

Fluid Types: Paints and Other Coatings

Concept and Theory Training



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Introduction

Welcome to *Fluid Types: Paints and Other Coatings*, a learning module in Graco's concept and theory sales training series. Your understanding of the information in this module provides the basis for further study on specific Graco products. Your ability to successfully promote and sell Graco products depends in part on how well you learn the basics and then apply this knowledge to addressing your customers' needs.

While this curriculum best fits the requirements of Graco and distributor sales people, it will also benefit anyone whose job function depends on knowledge of Graco's products.

Overview

Graco and distributor sales people must understand terms and concepts related to paints and other coatings, the class of fluids most commonly moved by Graco products. This module, *Fluid Types: Paints and Other Coatings*, introduces those basic terms and concepts and shows how they relate to the day-to-day world of Graco product specification and sales.

How to Use this Module

The basic concept and theory curriculum consists of a series of self-study modules. As the term self-study implies, you work through the materials on your own at a comfortable pace. Plan sufficient time (approximately 30 minutes) to complete at least one section of a module in a working session.

This module combines a variety of features to make the learning process convenient and productive:

- Learning objectives
- Text
- Charts, illustrations
- Progress checks
- Additional resources

Learning Objectives

Each section of material offers a set of learning objectives. Read the objectives and use them to guide you to the most important concepts. After you finish each section and before you complete the progress check, reread the objectives to confirm that you understand the key concepts.

Text

Definitions, examples, and explanations comprise the learning module text. Read it carefully and return for review if necessary.

Charts, Illustrations

An important element of any instruction is visualizing the concepts. This module contains graphics and illustrations to enhance the text material. Where appropriate, the module also contains charts that help you organize or summarize information.

Progress Checks

Progress checks are self-tests that provide reinforcement and confirm your understanding of important topics. After completing each section of the module, return to review the objectives, and then work through each of the progress check items. Upon completion, check your answers against those provided. If you answered any incorrectly, return to the text and reread the pertinent information.

Additional Resources

This module may refer you to other documents or sources that expand on the concepts covered in the module. The reference will include the name of the source and how you can obtain it.

The Basic Components of All Coatings

Learning Objectives

To help your customers choose Graco products that will effectively move and apply paints and other coatings, you must understand how those coatings are formulated. This section explains the basic composition of all coatings and shows how the components of coatings interact. After completing this section, you will be able to:

- List the four basic components of all paints and coatings.
- Explain the function of each component and how the components interact to form a useful coating.
- Explain the differences among common sub-types of each component.
- Explain some key factors considered by coating manufacturers when they formulate each component.
- Define and use correctly many terms relevant to coating technology.

Four Components

Virtually every coating contains four basic components:

- *Binder, resin, or polymer*, which holds together the other components prior to application and whose molecules bond to form a hard film that protects the *substrate*, the surface to which the coating is applied.
- *Pigment*, which hides the substrate, provides decorative color, and also may enhance desired properties of the coating, such as corrosion resistance.
- *Solvent*, which adjusts the viscosity of the binder to allow efficient flow and application as well as some desired characteristics of the cured film.
- *Additives*, which change the formulation in one or more ways.

Following is more detailed information on the four basic components of coatings.

Binder, Resin, or Polymer

The binder, resin, or polymer serves two essential purposes in a coating. As the name *binder* suggests, the first purpose is to hold the other components together prior to application of the coating. Then, during the *curing process*, which may be achieved by heating, radiation, or a chemical reaction, the binder's molecules join to form the hard protective film that protects the surface onto which the coating has been applied. This surface is often called the *substrate*.

For thousands of years, oils derived directly from plants, such as linseed oil and tung oil, have been used as binders. The word, “resin,” refers to the gritty, resinous quality of these materials in their unrefined state. But since the early twentieth century, synthetic binders have steadily replaced these oils. The synthetic binders can be formulated to have a variety of desired properties, including faster drying and greater durability of the cured coating. In the most technical and formal sense, all binders are also polymers (discussed later in this module). But today, usage in the coating industry is varied. Some people use “resin” to refer only to oil binders, and “polymer” to refer only to synthetic binders. But other people use all of these terms interchangeably.

The word, “polymer,” is formed from two Greek words: *poly* (many) and *meros* (parts). This derivation suggests both the structure and function of a polymer: Its molecules consist of one or more relatively simple molecular units—called *monomers* (*mono* means “single” in Greek)—linked any number of times in repeating chains to form very large molecules. The process of forming such large molecules is called *polymerization*. In some coatings, the molecules are already polymerized prior to curing; in others, polymerization occurs during curing. In another aspect of the curing process, additional chemical bonds are formed between adjacent large molecules; this process is called *cross-linking*. Polymerization and cross-linking are responsible for the hard, continuous surface that makes coatings so useful.

Convertible Binders

Binders are categorized as to whether their molecules are polymerized prior to or after application. A *convertible binder* is in an unpolymerized or partially polymerized state prior to application. The convertible binder undergoes polymerization after application to form the cured coating. Examples include:

- Alkyd resin—the most commonly used binder for many years
- Oils, such as linseed oil and tung oil
- Amino resin
- Epoxy resin
- Phenolic resin
- Polyurethane resin
- Silicone resin

Non-convertible Binders

The other type, the *non-convertible binder*, is polymerized prior to application but is mixed with or dissolved in a medium that evaporates after the coating has been applied, leaving a continuous film. Such a mixture or solution of binder and medium is called a *vehicle*. Examples of non-convertible binders are:

- Cellulose resin
- Chlorinated rubber resin
- Acrylic resin
- Vinyl resin

Pigment

The *pigment* in a paint is composed of solid particles of uniform and controlled size that are permanently insoluble in the vehicle or binder of the coating. The purpose of the pigment is to hide the substrate, provide decorative color, and in some cases also to enhance desired properties of the coating, such as corrosion resistance or mar resistance.

