Understanding Solvents: Part I

Solvents make stains and finishes work. You will never feel really comfortable with finishing until you have an understanding of solvents.

Following is an overview of each of the most commonly available solvents. For a deeper understanding that better relates all the finish solvents to each other, see Understanding Solvents, Part II. For an explanation of lacquer thinner, which is composed of about half-a-dozen individual solvents, see Lacquer Thinner.

Petroleum Distillates and Turpentine

Petroleum distillates are distillations of petroleum. They include mineral spirits (informally referred to as "paint thinner"), naphtha, toluene, xylene and some "turpentine substitutes" such as turpatine and T.R.P.S. Their primary use in wood finishing is for thinning waxes, oils, and varnishes, including polyurethane varnish, and for cleaning brushes. Petroleum distillates are also used to remove oil, grease and wax.

Turpentine is a distillation of pine-tree sap. Before the mid-twentieth century, turpentine was widely used as a thinner and clean-up solvent for oil paint and varnish and also as an oil, grease and wax remover.

With the growth of the automobile industry and its need for petroleum products, a large number of petroleum solvents were introduced and these have almost entirely replaced turpentine because they are less expensive and have less unpleasant odor. The only sector in which turpentine is still used in any quantity is fine arts.

To produce solvents from petroleum, the liquid is heated and gases are taken off and condensed as the temperature increases. The process is called distillation—and thus, petroleum distillates.

The first gas to come off is methane, which doesn't condense at room temperature, only at much colder temperatures. Then there's ethane, propane, butane, etc.

Heptane and octane are used to make gasoline, a liquid that evaporates very rapidly. Gasoline is sometimes used as a cleaner, but it is very dangerous because it is explosive. Don't use gasoline.

The petroleum distillates we use in wood finishing evaporate much slower than gasoline and are relatively safe to use in small quantities, even with poor ventilation. But it's still not wise to use them in a room with a flame such as a pilot light, and you should protect yourself with better ventilation if you use them for long periods of time.

Furniture polishes are primarily petroleum distillates in the evaporation range slightly slower than mineral spirits. Many furniture polishes are emulsifications of petroleum distillates and water making them appear white (like milk, which is an emulsification of water and animal fat). Emulsified furniture polishes are better cleaners because they remove both solvent- and water-soluble dirt.

Mineral Spirits, Naphtha and Turpentine

The two most widely used finishing solvents are mineral spirits and naphtha. For our purposes, the principal differences between the two are evaporation rate and oiliness.

Naphtha evaporates faster than mineral spirits and is "drier," that is, less oily. Naphtha is therefore better for cleaning all types of oily, greasy or waxy surfaces. Mineral spirits is better for thinning oils, varnishes (including polyurethane varnish) and oil-based paints because it provides more time for the coating to level after brushing.

Naphtha is a stronger solvent than mineral spirits, but this is rarely significant in wood finishing. Mineral spirits is strong enough for any normal operation.

To place turpentine among the petroleum distillates, think of it as having the solvent strength of naphtha but the evaporation rate and oiliness of mineral spirits. I don't know of any situation in wood finishing where this is important. But the better solvent strength is important with some artist's paints.

The nickname for mineral spirits is "paint thinner." Back in the early days of mineral spirits, before the Second World War, all paints were oil-based. So there was only one thinner for paint. The nickname made sense.

Today, with water-based paints and finishes in wide use, the name could be confusing to beginners. Paint thinner is used only with oil-based paints and finishes, never with latex paints or water-based finishes.

It's important to emphasize that mineral spirits and paint thinner are the same thing. Amazingly, there are manufacturers who try to trick you into paying more by labeling their containers "pure" mineral spirits and charging more.

The common naphtha available in paint stores is VM&P Naphtha. VM&P stands for "varnish makers and painters." Stronger and faster evaporating naphthas exist, but these are rarely sold to the general public.

Toluene and Xylene

Toluene, nicknamed "toluol," and xylene, nicknamed "xylol," are the strong, smelly, fast evaporating and "dry" parts of mineral spirits and naphtha. These solvents are removed from mineral spirits and naphtha at refineries and sold separately as oil and grease removers. They are also used as solvents for some high-performance spray finishes such

as conversion varnish. Toluene and xylene are very effective as oil and grease removers, but naphtha should be adequate for most situations.

Toluene evaporates a little faster than xylene, but this is significant only when using the solvent as a thinner.

The problem with these two solvents is that they are relatively toxic. They will affect your nervous system causing irritability and drunkenness, and in large doses could cause serious health problems. You should never use them in any sizeable quantity in a room without good exhaust.

