What's in a can of paint?

Introduction

In this document we will define what paint is and then reveal the magic ingredients that make it such a powerful substance. A mere 50-100 μms of paint is expected to give protection against rust and the elements to our most prized possessions, such as our homes and cars. Paint comes in a huge variety of types ranging from the early Resene Stipplecote, which was based on cement, to the latest waterborne enamel paints such as Resene Enamacryl (see Data Sheet D309). We will cover the basic raw materials that make up paint such as the binders, the pigments, the solvents, the thickeners and a group of ingredients that we conveniently call additives. It is important to get a good understanding of what these materials are and how they work to be able to understand paint.

What is paint?

Most definitions we have heard don't describe paint well. Paint can be anything from a coat of linseed oil to a sophisticated baked on silicone enamel for painting space shuttles. We will give you a reasonable definition, which you may like to think about. We are sure you will be able to find a number of exceptions to it.

Definition of a paint

A liquid material, that when applied to a substrate in a thin film, dries to form a cohesive, solid film that changes the properties of the substrate.

What is the purpose of paint?

Paint is used in quite diverse areas, which even so called technical experts don't know about or have only recently discovered. Cattle marking paint is one that would be left off many people's lists for example. Architectural paints are mainly used for decoration but do also play a serious role in protecting our major assets from natural weathering processes. Paints also act to waterproof, provide corrosion protection by a variety of methods, protect against fire, protect against mould, make surfaces cleanable in hygiene areas, act as a media for advertising and finally paint may act as a fashion statement on your latest vehicle.

Quality paint

For paint to perform any role well it needs to be a quality paint and be designed for that particular purpose. A quality paint is of no use, however, if specified for the wrong purpose. For example, Resene Aquapoxy (see Data Sheet RA43) performs brilliantly as an interior anti-graffiti coating but in exterior situations performs poorly because of a natural tendency to chalk badly. The less sophisticated Resene Lumbersider (see Data Sheet D34), is brilliant on exterior concrete or timber but unsatisfactory over bare steel.

Paint raw materials

The ingredients from which paint is made are referred to as 'raw materials'. The paint raw materials are listed on the product 'manufacturing docket' along with instructions about how and where to add them. Raw materials may be divided into five main groups:

- **Binders** to stick the paint together, form a film and give adhesion.
- **Pigments** to colour the paint, control gloss, prevent corrosion, add bulk and other properties.
- **Solvents** to make paint useable.
- **Thickeners** to hold the wet paint in suspension and prevent sagging.
- **Additives** to do all the little, but important jobs.

To create a quality paint, quality raw materials are essential but so is the skill of the chemist in deciding which quality raw material is the most suitable for the desired purpose. Raw materials are often interdependent, which means they will not work well in the paint unless accompanied by other critical raw materials.

The binder

The role of the binder is undoubtedly the most important in determining the properties of a paint. Paint binders come in a huge range of chemical types and are often tailor made for customers.

Binders have three major jobs to do:

- Provide adhesion to a substrate.
- Form a continuous film.
- Bind the pigments and additives into the paint.

The term binder is therefore quite an appropriate one. Solventborne binders are often referred to as resins and waterborne paint binders as a latex. Resins are very much like golden syrup in appearance, consistency and stickiness while many waterborne binders resemble milk.

Whether a paint is suitable for swimming pools, jet aircraft or weatherboards is determined by the binder. The other components can affect the performance (particularly in the case of highly specialised paints such as anti-corrosive paints etc) but the binder is much more important. A good understanding of the properties of binder types will be invaluable in helping you understand the paint made from them.

Binders may be labelled as belonging to one of two main categories - they are either **convertible** or **con-convertible**.

Convertible binders

By convertible we simply mean that as the binder dries it chemically reacts with a hardener, moisture, or oxygen from the air to form a completely new chemical compound that has quite different chemical and physical properties to the starting binder or resin. These types of resins often become very hard and as a consequence are difficult to recoat. This property also gives the paints made from some of these binders excellent chemical and abrasion resistance.

Convertible coatings may be further classified into four main areas; alkyd, urethane alkyd, moisture cured urethane and two pack.

Examples of convertible binders and Resene products made from them:

• Acrylic epoxy	Resene Imperite IF 503
• Acrylic urethane	Resene Uracryl 401, 402 and 403
• Alkyd resins	Resene Super Gloss Enamel, Armourcote 210,
• Epoxies	Resene Armourcote 510, Aquapoxy
• Ethyl silicate	Resene Zincilate 10 (Inorganic Zinc)
• Linseed oil	Resene Danska Teak Oil
• Moisture cured urethane	Resene Polythane
• Polyester urethane	Resene Imperite 413
• Special acrylic latex	Resene Enamacryl, Lustacryl
• Urethane alkyd	Resene Sidewalk, HD Poly-Satin, Sureseal

1. Alkyd type binders

These dry by chemically reacting with oxygen in the air to form a different chemical in the dry state. This reaction takes place over the lifetime of the coating and as a result alkyd borne paints tend to become brittle as they age. Alkyd resins are generally made from vegetable oils and other chemicals, such as glycerine and phthallic anhydride or their equivalents. The main vegetable oil used for common house paints is soya bean oil. Other common oils, such as safflower and linseed, may also be used depending on price. Alkyd resin borne paints may also be referred to as oil-borne, solventborne or as enamel paints.