Pigment Volume Concentration

One very important factor in pigment dispersion is the *pigment volume concentration* (PVC). Another name for PVC is pigment-to-binder ratio or *P to B ratio*. The PVC is defined as the volume percent of the cured film that is actually pigment, as opposed to binder or additives. When the pigment particles are in contact with each other in the vehicle, the concentration is referred to as the Critical Pigment Volume Content (CPVC). The PVC in various coatings ranges from zero percent in unpigmented films to over 90 percent in zinc-rich primers.

Pigment Types

Literally thousands of different pigments are used by coating manufacturers. However, all pigments fall into these general categories:

- Colored pigments
 - Natural pigments, such as red iron oxide and brown iron oxide
 - Synthetic pigments, of which there are many types
- White pigments, such as titanium dioxide and zinc oxide
- Metallic powders, such as powdered aluminum and zinc
- Functional pigments that provide corrosion resistance, slip resistance, or other desired properties

Solids

You will often hear coating industry people speak of the *solids* content of a coating. This term is used to refer to slightly different aspects of a coating, depending on whether the coating is in the as-supplied condition or has already cured.

Solids in the as-supplied coating

In many coating formulations, the binder and pigments comprise the solids component of the fluid. In other formulations, the binder is dissolved in the solvent prior to application; in that case, the binder is not considered part of the solids component prior to application. Some additives will be included in the total solids content of a coating, but when solid additives are present, they make up only a small percentage of total solids.

Solids in the cured coating

After all solvents have evaporated and the coating has cured, “solids” refers to the sum total of the components that remain as the hardened coating.

Solvent

The job of the solvent is to reduce the viscosity of the binder. This enhances flow characteristics and application, and maximizes the uniformity of the coating.

In the coating industry, the word, “solvent,” is used in several different—and sometimes ambiguous—ways. In the most formal sense, a solvent is any liquid that can dissolve some other substance. For example, water is a solvent for sugar. But in many coating formulations, a chemical referred to loosely as a solvent may not be dissolving anything. Instead it may simply dilute or thin the formulation.

Volatile Organic Compounds

The word “solvent” is often loosely equated with the term, *volatile organic compound*, commonly abbreviated VOC. VOC’s create air pollution problems when they evaporate into the air. The amount of VOC’s allowed in materials is specified and limited in many parts of the world.

Solvents, VOC's, and Water-borne Coatings

In water-borne coatings (discussed in detail later in this module; you may also hear them referred to as “water-based” but this is incorrect usage), water is the primary solvent—but not the only solvent. Most water-borne coatings also contain VOC's, but in smaller amounts than in conventional “solvent-borne” coatings. VOC's in water-borne coatings are called *co-solvents*. They function as intermediaries, allowing water and polymers that otherwise would not mix to co-exist in a mixture called a dispersion.

In spite of the fact that water-borne coatings contain VOC's, you will often hear people make a distinction between water-borne coatings and “solvent-borne.” In these cases, “solvent-borne” is being used to refer to coatings in which the primary solvents are VOC's.

Why Do You Need Multiple Solvents?

Many kinds of solvents are used in coatings. In fact, usually there are several solvents in one coating formula. One reason for this is that there is no such thing as a “universal solvent”—a fluid that can dissolve anything. Thus, a given fluid may reduce the viscosity of one binder, but may have no effect on another binder. And since a given coating may contain several binder components, several solvents may be necessary—each one to reduce a specific binder or binders. Also, various solvents may be chosen because they have varying evaporation rates. This reduces stresses on the coating during curing, leading to a more uniform, more highly protective coating.

Categorizing Solvents According to Their Effects on Binders

Solvents are categorized according to the effect they have on a given binder. There are three categories:

- An *active solvent* dissolves the binder and rapidly reduces viscosity.

The next two types work in combination with an active solvent, but have opposite effects on it:

- A *diluent*, when added with an active solvent, extends a solution and also weakens the solvency power of the active solvent.
- A *thinner*, when added with an active solvent, extends a solution but does **not** weaken the solvency power of the active solvent.

Solvent Choice Affected By Intended Application Method

One important factor considered by chemists when they are choosing solvents is the method to be used in applying a coating. For example, for a coating that will be sprayed, a chemist chooses a fast-evaporating solvent. During application, such a solvent will evaporate quickly enough to prevent running or sagging of the coating film. On the other hand, brush-applied coatings require slow-evaporating solvents to avoid premature curing and to allow enough flow so that brush and lap marks are minimized.

Additives

In general, manufacturers put *additives* into coatings to perform one or more of these tasks:

- Aid during manufacturing
- Enhance application characteristics
- Enhance properties of the cured coating

Usually the volume of additives is less than two percent, yet the additives profoundly affect the coating. Surfactants (a contraction of surface-active agent) are additives that affect the coating in one or more ways, including:

- Maximize adherence to the substrate
- Disperse the pigment evenly
- Stabilize an emulsion
- Prevent sagging of a newly applied coating
- Flatten the finish—that is, reduce gloss

Other types of additives include anti-foaming agents, UV (ultra-violet) stabilizers that protect the cured coating from ultra-violet light, and fire-retardants.