One very interesting use for toluene and xylene is to soften latex paint. Using a dampened cloth (and solvent-resistant gloves) you can easily remove latex paint that has spattered off a paint roller, or even a full coat of latex paint, from any finish except water-based finish (you'll remove the water-based finish too), without causing any damage to the underlying finish. In fact, the products sold specifically to do this, "Oops!" and "Goof-Off," are principally xylene.

Because white and yellow glues are the same chemistry as latex paint, you can also use toluene or xylene to soften and scrub these glues from wood when you have glue seepage or finger prints you didn't fully remove during sanding. You will need to use a toothbrush or soft brass-wire brush to get the glue out of the pores.

Odorless Mineral Spirits

The mineral spirits left after the toluene and xylene are removed is sold as "odorless" mineral spirits. When understood this way, it's obvious that odorless mineral spirits is a weaker solvent than regular mineral spirits. But I've never found this to be a problem. It still appears strong enough to thin all common oils, varnishes and oil paints.

The disadvantage of odorless mineral spirits, of course, is that it is considerably more expensive because of the extra steps necessary to produce it. You may find the extra expense worth it just to avoid the unpleasant odor of regular mineral spirits.

Turpentine Substitutes

The turpentine substitutes, turpatine and T.R.P.S., are more similar to turpentine than to mineral spirits. These petroleum substitutes have a solvent strength closer to naphtha and an evaporation rate closer to mineral spirits. So they are useful to fine artists but provide no special benefit to wood finishers.

Alcohol

Alcohol is an entirely different solvent than petroleum distillates. It is used as the solvent and thinner for shellac. Alcohol is the solvent because it dissolves solid shellac flakes and

the dried finish, and it's the thinner because it thins the liquid shellac after the flakes have been dissolved.

(Notice the technical difference between the terms "solvent" and "thinner," even though they are often used interchangeably. Alcohol both dissolves and thins shellac. Mineral spirits, on the other hand, doesn't dissolve varnish; it just thins varnish. For more on dissolving and thinning, see What Dissolves and Thins What.)

There are two types of alcohol available at paint stores: methanol (methyl alcohol) and denatured alcohol (shellac thinner).

Methanol evaporates a little faster than denatured alcohol, but methanol is toxic and could blind or even kill you if you breathe too high a vapor concentration for too long. **You shouldn't use it in large quantities unless you wear a respirator mask or a good exhaust system in your shop.**

Denatured alcohol is ethanol (the alcohol in beer, wine and liquor) that has been made poisonous so we don't have to pay liquor taxes to buy it. This is the alcohol you should use with shellac.

In situations where shellac is not the finish, denatured alcohol has the further use as a felt-tip-pen ink remover. Dampen a cloth with denatured alcohol and wipe over the mark. You will remove it in most cases. You won't damage any finish except shellac as long as you don't soak the surface.

Propylene glycol is a very slow evaporating alcohol that is often used as a "flow additive" in water-based finishes. Unfortunately, this solvent isn't widely available for consumers.

Acetone and MEK (methyl ethyl ketone)

Both acetone and MEK are very strong (high solvent strength) and fast evaporating solvents. Acetone evaporates faster than MEK and, in fact, is the fastest evaporating of all the solvents commonly available to consumers. It is used in many industries as a cleaner and degreaser.

In wood finishing acetone is used as a solvent for lacquers and, along with MEK, as a common ingredient in paint removers. You can add acetone to lacquer and shellac to get them to dry faster in cold temperatures. Acetone is also the most effective solvent for removing the oily resin from the surface of some exotic woods, including teak, wenge and cocobolo, before gluing with a water-based adhesive or finishing with an oil or varnish.

Acetone is unique in that it is the only common solvent that is exempt as a VOC (volatile organic compound) and HAP (hazardous air pollutant). VOCs are environmental (smog)

pollutants. HAPs are bad for us to breathe. Both are regulated and their use is limited in many parts of the country. You can use as much acetone as you want, everywhere.

Lacquer Thinner

Click here to read about lacquer thinner.

Brush Cleaners and Deglossers

Brands of brush cleaner and deglosser (liquid sandpaper) vary greatly in their composition. Some are even water-based, but these work slower and are less effective than solvent-based.

You can usually substitute a brush cleaner for the mineral spirits or lacquer thinner you may otherwise use to clean your varnish or lacquer brushes. (It's easiest to clean shellac with household ammonia and water.) Brush cleaners are usually more expensive, however.

What is left unsaid about deglossers is that it matters greatly what paint or finish you're trying to clean and dull. Cleaning grease or wax is no problem, but high-performance paints and finishes such as powder and UV-cured coatings, catalyzed lacquer, conversion varnish and even oil-based polyurethane are very solvent resistant. So it's rarely possible to dull them short of abrading with real sandpaper or steel wool.

