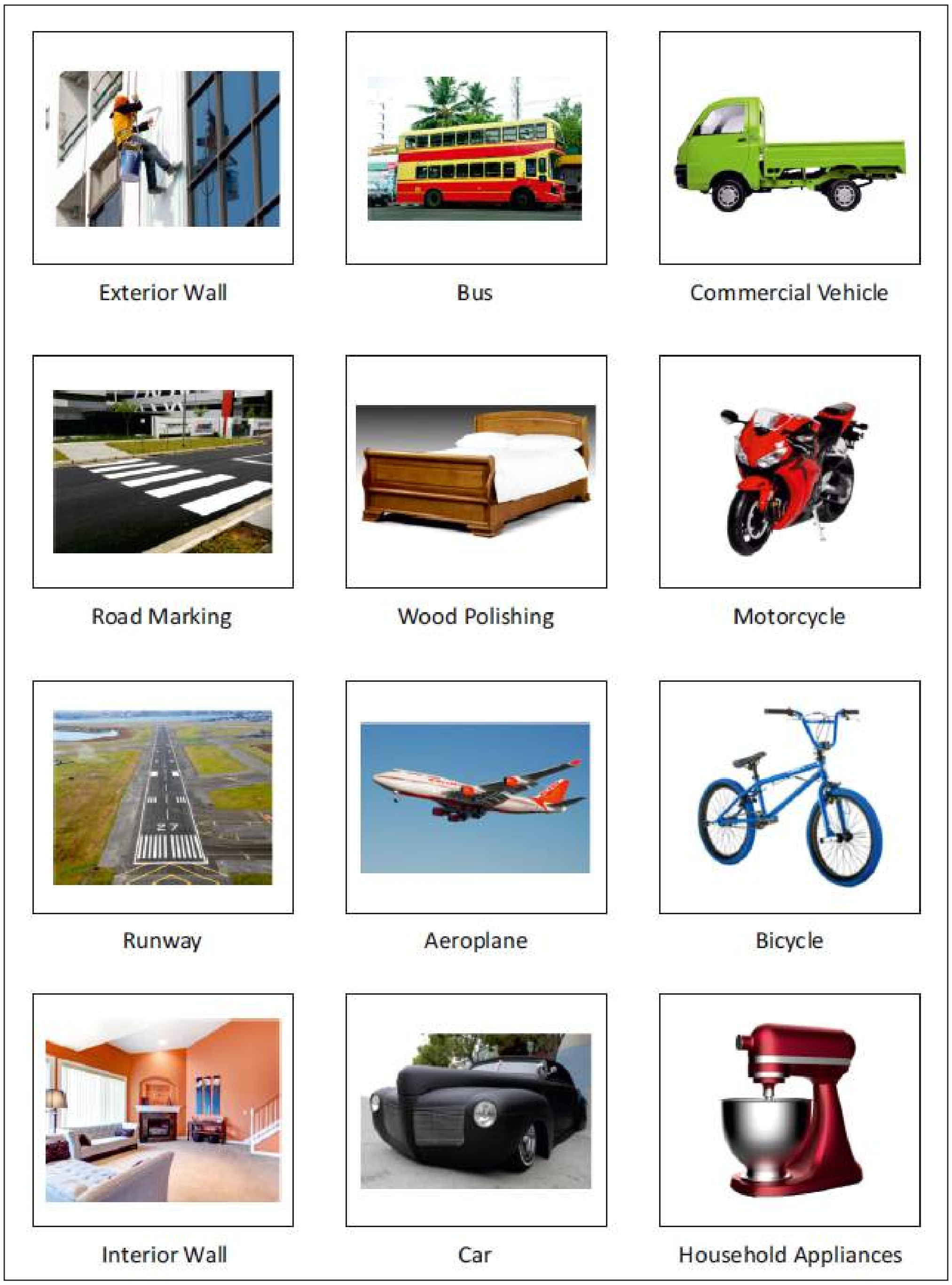
1. Explain what paints and coatings are
2. Describe the purpose behind the use of paints

Paints are present all around us. Wherever we look we see paint in some form – on walls, doors, floors, furniture, fans, cell phones, gas cylinders, cars, computers and laptops, motorcycles and scooters, trains and buses, shop signage and road signs, bridges, electric poles, pipelines — the list goes on. As you see, there are very few articles or items that we see or use in our daily lives that do not carry some coating or the other. You will be surprised to know that even metal cans that are used to pack food and beverages, glass bottles carrying soft drinks and other products, metal tips of shoe laces, door knobs and handles, airport runways and factory rooftops, aeroplanes and ships – all have coatings applied on them for protection, indication or decoration. The paint industry adds so much colour and convenience to our everyday lives that it would be difficult to imagine a world without it! As you look around and see the universal presence of coatings everywhere, you would also realise that the paint and coatings field is quite complex.

What is the purpose behind the use of paints? Decoration is certainly one important reason why paints are used. They lend colour and beauty to objects on which they are applied and greatly increase their visual appeal. An equally important reason for the use of paints is protection. The life of products, especially those made of metal or wood is enhanced if an appropriate coating is applied on them. The universal use of iron and steel on various industrial and household products would be unthinkable in the absence of coatings to protect them. Likewise, Wooden furniture and articles are known to last centuries if they are protected by regular application of coatings on them. Our ancestors understood this, which explains why varnishes and lacquers are as old as civilisation itself.

Coatings are also used for "indication". All of us are aware that red is a colour used to indicate danger or fire and hence fire tenders, stop signs and caution/danger signals are invariably painted red. Ambulances and hospital furniture are always painted white while school buses are yellow. You will find that paints help to identify and make life convenient for us. White road marking, red post boxes, green park fencing, black and yellow taxis and auto rickshaws – one can think of many such examples.

Paints also help to improve cleanliness and hygiene. Coatings with antifungal properties help to keep walls in homes and buildings free from fungus especially in damp weather. Coatings used in food cans prevent the contents from spoiling and serve as a protective barrier. Coatings can even help retard fire or enhance the protection against fire. Thus, there are many uses for paints and coatings in our everyday life. While the common person sees it as being colourful with a great deal of variety, to the technical people formulating and making paint and to those who apply it on surfaces, it is a complex world — of different chemistries and technologies, of a range of demanding and often conflicting requirements of many application challenges and steadily increasing customer expectations.



Exterior Wall

Bus

Commercial Vehicle

Road Marking

Wood Polishing

Motorcycle

Runway

Aeroplane

Bicycle

Interior Wall

Car

Household Appliances

Fig 1.1: Paints are used everywhere

Notes

UNIT 1.2 Classification of Paints and the Coatings Industry

Unit Objectives

At the end of this unit, you will be able to:

1. List different types of paints

Broadly, paints are of two types, viz. decorative and industrial.

Decorative paints consist mainly of products that go on interiors and exteriors of buildings as well as on furniture items to make them look aesthetically pleasing. Industrial paints include a wide variety and are further classified under various subgroups, such as Automotive OE, Automotive Refinish, Powder Coatings, General Industrial, Coil Coatings, Protective and Marine Coatings, Packaging Coatings etc.

DECORATIVE	INDUSTRIAL
Building Exteriors	Automotive OE Finish
Building Interiors	Automotive Refinish
Furniture	Powder Coatings
	General Industrial Paints
	Coil Coatings
	Protective Coatings
	Marine Coatings
	Packaging Coatings

Notes

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UNIT 1.3 Basics of Paint Chemistry and Paint Manufacture

Unit Objectives

At the end of this unit, you will be able to:

1. Talk about the components of paint and their types
2. Explain characteristics of resins/binders used for paints.
3. Explain different paint systems and their features or characteristics

1.3.1 Components of Paints and Coatings

The success of any coating depends on its nature, chemical composition, the physical condition of the substrate and application techniques. The compositions vary considerably depending on the end applications, economics and the durability expectations of the coated components. A typical paint product is a homogenous mixture of pigments, extenders, resins or binders, additives and solvents.

Pigments: Pigments are powder material insoluble in resin, water, or solvents and impart colour and opacity (hiding power) to the paint. They may be organic or inorganic. Combinations of different coloured pigments give a variety of other colours. In metallic colours, aluminium / other metal pigments and effect pigments (pearl mica) are used to impart sparkling / metallic effect.

Fig 1.3.1 (i): Colour pigments

Fig 1.3.1 (ii): White pigment

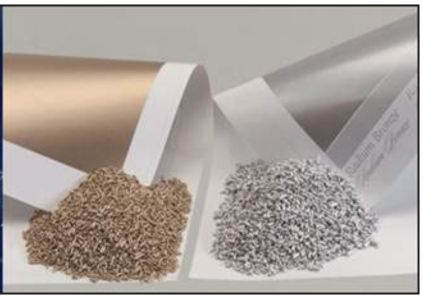


Fig 1.3.1 (iii): Metallic pigments

Fig 1.3.1 (iv): Extender

Extenders: Extenders are economical minerals added to increase the pigment content of the paint and contain the cost. They give filling properties, increase bulk volume and add certain desired properties to the paint. Calcium carbonate is a typical extender.

Resins or Binders: Resins are prepared by a chemical process called polymerisation. The resin helps to bind the pigment particles together and hence it is also called a binder. It is a major ingredient of any paint and is responsible for the film formation in a paint. The paint performance depends mainly on the type and quality of resin. Different resins are used in paints depending on the end use. Resins may be solvent based or water based.

Fig 1.3.1 (v): Resins used in coatings

Alkyd Resin **Polyester Resin** **Thermosetting Acrylic Resin** **Epoxy Resin**

Fig 1.3.1 (vi): Types of resins

Additives: Additives are used in small quantities for enhancing certain desired properties like pigment wetting and dispersion, ease of application, flow and levelling, drying, curing, UV resistance, colour stability etc. In general, additives upgrade the performance properties of paint. Examples – anti-settling agent, anti-skinning agent, anti-sag agent, flow modifier, adhesion promoter, de-foamer, wetting agent, driers, matting agents etc.

Fig 1.3.1 (vii): Additives in liquid and powder form

Solvents: These are liquids used to reduce the viscosity of paint so that it can be easily applied on the surface. Solvents can be classified as aliphatic (mineral turpentine), aromatic (xylene, toluene), alcohols, ketones and esters. For water based products, water is the solvent.

A solvent may be a true solvent, co-solvent or a diluent. Different solvents have different ability to dissolve resin. A solvent that dissolves a resin is the true solvent for that resin. Co-solvent dissolves the resin in the presence of the true solvent. A diluent is used only to reduce the viscosity. There are fast evaporating, medium evaporating and slow evaporating solvents. Generally, a combination of different solvents is used to achieve the desired film performance.

Powder coating, which is paint in a dry powder form, does not require any solvent during manufacture or application. As we shall see in the next sections, the manufacturing process for powder coating differs from that of liquid paints. The equipment used for powder manufacture are also different.

1.3.2 Characteristics of Different Resins

As we have already seen, resin is a major ingredient in paint and is responsible for making the paint into a film. There are different types of resins that can be used to make paint. It is important to understand the characteristics of each resin type as they determine the properties of the final paint.

TYPE OF RESIN	CHARACTERISTICS
ALKYDS	Alkyds are economical resins, mainly used in architectural paints. Enamel or oil paint is based on this resin. Technically, an alkyd is an oil modified polyester. By adding driers (special additive) these paints are made air-drying type. Paint film formation takes place at room temperature.
POLYESTERS	These resins are superior to alkyd resins in performance. They are mainly used in automotive/general industrial paints and powder coatings.
ACRYLICS	These resins have good durability against ultraviolet rays. They are mainly used in automotive clear coats, base coats and mono coats.
EPOXIES	Epoxies have good corrosion resistance, chemical resistance and water resistance properties. They are used mainly in protective coatings. These paints are supplied as base and hardener packed in separate containers. Such paints are called two pack (2K) paints.
AMINO	These are melamine formaldehyde (MF) or urea formaldehyde (UF) resins used for curing and achieving hardness of the paint film. These resins crosslink with alkyd, polyester, epoxy resins and give excellent toughness. This reaction starts at high temperature (above 120° C). Hence, such paints are supplied as one pack (1K) paint. MF resin is widely used in automotive paints.
ISOCYANATE	This hardener reacts with alkyd, polyesters and acrylic resins to form Polyurethane coatings. The crosslinking reaction between the -OH of the resins and -NCO of the isocyanate hardener starts at room temperature, once the two are mixed. Hence these paints are supplied as 2K (base and hardener) packed in separate containers.

1.3.3 Manufacture of Liquid Paints

There are five main stages in the manufacture of liquid paints as described below. A product may go through all or only some of these stages.

PRE-MIXING	GRINDING OR DISPERSION	THINNING/LET DOWN	FILTRATION	PACKING
This is the first stage. Measured quantities of raw materials are mixed using a high-speed stirrer. Agglomerates of pigments and other powder materials break down to give a uniform and homogeneous slurry	This is the most important stage in paint manufacture. Here the pre-mixed slurry passes through a mill that helps to break down the pigment agglomerates into primary particle size of the pigments. The output from this stage is finely ground pigment particles dispersed in the resin solution. It is referred to as the mill base.	The finely dispersed mill base is thinned down to the required viscosity. Adjustment for colour and other properties is also done at this stage. The quality of the paint is then tested for adherence to specifications	The paint is filtered to remove any foreign matter and/ or larger agglomerates before packing	This is the last stage where the product is packed, labelled as required for final sale

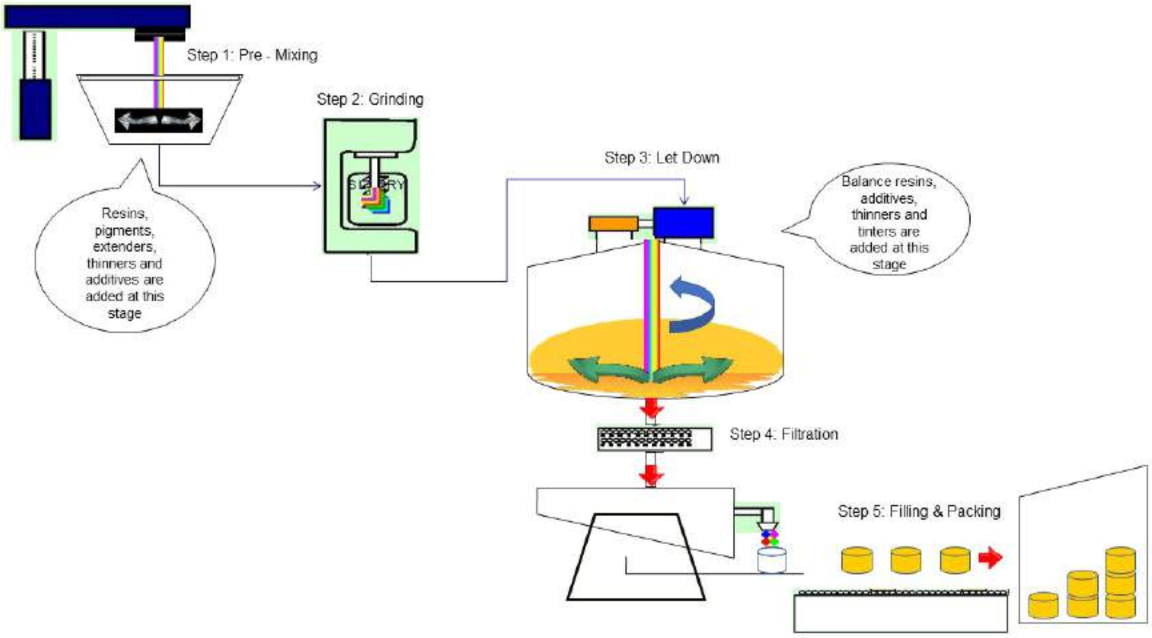
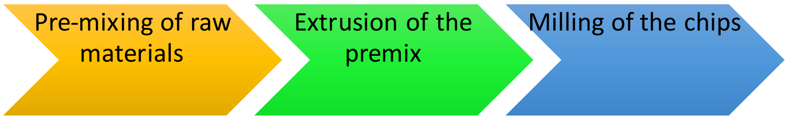


Fig 1.3.3: The main stages in the manufacturing process

1.3.4 Manufacture of Powder Coatings

The three principal steps in manufacture of powder coatings are illustrated and described as below.



PRE-MIXING RAW MATERIALS	EXTRUSION OF THE PREMIX	MILLING OF CHIPS
Measured quantities of resins, pigments, extenders and additives are added into a premix vessel. The homogenous mixture of all raw materials is referred to as the premix. After requisite adjustments and quality checks, it is sent to the next stage.	This stage helps convert the premix into chips (also called flakes). The premix, is homogenised by passing it through an extruder. In the extruder, the premix is heated to melt the resins and the pigments, extenders, additives etc. are dispersed in the molten resin. The compounded molten mass is forced out of the extruder and cooled. It then solidifies to form a thin sheet which is broken into flakes or chips.	Milling or pulverisation refers to the chips being ground to a powdered form, i.e. the final product.

Note: For some powders, a fourth step is also required after milling, called post blending or tumble blending. This is required for metallic and effect finishes. The metallic or pearl pigments are added with the powder and after homogeneous mixing, the finished product is packed.

Fig 1.3.4 (i): Powder extruder

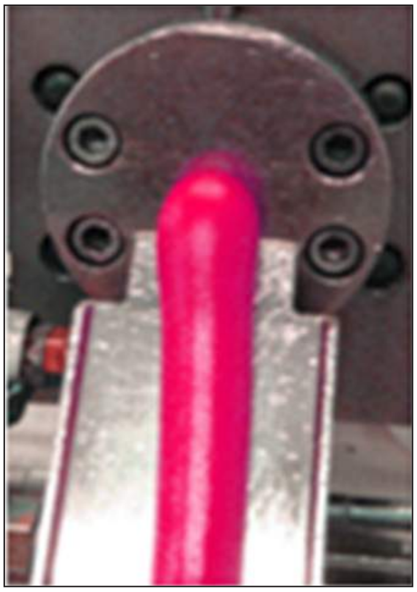


Fig 1.3.4 (ii): Powder extrudate

Fig 1.3.4 (iii): Chilled rollers

Fig 1.3.4 (iv): Flattening + cooling

Fig 1.3.4 (v): Powder chips

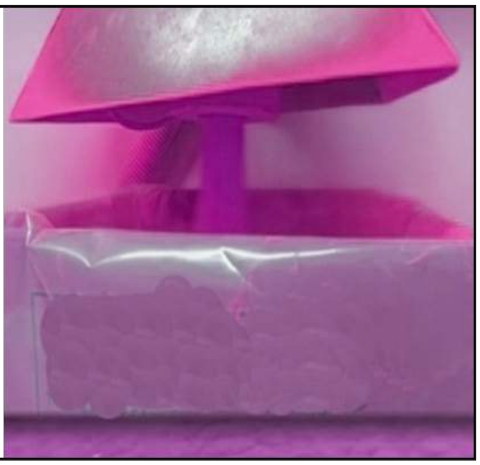


Fig 1.3.4 (vi): Powder pulverisation

1.3.5 Paint Systems

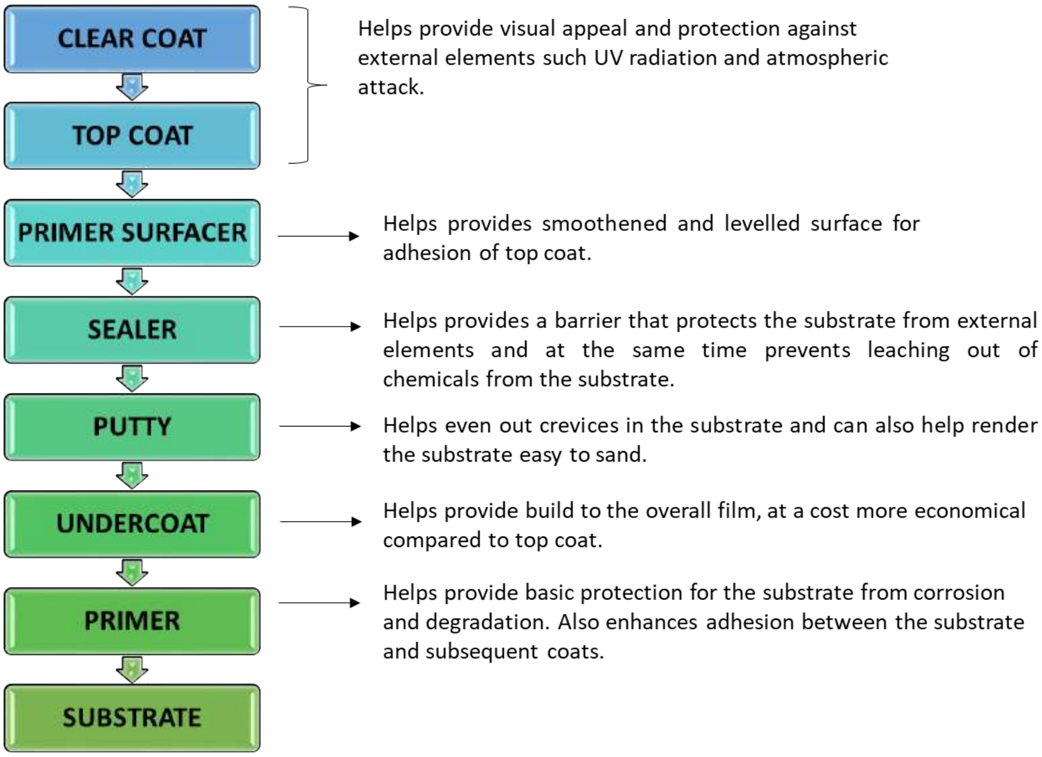
The beautiful smooth or textured walls in our homes and the gleaming cars that we see on a day-to-day basis are painstakingly achieved by applying layer after layer of different paint systems. Additionally, bridges and building exteriors withstand years of damage caused by natural elements such as sunlight and rains because of careful and scientific application of several layers of anti-corrosive paints.

A paint system is essentially a (usually pre-specified) systematic multi-layer application of paint products to various substrates. Each layer in the system has a specific function. Different products are applied in a defined sequence to achieve best results for each substrate. The paint system and the products employed depend on the following:

1. Substrate
2. The service to which the final product is put, extent of wear and tear with exposure to natural elements that it will be subjected to
3. Handling

A surface to be coated is referred to as a substrate. The coating on the substrate must work towards its protection and over all visual appeal. Commonly coated substrates we encounter everyday are wood, plastic, metals and masonry.

A typical paint system is illustrated below.



Helps provide visual appeal and protection against external elements such UV radiation and atmospheric attack.

Helps provides smoothened and levelled surface for adhesion of top coat.

Helps provides a barrier that protects the substrate from external elements and at the same time prevents leaching out of chemicals from the substrate.

Helps even out crevices in the substrate and can also help render the substrate easy to sand.

Helps provide build to the overall film, at a cost more economical compared to top coat.

Helps provide basic protection for the substrate from corrosion and degradation. Also enhances adhesion between the substrate and subsequent coats.

Fig 1.3.5: A typical paint system for automotive coating

1.3.6 Comparison of Paint Systems

We have already seen that there are many different types of resins that can be used in the manufacture of paints. Paint technologists refer to these as different paint chemistries. Thus, a paint chemistry is defined by the binders or resins that are used to make it.

Paints from different chemistries vary in properties such as curing time and temperature, appearance, mechanical properties, durability, chemical resistance, cost etc. Thus, depending on the end use requirements of the painted product / surface, the right chemistry is chosen.

Paints are classified based on the type of resin used such as alkyd based paints, polyester paints, acrylic paints, epoxy paints, alkyd-amino paints, polyurethane paints etc. Further, paints are classified by:

- The physical state - liquid paint, stiff paint, powder coating
- Mode of thinning: water thinnable / solvent thinnable
- End use: architectural, industrial, protective coatings, automotive coatings etc.
- Mode of drying: air drying, forced drying, baking / stoving, UV cured
- Order of application: Undercoats (primer, primer surfacer) and top coats

In the case of powder coatings, the types of powders based on resin chemistry include epoxy, epoxy-polyester, pure polyester, polyurethane and acrylic powders.

1.3.7 Comparison of Different Liquid Paint Systems

We have already seen different resins that are used in paint under section 1.3.2. As indicated there, each type of resin lends different characteristics to the paint where it is used. Paints also differ in terms of their curing pattern. Thus, a paint could be either one component (1K) or two component (2K). The two component paints are supplied as a base and hardener in separate packs.

DRYING/CURING	PAINT TYPES
AIR DRYING	• Enamel (IK) • Emulsion (IK) • Acrylic (1K) • Polyurethane (2K) • Epoxy (2K) • Chlorinated rubber (1K) • Bituminous Paint
STOVING	• Stoving Enamel • Thermosetting Acrylic • Epoxy Esters • Blocked Isocyanate • Polyesters • Powder Coating
MOISTURE CURED	• Polyurethane (IK) • Epoxy (IK)

1.3.8 Comparison of Different Powder Systems

The advantages and disadvantages of different types of powders are enumerated in the table below.

POWDER SYSTEM	ADVANTAGES	LIMITATION
EPOXY	• Good chemical resistance • Best corrosion resistance • Better surface hardness • Better mechanical properties	• Poor UV resistance • Sensitivity to colour variations when exposed to heat or sunlight
EPOXY POLYESTER	• Good flow • Good application properties • Low colour variation • Flexibility in formulation	• Slightly better UV resistance than epoxy.
POLYESTER	• Good outdoor durability • Good mechanical properties • Good colour stability	• Lower chemical and solvent resistance than epoxy.

POLYURETHANE	• Good mechanical properties • Good chemical resistance • Better outdoor durability • Good flow and smoothness	• High cost • Emission of blocking agent during curing
ACRYLIC	• Best flow and clarity • Good chemical properties • Best hardness • Better outdoor durability • Best for clear powders	• Severe incompatibility with other powders • Storage stability • Poor pigment wetting • Expensive

Fig 1.3.8 (i): Pure Epoxy (PE) usage on coated pipes and valves

Fig 1.3.8 (ii): Pure Polyester (PP) usage on wheel rims and stand of a car’s rear view mirror

Fig 1.3.8 (iii): Epoxy Polyester (EP-Hybrid) used on lockers and shock – absorbers

Fig 1.3.8 (iv): Polyurethane (PU) or Acrylic (Ac) applied on industrial parts

1.3.9 A World of Many Products and Opportunities

It would thus be seen that both in the case of liquid paints and in the case of powders there is a wide variety of products to choose from. Paint professionals needs to be aware of the different types of products and their properties. They should also be able to explain the advantages and disadvantages of different types of products. Further, the correct product as specified by the customer or in the technical specifications must be used.

You will thus notice that paint is a fascinating product. Just think of this one example: today a motor car made almost entirely of steel, a metal that corrodes easily and rapidly when exposed to normal weather, can, when correctly painted with good quality paint available in India, take the highly corrosive outdoor environment of coastal cities such as Mumbai or Kochi with hot summers and wet monsoons and not show any sign of corrosion even after ten years.

Several job opportunities exist in the making, packing, distribution and sale of paints, broadly referred to as the manufacturing sub-sector of the industry. You can acquire skills required by paint factories – for example in processing, colour matching, filling and packing or quality control; or in sales outlets, mixing and tinting colours to customer specifications.

However, the bigger part of the paint sector is the application sub-sector. It offers a much larger scope for employment - in the application of paints: be it architectural paints, wood finishes or industrial paints.

Notes

UNIT 1.4 Colour

Unit Objectives

At the end of this unit, you will be able to:

1. Explain concept of colour
2. Talk about different categories of colour
3. Discuss how we perceive colour

1.4.1 Colour Concepts

When we speak of paints, the first thought that comes to our mind is that of colour. We always associate paints with colour. We see the colour of an object when light falls on it and gets reflected. In darkness, we see no colour. Similarly, under different light sources such as sunlight, fluorescent light or sodium vapour street lights the same object will appear different in colour. So the colour that we perceive depends on the light source. When we speak of colour, we normally refer to what is seen in day light. The colour of an object that we perceive changes with the light source.

Colours can be classified as follows:

Primary colours

- Red, yellow and blue are called primary colours.
- They cannot be obtained by mixing together other colours.

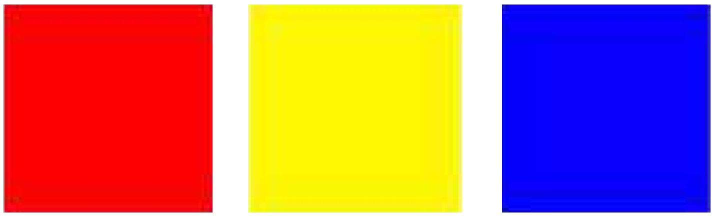


Fig 1.4.1 (i): Primary colours

Secondary colours

- Orange, green and violet are called secondary colours.
- They are obtained by mixing in equal amounts two adjoining primaries.

Fig 1.4.1 (ii): Secondary colours

Mixing of colours

- Yellow + Blue = Green
- Red + Yellow = Orange
- Blue + Red = Violet

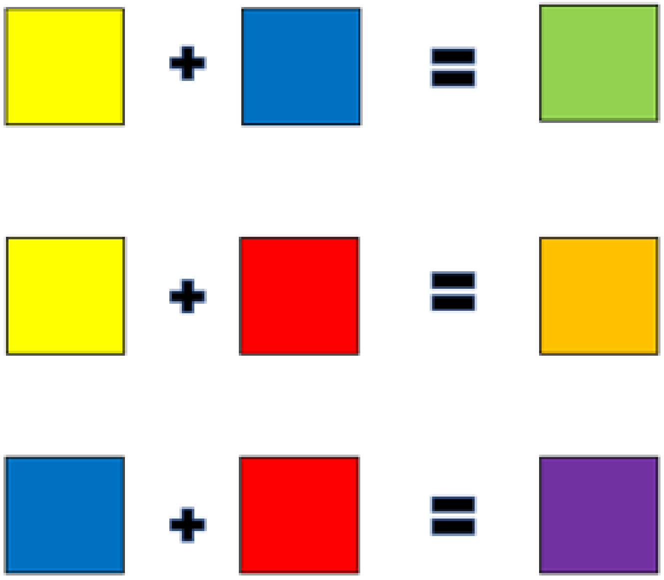


Fig 1.4.1 (iii): Mixing of colours

Intermediary colours

When the primaries are not mixed in equal amounts, intermediary colours are formed, such as yellow-green (chartreuse), green-yellow (apple green), etc.

- Yellow-Green
- Blue-Green
- Blue-Violet
- Red-Violet
- Red-Orange
- Yellow-Orange

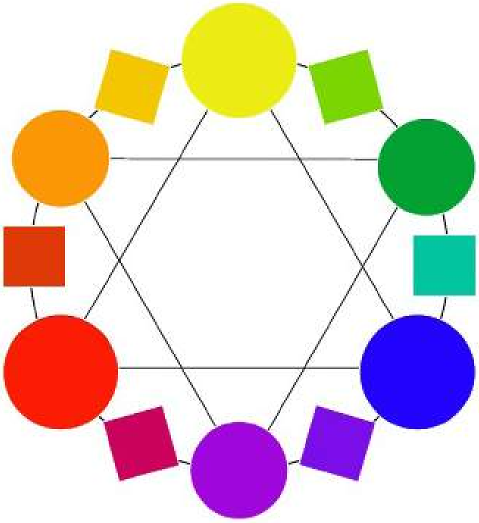


Fig 1.4.1 (iv): Intermediary colours (pinsdaddy.com)

Tertiary Colours: Tertiary colours are obtained by mixing two secondary colours, such as orange with green (olive), green with violet (slate) or violet with orange (russet).

Fig 1.4.1 (v): Tertiary colours (firstascentdesign.com)

Complimentary Colours: Colours that appear opposite each other on the colour wheel are called complimentary colours. Complimentary colours include: red and green, yellow and blue etc. A complimentary colour is often used to reduce the chroma (brightness or intensity) of its opposite. When two complimentary colours are mixed in equal parts, although theoretically they should produce black, they produce neutral a greyish dark brown.

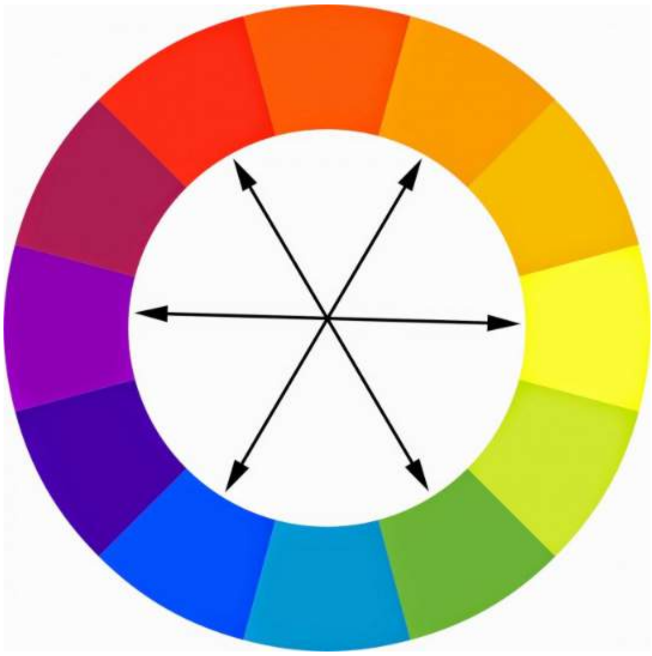


Fig 1.4.1 (vi): Complimentary colours (copicmarkertutorials.com)

	Warm Colours	**Cool Colours**
HUES	Reds Yellows Oranges Red violets	Blues Blue-greens Blue-violets
NATURE	Vivid, bold	Calming, soothing
USUALLY DEPICT	Sun, fire, heat, warnings	Water/water bodies, cold environs, freshness

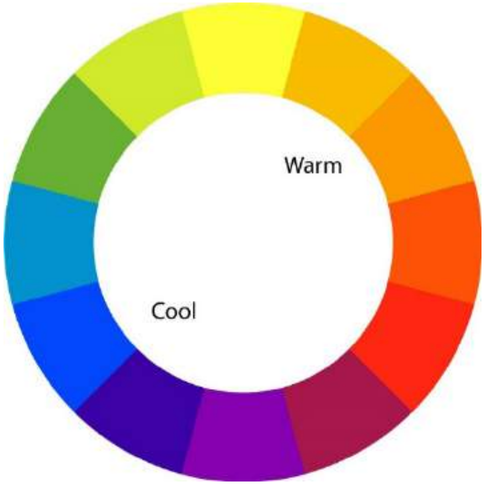


Fig 1.4.1 (vii): Warm and cool colours (webflow.com)

Notes

UNIT 1.5 Colour Standards

Unit Objectives

At the end of this unit, you will be able to:

1. Explain what are colour standards and why they are useful

Fig 1.5: RAL shade card

RAL is used for information defining standard colours for paint and coatings. It is the most popular central European Colour Standard used today. The colours are used in architecture, industry and road safety. The human eye distinguishes about ten million colour shades. How can we tell exactly which colour we mean? With the use of RAL colour charts!

Since 1927, RAL has created a uniform language when it comes to colour. It has standardised, numbered and named the abundance of colours. These standards are easily understandable and applicable - worldwide. Some example colours from the RAL colour chart are mentioned below. The first digit relates to the shade of the colour:

1xxx Yellow RAL 1000	Green Beige - RAL 1034 Pastel Yellow (27)
2xxx Orange RAL 2000	Yellow Orange - RAL 2012 Salmon Orange (12)
3xxx Red RAL 3000	Flame Red - RAL 3031 Orient Red (22)
4xxx Violet RAL 4001	Red Lilac - RAL 4010 Telemagenta (10)
5xxx Blue RAL 5000	Violet Blue - RAL 5024 Pastel Blue (23)
6xxx Green RAL 6000	Patina Green - RAL 6034 Pastel Turquoise (32)
7xxx Grey RAL 7000	Squirrel Grey - RAL 7047 Telegrey 4 (37)
8xxx Brown RAL 8000	Green Brown - RAL 8028 Terra Brown (19)
9xxx White/Black RAL 9001	Cream - RAL 9018 Papyrus White (12)

UNIT 1.6 Types of Finish

Unit Objectives

At the end of this unit, you will be able to:

1. Explain finish
2. List different types of finishes commonly used

Besides colour there are two other aspects describing the appearance of a finish that you will come across – 'Gloss' and 'Type of finish'. Gloss refers to the shine in the paint film. A high gloss surface appears mirror like whereas a matt finish is dull or flat. The gloss level is expressed as percentage of the light that is reflected from a surface in a mirror like fashion. Since the extent of reflection also depends on the angle at which the surface is held, gloss level is measured and expressed as a value at a specific angle.

FINISH	GLOSS LEVEL
Dead Matt	0-15%
Matt	15-30%
Egg Shell Matt	30-45%
Satin	45-60%
Semi Glossy	60-75%
Glossy	75-90%
High Gloss	90% +

Type of finish refers to the texture or the visual feel of the finish. Examples of common types of finish are illustrated below.

Fig 1.6 (i): Gloss, semi-gloss and matt finish

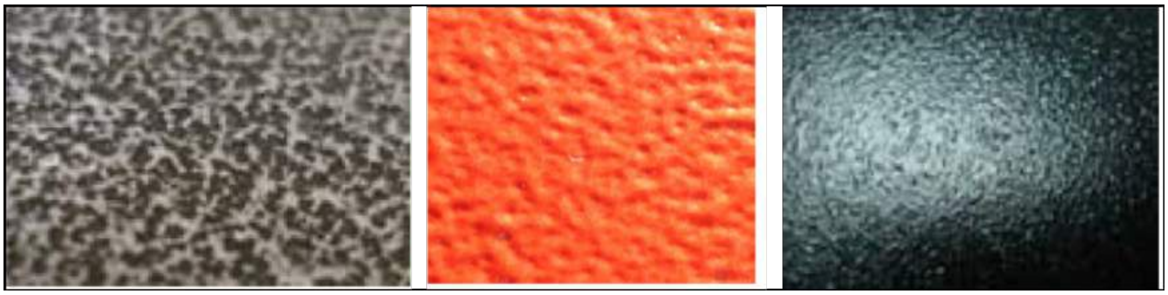


Fig 1.6 (ii): Hammer tone finish, structure finish and coarse texture

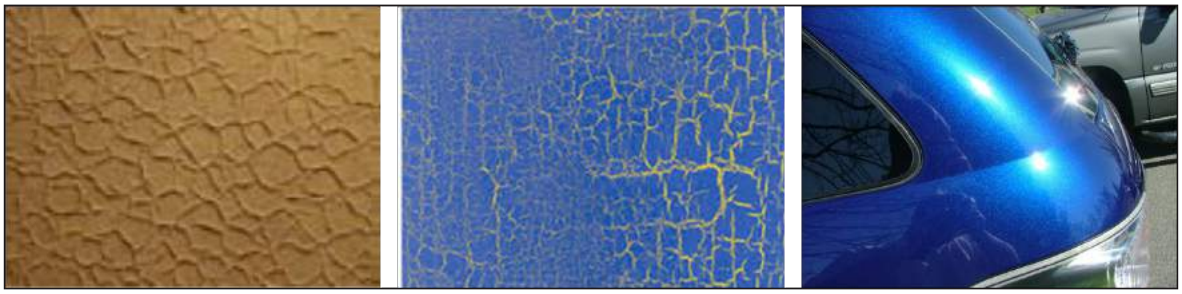


Fig 1.6 (iii): Wrinkle, antique and metallic finish

Notes

UNIT 1.7 Gloss Measurement

Unit Objectives

At the end of this unit, you will be able to:

1. Explain gloss and its measurement
2. Describe how gloss value is expressed

- Gloss is measured by a gloss meter at different angles
- Gloss reading depends on the angle at which it is measured. So, gloss is always expressed as a percentage at an angle (e.g.: 60% at 20°)
- An angle of 60° is most common in the coating industry. Usually recommended for medium gloss levels.
- An angle of 20° is used to achieve a more differentiated result of high gloss surfaces usually recommended for Automotive class "A" finish using liquid coatings
- An angle of 85° is used to achieve a more differentiated result of low gloss surfaces, not so popular in coating industry

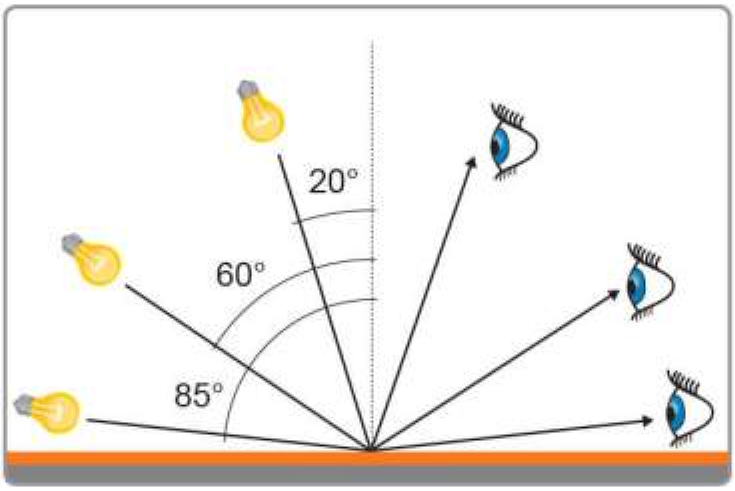


Fig 1.7: Reading gloss at different angles

Fig 1.8: Digital Glossmeter

UNIT 1.8 What are Protective and Marine Coatings?

Unit Objectives

At the end of this unit, you will be able to:

1. Describe what a protective and marine painter does
2. Learn and understand about advantages of protective coatings
3. Explain about different types of corrosion

Protective and marine coatings are products used for protecting industrial and marine assets which are subject to severe corrosion. Industrial assets falling in this category include refineries, oil storage tanks, factory structures, chemical plants, pipelines, bridges, wind mills etc. Likewise, marine assets include offshore platforms, jetties, ships and coastal installations. Application of protective coatings is aimed at prolonging the life of these assets by slowing down the process of corrosion.

1.8.1 Advantages of Protective Coatings

- Exceptional chemical, corrosion and UV resistance
- Superior abrasion resistance
- Anti-fouling property for marine vessels
- Long life and good finish

Paint is the most commonly used material to protect steel. Paint systems for steel structures have developed over the years to comply with environmental legislation and in response to demands for improved durability performance.

Fig 1.8.1 (i): Pipes (dynamicco.com)

Fig 1.8.1 (ii): Tanks

Fig 1.8.1 (iii): Ships

Fig 1.8.1 (iv): Bridges

Fig 1.8.1 (v): Steel structures

Fig 1.8.1 (vi): Refineries

Fig 1.8.1 (vii): Power plants and wind turbines

Fig 1.8.1 (viii): Offshore platforms

As illustrated above, protective coatings are applied on a variety of jobs in different environments. These are impacted by various types of corrosion, requiring different paint systems for protection. Protective coatings could be used on new assets as well as for re-painting of existing assets. There are many similarities between maintenance and new coating work. Some important additional considerations for maintenance work are:

- Compatibility with existing coatings
- Surface preparation and application
- Limited time
- High contamination by service conditions
- Application in a running facility

Based on the corrosion protection requirement, the nature and service conditions of the asset and economic considerations, the owner of the asset has a wide selection of paint systems to choose from. The table below lists different types of paint systems available and their characteristics/uses.

NO	PRODUCT	CHARACTERISTICS
1	**ACRYLICS**	• Excellent UV and weathering resistance • Can be applied as coalescence curing emulsions and water dispersions • Historically applied as decorative and durable coating rather than for corrosion resistance
2	**ALKYDS**	• Oxidative curing • Also known as “oil based paints” • Supplied as single pack material • Can be very slow curing products • Should not be applied on concrete
3	**CHLORINATED RUBBER**	• Evaporation curing • High" VOC" • Excellent resistance to water, sunlight and many petroleum-based chemicals • Use discontinued in most parts of the world

4	**EPOXY**	• Two component system - Epoxy resin (Base), Curing agent (Hardener) • Either solvent-based, water-based, or solvent-free • Excellent adhesion, chemical resistance, water-resistance, and wet adhesion
5	**PHENOLIC**	• Typically used where low pH environment and higher temperature are factors • Excellent resistance to acids
6	**POLYESTER**	• Have a short pot-life • Glass flake reinforced, high build coatings • Excellent moisture resistance Exceptionally high abrasion resistance
7	**POLYSILOXANE**	• Used in services with abrasion, chemicals, extreme UV and high temperatures. Three major categories: ♦ Inorganic Polysiloxanes ♦ Epoxy - Polysiloxane Hybrids ♦ Acrylic - Polysiloxane Hybrids
8	**POLYURETHANES**	• Two major types ♦ Aliphatic - more durable and resistant to UV attack ♦ Aromatic - better chemical resistance in immersion • Main hazard is the isocyanate component • Available with a variety of curing times
9	**POLYUREA**	• Very flexible materials • Very short cure times • Many require the use of an epoxy primer on steel
10	**SILICONES**	• Excellent high temperature and UV resistance • Cure by a combination of solvent evaporation and heat • Also used as foul-release coatings in the marine industry
11	**VINYL ESTERS**	• Often referred to as linings • Normally two-component coatings • Have rather short pot life • Excellent abrasion resistance with glass flake added
12	**VINYLS**	• One of the earliest industrial coatings • Were used on highway bridges and extensively in the marine industry • Banned from use in most countries due to high VOC
13	**ZINC (INORGANIC)**	• Probably the most used primer for steel structures in the world • Primer with the ability of providing cathodic protection • Very resistant to different chemicals and especially solvents • Very high heat resistance with a max of 400°C (750°F)
14	**ZINC (ORGANIC)**	• Similar to inorganic zinc • Epoxy coating with zinc filler • Cathodic protection factor

Understanding a coating with its functions will help us understand why specific a protective coating system is used for a specific application.