Progress Check

Directions: After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

For items 1 through 4, match the terms with their definitions:

Terms

- a. Binder, Resin, or Polymer
- b. Solvent
- c. Pigment
- d. Additives

Definitions

- ___ 1. Hides the substrate, provides decorative color, and in some cases also enhances desired properties of the coating, such as corrosion resistance.
 - ___ 2. Aid during manufacturing, enhance application characteristics, and/or enhance properties of the cured coating.
 - ___ 3. Holds the other components together prior to application and, after application, forms the hard protective film that protects the substrate.
 - ___ 4. Reduces the viscosity of the binder.
5. Synthetic polymers have replaced natural oils because polymers are more environmentally friendly.
- a. True
 - b. False
6. The process of joining monomers into large molecules is called _____, while the process of joining one large molecule to an adjacent large molecule is called _____.

For items 7 through 11, match the terms with their definitions:

Terms

- a. Convertible binder
- b. Active solvent
- c. Non-convertible binder
- d. Diluent
- e. Thinner

Definitions

- ___ 7. A fluid that, as a component of a coating formulation, extends the solution but does not weaken the solvency power of an active solvent that is also a component.
 - ___ 8. A binder that is in an unpolymerized or partially polymerized state prior to application.
 - ___ 9. A fluid that, as a component of a coating formulation, extends the solution and weakens the solvency power of an active solvent that is also a component.
 - ___ 10. A fluid that, as a component of a coating formulation, dissolves the binder and rapidly reduces viscosity.
 - ___ 11. A binder that is polymerized prior to application but is mixed with or dissolved in a medium that evaporates after the coating has been applied.
12. Write out the full name for each of these abbreviations:
- PVC _____
 - P to B Ratio _____
 - VOC _____
13. Name three common types of additives:
- _____
 - _____
 - _____

Answers to Progress Check

1. c. **Pigment** hides the substrate, provides decorative color, and in some cases also enhances desired properties of the coating, such as corrosion resistance.
2. d. **Additives** aid during manufacturing, enhance application characteristics, and/or enhance properties of the cured coating.
3. a. **Binder, Resin, or polymer** holds the other components together prior to application and, after application, forms the hard protective film that protects the substrate.
4. b. **Solvent** reduces the viscosity of the binder.
5. **False** Synthetic polymers have replaced natural oils because polymers can be formulated to do a better job than natural oil-based coatings.
6. The process of joining monomers into large molecules is called **polymerization**, while the process of joining one large molecule to an adjacent large molecule is called **cross-linking**.
7. e. A **thinner** is a fluid that, as a component of a coating formulation, extends the solution but does not weaken the solvency power of an active solvent that is also a component.
8. a. A **convertible** binder is one that is in an unpolymerized or partially polymerized state prior to application.
9. d. A **diluent** is a fluid that, as a component of a coating formulation, extends the solution and weakens the solvency power of an active solvent that is also a component.
10. b. An **active solvent** is a fluid that, as a component of a coating formulation, dissolves the binder and rapidly reduces viscosity.
11. c. A **non-convertible** binder is one that is polymerized prior to application but is mixed with or dissolved in a medium that evaporates after the coating has been applied.
12. PVC = pigment volume concentration
P to B Ratio = pigment to binder ratio
VOC = volatile organic compound
13. Acceptable answers: Surfactants, anti-foaming agents, UV (ultra-violet) stabilizers, and fire-retardants. Also acceptable as sub-types in the surfactant category are: stabilizers, anti-sag additives, and flatteners.

The Six Basic Curing Systems

Learning Objectives

Thousands of specific brands and types of coatings are in use. But all of these can be categorized into just six groups according to the curing method employed. This section gives you the basic characteristics of the six curing systems used in all coatings. After completing this section, you will be able to:

- Explain how each of the six basic curing systems works.
- Compare and contrast the six systems.
- State typical examples of each curing system.

Six major curing systems are used in virtually all coatings:

- Solvent loss
- Chemical reaction
- Air reaction
- Emulsion drying
- Radiation curing (also called UV curing)
- Polyurethanes

Following are brief discussions of each of these systems:

Solvent Loss

Coating manufacturers supply solvent-loss coatings with the polymers dissolved in solvents. Curing consists of evaporation of the solvent while the binders come out of solution to form the cured film. Curing may be by air drying at ambient temperature or the solvent may be evaporated faster by heating. Examples include acrylic lacquers, alkyd baking enamels, water-borne paints.

Water-borne Coatings: a Special Solvent-loss Class

Water-borne coatings are a special class of solvent-loss coating, wherein the major (but not the only) solvent is water. Water-borne coatings are covered in more detail later in this module.

Chemical Reaction

As with solvent-loss coatings, coating manufacturers supply chemical-reaction coatings with the binders dissolved in solvents. In the curing process of a chemical reaction coating, which may be initiated by heat or contact with moisture, the binders react with each other to form a three-dimensionally cross-linked film. Heat also may serve to evaporate the solvents faster. After curing, the coating will not dissolve or soften with application of heat; coatings of this type are called *thermosetting*. Chemical-reaction coatings are used in most industrial applications, including the automotive industry. Examples include urethane top coats and epoxy primers.

Air Reaction

Air-reaction coatings often contain highly viscous oil-type binders, such as linseed oil. This makes it necessary to include solvents in the formulation to decrease viscosity during application. In the curing process, these coatings react with oxygen in the air to form a cross-linked film. The solvents evaporate quickly leaving a coating that is dry to the touch. But cross-linking may go on for several weeks. Examples include enamels and alkyd baking primers.