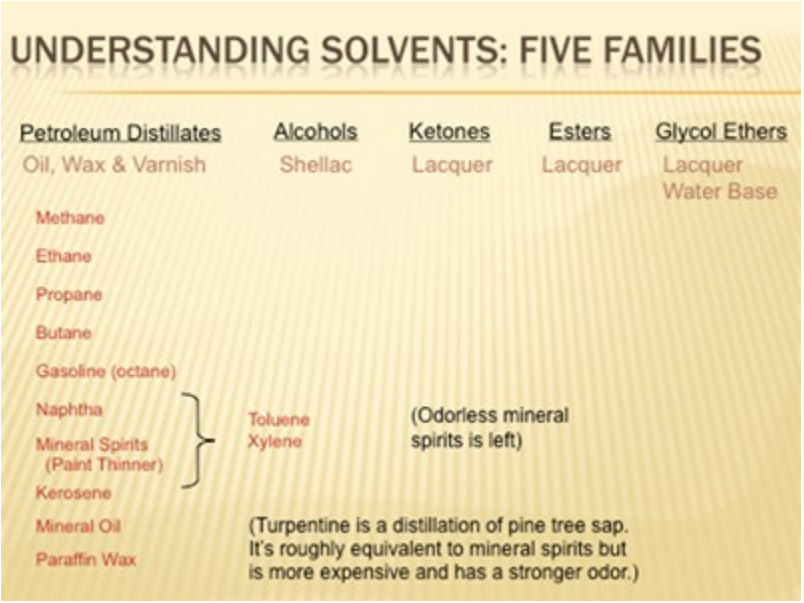
Table 1 – What Dissolves and Thins What

Solvent	Dissolves	Thins
Mineral spirits (paint thinner)	**Wax**	**Wax**
		Oil
Naptha		
		Varnish (incl. polyurethane varnish)
Turpentine		
		Wax
Toluene (toluol)	**Wax**	Oil
Xylene (xylol)	Water-based finish	Varnish (incl. polyurethane varnish)
		Conversion varnish
Alcohol (denatured)	**Shellac**	**Shellac**
		Lacquer
Lacquer Thinner	**Shellac**	**Lacquer (nitrocellulose, CAB-acrylic, catalyzed)**

	Lacquer (nitrocellulose, CAB-acrylic) Water-based finish	
	Shellac	**Shellac**
Glycol Ether	Lacquer (nitrocellulose, CAB-acrylic)	Lacquer (nitrocellulose, CAB-acrylic, catalyzed)
	Water-based finish	Water-based finish

Understanding Solvents: Part II

Solvents are difficult to understand because they all look alike in the can. One way to make sense of them is simply to learn what each does (see Understanding Solvents, Part I). A more sophisticated and very helpful method for understanding solvents is to organize them into their families.



Five Families 1

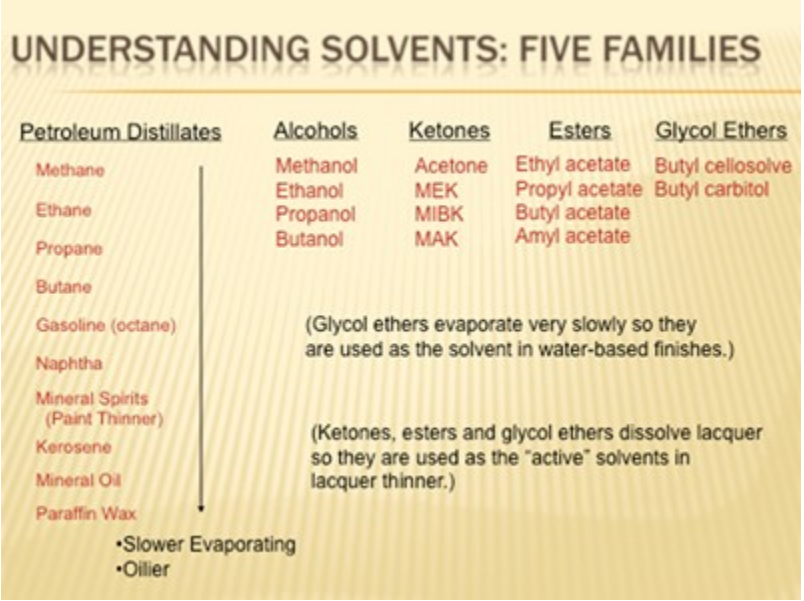
There are five solvent families used in finishes:

- Petroleum distillates (mineral spirits, naphtha, etc.)