Fig 1.8.1 (ix): Acrylics

Fig 1.8.1 (x): Alkyds

Fig 1.8.1 (xi): Chlorinated Rubber

Fig 1.8.1 (xii): Epoxy

Fig 1.8.1 (xiii): Phenolic

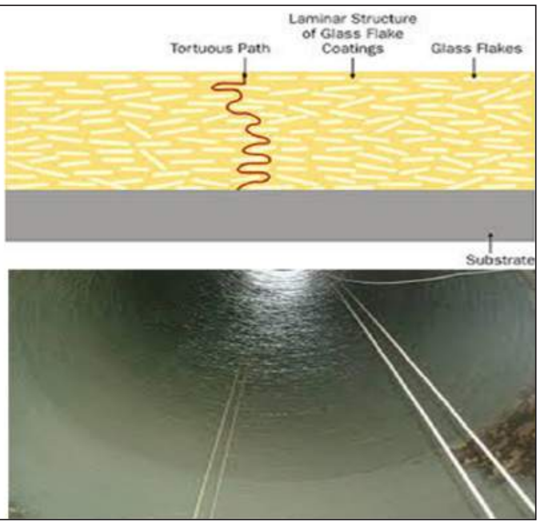


Fig 1.8.1 (xiv): Polyester

Fig 1.8.1 (xv): Polysiloxane

Fig 1.8.1 (xvi): Polyurethanes

Fig 1.8.1 (xvii): Polyurea

Fig 1.8.1 (xviii): Silicones

Fig 1.8.1 (xix): Vinyl Esters

Fig 1.8.1 (xx): Vinyls

Fig 1.8.1 (xxi): Zinc (Inorganic) alibaba.com

Fig 1.8.1 (xxii): Zinc (Organic)

The field of protective and marine coatings therefore encompasses a wide range of products applied under different kinds of demanding conditions. Since the technologies in designing and developing such products and for applying them require specialised expertise, this entire area of protective and marine coating is recognised as a separate field of expertise in the coatings industry.

1.8.2 Corrosion

Since corrosion protection is the basic function of a protective paint system, it is necessary to understand what it is. The most common example of corrosion is rust. The reddish-brown compound referred to as rust is iron oxide. It is a result of reaction between oxygen in the atmosphere and iron.

Fig 1.8.2 (i): Rust – a common example of corrosion

The oxidisation of iron is just one example of corrosion. Corrosion can take many forms, which are classified depending on the environmental causes. Corrosivity parameters typical for special environments include corrosive gases, chemical dust, splashes, biological, mechanical and thermal corrosion, and immersion in water or burial in soil. The immediate atmospheric environment that the surface is subject to is more important in terms of corrosion protection than the general environment. There are many types of corrosion, each of which can be classified by the cause of the metal's chemical deterioration. High humidity, moisture, or standing water allow corrosion to occur through the creation of an electrolyte. Steel generally corrodes when submerged in water. Humid environments have higher rates of corrosion than dry environments. The rate of corrosion can be slowed by dehumidifying the air, for example, in a confined space such as a ship's ballast tank or a storage tank. Presence of oxygen, chemical salts and elevated temperatures increases corrosion. Thus, offshore oil rigs, ships and chemical plants in coastal areas are exposed to severe corrosion. On the other hand, agricultural areas in dry desert regions are least effected. The nature of corrosion, the location of the structure, constraints if any on surface preparation application and economic reasons go into determining the paint system chosen for a given job.

The common types of corrosion are:

1. **General attack corrosion:** Also known as uniform attack corrosion, general attack corrosion is the most common type of corrosion and is caused by an electrochemical reaction that results in the deterioration of the entire exposed surface of a metal. Ultimately, the metal deteriorates to the point of failure. It accounts for the greatest amount of metal destruction by corrosion, but is considered a safe form, due to the fact that it is predictable, manageable and often preventable.

Fig 1.8.2 (ii): General attack corrosion

2. **Localised corrosion:** Unlike general attack corrosion, localised corrosion specifically targets one area of the metal structure. Localised corrosion is classified as one of three types:
    - Pitting
    - Crevice Corrosion
    - Filiform Corrosion

Fig 1.8.2 (iii): Localised corrosion

3. **Pitting:** It results when a small hole, or cavity, forms in the metal, usually as a result of de-passivation of a small area. This area becomes anodic, while part of the remaining metal becomes cathodic, producing a localised galvanic reaction. The deterioration of this small area penetrates the metal and can lead to failure. This form of corrosion is often difficult to detect as it is usually relatively small and may be covered and hidden by corrosion-produced compounds.

Fig 1.8.2 (iv): Pitting

4. **Crevice corrosion:** Like pitting, crevice corrosion occurs at a specific location. This type of corrosion is often associated with a stagnant micro-environment, like those found under gaskets, washers and clamps. Acidic conditions, or a depletion of oxygen in a crevice can lead to crevice corrosion.

Fig 1.8.2 (v): Crevice corrosion

5. **Filiform corrosion:** Occurring under painted or plated surfaces when water breaches the coating, filiform corrosion begins as small defects in the coating and spreads to cause structural weakness.

Fig 1.8.2 (vi): Filiform corrosion

6. **Galvanic corrosion**: It is also called dissimilar metal corrosion, occurs when two different metals are located together in a corrosive electrolyte. Three conditions must exist for galvanic corrosion to occur:
   - Electrochemically dissimilar metals must be present
   - The metals must be in electrical contact
   - The metals must be exposed to an electrolyte

Fig 1.8.2 (vii): Galvanic corrosion

7. **Environmental cracking:** This results from a combination of environmental conditions affecting the metal. Chemical, temperature and stress-related conditions can result in the following types of environmental corrosion:
   - Stress Corrosion Cracking (SCC)
   - Corrosion fatigue
   - Hydrogen-induced cracking
   - Liquid metal embrittlement

Fig 1.8.2 (viii): Environmental cracking

8. **Flow-assisted corrosion**: Also called flow-accelerated corrosion, it results when a protective layer of oxide on a metal surface is dissolved or removed by wind or water, exposing the underlying metal to corrode and deteriorate.

Fig 1.8.2 (ix): Flow-assisted corrosion

9. **Fretting corrosion**: It occurs due to repeated wear, weight and/or vibration on an uneven, rough surface. It results in pits and grooves, occurs on the surface. It is often found in rotating and impact machinery, bolted assemblies and bearings.

Fig 1.8.2 (x): Fretting corrosion

10. **High temperature corrosion:** Fuels used in gas turbines, diesel engines and other machinery, which contain vanadium or sulphates can, during combustion, form compounds with a low melting point. These compounds are corrosive when exposed to metal alloys that are normally resistant to high temperatures and corrosion, including stainless steel. High temperature corrosion can also be caused by high temperature oxidisation, sulphidation and carbonisation.

Fig 1.8.2 (xi): High temperature corrosion

1.8.3 The Effects of Corrosion

Safety: Corroded structures may be unsafe in a variety of ways. Steel bridges and structures that must support the weight of extreme loading are obvious examples. Corrosion cannot be allowed in the food and beverage industry, where metal corrosion products would contaminate the products.

Fig 1.8.3 (i): Effects of Corrosion—Safety

Cost: The cost of repainting and repairing rusted steel usually far outweighs the initial cost of protecting a surface against corrosion.

Fig 1.8.3 (ii): Effects of corrosion—cost of repairing and repainting

Appearance: Peeling coatings and rusting steel are an eyesore in any environment. For many engineers or facility owners, appearance is a major reason for painting their structures, just as we paint our house or finger nails to look nice.

Fig 1.8.3 (iii): Effects of corrosion—Appearance

Protective coatings: Paints and other organic coatings are used to protect metals from the degradative effect of environmental gases. The paint forms a layer on the surface and protects the steel from being corroded.

Fig 1.8.3 (iv): Coatings used to protect the surface

Notes

UNIT 1.9 Job Role of a Protective and Marine Painter

Unit Objectives

At the end of this unit, you will be able to:

1. Clearly state different aspects of your job

A protective and marine coater is a trained blaster / painter who possesses skills required to process steel for corrosion protection and apply protective coatings on products. This is a skilled job that requires specialised training. The value or benefit realised by the customer in terms of corrosion protection even from well formulated products could be severely compromised if the application is not carried out properly. Many customers therefore insist on painters having appropriate training, backed by recognised certification. A person trained in the application of protective and marine coatings could find employment with large organisations specialising in application of such coatings, engineering companies involved in project execution, maintenance departments of large public or private organisations in the infrastructure sector, railways, shipyards etc.

Building infrastructure is currently a key priority for India. Significant investments are being made in expanding highways, ports, oil and gas pipelines, water supply, rail network, power generation and distribution and green energy. Such investments will continue to expand in the foreseeable future as our country is still at a very early stage of development. Hence the need for persons qualified in the application of protective and marine coatings is expected to keep rising for several years to come, providing excellent employment opportunities to trained and experienced blasters and painters.

Persons skilled in this area can, over time, look forward to career growth in supervisory and managerial levels in contract painting organisations or in the maintenance sections of large chemical factories. They can also consider becoming entrepreneurs themselves by establishing a contracting organisation for carrying out painting contracts in this field.

Fig 1.9: High performance coating/inspection in progress

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2. Prepare to Paint the Substrate

Unit 2.1 - Environmental Conditions Affecting the Coating Job
Unit 2.2 - Inspecting the Surface
Unit 2.3 - Scaffolding
Unit 2.4 - Masking
Unit 2.5 - Surface Preparation

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Applicable NOS – PCS/N5110

Key Learning Outcomes

At the end of this module, you will be able to:

1. Discuss various preparatory steps to be completed during a protective coating job
2. Describe the impact of environmental conditions on the coating performance
3. Explain the importance of surface preparation and various methods available for ensuring the right quality of surface
4. Identify different types of scaffolding commonly used in protective painting jobs and ensure safe use of scaffolds
5. Describe blasting process, equipment used in blasting and types of blasting media

UNIT 2.1 Environmental Conditions Affecting the Coating Job

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the environmental conditions suitable for application of protective and marine coatings
2. State the methods of measuring relevant environmental parameters

Environmental conditions can greatly affect all phases of a coating operation. Environmental aspects that can affect a coating job are:

- Temperature at the surface of the substrate
- Ambient conditions, including:
    - Temperature
    - Relative humidity
    - Dew point
    - Wind velocity
    - Airborne contaminants (e.g., chemical fumes, auto exhaust, salt spray)

Surface Temperatures: Temperature of the surface to be painted and the ambient air temperature influence coating application. Both excessively cold and excessively hot temperatures can lead to coating defects. The acceptable range of surface temperature for coating is specified by the paint manufacturer and generally falls between 5°C and 50°C. It is also necessary to ensure that the substrate is at least 3°C above the determined due point to prevent moisture on the surface from being coated. Dew Point is the temperature at which moisture begins to form on a steel surface. The magnetic surface-contact thermometer is one of the most common instruments for determining surface temperature. The instrument must be allowed to stabilise before measurements are made; this takes at least 5 minutes. The measurement must be taken at several points within the area to be painted.

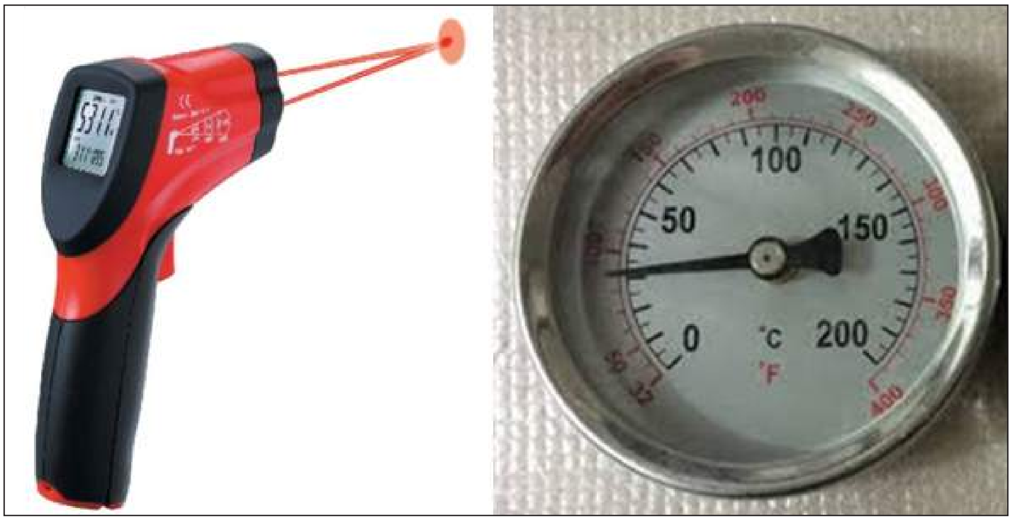

Fig 2.1 (i): Surface contact thermometer infrared and manual

Fig 2.1 (ii): Inspection and recording of ambient conditions

Ambient Conditions: No final blast cleaning or coating application should be done if the % relative humidity is more than 85% and the surface temperature is less than 3°C above the dew point. No coating should be applied or cured at temperatures below 0°C. The coating manufacturer specifies the maximum and minimum application and curing temperature and other relevant limitations regarding application and curing conditions for each product in any coating system.

% Relative Humidity: % Relative humidity is a measure of the amount of moisture in the air compared to saturation level (the amount it can hold at a given temperature) and may affect the coating operation because of either too high or too low % relative humidity. If the % relative humidity is too high, the solvent in the coating may not evaporate. This can result in solvent entrapment and problems in the proper curing of the film. Humidity at the site is measured using an electronic digital Hygrometer or a sling Psychrometer.

Fig 2.1 (iii): Sling psychrometer and digital meters to measure relative humidity

Wind Speed: Wind speed can adversely affect a coating job in several ways. It can:

- Blow abrasives from the abrasive-blast work area to an area where coatings are being applied
- Cause excessive drift or overspray of sprayed coatings
- Accelerate solvent evaporation after application
- Contribute to the formation of dry spray - There can be wind-blown contaminants (e.g., sea spray, salt, blast media, dust, or sand) on the coating job.

High wind speed can be a safety hazard. When work is performed at heights, wind speeds of 64 kmph or more are considered dangerous. When work is performed on offshore platforms, safety boats and rescue craft cannot operate reliably with high wind speeds, so work close to the sea or below deck level may be postponed until the wind speed drops. A wind speed monitor is an effective instrument to determine if conditions are appropriate for coating application.

Fig 2.1 (iv): Wind speed monitor

Dew Point: Dew point is the temperature at which water vapour will condense, leaving water on the surface. A high dew point is an indication of high % relative humidity. Dew point is an important consideration when blast cleaning, because moisture condensation will cause freshly blasted steel to rust. When coating is done outdoors, newly cleaned surfaces should usually receive the first protective coat long before nightfall, when lower temperatures may cause condensation on the surface. Dew point can be an important consideration in the overall coating process. A film of moisture between coats can cause premature coating failure. To help prevent such occurrences, a dew point/surface temperature safety factor has been determined. Final blast cleaning and coating application should not take place unless the surface temperature is at least 3°C higher than the dew point.

Notes

UNIT 2.2 Inspecting the Surface

Unit Objectives

At the end of this unit, you will be able to:

1. Inspect the surface to be painted correctly and say what type of surface preparation is required prior to painting
2. Identify different kinds of surface defects and how these can be corrected or dealt with during painting
3. Discuss different contaminants that are commonly present in the environment and how they can affect coating performance

The surface to be painted must be inspected prior to being taken up for painting. During inspection, one should look at:

- Oil/ grease on the surface
- Dirt and dust deposit
- Imperfections – design defects, fabrication defects, steel surface defects
- The condition of the old paint
- The condition of the new steel

The purpose of inspection is to assess the nature and extent of surface preparation required and to determine the paint system that would meet expectations of protection.

Fig 2.2 (i): Greasy and dusty surfaces

Fig 2.2 (ii): Imperfect surfaces of new steel

2.2.1 Airborne Contaminants

Debris: Dust, dirt, oil, mud, sand, leaves, blowing papers, and insects are debris. These contaminants can be blown onto the work surface and often become included in wet paint films. Inclusions may cause premature failure through loss of adhesion or other coating defects.

Chemically active contaminants: Salt spray, industrial waste, auto exhaust, chemical fumes, and other airborne contaminants can affect coating life by enhancing the efficiency of the electrolyte in the corrosion process or by forming deposits on the surface that lead to premature loss of adhesion. When salts become bonded to steel by chemical reaction, they are not easily removed by conventional surface preparation methods (e.g., solvent cleaning, dry abrasive blasting, etc.). In recent years, the significance of such deposits has been increasingly recognised. The most common salts known to cause problems with coating films applied to steel are:

- Sulfurous compounds generated by industry, particularly those that burn fossil fuels, e.g., coal and oil.
- Chloride compounds, particularly sodium chloride, most often generated by sea winds and likely to be deposited near marine environments.
- Nitrogenous compounds mostly generated in urban environments where vehicle exhaust output is high. The effect of nitrate contamination is most likely to be found on bridges and similar structures associated with roads.
- Soluble salt contaminants encourage corrosion and should be washed from surfaces wherever possible to reduce corrosive effects. In their natural state, these compounds are not, however, at their most dangerous. Chemical reaction between the compounds and the underlying substrate (most often steel) creates a new set of compounds, many of which are electrochemically bound to the surface. These include:
    - Sulphur dioxide reacts with moisture to form sulfurous and sulfuric acids. These, in turn, react with steel to form ferrous/ferric sulphate
    - Sodium chloride reacts with iron to form ferrous and ferric chlorides
    - nitrogen compounds react with iron to form nitrates of iron

Fig 2.2.1: Chemical / Salt Contaminants

The way a structure is designed can influence its resistance to corrosion. A design which avoids entrapment of moisture, chemical salts, dirt and allows access for coating operations will tend to be less susceptible to corrosive attack.

2.2.2 Design Defects

Many structures are not designed with the coating process in mind. Design flaws and fabrication faults can easily complicate the procedures used to achieve a successful coating system. The painter may be able to provide a valuable service by helping to identify problem areas resulting from a design and/ or fabrication of the work piece and suggesting solutions to some of the problems. Some common design defects that affect the coating process include:

- Hard-to-reach or inaccessible areas
- Rivets, bolts, or other connectors
- Welds
- Gaps (particularly skip welds or surfaces close together)
- Overlapping surfaces (e.g., roof plates in water tanks)
- Angle iron badly oriented or in complex arrangements
- Threaded areas
- Dissimilar metals
- Sharp edges, particularly on corners or rough-cut plate
- Construction aids

2.2.3 Steel Surface Defects

Surface preparation means not only the removal of mill scale, rust, and contaminants, but also suitable dressing of the steelwork to remove all surface defects that could break through the paint film or prove difficult to protect adequately by painting. Typical examples include:

- Sharp edges
- Surface laminations
- Cracks and crevices
- Inclusions

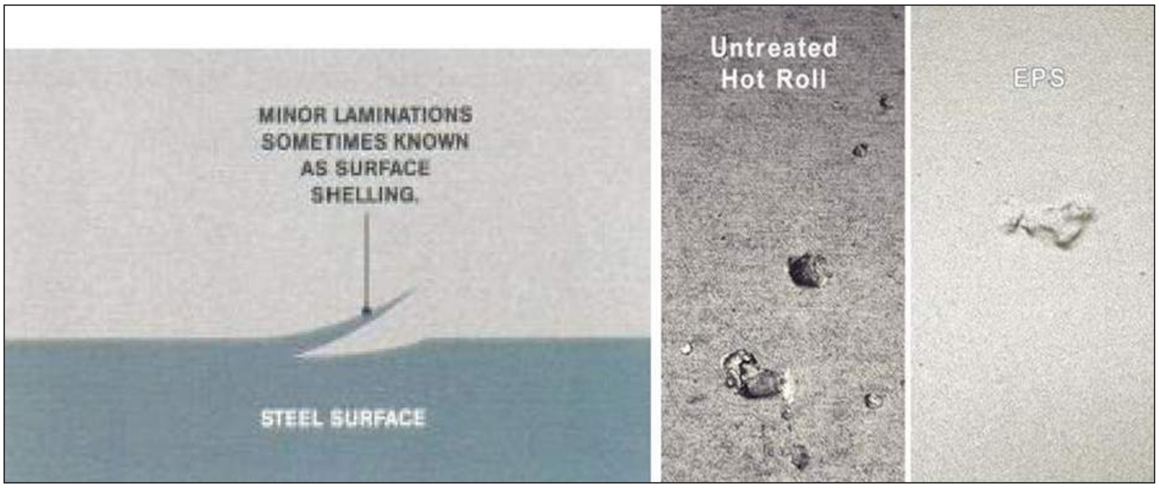

Fig 2.2.3 (i): Surface Lamination and manufacturing defects

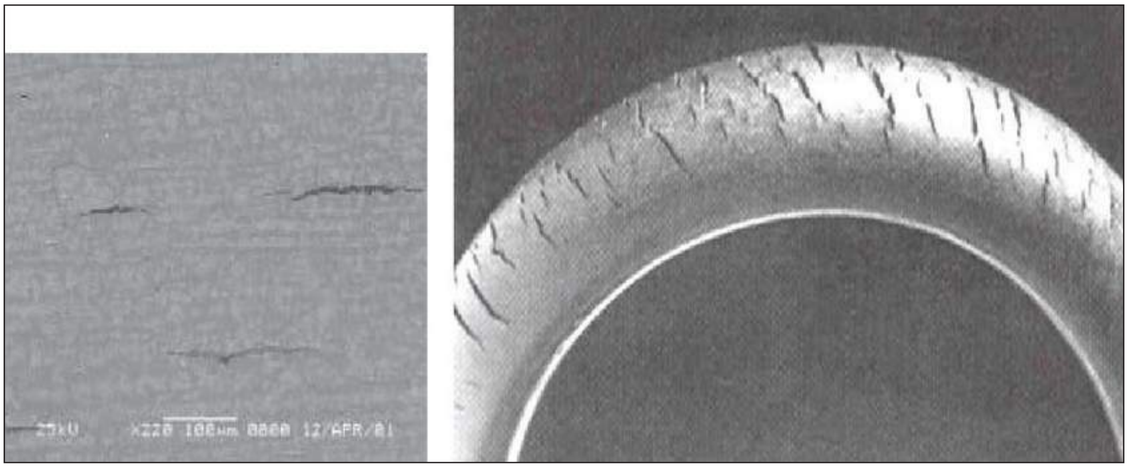

Fig 2.2.3 (ii): Stress cracks in steel

Where defects are exposed by blast cleaning and subsequently removed by grinding, it is necessary to re-prepare the immediate area to retain the surface profile.

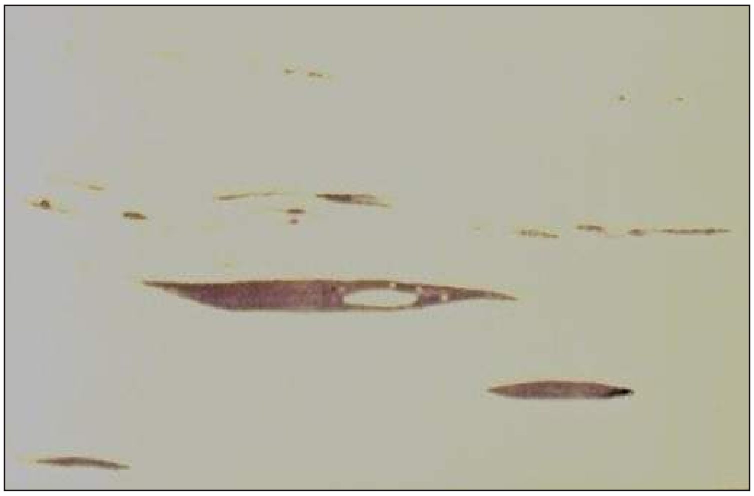

Fig 2.2.3 (iii): Inclusions in steel

2.2.4 Fabrication Defects

Fabrication defects can fall into several broad categories:

- Imperfect welds, including:
    - Weld spatter (also known as *weld splatter*)- must be removed by chipping or grinding
    - Skip welds - If continuous weld is not possible, caulking of overlap joints may be done
    - Rough welds- must be ground or repaired
- Laminations – must be removed
- Sharp corners and edges – must be rounded
- Sharp bends and angles – difficult to correct; so first apply a strip coating by brush and then spray the coating

Fig 2.2.4 (i): Defects that must be checked before pretreatment - Weld spatters

Fig 2.2.4 (ii): Rounded edged steel ready for treatment

Fig 2.2.4 (iii): Fabrication Defect—Weld Spatter

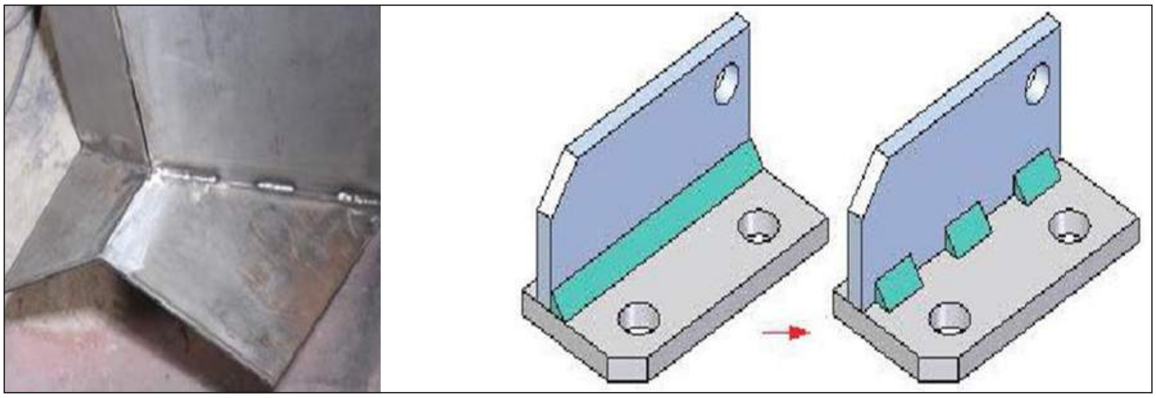

Fig 2.2.4 (iv): Fabrication Defect—Skip Welds

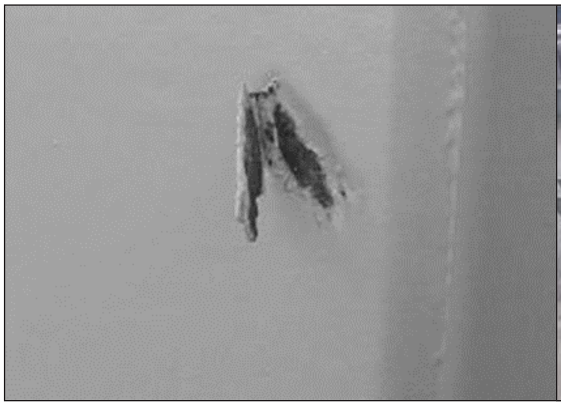

Fig 2.2.4 (v): Fabrication Defect—Lamination

Fig 2.2.4 (vi): Fabrication defect - sharp corner/edge

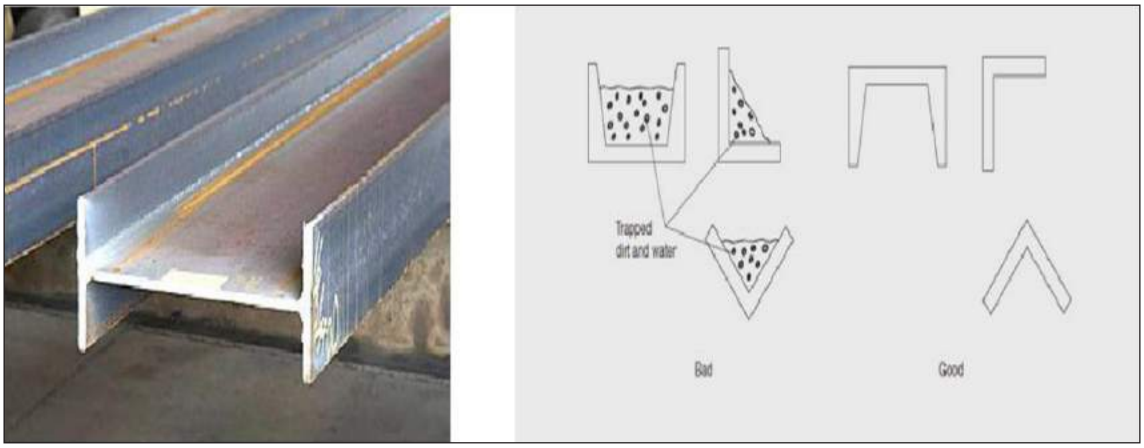

Fig 2.2.4 (vii): On the left-hand side, examples of structures not suitable for corrosion protection painting. On the right-hand side, examples of suitable sections for fabrication (ISO 12944-3)

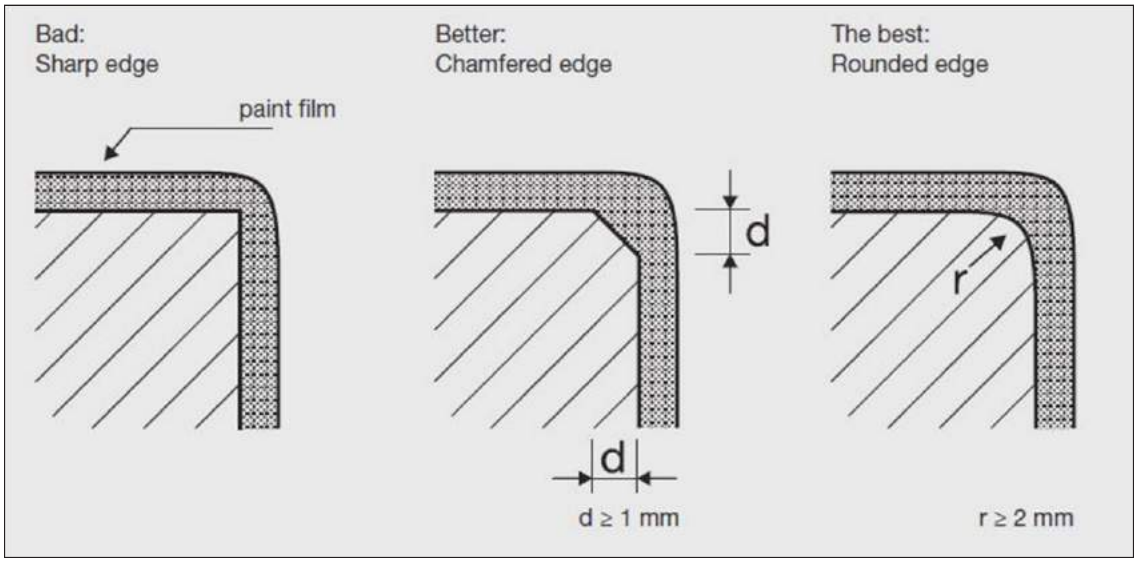

Fig 2.2.4 (viii): In terms of painting, rounded corners and edges are ideal, since coating thickness is uniform (ISO 12944. Sharp corners are to be avoided.

2.2.5 Condition of the Metal Surface to be Painted

Generally, the specific surface to be coated would fall under one of the following categories:

1. **New steel surface**: This is relatively easy to clean. Any mill scale deposits present can be removed by shot or grit blasting
2. **Unpainted aluminum or zinc surface**: Light blasting will clean and roughen the surface. Alternately, solvent cleaning followed by applying etch primers can give satisfactory result
3. **Corroded steel surface**: The process used for cleaning corroded steel are generally the same as those used for cleaning new steel and include hand and power tools, blast cleaning, and perhaps water jetting.
4. **Corroded zinc or zinc - Galvanised surface:** The surface should be water washed followed by a mild blasting. Alternately it may be treated with an etch primer
5. **Corroded aluminum surface**: Any powdery salts should be removed with a wire brush or by mild blast cleaning followed by etch primer treatment

Other surfaces that are commonly painted include plastics, wood, and concrete. All of them require special surface preparation and coatings suited to their special characteristics.

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UNIT 2.3 Scaffolding

Unit Objectives

At the end of this unit, you will be able to:

1. Describe various types of scaffolds used in painting jobs
2. Select the right kind of scaffold for a particular job
3. Exercise due caution while using scaffolding at the painting site

Coating assignments expose applicators to conditions and situations that represent actual or potential danger to themselves and to others in the area. Ladders, scaffolding and rigging must be used for areas which are not accessible from the floor or ground. The setting up and dismantling requires safety checks and precautions which require time and effort. A scaffold is defined as any temporary, elevated platform and its supporting structure used for supporting workmen and/or materials. It may be a raised platform, a plank, a swing or a chair, used to support workers or materials used in the job.

2.3.1 Scaffolding Process

Scaffolding process is the planning, design, erection, inspection, alteration, use or dismantling of any scaffolding and/or related components. Traditional scaffolding made of bamboo is still in use in many sites though it is getting replaced by modern scaffolding made of metal tubes. Platforms made of wooden boards or metal are fixed on the structure to provide a working deck. Scaffolding fixed to the ground or to a wall is safer, while mobile scaffolding offers greater positioning flexibility.

How to choose?

Scaffolding is chosen for its platform dimensions and maximum working height. Other factors include ease of assembly and disassembly and adapting to sloping ground. The scaffolding should meet applicable regulations and safety standards.

Fig 2.3.1: Fixed scaffolding, mobile scaffolding and suspended scaffolding

2.3.2 Design Requirements

Principles of design: The design of scaffolds should consider the following:

- The strength, stability and rigidity of the supporting structure
- The handling normally associated with scaffolding
- The safety of persons engaged in the erection, alteration and dismantling of the scaffold
- The safety of persons using the scaffold
- The safety of persons near the scaffold
- The scaffold's fitness for its intended purpose

Loads in scaffolding: Scaffolding foundations must be able to carry and distribute all the weight of the scaffold, including any extra loads placed on the scaffold. To facilitate this, when scaffolding is designed, attention should be given to ground conditions (subsidence, water courses, level, the nature of ground materials etc.) and to the loadings on the scaffold. Scaffolding should be able to carry the most adverse combination of dead loads, live loads and environmental loads that can reasonably be expected during the period that the scaffold is expected to be in service.

Structures supporting scaffolding: The supporting structure should be capable of supporting the most adverse combination of loads applied by the scaffold during the period of its service. Where necessary, it may need to be strengthened by propping or other means.

Sole boards and **baseplates** can also be used to evenly distribute the load from the scaffold to the supporting surface. Both sole boards and baseplates may be required for use on less stable surfaces, such as soil or gravel.

Stability: Scaffold stability may be achieved by:

- Tying the scaffold to a supporting structure
- Increasing the dead load by securely attaching counterweights near the base
- Adding bays to increase the base dimension

Prefabricated scaffold brackets: Prefabricated scaffold brackets that are attached to a structure to provide support for a working platform must:

- Have adequate and suitable means of attachment to provide vertical support and to resist accidental sideways movement
- Be stable in the longitudinal direction of the platform under the applied horizontal force
- Be fitted with guardrails, mid-rails and toe-boards on all platforms

2.3.3 Types of Scaffolds

Scaffolding comes in many types, from very basic ones to specialised scaffolding for tanks, chimneys or for very tall structures. The type of scaffolding chosen for a job will depend on the site factors and the structure to be painted. Some examples of different types of scaffolding are shown below:

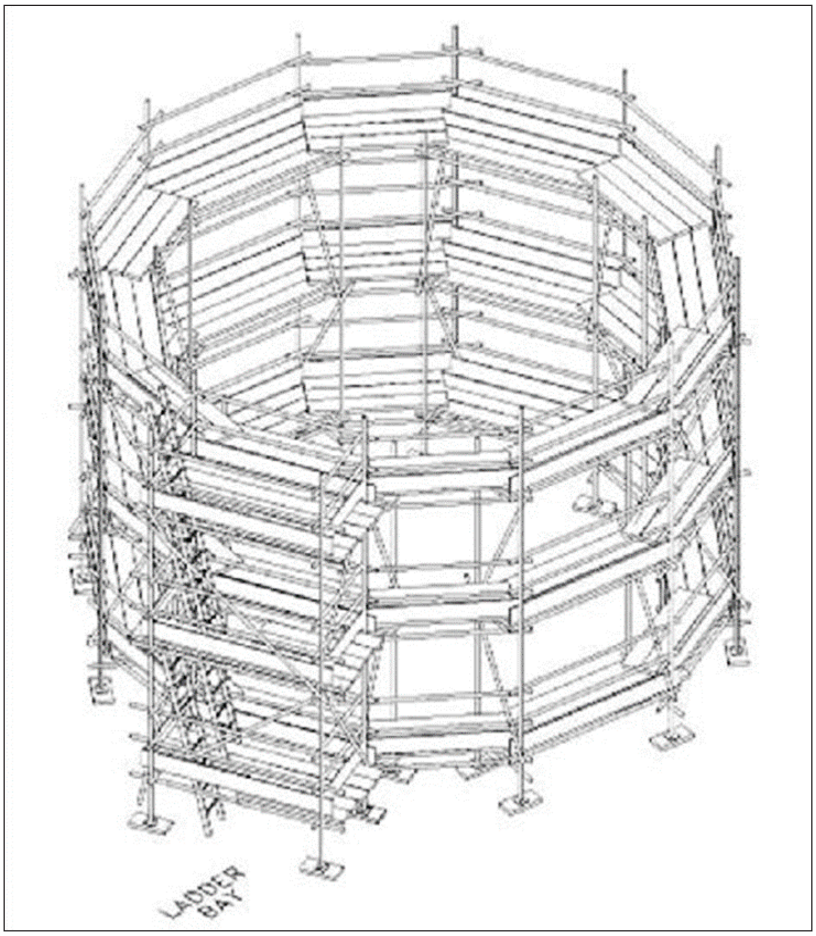

Fig 2.3.3 (i): Vessel scaffold

Fig 2.3.3 (ii): Suspended scaffolding

Types of suspended scaffolds

Fig 2.3.3 (iii): Swinging stage – manual

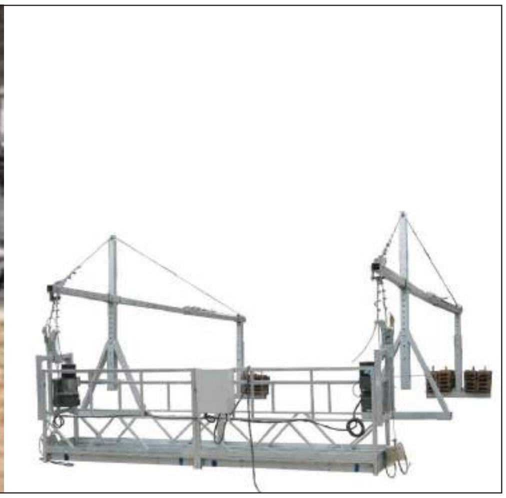

Fig 2.3.3 (iv): Swinging stage – mechanical

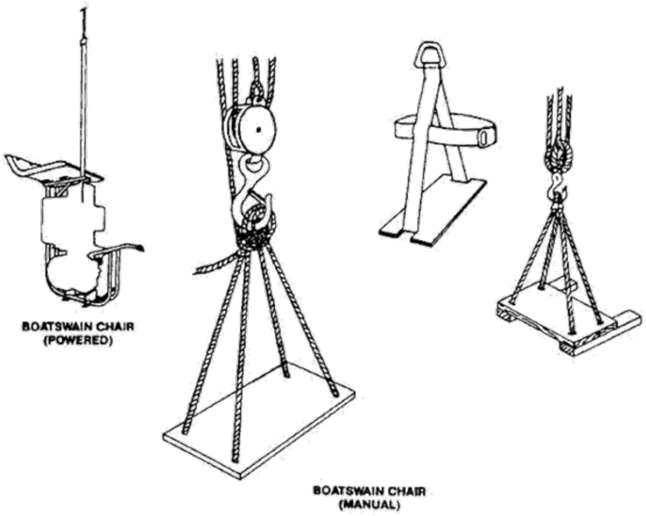

Fig 2.3.3 (v): Boatswains chair

Fig 2.3.3 (vi): Suspended safety chair

2.3.4 Ladders

Depending on the application, ladders are traditionally made from aluminum, timber or fiberglass. In providing ladder access to working platforms:

- Ladders should be pitched at a slope of not less than 1 in 4 and not more than 1 in 6. Though it is not recommended, it is acceptable to have a pitched ladder stop at the working platform height if sufficient guardrails (stop ends) are in place that can be used to hold onto for access and egress to and from the ladder
- Ladders should be securely tied to prevent movement
- Ladders should extend at least 1.0m above the working platform, landing or exit point
- Ladders must be in good structural condition

- The maximum height between working platforms or landings must not exceed 5.1m or a maximum of 2 lifts
- Ladders must be offset to prevent a single continuous ladder. This reduces the distance a person could fall to a maximum of 5.1m (2 lifts)
- Where possible ladders should be erected in an independent scaffold bay. This is the preferred method, as it does not interfere with the working platform
- All ladder access openings in a platform must be protected by either a hatch, gate or by tortured path

2.3.5 Quality Control

- All equipment used in the scaffolding must be in good condition and fit for its intended purpose.
- All defective equipment must be isolated and not used.
- Bent tube must be cut down or discarded.
- Faulty planks must be cut down so as to be safe or discarded.
- Faulty couplers and fittings must be serviced, repaired or discarded.
- Faulty tools must not be used.
- Faulty ropes must be cut down so as to be safe or be discarded.
- Gin wheels must be of solid construction and have a suitable wheel diameter.
- Gin wheels must be free turning and have an appropriate sheave size.
- Gin wheels must be able to be secured according to manufacturer's specifications or accepted industry practice.
- Gin wheels must not be overloaded and must be attached to an appropriately designed and constructed support. Note that additional ties may be required in the scaffolding to sustain the imposed load.
- Shackles used to secure gin wheels must be moused and prevented from movement along the support.

All electrical equipment must be in good condition and regularly checked for defects.

- Any defective electrical equipment must be repaired by a suitably qualified person
- All personal PPE must be in good condition and suitable for its intended purpose. Faulty PPE can lead to a false sense of security and must be discarded

Users of the scaffold must

- Understand any limitations of the scaffold that could affect their work, e.g. load limits
- Not alter the scaffold in any way
- Liaise with the main contractor or the scaffold erector to have ties, working platforms, etc. relocated or altered as necessary
- Carry out their own work so as not to endanger others in the vicinity

UNIT 2.4 Masking

Unit Objectives

At the end of this unit, you will be able to:

1. Describe where and why masking is required during a painting job
2. Demonstrate the correct way to mask different areas that are not to be painted

Masking is done when only a specific area of the surface of a part must be exposed to a process. Parts of surfaces which are not to be blasted or coated are masked. Masks include paper, wax, tape and any other methods where the mask is applied and then discarded after use. Using tape may appear to be a simple task, but a significant amount of skill needs to be employed.

Fig 2.4 (i): Masking portions that do not need to be blasted/painted

Fig 2.4 (ii): Masking with plugs and tapes before blasting/painting

Fig 2.4 (iii): Masking with tapes

Fig 2.4 (iv): Airless spray masking

Fig 2.4 (v): Masking in progress before surface preparation

Notes

UNIT 2.5 Surface Preparation

Unit Objectives

At the end of this unit, you will be able to:

1. Explain what surface preparation is and why it is critical to good painting
2. Describe different surface preparation methods in vogue and how to choose the most appropriate one for a given job
3. Identify various tools in surface preparation and explain how they are to be used
4. Describe the blasting process, types of equipment and media used in blasting

Surface preparation before the application of any coating is the most important factor affecting the total success of a corrosion protection system. The surface preparation process cleans the surface and introduces a suitable profile to receive the protective coating. The performance of a coating is significantly influenced by its ability to adhere properly to the substrate.

2.5.1 Why Surface Preparation

The purpose of surface preparation is to create adhesion. Adhesion is very critical for coatings subject to a corrosive environment. Modern coatings require a clean and roughened surface to achieve long term adhesion and durability. Steel and to a lesser extent concrete are the most common surfaces prepared and painted for protection.

Surface preparation includes

1. Assessment and inspection of surface, including design and fabrication defects
2. Removal of residues of oil, grease and soil
3. Removal of residues of (invisible) chemical salts, which can induce corrosion after coating
4. Removal of rust from the surface, which interferes with the bonding/ adhesion of the coat.
5. Removal of loose or broken mill scale resulting in early coating failure and tight mill scale resulting in later failure
6. Removal of sharp ridges, burrs, edges, or cuts from mechanical cleaning equipment, which prevent adequate thickness of coatings over the irregularities
7. Removal of surface condensation which, if painted over, may result in blistering and delamination failure
8. Removal of old coatings that may have poor adhesion or may be too deteriorated for recoating

Fig 2.5.1: Removal of residue for bonding of coatings

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Adequate cleaning of surfaces, including aluminum, wood, concrete, zinc (galvanising), and steel, especially previously used steel, is essential to achieve proper performance of the selected coating system. The nature and condition of the surface to be prepared and painted affects the degree of surface preparation required.

A severe environment, marine or chemical, normally requires a higher degree of cleanliness to ensure good performance of the coating system. A more rural environment—with less pollution—will allow better performance of the same coating system or the same performance when applied to a lesser degree of surface preparation.

Coating systems vary significantly in their ability to bond to steel. Some coatings with good wetting properties, such as epoxy mastics, medium and long oil alkyds, and some bituminous products, will adhere better to a less thoroughly cleaned surface than others. All systems, though, will perform better on a properly cleaned surface with a good surface profile.

2.5.2 Surface Preparation Methods

Techniques available for surface preparation include:

- Solvent cleaning
- Hand tool cleaning
- Power tool cleaning
- Flame cleaning
- Acid pickling
- Blast cleaning, using shot or grit
- Water jetting, using water only
- Wet abrasive blasting, using water with injected abrasives

Solvent Cleaning: Solvent cleaning is a method for removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces. SSPC-SP 1 is the only commonly used standard that formally governs solvent cleaning to remove oil, grease, dirt, soil, drawing compounds, and other similar organic compounds.

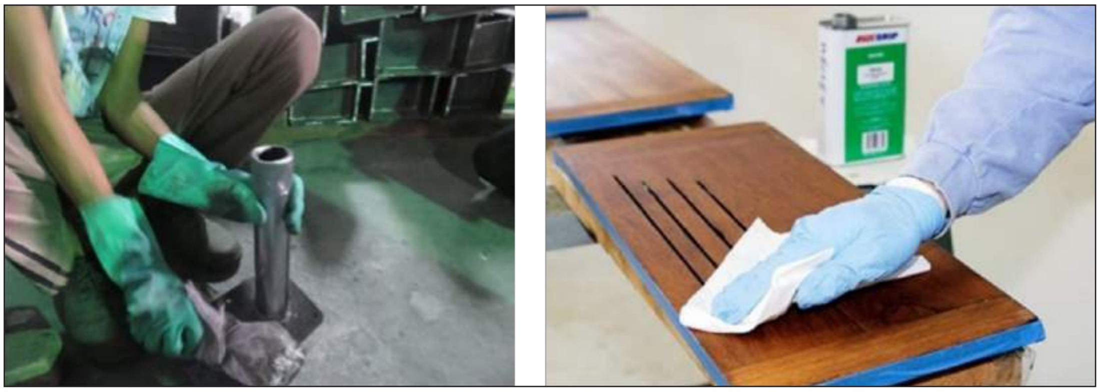


Fig 2.5.2 (i): Cleaning solvent with a soft swab

Chemical paint stripping: Solvents such as kerosene, turpentine, naphtha, mineral spirits, xylol, etc., clean the metal by dissolving and diluting the oil and grease contamination on the surface. Inorganic materials such as chlorides, sulphates, weld flux, and mill scale are not removed by organic solvents. The last wash or rinse should be made using clean solvent to remove the slight film of oil or grease that may be left on the surface. This film, if left in place, may interfere with the adhesion of the coating to the surface.