Air-reaction Versus Solvent-loss

The difference between solvent-loss and air-reaction systems is that a solvent-loss coating cures *in* the air but does not react chemically with the air, while an air- reaction coating cures in a chemical reaction *with* the oxygen in the air.

Emulsion Drying

Coating manufacturers supply these coatings with the binder and solvent in an emulsified mixture. During the curing process, the solvents evaporate and the binder and particles of pigment form a continuous film. Solvents may be either water or organic compounds. An example of an emulsion-drying coating is latex paint.

Emulsion-drying Versus Air-drying

The difference between emulsion-drying and air-reaction coatings is simply that, in emulsion-drying coatings, the binder and solvent are an emulsion, while in air- reaction coatings, the binder is dissolved in the solvent.

Radiation Curing; also called UV (Ultraviolet) Curing

Coating manufacturers supply radiation-curing coatings as low-molecular weight binders in diluents. Curing is accomplished by exposing the applied coating to either UV, electron beam, or gamma ray radiation. The result is a highly cross- linked coating. Radiation-curing systems are considered to be 100 percent nonvolatile since both the polymer and the diluent enter into the curing reaction; thus, these coatings are relatively environment-friendly.

Polyurethane Resins and their Curing Systems

Polyurethane resins are in a class by themselves, both in terms of chemical composition and curing system. Curing is accomplished via the reaction between two kinds of chemicals: an *isocyanate*, of which there are many types, and a chemical that contains *hydroxyl* groups, of which there are also many types. Cured polyurethane resin coatings are especially noted for:

- Abrasion resistance
- Toughness
- Flexibility
- Resistance to chemicals
- Excellent electrical insulation

These attributes make polyurethane coatings especially well suited to aerospace and automotive applications where very strong, tough coatings are needed.

Four Polyurethane Curing Systems

One-Package Oxidation-Cure

These coatings cure via oxidation in the air. Technically, they are not true polyurethanes, but are considered a special class of alkyds referred to as *uralkyds*.

One-Package Moisture-Cure

These coatings cure rapidly by reacting with moisture in the air. Special equipment is used to isolate the material from moisture prior to curing, including moisture-impervious tubing and special air-tight containers that place either a nitrogen or dry-air bath over the material.

One-Package Heat-Crosslinking

Manufacturers supply these coatings with the polyurethane blocked from curing by being chemically combined with an alcohol or phenol. To initiate the curing process, the material is heated to evaporate the blocking chemical. This leads to a series of reactions that, in the end, yields the cured coating.

Two-Package Systems

Manufacturers supply these coatings in two separate packages. One contains the isocyanate (often called the “A” component), and the other contains either a polyol or polyamine (called the “B” component). Once the two components are combined, the coating must be deposited promptly. If application is delayed, the coating becomes difficult to apply and the desired finish characteristics may not be achieved. Curing usually takes between two and eight hours.

Progress check

For items 1 through 6, match the terms with their definitions:

Terms

- a. Solvent-loss curing system
- b. Chemical-reaction curing system
- c. Air-reaction curing system
- d. Emulsion-drying curing system
- e. Radiation curing system
- f. Polyurethane curing system

Definitions

- ___ 1. Curing is accomplished via the reaction between an isocyanate and a chemical that contains hydroxyl groups.
- ___ 2. The coating is supplied with the binders dissolved in solvents. During curing, the binders react with each other to form a three-dimensionally cross-linked film. The cured coating is thermosetting.
- ___ 3. As supplied, the binder and solvent are components in an emulsified mixture. During the curing process, the binder and pigment particles merge form a continuous film. Solvents may be either water or organic compounds.
- ___ 4. The coating is supplied with the polymers dissolved in solvents. Curing consists of evaporation of the solvent while the binders come out of solution to form the cured film.
- ___ 5. As supplied, this type of coating consists of a low-molecular weight binder in a diluent. Curing is accomplished by exposing the applied coating to either UV, electron beam, or gamma ray radiation. The result is a highly cross-linked system.
- ___ 6. Often contain highly viscous oil-type binders as well as solvents to decrease viscosity. In the curing process, these coatings react with oxygen in the air to form a cross-linked film.

Answers to Progress Check

1. f. **Polyurethanes** cure via the reaction between an isocyanate and a chemical that contains hydroxyl groups.
2. b. In the **chemical-reaction curing system**, the coating is supplied with the binders dissolved in solvents. During curing, the binders react with each other to form a three-dimensionally cross-linked film. The cured coating is thermosetting.
3. d. In the **emulsion-drying curing system**, the binder and solvent are supplied as components in an emulsified mixture. During the curing process, the binder and pigment form a continuous film. Solvents may be either water or organic compounds.
4. a. In the **solvent-loss curing system**, the coating is supplied with the polymers dissolved in solvents. Curing consists of evaporation of the solvent while the binders come out of solution to form the cured film.
5. e. In the **radiation curing system**, the coating is supplied in the form of a low-molecular weight binder in a diluent. Curing is accomplished by exposing the applied coating to either UV, electron beam, or gamma ray radiation. The result is a highly cross-linked system.
6. c. In the **air-reaction curing system**, the coatings often contain oil-type binders along with a solvent to decrease viscosity. In the curing process, these coatings react with oxygen in the air to form a cross-linked film.

Comparing Three Types of Coatings: Conventional Solvent-borne, High-solids Solvent-borne, and Water-borne

Learning Objectives

There are many ways to compare coatings. For example, in the last section, we categorized coatings according to their various curing mechanisms. Another way is to compare the three most common formulations available in today's market:

- Conventional solvent-borne
- High-solids solvent-borne
- Water-borne

This section gives you an overview of key ideas regarding each of these formulation categories. After completing this section, you will be able to:

- Explain the pros and cons of conventional solvent-borne, high-solids solvent-borne, and water-borne coatings.
- Discuss specific issues that arise in connection with each of these three types of coatings.
- Explain why there has been a movement away from conventional solvent-borne coatings and toward the high-solids and water-borne alternatives.