Alkyd resins, are made by cooking oils, such as soya bean oil or linseed oil, and reacting them with glycerine and other chemicals in giant kettles that may be capable of producing up to 10,000 litres at once. These kettles are equipped with stirrers, thermostats, condensers and are usually heated by pumping hot oil around an outside jacket.

The properties of resins depend not only on the raw materials added but also on how well the cooking process is controlled. Resins may be made with high solids but still be low in viscosity. These types are ideal for gloss enamel paints. At the other end of the scale resins may be produced at very low solids and in a gel form. These resins can be used as thickening agents. In fact alkyd resins may be tailor made to give a wide range of properties.

Varying the raw materials in a resin changes the properties also. The use of tung oil (also known as wood oil) will give better water and alkali resistance to paint made from it but will be much worse for yellowing and have significantly worse chalk resistance than a resin made on soya bean oil.

Strengths of alkyd resins

- Excellent initial gloss.
- Dry hard and can have excellent block resistance.
- Single component.
- Excellent flow and levelling.
- Relatively easy to apply.
- Resistant to oil and grease (in kitchens).
- Relatively easy to recoat.
- May be easily tailor made for special purposes.

Weaknesses of alkyd resins

- Yellow in shady situations.
- Poor alkali resistance.
- Susceptible to mould growth (because they have been made from vegetable oils).
- Chalk quite badly on exterior exposure.
- Lose flexibility as they age.
- Paints made from them contain large volumes of unhealthy solvents.

2. Urethane alkyd type binders

These are made by modifying alkyd resins with isocyanate to toughen them up and to give them faster dry properties and better water and alkali resistance.

With urethane alkyd resins there is absolutely no free isocyanate in the resin after manufacture. The other properties of these resins are similar to the alkyds except that water and chemical resistance is improved and exterior weathering properties are considerably downgraded. This is because the resin is much more susceptible to damage by UV light.

Isocyanates

Isocyanate containing binders are often referred to as urethanes. The isocyanate chemical group is potentially one of the best and toughest we have to make paints from. Typically forms of it are used to catalyse products such as Resene Uracryl 403 and Resene Imperite 413. There is free isocyanate in these products that can be very unhealthy if vaporised by spray application. Free isocyanate is only a danger if atomised by spraying. Products may be safely applied by brush.

Isocyanates are also used in moisture cured urethanes. These products, such as Resene Polythane, normally contain free isocyanate so we strongly advise against spraying. Urethane alkyds contain fully reacted isocyanate groups and no free isocyanates.

3. Moisture cured binders

These binders dry by reacting with moisture in the air. Moisture cured urethane resins make excellent tough, durable, chemical resistant finishes ideal for flooring. They are based on isocyanate chemicals.. The major benefit of these resins is that a finish equivalent (or better) than that from two pack product is obtainable without the confusion of having to mix two components together that then have a finite pot life.

Disadvantages of moisture cured urethanes

- Moisture contamination of the resin in storage at the manufacturing plant or of the product after it has been canned off will result in it gelling.
- Low film build restrictions (carbon dioxide gas is formed in the curing process and high film builds trap the gas causing bubbles in the dry paint).
- The resin contains free isocyanates, which are hazardous if sprayed.
- Recoatability is a problem.

Ethyl silicate

There is another type of moisture cured resin in common use and that is the ethyl silicate type resin used in our inorganic zinc products. This is our only binder that does not contain carbon when it has cured. Some of these products can also be classified as two pack products because the extremely moisture sensitive zinc metal powder used to pigment these paints is often packed separately to ensure it remains dry.

3. Two pack binders

These dry as a result of a chemical reaction between a base and a hardener. The resulting dry paint is quite different to either component and usually has much superior chemical resistance as the result of the considerable chemical cross-linking that occurs. Normally if either component is used alone it will produce a very poor result and in the case of epoxy bases may never dry. There is a large range of different categories into which two pack products can be placed. We will not dwell too long on these but will include basic details about each main type.

Two pack products

Two pack products are desirable where superior durability is needed because access for maintenance painting may be difficult.

- The base is usually pigmented and often tintable.
- The hardener does not necessarily harden the base but it chemically reacts with it to form a new highly cross-linked chemical. Some two packs have the hardener as the base.
- The mix ratio of the two components is critical.
- It is critical that the two components are thoroughly mixed together or there will be spots of unmixed base in the dried paint.
- Once mixed do not exceed the pot life. This will be shorter in hot conditions and longer in cold conditions.
- Dry time depends on temperature. At temperatures around 0°C no chemical reaction will occur. It will start up as temperatures rise.
- Avoid spraying products containing isocyanates if possible.
- Avoid water contamination of urethane hardeners, such as Resene Uracryl 400 Hardener.

- Clean equipment thoroughly after use or you may have to throw it away the next day.
- Two pack acrylic urethanes, such as Resene Uracryl 403, have excellent gloss and weathering properties.
- Two pack epoxies, such as Resene Armourcote 510, have excellent build, chemical resistance and barrier properties but chalk badly on exterior exposure.