Fig 2.5.2 (ii): Use of alkaline cleaners

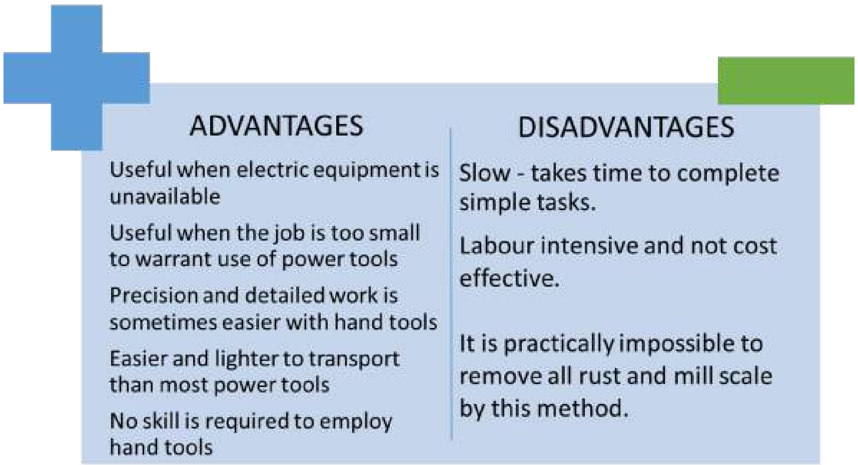
Hand and power tool cleaning: Cleaning with hand tools removes all loose mill scale, rust, paint, and other detrimental foreign matter. Adherent mill scale, rust, and paint are not generally intended to be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife. A standard commonly used to control the hand tool cleaning process is "Hand Tool Cleaning," SSPC-SP 2 (comparable to ISO 8501-1, St 2 or St 3).

Fig 2.5.2 (iii): Hand tool cleaning

Tools used in hand cleaning include:

- Wire brushes
- Scrapers
- Chisels
- Knives
- Chipping hammers

Fig 2.5.2 (iv): Hand cleaning tools



ADVANTAGES	DISADVANTAGES
Useful when electric equipment is unavailable	Slow - takes time to complete simple tasks.
Useful when the job is too small to warrant use of power tools	Labour intensive and not cost effective.
Precision and detailed work is sometimes easier with hand tools	It is practically impossible to remove all rust and mill scale by this method.
Easier and lighter to transport than most power tools	
No skill is required to employ hand tools	

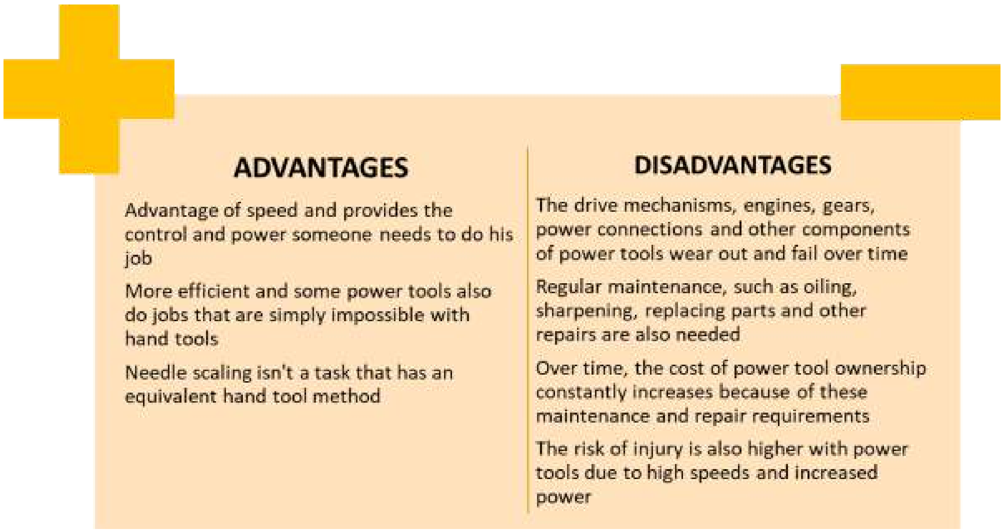
Fig 2.5.2 (v): Advantages and disadvantages of using hand tools

Power Tool Cleaning: Power tool cleaning is a method of surface preparation using power assisted mechanical cleaning tools. These tools are essentially like the tools used for hand tool cleaning, but a power source, such as electricity or compressed air, is used. This process can remove loose mill scale, rust, paint, and other detrimental foreign matter, but is not intended to remove adherent mill scale, rust, and paint. This method can also remove weld flux, weld spatter and laminations and to smooth rough welds and round out gouges before abrasive blast cleaning. Power tool cleaning is frequently used in maintenance operations to remove loose mill scale, rust, and paint.

Modern power tooling has been developed not only to achieve a good standard of surface cleanliness and profile but also to provide near total containment of all dust and debris generated. New equipment is now available to use percussive reciprocating needles, rotary abrasive coated flaps and right-angle grinders, all within a vacuum shroud to enable on-site surface preparation to be environmentally acceptable. The surface preparation by hand and power tools is covered by BS EN ISO 8504-3, with the standard grades of cleanliness in accordance with BS EN ISO 8501-1.

Fig 2.5.2 (vi): Rotary Wire Brush *Rotary Grinder* *Needle Gun*

Fig 2.5.2 (vii): Power tools for cleaning



ADVANTAGES

Advantage of speed and provides the control and power someone needs to do his job

More efficient and some power tools also do jobs that are simply impossible with hand tools

Needle scaling isn't a task that has an equivalent hand tool method

DISADVANTAGES

The drive mechanisms, engines, gears, power connections and other components of power tools wear out and fail over time

Regular maintenance, such as oiling, sharpening, replacing parts and other repairs are also needed

Over time, the cost of power tool ownership constantly increases because of these maintenance and repair requirements

The risk of injury is also higher with power tools due to high speeds and increased power

Fig 2.5.2 (viii): Advantages and disadvantages of power tool cleaning

The most commonly used power tools include:

- Rotary wire brush
- Impact tools, such as:
  - Chipping hammer (scaling hammer)
  - Needle scaler
  - Piston scaler
  - Rotary scaler
  - Grinders and sanders

Rotary wire brushes

Machine design is of two general types:

- Straight or in-line
- Vertical or right-angle

Problems with polishing the surface rather than providing a roughened surface are particularly likely with this technique; therefore, the use of rotary wire brushes is considered less desirable than other forms of power tool cleaning. Solvent cleaning is an essential step before power wire brushing to prevent the spread oil and grease over the surface.

Fig 2.5.2 (ix): Rotary wire brush

Impact tools

Chipping/scaling hammer: A chisel is inserted into the power tool and the impact from an air-operated or electrically operated piston is transmitted to the chisel and, in turn, to the surface to be cleaned. Chisels may be of different shapes and materials. Scaling or chipping hammers are generally a slow, costly method of cleaning the surface. Care must be exercised in using these tools because of the tendency to cut into the surface excessively, removing sound metal and leaving sharp burrs where the paint will fail prematurely. These tools may be used to remove some tight mill scale and surface rusting. There is a high possibility of gouging the metal, which must then be smoothed to do a thorough job.

Needle scaler: A needle gun, or needle scaler, consists of a number of hardened steel rods which are vibrated against the surface. It is slow in operation and has a burnishing effect when producing a relatively clean surface. It does, however, produce a surface profile. The needle scaler is effective on welds, corners, and irregular surfaces.

Fig 2.5.2 (x): Needle scaler

Piston scalers: Piston scalers operate in a similar way to scaling hammers, but the piston also acts as the impact tool. A hammer piston, which takes the place of the chisel, is a circular shaft with the cutting end cross-shaped, somewhat like a star chisel.

Fig 2.5.2 (xi): Piston scalers

Rotary scalers: These tools can be used advantageously on large areas to remove rust and scale. Care must be exercised to prevent the cutters of these large rotary scalers from cutting the metal to such an extent that metallic points extend far above the surface causing early paint failure due to insufficient paint coverage. If these tools are used to remove mill scale and rust from the surface, it is very likely that the surface will be very rough and care must be taken to ensure that all peaks of the anchor pattern are covered by the coating applied.

Fig 2.5.2 (xii): Rotary scaler wheel

Grinders and sanders: These are used to prepare surfaces. Grinding is well suited for removing weld spatter, smoothing weld seams, or rounding off sharp edges or corners. Grinders are frequently used in repairing minor fabrication defects. The anchor profile produced can be very good, with complete removal of rust and mill scale; however, such methods of cleaning are very expensive for large areas.

Fig 2.5.2 (xiii): Grinders and sanders

Disc sanders: Pneumatic and electrically operated sanders are available with a normal or orbital motion. Flexible shafts are used on a small scale to operate rotary wire brushes and grinding wheels. The discs or wheels may be mounted directly on the main shaft of the motor or other portable or stationary units.

Vacuum connections: Many authorities are concerned with eliminating dust emissions from work that involves removal of old coatings. For that reason, many power tools are now fitted with collectors and vacuum lines that gather most dust as the tool is used. The effects of the power tools on the surface remains the same, but the equipment is heavier and more difficult to handle. Acceptable results can still be achieved.

2.5.3 Abrasive Blast Cleaning

By far the most significant and important method used for the thorough cleaning of mill-scaled and rusted surfaces is abrasive blast cleaning. This method involves mechanical cleaning by the continuous impact of abrasive particles at high velocity on to the steel surface either in a jet stream of compressed air or by centrifugal impellers.

Blasting abrasives: Blasting abrasives shall be dry, clean and free from contaminants which will be detrimental to the performance of the coating. Size of abrasive particles for blast cleaning shall be such that the prepared surface profile height (anchor pattern profile) is in accordance with the requirements for the applicable coating system. The surface profile shall be graded in accordance with ISO 8503. The cleanliness of the blast cleaned surface shall be as referred to for each coating system, i.e. Sa 2 1/2 or Sa 3 in accordance with ISO 8501-1.

Pre-blasting preparations

- Sharp edges, fillets, corners and welds shall be rounded or smoothed by grinding
- All welds shall be inspected and if necessary repaired prior to final blast cleaning of the area
- Any major surface defects, particularly surface laminations or scabs detrimental to the protective coating system, shall be removed by suitable dressing
- Hard surface layers, e.g. resulting from flame cutting, shall be removed by grinding prior to blast cleaning
- The surfaces shall be free from any foreign matter such as weld flux, residue, slivers, oil, grease, salt etc. prior to blast cleaning
- Any oil and grease contamination shall be removed by solvent or alkali cleaning prior to blasting operations, ref. SSPC-SP-1

Automatic blasting method requires large stationary equipment fitted with radial bladed wheels onto which the abrasive is fed. As the wheels revolve at high speed, the abrasive is thrown onto the steel surface, the force of impact being determined by the size of the wheels and their radial velocity. Modern facilities of this type use automatic blasting with several wheels, typically 4 to 8, configured to treat all the surfaces of the steel being cleaned. The abrasives are recycled with separator screens to remove fine particles. This process can be 100% efficient in the removal of mill scale and rust.

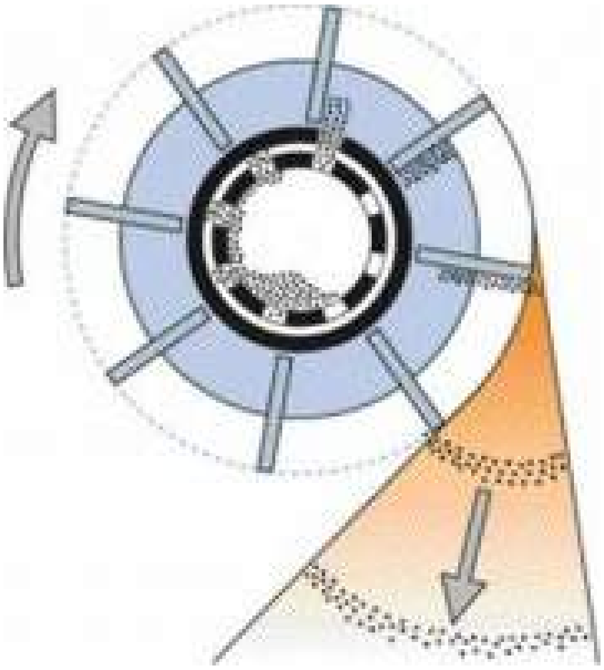
Blast cleaning methods: Some of the methods of blast cleaning are:

- Centrifugal blasting
- Sand-injected water blast
- Slurry blast
- Wet abrasive blast
- Dry abrasive blast
- Dry Grit Blast Cleaning

The most generally established method of surface preparation for the application of coatings is by dry *grit blasting* as defined below. Indeed, when modern sophisticated coatings are applied for surface protection, there is no truly satisfactory or economically equivalent alternative process. Dry grit blasting (using grit) is a highly-concentrated stream of small abrasive particles projected at a surface removing rust, mill scale, or other contaminants creating a rough surface good for adhesion. The fundamental principle of the grit blasting process is the removal of rust, mill scale, or other surface contaminant (and obtaining a suitably roughened surface) by projecting a highly-concentrated stream of relatively small abrasive particles at high velocity against the surface to be cleaned. The surface is abraded through the high-velocity impact of abrasive particles. In preparing steel surfaces for painting by blast cleaning, rust, mill scale, and old paint are removed along with some of the base metal.

Various degrees, or standards, of surface cleanliness achieved by abrasive blast have been defined. The abrasive blast cleaning standards for new steel most commonly used in abrasive blast cleaning applications are produced by NACE, SSPC, and ISO.

Fig 2.5.3 (i): Manual abrasive blasting



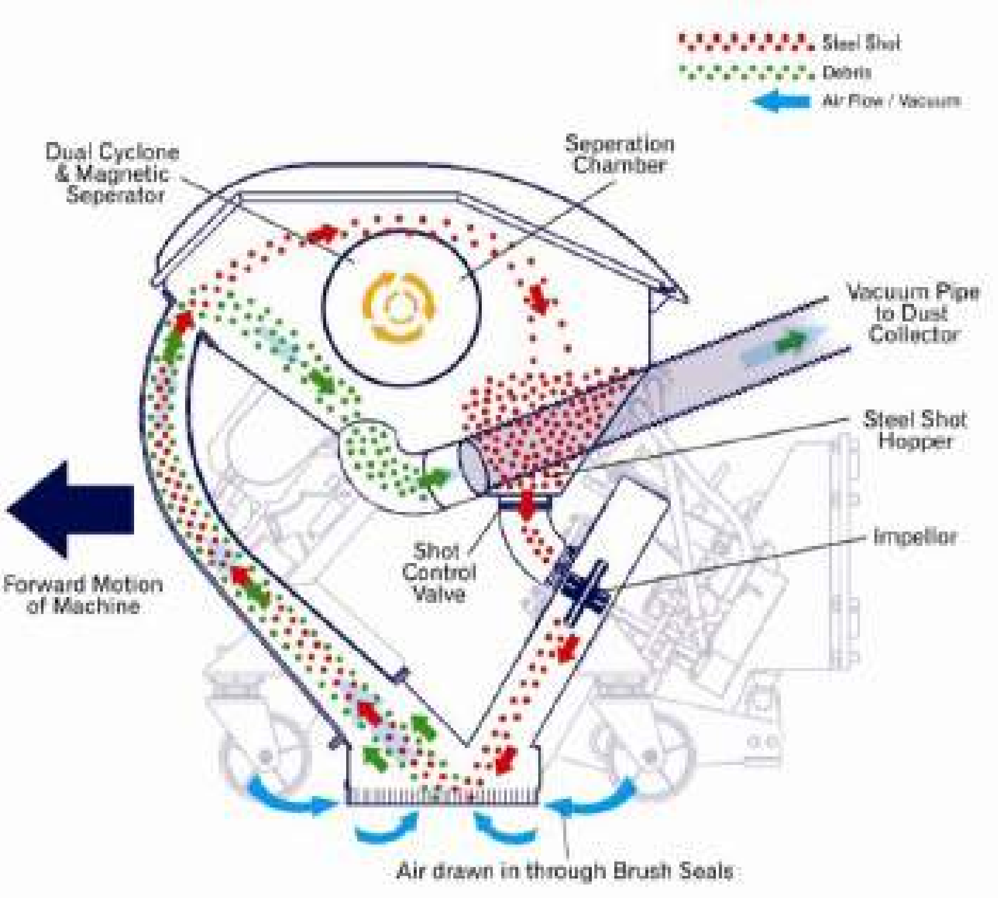


Fig 2.5.3 (ii): Automotive centrifugal blasting

Abrasive blasting automatic

Fig 2.5.3 (iii): Blasting chamber

Fig 2.5.3 (iv): Dry grit blasting open

Standard	Method	Description of Finish
Sa 1	Blast Cleaning	Poorly adhering mill scale, rust and old paint and foreign matter are removed. Well adhered contaminants remain.
Sa 2	Blast Cleaning	Most of the mill scale rust and paint etc. are removed and any remaining is very well adhered.
Sa 2 ½	Blast Cleaning	Mill scale, rust paint and foreign matter are removed completely. Any remaining traces are visible only as slight stains or discoloration in the form of spots or stripes.
Sa 3	Blast Cleaning	All mill scale, rust etc. is removed and the surface has a uniform white metal appearance with no shading, stripes, and spots of discoloration

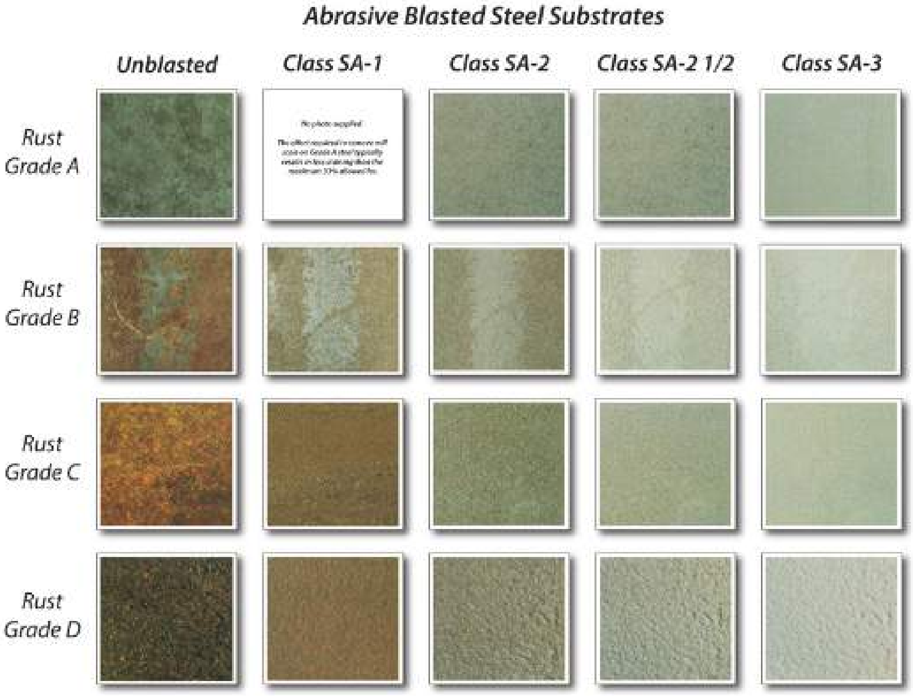


Fig 2.5.3 (v): Standards of blast cleaning

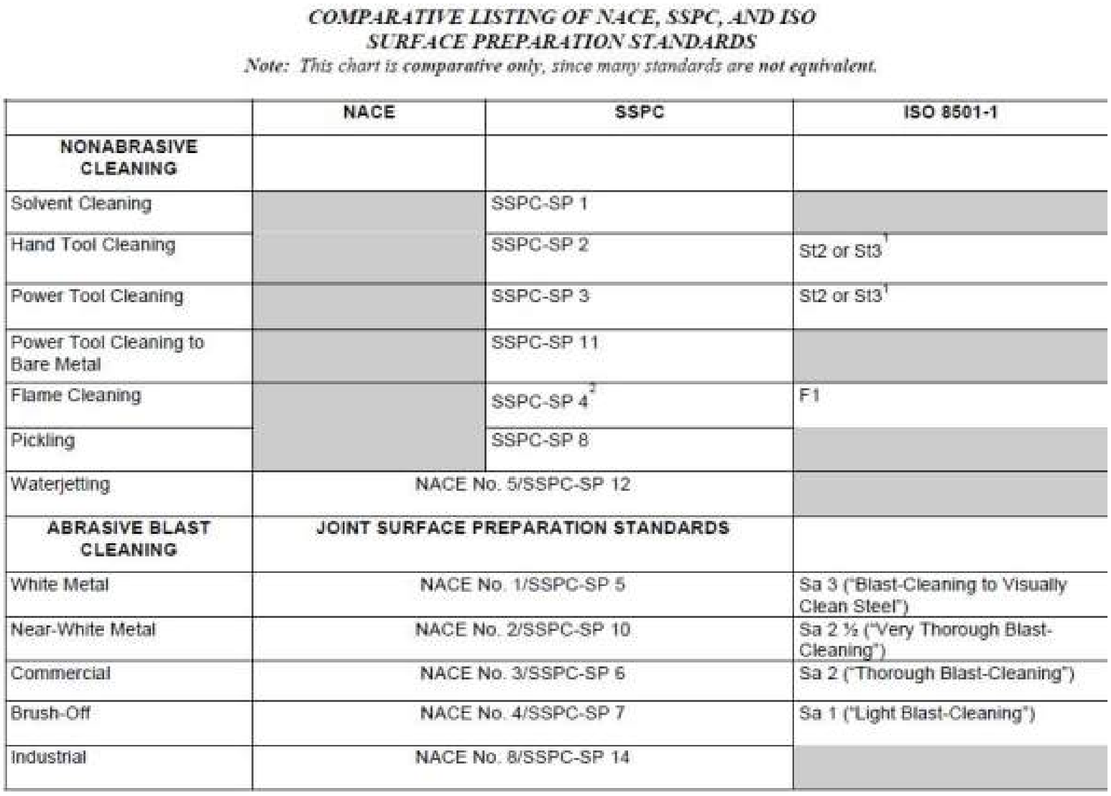
These standards are roughly equivalent to the ISO standards that were developed from the original Swedish standards. ISO 8501-1 was published in 1988 and contains four standards:

- Sa 3, “Blasting to Visually Clean Metal”
- Sa 2½, “Very Thorough Blast Cleaning”
- Sa 2, “Thorough Blast Cleaning”
- Sa 1, “Light Blast Cleaning”

Each system of standards represents a progressive scale of visual appearance only; the best grade being shown first in each case. The quality of blast cleaning is determined visually, and hotographic standards are generally used for comparison purposes. There is no correlation between the degree of blast cleaning used and the surface profile produced, and no specific correlation with removal of chemical contamination (or nonvisible salts). For these issues, other standards and measuring techniques must be used.

COMPARATIVE LISTING OF NACE, SSPC, AND ISO SURFACE PREPARATION STANDARDS

Note: *This chart is* ***comparative only****, since many standards are* ***not equivalent.***



COMPARATIVE LISTING OF NACE, SSPC, AND ISO
SURFACE PREPARATION STANDARDS

Note: This chart is comparative only, since many standards are not equivalent.

	NACE	SSPC	ISO 8501-1
NONABRASIVE CLEANING			
Solvent Cleaning		SSPC-SP 1	
Hand Tool Cleaning		SSPC-SP 2	St2 or St3[1]
Power Tool Cleaning		SSPC-SP 3	St2 or St3[1]
Power Tool Cleaning to Bare Metal		SSPC-SP 11	
Flame Cleaning		SSPC-SP 4[2]	F1
Pickling		SSPC-SP 8	
Waterjetting	NACE No. 5/SSPC-SP 12		
ABRASIVE BLAST CLEANING	**JOINT SURFACE PREPARATION STANDARDS**		
White Metal	NACE No. 1/SSPC-SP 5		Sa 3 ("Blast-Cleaning to Visually Clean Steel")
Near-White Metal	NACE No. 2/SSPC-SP 10		Sa 2 ½ ("Very Thorough Blast-Cleaning")
Commercial	NACE No. 3/SSPC-SP 6		Sa 2 ("Thorough Blast-Cleaning")
Brush-Off	NACE No. 4/SSPC-SP 7		Sa 1 ("Light Blast-Cleaning")
Industrial	NACE No. 8/SSPC-SP 14		

Blast finishing: Blasting is the process where small angular or spherical particles are propelled at a part by compressed air, or mechanical high-speed rotating wheels or water pumps. The blast media type, shape, size, density, and hardness, along with media acceleration and volume of media, combined with blasting distance from the workpiece, angle of impact and time cycles are important factors in the blast process capabilities. The blasting equipment is produced to deliver, reclaim and contain the media, contain the part to be blasted and collect the dust from the blasting process. Parts can be processed individually as a batch process or can be automated through the system. Surface effects from the blasting process are:

VISUAL
Bright Matte finish
Dull Matte Finish
Satin finish
Satin luster finish
Blending of tool marks
Removal of weld discoloration
Surface cleaning
Glass frosting and etching
Pre-plate and anodise finishes

MECHANICAL
Deburring
De-flashing
Paint and coating removal
Peening
Pre-paint and coating adhesion
Heat treat, mill scale removal
Weld splatter removal
Thermal metal spray prep
Rust and mould removal

Factors that affect blast finishing are:

1. Media delivery systems
2. Blast containment enclosures, media recovery and dust collection systems.
3. Media used in industrial blasting systems

Media delivery systems – These are three media delivery systems that propel and deliver media for high speed impact to the part being processed.

- Air Blasting (Pneumatic)
- Mechanical Wheel (airless blasting)
- Hydro blasting (pumped water)

Air blasting: It utilises an air compressor's energy to deliver air/media mix at speeds and volumes to impact the parts being processed. The air speed or pressure of an air compressor is controlled by a pressure regulator. The regulator can increase or decrease the speed of the media delivery. Air pressure is measured in pounds per square inch (psi). Industrial blasting is effectively done between 20 and 90 PSI. The higher the PSI the higher the air speed. The volume delivered of the air/media mix is determined by the orifice or diameter of the nozzle with pressure blast systems or air jet diameter of the suction blast gun body. Air volumes are measured by surface cubic feet per minute (scfm). The larger the orifice ID opening the larger volume of air/media. Other factors that affect volume of air into the blast system is media and air hose diameter. Increased air pressure (PSI) also increases the SCFM with a given size orifice. Industrial blasting gun bodies of suction cabinet blast systems range between 12 to 38 SCFM. The pressure blast cabinet systems range between 12 to 68 scfm and the pressure blast room systems use up to 254 scfm. Industrial air compressors produce approximately 4.5 SCFM per horse power (hp). Blasting cabinets require 3 to15 hp compressors per nozzle and blast rooms can use up to 53 h.p. per man or nozzle.

There are two types of air blasting systems.

- Suction (used in blast cabinets)
- Pressure (used in blast cabinets, blast rooms, and outdoor blasting)

Suction blasting uses the ventura principle sucking media from a hopper. The air jet is 1/2 the ID of the nozzle and as the air stream is passed through both, it creates a low pressure which sucks the media from the hopper into the air stream. The media acceleration distance is very short (from the nozzle to the workpiece-approximately 4 to 14"). The suction systems work fine and can be continuously blasted as long as there is blasting media in the hopper. Suction systems do not deliver media well at very low air pressures (5 to 25 psi) and they have limits on the lenght of the suction feed hose. Very heavy blasting (larger steel media) cannot be conveyed into the air stream with suction blasting. Most industrial blast cabinets are suction systems and work well with most media.

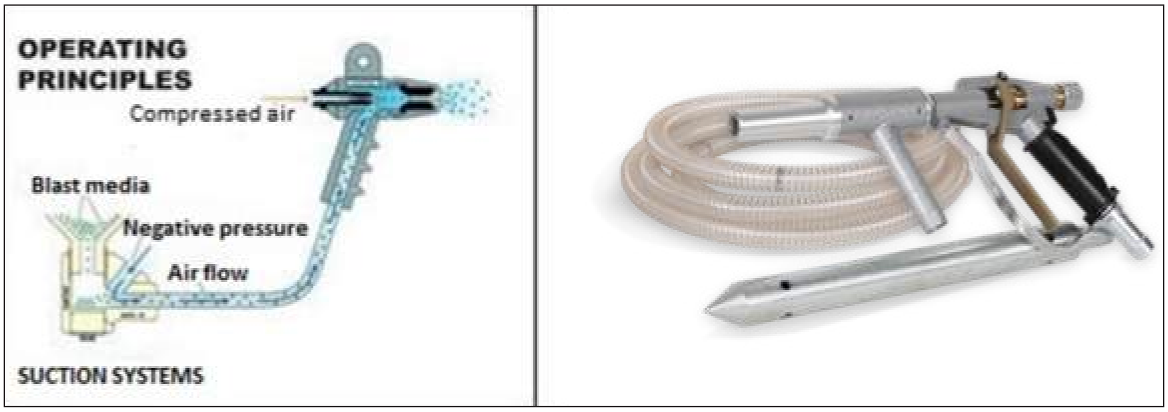


Fig 2.5.3 (v): Suction blasting equipment

Pressure blasting utilises various sizes of ASME approved pressure vessels called pressure pots. The pressure pot contains the media, and as it is energised with compressed air, it pressurises the pot. When the air/media mix is released from the pot it accelerates from the pot through at least 5-10 feet of hose and then even faster as it travels thru the ventura of the nozzle. The acceleration rates of air/media mix are much higher in pressure blasting than suction blasting. When the pressure pot empties of the media and air, the pressure pot has to be depressurised to refill the pot with media. The pressure blasting systems are much more productive than suction systems. Pressure systems can blast all media regardless of weight or size and can also deliver medias at very low psi.

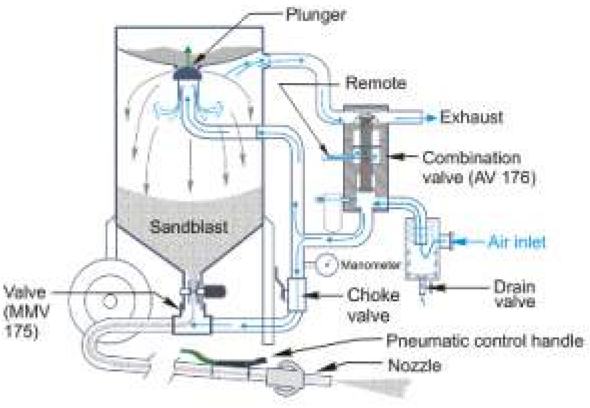


Fig 2.5.3 (vi): Blast hopper with mechanical metering valve

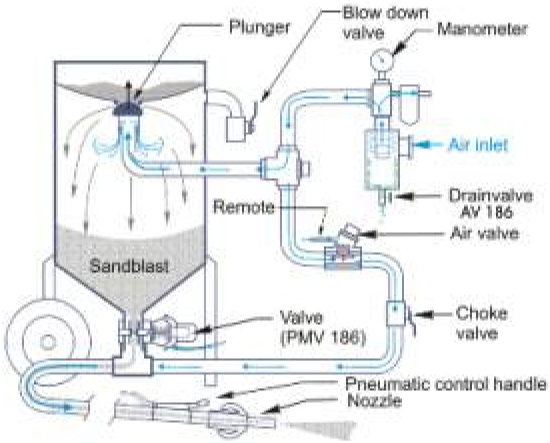


Fig 2.5.3 (vii): Blast hopper with pneumatic controlled metering value

Blast cleaning equipment: Particles of abrasive may be projected by direct feed of the particles from a pressurised container into a high-pressure air stream (*pressure blasting*) or by centrifugal projection from rapidly rotating impellers (*centrifugal blasting* or *airless blasting*).

Direct-pressure unit: This is the most commonly used method of abrasive blasting. Abrasive is forced under pressure from the pressure vessel (blast pot) through the blast hose. It is a high-production method used for heavy-duty jobs, for example, in shipyards, refineries, and chemical plants and for cleaning railroad cars and buildings.

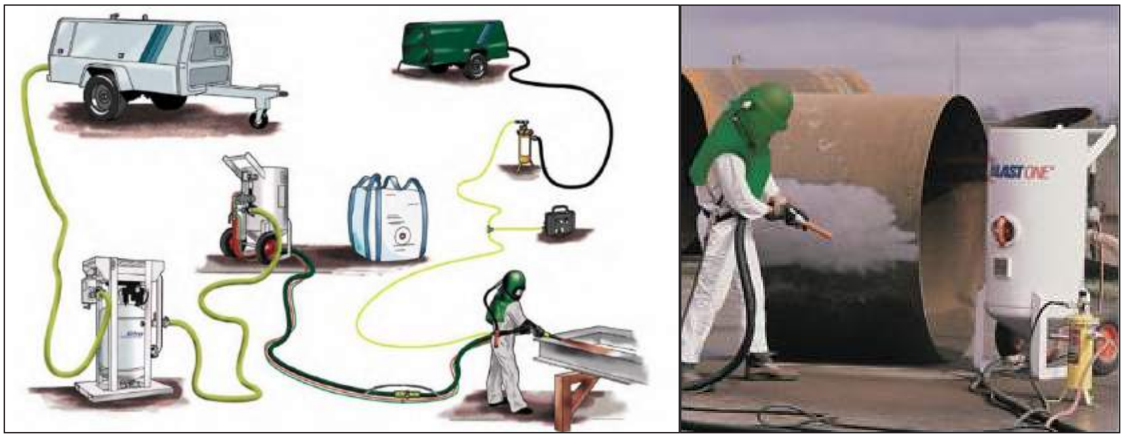


Fig 2.5.3 (viii): Blast cleaning equipment

Blast cleaning cabinets: It is sometimes desirable to blast clean individual items in an enclosed space so that other trades can continue to work in the immediate vicinity. If this is a regular requirement, many factories will buy or build a blast cleaning cabinet. The size of typical cabinets may vary from the very small cupboard where blasting is done from outside the cabinet, with hands inserted through holes in the side to the relatively large blasting room. The more sophisticated blast rooms may have a rail system to transport large items into the blasting area and will have grit recovery and recycling systems. In general, the blast cleaning apparatus is similar to that used for onsite blasting.

Fig 2.5.3 (ix): Blast room (Controlled environment with special lighting)

Blast rooms and outdoor systems – air requirements: Air consumption and media delivery rates are much higher on blast rooms and outdoor blasting systems than in pressure blast cabinets. The air supply hose ID, the media blast hose ID, the nozzle ID, the pressure pot and pot piping are all much larger on the blast rooms than cabinet systems. The increase in production is also due to the further distance that the nozzle is from the work piece in blast rooms creating a larger blast pattern.

Fig 2.5.3 (x): Blast machine for small parts

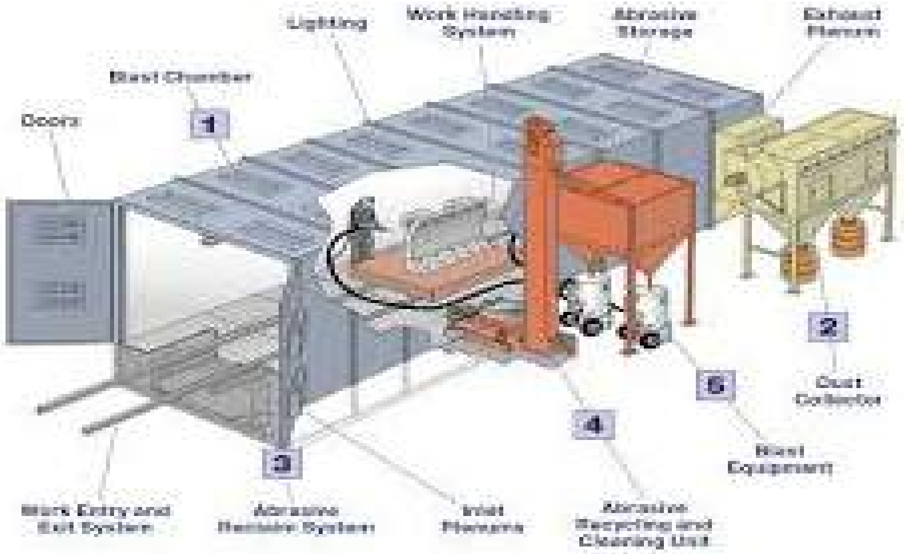
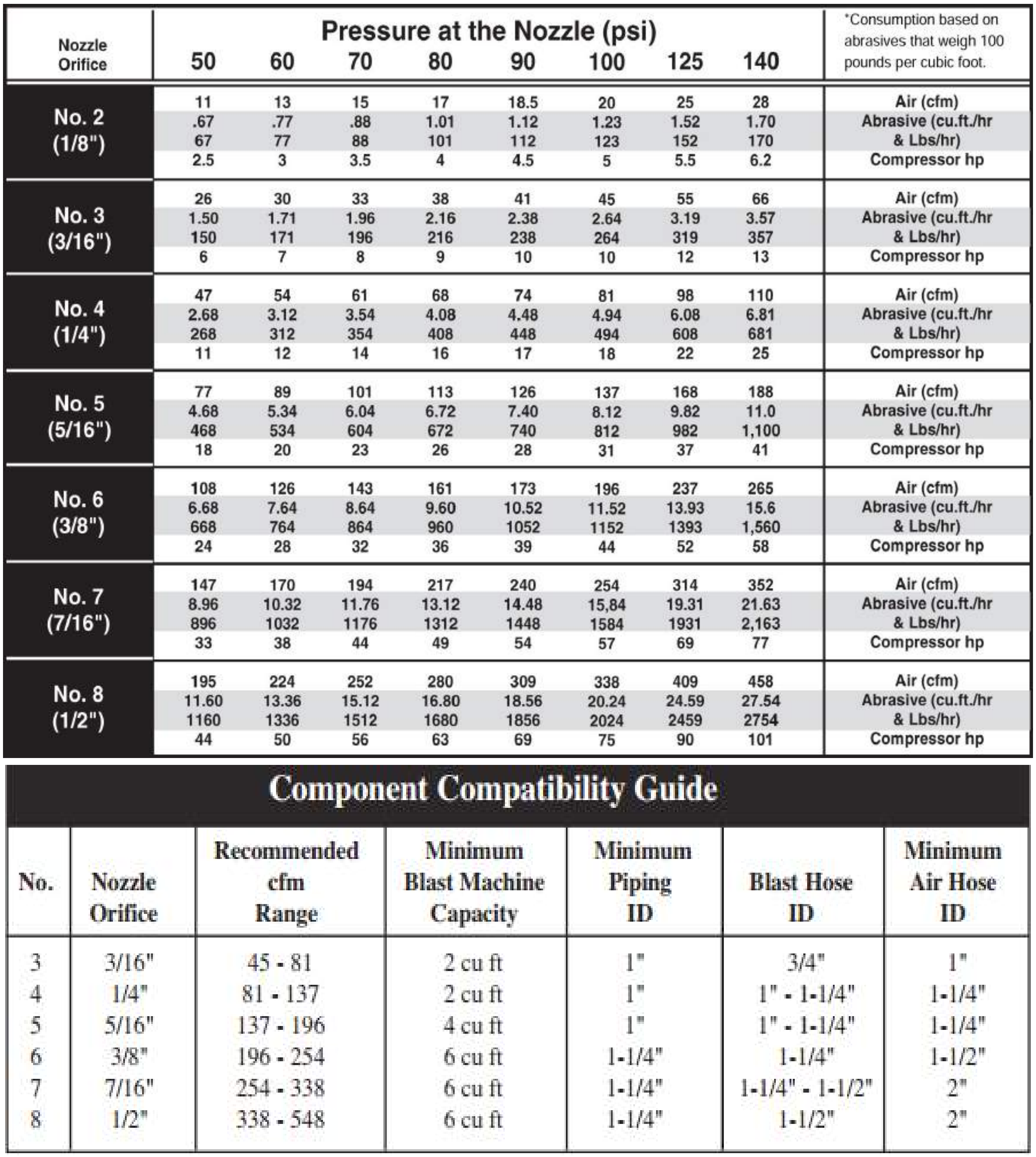


Fig 2.5.3 (xi): Blast cleaning booth system with abrasive recycling system

Fig 2.5.3 (xii): Abrasive blasting nozzles

Air blast systems – air consumption rates: Below are charts of air volume (SCFM) used in blasting with pressure and suction systems utilising various pressures (PSI) and orifice sizes.



Nozzle Orifice	Pressure at the Nozzle (psi)								*Consumption based on abrasives that weigh 100 pounds per cubic foot.
	50	60	70	80	90	100	125	140	
No. 2 (1/8")	11	13	15	17	18.5	20	25	28	Air (cfm)
	.67	.77	.88	1.01	1.12	1.23	1.52	1.70	Abrasive (cu.ft./hr
	67	77	88	101	112	123	152	170	& Lbs/hr)
	2.5	3	3.5	4	4.5	5	5.5	6.2	Compressor hp
No. 3 (3/16")	26	30	33	38	41	45	55	66	Air (cfm)
	1.50	1.71	1.96	2.16	2.38	2.64	3.19	3.57	Abrasive (cu.ft./hr
	150	171	196	216	238	264	319	357	& Lbs/hr)
	6	7	8	9	10	10	12	13	Compressor hp
No. 4 (1/4")	47	54	61	68	74	81	98	110	Air (cfm)
	2.68	3.12	3.54	4.08	4.48	4.94	6.08	6.81	Abrasive (cu.ft./hr
	268	312	354	408	448	494	608	681	& Lbs/hr)
	11	12	14	16	17	18	22	25	Compressor hp
No. 5 (5/16")	77	89	101	113	126	137	168	188	Air (cfm)
	4.68	5.34	6.04	6.72	7.40	8.12	9.82	11.0	Abrasive (cu.ft./hr
	468	534	604	672	740	812	982	1,100	& Lbs/hr)
	18	20	23	26	28	31	37	41	Compressor hp
No. 6 (3/8")	108	126	143	161	173	196	237	265	Air (cfm)
	6.68	7.64	8.64	9.60	10.52	11.52	13.93	15.6	Abrasive (cu.ft./hr
	668	764	864	960	1052	1152	1393	1,560	& Lbs/hr)
	24	28	32	36	39	44	52	58	Compressor hp
No. 7 (7/16")	147	170	194	217	240	254	314	352	Air (cfm)
	8.96	10.32	11.76	13.12	14.48	15,84	19.31	21.63	Abrasive (cu.ft./hr
	896	1032	1176	1312	1448	1584	1931	2,163	& Lbs/hr)
	33	38	44	49	54	57	69	77	Compressor hp
No. 8 (1/2")	195	224	252	280	309	338	409	458	Air (cfm)
	11.60	13.36	15.12	16.80	18.56	20.24	24.59	27.54	Abrasive (cu.ft./hr
	1160	1336	1512	1680	1856	2024	2459	2754	& Lbs/hr)
	44	50	56	63	69	75	90	101	Compressor hp

Component Compatibility Guide

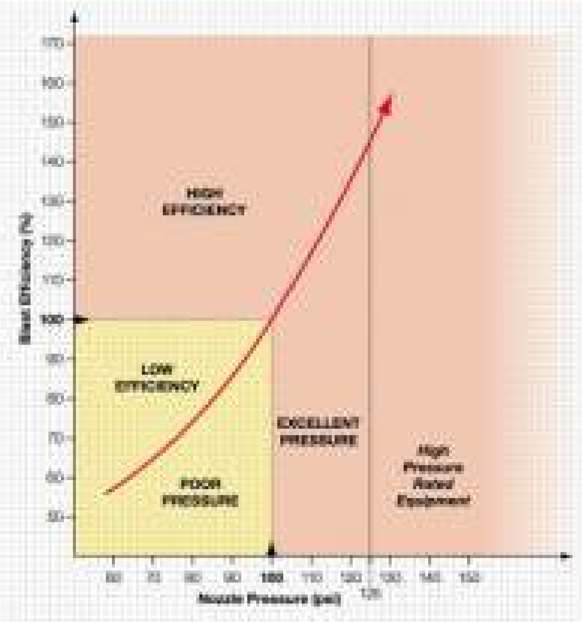
No.	Nozzle Orifice	Recommended cfm Range	Minimum Blast Machine Capacity	Minimum Piping ID	Blast Hose ID	Minimum Air Hose ID
3	3/16"	45 - 81	2 cu ft	1"	3/4"	1"
4	1/4"	81 - 137	2 cu ft	1"	1" - 1-1/4"	1-1/4"
5	5/16"	137 - 196	4 cu ft	1"	1" - 1-1/4"	1-1/4"
6	3/8"	196 - 254	6 cu ft	1-1/4"	1-1/4"	1-1/2"
7	7/16"	254 - 338	6 cu ft	1-1/4"	1-1/4" - 1-1/2"	2"
8	1/2"	338 - 548	6 cu ft	1-1/4"	1-1/2"	2"

Fig 2.5.3 (xiii): Choose your Compressor / Blast Machine according to your output required

Air blast production rates: Blast nozzle spray patterns are affected by orifice size, air pressure, and distance from the workpiece. The total diameter of the blast pattern increases as the distance from the workpiece is increased. The hot spot (where work speed is maximised) can be obtained at larger distances from the workpiece with pressure air blast systems.

Nozzle pressure vs blasting efficiency

The golden rule of thumb: Every 1 psi below 100 psi pressure at the nozzle equates to a 1.5% loss of blasting efficiency. Increasing your nozzle pressure to 100 psi will boost your efficiency substantially!



Distance from Workpiece

Gun ID	6"		12"		18"	
1/4"	1-3/8"	2-5/8"	–	2-3/4"	–	1"
5/16"	1-1/2"	3-1/2"	1-3/4"	4-1/2"	–	3-3/4"
7/16"	2"	3-3/4"	2"	4-1/2"	–	3-3/4"

*Standard Nozzle
🟩 Brush-off
Hot Spot

Fig 2.5.3 (xiv): Cabinet suction blasting

Distance from Workpiece

Nozzle ID	6"		12"		18"	
1/8"	3/4"	1"	1"	1-1/2"	–	1-1/8"
3/16"	1-1/4"	1-3/8"	1-1/2"	2"	1-5/8"	2-1/2"
1/4"	1-1/4"	1-1/2"	1-7/8"	2-1/4"	2-1/8"	2-3/4"

*Standard Nozzle
🟩 Brush-off
Hot Spot

Fig 2.5.3 (xv): Cabinet pressure blasting

Mechanical wheel blasting system utilises a high-speed rotation wheel using centrifugal force to propel the media. The wheel size design and rotation speed affect the velocity and pattern of the media. The abrasive is fed into the rotating wheel. The impact on the media by the hard-rotating wheel usually restricts media selection to a very tough steel or stainless-steel shot or grit. Machines can be built with multiple wheels for automation. Automated systems include basket, table, spinner hangers and continuous conveyor processing. Wheel blast systems are a less expensive way to blast (due to higher media recyclability and automation) than air blasting by a factor of 10. Their disadvantage are restrictions to very few media.