Conventional Solvent-borne Coatings

In terms of composition, this category is comprised of coatings with 50 - 70 percent solvent content. Or to look at it the other way, this category is comprised of coatings with 30 - 50 percent solids content. (It may be important to know whether stated percentages are in terms of weight or volume; consult with the coating supplier.) You may hear these coatings referred to as low-solids coatings. "Conventional" refers to the fact that these coatings have been in use much longer than the other two systems we are comparing here. In fact, low-solids solvent-borne coatings have been in use for thousands of years.

Available and Familiar

Often, conventional solvent-borne coatings are more readily available than other types simply because they are well established in the marketplace. Spray operators often choose these coatings because they are experienced with them and know how to work with them.

Environmental Impact

Most of the solvents in conventional solvent-borne coatings are VOC's.

High-solids Solvent-borne Coatings

High-solids coatings were first introduced in direct response to the environmental problems associated with conventional solvent-borne coatings. With strong competition among suppliers in a free market, it is not surprising that there is little agreement as to just what percentage of solids constitutes a “high-solids” coating. According to one set of definitions, high-solids coatings are those that contain 50 - 80 percent solids (resin + pigment).

Changes in the Formulation of High-solids Coatings

When high-solids coatings were first introduced, suppliers made them with the same kinds of polymers they had used in conventional coatings; they simply reduced the amount of solvents in the formulations, thus achieving a higher percentage of solids. Therefore, these coatings may have higher viscosities than conventional coatings and may require pumping equipment sized to move higher viscosity fluids. On the other hand, users can thin the coatings by adding solvents. But this simply re-introduces the environmental problem that everyone was trying to get away from in going to the high-solids coatings.

Later, coating suppliers changed to formulas that contain *short-chain* polymers; these are polymers are more dependent on cross-linking between polymer chains to cure. These formulations have two major advantages: They are less viscous than the earlier formulations, and they contain fewer solvents than the earlier formulations, so they are less harmful to the environment.

Achieving good adhesion and finish quality with the newer formulations requires strict adherence to the supplier’s application instructions. The new formulations may not perform well if errors are made during substrate preparation or coating application. Nonetheless, most industrial users are choosing these newer formulations, because they are required to meet today’s strict pollution control standards.

Cost and Equipment Considerations

High-solids solvent-borne coatings may be more expensive by volume than conventional solvent-borne coatings. But when correctly applied, one gallon of a 60 percent-solids coating should cover twice as much surface area as a 30 percent-solids coating. Many high-solids coatings are baking enamels. The ovens required for proper curing of these baking enamels add to the total cost of using high-solids coatings as compared to coatings that cure at room temperature.

Abrasiveness

Many high-solids coatings contain highly abrasive pigments; also, to achieve the desired solids content, some may contain highly abrasive fillers. Therefore, abrasion-resistant pumping equipment is required, such as Graco chrome-over-stainless steel pumps with ultra-high molecular weight polyethylene (UHMWPE) packings.

Problems Associated with High Viscosity

There are problems associated with the high viscosities of high-solids coatings. For example, they tend to have problems with inconsistencies in the cured film. This, in turn, may lead to a high number of rejected parts. While the viscosities of high-solids coatings cannot be reduced much by adding further solvent, in most cases, viscosities can be reduced by heating during circulation. The Graco Vis-con² in-line heater can do this job for your customer. Also, the “overspray” of a high-solids coatings, if left to accumulate on the floor of a paint booth, can become a problem for operators.

Water-borne Coatings

Water-borne coatings are those in which water is the major solvent and in which a small amounts of VOC's serve as co-solvents.

Terminology

- Water-borne coatings are more properly (but less often) called *water-reducible*. This term refers to the fact that the viscosity of the coating may be reduced with the addition of water.
- Water-borne coatings are available with a variety of binders, including *epoxy*, *polyester*, *acrylic*, and *alkyd*.
- In water-borne coatings, the binder-water relationship is one of these:
 - A *true solution*, in which the binder is dissolved in water.
 - An *emulsion*, which is defined as a dispersion of droplets of a liquid in a second carrier liquid.
 - A *dispersion*, which is defined as a mixture of fine solid particles and a liquid. An example of a dispersion is latex paint, which is discussed below.
- Manufacturers supply *latex paint* as a fine dispersion of either resin, natural rubber, or synthetic rubber particles in water. Synthetic rubber formulations dominate the marketplace today. Most of these synthetics are made by a chemical process called *emulsion polymerization*. While the emulsion polymerization process involves the use of an emulsion, the result of the process is **not** an emulsion but a *dispersion*. Nonetheless, paint industry people use the words, “latex” and “emulsion” interchangeably to refer to this type of paint.

- Water-borne coatings may be either *thermoplastic*—that is, capable of being repeatedly softened by heat and hardened by cooling; or *thermosetting*—that is, capable of reaching a relatively infusible state via a chemical reaction induced by heat, catalysts, ultraviolet light, etc.

Flammability and Hazardousness

Water-borne coatings usually contain about 10-30 percent of VOC's by volume—as compared with conventional solvent-borne coatings that usually contain up to 70 percent VOC's. So water-borne coatings are less stressful to the environment and are less of a fire hazard. But the VOC's in water-borne coatings are still environmentally hazardous and flammable. Therefore, while switching to water-borne coatings has helped, doing so does not completely eliminate environment and fire-hazard problems.