Acrylic urethane binders

These types of paints are made using an acrylic base and a hardener containing isocyanate. The resultant paints have excellent gloss and gloss retention on exterior exposure, which is because of the excellent properties of the acrylic resin component. They have good solvent resistance and generally have good chemical and abrasion resistance. Recoatability may be difficult depending on the formulation. When spray applied there is a danger of free isocyanate in the air and full air fed respirators are recommended. The disadvantages of these products, and all other two pack products, are that they have a finite pot life. This may range from 1 - 8 hours depending on the product. At Resene we also have a polyester urethane, which has slightly improved chemical and solvent resistance but is more difficult to recoat.

Acrylic epoxy binders

These types of paints are made using an acrylic base and an epoxy containing hardener. The properties of these are slightly inferior to the acrylic urethanes but they have the advantage of being isocyanate free and can therefore be spray applied with significantly less potential danger to health.

Epoxy binders

These are made using an epoxy resin base and an amine or polyamine/amide hardener. The resultant paints are highly cross-linked and generally have excellent chemical and water barrier properties. The disadvantages are very poor chalk resistance when exposed to natural weathering. The hardeners are also very yellow toned, which makes the production of clean colours difficult.

Non-convertible binders

This is the category for all binders that do not change chemically as they dry. In this range lacquers and latex paints dominate. The advantage of these types of binders is that because they do not change chemically as they dry we know exactly what they will be like when dried for 1 day and after 10 years. Generally the better performing non-convertible binders are of high molecular weight, which gives them good toughness and durability without them having to chemically react further as convertible coatings do.

The high molecular weight also means that it will take a lot of strong solvent to dissolve these binders to a useable consistency. This results in these types of binders being low in solids content. This obviously makes the solventborne types quite unfriendly to the environment.

Their advantages are that they are always single pack, their physical properties will not change over time and they will always be easy to recoat (at least with themselves). Recoating is easy because the next coat simply dissolves the one underneath and they fuse together as if they had been arc welded together. Coat to coat adhesion (intercoat adhesion) is therefore generally excellent.

A good example of a non-convertible coating is Resene Swimming Pool Paint (see Data Sheet D69). This is based on a chlorinated rubber binder. Chlorinated just means that the resin is full of the chemical element chlorine. This does not give the resin super resistance to mould but imparts excellent water resistance. Typically Resene Swimming Pool Paint has a volume solids of approximately 30%. The reason it is so popular is that it is so simple to repaint and has excellent water barrier properties.

A major disadvantage of non-convertible binders is that they are thermoplastic. This means that they soften when heated and often have poor block resistance. They will also suffer if any grease or oil is deposited on them. They will absorb the contaminant and become soft in that area.

Non-convertible coatings obviously have poor solvent resistance but often have excellent chemical resistance.

Examples of non-convertible binders and Resene products made from them:

- Acrylic latex — Resene Hi-Glo, Sonyx 101, X-200
- Acrylic urethane latex — Resene Aquaclear
- Bitumen — Resene Blacktop
- Chlorinated rubber — Resene Swimming Pool Paint, Armourchlor HB-P
- Solution acrylic — Resene F.10 Glaze
- Vinyl acrylic — Resene Polymeric AV8
- Vinyl butyral — Resene Vinyl Etch Primer

Non-convertible binders may be divided into three main groups:

1. Lacquers.
2. Latex types.
3. Specialised latex types.

1. Lacquer binders

These dry by solvent evaporation. Once solvent has evaporated from the wet paint there is nothing else that needs to happen. Lacquers may be dissolved after they have dried and in theory you could make them up into the same wet paint again. Note that although lacquers may be redissolved in ‘a’ solvent they cannot be redissolved in all solvents.

A test for chlorinated rubber, for example, is that it dissolves readily in a strong aromatic solvent but is not affected by meths. Lacquers vary widely in type from the old nitro-cellulose types used for car paints to solutions of acrylic resin in aromatic solvent to solutions of very poor durability resins dissolved in turps that are chosen for products such as Resene Curecrete.

2. Latex type binders
These exist in a colloid form. (Milk is a well known colloid being made up of fine particles of fat suspended in water). Latex binders are made up of tiny particles of acrylic resin suspended in water. Latex binders dry by a complicated process called coalescence. The coalescing process needs to be understood because freshly applied latex paint may be totally ruined if applied in adverse weather conditions.

The process of latex paint coalescing
If enamel or two pack paints are applied in cold weather nothing happens. That is to say that the drying or curing process is simply postponed until the temperatures rise. Until this happens these coatings are obviously prone to physical damage by rain, dust or foot traffic etc. but if they survive these possible disasters and temperatures return to normal these paints will restart their drying process as if nothing had happened

This is not the case with latex paints. It is not so much the cold conditions that are the problem but the high level of moisture in the air that nearly always accompanies cold conditions. When there is a lot of water in the air the water in a latex paint cannot evaporate off. There is no room for it in the air.

The latex binder is made up of millions of tiny little spheres of solid acrylic resin suspended in water. Each particle is in the range of 0.1 to 1 μms depending on the type of latex.