- Alcohols (methanol, denatured alcohol, etc.)
- Ketones (acetone, MEK, etc.)
- Esters (butyl acetate, amyl acetate, etc.)
- Glycol ethers (butyl cellosolve, butyl carbitol, etc.)

Within each family, the individual members have the same relationship to each other. The smaller molecules evaporate faster and the larger molecules evaporate slower. The larger molecules are also oilier.

Petroleum Distillates

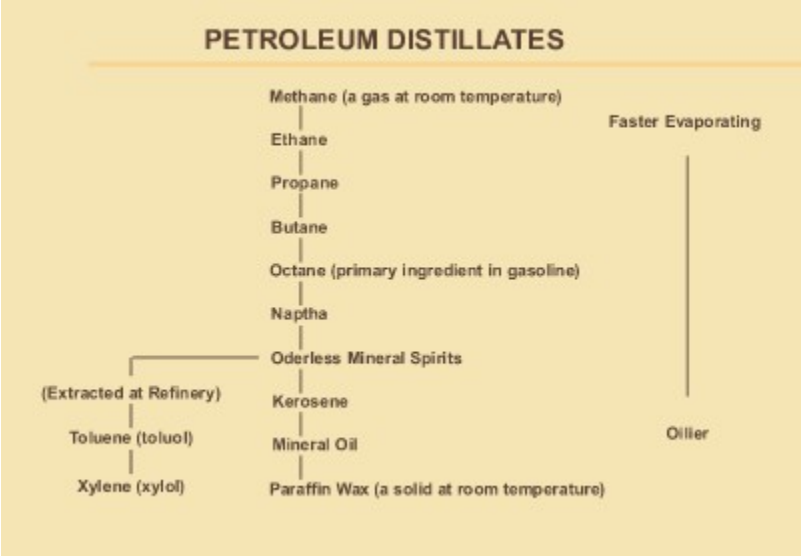


Five Families 2

The best way to illustrate this relationship is to break down the petroleum-distillate family, the one you are surely most familiar with. (See Chart.)

The smallest molecule in this family is methane, which is a gas at room temperature. Methane is so "fast-evaporating" that it has already evaporated at this temperature.

Following methane in evaporation rate are ethane, propane, butane, etc., up to heptane and octane, which are primary ingredients in gasoline, a very fast-evaporating liquid at room temperature. The next common distillations are naphtha and mineral spirits (commonly nicknamed "paint thinner"), naphtha being less oily and faster evaporating than mineral spirits.



Petroleum Distillates

Toluene (toluol) and xylene (xylol) make up the strong and smelly parts of naphtha and mineral spirits. Refineries remove the toluene and xylene to be sold separately and sell what is left as odorless mineral spirits. This less smelly mineral spirits has less solvent strength than regular mineral spirits, but it is usually strong enough to thin oils and varnishes and dissolve wax. Toluene and xylene are very fast-evaporating and dry (non-oily).

The next common petroleum distillate is kerosene, which is so oily that it barely evaporates at all at room temperature. Mineral oil is next, and it is a full-fledged oil that doesn't evaporate. Paraffin wax is a solid at room temperature. It liquidifies at around 130 degrees.

Notice that petroleum distillates range all the way from a gas to a solid at room temperature. Other families don't have quite this range.

The Other Families

Alcohols, ketones, esters, and glycol ethers work the same as petroleum distillates, with the smaller molecules being faster-evaporating and drier, and the larger molecules being slower-evaporating and oilier. Some of the faster evaporating alcohols, ketones and glycol ethers are sold to consumers. No esters are commonly available.

Within the alcohol family, methanol (wood alcohol) evaporates faster than ethanol (grain alcohol). Ethanol is the alcohol in beer, wine and liquor, and it is highly taxed. So a poisonous substance, often methanol, is added to make it undrinkable and avoid the tax. This product is sold as "denatured alcohol" or "shellac thinner." Methanol itself is highly toxic and should not be used except outdoors or with good ventilation.

Within the ketone family, acetone evaporates faster than methyl ethyl ketone (MEK). All other ketones evaporate slower.

The molecules in the glycol-ether family are large and evaporate very slowly. This makes them good solvents for water-based finishes because they evaporate slower than water. First the water evaporates from these finishes, then the small amount of remaining glycol ether softens the droplets of emulsified resin so they stick together and form a film as the rest of the solvent evaporates.

An example of a glycol ether you may be familiar with is ethylene glycol monobutyl ether, which is commonly sold under its trade name, Butyl Cellosolve.