Substrate Cleaning

Starting with a clean substrate is important to the quality of the cured film with all coatings. But cleaning is more critical with water-borne coatings than with solvent-borne coatings. Expensive part washers are commonly used in industrial water-borne coating systems.

Over-reduction

If water is added to a water-borne coating, the consistency can quickly become too thin for good coating—a condition that may not be reversible, in which case the material must be discarded. Customers should always follow label directions for use of these products.

Metallic-Pigment and Pearlescent-Pigment Water-borne Paints

For many years, the automobile industry has used conventional solvent-based paint formulations that contain metallic pigments such as flaked aluminum or pearlescent pigments such as iron-oxide-coated mica. But recently these pigments have also become readily available in water-borne formulations. Auto makers prefer the water-borne formulations because they produce better looking coatings and because of their superior environmental characteristics.

Drying/Curing

Water-borne coatings dry more slowly than conventional solvent-borne coatings. And, since water evaporation is the major action involved in curing water-borne coatings, their curing times are affected more by changes in ambient temperature and humidity than are those of conventional solvent-borne coatings. A common response to this problem is to bake the coating / substrate after application. This adds to the cost of using these coatings. And, if heating is done too quickly, the coating may blister.

Viscosity

The at-rest viscosity of a water-borne coating may be two to three times that of a conventional solvent-borne coating. But like many other types of coatings, water-borne coatings are pseudoplastic—that is, their viscosities are reduced with increased shear. There are several implications for specifying Graco equipment:

- Greater pressure is needed to initiate flow; this may require heavier-duty, more costly equipment than that used for conventional solvent-borne coatings.
- The various system components—pumps, regulators, agitators, and piping—will all cause different amounts of shear. This makes prediction of the resulting viscosity difficult.
- The viscosity of water-borne coatings may vary from supplier to supplier. Be sure your customer has chosen a specific coating before you recommend equipment.

Because of these (and other) factors, the design of systems used to move water-borne coatings is critical to success. For help with system design, call Graco Technical Assistance: 1-800-543-0339.

Corrosion Resistance

Water corrodes carbon steel. Under long service, water even corrodes some stainless steel alloys. Thus, a major corrosion problem is presented by the water in water-borne coatings and the de-ionized water that is used to flush water-borne coatings from pumping systems.

One common problem is that corrosion products flake off from system components and contaminate the finish. Accordingly, you should specify Graco equipment specially designed for moving water-borne coatings. If your customer requests a particular grade or type of stainless steel, call the specialists at Graco Technical Assistance: 1-800-543-0339. They can tell you what materials are used in specific Graco products. They also may be able to help with special-orders of equipment made with specific stainless steel types.

Agglomeration

Metal ions can degrade water-borne coatings by causing *agglomeration*, a clumping or curdling of the solids. Metal ions are removed from internal metal parts in Graco equipment by passivation and electropolishing. If a question arises about the compatibility of Graco equipment with water-borne coatings, call Graco Technical Assistance: 1-800-543-0339.

Problems Related to Premature Curing in the Circulating System

A skin of dried paint may build up on the internal surfaces of pumps and other system components. This is especially a problem because water-borne coatings cannot be re-dissolved after drying. The dried paint may flake off and become a contaminant. Or conversely, it may adhere to the container so strongly that sandblasting will be required to remove it. In such cases, you and your customers should take the following steps:

- To assure that flakes are removed from the system prior to paint application, specify appropriate filters in all systems.
- Customers should maintain high coating levels in the system and should minimize contact between the coating and air.
- Recommend that customers always flush the system before the coating dries.

For help with system design, call Graco Technical Assistance: 1-800-543-0339.

Progress check

1. In the phrase, “conventional solvent-based coating,” the word, “conventional” refers to the fact that: _____
_____.
2. Select the formulation that typically has the lowest at-rest viscosity:
 - a. Conventional solvent-based coating
 - b. High-solids solvent-based coating
 - c. Water-borne coating
3. The advantage of water-borne coatings is that they do not contain hazardous solvents.
 - a. True
 - b. False
4. When correctly applied, a 60 percent solids solvent-borne coating should cover about twice the surface area of a 30 percent solids solvent-borne coating.
 - a. True
 - b. False
5. You should specify chrome-over-stainless steel pumps to move high-solids solvent-borne coatings because these coatings are highly corrosive.
 - a. True
 - b. False
6. Cleaning of substrates prior to coating is much more important with water-borne coatings than with other types.
 - a. True
 - b. False
7. Auto makers prefer metallic-pigment water-borne paints because they present less of an environmental problem and because they cure to form better looking coatings than conventional solvent-based metallic-pigment paints.
 - a. True
 - b. False

For items 8 through 14, match the terms with their definitions:

Terms

- a. Water-reducible
- b. Emulsion
- c. Dispersion
- d. Latex paint
- e. Thermoplastic
- f. Thermosetting
- g. Agglomeration

Definitions

- ___ 8. Capable of being repeatedly softened by heat and hardened by cooling.
 - ___ 9. A better name for water-borne coatings.
 - ___ 10. A mixture of fine solid particles and a liquid.
 - ___ 11. Capable of reaching a relatively infusible state via a chemical reaction induced by heat, catalysts, ultraviolet light, etc.
 - ___ 12. A mixture of small droplets of two liquids.
 - ___ 13. A clumping or curdling of the solids in a water-borne coating.
 - ___ 14. A fine dispersion of either resin, natural rubber, or synthetic rubber particles in water.
15. Why is greater pressure required to initiate flow of a water-borne or high-solids coating than to initiate flow of a conventional solvent-borne coatings?
-
16. What should you do if your customer requests Graco equipment made of a specific type of stainless steel?
-
17. Select possible results of premature curing of a water-borne paint in the circulation system:
- a. Dried paint may flake off and become a contaminant.
 - b. All of the paint throughout the system may harden and destroy the system.
 - c. It may be necessary to dissolve the dried paint by flushing the system with a solvent.
 - d. It may be necessary to sandblast the interior surfaces of the system.