Each individual latex particle is made up of a core containing long chains of carbon atoms up to 50,000 long. Each particle can also be imagined as being covered in tiny hair-like mini bumper bars, which act to keep each particle separated from its neighbour. These restrict the solids content for acrylic binders to a maximum of 60% and often much lower.

As water evaporates from the film the latex particles are deformed until they are pressed against each other. As this happens the coalescing solvent is left in close contact with the latex and acts to dissolve it and fuse it to its neighbours. As the last water leaves the film all air pockets are removed and a uniform film of paint is formed.

The last stage of the drying process is the fusing together of the latex particles and the evaporation of the last of the coalescing solvent.

Coalescing solvent
Unfortunately, there is another key player involved, the coalescing solvent. This is a vital part of the drying process for latex paints. The coalescing solvent is needed to soften the solid suspended acrylic binder particles in order for them to fuse or stick together in one unified mass.

The coalescing solvent is a lot slower to evaporate than water in normal conditions. Normally the water evaporates quickly and the drying paint becomes quite thick making it difficult for the coalescing solvent to escape. In cold conditions this is not the case. The paint remains quite liquid (because the water is not evaporating) and the coalescing solvent is given much more freedom with which to escape the paint film. There is never any coalescing solvent vapour in air (unless you live in a paint factory) so in time all the coalescing solvent will evaporate from the coating leaving the water behind. It may take about 3-5 hours for this to happen. As a result the latex particles are left surrounded by only water.

When the weather eventually warms up the water will evaporate leaving behind a poorly coalesced acrylic paint. The severity of this poor coalescence on the paint's physical properties varies depending on time and temperatures. The worst that may happen is that the paint dries as a powder. In real life this may not be the case and the actual result will be something in between a powder and a normal paint film.

The visible results may be a patchy appearance with possible loss of gloss and adhesion. The next rain may result in blistering or the entire coating may be washed off.

Drying mechanism of latex paint

Event	Time
Water evaporation	0 - 3 hours
Coalescing solvent left behind	0 - 3 hours
Resin particles move together	½ - 3 hours
Coalescing solvent softens resin	½ - 3 hours
Last water leaves film	1 - 6 hours
Resin particles fuse together	1 - 3 hours
Coalescing solvent leaves film	1 - 5 days
Glycols, leave film	0 - 5 days
Film fully dry	About 1 week
Resin properties remain stable	10 years **+**

3. Specialised latex binders

These are very much like the latex types described previously but are modified to give quite different performance in specialised areas. For example, they may be tailor made to have far superior flexibility or cure to a harder block resistant finish. These binders do not properly fit the non-convertible coating class but are very similar in most features to the latex binders.

Resene Broadwall Acrylic Wallboard Sealer (see Data Sheet D403) uses a polymer with a soft and a hard component. The soft part can bind together to form a film even at temperatures as low as 3°C, while the hard part contributes to good surface hardness and sanding properties. Resene Wintergrade Lumbersider (see Data Sheet D34a) and Wintergrade Hi-Glo (see Data Sheet D31a) use similar types of latex.

Resene Enamacryl (see Data Sheet D309) and Resene Lustacryl (see Data Sheet D310) also use the two component concept but it is developed further as the binder also has cross-linking properties, which slowly cure over a month to develop alkyd type solvent and stain resistance properties.

Resene Broadwall Surface Prep (see Data Sheet D807) uses a hybrid type of binder which is somewhere between a standard acrylic colloid (milk like) type binder and a solution type binder (the binder dissolved in solvent). This allows good pigment binding normally associated with soft binders combined with the excellent sanding properties of the very hardest binders.

The acrylic Resene Roadmarking Paint uses a binder, which has the ability to 'set' when exposed to air and become shower resistant even though it is still full of water.

Pigments

A pigment may be defined as a solid, insoluble, material that is added to a binder to produce colour, reduce gloss, provide physical properties (such as sandability), reduce permeability to moisture, produce texture or even act to prevent corrosion.

Pigments usually have a particle size of about 0.5 to 5 μms in standard paints but can be as small as 0.01 μms in the case of some bright organic pigments. In products such as Resene Resitex Coarse (see Data Sheet D70) the particle size may be measured in millimetres rather than μms.

Pigments may be classified into three main groups:

1. Prime pigments provide colour; either inorganic or organic.
2. Extender pigments control gloss level, texture, etc.
3. Anti-corrosive and special function pigments.

A good knowledge of pigments will help your overall understanding of how paints work, why some colours are better than others and why some colours are more expensive.

The quality of a paint is very much linked to the choice of pigment for that paint. For example red and yellow pigment prices can vary from $20 a kilogram up to $200. The lightfastness, or fade resistance, of these pigments generally improves as the price increases. A quality exterior red or yellow paint will just not be able to be made and sold at the same price as standard colours where the pigment may only cost $3 to $10 per kilogram.

1. Prime pigments - inorganic

The term prime means 'colour giving' when used with the word pigment. The term inorganic means the pigment is of mineral origin and inorganic prime pigments are usually metal oxides. They are called prime because the first use of paints was for decoration and colour was therefore of first (prime) importance.

Many metal oxides were found naturally, such as red and yellow iron oxides. Today most are made synthetically to get the cleanest colours possible. Titanium dioxide is the white pigment that colours just about everything we see that is white. This includes paper, plastics and paint.