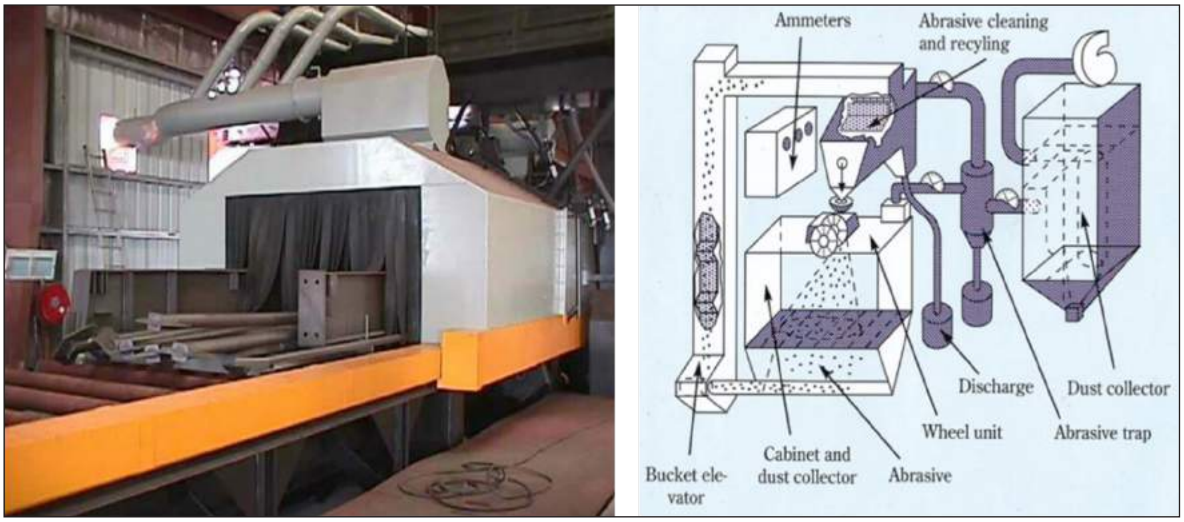


Fig 2.5.3 (xvi): Automatic blasting machine

Wet abrasive blast cleaning: There are two forms of water blast cleaning have been developed.

Water jetting and water blasting: For several years, industry has used water under high pressure as a means of surface preparation of steel and other hard surfaces where abrasive blasting was not feasible. Certain surface preparation standards, such as NACE Standard RP0172, incorporated the term *water blast* in the title and body of the document. The use of this term has been confusing to many users, since it seems to imply that some type of abrasive in the water is always necessary. Currently, when preparing surface preparation standards, NACE, SSPC, and other societies have agreed to use the term *water jetting* to describe the cleaning process where water alone is the cleaning medium. The term *water blast* is used to describe any cleaning process where abrasive of some type is incorporated with water to form the cleaning medium.

Fig 2.5.3 (xvii): High pressure water jetting

The introduction of water into an abrasive blast stream contributes to the reduction of the dust hazard, particularly when removing old lead based paints and water-soluble contaminants. Several methods of using water with abrasives have been developed. Wet abrasive blast cleaning uses the same pressures as for conventional dry blasting and similar equipment. The water is usually introduced immediately behind the nozzle so that it is atomised and accelerated through the nozzle orifice along with the air and abrasive. Water can also be introduced in controlled amounts at the base of the blast pot and is then mixed with the air and abrasive as it passes along the blast hose. Because of the low water to air ratio of the system, fine particulates of abrasive can remain on the steel surface and need to be removed by water washing. This method can produce a high visual standard of cleaning and is effective in removing a high proportion of soluble salts. Some wet abrasive processes use inhibitors in the water to prevent rusting of the cleaned surface. It is important to establish whether any remaining traces of such inhibitors will be compatible with the paint coating to be applied subsequently. Generally, where inhibitors are not used, any surface rusting after wet abrasive blasting is usually removed by final light dry blast cleaning.

Fig 2.5.3 (xviii): Wet abrasive blast cleaning

Fig 2.5.3 (xix): Ultra-high-pressure water jetting

Fig 2.5.3 (xx): Ultra-high-water pressure blasting (No profile is created)

Ultra-high-pressure water jetting over 1,700 bars (25,000 psi) is gaining in popularity, partly because of its ability to remove high percentages of soluble salts from the steel surface. It has the advantage of not generating spent abrasive and not incurring the cost of abrasive disposal. Also, at the higher pressure, lower volume of water is used, and this makes disposal costs lower than with traditional water blasting methods. Ultra-high-pressure water jetting leaves a warm surface from which traces of residual water quickly dry but does not generate sufficient heat to cause thermal stress in the steel surface.

HIGH PRESSURE WATER BLASTING	
ADVANTAGES	**DISADVANTAGES**
• Shearing and lifting rust, coatings and soluble salts from the steel surface relatively easily • Does not create a profile but helps expose the earlier profile • Environmentally friendly and emerging technology for the near future • Eliminates the need to use nasty chemicals • Leaves a very attractive satin finish on stainless steel, aluminium and brass • Provides an excellent lightly etched surface for bonding within the specialty coating markets • Allows optimal surface cleanliness and preparation for final operations • Provides an excellent surface by cleaning the topography of the surface	• Contamination • Expensive equipment • Does not provide a profile without the use of media • Operator safety at high pressure

Fig 2.5.3 (xxi): Water blasting

Fig 2.5.3 (xxii): Water jetting equipment

The protective equipment usually required for water jetting includes:

- Waterproof suit
- Helmet and visor
- Protective heavy-duty gloves and boots with steel toe caps and metatarsal protection
- Hearing protection
- Safety fluid shut-off valve (dead man valve) In addition, the use of a regulator to gradually increase pressure at start-up will help the operator adjust to the back pressure of the spray nozzle

Abrasive-injected water blast: This method uses the same basic equipment required for high-pressure water jetting plus several additional items, including:

- Abrasives injector and adapter
- Abrasive hose
- Abrasive container

The force of the water through the gun and gun lance draws the abrasive into the water stream by suction. The principal advantage of this method compared with water jetting is that it is possible to create a desired surface profile on the cleaned surface. As with dry blasting, the surface profile created depends largely on a combination of abrasive size and pressure used. In general, the abrasive will be less effective when mixed with water, and the surface profile will be less than that produced by the same abrasive used dry. Production cleaning rate is much better with abrasive injected into the water stream, and up to 90% of the dry blasting production rate can be achieved with this type of equipment. Typical water usage is in the range of 8 to 60 L/min. The production rate is around 50% of that achieved by dry blast cleaning.

Fig 2.5.3 (xxiii): Abrasive injected water blasting

Slurry blasting with water/abrasive mix: In this method, the abrasive and water are mixed together at or near the blast pot with constant agitation to form a slurry. The slurry then is pumped through a single hose to the blast nozzle.

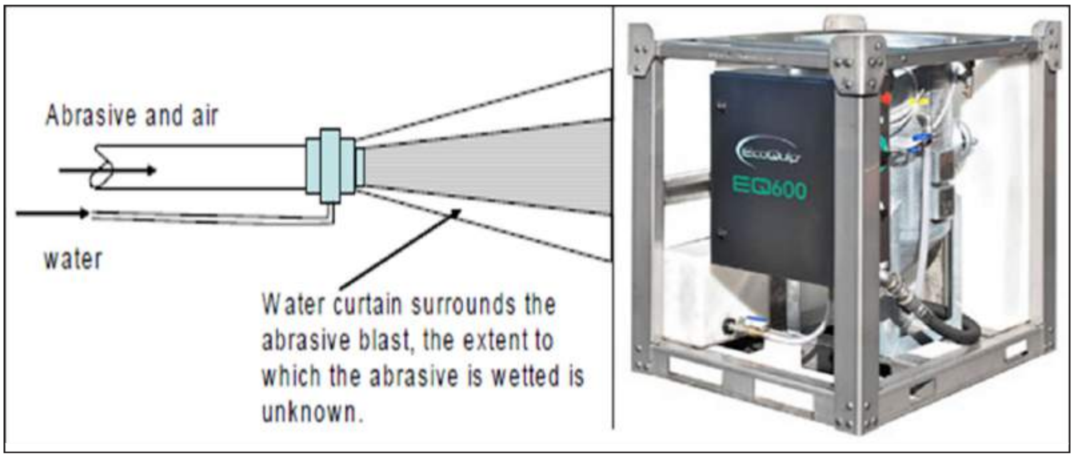


Fig 2.5.3 (xxiv): Wet blasting with abrasive air and water

Final surface conditioning: The surface to be coated shall be clean, dry, free from oil/grease and have the specified roughness and cleanliness until the first coat is applied. Dust, blast abrasives etc. shall be removed from the surface after blast cleaning so that the particle quantity and particle size do not exceed the required standards. The maximum content of soluble impurities on the blasted surface as sampled using ISO 8502-6 and distilled water, shall not exceed a conductivity corresponding to a NaCl content of 20 mg/m2. Equivalent methods may be used.

Surface profile and amplitude: The type and size of the abrasive used in blast cleaning have a significant effect on the profile and amplitude produced. In addition to the degree of cleanliness, surface preparation specifications should also consider 'roughness' relative to the coating to be applied. High build paint coatings and thermally sprayed metal coatings need a coarse angular surface profile to provide a mechanical key. This is achieved by using grit abrasives. Shot abrasives are used for thin film paint coatings such as pre-fabrication primers. The difference between shot and grit abrasives and the corresponding surface profiles produced is illustrated below in the three-dimensional diagrams obtained from noncontact surface characterisation equipment.

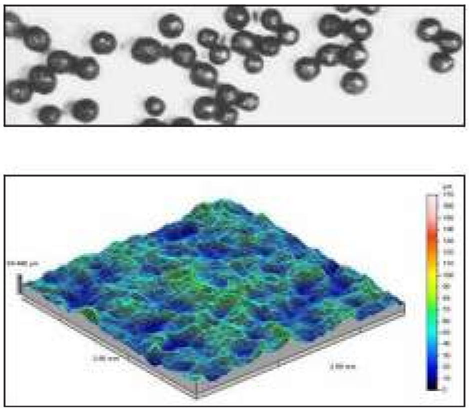


Fig 2.5.3 (xxv): Shot abrasive

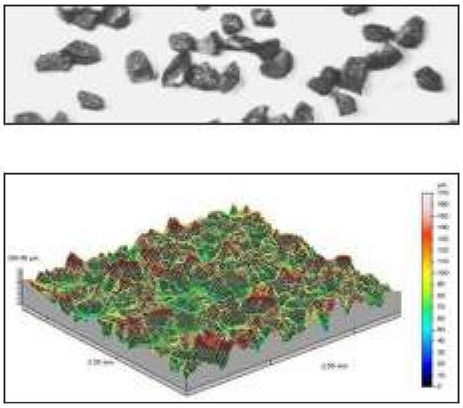


Fig 2.5.3 (xxvi): Grit abrasive

Surface profile inspection

Anchor profile: Know exactly what anchor pattern tolerances are allowed. If the specification states a minimum 38-µm (1.5-mil) anchor pattern (surface profile), 33 µm (1.3 mil) is not acceptable. A well written specification will require a surface profile range, such as between 25 to 50 µm (1.0 and 2.0 mil), or will express surface profile with a variable, such as 38 µm (1.5 mil) +/- 12.7 µm (0.5 mil).

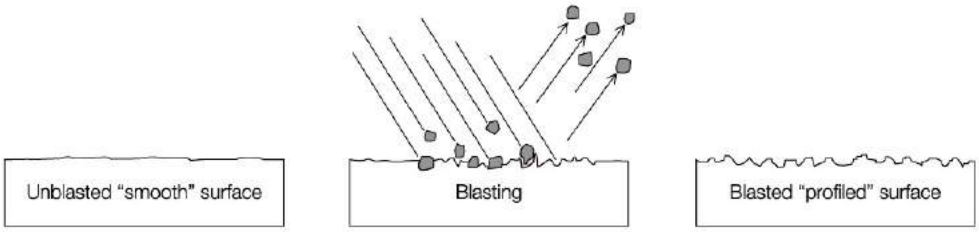


Fig 2.5.3 (xxvii): Anchor profile created by blasting

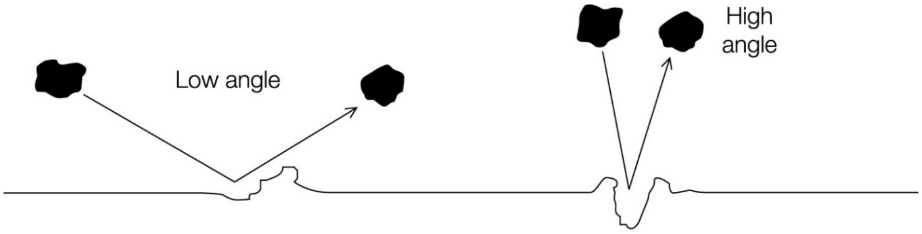


Fig 2.5.3 (xxviii): Angle of blasting helps create different profiles

The surface treatment specification should describe the surface roughness required, usually as an indication of the average amplitude achieved by the blast cleaning process. Several methods have been developed to measure or assess the distance between the peaks and troughs of blast cleaned surfaces. These have included comparator panels, special dial gauges, replica tapes and traversing stylus equipment. Usually, comparators or replica tapes are used, and the relevant standards are BS EN ISO 8503-1 and BS EN ISO 8503-5 respectively.

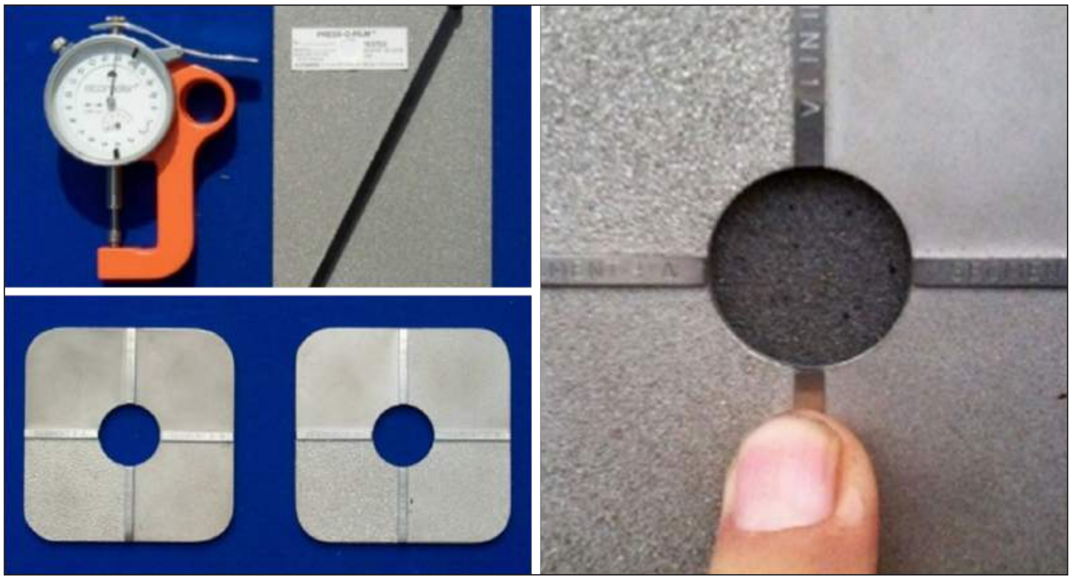


Fig 2.5.3 (xxix): Replica tape method and surface profile comparators

Surface dust: The blast cleaning operation produces large quantities of dust and debris that must be removed from the abraded surface. Automatic plants are usually equipped with mechanical brushes and air blowers. Other methods can utilise sweeping and vacuum cleaning. However, the effectiveness of these cleaning operations may not be readily visible, and the presence of fine residual dust particles that could interfere with coating adhesion can be checked using a pressure sensitive tape pressed onto the blast cleaned surface. The tape, along with any dust adhering to it, is then placed on a white background and compared to a pictorial rating. This method is described in BS EN ISO 8502-3. Although the standard provides a method of checking for dust, there are no recommendations for acceptable levels.

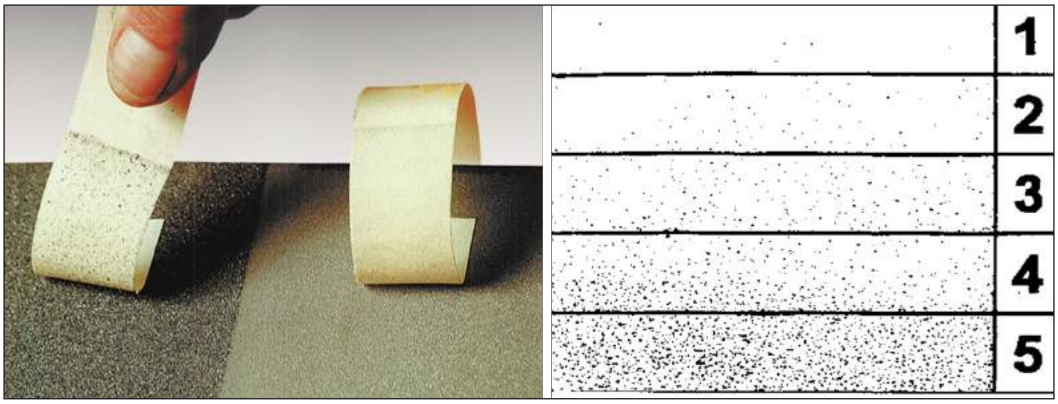


Fig 2.5.3 (xxx): Checking dust levels on blasted surface

Media reclaim systems: Recoverable medias used in industrial blast systems will run from 5 to 100 times through the blast system. These recoverable medias need to be cleaned, sized and returned to the blast system after being blasted. The media reclaim system accomplishes this. The reclaimer keeps finish and production rates consistent. Media reclaim systems can be Air Cyclones or Mechanical Systems.

Dust collection: All industrial blast systems utilise dust collectors to allow blast systems to be indoors. The dust collector removes the fine blasting dust keeping the media clean and the operators safe through visibility and breathable air. Dust collectors remove 99% of 1 micron or larger material. Hepa filters can be added to remove dust particles down to 1/2 micron. Dust collectors are sized to the cabinet size, media type, and amount of blast nozzles or wheels being used.

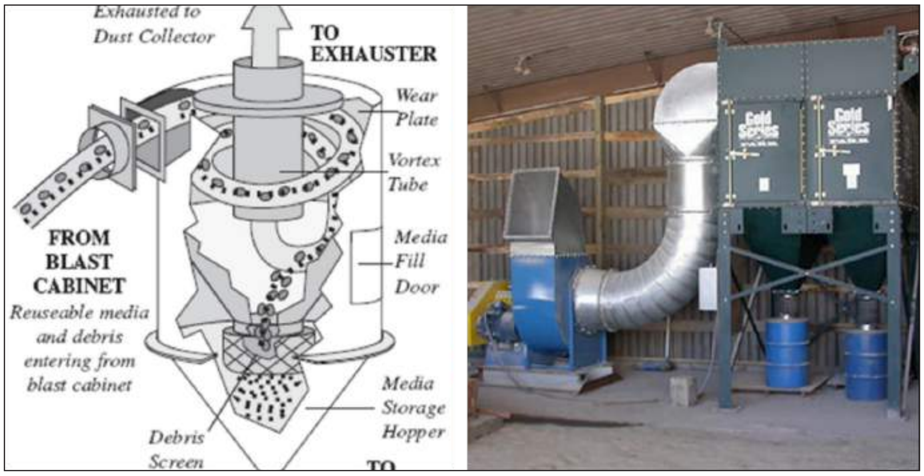
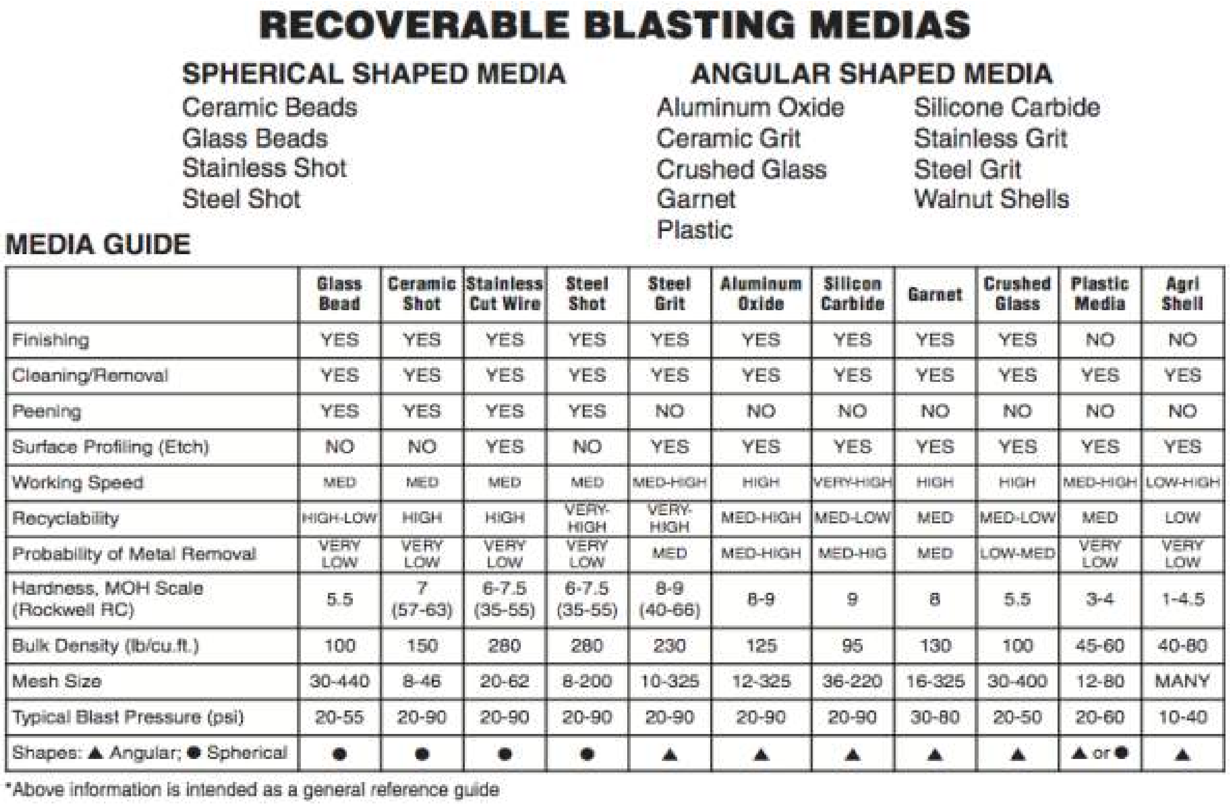


Fig 2.5.3 (xxxi): Dust collection system in blast room

Blast medias: Recoverable blasting media are used in industrial blasting. Indoor blasting systems require media with extended life. Blast media, type, shape, size and hardness affect the process and materials they are capable of blasting. Spherical media is used for peening and produce smoother surface finishes. Angular media chip at a part's surface; removing paint, rust and scale quicker, with better results than round media. Angular media produce a rougher surface finish and produce superior anchor patterns for paint and coating adhesions. Higher blast pressures increase production but reduce media life. Blasting harder workpieces also reduces media life. Recoverable blasting media have two basic shapes. Round (spherical) and angular. The most common recoverable industrial blast media are:

Fig 2.5.3 (xxxii): Types of blasting media



RECOVERABLE BLASTING MEDIAS

SPHERICAL SHAPED MEDIA

Ceramic Beads
Glass Beads
Stainless Shot
Steel Shot

ANGULAR SHAPED MEDIA

Aluminum Oxide
Ceramic Grit
Crushed Glass
Garnet
Plastic
Silicone Carbide
Stainless Grit
Steel Grit
Walnut Shells

MEDIA GUIDE

	Glass Bead	Ceramic Shot	Stainless Cut Wire	Steel Shot	Steel Grit	Aluminum Oxide	Silicon Carbide	Garnet	Crushed Glass	Plastic Media	Agri Shell
Finishing	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
Cleaning/Removal	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Peening	YES	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO
Surface Profiling (Etch)	NO	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES
Working Speed	MED	MED	MED	MED	MED-HIGH	HIGH	VERY-HIGH	HIGH	HIGH	MED-HIGH	LOW-HIGH
Recyclability	HIGH-LOW	HIGH	HIGH	VERY-HIGH	VERY-HIGH	MED-HIGH	MED-LOW	MED	MED-LOW	MED	LOW
Probability of Metal Removal	VERY LOW	VERY LOW	VERY LOW	VERY LOW	MED	MED-HIGH	MED-HIG	MED	LOW-MED	VERY LOW	VERY LOW
Hardness, MOH Scale (Rockwell RC)	5.5	7 (57-63)	6-7.5 (35-55)	6-7.5 (35-55)	8-9 (40-66)	8-9	9	8	5.5	3-4	1-4.5
Bulk Density (lb/cu.ft.)	100	150	280	280	230	125	95	130	100	45-60	40-80
Mesh Size	30-440	8-46	20-62	8-200	10-325	12-325	36-220	16-325	30-400	12-80	MANY
Typical Blast Pressure (psi)	20-55	20-90	20-90	20-90	20-90	20-90	20-90	30-80	20-50	20-60	10-40
Shapes: ▲ Angular; ● Spherical	●	●	●	●	▲	▲	▲	▲	▲	▲ or ●	▲

*Above information is intended as a general reference guide

		General Application Guide for Abrasive Media (for comparative purposes only)				
1= best						
2= effective				APPLICATION		
3=acceptale		ETCH	PEEN	REMOVE PAINT	CLEAN	DEBURR
STEEL	1	Silicon Carbide	Cast S.S. Shot	Soda Blast	Soda Blast	Steel Grit
	2	Aluminum Oxide	Steel Shot	Silicon Carbide	Silicon Carbide	Silicon Carbide
	3	Black Beauty Slag	Glass Bead	Aluminum Oxide	Aluminum Oxide	Aluminum Oxide
ALUMINUM	1	Ground Glass	Glass Bead	Glass Bead	Glass Bead	Agricultural Shells
	2	Glass/Aluminum Oxide	Agricultural Shells	Soda Blast	Soda Blast	Plastic Grit
	3	Aluminum Oxide	Plastic Grit	Plastic Grit	Plastic Grit	Glass/Aluminum Oxide
PLASTIC	1	Ground Glass	Glass Bead	Soda Blast	Soda Blast	Plastic Grit
	2	Glass/Aluminum Oxide	Plastic Grit	Plastic Grit	Plastic Grit	Agricultural Shells
	3	Plastic Grit	Agricultural Shells	Agricultural Shells	Agricultural Shells	Glass/Aluminum Oxide
WOOD	1	Plastic Grit	N/A	Soda Blast	Soda Blast	N/A
	2	Agricultural Shells	N/A	Plastic Grit	Plastic Grit	N/A
	3	Soda Blast	N/A	Glass Bead	Glass Bead	N/A

Blast media inspection: Blast media needs to be inspected for dust and oil and size, else it will hamper the quality of the blasting. Oil will contaminate the surface and dust will cause poor adhesion.

Fig 2.5.3 (xxxiii): Apparatus to check blast media for impurities

Moisture in compressed air line: Moisture in the compressed line causes flash rusting of the blasted surface.

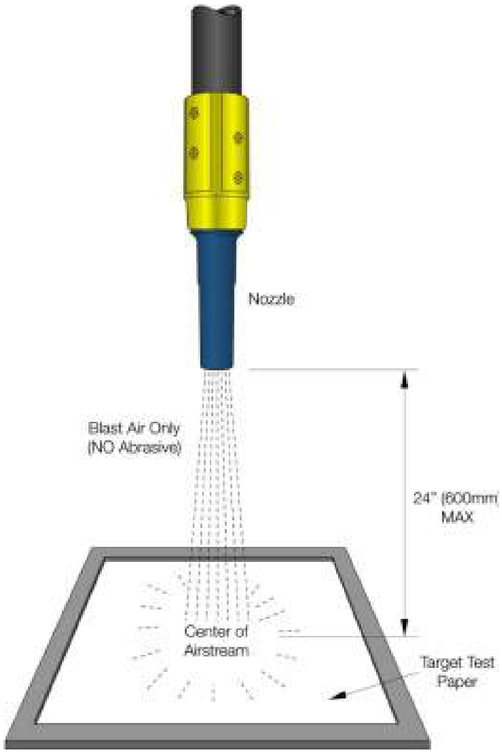


Fig 2.5.3 (xxxiv): Test to check compressed air quality

Blasting nozzle inspection: Blast nozzle gauge measures the orifice size of an abrasive blasting nozzle. This gauge is used to determine the nozzle orifice wear which leads to low nozzle pressure and decreased efficiency in the performance of the nozzle's venturi. Nozzle orifice wear results in decreased productivity and increased abrasive media consumption. Regular blast nozzle checking and timely replacement will help reduce losses and improve productivity.

Fig 2.5.3 (xxxv): Blast nozzle inspection gauge

Blast nozzle gauge: Needle pressure gauge is designed to measure air pressure in blast and air hoses. Pressure drop is responsible for decreased production rates, increased abrasive consumption and reduced anchor profile in abrasive blasting systems.

Fig 2.5.3 (xxxvi): Hypothermic needle pressure gauge

2.5.4 Initial Surface Condition

Structural steel elements in new structures are usually either hot rolled sections or fabricated plate girders. The initial steel surfaces normally comply with rust grades A or B according to BS EN ISO 8501-1[1]. Descriptions of rust grades A to D are as follows.

A - Steel surface largely covered with adhering mill scale, but little if any rust

B - Steel surface which has begun to rust and from which mill scale has begun to flake

C - Steel surface on which the mill scale has rusted away or from which it can be scraped, but with slight pitting under normal vision

D - Steel surface on which the mill scale has rusted away and on which general pitting is visible under normal vision

Material that is pitted, i.e. rust grades C or D, should be avoided if possible, since it is difficult to clean all the corrosion products from the pits during surface preparation.

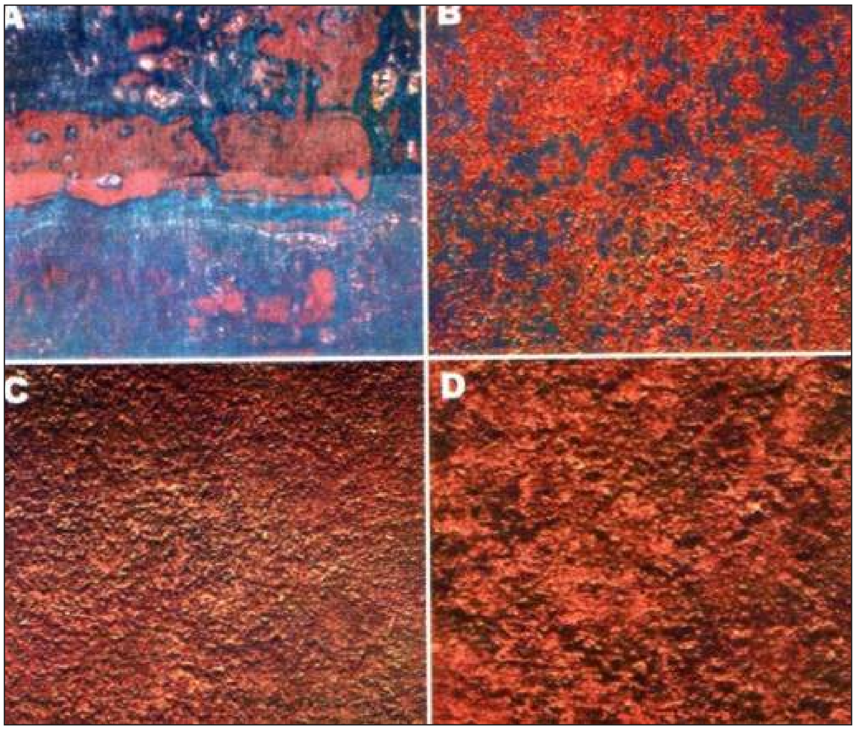


Fig 2.5.4 (i): Examples of rust grades

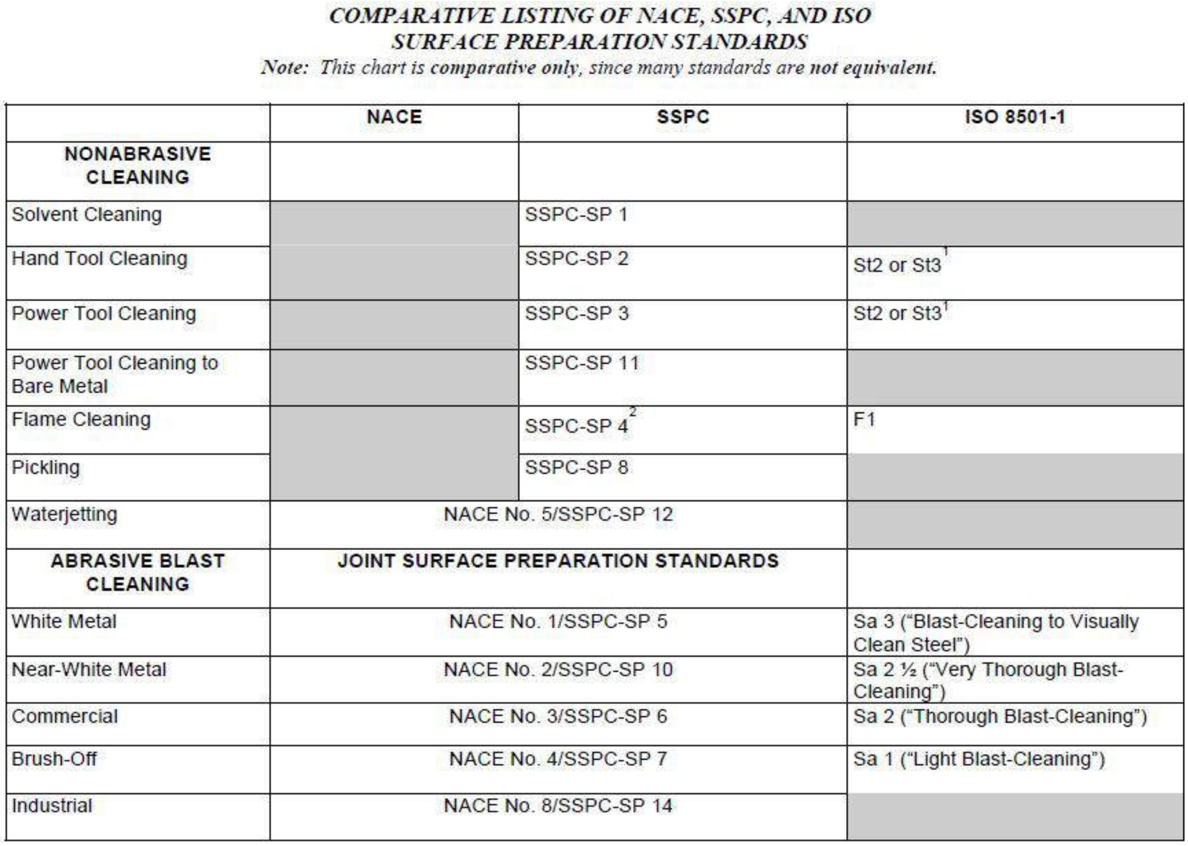
Fig 2.5.4 (ii): Hot rolled sections with mill scale (Grade B)

2.5.4.1 Methods of Preparation and Grades of Cleanliness

Various methods and grades of cleanliness are presented in BS EN ISO 8501-1. Types of surface cleaning include:

- Hand cleaning
- Power tool cleaning
- Abrasive blast cleaning
- Flame cleaning

This standard essentially refers to the surface appearance of the steel and gives descriptions with pictorial references of the grades of cleanliness.



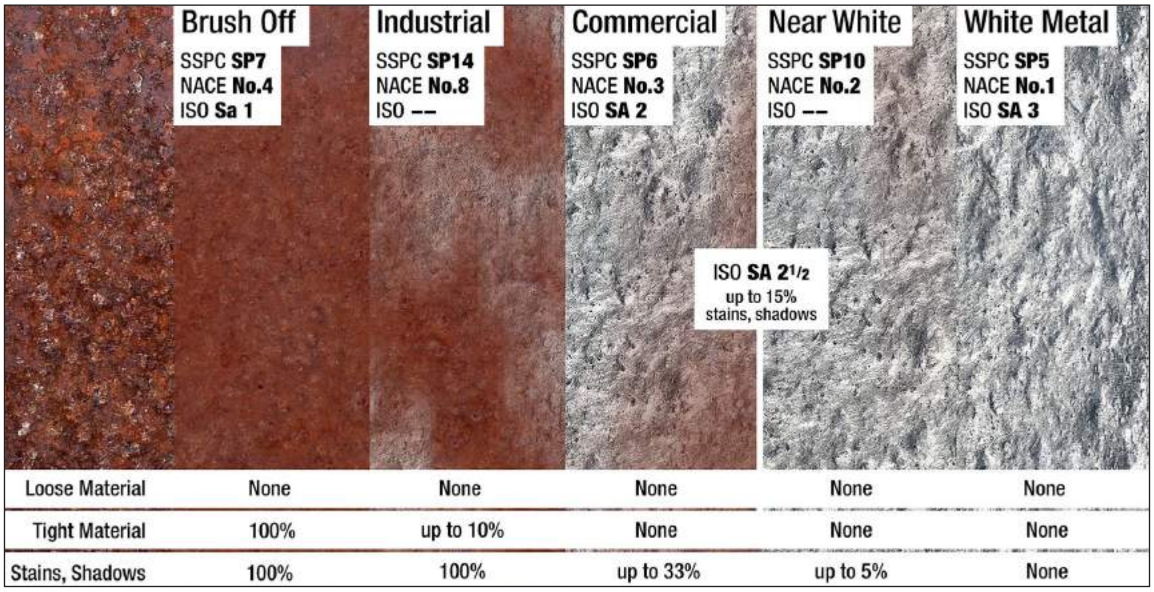
COMPARATIVE LISTING OF NACE, SSPC, AND ISO SURFACE PREPARATION STANDARDS

Note: This chart is comparative only, since many standards are not equivalent.

	NACE	SSPC	ISO 8501-1
NONABRASIVE CLEANING			
Solvent Cleaning		SSPC-SP 1	
Hand Tool Cleaning		SSPC-SP 2	St2 or St3[1]
Power Tool Cleaning		SSPC-SP 3	St2 or St3[1]
Power Tool Cleaning to Bare Metal		SSPC-SP 11	
Flame Cleaning		SSPC-SP 4[2]	F1
Pickling		SSPC-SP 8	
Waterjetting	NACE No. 5/SSPC-SP 12		
ABRASIVE BLAST CLEANING	**JOINT SURFACE PREPARATION STANDARDS**		
White Metal	NACE No. 1/SSPC-SP 5		Sa 3 ("Blast-Cleaning to Visually Clean Steel")
Near-White Metal	NACE No. 2/SSPC-SP 10		Sa 2 ½ ("Very Thorough Blast-Cleaning")
Commercial	NACE No. 3/SSPC-SP 6		Sa 2 ("Thorough Blast-Cleaning")
Brush-Off	NACE No. 4/SSPC-SP 7		Sa 1 ("Light Blast-Cleaning")
Industrial	NACE No. 8/SSPC-SP 14		

The standard grades of cleanliness for abrasive blast cleaning in accordance with BS EN ISO 8501-1[1] are:

- Sa 1 – Light blast cleaning
- Sa 2 – Thorough blast cleaning
- Sa 2½ – Very thorough blast cleaning
- Sa 3 – Blast cleaning to visually clean steel



Loose Material	None	None	None	None	None
Tight Material	100%	up to 10%	None	None	None
Stains, Shadows	100%	100%	up to 33%	up to 5%	None

Fig 2.5.4.1 (i): Standard grades of cleanliness

Fig 2.5.4.1 (ii): Specifications for steelwork usually require either Sa 2½ or Sa 3 grades

Fig 2.5.4.1 (iii): Blast cleaned steel surface to Sa 2½ standard

Abrasive media for blasting: The cleaned surfaces should be compared with the appropriate reference photograph in the standard according to the specification. A very wide range of abrasive is available. These can be non-metallic (metal slags, aluminum oxide, etc.) and metallic (steel shot or grit, etc.)

Fig 2.5.4.1 (iv): Types of abrasives used for surface preparation (hodgeclemco.co.uk)

The particle size of the abrasive is also an important factor affecting the rate and efficiency of cleaning. In general terms, fine grades are efficient in cleaning relatively new steelwork, whereas coarse grades may be required for heavily corroded surfaces. The removal of rust from pitted steel is more easily effected by fine grades and, depending upon the condition of the steel surface, a mixture of grades may be required initially to break down and remove mill scale and clean in pitted areas.

Surface Preparation - Problem with repair work maintenance blasting

1. Limited access to areas to be blasted
2. Vulnerability of outfit items to damage from abrasive
3. Increased labor due to masking and damage control procedures
4. Reduced blaster visibility
5. Increased difficulty of spent abrasive removal
6. Increasing costs and environmental impact of abrasive disposal
7. Permanent abrasive entrapment
8. Added man hours for damage repair

Fig 2.5.4.1 (v): Challenges for maintenance blasting project

Flame cleaning: This method uses an oxy/gas flame that is passed over the steel surface. The sudden heating causes rust scales to flake off due to differential expansion between the scales and the steel surface. All loose rust can then be removed by scraping and wire brushing followed by dust removal. Flame cleaning is not an economic method and may damage coatings on the reverse side of the surface being treated. Also, the technique is not very effective in removing all rust from steel, so it is rarely used.

Fig 2.5.4.1 (vi): Flame cleaning

Removal of soluble iron corrosion products: Depending upon the condition of the steelwork prior to blast cleaning, there may be surface contaminants present other than mill scale and rust. Initial steel surface conditions of Grades A to C are unlikely to be affected, however Grade D condition (steelwork that is pitted) could contain contaminants within the pits that may not be removed by the dry blast cleaning process. The testing for soluble iron corrosion products is not usually required for new steelwork but is sometimes carried out on steelwork which has been stored in an external environment for long periods of time and on existing structures undergoing maintenance treatments.

Fig 2.5.4.1 (vii): Iron corrosion

Surface condition before surface preparation / coating: Re-rusting can occur very quickly in a damp environment and unless the steel is maintained in a dry condition, coating of the surface should proceed as soon as possible. Any re-rusting of the surface should be considered as a contaminant and be removed by re-blasting.

Additional surface treatments – inspection: After abrasive blast cleaning, it is possible to examine for surface imperfections and surface alterations caused during fabrication processes, e.g. welding. Welds on fabricated structural steelwork represent a relatively small but important part of the structure and can produce variable surface profile and uneven surfaces or sharp projections that can cause premature failure of the coating. Although welded areas are inspected, the requirements for weld quality do not usually consider the requirements for coating. Welds must be continuous and free from pinholes, sharp projections and excessive undercutting. Weld spatter and residual slags should also be removed.

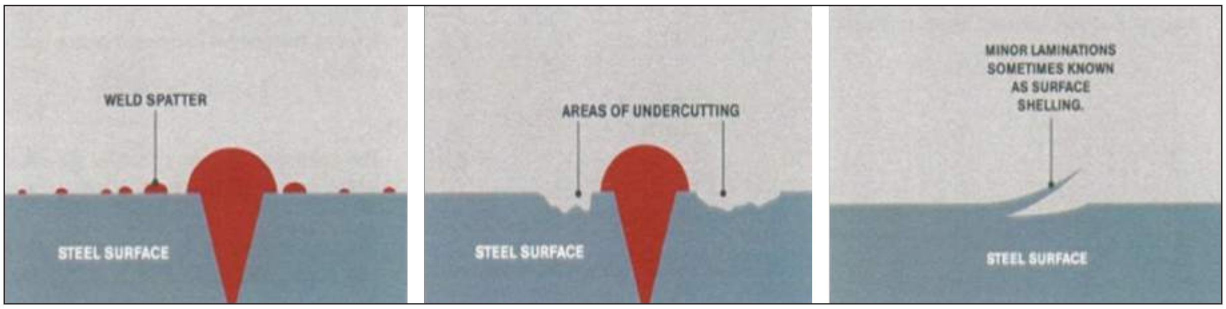


Fig 2.5.4.1 (ix): Examples of surface imperfections produced during welding

BS EN ISO 8501-3:2006 describes preparation grades of welds, cut edges and other areas, on steel surfaces with imperfections to make the steel surfaces suitable for the application of coatings. Three preparation grades are described, with illustrated examples of relevant imperfections, as:

- P1 - Light preparation
- P2 - Thorough preparation
- P3 - Very thorough preparation

Site considerations: After welding, it is essential that the joint surfaces, including the weld itself, are prepared to the specified standard of cleanliness and profile. Because of the contamination that occurs from the welding flux, attention needs to be paid to cleaning off all residues. The surfaces of welds themselves should not need any grinding if they comply with the requirements of BS EN 1011: Part 2 for smoothness and blending into the parent metal. However, rough profiles, badly formed start-stops, sharp undercut and other defects such as adherent weld spatter should be removed by careful grinding. Attention needs to be paid to the blast cleaned profile because weld metal is harder and site blast cleaning is more difficult than shop blasting.

Tips

Good surface preparation is an essential pre-requisite for achieving good coating quality and coating performance. If you pay careful attention to this aspect and ensure that the surface is well prepared, half the battle is won.

Notes

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PAINTS AND
COATINGS
SKILL COUNCIL

3. Paint the Substrate

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Applicable NOS – PCS/N5111

Key Learning Outcomes

At the end of this module, you will be able to:

1. Explain the overall process of applying the paint over a prepared substrate
2. Explain the importance of mixing paint thoroughly before use and right way to do it to get a consistent product
3. Describe various application methods available and how to select the right method
4. Describe the steps in paint application using a spray gun and techniques for getting correct results

UNIT 3.1 Process of Mixing Paints

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the correct process for mixing paint and thinning it to the desired consistency for application
2. List problems that may arise if paint is not mixed properly

Modern paint specifications usually comprise a sequential application of paints or alternatively paints applied over metal coatings to form a 'duplex' coating system. The protective paint systems usually consist of primer, undercoat(s) and finish coats. Each 'coat' in any protective system has a specific function, and the different types are applied in a specific sequence of primer followed by intermediate/ under coats and finally the finish or top coat

Before using the paint, ensure it has not been damaged by age, improper storage conditions, handling, etc. Old, rusty, or dirty cans would imply that there could be a problem. Products in cans that appear to have been opened previously should also be carefully examined, before use. If the paint appears to be very thin, it may indicate severe settlement of pigment and require significant mixing or even reprocessing at the factory. Coatings that appear to have separated or gelled should also be carefully examined. If in doubt, call for the manufacturer's opinion, preferably in writing, if the coatings are to be used.