Butyl Cellosolve evaporates very slowly and is used as the most potent retarder for lacquer. You can buy this solvent separately to add to lacquers to slow their drying, or it may be included with other solvents and sold as lacquer retarder.

You can usually recognize a solvent by its suffix. Alcohols, which dissolve and thin shellac, have the suffix -ol. Ketones, which dissolve and thin lacquers, have the suffix -one. Esters, which dissolve and thin lacquers, have the suffix -ate (methyl acetate, amyl acetate, etc.). Glycol ethers, which dissolve water-based finishes and dissolve and thin lacquers, end in "ether."

It's helpful for understanding to group the solvents in their families. Once you understand this organization, lacquer thinner, which is made up of a number of solvents, makes more sense.

Lacquer thinner is the solvent and thinner used with all types of lacquer, including nitrocellulose, CAB-acrylic and catalyzed. It's the most interesting of the finish solvents because it's composed of half-a-dozen or so individual solvents. Manufacturers vary these to control solvent strength and evaporation rate.

Solvents from all five of the solvent families are used in lacquer thinners. (See Understanding Solvents, Part II). Toluene, xylene and "high-flash" (meaning fast evaporating) naphtha are from the petroleum-distillate family. The other four families are ketones, esters, glycol ethers and alcohols.

All the individual solvents from the ketone, ester and glycol ether families dissolve lacquer on their own and are called "active" solvents. But they evaporate at different rates, so manufacturers choose among them to make a thinner that evaporates in steps at the speeds they want.

Alcohol doesn't dissolve lacquer on its own, but it does in combination with these other solvents, so it is called a "latent" solvent. One or more of the alcohols is usually added to the mix to reduce cost.

The nature of lacquers is that they can be fully dissolved (meaning the lacquer molecules are separated) and still be too thick to spray without getting severe orange peel. So to further “thin” the lacquer (and also lacquer thinner) without adding expensive dissolving solvents, manufacturers add up to 50% toluene, xylene or high-flash naphtha.

These solvents are called “diluents” or “diluting” solvents.

Because the diluting solvents don’t dissolve lacquer, they have to evaporate fast enough to be out of the lacquer before all the dissolving solvents have evaporated. Otherwise, the lacquer will come out of solution and appear as white, cotton-like, particles on the dried finish.

1 - Solvent Strength

Solvent Strength

By varying the individual solvents and the ratios used, manufacturers control the strength of the lacquer thinner and the speed the lacquer dries.

Strength is important to insure the lacquer fully dissolves. All commonly available lacquer thinners sold for thinning lacquer will adequately dissolve the lacquer. But less expensive lacquer thinners sold for clean up don’t dissolve lacquer adequately. If too much of this thinner is added, the lacquer will come out of solution.

Automotive lacquers require a higher ratio of dissolving solvents than do wood lacquers. So thinners sold for automotive lacquers are more expensive, but they still work well with wood lacquers. On the other hand, lacquer thinners sold for wood lacquers may not be strong enough to thin automotive lacquers.

Multiple Solvents

Arguably, the most unique characteristic of lacquer finishes, and the reason so many finishers love spraying lacquer, is its resistance to running and sagging of vertical surfaces. The finish can be sprayed quite thick without problems. It’s hard to screw up a sprayed lacquer finish.

The explanation is the lacquer thinner. It is composed of a number of individual solvents that evaporate at different rates.

Lacquer is a thick finish that requires a lot of solvent (as much as 75% or more) to make it thin enough to get through the nozzle on the spray gun without orange peel. But once the finish gets through nozzle, it no longer needs to be so thin. It no longer needs so much thinner.

So individual solvents are chosen to evaporate very quickly after the lacquer finish is sprayed. These solvents, beginning with those that don't dissolve the lacquer, evaporate one after another, beginning as soon as the finish leaves the spray gun, so the lacquer thickens quickly on the surface. Some slower evaporating solvents, called "tail" solvents, remain for a while to allow the lacquer to level out.

To better understand what's happening, please refer to the Table of Solvents, which I include here only for illustration, not with the idea that you should have to learn these names. These are the most common individual dissolving solvents added to lacquer and used to make up lacquer thinners.

The solvent, butyl acetate, almost halfway down in bold, is used as the standard to which the other solvents are compared. It is assigned the value of "1."

So acetone, at the top of the list with a value of 5.7, evaporates 5.7 times faster than butyl acetate, and Butyl Cellosolve, at the bottom of the list with a value of .08, evaporates about 1/12 as fast as butyl acetate. Acetone evaporates very rapidly; Butyl Cellosolve evaporates very slowly; and all the other solvents listed evaporate somewhere in between.