Answers to progress check

1. **Conventional** refers to the fact that these coating formulations have been in use for thousands of years.
2. **Conventional solvent-based coatings** typically have the lowest at-rest viscosity of the three types named.
3. False: Most water-borne coatings do contain hazardous solvents—but they contain less of these solvents than other formulations.
4. True: When correctly applied, a 60 percent solids solvent-borne coating should cover about twice the surface area of a 30 percent solids solvent-borne coating.
5. False: You should specify chrome-over-stainless steel pumps to move high-solids solvent-borne coatings—but **not** because they are highly corrosive. The reason is that they are **highly abrasive**.
6. True: Cleaning of substrates prior to coating is much more important with water-borne coatings than with other types.
7. True: Auto makers prefer metallic-pigment water-borne paints because they present less of an environmental problem and because they cure to form better looking coatings than conventional solvent-based metallic-pigment paints.
8. e. A material that is capable of being repeatedly softened by heat and hardened by cooling is called **thermoplastic**.
9. a. A better name for water-borne coatings is **water-reducible**.
10. c. A **dispersion** is a mixture of fine solid particles and a liquid.
11. f. A material that is capable of reaching a relatively infusible state via a chemical reaction induced by heat, catalysts, or ultraviolet light is called **thermosetting**.
12. b. An **emulsion** is a mixture of small droplets of two liquids.
13. g. An **agglomeration** is a clumping or curdling of the solids in a water-borne coating.
14. d. **Latex paint** is a fine dispersion of either resin, natural rubber, or synthetic rubber particles in water.
15. Greater pressure is required to initiate flow of water-borne and high-solids coatings than to initiate flow of conventional solvent-borne coatings because water-borne and high-solids coatings are more viscous in the at-rest state.
16. If your customer requests Graco equipment made of a specific type of stainless steel, you should call Graco Technical Assistance: 1-800-543-0339.
17. a. Dried paint may flake off and become a contaminant.
and
d. It may be necessary to sandblast the interior surfaces of the system.

Sources of Information on Coatings

Learning Objectives

To specify the right Graco equipment for your customers, you will often want detailed information about the coatings your customers need to move. This section introduces the three kinds of documents that typically will be your sources of such information: material safety data sheets, application data sheets, and military specifications. After completing this section, you will be able to:

- Explain the concept known as the “sales triangle.”
- Explain the differences among material safety data sheets, application data sheets, and military specifications and how each type of document is likely to be useful to you.

The Sales Triangle

At Graco, we often speak of the *sales triangle*. This is a graphical representation of the inter-relationships among our customer, Graco, the distributor of Graco products (if one is involved), and the supplier of the coating (or other fluid) to be moved. Figure 1 shows the sales triangle.

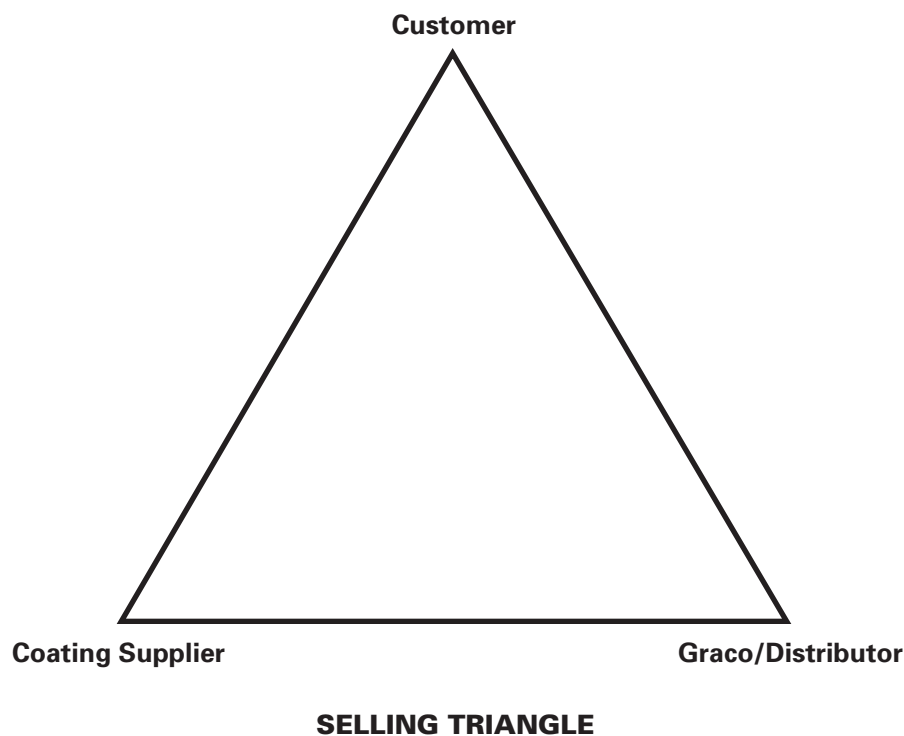


Figure 1 The sales triangle.