Paints must be thinned, if needed, only to the desired extent and thinner used should be recommended by the material supplier.

Fig 3.1 (i): Mixing coatings

Paint mixing: Before mixing plural component coatings, ensure that the individual components are mixed separately first to form a homogeneous liquid.

- Mix the components in the recommended proportion.
- Failure to mix the components sufficiently or in correct proportion may result in poor film properties, inadequate or non-uniform cure, or partial separation of components after application.

In heavily pigmented paints, settlement is likely to occur during storage. Unless the paint is thoroughly mixed before use, it will not perform satisfactorily. Poor opacity, slow drying, poor gloss, and other problems often result from failure to mix the paint properly before use. All settlement should be mixed by stirring, using a beating and lifting action. If large quantities of paint (20 L) are to be mixed, it is advisable to use a mechanical mixer, preferably of the type driven by compressed air.

Fig 3.1 (ii): Improper mixing can cause coating failures

Use the recommended quality and quantity of thinner to achieve the desired application viscosity. Too much thinner may result in reduced dry-film thickness, together with runs and sags. Too little thinner may cause the coating to *cobweb* or *dry spray***.** A non-uniform film with poor integrity, pinholes, or poor appearance may result.

Fig 3.1 (iii): Correct thinning of paints as per specifications

Fig 3.1 (iv): Different kinds of paint stirrers

Notes

UNIT 3.2 Paint Application Methods

Unit Objectives

At the end of this unit, you will be able to:

1. List various methods available for application of paint
2. Describe the advantages and disadvantages of each method
3. Explain the basic principle behind various spray techniques/equipment
4. Explain the concept of Transfer Efficiency and how it is measured

The method of application and the conditions under which paints are applied have a significant effect on the quality and durability of the coating. Standard methods used to apply paints to structural steelwork include application by brush, roller, conventional air spray and airless spray. Airless spraying has become the most commonly used method of applying paint coatings to structural steelwork under controlled conditions. Brush and roller application are more commonly used for site application, though spraying methods are also used.

Brushing: This is the simplest method and the slowest. It is therefore not the most expensive application. Nevertheless, it has certain advantages over the other methods, e.g. better wetting of the surface and can be used in restricted spaces. It is useful for small areas, results in less wastage and contamination of surroundings.

Fig 3.2 (i): Range of brushes for variety of applications

Roller: This process is quicker than brushing and is used for large flat areas. It requires suitable flow properties in the paint. Never apply primers with roller as it will not wet the surface properly.

Fig 3.2 (ii): Roller application
kasselpainting.com

ADVANTAGES	DISADVANTAGES
1. Faster than brush application	1. Poor wetting of the surface
2. Less messy	2. Can leave unpainted surfaces
	3. Needs to be rolled multiple times
	4. Requires more thinner for cleaning
	5. Finish depends on the type of roller

Fig 3.2 (iii): Advantages and disadvantages of using rollers

Air spray: Paints for structural steelwork are also spray applied. The paint is atomised into fine droplets and projected onto the surface to be painted where the droplets join to form a continuous film. The atomisation can be accomplished in several ways. In air spraying, the paint is atomised by mixing it with a stream of compressed air in a conventional spray gun. The paint can be either sucked into the air stream (as in the simple suction-cup gun used for application to small areas) or fed to the spray gun under pressure from a pressure pot. For ideal application, careful adjustments of the spray nozzle and air pressures must be made by a skilled operator, according to the consistency and composition of the paint and the film thickness required. The application rates for air spray are quicker than that for brushing, or rolling. However, paint wastage, due to overspray, is high.

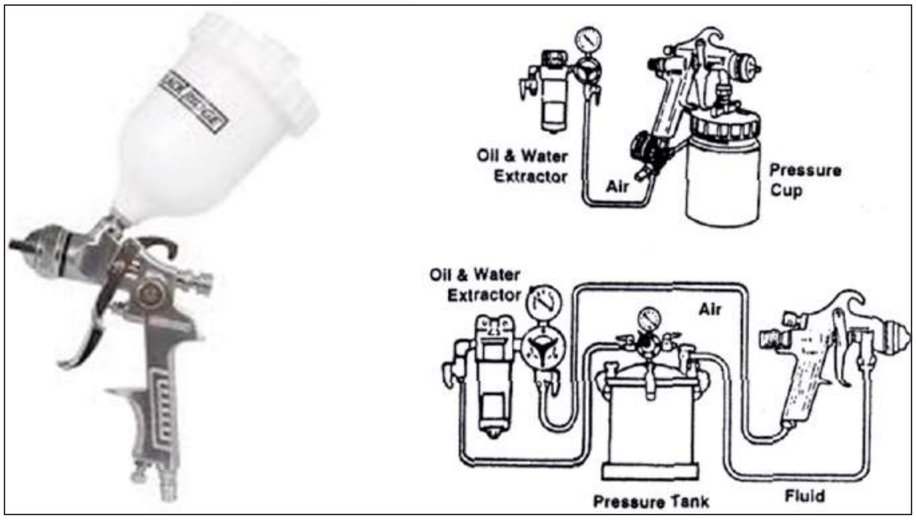


Fig 3.2 (iv): Air spraying equipment

ADVANTAGES	DISADVANTAGES
Faster application High finish quality	Require larger jobs Lower transfer efficiency Expensive method compared to brush and roller application Difficulty to achieve high thickness

Fig 3.2 (v): Advantages and disadvantages of using air spray

Airless spray: For airless spraying, the paint is hydraulically compressed and, on release through a small orifice in an airless spray gun, it is atomised and projected onto the surface. By changing the orifice size and shape and by varying the hydraulic pressure, atomisation can be accomplished for a wide range of paint consistencies from thin to thick, to give a wide range of rates of deposition. The equipment required is much more expensive than for conventional air spraying, because it must withstand the much higher pressures involved. However, the application rates are higher than for conventional air spray with overspray wastage greatly reduced. For conventional air spraying, the maximum air pressure will normally not exceed 100 psi (6.9 bar); for airless spraying, hydraulic pressures up to 4,000 psi (280 bar) may be required. A variant of the above involves heating to reduce the consistency of the paint rather than adding diluents. In this way, higher film thickness per coat is achieved. This method can be used for the application of solvent-free materials. The use of expensive equipment and highly skilled labour is necessary for the achieving optimum results but may be justified for the protection of large and important structures.

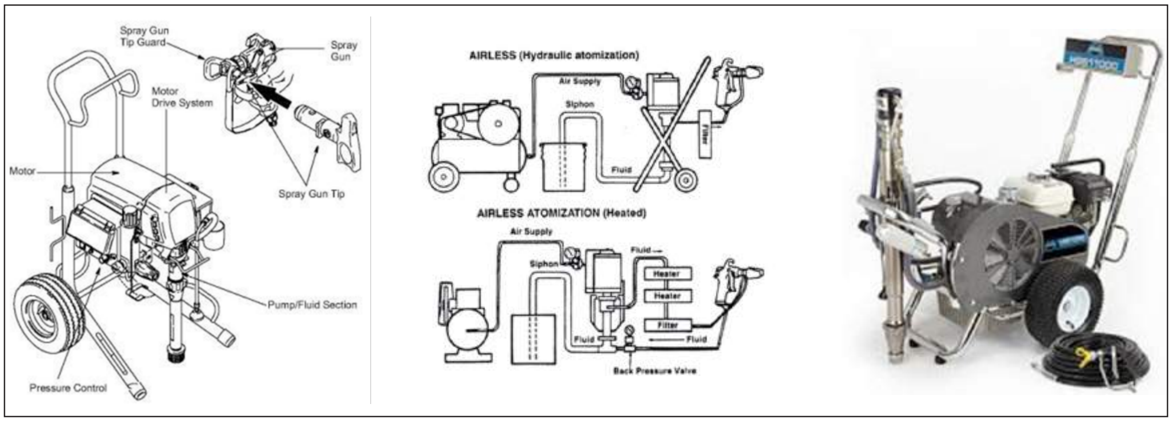


Fig 3.2 (vi): Airless spray equipment – electric, air operated and gas/petrol operated

Fig 3.2 (vii): Airless spraying application

Fig 3.2 (viii): High pressure airless spray guns with and without gun filter

Airless sprayers are typically rated using these methods:

- Maximum tip size (with one gun, with two guns, etc.)
- Gallons per minute (gpm)
- Pounds per square inch or the maximum pressure (psi)
- Horse power (hp) gpm — (gallons per minute) a flow rate measurement associated with the pump's output capacity and the tip orifice (hole) size.

CAUTION: *There is no industry standard for rating a sprayer's output capacity. Psi — (pounds per square inch) a pressure measurement. The pressure rating (e.g., 3300 psi) is the maximum working pressure (stall pressure) of the sprayer. That is, the maximum amount of pressure the sprayer can build. However, the pressure at the tip does not equal the maximum working pressure. Hose length, tip size, the type of coating being sprayed, and even the filters impact the amount of pressure available at the tip while spraying.*

TYPICAL MAXIMUM AIRLESS SPRAYER PRESSURE RATINGS:	TYPICAL ATOMISATION PRESSURES NEEDED FOR AIRLESS APPLICATIONS:
• 2000 psi • 2800 psi • 3000 psi • 3300 psi • 4000 psi	• 800 -1100 psi for lacquers • 1200 – 1800 psi for stains, zinc coatings • 2000+ for latex coatings, urethanes

Air-assisted airless: Air-assisted airless spray guns first partially atomise the fluid with a special fluid nozzle tip like a standard airless tip. Second, they complete the atomisation with small amounts of compressed air from the face and/or the horns of the air nozzle that they use. The result is a finely atomised spray pattern closely resembling that of a compressed air system. Newly designed low-pressure, air-assisted airless systems are also available. Some systems restrict the atomising air pressure to comply with various EPA guidelines; as a result, these systems can be considered HVLP air-assisted airless.

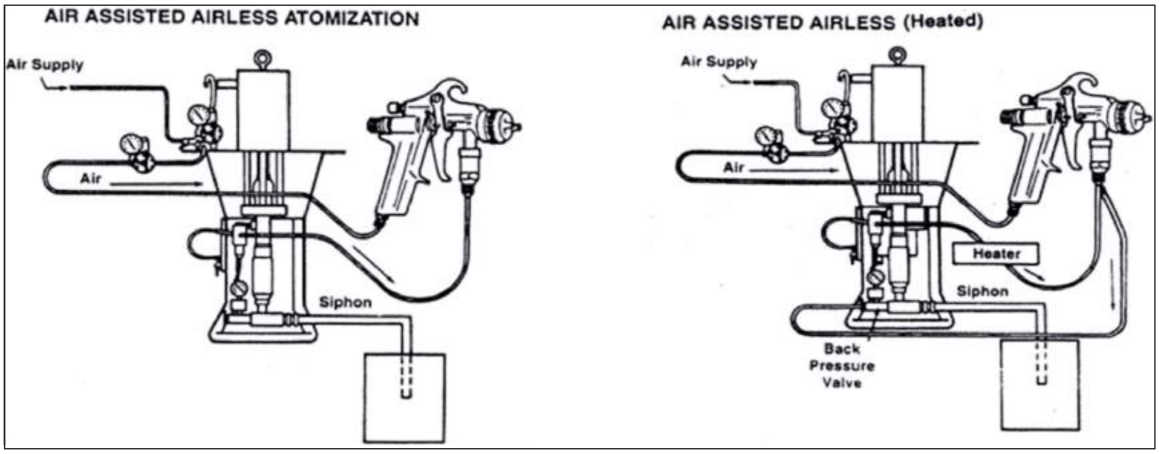
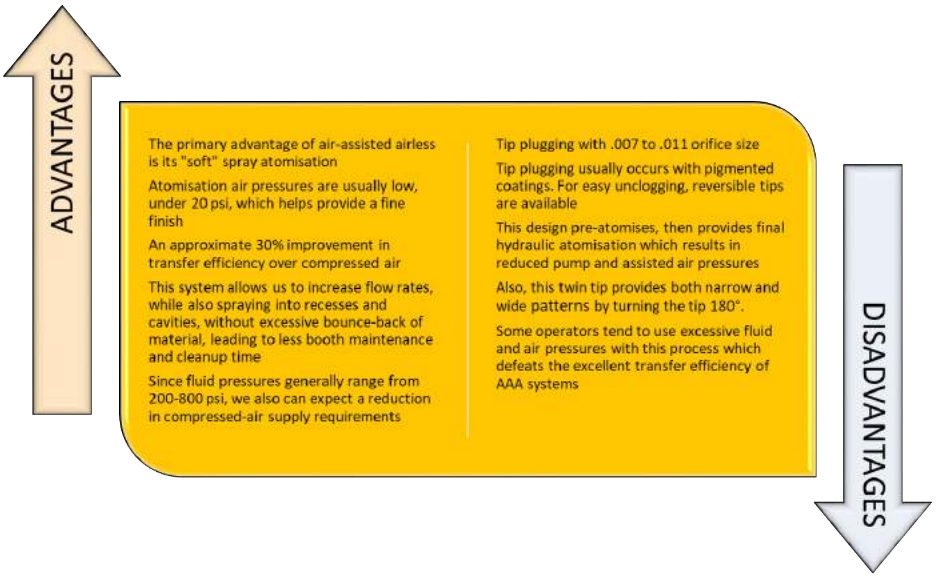


Fig 3.2 (ix): Air assisted airless spray equipment



ADVANTAGES

The primary advantage of air-assisted airless is its "soft" spray atomisation

Atomisation air pressures are usually low, under 20 psi, which helps provide a fine finish

An approximate 30% improvement in transfer efficiency over compressed air

This system allows us to increase flow rates, while also spraying into recesses and cavities, without excessive bounce-back of material, leading to less booth maintenance and cleanup time

Since fluid pressures generally range from 200-800 psi, we also can expect a reduction in compressed-air supply requirements

DISADVANTAGES

Tip plugging with .007 to .011 orifice size

Tip plugging usually occurs with pigmented coatings. For easy unclogging, reversible tips are available

This design pre-atomises, then provides final hydraulic atomisation which results in reduced pump and assisted air pressures

Also, this twin tip provides both narrow and wide patterns by turning the tip 180°.

Some operators tend to use excessive fluid and air pressures with this process which defeats the excellent transfer efficiency of AAA systems

Fig 3.2 (x): Advantages and disadvantages of using air assisted airless spray

Electrostatic spray

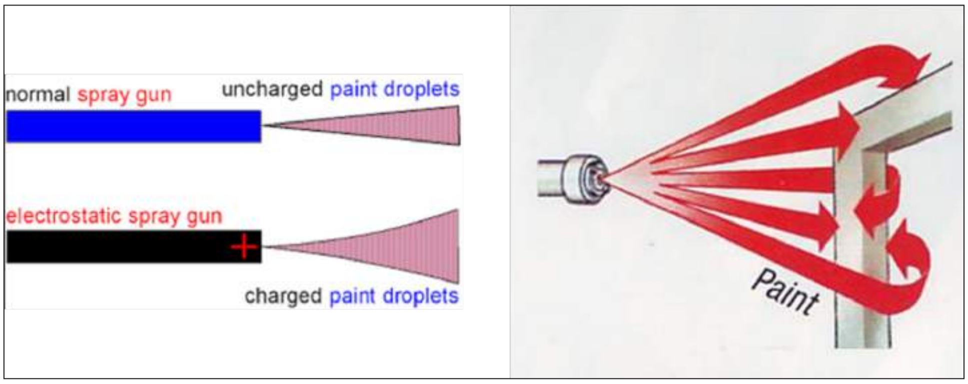


Fig 3.2 (xi): Electrostatic charging and wrap-around of coating on substrate

Electrostatic coating: It is a manufacturing process that employs charged particles to more efficiently paint a workpiece. Paint, in the form of either powdered particles or atomised liquid, is initially projected towards a conductive workpiece using normal spraying methods, and is then accelerated toward the work piece by a powerful electrostatic charge.

Fig 3.2 (xii): Electrostatic spray application

TYPE	PRESSURE	ADVANTAGES	DISADVANTAGES
Air Spray / Conventional	Max 7 bar	• Very good finish achieved • Good control ability • Small amounts of material can be used	• Poor transfer efficiency. 60% waste due to over spraying • Slow application rate • Can only spray low viscosity paints
HVLP (High Volume Low Pressure)	Max 0.7 bar	• Approximately 80% efficient vs. air spray • Good paint saving • Environmental friendly • Cleaner application • Less maintenance	• Slow application rate • Can only spray low viscosity materials
Airless	Max 500 bar	• Fast application • Good transfer efficiency • Application of high build coatings • High film build	• Poor control • Reduced quality of finish • Incapable of partial triggering • Susceptible to “tails”
Air Assisted Airless / Airmix / Aircoat	Max 400 bar	• More control, high production rates • Better transfer efficiency • Better quality finish • Reduced wear on fluid nozzle and pumps	• No partial triggering • Requires extra air hose • Fluid injection hazard • Susceptible to lower transfer efficiency than airless due to improper set up of air and fluid pressure
Electrostatic		• Greatly reduced overspray • Paint saving • Low booth maintenance • Labour saving • Less spraying ability required	• Spray equipment more expensive • Can produce minor shocks • Electrostatics can be easily deactivated and thereby become more inefficient • Undergrounded areas will repel coatings • Required good ground, <1 meg ohm

Plural component application: These have benefits such as shorter curing times, less waste, lower VOCs emitted. The increased demand for heavy-duty, plural component coatings has led to rapid improvements in the methods used to apply them. While some plural component spray systems have become easier to use as a result of technological advances, the capabilities needed to own, operate and maintain these systems have increased dramatically. This has driven the demand for highly professional industrial painting operators that understand how to employ plural component spray systems to achieve the high level of performance expected from these coatings.

Fig 3.2 (xiii): Plural component paints

Advances in plural component equipment: Many operations still rely solely on the manual, hand-mixed application (sometimes known as "hot pot") method for applying lower solids coatings to substrates. This method has been in widespread use for longer than plural component systems, so many industrial painters still choose this method simply because they are more comfortable with it. The initial investment in equipment is lower, the systems are easier to use, and the components often come pre-measured to ensure the correct mixing ratio.

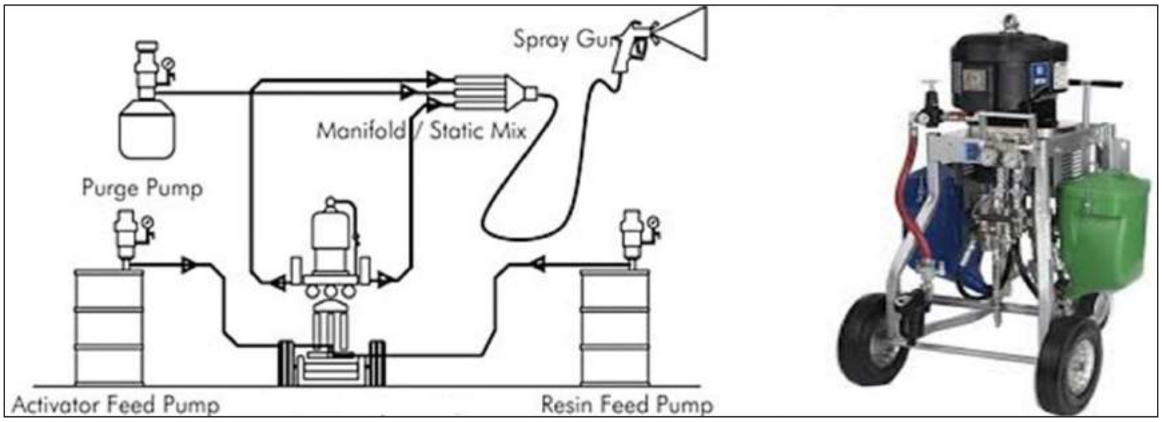


Fig 3.2 (xiv): Plural component system

Despite the comfort "hot pot" provides the applicators, the finished product sometimes does not perform as well as it should. The need for more solvents can lead to a lower film build, increased cure time and more VOC released into the environment. Manual mixing leads to higher labour cost and greater strain on the crew doing the mixing. As the mixed material has limited life, unused material must be thrown away at the end of the day. Plural component application systems offer faster cure times, and result in less wastage because the components are not mixed until the moment before they're applied. This also means that equipment is easier to clean and maintain because catalysed material doesn't clog the system.

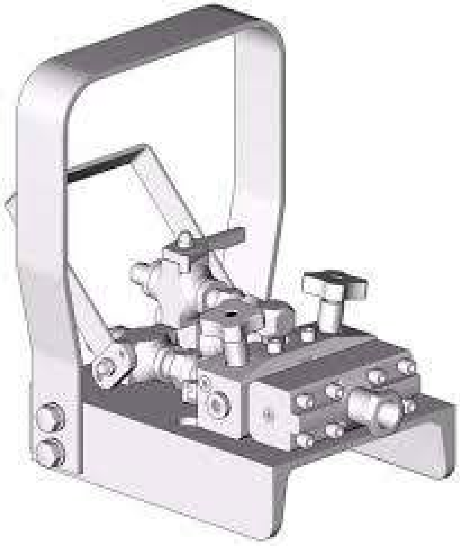


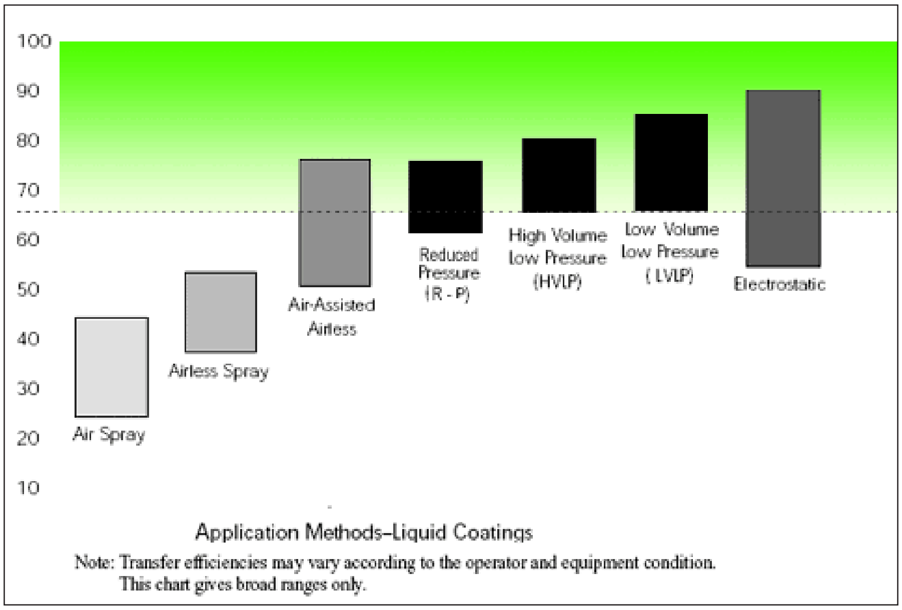
Fig 3.2 (xv): Remote mix manifold

Many advanced plural component systems incorporate auto-shutoff mechanisms if the mixture ratio falls out of balance, giving painters the confidence that the product is being mixed and applied in the correct proportion.

Transfer efficiency (TE): It is the ratio of the weight of the coating solids deposited on a substrate to the total weight of coating solids used in the application, expressed as a percentage. Simply stated, the transfer efficiency of an application system is the amount of material that adheres to the target compared to the amount of material that was conveyed through the applicator towards the target. Transfer efficiency is expressed as a percentage. Transfer efficiency is critical to the finishing industry from both a cost and a regulatory standpoint.

Factors impacting TE are:

- Substrate (target or part) characteristics, such as size and shape
- Operator variability
- Finishing methods
- Equipment characteristics, including the balance of fluid pressure and air pressure in spray applications
- Ambient conditions at the application site/ spray booth, such as humidity, temperature, and air velocity
- The electrical condition of the equipment, target, operator, and spray booth
- Material characteristics such as viscosity and conductivity
- Electrode voltage and position in the spray pattern for electrostatic application)



Spray gun safety: Spray guns are key to spray application., These act as a valve and open and close multiple times to spray the paint, are subjected to high wear and tear due to the high velocity and flow of paints thru the small orifice. Some guns are fitted with filters to add to the filtration process and to help save the tips from getting choked. Spray guns are designed for different pressures and are mounted with safety locks to prevent injury hazard.

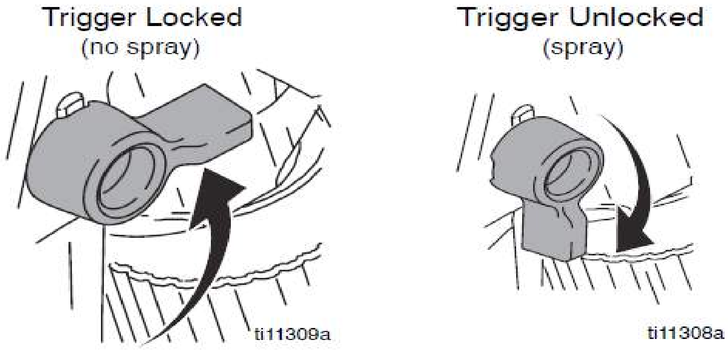


Fig 3.2 (xvi): Safety lock

Setup an airless spray gun

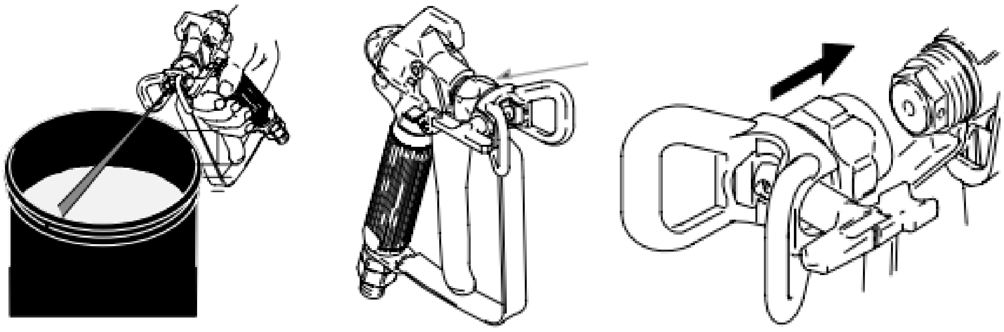


Fig 3.2 (xvii): Trigger gun into grounded, loosen tip guard retaining nut and install tip and guard a metal bucket to release pressure

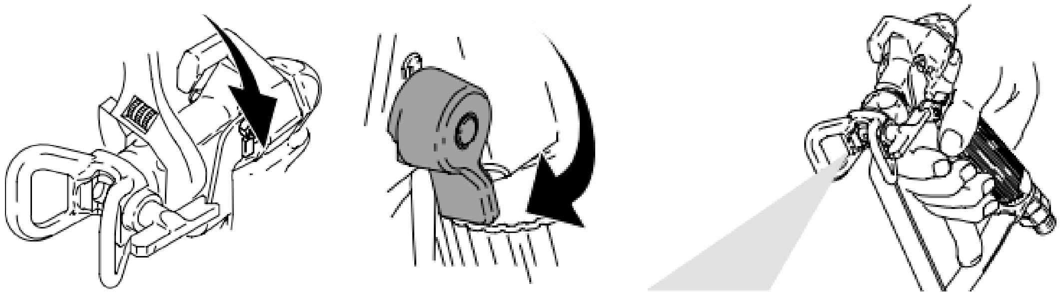


Fig 3.2 (xviii): Tighten retaining nut, remove trigger lock and trigger gun

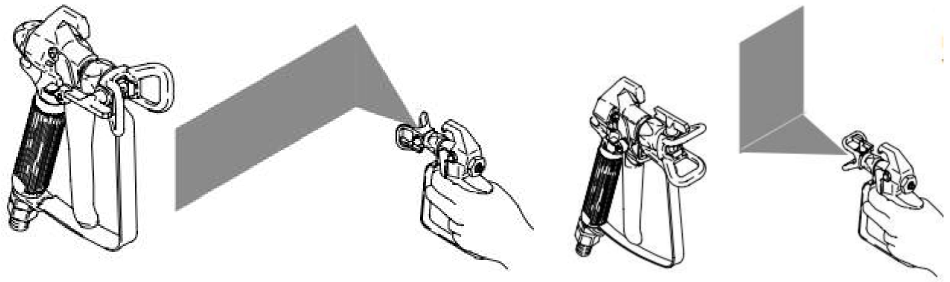


Fig 3.2 (xix): Turn tip guard horizontally to spray horizontal pattern and turn tip guard vertically to spray vertical pattern

Repairing an airless spray gun

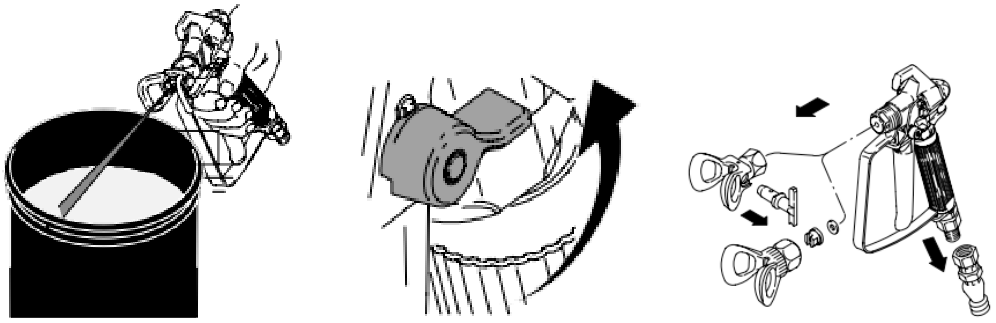


Fig 3.2 (xx): Relieve pressure, set trigger lock and remove tip and guard and disconnect gun from fluid hose

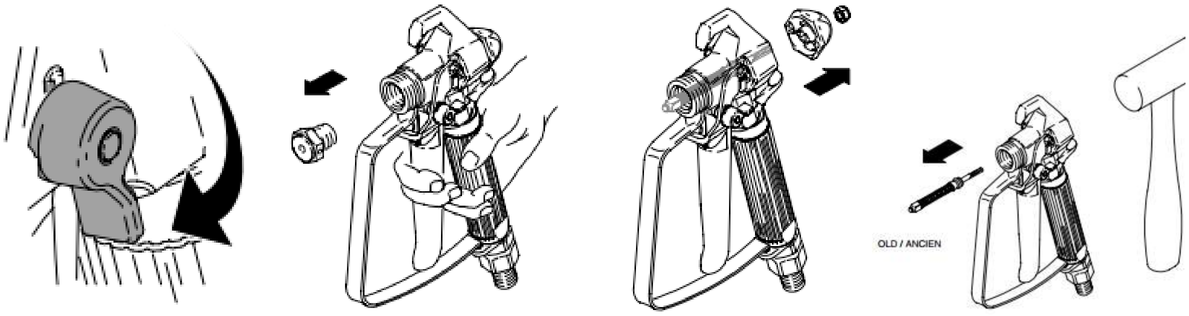


Fig 3.2 (xxi): Release trigger lock, squeeze trigger while unscrewing the diffuser, remove locknut and end cap and tap out needle

Fig 3.2 (xxiii): Clean internal passages of gun, grease o–rings of new needle and guide new needle into gun using a non-silicon grease

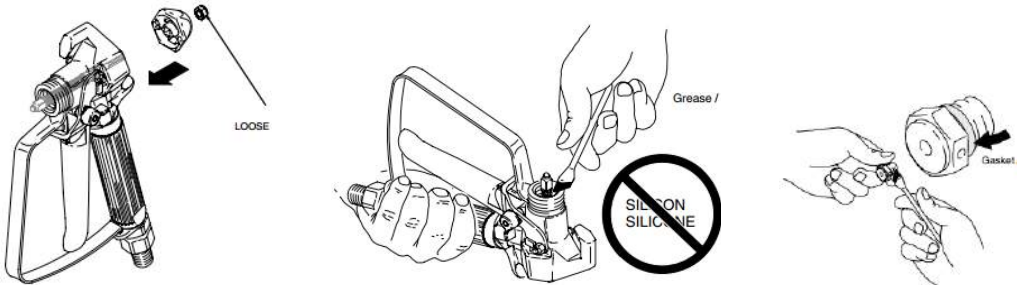


Fig 3.2 (xxiv): Fit end cap and locknut, loosely, grease o rings of new needle using a non-silicon grease, grease threads of diffuser/seat and place gasket on diffuser/seat

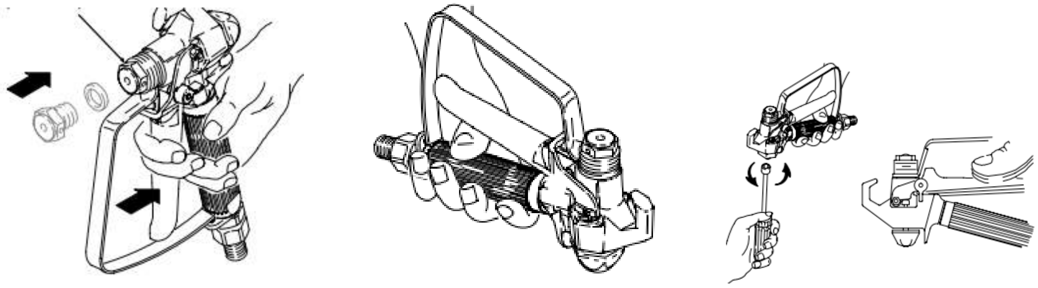


Fig 3.2 (xxv): Squeeze trigger while installing gasket and diffuser/seat, hold gun with nozzle straight up and turn locknut clockwise until trigger rises slightly

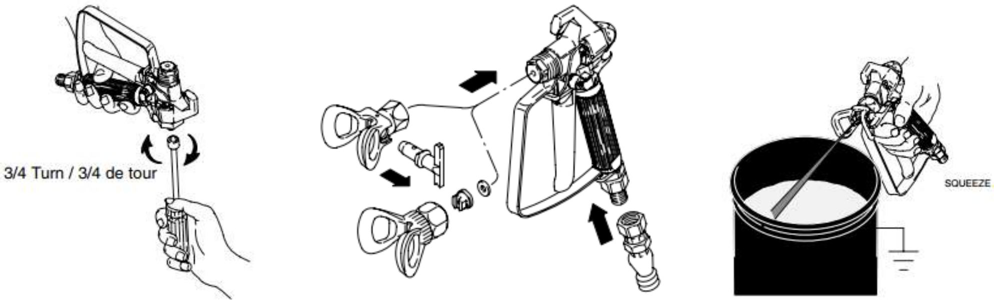


Fig 3.2 (xxvi): Turn locknut 3/4 turn counter-clockwise, connect fluid hose, install tip and guard, trigger gun into grounded metal bucket until fluid flows from gun

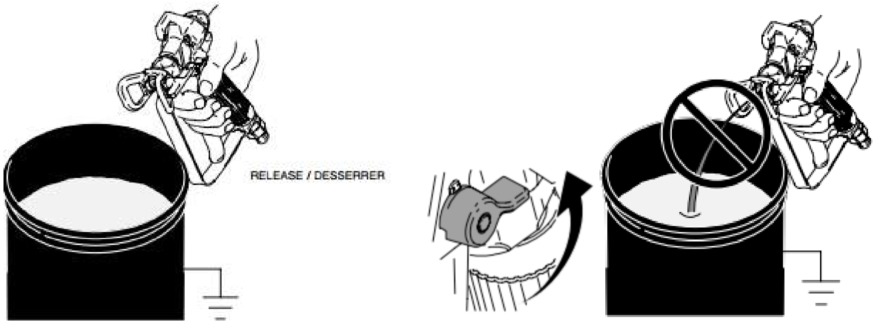


Fig 3.2 (xxvii): Release trigger. Fluid flow should stop immediately, set trigger lock, try to trigger gun. No fluid should flow

If the gun fails either test, relieve pressure, disconnect hose and readjust needle, repeat tests.

Choosing the correct spray tip: Choosing the right tip is vital can be as important as having the right pressure. Larger tips generally require more pressure and higher flow pumps but can cover more area effectively. Narrower tips, on the other hand, are best for precision work

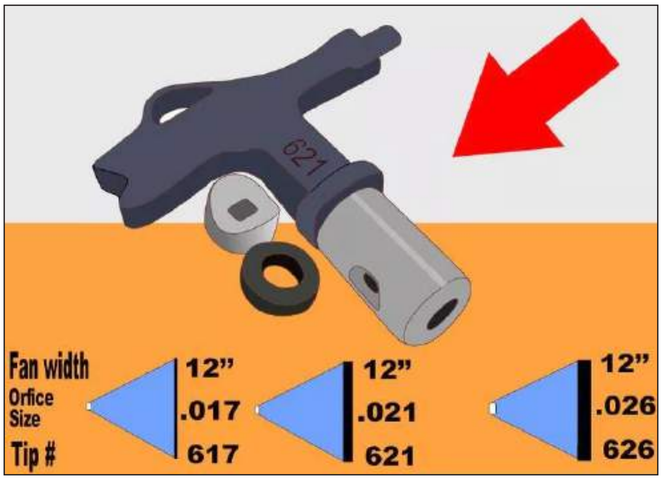
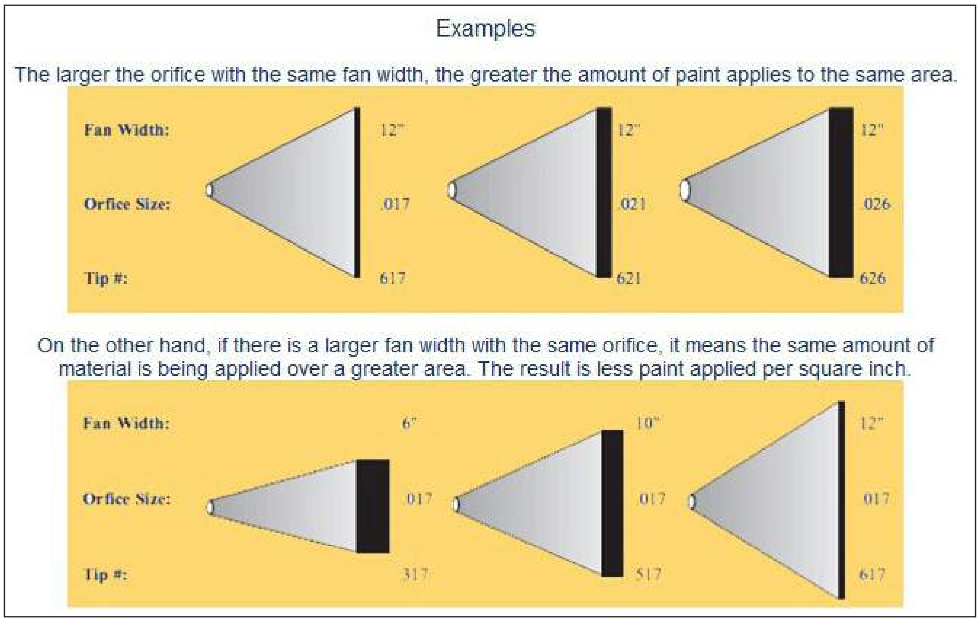


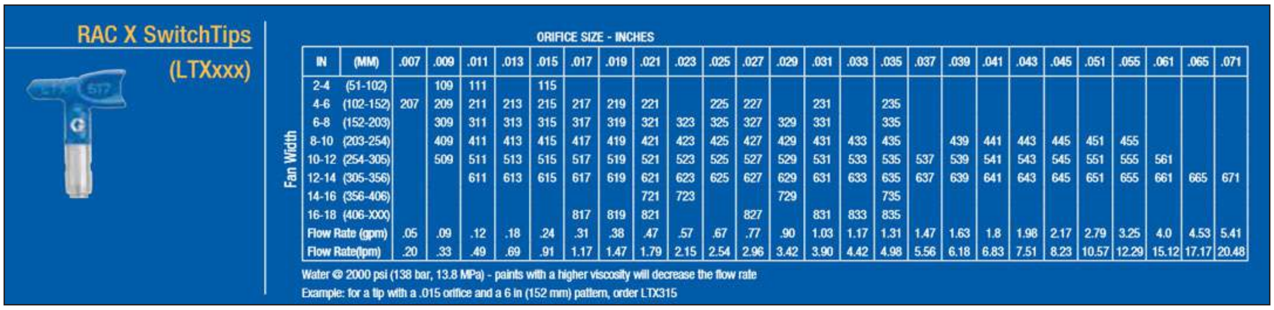
Fig 3.2 (xxviii): Tip importance and functions


Examples

The larger the orifice with the same fan width, the greater the amount of paint applies to the same area.

On the other hand, if there is a larger fan width with the same orifice, it means the same amount of material is being applied over a greater area. The result is less paint applied per square inch.

Fig 3.2 (xxix): Tip functions when choosing some orifice and different angles and vice versa



RAC X SwitchTips

(LTXxxx)

Fan Width

ORIFICE SIZE - INCHES

IN	(MM)	.007	.009	.011	.013	.015	.017	.019	.021	.023	.025	.027	.029	.031	.033	.035	.037	.039	.041	.043	.045	.051	.055	.061	.065	.071
2-4	(51-102)		109	111		115																				
4-6	(102-152)	207	209	211	213	215	217	219	221		225	227		231		235										
6-8	(152-203)		309	311	313	315	317	319	321	323	325	327	329	331		335										
8-10	(203-254)		409	411	413	415	417	419	421	423	425	427	429	431	433	435		439	441	443	445	451	455			
10-12	(254-305)		509	511	513	515	517	519	521	523	525	527	529	531	533	535	537	539	541	543	545	551	555	561		
12-14	(305-356)			611	613	615	617	619	621	623	625	627	629	631	633	635	637	639	641	643	645	651	655	661	665	671
14-16	(356-406)								721	723			729			735										
16-18	(406-XXX)						817	819	821			827		831	833	835										
Flow Rate (gpm)		.05	.09	.12	.18	.24	.31	.38	.47	.57	.67	.77	.90	1.03	1.17	1.31	1.47	1.63	1.8	1.98	2.17	2.79	3.25	4.0	4.53	5.41
Flow Rate(lpm)		.20	.33	.49	.69	.91	1.17	1.47	1.79	2.15	2.54	2.96	3.42	3.90	4.42	4.98	5.56	6.18	6.83	7.51	8.23	10.57	12.29	15.12	17.17	20.48

Water @ 2000 psi (138 bar, 13.8 MPa) - paints with a higher viscosity will decrease the flow rate

Example: for a tip with a .015 orifice and a 6 in (152 mm) pattern, order LTX315

Fig 3.2 (xxx): Tip charts with flow rates

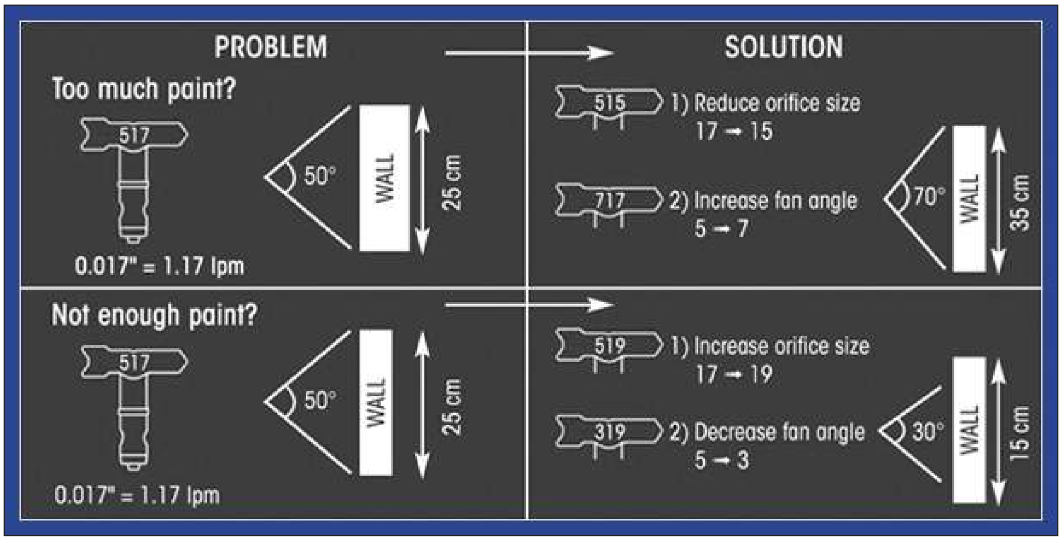


Fig 3.2 (xxxi): Understanding spray tips

MATERIAL	TIP SIZE
LACQUER AND STAIN (WOOD COATINGS)	.011 TO .013
OIL BASE PAINT (ENAMELS) – UP TO 30% VOLUME SOLIDS TO ACHIEVE 30-50 MICRON DFT	.013 TO .015
LATEX PAINT (INTERIOR EXTERIOR WATER BASED PAINTS) 30-50% VOLUME SOLIDS TO ACHIEVE 50-100 MICRON DFT	.015 TO .019
HEAVY LATEX AND SMOOTH ELASTOMERIC, EPOXIES AND PUS WITH 50 TO 80% VOLUME SOLIDS TO ACHIEVE 150-250 MICRON DFT	.021 TO .025
ELASTOMERIC AND BLOCK FILLER HIGH BUILT COATINGS TO ACHIEVE 80% TO 100% VOLUME SOLIDS TO ACHIEVE ABOVE 250 MICRON DFT	.025 TO .035

Strain the paint: No matter how well the paint is mixed, there may still be little clumps of solid paint. It doesn't take much to clog a sprayer nozzle. Take a strainer and strain the paint into another bucket, removing the solid bits and discarding them.

Prime the pump: All airless sprayers require priming before they're ready for use. Many airless sprayers will have a "Prime" setting. If the airless sprayer isn't priming successfully, it may help to give the device a slight tap with a hammer. This can loosen any clogged paint inside the sprayer. Keep the nozzle face downward in a bucket to account for paint drips while the sprayer is made ready.

Adjust the pressure if required. If the paint isn't spraying evenly and thickly, it is a sign to increase the pressure. There should be a pressure gauge on the airless sprayer to control this with. As a rule, keep the pressure as low as possible without resulting in a weaker paint job. Unnecessarily high pressure wears out the tip faster. Overall, the tip size rating is the most useful rating method for selecting tips and sprayers for your job.

Spray tip wear: Choosing the right spray tip is essential for ensuring a quality finish no matter which coating material is being applied. All spray tips will wear with normal use. It is important to understand the wear effect coatings have on spray tips. All coatings contain solids that are abrasive; some are more abrasive than others. For example, latex paint may be very abrasive because of the solids used in the manufacturing process. The level of abrasiveness often depends upon how finely the solids have been ground.