Include three or four of these solvents together with some very fast evaporating toluene or high-flash naphtha and it's easy to understand how the sequential evaporation of each solvent causes lacquer finishes to seize up quickly on vertical surfaces so they don't run or sag.

2 - Fast & Slow

Fast and Slow

It’s also easy to understand how lacquer thinners can be made to evaporate faster or slower simply by choosing solvents nearer the top of the list or nearer the bottom of the list.

Lacquer retarders, used to eliminate blushing (turning white) on humid days and eliminate dry spray (a sandy surface) on hot, dry days or when spraying the insides of cabinets, are made up of individual solvents nearer the bottom of the list.

The slowest evaporating retarder and the most effective in extremely humid conditions, such as those found near the Gulf of Mexico, is Butyl Cellosolve, which is commonly sold separately as a “super” retarder.

Be aware that adding any retarder to lacquer slows the drying and may affect your production (more time between coats and more time before you can deliver or stack parts).

Fast lacquer thinners, usually available from auto-body supply stores but not from wood-finish suppliers, are made up of solvents nearer the top of the list. These thinners make it possible to spray with near normal drying times in cold temperatures.

Acetone can also be used to speed the drying of lacquer in cold temperatures. You add it to the finish similar to the way you add retarder, judging how much will be necessary to achieve the drying rate you want. It’s always trial and error with both retarder and with acetone or fast lacquer thinner.

3 - Brushing Laquer

Standard lacquer thinners from different manufacturers all dissolve and thin lacquer adequately, but they may differ somewhat in their evaporation rate. If you switch brands of lacquer thinner, you may have to adjust your finishing schedule.

Brushing Lacquer

Some lacquers are made for brushing. To achieve this, manufacturers simply use slower evaporating solvents to dissolve the lacquer. Spraying one of these brushing lacquers requires more attention because they have a much greater tendency to run and sag on vertical surfaces, and they slow production because they dry slower.

Restricted Areas

Some parts of the country have VOC laws that restrict the percentage of solvent that can be included in a finish. Typically, these laws restrict lacquer to 27.5 percent VOC solvent, which is way too little for spraying.

4 - Restricted Areas

Acetone, however, is an exempt solvent. It can be added to lacquer in any amount, so manufacturers typically make up the difference between 27.5% and about 75% with acetone.

This has two impacts. First, it makes the lacquer more expensive. Second, and much more significant, it makes the lacquer dry so fast it can't be sprayed in warm temperatures without getting dry spray. (The lacquer works great in cold temperatures, however.)

Finishers get around the fast drying by adding Butyl Cellosolve to the lacquer. It's legal to sell and buy this solvent, but you should be aware that adding it to your lacquer may take it out of compliance.

Table 1 – Solvent Evaporation Rates

Dissolving Solvent	Relative Evaporation Rate
Acetone	**5.7**
Ethyl Acetate	**4.1**
Methyl Ethyl Ketone (MEK)	**3.8**

Isopropyl Acetate	**3.0**
Methyl n-Propyl Ketone	**2.3**
Propyl Acetate	**2.3**
Methyl Isobutyl Ketone (MIBK)	**1.6**
Isobutyl Acetate	**1.4**
Butyl Acetate	**1.0**
Propylene Glycol Methyl Ether (Eastman PM)	**.7**
Methyl Isoamyl Ketone (MIAK)	**.5**
Methyl Amyl Acetate	**.5**
Propylene Glycol Methyl Ether Acetate (Eastman PM Acetate)	**.4**
Amyl Acetate	**.4**
Methyl Amyl Ketone (MAK)	**.4**
Isobutyl Isobutyrate (IBIB)	**.4**
Cyclohexanone	**.3**
Diisobutyl Ketone	**.2**
Ethylene Glycol Propyl Ether (Eastman EP)	**.2**
Diacetone Alcohol	**.12**
Ethyl 3-ethoxypropionate (EEP)	**.12**
Propylene Glycol Butyl Ether	**.08**
Ethylene Glycol Butyl Ether (Butyl Cellosolve, Eastman EB)	**.08**