Titanium dioxide

By far the most important pigment in use today is titanium dioxide. Titanium dioxide, as we use it in paint, first came into commercial production in 1941. Since then its sales have climbed and its superb properties have seen it established as being far superior to any other white pigment. It has had no rivals since the banning of white lead in the early 1970's. Any white paint, plastic or paper you see will contain titanium dioxide. Today it has been refined to such an extent that you can get it in a wide range of 'flavours' depending on whether you wish to have a paint with minimum chalking or maximum gloss or whatever. What grade is chosen depends on the skill of the humble Designer Paint Chemist. Although titanium dioxide is far ahead of any other white pigment for hiding power it is still relatively poor compared to most other inorganic pigments.

Main types of inorganic pigments:

- **White:** Titanium dioxide. Comes in two forms anatase and rutile. The anatase is seldom used in paint because it chalks dramatically on exterior exposure.
- **Red:** Red iron oxide. This is the colour seen on old farm barns throughout the country. Comes in differing shades, which are determined by the pigment particle size.
- **Yellow ochre:** A yellow form of iron oxide.
- **Mixed metal oxide yellow:** A whitish shade of clean yellow. This pigment has excellent fade resistance but is very pale in colour.
- **Green:** Chrome oxide.

Main properties of inorganic pigments:

- Excellent opacity or hiding power.
- Excellent lightfastness or resistance to fading.
- Relatively inexpensive and easy to mix into paint millbases.
- Colours are generally dirty in tone.
- There are bright clean inorganic red, orange and yellow pigments but these have mostly slipped into obsolescence because of their toxicity. These include lead chromate type pigments, cadmium and selenium based pigments and of course white lead and red lead.
- Quite dense pigments and will tend to settle out unless precautions are taken.
- Relatively heat stable and chemical resistant.
- Largish particle size of 0.3 to 1 μms.

- Durability depends on the type of chemical treatment these pigments are given during manufacture.

2. Prime pigments organic

The term organic means that the pigment is based on the chemical element carbon. It was once thought that all organic chemicals could only be obtained from living things and hence the name. Today there are millions of different organic chemicals most of which may be produced synthetically without the need to source raw materials from living things. Most organic pigments are not naturally occurring and are made from petroleum by-products in very complicated chemical processes by clever chemists. Organic pigments are the brightly coloured ones used for the clean colours red, yellow, bright green and blue, purple and magenta.

Organic pigments have really sprung into prominence in the last 10-20 years for two main reasons:

1. The awareness of the dangers of lead in the older bright red and yellow lead chromate type pigments meant that these pigments had to be replaced.
2. The advancing technology in manufacturing and chemical engineering in the organic pigment industry.

Main types of organic pigments:

- **Black:** A form of carbon that resembles the soot in your granny's old chimney. Surprisingly comes in quite a range of shades that may be clearly seen when it is reduced with white. Extremely good hiding power and lightfastness.
- **Bright yellow:** Dozens of different yellows exist. Most have very poor hiding and tinting power and are not very lightfast.
- **Blue:** Most durable blue organic pigments have a little bit of copper chemically bound into the pigment to help them. Good lightfastness and excellent tinting strength.
- **Green:** There are yellow and blue shades available. Good lightfastness and tint strength.
- **Orange:** Orange organic pigments are generally very poor in hiding power and very poor in lightfastness. Very expensive.
- **Violet:** Any decent grades are extremely expensive and even then are of average lightfastness.
- **Magenta:** Very expensive if any good. Very poor tint strength and poor hiding power. Good lightfastness.

Characteristics of organic pigments:

- Available in bright vivid colours to match all shades of the rainbow.
- Generally at least 10 times as expensive as the closest inorganic pigment.
- Very difficult to get clean reds and yellows with good opacity and good exterior lightfastness. These properties are available in pigments that typically cost about $200 per kilogram.
- Often these pigments are very difficult to grind into paint millbases.
- Pigments are generally low in density and not prone to settling out.

- Organic pigments often have a very high oil absorption or demand for binder. This means that in many paints only so much pigment may be added until the paint becomes low in gloss and very thick. This results in paints with poor opacity.
- Low density and may tend to float to top of paint.
- Excellent to very poor hiding power.
- Excellent to very poor lightfastness.
- Colours are usually very bright and clean toned (apart from black).
- Poor hiding power means that many organic pigments have transparency properties. This makes them ideal for automotive type metallic finishes when they are used to tint aluminium flake containing bases.
- Generally the pigment particle size is very small 0.01 to 0.1 μms. This makes handling in the factory difficult as spilling just a few grams may contaminate a large area. Some of these pigments are more like gases to handle than powders.
- Often not heat stable.

3. Extender pigments

Extender pigments are usually naturally occurring minerals, such as clay, mica, talc, and limestone (or marble or whiting or calcite (all forms of calcium carbonate), and were often used as a cheap way of reducing the cost of a can of paint. Adding extra volume or weight of a cheap extender pigment (extender pigments usually cost under $1/kg) allowed savings to be made on expensive binders and prime pigments (inorganic pigments cost 5-10 times this and organic pigments 50-100 times this). This tool was particularly useful when paint was sold by the pound or kilogram rather than by a volume basis. If we wished to cheapen a paint today we would normally do it by adding extra thickener and solvent or water. The term extender does not really convey a true meaning of the purpose of the non colouring pigments used in modern paints but is still used to describe them.