Effects of tip wear: When a tip wears, the size of the tip orifice increases and the fan width decreases. Tip wear affects the spray pattern. If the fan size has lost 25% of its original size, then it is time to replace the spray tip. Continuing to spray would simply result in a poor-quality spray job, and a substantial waste of paint and labour.

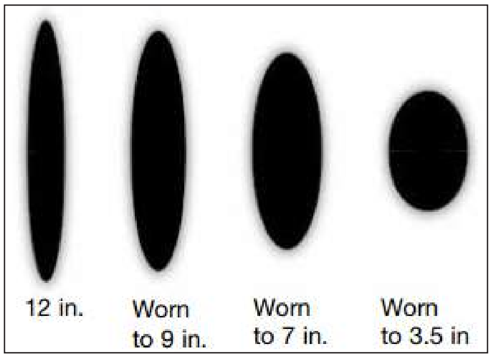
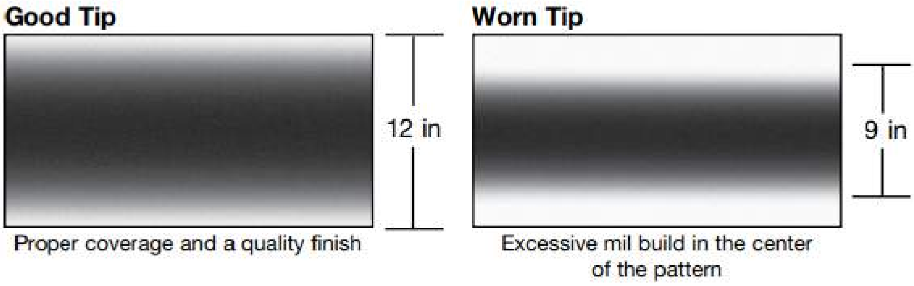


Fig 3.2 (xxxii): Tip wear and its spray pattern

Tips for extending the life of spray tips:

- Spray at the lowest pressure necessary to atomise material
- Strain the coating material prior to spraying, using a nylon strainer bag
- Use correct size filters
- Clean filter after each use
- Use a soft bristle brush to clean tips



If abrasive materials are sprayed at too high pressure, the spray tip will wear a lot faster, resulting in loss of both paint and money.

Greater Pressure = Greater Wear

Turn down the pressure as low as possible, still spraying a good spray pattern to reduce your tip and pump wear. Turning down the pressure also saves paint by reducing overspray.

UNIT 3.3 Spray Techniques

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the actual process of spray painting a surface, the do's and don'ts for executing a quality paint job
2. Describe how normal cleaning and maintenance of sprayers is to be done
3. Observe safety precautions during a spray-painting job

Maintain a steady distance while you spray: Hold the spray gun 10-12 inches (30.5 cm) from the surface to be painted. This will make it close enough to apply effectively, but far enough to cover a good area of the surface.

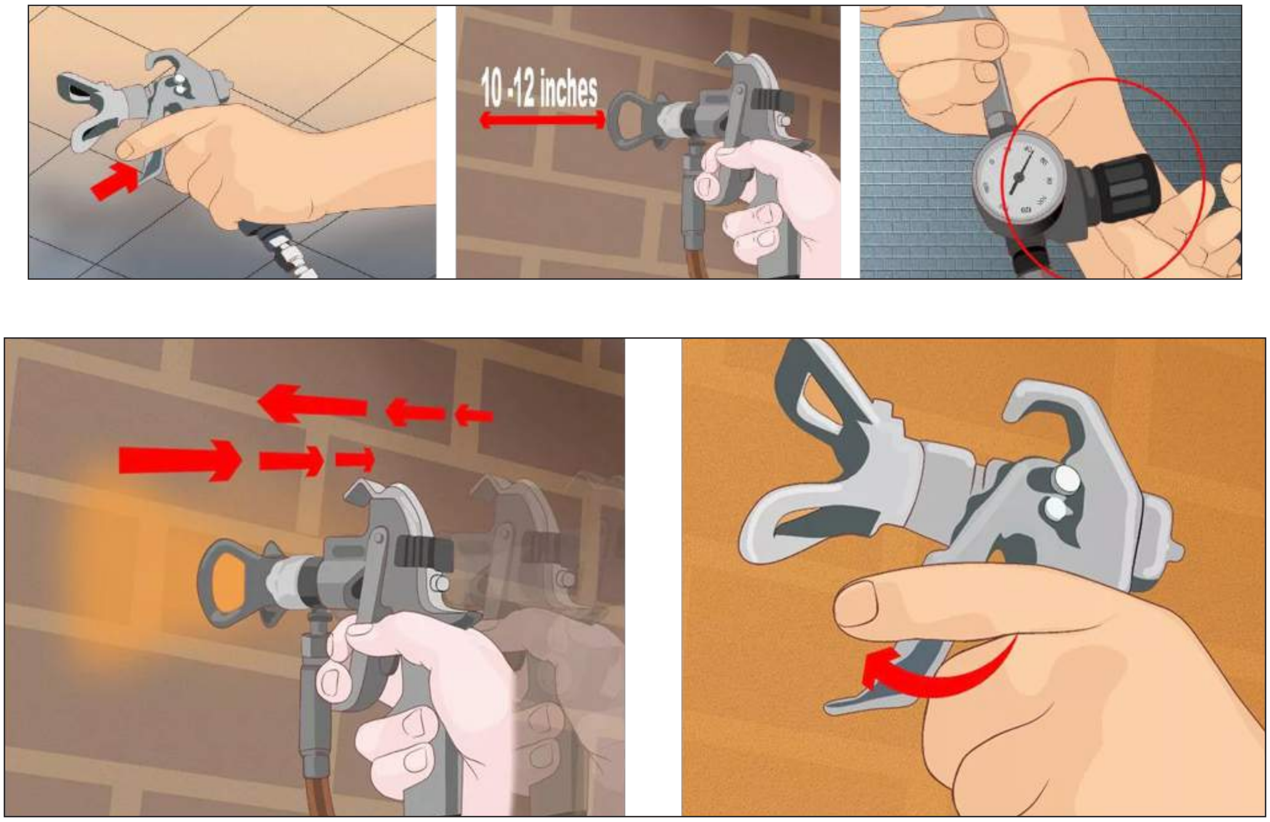


Fig 3.3 (i): Spray techniques

Release the trigger to stop painting: After completing a lap of painting/ at the edge of the part or component being painted, release the trigger to stop painting. The trigger is pressed just at the edge of the part/ component at the beginning of painting. In an automatic application, the applicator is programmed to achieve this.

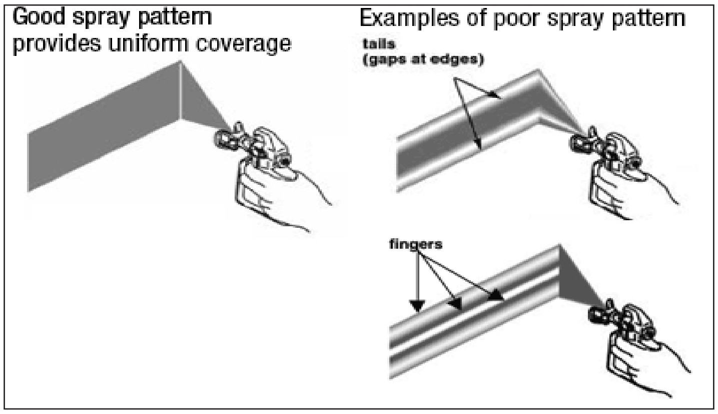


Fig 3.3 (ii): Good and poor spray pattern

Fig 3.3 (iii): Bad spray pattern - spraying at too low pressure or clogged filters

3.3.1 Maintaining the Sprayer

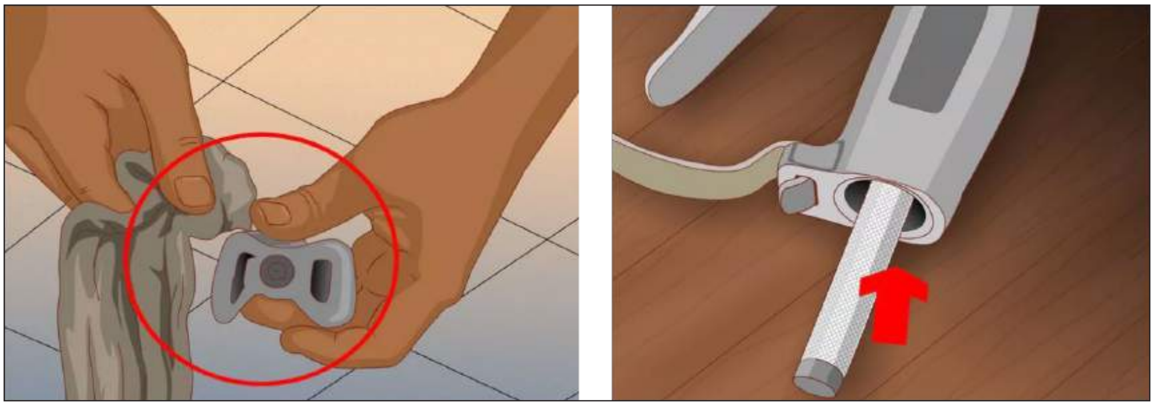


Fig 3.3.1 (i): Upkeep of the airless sprayer

Clean the sprayer after each use: The paint in a spray gun will harden if it's not cleaned promptly. It's a good idea to clean the spray gun after every use. Remove the nozzle and clean the paint out of the nozzle with a damp paper towel. Dry the nozzle so that the moisture doesn't affect the next load of spray paint.

Check hoses for breaks before use: Checking hoses is an important part of maintenance. This is best done visually and by feeling the hose. If there's a micro-fracture anywhere in the hose, it will shoot out paint and lower the effective pressure of the device.

Airless spray safety: An airless spray guns operates at very high pressures and can easily cause injury if the spray is directed onto the body. It can inject paint into the tissues or bloodstream without visible cut or bleeding. The skin can open and allow the passage of the paint and then close again, making it appear that nothing is wrong. This is a "fluid injection injury", and should be treated by a professional immediately.

Fig 3.3.1 (ii): Do not spray at anyone

To help prevent a fire and/or explosion when spraying flammable or potentially flammable materials, always:

- Spray in well-ventilated areas with good air movement
- Use only flame proof switches
- Remove, extinguish or unplug all ignition sources such as:
  - Cigarettes
  - Pilot lights; stove ranges, water heaters, furnaces
  - All electric appliances
- Put gas powered spray guns outside the building and run the hose into the room to be sprayed
- Ground the spray gun to prevent static sparking
- Keep the work area free of flammable waste such as:
  - Open or empty paint/material cans
  - Open or empty solvent/thinner cans
  - Rags, especially used ones
  - Paper, masking
- Prevent sparks and static sparking
- Use only grounded hoses
- Check hoses periodically for electrical continuity using an ohm meter
- Tape wall switches to prevent them from being used
- Use only grounded metal pails when spraying/painting, flushing or cleaning
- Connect the pail to a true earth ground according to the local electric code

- Plug Electric Powered Sprayers into a properly grounded 3-wire outlet
- Ground the sprayer even if the power source is a 3-pin outlet
- Check to make sure that the outlet is well grounded.
- Connect the pail to a true earth ground
- Always use the spray gun trigger safety when not spraying
- Relieve fluid pressure when cleaning or servicing any part of the equipment.
- To relieve pressure, shut off the air supply to the gun, trigger the gun, and open the pressure drain valve
- Always point the gun away from yourself and others
- Do not try and stop leaks with your hand or body
- Follow the instruction manual for correct flushing method. Remove the spray tip, reduce the material/fluid pressure and immerse the gun nozzle in the fluid when flushing

3.3.2 Other Safety Considerations

- Wear safety glasses to protect your eyes from spray material / paint or solvent
- Wear a respirator when using toxic or noxious paint or solvent
- Follow the material manufacturers' guidelines to select the correct respirator and or cartridges
- Read and save the instruction manuals supplied with the equipment. The manuals contain important information on airless spray safety

Airless paint spraying techniques: Some techniques used for successful application of materials with using airless equipment. Tips and pointers, some do's and don'ts and common errors.

Overspray: Overspray depends on several factors: tip size, tip condition (new or used, clean or dirty etc.), pressure setting, distance between spray gun and surface, angle of spray gun in relation to surface, and wind; to name a few.

Any airless spray will produce some form of overspray, but there are two main ways to help reduce it.

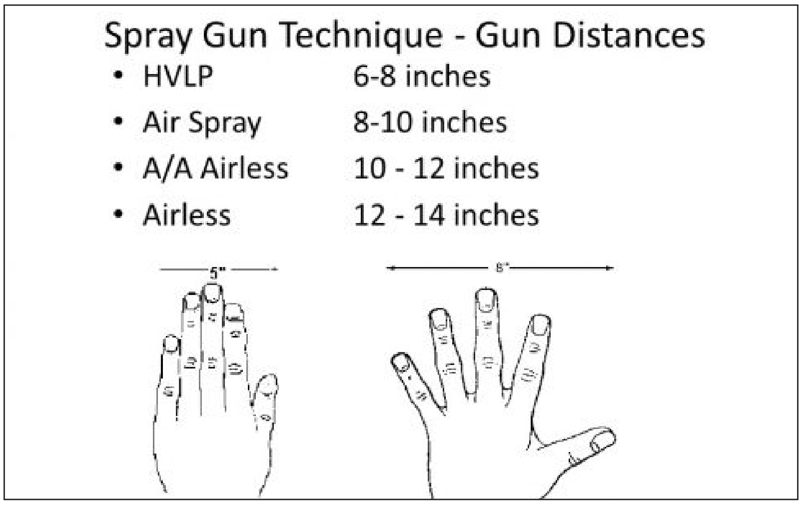
1. Set the pressure control at the lowest possible level, while maintaining a solid fan pattern.
2. Ensure that the correct tip size is being used. Using a tip that is too big, will result in excess paint being applied to the surface. (For more information on tips, see our tip sizing section).

Airless spraying: Safety First! Read about airless spray painting safety.

- In any airless spray application, a careful study to determine correct spray techniques for each work piece configuration can save both time and material.
- A balanced combination of these three factors will generate the best finish quality, with the least effort and the lowest cost
    - o Operator technique
    - o Gun position and movement
    - o Work piece configuration

Operation techniques - gun position

- Hold the spray gun with a firm, but comfortable grip
- Use the index and middle fingers to trigger the spray gun
- The gun should be a natural extension of the operator's arm - There are both two and four finger guns
- The distance of the spray gun from the product will depend on the equipment being used



Spray Gun Technique - Gun Distances

• HVLP	6-8 inches
• Air Spray	8-10 inches
• A/A Airless	10 - 12 inches
• Airless	12 - 14 inches

Fig: 3.3.2 (i): Recommended gun distance

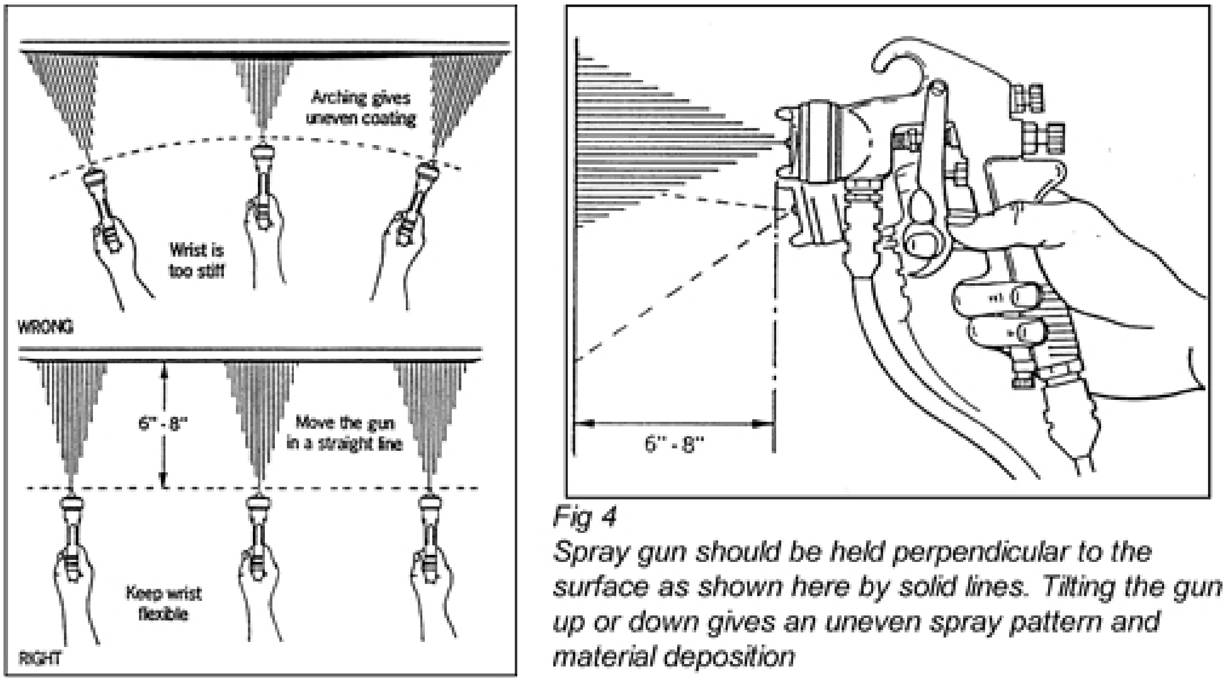


Fig 4
Spray gun should be held perpendicular to the surface as shown here by solid lines. Tilting the gun up or down gives an uneven spray pattern and material deposition

Fig 3.3.2 (ii): Spray techniques operation

3.3.3 Correct Techniques of Spray Gun Usage

- Typically holding a spray gun too close to the product while painting will result in too much paint being applied which will cause the paint to run.
- If the spray gun is too far away from the product's surface, then the spray deposition is dusty or sandpaper like.
- Another important consideration about the distance of the spray gun, while painting, is the back and forth movement of the spray gun and not side to side

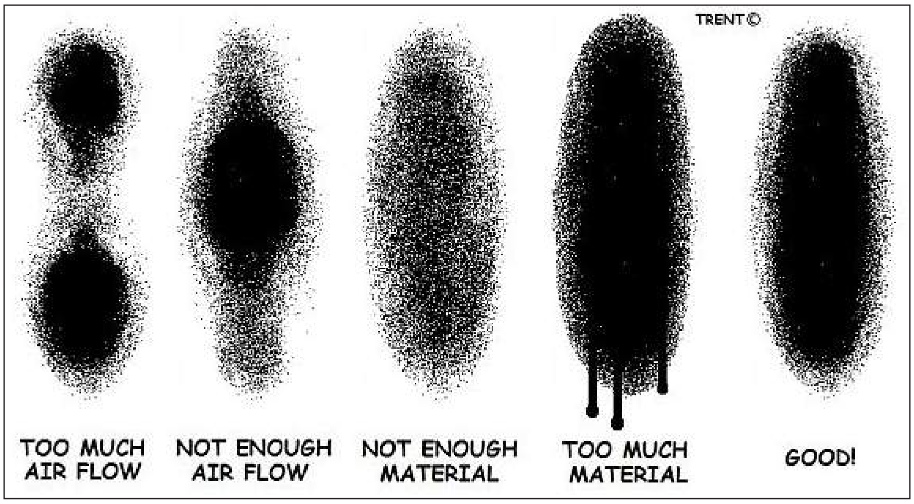


Fig 3.3.3 (i): Setting air spray gun, air/fluid ratio

Hose position: Hold the gun in one hand and the fluid hose in the other hand. When using long hoses or when more flexibility at the gun is needed, a small "whip-hose" hose can be installed between the end of the supply hose and the gun. The whip-hose will allow the operator to move more smoothly during the spray stroke.

Fig 3.3.3 (ii): Correct gun and hose position

Body position: There are no set rules for body position, but here are some recommendations. While facing the part, stand with your legs a little wider than shoulder width. Pull the leg opposite the spray gun back slightly. Use the forward foot to pivot during the spray strokes.

Gun movement and position – Distance: The fan angle and orifice size of a spray gun affects the spray pattern. Gun tip distance from the work piece being sprayed also affects the spray pattern. As the gun distance from the part increases, the fan width becomes wider, eventually causing an overspray and uneven coverage. A gun distance of approximately 12” produces the best coverage. If the 12” distance must be exceeded, select a narrower fan width to retain efficiency. All airless tips are sized at the 12” spray distance.

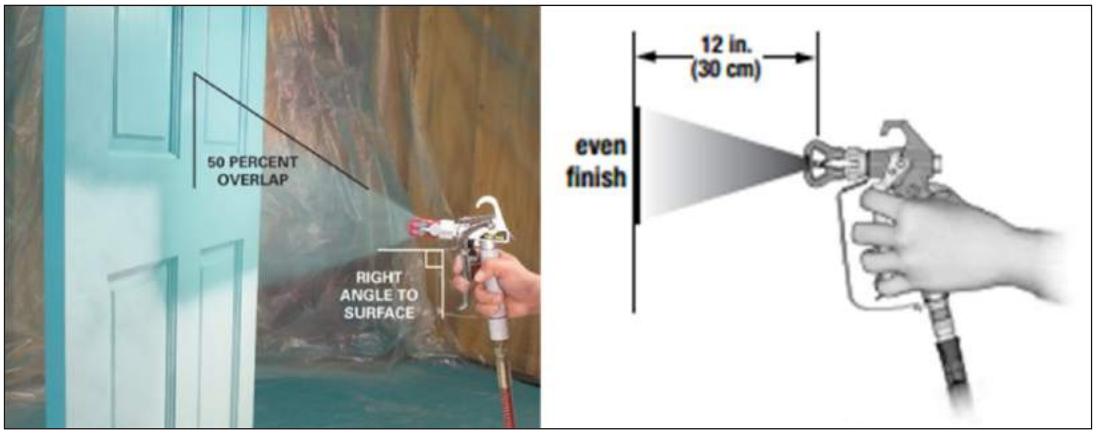


Fig 3.3.3 (iii): Spray techniques and gun distance from substrate

Gun position: Hold the gun perpendicular to the surface whenever possible to reduce the chance of uneven paint coverage. Tilting the gun either up or down will produce a heavy build-up of paint on the top or bottom of the spray pattern. Arcing the gun causes a heavy coverage of paint on the left and right side of the pattern. Both arcing and tilting the air spray gun also causes an angle at which the paint can bounce off the work piece surface.

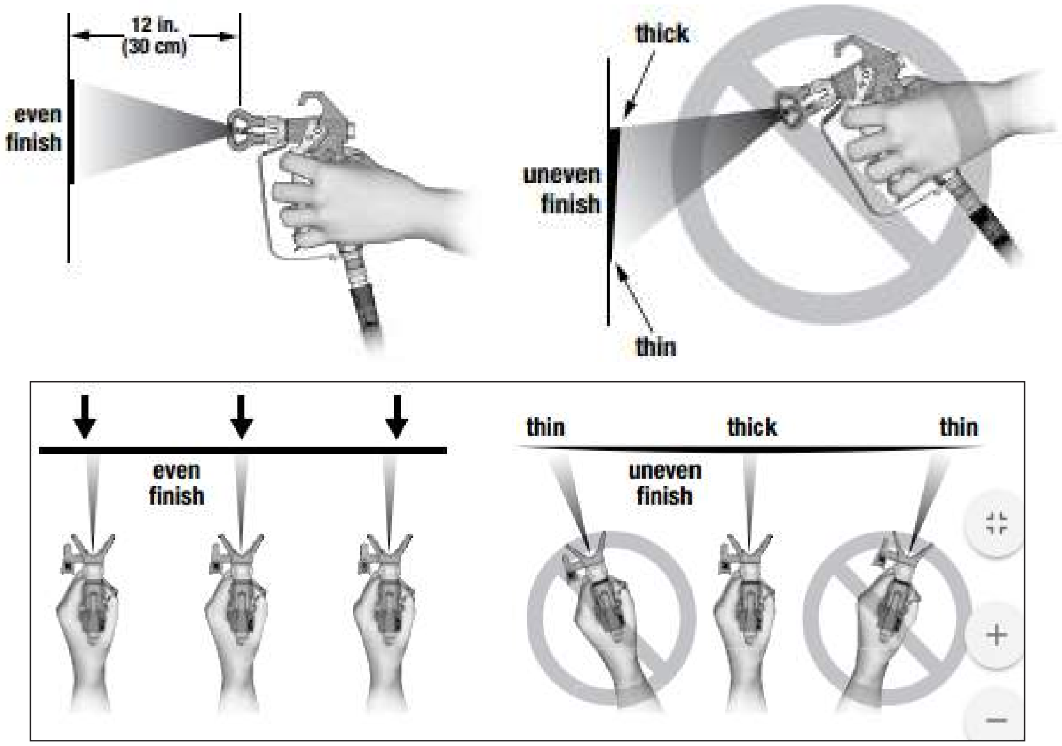


Fig 3.3.3 (iv): Spray techniques

Triggering: The gun is either "full on" or "off", there is no partial triggering or feathering. Timing the triggering movement is key to an even paint coverage on the part. The gun stroke or movement should be started before triggering. Release the trigger before the stroke-end. This method provides a "lead and lag" for more even coverage. Proper triggering also conserves paint and prevents excessive material build-up at the beginning and end of each stroke.

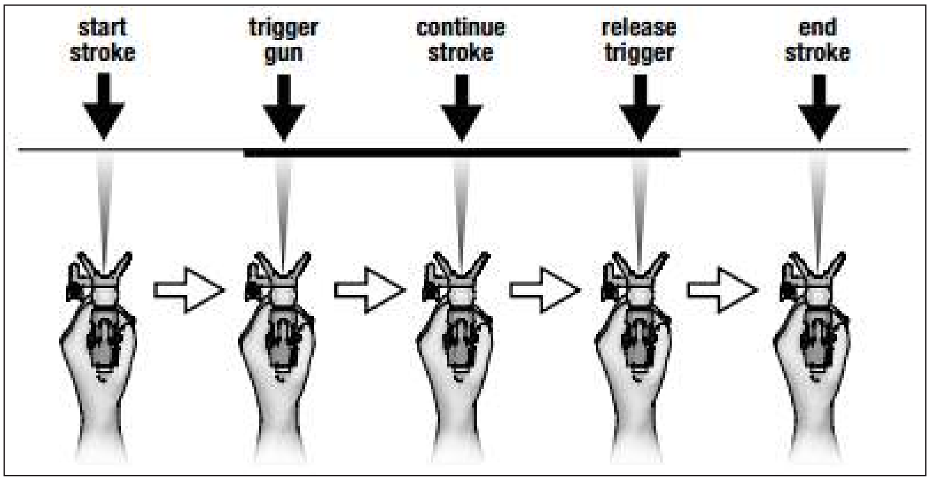


Fig 3.3.3 (v): Trigger spray technique in airless spray

Overlapping: If the first stroke is begun on the left side of the work piece, the gun is moved down at the end of that stroke and the second stroke begins at the right side. A means of judging the amount of overlap is aiming the spray gun directly at the bottom of the previous stroke. As spray technique experience becomes more effective, the amount of spray overlap will be reduced, increasing the efficiency.

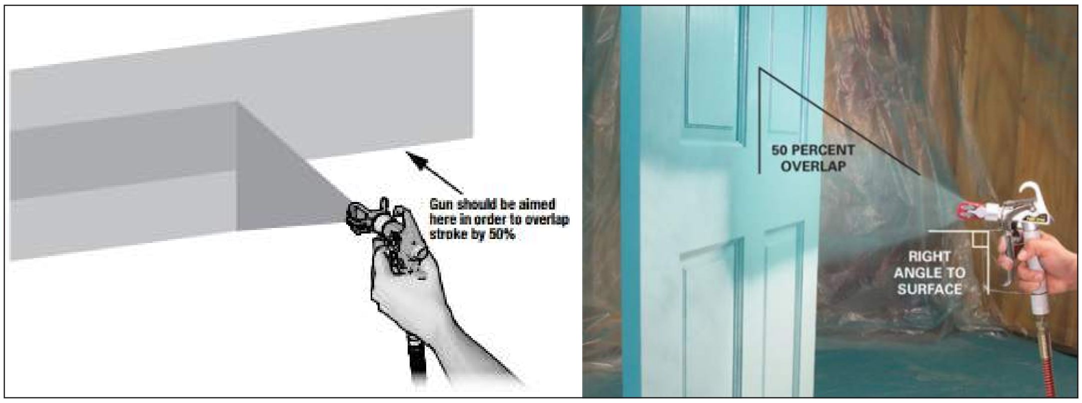
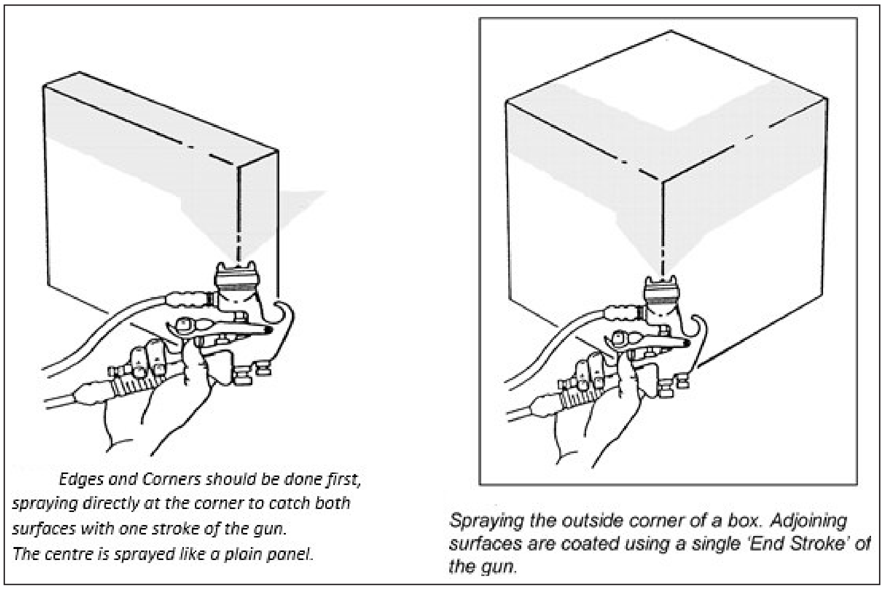


Fig 3.3.3 (vi): Correct gun position and overlapping

Spray speed: The proper spray speed applies a full wet coat with each stroke without sagging. If the desired film thickness cannot be obtained with a single pass because of "sagging", then two or more coats can be applied with a flash off period between each coat. The spray movement should be at a comfortable rate. If excessive spray gun movement is necessary to avoid flooding the work, then the fluid tip orifice is too large or the fluid pressure is too high. If the stroke speed is very slow to apply full wet coats, then the fluid pressure should be increased slightly, or a larger tip be used.

Work piece configurations: Rehearsing the spray strokes before doing the actual work is a good practice for a new work piece and for a new operator. By rehearsing the gun movement for a part, the operator can save paint with reduced overspray, have less fatigue by using more effective gun movements and obtain a finer quality of finish. This section examines various configurations and recommends some spraying techniques using the least effort, with minimum paint wastage, yet providing the best quality of finish.

Banding: To reduce overspray on a work piece, use the “banding” technique. Use a vertical stroke at each end of a large panel, rather than trying to cover the ends with horizontal strokes. This reduces paint usage and overspray. The banding technique can also be used on the edges and outside corners of some work pieces such as tables. Aim the spray gun at the leading corner of the part. Use this same technique to spray the outside corner of a box or cabinet.



Edges and Corners should be done first, spraying directly at the corner to catch both surfaces with one stroke of the gun. The centre is sprayed like a plain panel.

Spraying the outside corner of a box. Adjoining surfaces are coated using a single 'End Stroke' of the gun.

Fig 3.3.3 (vii): Banding techniques

Inside corners: To apply an even coat of paint to an inside corner, point the spray gun at an angle. To avoid double coating the same area, use horizontal strokes to spray the area adjacent to the corner. Spray each side of the corner separately. A vertical pattern is often used.

Outside corners: To spray the outside of a corner, a straight-on method can be used. The adjoining surfaces are then banded.

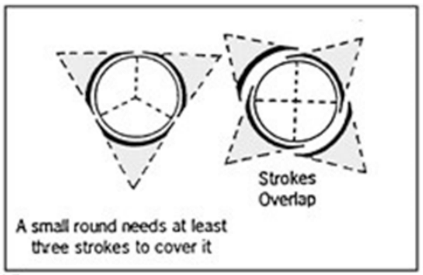
Small/vertical flat surfaces: When spraying small, vertical flat work piece configurations, the banding technique is used. Using a horizontal pattern, band the edges of the part. After banding the edges of the part, finish the part with horizontal strokes. First, spray the Class B side of a work piece (the side that will not be finished), then spray the Class A (finished) side. If there is any overspray turbulence, it will not appear on the Class A side of the work piece.

Long/vertical flat surfaces: Spray long vertical flat surfaces with horizontal strokes in sections from approximately 18” to 36” wide. As on small vertical flat parts, use the same banding technique on each end of a long vertical flat part. Use the same triggering technique as with a smaller panel, but overlap each section approximately four inches.

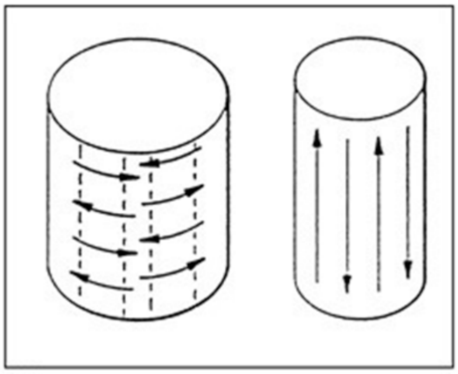
Level surfaces: When spraying a level or horizontal surface, always start on the near side of the part and work to the far side of the part: this technique allows the overspray to fall on the uncoated work. Some gun tilt will be necessary.

Slender parts: When spraying slender parts, choose a spray pattern that fits the part to be finished. When using a vertical pattern, the spray speed must be faster.

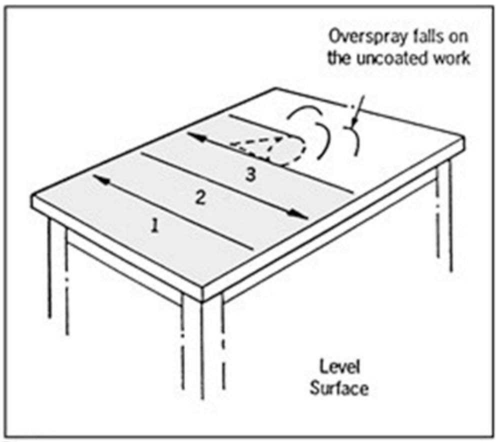
Round parts: Small cylinder shapes, like furniture legs, are best sprayed with a narrow spray pattern, using three vertical strokes. A vertical pattern and stroke can be used, but the gun movement must be quicker to prevent sags and runs. Spray smaller or medium diameter cylinders with lengthwise strokes. Spray large cylinders like a flat vertical surface, only with shorter strokes.



Use a round spray or vertical fan pattern for table leg turnings or similar small round surfaces



Round work should be treated to curve the strokes



Start at near edge to avoid depositing dry spray on already coated work.

Fig 3.3.3 (viii): Spray techniques for different objects

3.3.4 Common Spray Technique Errors

It is easy to just crank up the pressure control to the maximum and slap on the material. For professional results, turn down the pressure as low as possible without getting tails. Benefits:

1. Reduced pump wear, thereby decreasing the risk of costly repairs
2. Reduced spray tip wear, saving money from replacing worn tips
3. A more consistent and an even finish
4. Reduced overspray - saves money and paint

Trigger the gun: It is common tendency to just pull the trigger and keep moving the gun up and down or side to side, overlapping and moving down the wall spraying constantly. If the gun is not triggered every time the direction is changed, it will result in at least double the thickness at every spot the direction was changed. For the best finish, trigger the gun on each stroke and be moving into and out of each trigger pull.

Maintenance guide: Spray guns get the job done quicker but also require regular maintenance to keep them running well, and lasting long. Keeping the spray guns clean is an important and first step. There are a few kinds of maintenance such as:

- Regular
- Winterising
- Spring

Regular maintenance

Daily:

- Inspect, clean and replace as needed
- Replace manifold filter, gun filter and inlet strainer, if found damaged
- Check wet cup for leakage, tighten if needed. Add TSL to lubricate packing and increase life of the packings
- Gun trigger safety check
- Check tip wear, replace if worn out to save paint

Weekly:

- Check tightness of wet cup
- Inspect all high-pressure paint hoses

Repair

- If the gun is leaking, change the packing kit
- If pump is leaking change the packing kit

High pressure fluid from the spray gun/dispense valve, hose leaks, or ruptured components can inject fluid into your body and cause serious injury, including the need for amputation. Fluid splashed in the eyes or on the skin can also cause serious injury.

- Fluid injected into the skin might look like just a cut, but it is a serious injury. Get immediate medical attention
- Do not point the gun/valve at anyone or any part of the body
- Do not put hand or fingers over the spray tip
- Do not stop or deflect fluid leaks with your hand, body, glove, or rag
- Do not “blow back” fluid on high pressure airless systems
- Always have the tip guard on the spray gun when spraying
- Check the gun diffuser operation weekly
- Be sure the gun trigger safety operates before spraying
- Lock the gun trigger safety when not spraying
- Follow the Pressure Relief Procedure in the instruction manual to:
    - o Release pressure
    - o Stop spraying
    - o Clean, check, or service the equipment

  - Install or clean the spray tip
  - Tighten all fluid connections before operating the equipment
- Check the hoses, tubes and couplings daily. Replace worn, damaged, or loose parts immediately. Permanently coupled hoses cannot be repaired; replace the entire hose

Notes

UNIT 3.4 Applying the Coating

Unit Objectives

At the end of this unit, you will be able to:

1. List steps involved in coating application using a spray gun
2. Explain techniques for different stages of the spray process - applying tack coat, strip coat, covering corners and edges, Spraying large areas, application of mist coat etc.

The information in this section applies to both airless spray and conventional air spray methods.

- Before beginning to apply a coating, the operator should check that the spray gun is delivering a normal spray pattern.
- The painter should adjust the gun to develop the optimum fan shape. Hold the gun so the pattern is perpendicular to the surface at all times, keeping the gun at a uniform distance (about 25 to 30 cm for conventional spray) from the surface being sprayed.
- The stroke is made with a free arm motion, keeping the gun at right angles to the surface at all points of the stroke. Triggering should begin just before the edge of the surface to be sprayed is in line with the gun nozzle.
- 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 flow, but the motion is continued for a short distance until it is reversed for the return stroke.
- When the edge of the sprayed object is reached on this return stroke, the trigger is again fully depressed and the motion continued across the object.
- Overlap each stroke 50% over the preceding one. Move the gun at a constant speed while the trigger is pulled, since the material flows at a constant rate. A 50% overlap will provide uniform coverage.
- Arcing the gun results in uneven application and excessive overspray at each end of the stroke. When the gun is arced 45° away from the surface, up to 65% of the material is lost.

Some special techniques are used to provide specific types of coating film.

Tack coat: A light covering coat applied to the surface and allowed to flash until it is just tacky, which usually takes only a few minutes. The finish coats are then sprayed over the tack coat. This method allows the application of heavier wet coats without sagging or runs.

Fig 3.4 (i): Tack coat application

Stripe coat: It is a separate coat applied to edges, corners, welds, and other vulnerable areas to provide extra thickness at those locations. The stripe coat may be applied by brush (recommended for primer coats especially) and may be applied once in a coating system or once for each coat in the coating system. Stripe coats are applied to prepared bare metal edges, bolt heads, welds, corners, and similar edges.

Fig 3.4 (ii): Stripe coating

Corners and edges: Large, flat areas are relatively easier to coat than corners, edges, bolts, nuts, rivets, etc. It is important, then, to pay particularly close attention to hard-to-coat areas.

Fig 3.4 (iii): Stripe coating edges and corners

Fig 3.4 (iv): Applying a mist coat

Mist coat: An incomplete spatter coat applied with a very fast gun motion. The idea is to partially displace the air in porous coatings, like inorganic zinc primer, before over coating.

Fig 3.4 (v): Applying a full coat

Full wet coat: A heavy, glossy coat applied to full thickness, almost; but not quite—heavy enough to run. It requires skill and practice to spray such a coat.

UNIT 3.5 Application Methods

Unit Objectives

At the end of this unit, you will be able to:

1. Describe how to select the right application method based on the job and the product to be applied
2. Explain what anti-fouling paint is and how it is to be applied
3. Explain how film thickness in a protective coating application is measured

There are many methods used to apply protective coatings for industrial use, including:

- Brush
- Mitt
- Roller (hand or power)
- Spray (including conventional air spray, airless spray, or some modification of these)

Of these, spray application is probably the most widely used for industrial protective coatings. One or more of the following may influence the choice of the method used:

Size and type of job: Bigger jobs are more likely to use more equipment and more sophisticated equipment. The type of job (defined by the specification) will determine what application method is required or most suitable.

Accessibility of areas to be coated: Some projects (e.g., elevated water tanks, radio/TV masts) will place restrictions on the type of application equipment used for practical reasons.

Configuration of areas to be coated: More complex areas may be difficult to coat adequately with spray equipment. Large flat areas (e.g., ships, tanks, etc.) are mostly suited for spray application. The use of brushes and rollers rather than spray equipment is preferred in the presence of critical areas or surrounding environment that could be damaged by overspray.

Type of coating: Many modern coatings, particularly high-solids and high-build coatings, are designed for spray application. Brush or roller application is not recommended and should be used only when spray application is not possible or for coating small areas such as repair areas. Application method depends on the type of coating being used. Some specialised coatings, in particular, may be restricted to a specific application method. Some coatings that are 100%-solids, for example, can only be applied using special equipment such as heated plural-component airless spray pumps or by mechanical methods, such as by trowel or by hand.

Conventional liquid coatings: Applied by brush, roller, or spray—should generally be applied in multiple passes, thin enough to allow proper evaporation of the solvents as the coating dries and cures. Some high-build coatings, particularly those with thixotropic qualities, dry too fast to allow reworking that would occur with brush application, and must be sprayed. Other high-build coatings cannot tolerate the thinning that would be necessary to make them pass through conventional spray equipment, and airless spray equipment must be used. Coatings used on porous surfaces should be able to penetrate and fill the surface voids in the substrate, and should be thinned if necessary to ensure penetration.

Execution of the painting work: How the paint is applied greatly influences the performance and durability of the coating. All painting work must be performed according to the manufacturer's instructions provided in the technical data sheet.

Fig 3.5 (i): Execution of the painting work with airless spray

Fig 3.5 (ii): Spray application with proper protection

Recoating: This is also referred to as "to recoat" or "recoat window." This is the time within which a previous coating can receive an intermediate coat or a topcoat at a referenced temperature and humidity. When the recoat window has been exceeded, the coating surface may require further surface preparation for which most manufacturers recommend abrading the surface or solvent application or both. Recoat windows vary widely, from a few minutes to a month or longer, depending on the type of coating material. If temperature and humidity are not shown or are outside the listed values on the manufacturer's instructions, the coating manufacturer should be consulted. Reclamation specifications specify the manufacturer's recommended recoat window because recoat windows vary greatly with material type.

Fig 3.5 (iii): Recoating on repair work

Fig 3.5 (iv): Curing paint in controlled conditions

Curing: This is the time required, at a referenced temperature and humidity combination, to allow the coating to complete the chemical reaction and to achieve structural integrity so that it will be ready for the intended service exposure. Excessive moisture high humidity or low temperature can stop or retard the curing process. Most manufacturer's instruction sheets provide information for cure time and cure time to immersion.

Drying: Drying is the period after which a coated item can be moved or can accept traffic without damage to the coating, before full cure at a referenced temperature and humidity. Most manufacturer's product data sheets refer to drying times as "tack free," "to touch," "to handle," or, "to stack" (to stack items one on top of another, e.g., pipe stacking), meaning the time between application and when the surface is tack free or dry enough to touch, to handle, or to stack. Reclamation specifications consider a coating to be dry "when it cannot be distorted or removed by exerting substantial, but less than maximum, pressure with the thumb and turning the thumb through 90 degrees in the plane of the coating film."

Fig 3.5 (v): Drying and inspection of paint coating

Notes

UNIT 3.6 Antifouling Paint

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the purpose of antifouling paint in marine painting
2. Explain how antifouling paint is to be applied

Back in time sailing vessels suffered severely from the growth of barnacles and weeds on the hull, called "fouling". Thin sheets of copper were nailed onto the hull to prevent marine growth.

The maximum speed of a ship decreases as its hull becomes fouled with marine growth. Fouling hampers a ship's ability to sail upwind. Some marine growth, such as shipworms, would bore into the hull causing severe damage over time. The ship may transport harmful marine organisms to other areas.

Fig 3.6 (i): Fouling of ship hulls

Fig 3.6 (ii): Cleaning of antifouling with high pressure (5000 psi pressure) jet washer

In modern times, antifouling paints are formulated with cuprous oxide (or other copper compounds) and/or other biocides—special chemicals which impede growth of barnacles, algae, and marine organisms.

Fig 3.6 (iii): Application of antifouling paint using airless spray

“Hard” bottom paints, or “non-sloughing” bottom paints, are made in several types. “Contact leaching paints” create a porous film on the surface. Biocides are held in the pores and released slowly. “Hard bottom paints also include teflon and silicone coatings, which are too slippery for growth to stick. Sealcoat systems dry with small fibres sticking out from the coating surface. These small fibres move in the water, preventing bottom growth from adhering.

3.6.1 Applying Antifouling Paint

1. Use a pile roller with an extension handle
2. Specialist facilities are essential to avoid the risk of breathing harmful vapours and toxic particles
3. Face mask, overalls, gloves and goggles are needed to protect against contact with the paint

Fig 3.6.1: Applying antifouling coating by roller and spray

As soon as a ship is hauled ashore the bottom should be pressure washed to remove any existing fouling – if this is allowed to dry it becomes many times more difficult and time-consuming to remove. Small areas or loose or flaking antifoul can be removed with a paint scraper. However, if many layers of antifoul have been allowed to build up and large areas have poorly adhered to the hull it makes sense to strip the hull back to a sound surface. Antifouling dust is extremely hazardous. The only safe options are wet sanding, or stripping with a chemical stripper that's formulated for use on fiberglass. Full protective clothing, including goggles and an effective face mask are required for safety.