Moister Scavanger

ZOLDINE® MS-PLUS

ZOLDINE® MS-PLUS Oxazolidine Moisture Scavenger
3-ethyl-2-methyl-2-(3-methylbutyl)-1,3-oxazolidine
CAS Reg. No. 143860-04-2
ZOLDINE MS-PLUS Moisture Scavenger is a fast reacting, low viscosity oxazolidine-based moisture scavenger for use in polyurethane and polyurea coatings, sealants and elastomers. ZOLDINE MS-PLUS Moisture Scavenger will safely and effectively eliminate moisture from the raw materials used in most polyurethane and polyurea systems. ZOLDINE MS-PLUS Moisture Scavenger will also alleviate the detrimental effects of humidity in the cast or spray application of two-component polyurethane and polyurea systems.
The use of ZOLDINE MS-PLUS Moisture Scavenger in a two-component polyurethane or polyurea system will provide the following benefits:
••Eliminates bubbles and pinholes
••Alleviates downglossing and hazing
••Improves distinctness of image (DOI)
•• Improves abrasion and chemical resistance
••Improves adhesion
••Eliminates gassing
••Leaves no unreacted fillers in polyurethane or polyurea matrices
••Excellent handling properties
Key Performance Advantages
•• Controls problems associated with moisture in isocyanate-based (polyurethane and polyurea) coatings, sealants and elastomers
•• Prevents downglossing, bubbles, pinholes and hazing
•• Fast-acting, safe and effective

Uses
Most components of polyurethane or polyurea systems contain various amounts of moisture. Pigments and fillers possess a monomolecular layer of water strongly adsorbed on the surface. In addition, pigments will pick up moisture during storage. Solvents, polyols and other components often require drying. Failure to remove moisture from solvents in two-component polyurethane or polyurea compositions can cause gassing in the isocyanate portion along with the formation of insoluble urea precipitates. Moisture contamination in polyols and pigments

will ultimately result in CO_2 bubble formation and lower gloss levels in curing films. Humidity present in the application environment brings additional moisture into polyurethane or polyurea compositions as they are applied. This is especially common in spray applications. Often, substrates themselves may be wet, which can cause additional problems. For example, polyurethane maintenance coatings are routinely applied to moist substrates. Failure to remove moisture from the environment of the curing film results in the formation of CO_2 bubbles which become trapped in the coating. Excessive moisture in curing films also results in significantly lower gloss levels. This phenomenon is commonly referred to as “downglossing”.

ZOLDINE MS-PLUS Moisture Scavenger will react rapidly with water and eliminate it from the formulation. As it reacts with water, ZOLDINE MS-PLUS Moisture Scavenger hydrolyzes to form a volatile ketone and a secondary amino alcohol (see reaction to the right). Thus, ZOLDINE MS-PLUS has an equivalent weight of 93. Care should be taken not to upset the isocyanate/hydroxyl ratio when incorporating ZOLDINE MS-PLUS Moisture Scavenger into a polyurethane or polyurea composition.

ZOLDINE MS-PLUS Moisture Scavenger reaction products either become a part of the polyurethane or polyurea polymer matrix or leave the film completely. There is no violent release of carbon dioxide as a result of this process, nor is there any exposure to monomeric isocyanates (e.g. PTSI) with this product.

ZOLDINE MS-PLUS Moisture Scavenger will also continue to protect the two-component formulation from moisture contamination when applied to moist substrates or when used in humid environments. Ultimately, as the urethane polyurethane or polyurea film cures, ZOLDINE MS-PLUS Moisture Scavenger will hydrolyze and then react with the isocyanate constituent. No unreacted material is left behind to detract from the appearance or structural integrity of the film.

Efficient removal of water is best obtained with treatment levels of 18-22 parts of ZOLDINE MS-PLUS Moisture Scavenger per part of water by weight. Best results are obtained when the amount of moisture present in the system is known beforehand. Water content can be measured by Karl Fischer reagent or gas chromatography. Knowing the level of water present allows for the addition of the optimum level of ZOLDINE MS-PLUS, avoiding under- or overdosing.

For control of humidity during the spray application of twocomponent polyurethane or polyurea systems, ZOLDINE MSPLUS Moisture Scavenger can be added at virtually any time to

the polyol and/or amine side of the formulation. Usually about three to four percent by weight is enough to totally eliminate down-glossing or pinholing problems caused by excessive environmental humidity.
For water removal from polyols or amines, it is suggested that ZOLDINE MS-PLUS Moisture Scavenger be added to the wet material and stirred at an elevated temperature (60°C) for a minimum of one hour.
For water removal from pigments, ZOLDINE MS-PLUS Moisture Scavenger should be added early in the grind process. The shear-induced temperatures found in typical pigment grinds (110°F/43°C) are sufficient to promote complete reaction of ZOLDINE MS-PLUS Moisture Scavenger with water. Experimental evidence indicates that under the above conditions, moisture levels should easily be reduced to less than 500 ppm in one hour or less.
Special care must be taken when using ZOLDINE MS-PLUS Moisture Scavenger in one-component systems. It has been found to be relatively stable with IPDI-based isocyanates. However, it has been found to act as an isocyanurate or trimer catalyst in the presence of aromatic isocyanates. It is therefore not recommended for use in aromatice isocyanate-based onecomponent moisture cure polyurethane systems.