Characteristics of some extender pigments

- **Talc:** This is a very slippery mineral and is used to give paint good sanding properties.
- **Talc and mica:** These extenders are platelike in shape and are used to give barrier properties to the paint. They spread out and prevent moisture travelling through the paint.
- **Calcium carbonate:** Also known as whiting, limestone, chalk or even as marble dust. This may be used for a variety of purposes from creating a very rough finish in texture coatings to being used to help flatten the gloss of semi-gloss and low sheen paints. Usually a very cheap pigment.
- **Silica:** Silica comes in a number of different forms but is generally best known as a flatting pigment. Synthetically produced precipitated silicas are very clean in colour and are used (along with waxes) to produce satin and flat clear varnishes. Coarse silica sands may be used to give non slip properties and extra hardness to paint. Flat waterborne paints are usually flattened using diatomaceous earth. This material is made from the skeletons of tiny sea creatures deposited on the ocean floor millions of years ago.

- **Clays:** Clays are used to give paint some extra body and can help to prevent settling. Specially modified clays are often used as the main means of thickening solventborne paints.
- **Barytes:** This is an extremely hard dense pigment that is good for abrasion resistance.

4. Anti-corrosive pigments

Anti-corrosive pigments, such as zinc chromate, red lead, zinc phosphate and zinc metal, are used in paints to help prevent metals from rusting. Red lead is now almost obsolete but is still present on many structures around the country. They work in three basic ways.

- **Traditional anti-corrosive pigments,** such as zinc chromate, work by chemically or electrically interfering with the process of rusting. We will not delve into the chemistry of this process in this paper.
- **Metallic zinc pigments** work by sacrificing themselves for the steel in the corrosion process. As the zinc sacrifices itself zinc corrosion products are formed, which are commonly referred to as white rust. These types of priming paints are sometimes referred to as cold galv. This is a reference to galvanised iron, which is steel coated with zinc. By dipping it into hot molten zinc metal zinc rich paints achieve a similar end result but no heat is involved.
- **Barrier pigments** are used in high build paints and the idea is that they provide a physical barrier to any water and oxygen that tries to wriggle through the paint film. If a steel surface can be starved of water and/or oxygen no corrosion can take place. Barrier pigments are platelike in structure. Typical examples are leafing aluminium flakes, glass flake and micaceous iron oxide. The extender pigments talc and mica also act as barrier pigments because of their platelike structure.

5. Special purpose pigments

We will not dwell on these for long but you always need an extra category for the bits and pieces. You should be aware that special pigments, such as copper, may be used in anti-fouling paints for ships.

Another oddball area for speciality pigments is in intumescent coatings. These pigments break down when heated and initiate chemical reactions that eventually result in the formation of a thick skeleton of carbon about 50-100 times the original paint thickness. This skeleton forms a physical barrier, which saves the substrate from burning for long enough for people to escape from a fire.

Other special pigments are the non leafing aluminium flake pigments and the special effect, iridescent, pearl afflair pigments used in automotive finishes.

Solvents

Solvents are liquids that can dissolve other substances in the same way you dissolve sugar into your cup of tea. The dissolved material may be reclaimed from a solution in the solvent by evaporating the solvent off. Water, surprisingly, is the most powerful solvent known to exist. It can dissolve more materials than any other liquid we know of. When we speak about solvents in paint however, we are really excluding water and referring to the organic solvents.

Organic solvents are best known for their role as thinners for paints but also play important roles in a wide range of other industries, such as plastics, footwear, dry cleaning, building, photographic, adhesives, printing inks and even haircare products.

Organic solvents may be broken into three main categories.

- Hydrocarbon solvents.
- Oxygenated solvents.
- Others, such as chlorinated solvents.

Solvents have a wide variety of roles to play in wet paint. Their most basic job is to make the paint easy to apply. There are other important functions of solvents such as their role as coalescing solvents in waterborne paints as discussed earlier.

Hydrocarbon solvents

Hydrocarbon solvents are made from the chemical elements carbon and hydrogen alone and include the famous solvents; kerosene, turps, xylol. Petrol is also a hydrocarbon solvent but is used as a fuel. Typically these types of solvents are relatively cheap compared to the oxygenated types and find use in thinners for the common alkyd enamel or solventborne paints. Hydrocarbon solvents are often a blend of different solvents. Their solvency (power in thinning paint) is related to how much aromatic type of solvent they contain. Aromatic solvents are based on a chemical called benzene. Aromatic solvents are in fact quite the opposite and are not at all nice to sniff. Xylol and toluol fit into this group. Hydrocarbon solvents are generally good solvents for grease and oil.

Oxygenated solvents

Oxygenated solvents were often known in the early days as chemical solvents because they required complicated chemical reactions to make them whereas other solvents were simply the result of distilling and refining oil. This still applies but many hydrocarbon solvents are also made synthetically today. Oxygenated solvents are often very similar in composition to hydrocarbon solvents but always contain oxygen.