Of course, you are the link in the relationship between Graco and the customer. But what about the relationships with the coating supplier? How can you get the information about the supplier's products that you need to select appropriate Graco products? The answer is that sometimes your customer will be able give you this information; and other times, you may need to get it directly from the supplier. In any case, the information you need will usually come in the form of one of these documents:

- Material safety data sheet
- Application data sheet
- Military specification

Before you read the following information, we suggest that you obtain and look over samples of each of these documents. Your supervisor may be able to provide these samples.

Material Safety Data Sheets

The U.S. Occupational Safety and Health Administration (OSHA) and similar agencies of other national governments require suppliers of chemical products to make available safety information about their products. In OSHA regulations, the document that contains this information is called a *material safety data sheet*. In common usage, this is always referred to as an MSDS. OSHA states that each MSDS should contain at least the following information:

- Product identification, such as a chemical name and / or a common name
- Listing of all hazardous ingredients
- Physical/chemical characteristics, such as boiling point and evaporation point
- Fire and explosion hazard data, including counteractive measures
- Reactivity data, such as conditions to avoid and hazardous byproducts of decomposition, if any
- Health hazard data, such as whether the product is known to cause cancer
- Precautions for safe handling and use, including steps to be taken if the material is spilled

The name "material safety data sheet" suggests that an MSDS will be one sheet of paper. However, since it must convey all of the above information and more, a complete, well-designed MSDS is usually several pages long. You will find considerable variation among MSDS's obtained from various suppliers. Some are much more complete than others. Some are much easier to read than others. In any case, MSDS's are likely to provide some of the information you need to correctly specify Graco products for your customers.

Application Data Sheet

Another document available from coating suppliers is an *application data sheet*. While an MSDS focuses on safety measures to be taken with a coating, an application data sheet focuses on how to apply the material to obtain a good coating. In fact, many application data sheets recommend specific Graco products to be used in applying the coating. Obviously then, you should ask your customer if he or she can show you an application data sheet for the coating that will be applied. It may give you precisely the information you need to close your sale.

Military Specifications

A third type of document you may encounter is a *military specification*—commonly called a “mil spec.” Mil specs are published by the U.S. Defense Department to define requirements for products sold to the U.S. military. Also, the U.S. federal government publishes *federal specifications* to define requirements for products sold to non-military parts of the government. Usually, there will be a mil spec and a federal spec that contain exactly the same requirements for a given product.

Literally thousands of these specs are available from the U.S. government covering an extremely wide range of products—everything from tanks to tin cups. If your customer is a supplier to a government agency, that agency may require that the supplied products meet one or several specs. For example, your customer may tell you that the paint on the tractor he manufactures and sells to the government must meet a mil spec.

Mil specs always focus on the *performance* of the item specified. Therefore, for coatings, a mil spec will state detailed, specific requirements for the cured coating, such as minimum peel strength, color, film thickness, and so on. Specific test methods are also usually specified for determining if a coating meets the specification. Mil specs usually do not contain information on how to obtain the required specifications. Therefore, unlike a supplier’s application data sheet, you will not find a requirement in a mil spec to use a particular Graco product—or any other brand-name equipment.

Progress check

1. In the sales triangle, the link between Graco and the customer is:

_____.

For items 2 through 4 match the terms with their definitions:

Terms

- a. Mil spec
- b. MSDS
- c. Application data sheet

Definitions

- ___ 2. Provides information on how to use a coating.
- ___ 3. Specifies requirements for the cured coating.
- ___ 4. Includes information on hazardousness of a coating.

Answers to progress check

1. The sales person.
2. c. An application data sheet provides information on how to use a coating.
3. b. A mil spec specifies requirements for the cured coating.
4. a. An MSDS includes information on hazardousness of a coating.

Module Evaluation

The purpose of this Module Evaluation is to help the Graco Technical Communications department determine the usefulness and effectiveness of the module.

Instructions: Please complete the evaluation, tear it on the perforation, and return it Graco Technical Communications Department, P.O. Box 1441, Minneapolis, MN 55440-1441, USA.

1. *Based on the objectives, this module:*

- Significantly exceeded my expectations
- Exceeded my expectations
- Met my expectations
- Was below my expectations
- Was significantly below my expectations

2. *Why did you select the above rating?*

3. *How do you plan to use the module information in your job?*

4. *How do you think the module could be improved?*

I verify that I have successfully completed Module No. 321-032

Title: Fluid Types: Paints and Other Coatings

Signature _____

Date _____

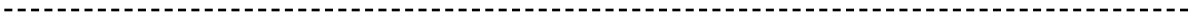


Graco

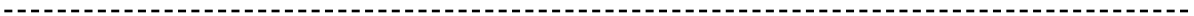
Technical Communications Dept.

P.O. Box 1441

Minneapolis, MN 55440-1441 U.S.A.



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This module was developed by the Graco Technical Communications Department with assistance from the following individuals:

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The Graco Concept and Theory Training program consists of the following topics:

Fluid Basics

Atomization

Electrostatic Spray Finishing

Safety

Airspray Technology

Fluid Types: Paints and Other Coatings

Fluid Types: Lubricants

Fluid Types: Sealants and Adhesives

Airless Atomization

Spraying Techniques

Transfer Efficiency

Fluid Movement

Fluid Controls

Pumps

Motors and Power Sources

Plural Component Paint Handling

Plural Component Sealant and Adhesive Handling

Paint Circulating Systems

Automatic Finishing

Lube Reels and Dispense Valves

Lube Metering Systems

Electronic Fluid Management Systems