Typical Properties

The following are typical properties of ZOLDINE MS-PLUS Moisture Scavenger. They are not to be considered product specifications.

Freezing Point <-35°C/-31°F
Molecular Weight 185
Density @ 24°C 0.872 g/mL
Weight/Gal 7.27 lb
Boiling Point 209°C/408°F
Flash Point (Pensky-Martens Closed Cup) 79°C/174°F
Viscosity <100 cp
Vapor Pressure @25°C 2.4 mm Hg
Solubility Soluble in polyols and most organic solvents (e.g. Toluene, MIBK, butyl acetate).
Activity 100%
Functionality 2
Equivalent Weight 93

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Toxicology

ZOLDINE MS-PLUS Moisture Scavenger would be considered only slightly toxic by most toxicologists, but it is a severe irritant to eyes and skin. Specifically, the LD50 by oral ingestion in the rat was determined to be 2.36 g/kg. It is not a skin sensitizer and was not mutagenic in the Ames bacterial mutation test. Individuals handling ZOLDINE MS-PLUS Moisture Scavenger should wear protective equipment sufficient to prevent contact with skin and eyes (i.e. rubber gloves, apron, eye protection).

Environmental Effects

Proper use of ZOLDINE MS-PLUS will not result in releases to

the environment. Also, when released to water, it will rapidly hydrolyze as depicted on page two of this publication.
ANGUS has conducted some testing on ZOLDINE MS-PLUS and found the 48-hour EC50 for daphnia magna to be 52 mg/L (ppm). In addition, ready biodegradability was investigated using OECD Guideline No. 301D. Based upon actual oxygen depletion versus the theoretical oxygen demand, ZOLDINE MS-PLUS was 43% biodegraded after 28 days. The compound was not inhibitory to activated sludge.

Regulatory

The components of ZOLDINE MS-PLUS appear on the U.S. EPA TSCA Chemical Substance Inventory.
It also has been notified in Canada as a “transitional” substance.
In Australia, ZOLDINE MS-PLUS has been notified and assessed under the Industrial Chemicals Act (see the Australian Chemical Gazette No. C5,7 May 1996). Full notification also has been made in Europe and it has been placed on ELNCS.
Approval also has been obtained for import into Japan under MITI regulations.

Precautionary Labeling

Labels for ZOLDINE MS-PLUS Moisture Scavenger bear the following precautionary statements:
WARNING! CAUSES SEVERE EYE DAMAGE AND SKIN BURNS. COMBUSTIBLE LIQUID AND VAPOR.
Do not get in eyes, on skin or clothing. Wash thoroughly after handling. Keep away from heat and flame. Wear goggles or face shield and rubber gloves when handling.
FOR INDUSTRIAL USE ONLY
After this container has been emptied, it may contain ignitable vapors; observe all warnings and precautions listed for this product. Do not cut, puncture, or weld on or near this product.

First Aid

In case of eye contact – immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.
If swallowed – do not induce vomiting; give victim several glasses of water and see a physician.

Shipping and Packaging

ZOLDINE MS-PLUS Moisture Scavenger is classified as a Class 8 (corrosive) material by the U.S. Department of Transportation (DOT). The bill of lading description used by ANGUS is:
CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S. (OXAZOLIDINE/N-ETHYLETHANOLAMINE)8,UN3267,III. IN CASE OF EMERGENCY USE DOT GUIDE 153 ATTACHED.
TRADE NAME = ZOLDINE MS-PLUS

Shipping Containers Net Wt

5-gallon steel drum 35 lb
55-gallon steel drum 400 lb

Storage Conditions

ZOLDINE MS-PLUS Moisture Scavenger is supplied under a nitrogen atmosphere. If the entire contents of the container are not used, the remaining product should be stored under nitrogen in order to eliminate any chance of contamination by moisture.

Product Stewardship

ANGUS encourages its customers to review their applications of ANGUS products from the standpoint of human health and environmental quality. To help ensure that ANGUS products are not used in ways for which they are not intended, ANGUS personnel will assist customers in dealing with environmental and product safety considerations. For assistance, Safety Data Sheets, or other information, please contact your ANGUS representative at the numbers provided in this document.

When considering the use of any ANGUS product in a particular application, review the latest Safety Data Sheet to ensure that the intended use is within the scope of approved uses and can be accomplished safely. Before handling any of the products, obtain available product safety information including the Safety Data Sheet(s) and take the necessary steps to ensure safety of use.