Well-known oxygenated solvents are ethyl alcohol, acetone, ether, methyl ethyl ketone (MEK) and butyl acetate. These solvents are typically used in nitro-cellulose paints, nail lacquer remover, gin and specialised two pack paints. They can mostly be distinguished from hydrocarbon solvents because of their distinctive, often fruity, smells. This can range from very sweet (acetates) to quite foul (butyl alcohol).

Chlorinated solvents

We will not dwell on these but they used to be very popular in the area of use as paint strippers. Chlorinated solvents, such as methylene chloride, have been found to be carcinogenic and are seldom used:

Due to the hazards of working with solventborne paints, it is recommended that solvent rich paints be substituted with Environmental Choice approved products where possible.

Solvency

In paint terms solvency describes the power of a solvent in dissolving or thinning a particular type of binder. A solvent that works well with one binder may be completely inadequate with another. For example, xylol is an excellent, powerful solvent to use to thin or clean up spills of alkyd enamel type paints but it is quite useless for nitro-cellulose lacquers. When thinning alkyd enamel paints kerosene has quite poor solvency, turps is better and toluol is excellent.

Evaporation rate

The rate at which a solvent evaporates is very important when it is used in paints and adhesives. Slow evaporating solvents, such as kerosene for some types of alkyd paints and propylene glycol for latex paints, are needed for good brushing properties. These types of solvents keep the paint wet and fluid longer and allow painters to maintain what we refer to as a good wet edge.

Resene Hot Weather Additive is available to help keep a good wet edge in hot weather and is recommended for exterior waterborne paints, such as Resene Hi-Glo (see Data Sheet D31) and Resene Enamacryl (see Data Sheet D309).

Spraying thinners

For spray applied paint the solvent needs to be fast evaporating so the paint will not run off the wall. The blend of solvents used in these types of paints is also critical. Spraying thinners need to be designed so that the last solvent to evaporate from the paint surface after spray application is one with high solvency for the binder in that paint. If this is not the case there could be serious gloss problems. The use of excessively fast evaporating solvent when spraying paints may result in dry spray or solvent popping or bubbling.

Thickeners

One of the most interesting misconceptions about paint and quality is the perception by many painters that the thicker a paint is, the better the quality. The exact opposite may be the case, especially if a large volume of thinner is needed to get the paint to a useable consistency.

Be aware that there is nothing natural about the thickness of a paint. All paint is artificially thickened and we can make most paints as thick or as thin as we like. You should be aware that the thickeners used to thicken paint also control other paint properties and that if paint is thinned more than a few percent these properties may be compromised.

Thick does not necessarily mean high quality. Cheaper paints are often disguised by making them thicker than necessary.

Paint thickeners have two main roles:

- Prevent the paint solids from settling out in storage and to prevent the paint from sagging during application. The use of too much will result in poor flow and the paint being full of brush marks.
- Make the paint harder to spread and to impart what we call brush drag. In enamel paints this property is often built into the particular binder rather than being given by a special thickener. This allows the painter to apply the correct amount of paint by applying the paint at a natural spreading rate. These thickeners also act to minimise roller fly off (paint spattering everywhere when roller applied).

Waterborne paints use special thickeners called rheology modifiers, which give excellent flow and levelling and also impart brush drag.

When thinners are added to paint the carefully engineered designer flow properties may be lost and the paint may run off the wall. Enamel paints in particular are very sensitive to thinning.

Other additives

Paints, unfortunately and unavoidably, are invariably loaded with what we can call **gunge** or other additives. Gunge is an appropriate term because it confers the impression of unwanted. Gunge is an acronym for **G**enerally **U**nacceptable **N**asty **G**ooey **E**ngredients-(or to correct the spelling of the initiator of this term ingredients). Gunge describes all the ingredients we have to reluctantly add to paint that do not improve the durability of the paint but are required for mainly cosmetic purposes.

Some additives are of technical assistance to the applied paint and assist in the overall durability of the paint. Most additives are a nuisance and we would rather not have them. Often they are there because we have too much of another ingredient. For example we need to add defoamers to waterborne paints because of the large amounts of wetting agents (soap or detergent type chemicals) needed to make a tinting system work.

Types of additives used are:

- Anti-skinning agents for alkyd type paints only.
- Deodorants.
- Driers for alkyd type paints only. We do not have driers for latex paints.
- Fungicides.
- Moisture scavengers.
- Silicones and waxes for mar resistance and slipperiness.
- UV absorbers.

Wetting and dispersing agents

Wetting agents and dispersing agents are essential for getting pigments into paints. They are related to the detergents used for washing dishes and act to wet the pigments and allow them to be more easily dispersed into paint.

They are more often needed in latex type paints than in solventborne paints where the binder may often do a very good pigment wetting job. Latex binders are generally not suitable for grinding pigments into because of their colloid structure. They tend to become extremely aerated and may gel if subjected to too much mechanical stress, such as is needed to disperse pigments.

Organic pigments, in particular, may be very difficult to grind up into paint and need quite specialised, individually tailored, wetting and dispersing agents to achieve this.