Final preparation before you apply antifouling: Good preparation and priming is essential to ensure that the antifouling adheres to the surface. In addition, that surface should ideally be as smooth as possible. The faster the ship the more important this aspect becomes. If the hull has been stripped back to the gelcoat, it's also worth considering applying epoxy coatings to guard against osmosis. It important to first get an inspector to test the moisture levels of the hull as sealing excess water in with epoxy is counterproductive. Keels need special preparation, both to ensure they are perfectly faired, and to give the antifoul the maximum opportunity to remain strongly adhered to the surface. Any rust on cast iron keels should be removed with an angle grinder, such that the surface of the metal is bright. It can then by primed and faired before application of antifouling. With unpainted lead keels the tarnished oxide layer should be removed rubbing down with emery paper or with a wire brush in a power drill. Then remove the grease and contamination by washing with a suitable cleaner, before initial priming with an etch primer. This can then be followed by the recommended primer for the antifoul used.

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UNIT 3.7 Film Thickness and Associated Measurement

Unit Objectives

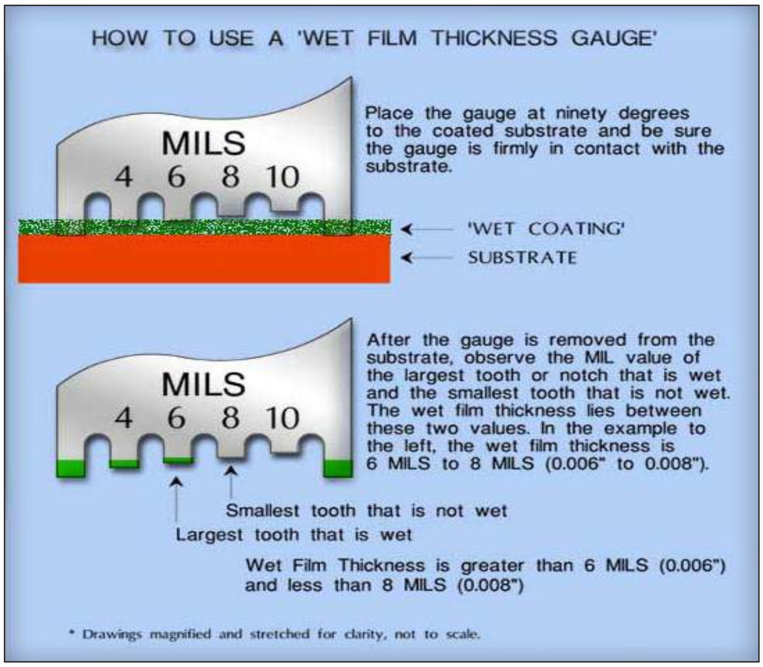
At the end of this unit, you will be able to:

1. Explain what film thickness is and the concept of dry film thickness
2. Describe the instruments used for measuring film thickness and demonstrate their use
3. Differentiate between non-destructive and destructive methods of measuring film thickness

Film thickness: Film thickness refers to the thickness of an individual wet or dry film, and to the thickness of a paint system. Film thickness is presented as micrometres (µm) or millimetres (mm).

The corrosivity category, the paint type, and the desired durability determine the film thickness of a paint system. In the painting standards, paint system specifications and technical data sheets, the film thickness is indicated as the nominal dry film thickness (NDFT). EN ISO 12944-5 (section 5.4) specifies the nominal dry film thickness. Wet film thickness is determined using a wet film thickness gauge. The thickness of dry film can be measured applying either a destructive or non-destructive method. As the standards specify the inclusion of the surface profile in the dry film measurement in different ways, it is important to agree upon the applicable standard and specification. The film measurement methods are described in ISO 2808.

Measurement of wet film thickness: Wet film thickness gauges are designed to quickly and easily measure the thickness of coatings immediately after the coating has been applied to a substrate. These gauges are also known as Combs, MIL Gauges, Step Gauges and Notched Gauges. The gauges incorporate a series of notches cut into their sides much like the teeth on a comb. The measurement method is described in ISO 2808. The wet film thickness value (Km) can be read directly from the comb/wheel.


HOW TO USE A 'WET FILM THICKNESS GAUGE'

Place the gauge at ninety degrees to the coated substrate and be sure the gauge is firmly in contact with the substrate.

After the gauge is removed from the substrate, observe the MIL value of the largest tooth or notch that is wet and the smallest tooth that is not wet. The wet film thickness lies between these two values. In the example to the left, the wet film thickness is 6 MILS to 8 MILS (0.006" to 0.008").

Wet Film Thickness is greater than 6 MILS (0.006") and less than 8 MILS (0.008")

* Drawings magnified and stretched for clarity, not to scale.

Fig 3.7 (i): Wet film thickness gauge readings

Non-destructive coating thickness measurement: The non-destructive coating thickness measurements can be taken on either magnetic steel surfaces or non-magnetic metal surfaces such as stainless steel or aluminum. Digital coating thickness gauges are ideal to measure coating thickness on metallic substrates. Electromagnetic induction is used for non-magnetic coatings on ferrous substrates such as steel, whilst the eddy current principle is used for non-conductive coatings on non-ferrous metal substrates. A coating thickness gauge (also referred to as a paint meter) is used to measure dry film thickness. Dry film thickness is probably the most critical measurement in the coatings industry because of its impact on the coating process, quality and cost. Dry film thickness measurements can be used to evaluate a coating's expected life, the product's appearance and performance, and ensure compliance with a host of International Standards.

Measurement of dry film thickness: Once the film is cured, dry film thickness will be measured. Dry film thickness (DFT) can be measured using two methods: destructive thickness measurement, where the coating is cut to the substrate using a cutter; and non-destructive coating thickness measurement, using techniques which do not damage the coating or the substrate such as magnetic, magnetic induction and eddy current thickness measurement methods. Non-destructive methods like magnetic film thickness gauges are used to determine the dry film thickness on metal substrates. If the metal substrate is ferrous, the magnetic gauges use one of two principles of operation: magnetic/ electromagnetic induction or magnetic pull-off using a permanent magnet as the source of the magnetic field. Eddy current coating thickness gauges are used for non-ferrous metal substrates. The substrate characteristics and the distance of the probe from the substrate, i.e. the coating thickness, affects the magnitude of the eddy currents.

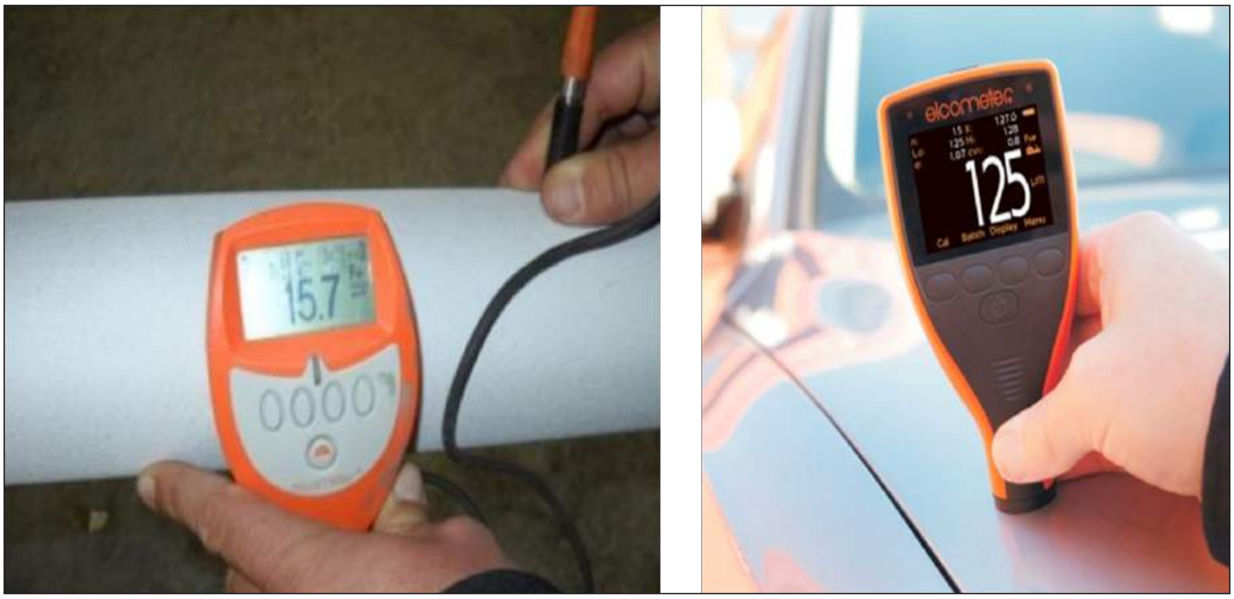


Fig 3.7 (ii): Measurement of dry film thickness with electronic gauge

Destructive measurement methods: The dry film thickness can also be measured using a destructive method where desired. ISO 2808 describes the measurement of dry film thickness using a micrometre (method 3A), rollback dial (method 3B), and cutting tool making a V-groove incision (method 5B). All the methods cut through the film into the substrate.

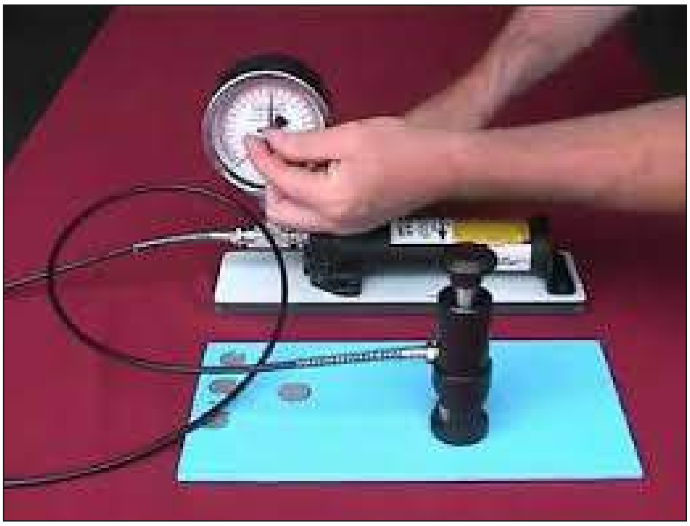


Fig 3.7 (iii): Pull off test

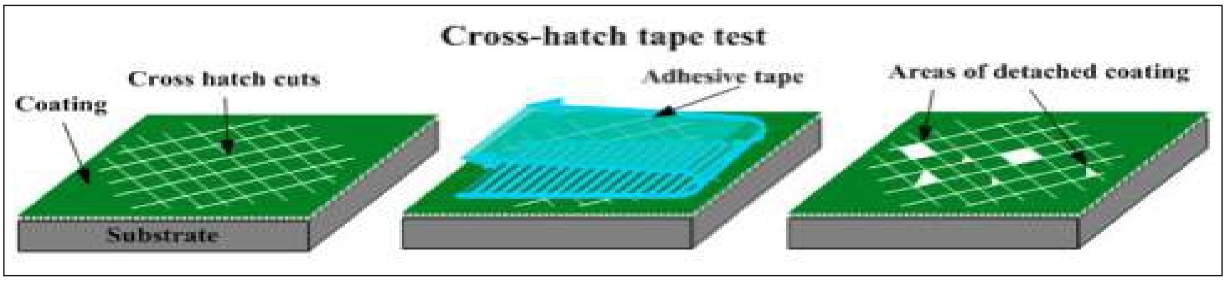


Fig 3.7 (iv): Cross hatch test
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Tips

For best corrosion protection, the coating must be applied soon after the surface is prepared. It is important to ensure that the product is within it's shelf life, is uniformly mixed and applied to the specified thickness.

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4. Coordinate with Colleagues and Customers

Unit 4.1 - Interacting with Superior
Unit 4.2 - Communicating with Colleagues
Unit 4.3 - Communicating Effectively with Customers

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Applicable NOS – PCS/N9901

Key Learning Outcomes

At the end of this module, you will be able to:

1. Learn behavioural skills to interact with your colleagues and co-workers effectively
2. Describe steps to achieve customer satisfaction
3. List quality and service orientation markers

UNIT 4.1 Interacting with Superior

Unit Objectives

At the end of this unit, you will be able to:

1. Describe best ways of interaction with your superiors at work

An organisation is a group of people working collectively towards a common goal linked to an external audience/environment. Simply put, all the employees in an organisation act as tiny parts of a large machinery which help seamless and efficient functioning.

Every organisation must have a structure. The organisation structure enables clarity of purpose and role of every individual ensuring there are no overlap in functions. It also clearly defines a hierarchy which determine who takes what decision and thus how those decisions shape the organisation. These decisions provide the direction needed in the organisation.

Interpersonal relations / communication between employees across hierarchies are thus very important. A code of conduct / protocol ensures expectation management and reducing the gap between superior and subordinates by increasing the levels of trust and support ultimately achieving organisational and personal goals.

Openness and comfort in communication plays a very important role in achieving job satisfaction. Reporting problems and asking for possible solutions after your own unsuccessful attempts, taking feedback etc. all come under interactions with your superior.

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UNIT 4.2 Communicating with Colleagues

Unit Objectives

At the end of this unit, you will be able to:

1. Describe best ways of communication with colleagues

Building trust with colleagues and co-workers is as important as doing your work efficiently and effectively. Here are a few actions you can take to build a relationship of trust and respect with your colleagues and co-workers:

- Greet everyone in the workplace with a smile and positive body language.
- Offer help to a new colleague to settle down in the job.
- Show courtesy and respect to colleagues.
- Do not disturb others when they are working.
- Keep your workstation clean.
- Leave washroom and other common facilities clean after use, for others.
- Do not waste your time and others' time by holding long conversations which are not related to work.
- Do not use cell phones at work.
- Do not mope. Keep a smiling face.

Following right communication rules is very important to keep a healthy relationship with colleagues and co-workers. In modern day workplace, people generally work in teams. It is important to build healthy relationship with the team members. Following are some important communication rules to follow:

- Speak in a polite and respectful tone. A voice tone suggesting impatience, sarcasm or taunt is not acceptable in the workplace.
- Use positive words and body language. Avoid words and topics which may offend anyone at workplace.
- If there is any conflict with a co-worker, resolve the issue amicably without raising your voice or getting angry.
- Greet your colleagues and co-workers in the morning or at the beginning of the shift.
- Use positive words and body language.

The quality of relationship you build with your colleagues and co-workers will depend on the behaviour you demonstrate while interacting with them. A relationship built on trust, good and clear communication, polite language and appropriate behaviour at all times helps you to be successful at work.

UNIT 4.3 Communicating Effectively with Customers

Unit Objectives

At the end of this unit, you will be able to:

1. Describe best way of communicating with customers
2. List quality and service satisfaction markers

A customer in your context is anyone – internal or external who might legitimately have a work-related expectation from you. Both their opinions are critical to the success of your company and sale of your products.

Internal customers are persons within the organisation who use products or services delivered by you as inputs in their work. For example, production staff in a factory are internal customers of maintenance technicians. The feedback provided internal customers is valuable. It must be implemented and taken seriously.

External customers are the end consumers and/or companies who buy your products. They do not belong to your organisation. These individuals are essential to the success of your company, as they purchase your product. Satisfied external customers make repeat purchases. They also refer the experience to others.

- Understanding customer expectations and implementing the same helps achieve customer satisfaction. Delivering more than expected adds to the overall experience of a good sale. It brings repeat customers.
- Managing customer relations requires dedicated and committed effort. It involves understanding the customer's need correctly and fulfilling it every time. With a business customer, it involves understanding their business and in what ways our product / service can help grow and improve their business.

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General tips for interactions with customer are as follows:

- Greet and welcome the customer in a friendly manner
- Make an earnest effort to understand customer needs. Ask specific pertinent questions.
- Be attentive, listen carefully and make notes. Suggest upgradation and add-ons if they give value to the customer.
- Find out customer's likes and dislikes by soliciting their opinion and comments on the demonstrated samples
- Never promise more than you can deliver. Always deliver more than you promise, never fall short
- Agree on all terms and conditions

When the customer is another organisation (such as an OE company, a cooperative society or a club), many persons from the customer organisation get involved. Each may have different needs and expectations. In such situations,

- Identify all the stakeholders (internal and external) and opinion makers right at the outset and understand their needs
- Understand the organisation's strategy and its priorities. This is critical to understanding which needs rank high.
- Be aware that there will be internal dynamics at work in any organisation, and one needs to steer clear of getting caught up in any interpersonal conflicts.
- Document what will be delivered (quantities, specifications and timelines) with a formal sign-off from the customer's side. This can avoid misunderstanding and disappointment later. Such document should also list key expectations from the customer that are critical for timely and quality delivery.
- With a long-term customer, explore ways of bringing about continuous improvements that can help the customer's business. This is critical to keep getting continuing business.
- Be available to deal with the customer's queries and concerns promptly and at all times.

4.3.1 Quality and Service Orientation

Quality is the sum total of all the elements connected with the product and service that impact the customer's perception positively. Examples are the product's functional performance, aesthetic appeal, reliability, durability, quality of the material used, meeting the design specifications of the end user, customer service during and after the delivery etc. The test of quality is when the customer is totally satisfied with the product in every respect.

Service orientation is the ability and desire to anticipate, recognise and meet customers' needs. It is a personality characteristic which makes people focus on providing satisfaction and making themselves available to others. Excellent customer service is unthinkable without customer service orientation.

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4.3.2 Customer Satisfaction

Customer satisfaction means the customer is satisfied and happy with the work we have done. A satisfied customer is ready to give us repeat business or recommend us to friends and acquaintances.

Customer satisfaction is important because in today's competitive market place every business competes for customers. Your business is constantly under threat from competition trying to take it away; consistently maintaining high customer satisfaction is crucial to retain customers for the long term. Customer satisfaction is the best indicator that the customer is likely to be a repeat customer. It is always cheaper to retain an existing customer than to acquire a new one.

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Tips

Always remember customer is King! Think of the many ways in which you can contribute to increased customer satisfaction.

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5. Maintain Standards of Product / Service Quality

PAINTS AND
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Unit 5.1 - Meeting and Exceeding Customer Expectations
Unit 5.2 - Coating Defects, Tests and Standards
Unit 5.3 - Your Responsibility as a General Industrial (Liquid) Painter
Unit 5.4 - Prevention of Injuries

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Applicable NOS – PCS/N9902

Key Learning Outcomes

At the end of this module, you will be able to:

1. Explain product / service quality requirements for general industrial painting
2. Follow company's policy and work instructions on quality standards to achieve customer satisfaction.
3. List out various defects and tests to check the quality of the painting job done

UNIT 5.1 Meeting and Exceeding Customer Expectations

Unit Objectives

At the end of this unit, you will be able to:

1. Describe the target customer and the quality standards defined by the company.
2. Implement the improvement suggested by supervisor and the customer.

A thorough understanding of the total coating system is necessary to begin the discussion with the customer.

1. Understand customer requirements

You should be able to obtain clear instructions and specifications from the customer about the desired finish, look, durability expectation and corrosion protection specifications. Some customers may not have a clear idea about their requirements. In such cases they will need to be guided. Prepare a few samples and get the customer to choose finish, gloss, and shade, which are some basic visual requirements for a coated film.

Established industries generally have well defined specifications stating their requirement. However, even here it is necessary to engage with the customer to ensure common understanding on tolerances, subjective parameters, working limitations and skill levels at customer factory as well as other unstated terms. For example

- When the customer asks for exact match to a standard colour panel, what is the level of tolerance permitted? Will the customer go by visual judgement or by an instrument match?
- What are the testing methods and standards that the customer would use?
- What is the process for maintaining and updating standard panels?
- What are the application equipment, parameters and conditions at the customer end?
- Are there any work restrictions at the customer's premises, for example on working hours, holidays, use of elevators, etc.? It is important to be clear on these while committing to aggressive completion targets.
- Can we describe what performance would be seen as exceeding the customer's expectations?
- Does the customer have internal targets for continuous improvements over time? What are the expectations from the coating supplier/ contractor in this regard?

2. Understand the total coating application system/process, nature of the facility and limitations

Delivering good and consistent quality in the design, production or application of paints and coatings requires understanding application conditions in detail. This includes obtaining insights and information on all relevant factors such as:

- Type and quality of the substrate and variations that may be encountered
- Surface preparation needed
- The type of coatings to be applied

- The application equipment available/ needed
- Applicable/expected quality standards
- Ambient conditions and site conditions
- Maximum size of components which can be fitted
- Overall magnitude of the job
- Maximum weight the conveyor can take (known as point load)
- Bake conditions, oven design, baking window
- Support facility limitations (e.g. conveyor speed, maximum loading etc.)

3. Fool-proof the process and have the right equipment

Analyse and find areas which need to be corrected to gain control of the overall process. This will reduce variations/ surprises and facilitate meeting quality expectations in a consistent and timely manner.

- Inspect the material(s) to be coated before starting the process to ensure good quality and good finish
- Check materials and consumables to be used. Make sure that they conform to specifications
- If the input jobs do not meet the requirements, discuss with the customer and quality in-charge and take appropriate actions
- Follow the right processes and use correct equipment for the job
- Ensure that applicable SOPs are adhered to

4. Get feedback from the customer and incorporate suggestions for improvement:

- After delivering the product/ output, proactively find out specific customer feedback
- Make a note of the feedback and improvements the customer is looking for
- Tell the customer what improvements you will incorporate in the next job

5.1.1 Quality Standards of the Company

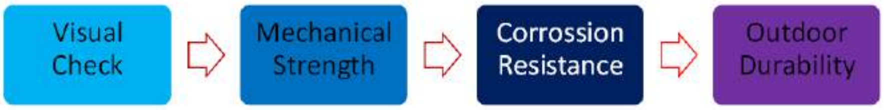
When coating is carried out under proprietary or customer specifications usually the following criteria are considered to check the quality of the finished job.

(a) On visual inspection, the coating should show the desired finish and correct curing without defects or blemishes.

(b) Mechanical strength checks are performed to ascertain that the DFT (Dry Film Thickness), hardness and flexibility criteria are met

(c) The film is tested for corrosion resistance. This may include salt spray resistance test, humidity resistance test etc.

(d) Outdoor durability tests include ultraviolet resistance test and actual outdoor resistance test



UNIT 5.2 Coating Defects, Tests and Standards

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the process of maintaining and enhancing quality standards.
2. Describe various tests and their pass/fail criteria and acceptable tolerance level.
3. List the equipment used for quality tests.
4. Describe the ways to improve company's customer satisfaction rating.

A company's policy defines and helps ensure adherence to quality standards.

- What kind of durability must the finished product meet?
- What are the criteria laid out for the quality assurance program?
- What are the customer specifications?

Based on these a 'Standard Operating Procedure' or 'SOP' is generated with specific work instructions. An **SOP** is a procedure specific to the operation that describes the activities necessary to complete tasks in accordance with industry regulations, legal requirements and quality standards

Why is it important to follow an SOP?

- Saves time and eliminates mistakes
- Ensures that consistent standards are followed throughout the process
- Reduces training costs
- Supports quality goals

5.2.1 Tests and Standards to Check Quality

- Dry Film Thickness (DFT) measurement
- Gloss
- Colour
- Flexibility / bend test
- Pencil hardness test
- Adhesion test

5.2.1.1 Dry Film Thickness (DFT) Measurement

This test is devised to check the correct coating thickness on the components as per the specifications.

- Dry film thickness (DFT) is the thickness of the coating
- DFT is measured for cured coatings. Proper thickness range is recommended in specifications

- There are various types of DFT Gauges available in the market, from simple magnetic gauges to digital gauges
- The gauge should be calibrated periodically by using a bare metal plate (zero setting) & standard thickness plastic foils (shims) which are supplied with the gauge
- Different gauges are available for Ferrous and Non-Ferrous substrates (F and NF)

Fig 5.2.1.1 (i): Magnetic Gauge

Fig 5.2.1.1 (ii): Digital Gauge

5.2.1.2 Gloss Check

Fig 5.2.1.2: Gloss meter

- Gloss is measured with Gloss Meter of different designs. The reflection is measured, and the angle of reflection is specified at 20°, 45°, 60° and 85°
- An angle of 60° is most common in the coating industry
- An angle of 20° is used for a more differentiated result of high gloss surfaces; usually recommended for **Automotive class "A" finish**
- An angle of 85° is used for a more differentiated result of matt surfaces, not so common

5.2.1.3 Colour Check

Colour may be checked visually or using a computer aided spectrophotometer. If measured by a spectrophotometer, the colour difference is reported as ΔE (Delta E). The ΔE should fall within the demarked tolerance zone.

- Visual inspection compared to a master. It is very important to use a relevant light source when judging colour
- Computer aided spectrophotometer
- Stationary equipment or portable equipment

Fig 5.2.1.3: Spectrophotometer

5.2.1.4 Flexibility - Bend Test

This test is to determine the elasticity, adhesion and elongation ability of a dry coated film applied on a flat metal support.

- It is checked using either a conical or cylindrical mandrel with a graduated scale
- The apparatus contains a holder for a mandrel, a bending lever fitted with height adjustable rollers, and sliding tongs for fastening the sample
- It is a laboratory apparatus to bend coated test panels over a conical/cylindrical shaped mandrel in order to assess the elasticity of the coating, in accordance with ISO 6860 and ASTM D522
- The conical shape of the bending area allows the deformation of the test panel and examination of the elasticity range of a coating over any diameter between 3.1 and 38 mm in one single test

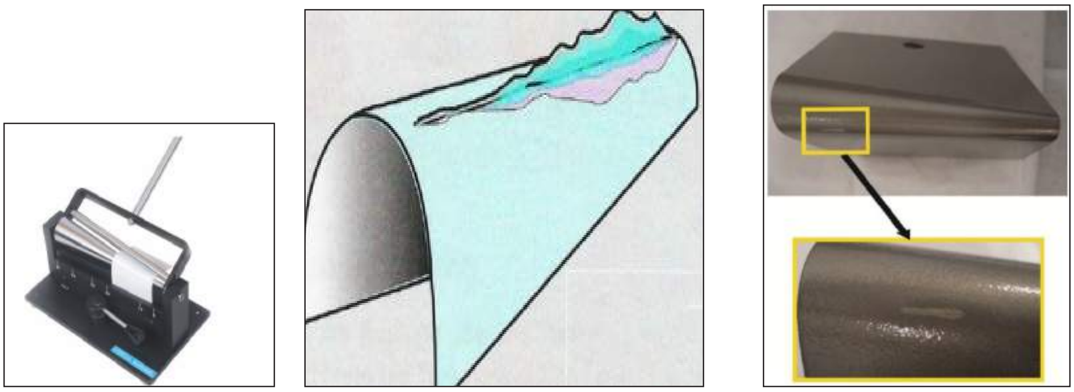


Fig 5.2.1.4: Bend test on a conical mandrel

5.2.1.5 Pencil Hardness Test

Fig 5.2.1.5: Pencil Hardness Test

Pencil hardness test is one of the many tests used to evaluate coatings. It is a simple and dependable test that uses pencils that are graded. The grade of the pencil is determined by the amount of baked graphite and clay in its composition. The test is performed by scratching the coated surface with pencils of known hardness. Mitsubishi UNI pencils are international industry standard.

Softer Pencils							Harder Pencils						
6B	5B	4B	3B	2B	B	HB	F	H	2H	3H	4H	5H	6H

5.2.1.6 Adhesion Test

Adhesion test is used to determine if the paint or coating will adhere properly to the substrate to which it is applied. There are three different tests to measure the adhesion of the coating to the substrate.

- Cross-cut test
- Scrape adhesion
- Pull-off test

Cross-cut test: This test determines the resistance of the coating to separation from the substrate by utilising a tool to cut a right-angle lattice pattern into the coating, penetrating all the way to the substrate. It is a quick test to establish pass/fail test. When testing a multi-coat system, the resistance to separation of different layers from one another can be determined by this test.

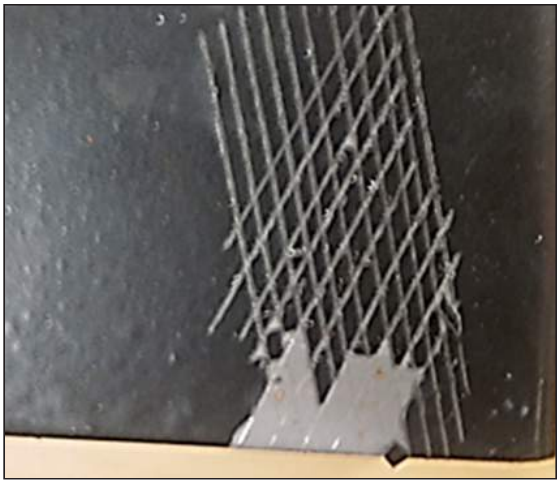


Fig 5.2.1.6 (i): Adhesion test fail

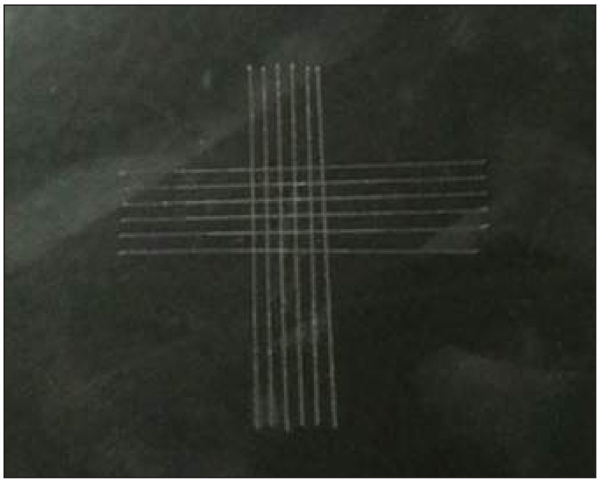


Fig 5.2.1.6 (ii): Adhesion test pass

Pull off dolly test: Unlike the other methods, this method maximises the tensile stress, therefore results may not be comparable to the others.

- The test is done by securing loading fixtures (dollies) perpendicular to the surface of a coating with an adhesive. Then the testing apparatus is attached to the loading fixture and is then aligned to apply tension perpendicular to the test surface.
- The force that is applied gradually increases and is monitored until a plug of coating is detached

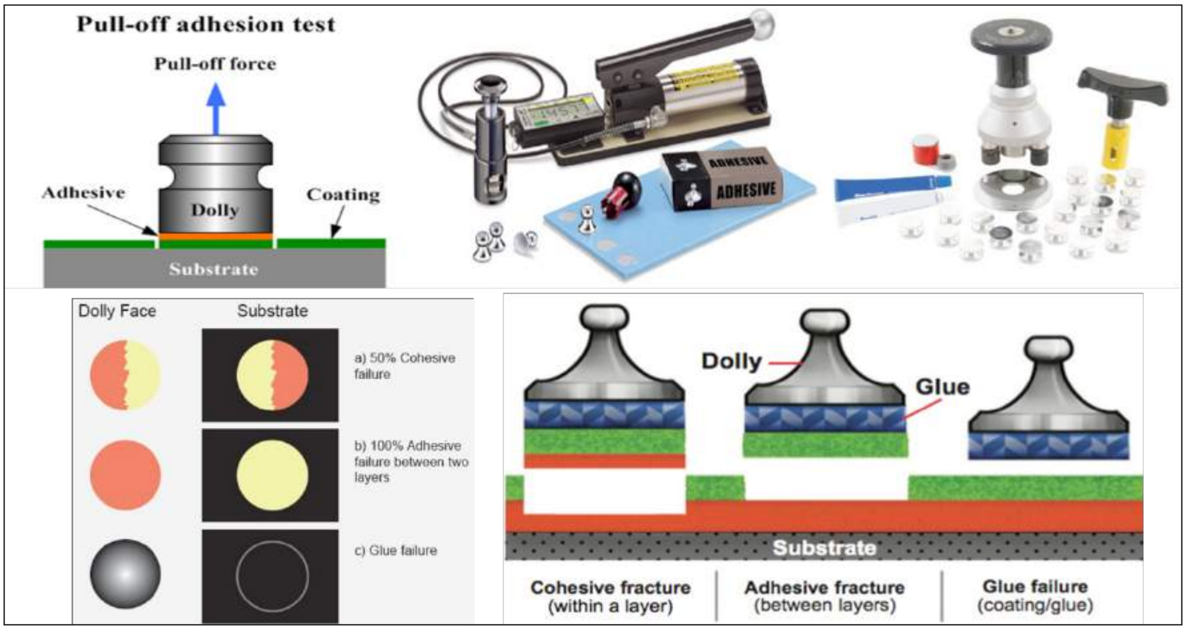


Fig 5.2.1.6 (iii): Pull-off Adhesion Test

5.2.1.7 Impact Test

Impact test is also known as drop weight test. The coated panel is subjected to mechanical impact by dropping a standard weight which can deform the coating and /or the substrate. With this test coating is tested for elasticity, brittleness, and adhesion to the substrate. As per ISO 6272-1:2011 - it is a method for evaluating the resistance of a dry coating film to cracking or peeling from a substrate when it is subjected to a deformation caused by a falling weight, with a 20-mm-diameter spherical indenter, dropped under standard conditions.

- Measures the deformation of a coating film
- Test performed on the front and reverse sides of a panel
- Result expressed as Pass or Fail

Fig 5.2.1.7 (i): Impact Tester Fig 5.2.1.7 (ii): Impact Test

5.2.2 Defects in a Coated Film

Quality checks and maintenance are a mandate every coating applicator must follow. Quality maintenance reflects excellence in your own skills and makes you an expert at your job. The quality parameters to be met and the checks to be performed will depend on the coating and where it is applied. For example, the requirements of a performance or industrial coating are very different from that of a house paint.

No.	DEFECT	CAUSES
1	**RUNS AND SAGS**	• Over thinned paint • Use of very slow evaporating thinner • Applying paint without proper flash time between coats • Very low air pressure during spray application • Improper spray gun set-up or an unbalanced spray pattern • Very cold substrate

2	**CHALKING**	• Chalking is a surface phenomenon, generally caused by exposure to UV radiation produced by the sun and its action on the organic binder • In the presence of UV light, airborne reactants such as oxygen, humidity, and pollution react with the resins in the binder, causing it to disintegrate and leaving the pigments free on the surface • Typically, amine-cured epoxies and epoxy esters chalk rapidly, and acrylics and acrylic-modified resins have good chalk-resistant properties since they are less affected by the sun's radiation • Chalking may not be a serious problem, and typically the coating will continue to provide protection in most cases, even though it may look faded
3	**EROSION**	• It is a surface defect often associated with chalking and often seen in brush applied coatings where the brush marks are exposed as the coating wears away • It is caused largely by heavy rainfall, high winds, hail or a combination of wind and rain; by sand erosion along beach areas; or by sandstorms in desert areas • Erosion of internal linings can be a significant problem in pipes carrying slurry or cooling water • Resins with some elastomeric quality may be effective, providing resilience to combat the impact of the eroding particles
4	**CHECKING**	• Checking is a form of cracking and is identified by small breaks in the coating that form as the coating ages and becomes harder and more brittle • It is a surface phenomenon that does not go all the way to the substrate • It can be caused by the mixture of resins, solvents and pigments that are not compatible. • Excessive film thickness, low flash off between coats, inadequately dry or thick undercoat are also some of the causes for checking • To minimise checking, the coating should be formulated with weather resistant resins, non-reactive pigments that do not contribute to checking, long lasting and stable plasticisers, and reinforcing pigments that reduce stress in the coating surface • Apply thinner coats of paint with adequate flash off or drying between coats

5	**ALLIGATORING**	• It is mostly a formulation-related failure and prevention is a matter of selection • The coating system selected should not specify a soft primer under a harder topcoat. The coating should be applied in thin coats, which should be allowed to cure before application of successive coats • Never apply a hard coating that oxidises or requires polymerisation over a permanently softer or more rubbery primer
6	**CRACKING**	• This formulation related failure is due to premature aging or weathering and, unlike checking or alligatoring, the cracks break through the coating, extending to the substrate • Cracking is a much more serious type of failure than checking • Checking results from the stress on the coating surface, while cracking results from stress throughout the film and between the film and the substrate • The use of proper resins, plasticizers, and pigments in coating formulation minimises the tendency of the coating to cracking • Fibrous or acicular (needle shaped) reinforcing pigments can help in reinforcing the coating against cracking
7	**MUDCRACKING**	• Unlike alligatoring, mudcracking goes directly to the substrate. It presents an immediate corrosion problem with possible chipping and flaking of coating from the surface • It occurs when highly filled or pigmented coatings, particularly zinc rich coatings are applied too thick • Highly filled water-based coatings sometimes mud crack, with the reaction occurring as soon as the solvent or water carrier begins to dry out of the coating • Mudcracking can be prevented by a combination of coating selection and proper application. If fast drying conditions exist or are expected, the user should avoid highly filled water-based coatings. • The coating should be applied during more moderate drying conditions, in thin coats without runs and sags
8	**WRINKLING**	• Wrinkling generally occurs when coatings are applied too thick. • It results from the swelling of a coating where the surface of the coating expands more rapidly during the drying period than the body of the coating • Occurs most with oil-based coatings • If a coating contains an excess of surface driers, wrinkling may occur wherever the coating is thicker than normal • Wrinkling is likely to occur in cold weather when the thickened coating is applied so that a heavy film develops or in hot weather when the topcoat dries quickly but the coating underneath remains soft

9	**BLISTERING**	• Blister develops first in localised spots where the adhesion is weakest • Blisters can be large or small and may exist in isolation or in groups • Blisters may be initiated by several causes. Mostly, they are formed due to the presence of moisture or other vapours, such as air or solvent, within the coating • A blister generally first appears when the vapour within the coating expands at elevated temperatures. It can also arise from soluble pigments in the primer and soluble chemical salts. • Yet another cause could be inadequate solvent release by the coating
10	**INTER-COAT DELAMINATION**	• Delamination is the loss of adhesion between coats in a multi coat system and is most common where repair or maintenance coatings are applied over cured coatings • New coatings applied over existing coatings may not be compatible with the previous coating, and delamination can occur • Precautions should be taken to minimise the problem by cleaning adequately and by applying coatings as quickly as possible after the cleaning operation • Another cause of delamination is the application of a coating over another coating that has over cured • Some modern coating formulations have been specifically developed with a low cross-link density to reduce this problem
11	**EXCESSIVE ORANGE PEEL**	• Film thickness out of proper range In case of powder coating, too slow heat-up rate and slow oven ramp-up time is the main cause • The oven temperature should cross 120°C -140°C very quickly • Grounding should be checked • The kV setting of the spray gun to be lowered • In case of liquid paints, a balance of slow and fast evaporating thinner should be maintained to achieve a smooth, orange peel free film without causing runs and sags. • In air assisted spray, the recommended air pressure should be maintained
12	**GLOSS TOO LOW FOR HIGH GLOSS TYPE COATING**	• Incompatibility between different coats • Micro-pinholing from outgassing • Excessive orange peel due to inadequate DFT • Over-curing of parts

13	**INCONSISTENT FILM THICKNESS**	• Incorrect positioning of spray guns • Defective spray equipment / nozzle • Reciprocators not matched to line speed • Air flow in booth disturbing spray pattern • Improper manual technique
14	**POOR IMPACT RESISTANCE AND/ OR FLEXIBILITY**	• Over baked film • Poor cleaning • Excessive film thickness
15	**POOR ADHESION**	• Poor cleaning / pretreatment • The PT line is not properly maintained • Oil removal from the degreasing stages not proper • Under-cured film
16	**PINHOLES**	• Moisture in coating • Moisture in compressed air • Mixing of two different coating types • Porous component like casting • Heating too fast creating outgassing while curing
17	**CISSING OR CRATERS**	• Moisture in coating • Oil in compressed air
18	**CHIPPING**	• Loss of adhesion of the film to the substrate due to impact from stones or other hard objects • Sand and featheredge damaged areas to remove chips, then refinish. • Use premium two component undercoat and topcoat system. • Use a flex agent in undercoat and/or topcoat system in areas that are prone to chipping.
19	**DUST CONTAMINATION**	• Inadequate cleaning of the surface • Dirty spray environment • Inadequate air filtration in the booth • Use of poor grade masking paper • Dirty spray gun • Dirty work clothes • Fine dust contamination can be removed by sanding and polishing

20	**FISHEYES**	• Spraying over surfaces contaminated with oil, wax, silicone, grease etc. • Use of thinner/ reducer in place of a solvent cleaner Spraying over previously repaired areas containing fisheye eliminator additive • Remove wet paint film with solvent cleaner and refinish. Add recommended fisheye eliminator and respray the affected areas. • Do not use fisheye eliminator in undercoat or basecoat colour. • If the paint has dried, sand to a smooth finish below the fisheye cratering and refinish
21	**LOSS OF GLOSS**	• Top coat applied in heavy, wet coats • Inadequate flash time between coats • Insufficient film thickness of topcoat colour or clearcoat • Using a poor grade and/or too fast evaporating thinner • Improper cleaning of the substrate • Insufficient air movement during and after application • Spraying over a deteriorated or solvent sensitive substrate finish without proper priming or sealing procedures • Natural weathering of the finish • Allow finish to cure thoroughly, compound or polish to restore gloss. • Sand and refinish
22	**MOTTLING**	• An uneven distribution of metallic flake • Too much thinner/reducer • Colour overthinned/ reduced • Applying clear coat to a basecoat that has not thoroughly flashed/dried • Improper application of basecoat To get a uniform single stage metallic finishes, apply a higher-pressure mist coat, panel by panel, while previous coat is still wet or allow basecoat colour to flash, then apply a low-pressure mist coat. Finishes that have dried must be sanded and refinished. Use recommended spray gun, including fluid tip and air cap for the material being sprayed
23	**SANDING MARKS**	• Scratching or distorting metallic/mica flakes close to the surface of the paint film Allow finish to dry, sand and refinish. Avoid sanding basecoat finishes before clear coating. If sanding is necessary, apply additional colour following label direction. When sanding single stage, finishes confine the sanding to minor imperfections – nib sanding rather than entire panel

24	**SOFT FILM**	• Applying undercoat and/or topcoat excessively wet • Insufficient dry time between coats • Improper shop ventilation or heating • Adding too much or too little hardener to the paint material. • Using the incorrect thinner/reducer for spray conditions • Omission of drier in enamel/ urethane topcoat Allow additional dry time, maintaining a shop temperature of 30 degrees centigrade or above or force dry following temperature and time recommendations or remove coating film and refinish. Use recommended spray gun, fluid tip and air cap for the material being sprayed.
25	**BLEEDING**	• Solvent in the new topcoat dissolves soluble dyes/pigments in the original finish, allowing them to seep into and discolour the new topcoat. • Remedial measures can be to remove original paint film and refinish. • Preventive measure can be to isolate the suspected bleeding finish by applying a two-component surface/sealer. • Allow to cure and then apply desired topcoat.
26	**TRANSPARENCY**	• Paint not thoroughly stirred • Colour over thinned/reduced • Substrate not uniform in colour • Wrong colour undercoat used • Insufficient number of colour coats applied Apply additional coats of colour until hiding is achieved or sand and apply similar coloured undercoat/ground coat and refinish.

Fig 5.2.2 (i): Sagging of paint coating

Fig 5.2.2 (ii): Chalking

Fig 5.2.2 (iii): Erosion

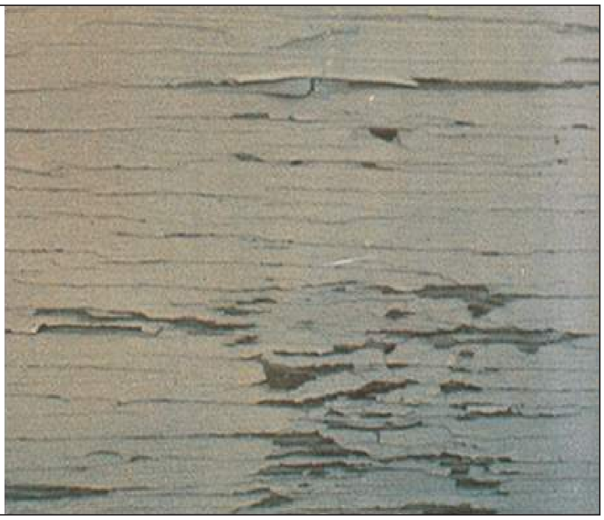


Fig 5.2.2 (iv): Checking

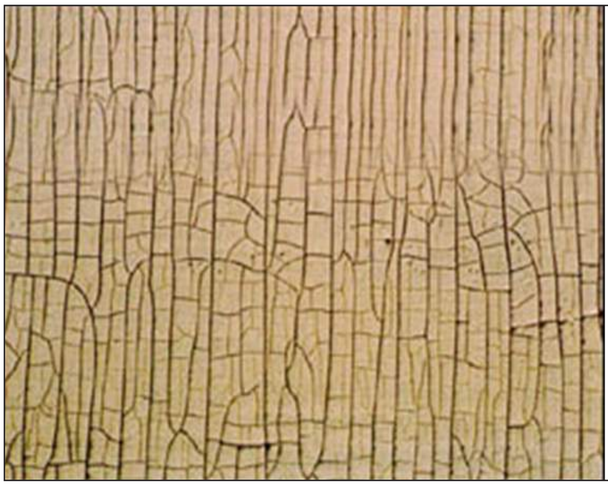


Fig 5.2.2 (v): Alligatoring

Fig 5.2.2 (vi): Cracking

Fig 5.2.2 (vii): Mud cracking

Fig 5.2.2 (viii): Wrinkling

Fig 5.2.2 (ix): Blistering

Fig 5.2.2 (x): Inter-coat delamination

Fig 5.2.2 (xi): Orange peel

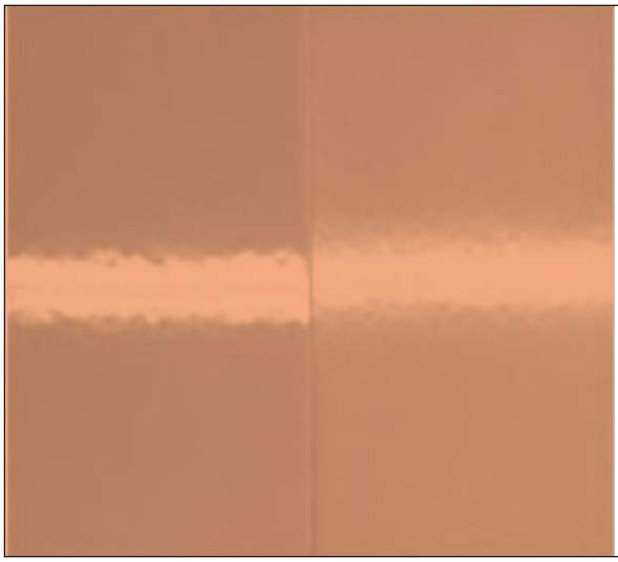


Fig 5.2.2 (xii): Standard Gloss Lower Gloss

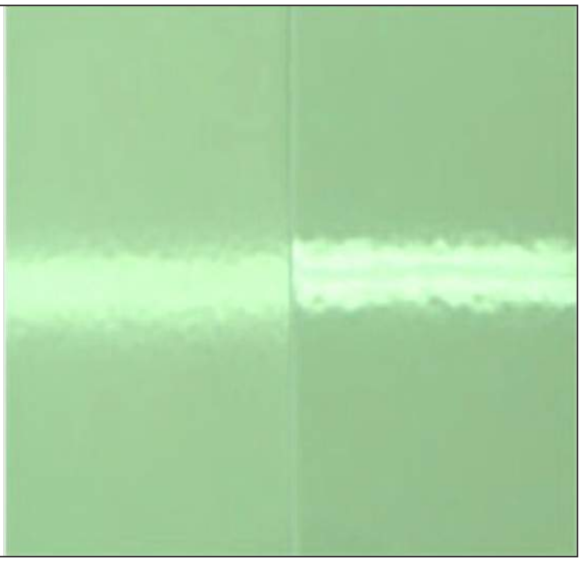


Fig 5.2.2 (xiii): Standard Gloss Higher Gloss

Fig 5.2.2 (xiv): Varied DFTs mentioned on panel

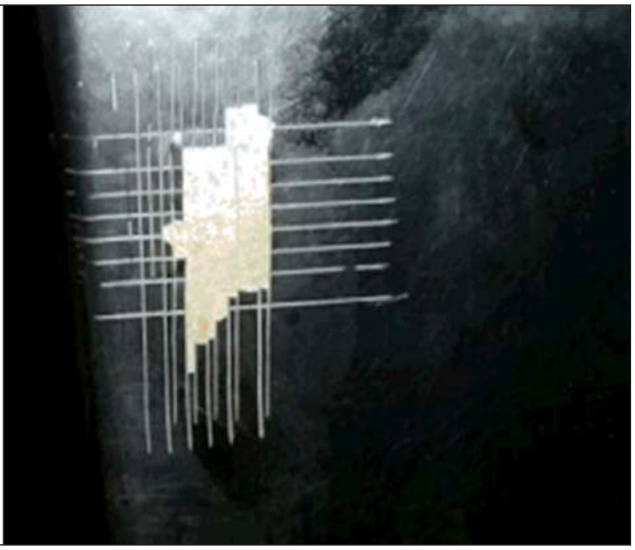


Fig 5.2.2 (xv): Poor pencil adhesion

Fig 5.2.2 (xvi): Impact Reverse Impact

Fig 5.2.2 (xvii): Failed impact test

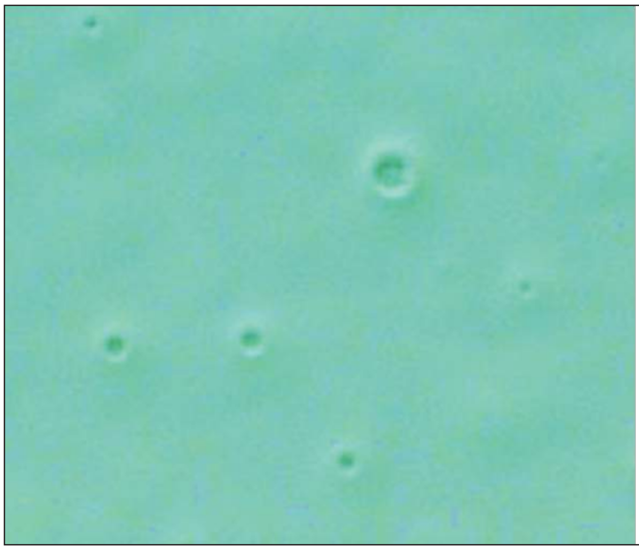


Fig 5.2.2 (xviii): Pinholes

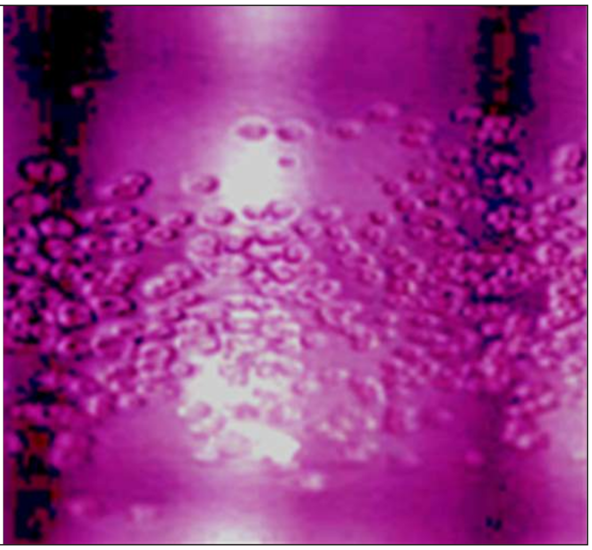


Fig 5.2.2 (xix): Cissing or craters

Fig 5.2.2 (xx): Chipping

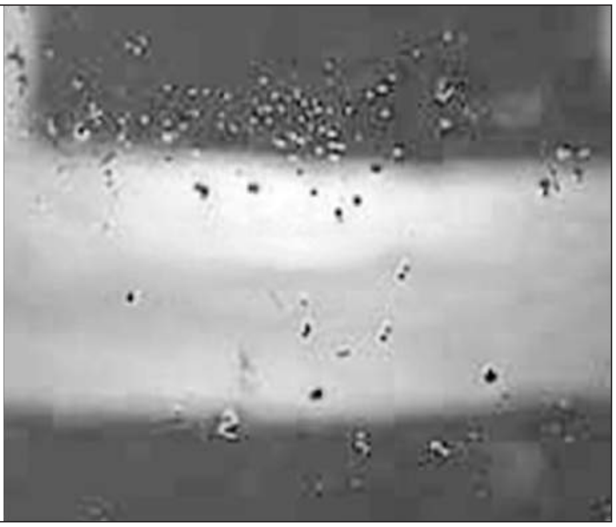


Fig 5.2.2 (xxi): Dust contamination

Fig 5.2.2 (xxii): Fisheyes

Fig 5.2.2 (xxiii): Loss of gloss

Fig 5.2.2 (xxiv): Mottling

Fig 5.2.2 (xxv): Sanding marks

Fig 5.2.2 (xxvi): Soft film

Fig 5.2.2 (xxvii): Bleeding

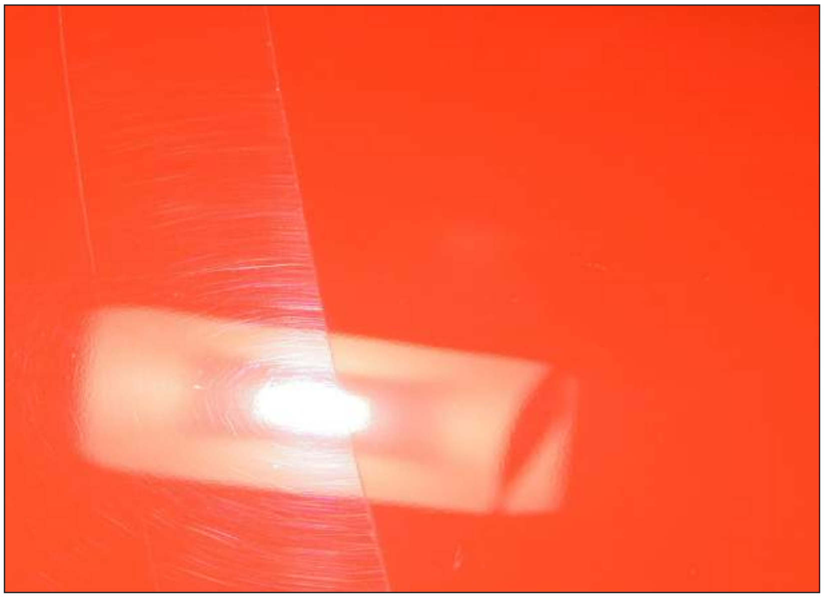


Fig 5.2.2 (xxviii): Transparency

Notes

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UNIT 5.3 Your Responsibility as a Protective and Marine Painter

Unit Objectives

At the end of this unit, you will be able to:

1. Organise paint material and tools for painting as per customer's requirement
2. List down the quantity of paint consumed and consumables used to work out the cost incurred

Your job responsibilities may vary from job to job, but general duties always include:

- Obtain, read, and fully understand the coating specification. Bring up any questions with the appropriate person, and get them resolved
- Fully comply with specification requirements and that work performed matches the required standard of quality
- Determine that all essential raw materials, especially coatings, are stored correctly and used in batches within the manufacturer's recommended shelf life
- Maintain records of all work done, the conditions under which it was done, and any other appropriate report items required by the supervisor
- Ensure that the necessary test instruments and standards required are available at all times and that each instrument is fully functional and properly calibrated

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UNIT 5.4 Prevention of Injuries

Unit Objectives

At the end of this unit, you will be able to:

1. Apply safe working practices to avoid injuries due to use of high-pressure equipment, moving parts and electric shocks
2. Identify toxic ingredients by reading a MSDS and use recommended PPE

Avoiding skin injections

- Stay clear of high-pressure fluid streams and sprays
- Never remove protective devices, such as spray gun tip guards, during application
- Use proper pressure-relief procedures
- Use proper flushing practices described in instruction manual
- Never try to stop leaks with your hands or body
- Always use the spray gun trigger safety lock when not spraying
- Don’t feel for leaks with your hands or a rag

Avoiding pressure-related injuries

- Do not exceed the working pressure ratings (WPR) of components, paying special attention to high-pressure equipment
- Operate the motor within the recommended air or hydraulic pressure
- Do not repair permanently coupled hoses
- Use only genuine service parts as specified by the manufacturer
- Properly align spray tips to prevent back-spray
- Do not use low-pressure fittings on high-pressure equipment
- Do not use damaged or worn out equipment
- Check for proper connections and make sure they are tight before pressurising the system
- Follow procedures for relieving fluid pressure whenever you stop equipment for service or repair

Avoiding injury from moving parts

- Never operate equipment with guards or other protective devices removed
- Check regularly to ensure that safety devices are operating properly
- Properly use bleed type shut-off valves

Avoiding toxicity

- Use recommended personal protection equipment (PPE) to avoid contact with hazardous materials
- Read and follow directions on all coating material labels and material safety data sheets (MSDS)
- Never operate gas engines indoors

Avoiding electric shocks

- Properly ground all objects in the system, including operators
- Follow the procedures in instruction manuals to avoid shocks from electrostatically charged components
- Never operate electric equipment when it is wet or when the surrounding area is wet
- Use only grounded outlets, extension cords and fluid hoses designed for high-pressure spraying that are in good condition
- Do not modify or remove electrical cords

Tips

Defects on the painted / coated surface reflects poor skills and workmanship. This may lead to early failure of the coating. Hence a greater emphasis on excelling at your job is important.

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National
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Corporation
Transforming the skill landscape

PAINTS AND
COATINGS
SKILL COUNCIL

6. Maintain OH&S Standards and Follow Environmental Norms

Unit 6.1 - Responsibility Regarding Safety
Unit 6.2 - Waste Disposal
Unit 6.3 - Use Safety Tools and Personal Protective Equipment (PPE)
Unit 6.4 - Handling of Coating Materials and Equipment as per Safety and Environmental Standards
Unit 6.5 - Precautionary Measures

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Applicable NOS – PCS/N9903

Key Learning Outcomes

At the end of this module, you will be able to:

1. List the personal protective equipment and its uses to be used at the workplace
2. Explain the precautionary measures for emergencies

UNIT 6.1 Responsibility Regarding Safety

Unit Objectives

At the end of this unit, you will be able to:

1. Explain safety
2. Identify various types of hazards in your workplace
3. Describe what an MSDS is and why it is important

Safety is the responsibility of all employees whether at the job site or in a factory. The employer has the prime liability for safety, but every employee should be knowledgeable on safety. They should be able to work in a safe manner without any safety violation.

As a member of the plant team or the site team you are responsible for:

- Your own safety
- Reporting any unsafe conditions or practices to the safety engineer or supervisor
- Following all specific safety requirements as set forth in the specification and by the safety engineer or supervisor
- Adopting safe practices while working with solvents, coatings, spray equipment, scaffolding, abrasive blasting, etc.
- Knowing the location of first aid stations
- Knowing the location of the nearest telephone and emergency telephone numbers like ambulance, fire department, safety engineer etc.

6.1.1 Primary Hazards

Fire	Explosion	Reactivity	Health Hazards
• All solvent based coatings, whether in a container or as a wet film on a surface, are flammable. In most cases, the coating's binder resin is also flammable. Precaution should be taken to prevent a spark or a flame from coming in contact with wet film or liquid paint.	• When sufficient solvent vapour is present in the air, a spark or a flame, can cause the entire air volume to react at one time, creating an explosion. Explosion can occur without fire, although they are often combined. Every effort should be made to prevent the solvent-air mixture from reaching 50% of the lower explosive limit.	• Reactivity is not ordinarily a major problem from safety standpoint. However, in two pack systems, the mixing of the base and the hardener makes the system reactive and can generate substantial amount of heat. Epoxies, polyurethanes, and similar reactive materials such as polyesters catalysed with acid, develop a substantial amount of heat, whenever they are mixed. Hence the base and the hardener or catalyst should be stored separately.	• Most coatings are not so toxic and protective clothing and proper equipment can provide full protection. Any worker sensitive to heights should not work on ladders, scaffolds, or rigs.

6.1.2 Hazards Associated with Coating Materials and Equipment

Most paint materials are hazardous to some degree. All paints, except water-based paints are flammable; many are toxic, and others can irritate the skin. However, most paints are quite safe to use if simple precautions are followed every time.

Among paint raw materials, solvents, resins and solvent based drier solutions are flammable. Some solid materials such as metallic powders carry explosion risk. Products such as fungicides used in certain water-based paints are toxic. Powder raw materials such as pigments and extenders pose risk of inhalation. All these materials need to be handled with appropriate personal protective equipment and, following all safety instructions correctly.

Surface preparation materials like solvents, acid or alkali cleaners can cause skin irritation if not used with care.

Due precautions need to be observed during the use of high pressure abrasive or water blasting methods for surface preparation. Safety gear should be used when using ladders, scaffolds and rigs for working at heights.

Slippery floors and obstacles located on the floor may cause falls.

Electrical /mechanical equipment may produce shocks or other serious injuries if not handled with care. An obvious hazardous location is the interior of a tank at a paint factory or at a customer site. Deviations or taking short cuts and not following proper procedures may produce unsafe working conditions which may result in accidents, loss of life, time and materials.

6.1.3 Chemical Hazards

Chemical manufacturers are required to evaluate chemicals produced to determine if they are hazardous. The manufacturer reviews the chemical substance to determine if it is carcinogenic, toxic, irritant or dangerous to human organs, flammable, explosive, or reactive. This information is available in the material safety data sheets (MSDS) that are supplied with materials.

What is a Material Safety Data Sheet (MSDS)?

A Material Safety Data Sheet (MSDS) is an information sheet that lists the hazards, safety and emergency measures related to specific products. An MSDS is required for industrial products used in the workplace like chemicals, paint, thinners, pretreatment chemicals and cleaners.

Why do I need to use an MSDS?

You may want to know if there are chemicals in the products that can cause adverse health effects such as allergies or asthma during its handling and use. This information may be helpful to prevent exposure to chemicals from new products or in finding out if existing products may be causing symptoms.

Where can I get an MSDS?

Suppliers provide a MSDS for each product supplied to the customer. This may be available with the safety department of your company. You may also obtain an MSDS from data bank available on internet.

Why is an MSDS sheet required for a medical emergency?

In an emergency, the doctor can request an MSDS, to understand the nature of the hazard and the anti-dote recommended for treatment.

Where can I get more Information?

Some product labels include a full list of ingredients. Some suppliers will provide a full list if you request it. You can also ask the supplier's chemist for more information, including a list of additional ingredients.

Are all ingredients Included in MSDS?

No. Only specific hazardous chemicals are mentioned on a MSDS. Thus, perfume or a chemical odorant that may not be considered hazardous may not show up in the MSDS. Manufacturers do not disclose information they consider proprietary. Such information may relate to the chemical composition.

The MSDS lists each required substance that makes up more than 1 per cent of the product. However, if the chemical causes cancer, respiratory sensitisation, or reproductive effects, then it must be listed even if it makes up more than 0.1 per cent.

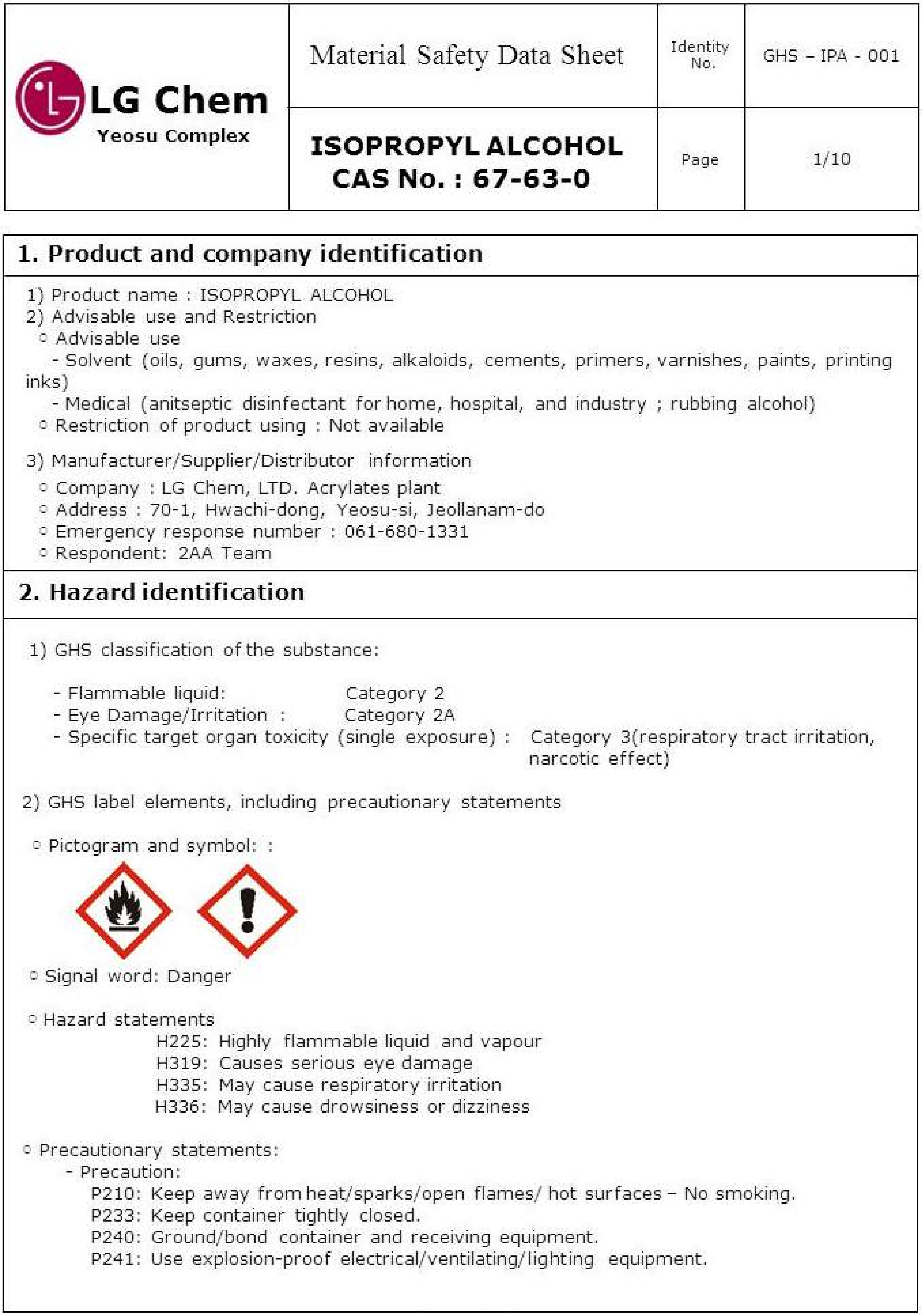
How much of a chemical is a problem?

It is important to consider several factors to determine if you should be concerned. For example, the

quantity, toxicity and other effects, and the potential exposures of each chemical are important to think about. It is also important to know that most of the information on an MSDS relates to exposure to one chemical at a time.

Technical Terms: Listed below are some definitions of terms you may find on an MSDS.

- Carcinogen: causes cancer
- Hormonal: some chemicals act like hormones
- Reproductive toxin: damages the male or female sex organs, sperm, or eggs
- Sensitisation: a body response which makes you react to a smaller amount than before
- Teratogen: causes developmental abnormalities to the foetus (unborn child)
- Toxin/toxic: poison/poisonous



LG Chem Yeosu Complex	Material Safety Data Sheet	Identity No.	GHS – IPA - 001
	ISOPROPYL ALCOHOL **CAS No. : 67-63-0**	Page	1/10

1. Product and company identification

1) Product name : ISOPROPYL ALCOHOL
2) Advisable use and Restriction
  ○ Advisable use
    - Solvent (oils, gums, waxes, resins, alkaloids, cements, primers, varnishes, paints, printing inks)
    - Medical (anitseptic disinfectant for home, hospital, and industry ; rubbing alcohol)
  ○ Restriction of product using : Not available

3) Manufacturer/Supplier/Distributor information
  ○ Company : LG Chem, LTD. Acrylates plant
  ○ Address : 70-1, Hwachi-dong, Yeosu-si, Jeollanam-do
  ○ Emergency response number : 061-680-1331
  ○ Respondent: 2AA Team

2. Hazard identification

1) GHS classification of the substance:

- Flammable liquid: Category 2
- Eye Damage/Irritation : Category 2A
- Specific target organ toxicity (single exposure) : Category 3(respiratory tract irritation, narcotic effect)

2) GHS label elements, including precautionary statements

○ Pictogram and symbol: :

○ Signal word: Danger

○ Hazard statements
H225: Highly flammable liquid and vapour
H319: Causes serious eye damage
H335: May cause respiratory irritation
H336: May cause drowsiness or dizziness

○ Precautionary statements:
  - Precaution:
    P210: Keep away from heat/sparks/open flames/ hot surfaces – No smoking.
    P233: Keep container tightly closed.
    P240: Ground/bond container and receiving equipment.
    P241: Use explosion-proof electrical/ventilating/lighting equipment.

Fig 6.1.3: Material Safety Data Sheet (freeenergystore.com)

UNIT 6.2 Waste Disposal

Unit Objectives

At the end of this unit, you will be able to:

1. Describe how and why improper waste disposal is hazardous

Impact of dumping waste in the open:

- Water pollution – toxic liquid seeps into surface and groundwater
- Soil pollution – toxins seeps into the soil and surrounding vegetation
- Dump fires – waste decomposition releases inflammable methane which can result into explosion
- Disease – flies, rodents and pets can spread diseases from open dumpsites
- Other impacts – visual ugliness, foul smell, bird menace which can be a hazard to airplane

Waste is treated in an effluent treatment plant, as recommended by the supplier and then disposed of safely, in a specially designed landfill with protective measures to save the environment. Landfills also serve as a backup in case of malfunction in the plant treatment facility.

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UNIT 6.3 Use Safety Tools and Personal Protective Equipment (PPE)

Unit Objectives

At the end of this unit, you will be able to:

1. List the different types of personal protective equipment mandatory while working

Personal Protective Equipment (PPE) and their usage is not an option; it must be practiced always without any deviations. In case of emergency, ensure you safeguard yourself first before helping others.

Personal Safety	Ladders	Scaffolding	Power Tools
• Use Personal Protective Equipment (PPE) to limit exposure to the eyes while handling powders or while spraying paint • Use regulated air respirator while spraying • Position yourself upwind of object being sprayed	• Use ladders that are stable • Wear shoes with heels • Inspect for loose, worn, or damaged rungs • Do not carry any tools in hand while climbing • While climbing face ladder, never jump from a ladder • Guard against metal ladder coming in contact with electric power lines	• Inspect for damage or deterioration • Ensure scaffolding is plumb and level • Ensure handrailing is provided on all scaffolding	• Verify safety guards are fitted and operational • Dust collection systems are operational when working with hazardous materials

Recommended PPEs

1. **Gloves**
   - (a) Nitrile gloves - used against solvent handling / painting
   - (b) Leather gloves - used against handling hot objects / blasting
   - (c) Surgical gloves - made up of latex, general purpose
   - (d) Polyethylene and cotton gloves - in powder coatings / painting

Fig 6.3 (i): Latex gloves for pretreatment Fig *6.3 (ii): Gloves for component handling*

2. **Masks**

- Solvent mask - Dry charcoal network is used as filter in mask used with cartridge or pre-filtered
- Powder mask - It is used while feeding and it is not efficient than solvent mask

Fig 6.3 (iii): Worker with a mask

3. **Ear plug/Muff**

- Ear plugs are used to protect ears when large sounds are produced
- Ear plus- it can be used for 2 hours
- Non-disposable ear muffs - these can be reused after washing with water

Fig 6.3 (iv): Ear plugs

4. **Eye shield**

- Eye shield must be used while spraying and working with dust and powder.
- Eyewash bottle is also used.
- An eye shield can be used for 8 hours

Fig 6.3 (v): Eye shield

5. **Industrial barrier cream**

   It should be used before work on hand so that any paint can be removed easily.

6. **Renal hands rub cream**

   It is used after work to remove paint on hands.

7. **Head guards and steel toe shoes (safety shoes)**

   They are used while working on the shop floor.

Fig 6.3 (vi): Safety precaution chart

Notes

UNIT 6.4 Handling of Coating Materials and Equipment as per Safety and Environmental Standards

Unit Objectives

At the end of this unit, you will be able to:

1. State how one can practice safe handling of materials and equipment used in painting and coating

Coatings Materials	Pretreatment Chemicals	Safety actions for fire risk	High temperature environments
• Read the MSDS. • Avoid excessive skin exposure. • Wear proper respiratory equipment. • Wear proper clothing and eyewear. • Always follow the manufacturers written procedures.	• Read the MSDS • Avoid skin contact • Wear recommended safety clothing • Maintain good ventilation • Always stay alert while handling chemicals	• Eliminate sources of ignition • Maintain a safe concentration of powder/ solvent vapour in air- below 50% of the lower explosion (flammability) limits • Maintain a good ground throughout the racks • Maintain a good ground on everything in the electrostatic coating application system	• Allow the temperature to attain the room temperature before carrying out any work • Disconnect power before entering • Use good lighting when entering • Wear a hard hat in areas where it is necessary to stoop • Never open washer or oven during operation • Know the hazards inside the equipment

Other than the above mentioned, basic elements of combustion such as electrical equipment, matches and cigarettes should be eliminated from site.

Notes

UNIT 6.5 Precautionary Measures

Unit Objectives

At the end of this unit, you will be able to:

1. Learn about ergonomic lifting, bending and moving equipment
2. List what goes into a first aid kit
3. Learn the actions to take during emergency procedures
4. Identify different kinds of safety signs

6.5.1 Ergonomic Lifting, Bending or Moving Equipment and Supplies

Fig 6.5.1 (i): Correct lifting techniques (worldartsme.com)

6.5.2 First Aid

A well-stocked first aid kit is a must at the workplace. It is essential to check the kit regularly and have items such as medications, emergency phone numbers, allergy details of employees and medical assistance numbers in the first aid kit. All expired and out dated medication should be discarded.

As per Red Cross recommendation, following articles must feature in a first aid box.

- 2 absorbent compress dressings
- 25 adhesive bandages (assorted sizes)
- 1 adhesive cloth tape
- 5 antibiotic ointment packets
- 5 antiseptic wipe packets
- 2 packets of aspirin
- 1 blanket
- 1 breathing barrier (with one-way valve)
- 1 instant cold compress
- 2 pair of no latex gloves (size: large)
- 2 hydrocortisone ointment packets
- Scissors
- 1 roller bandage (3 inches wide)
- 1 roller bandage (4 inches wide)
- 5 sterile gauze pads
- 5 sterile gauze pads (4 x 4 inches)
- Oral thermometer (non-mercury)
- 2 triangular bandages
- Tweezers

6.5.3 Emergency Procedures

On rare occasions, you may experience an emergency while working in a coating plant such as:

- Fire
- Medical emergency
- Armed hold up/robbery
- Bomb threat
- Natural disaster

Find out the emergency procedures and evacuation plans for emergency and obtain information on the evacuation plan of the company. Emergency procedures are reviewed from time to time based on the actual incidents. Remember your safety is of utmost importance in case of any emergency. Please refer to your supervisor/manager for specific information regarding your workplace.

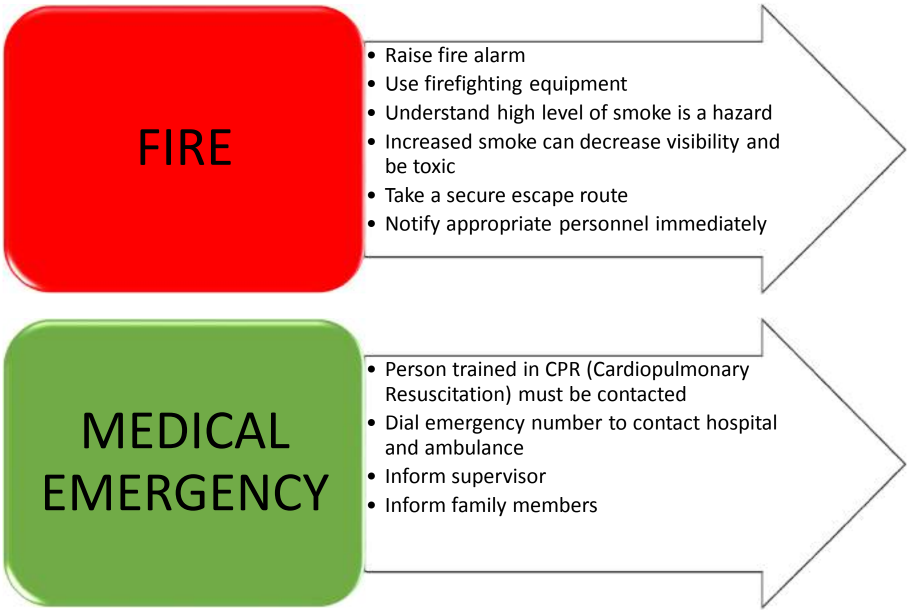
- Evacuation routes and exits are prominently displayed in the building and premises.
- Emergency exits, and evacuation routes must comply with local building codes.

You must know

- Preferred method of reporting
- Evacuation policy and procedures
- Emergency escapes procedures and route assignments
- List of emergency contact numbers inside and outside the facility
- Procedure for employees during shutdown of critical operations

You must locate

- Nearest telephone
- Identified restricted areas
- Fire alarm
- Fire extinguisher and fire blankets
- Safety warning tags and signs



FIRE

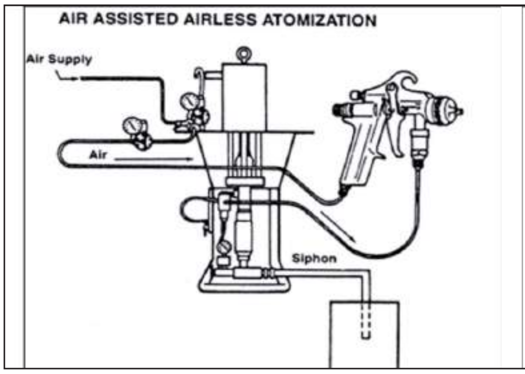
- Raise fire alarm
- Use firefighting equipment
- Understand high level of smoke is a hazard
- Increased smoke can decrease visibility and be toxic
- Take a secure escape route
- Notify appropriate personnel immediately

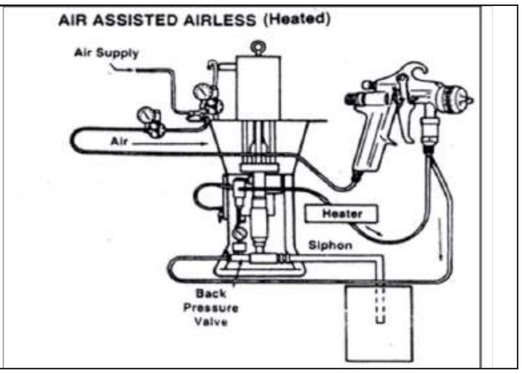
MEDICAL EMERGENCY

- Person trained in CPR (Cardiopulmonary Resuscitation) must be contacted
- Dial emergency number to contact hospital and ambulance
- Inform supervisor
- Inform family members

6.5.4 Display Safety Signs

- Learn to respect safety signs
- Learn to display them at appropriate places
- It is crucial for your safety and safety of other people
- Never take safety sign instructions lightly





6.5.5 Safety Checklist

As a paint/powder applicator, for all emergency situations, you must

- Know how to report a safety incident
- Understand the evacuation policy and procedures
- Have access to the list of emergency contact numbers inside and outside the facility
- Understand the procedure for employees during shutdown of critical operations
- Never disconnect hose under pressure
- Not leave pressurised unit unattended
- Never point the spray gun at human body
- Ensure the gun has required trigger guard
- Use electrically conductive hose in airless applications
- Ensure that no ignition source is present when flammable materials are used
- Minimise use of low flash point materials
- Check for adequate ventilation

GENERAL SAFETY	• Locate nearest telephone • Identify restricted areas • Locate fire alarm • Locate fire extinguisher and fire blankets • Locate moving objects, cranes, and traffic • Identify and observe safety warning tags and signs • Learn facility alarms, evacuation procedures, and general emergency protocols
LADDERS	• Periodically inspect for loose, worn, or damaged rungs • Never carry any tools in hand while climbing • Always face ladder while climbing • Never jump from a ladder • Guard against danger of metal ladder coming in contact with electric power lines • Secure the ladder
SCAFFOLDING	• Periodically inspect for damage or deterioration • Ensure scaffolding is plumb and level • Ensure handrailing is provided on all scaffolding • Never ride scaffolding on rollers when it is being moved • Verify inspection tags are valid and in place at all times
POWER TOOLS	• Ensure safety guards are fitted and operational • Ensure dust collection systems are operational when working with hazardous materials
ABRASIVE BLAST	• Ensure that the following are installed and in working order: o Deadman valve o Pressure control valves o Adequate moisture and oil separators o Protective clothing (hoods and gloves) o Filtered and regulated air-supplied respirator • Make certain that: o Entire system is grounded, including hoses, operator, and work piece o Hose couplings are wired shut o Abrasive hose is stored in a dry place o Abrasive hose is curved around, not bent at 90° angle o Nozzle is never pointed at human body or breakable object o Abrasive hose is inspected for damage and wear

SPRAY APPLICATION	• Ensure no ignition sources are present • Minimise use of low flash point materials • Adequate ventilation must always be provided • Ensure spray booth is clear of exhaust fumes from previous spraying • Ensure no rags become soaked with flammable liquid in spray area
PERSONAL PROTECTION	• Goggles and safety glasses must be worn at all times • Regulated air respirator must be used always • Operator must always be positioned upwind of object being sprayed
HOSE AND GUN	• Hoses must be inspected periodically for weak and worn spots • Hose connections must be correct and tightened • Hose must never be disconnected or recoupled while under pressure • Pressurised unit must never be left unattended • Gun must be grounded through hose connections • Operator uses electrically conductive hose in airless applications.
TEST EQUPMENT	• Holiday detectors must always be grounded • No volatile substances must be present when high voltage detectors are in use • Equipment must be suitable for the environment in which it is being used, e.g., intrinsically safe in hazardous confined spaces

Tips

- Working in a safe, environmentally clean manner without adversely impacting your health and that of your co-workers is not an option, but a mandatory requirement in any job.
- Be conscious of the health hazards posed by various chemicals and substances you use and learn and practice ways of mitigating them.
- Always learn to respect safety signs.
- Make safe working a habit.
- Never take safety sign instructions lightly.

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7. Maintain IPR of Organisation and Customer

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Applicable NOS – PCS/N9904

Key Learning Outcomes

At the end of this module, you will be able to:

1. Understand what Intellectual Property Rights are and their significance in your job
2. Describe what aspects of your job come under Intellectual Property Rights

UNIT 7.1 Secure Company's Intellectual Property Rights (IPR)

Unit Objectives

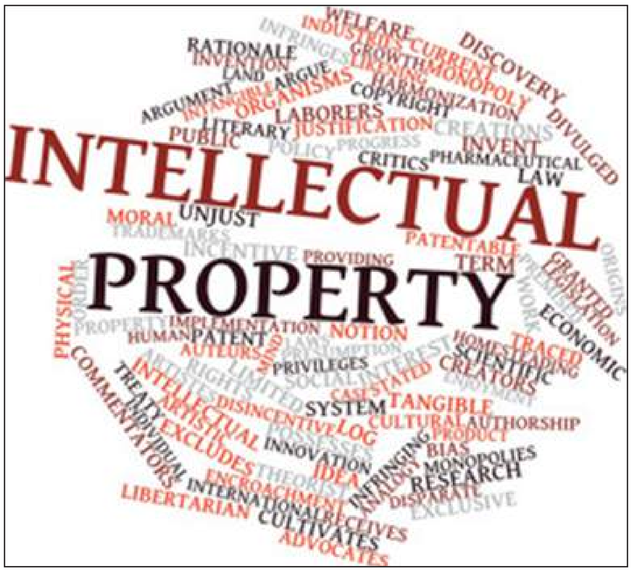
At the end of this unit, you will be able to:

1. Describe and discuss about various kinds of IPRs in the country

With the advent of the knowledge and information technology era, intellectual capital has gained substantial importance. Companies are carrying on business in several countries and selling their goods and services to entities in multiple locations across the world. Since intellectual property rights ("IPRs") are country-specific, it is imperative, in a global economy, to ascertain and analyse the nature of protection afforded to IPRs in each jurisdiction. We will discuss here the IP law regime in India and the protections provided thereunder.

Intellectual Property Right (IPR) a term referring to creations of the intellect for which a monopoly is assigned to designated owners by law.

- Some common types of intellectual property rights (IPR) are copyright, patents and industrial design rights; and the rights that protect trademarks, trade dress and in some jurisdictions trade secrets.
- All these cover music, literature, and other artistic works; discoveries and inventions; and words, phrases, symbols and designs.



IPR in India

The importance of intellectual property in India is well established at all levels - statutory, administrative and judicial. The agreement provides for norms and standards in respect of trademarks, copyrights, industrial designs and patents. The Indian government has taken several initiatives to create a conducive environment for the protection of intellectual property rights of innovators and creators by bringing about changes at legislative and policy level.

Aim

- Establish a vibrant IP regime in the country
- Adopt best practices in IP processing
- Strengthen public delivery of IP services
- Ensure a high level of transparency and user-friendliness

TYPE OF IPR	DEFINITION & SIGNIFICANCE	IPR ADMINISTERED THROUGH
PATENT	A patent is granted for an invention which is "a new product or process, that meets conditions of novelty, non-obviousness and industrial use".	• Department of Industrial Policy and Promotion, Ministry of Commerce & Industry • The Patents Act, 1970 (as amended in 2005)
DESIGN	A design refers only to the features of shape, configuration, pattern, ornamentation, composition of colour or line or a combination thereof, applied to any article, whether two or three dimensional or in both forms by any industrial process or means which, in the finished article, appeal to and are judged solely by the eye.	• Department of Industrial Policy and Promotion, Ministry of Commerce & Industry • Designs Act 2000
TRADE MARK  	A Trade Mark can be a device, brand, heading, label ticket name, packaging, sign, word, letter, number, drawing, picture, emblem, colour or combination of colours, shape of goods, signature or a combination thereof.	• Department of Industrial Policy and Promotion, Ministry of Commerce & Industry • Trade Marks Act 1999 (as amended in 2010) For example, paint and powder coating company logos which are Trade Marks of the companies and which the companies have the copyright to.
SEMICONDUCTOR INTEGRATED CIRCUITS LAYOUT-DESIGN	The aim of the Semiconductor Integrated Circuits Layout-Design Act 2000 is to provide protection of Intellectual Property Right (IPR) in the area of Semiconductor.	• Department of Electronics and Information Technology, Ministry of Communications, and Information Technology • Semiconductor Integrated Circuits Layout-Design Act, 2000

Fig 7.1: Logos of various paint companies (for representation purpose only)

Notes

UNIT 7.2 Copyright

Unit Objectives

At the end of this unit, you will be able to:

1. Explain in detail what is Copyright and what aspects get covered under Copyright

A Copyright is a right given by the law to creators of literary, dramatic, musical and artistic works and producers of cinematograph films and sound recordings. In fact, it is a bundle of rights including, inter alia, rights of reproduction, communication to the public, adaptation and translation of the work.

It is administered by The Ministry of Human Resource Development and The Copyright Act, 1957 (as amended)

A copyright gives the creator of an original work exclusive rights to it, usually for a limited time. Copyright may apply to a wide range of creative, intellectual, or artistic forms, or "works". Copyright does not cover ideas and information themselves, only the form or manner in which they are expressed.

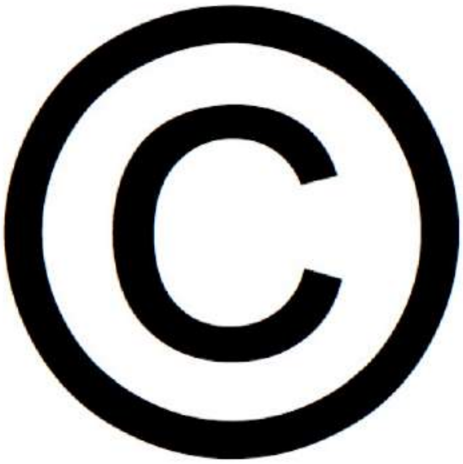


Fig 7.2: Copyright symbol

What rights does Copyright provide?

A copyright grants protection to the creator and his representatives for the works and prevents such works from being copied or reproduced without his/their consent. The creator of a work can prohibit or authorise anyone to:

- Reproduce the work in any form, such as print, sound, video, etc.
- Use the work for a public performance, such as a play or a musical work
- Make copies/recordings of the work, such as via compact discs, cassettes, etc.
- Broadcast it in various forms
- Translate the same to other languages

What is the term of Copyright?

The term of copyright is, in most cases, the lifetime of the author plus 60 years thereafter.

Copyright Infringement

- Copyright infringement is reproducing, distributing, displaying or performing a work, or to make derivative works, without permission from the copyright holder. It is often called "piracy".
- Enforcement of copyright is generally the responsibility of the copyright holder

A Copyright is infringed if a person without an appropriate license does anything that the owner of the Copyright has an exclusive right to do. However, there are certain exceptions to the above rule (e.g., fair dealing). The Copyright Act provides for both civil and criminal remedies for Copyright infringement. When an infringement is proved, the copyright owner is entitled to remedies by way of injunction, damages, and order for seizure and destruction of infringing articles.

Importation of infringing Copies

The amendment in the Copyright law has introduced a revised Section 53. This provides a detailed procedure whereby the owner of the Copyright can make an application to the Commissioner of Customs (or any other authorised officer) for seizing of infringing copies of works that are imported into India.

Rules and Acts related to Copyrights:

- Copyright Act, 1958
- Copyright Act, 1987
- International Copyright Order, 1999
- The Copyright (Amendment) Act, 2012

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UNIT 7.3 Confidential Information and Trade Secrets

Unit Objectives

At the end of this unit, you will be able to:

1. Describe what comes under confidential information and understand why trade secrets must be protected

Confidential information and trade secrets are protected under the common law and there are no statutes that specifically govern the protection of the same. In order to protect trade secrets and confidential information, watertight agreements are signed between the employee and the owner/ management supported by sound policies and procedures.

Non-Disclosure Agreements

- Sound and concise company policies and non-disclosure agreements with the employees protect confidential information and trade secrets of the company. Such agreements should define "confidential information" and the exceptions to confidentiality.
- Non-compete clauses, afford an organisation added protection with respect to its confidential information. Such provisions must have a clear purpose, which is to restrict the use of confidential information and trade secrets obtained during employment.
- To ensure that the rights of third parties are not violated, the non-disclosure/employment agreement imposes an obligation on the employee not to integrate into the organisation's data or intellectual property, any confidential information of a third party. Organisations execute such agreements at the time of employment, subsequently executed agreements should expressly cover the confidential information obtained by the employee from the date of his employment.

Internal Processes

- You should be able to identify information that is confidential and a trade secret of your company. Data that is confidential should clearly be not shared with any one.
- Third-party interaction and disclosures should be channelled only through specified personnel. Confidential information should only be shared with those employees who have a legitimate need to know such information, thus enabling the employees to perform the assigned tasks.

UNIT 7.4 Organisation Information to be Kept Confidential

Unit Objectives

At the end of this unit, you will be able to:

1. Understand why organisational information is crucial to the success of an organisation

Organisation's information regarding the following should be kept confidential at all times. It should not be disclosed to anyone other than the immediate supervisor and employees who need to know the information legitimately.

- Process adopted including equipment/s used
- Production volume
- Cost of the product
- SOP of the company

The new product design and application process gives the company a competitive advantage in the market. Any leakage of the new design and its launch plans will reduce the competitive advantage as competitors' can also launch new designs simultaneously. Any information on this should be passed on to the immediate supervisor only. Report any infringement of the brand and/ or logo observed in the market, to the immediate supervisor. It takes only one employee to commit the mistake and the entire company suffers.

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UNIT 7.5 Customer Information to be Kept Confidential

Unit Objectives

At the end of this unit, you will be able to:

1. Understand why customer information is important and is crucial to the success of a company

Customer's information regarding the following should be kept confidential. It should not be disclosed to any other customer or outside agency but only with the immediate supervisor or persons who have the legitimate right to have the information within and outside the company.

- Process adopted
- Equipment/s and products used
- Line design, component/ parts design, its loading pattern
- Production volume/ day/ month/ annual

Why is confidentiality important?

- Failure to protect confidential customer and business information can lead to the loss of business/clients.
- Confidential information in wrong hands can be misused to commit illegal activity e.g., fraud which can result into costly lawsuits for the employer.

What type of information of your company should be protected?

- Employee information – personal information of your colleagues and superiors like personal phone number, email id, etc.
- Confidential management information includes disciplinary actions, employee relations issues, impending layoffs/reductions-in-force, terminations, workplace investigations of employee misconduct, etc. While disclosure of this information is not "illegal," it can seriously damage the image of the company.
- Trade secrets like business plans, manufacturing processes and methods, computer program and data compilation, financial data, budgets and forecasts, client/customer lists, ingredient formulas and recipes, employee lists, supplier lists, etc.

Tips

- Do not share confidential information of the company with people outside your organisation.
- Do not take photographs of components, parts, SOP or any other company documents.
- If anyone other than the employee of the company is taking photographs of components or parts or any document, you must not allow them and immediately inform your supervisor.
- Do not upload confidential information on social media.
- Remember, sharing secret and confidential information and documents can result in customer withdrawing the project from your company and can also be punishable by law.

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