Our architectural tinters are loaded with wetting agents. Not only are they needed to wet the pigments in the tinter, but a lot of extra wetting agent is also needed to allow the tinters to be added to both solventborne and waterborne paints. The level of these machine tinters in our paint should be kept as low as practicable. The presence of glycols, wetting agents and surfactants in our latex roof paints is the reason we recommend that roofs used for collecting drinking water are disconnected for the first few rains. We don't think these materials are dangerously poisonous but they tend to make water foamy and give a slightly unpleasant taste.

Defoamers

You may not be surprised to know that the addition of wetting agents to waterborne paints tends to make them foamy. We therefore add even more gunge in the form of defoamers and anti foam chemicals to restore the balance.

Anti-skinning agent

An important additive for enamel paints is the anti-skinning agent. Without this ingredient all enamel paints would skin in the can. Note that excessive stirring of alkyd paints or leaving lids improperly sealed may result in permanent loss of the volatile anti-skinning agent. Never shake up old cans of enamel paint that have been in storage. In most cases skins can be removed by carefully cutting away from the top of the paint layer. If planning to store a can of enamel that is less than half full either decant it into a smaller can or place a layer of greaseproof paper on top of the paint.

Driers

Alkyd enamel paints require driers to catalyse the drying of the alkyd resin. These driers are salts of the metals cobalt, manganese, calcium, zinc, zirconium and a few other metals. Contrary to some opinions the levels of these driers in our paints has been pretty well optimised. There is a level at which they will work best and more is not better - more can in many cases actually spoil the dry or even cause the paint to wrinkle. We advise against adding extra paint driers to our paints. Specialised blends of driers for enamel paints are called terebine.

Other 'other additives'

Other additives that may be used in paints are:

- Silicones and waxes to give slipperiness and mar resistance.
- Fungicides.
- UV absorbers.
- Special accelerators for two pack products.
- Additives to prevent in can corrosion.
- Deodorants to mask nasty odours.
- Moisture scavenging additives to prevent certain paints gelling or gassing.

Paint film measurement

The thickness of dry paint films is usually measured in units of length called '*microns'.* In reports and data sheets the word '*micrometre*' may be substituted for micron or it may be abbreviated to '**μm**'. It is important for you to realise just how small a micron is.

- 1 μm is equal to 1 millionth of a metre.
- There are 1000 μms in a millimetre. 1 millimetre = 1 mm.
- There are 10 millimetres in a centimetre.
- 1 millimetre is the smallest division on normal metre rulers.
- 1 μm = 1 micron. 1 μm = 1 micrometre.
- 1 inch = 25,400 μms.
- This paper is about 60 μms thick. A human hair is about 50-60 μms thick.
- A normal coat of Resene Hi-Glo applied at 12 square metres per litre will give a dry film build of 35 μms. If you have a 1mm crack in a concrete wall it would take about 28 coats of standard Resene Hi-Glo to bridge the gap.
- Some people make measurements in units called 'thous' or mils.
- A thou is equal to 1 thousandth of an inch. 1 thou = 25 μms = 1 mil.

Summary

Paint raw materials are made up of the binder, pigments, solvents, thickeners and other additives. The paint's critical properties are nearly always determined by the properties of the binder used.

The common **binders** used in most Resene architectural paints are either an alkyd resin or an acrylic latex. The main differences between these binders are:

Property	Alkyd	Acrylic
Alkali resistance	Poor	Excellent
Block resistance	Very good	Poor
Dry time	Slow	Fast
Exterior durability	Average	Excellent
Flexibility	Embrittles with age	No change with age
Solvent content	High	Low
Yellowing	Poor	Good

There are thousands of different types of alkyd and acrylic binders available on the world market. Quality manufacturers, such as Resene, choose only high quality binders that are tailor made for the product's end use.

Prime pigments

Prime pigments are used to colour paint. They are either inorganic, such as metal oxides like red iron oxide, or organic - made synthetically from carbon as the building block. Inorganic pigments generally give paints excellent opacity and fade resistance. They are generally much cheaper than organic pigments and tend to be quite dull in colour. Brightly coloured red and yellow lead based inorganic pigments may still be used in automotive paints.

Prime organic pigments

Prime organic pigments are often very difficult to grind into paint and often give poor opacity. Durable reds and yellows are extremely expensive and quite poor in opacity.

Extender pigments

Extender pigments are usually very cheap but serve useful functions in controlling gloss level, may aid sanding and help to body up a paint,

Anti-corrosive pigments

Anti-corrosive pigments, such as zinc chromate, act to prevent metal from corroding by working to chemically resist the corrosion process , working in a sacrificial manner (e.g. zinc metal powder) or acting as a physical barrier (e.g. aluminium flake).

Solvents

Solvents in a paint need to have the correct solvency for the binder used and the right rate of evaporation to suit application. Slow evaporating solvents such as kerosene in enamel paints and glycol in water based paints help keep a good wet edge when brushing. It is very important to use the correct thinner for any paint.

Thickeners

All paints are artificially thickened. The thickness (or high viscosity) of a paint is not a measure of paint quality.

Other ingredients

The other ingredients in paint such as wetting agents, driers, defoamers, etc., are generally not desirable for durability and quality paints will have minimal quantities of them.