US Ink® A Division of Sun Chemical Corporation

Printing UV Inks on Coldset Web Presses

Volume *XXXIX*

Introduction

Printing with inks that cure with ultra-violet (UV) light is not a new concept. Interest began in the late 1960's and became more wide-spread during the 1970's. For example, interest in UV curing inks began in the beverage industry in the early 1970's due to their high dependence on natural gas for energy to cure their solvent based inks and coatings. The switch to UV inks that used the more readily available electrical energy led to substantial cost savings. In addition, the UV curing process does not yield the emissions of volatile organic compounds (VOC's) that are in the solvent based or heatset printing process. These combined benefits of energy savings and reduced VOC emissions helped spur growth of printing with UV curing technology over these past decades.

What is relatively new is the emergence of printing UV inks on traditional coldset web or newspaper presses. As the coldset print market has shrunk, press capacity has increased. Thus, coldset printers have been looking for ways to use this under utilized capacity. One way was to expand into the coated web print market. Unfortunately, these presses use coldset inks. These inks will not dry or absorb into the coated paper and will smear. This non-drying issue on coated paper could be overcome with the use of heatset inks, but that meant installing ovens. The initial equipment expense, lack of space and the increased VOC emissions problems usually did not justify the investment. A relatively lower cost investment in UV lamps which took up little space and does not emit VOC's was a logical step for those printers wishing to further utilize their equipment and expand their markets.

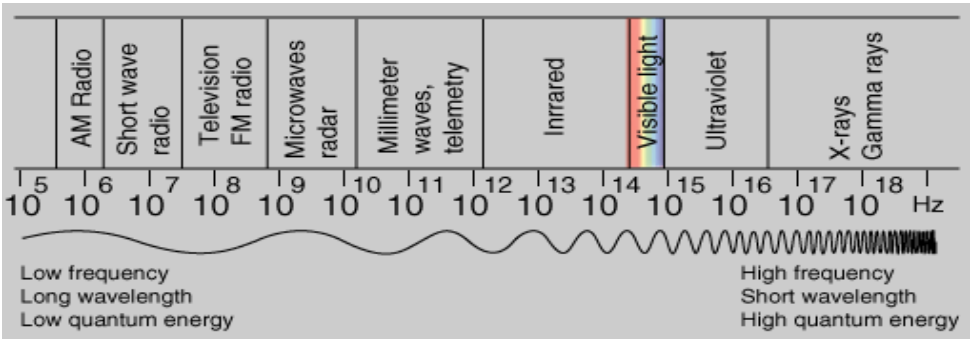
As with all transitions to a new process, there is a learning curve. This includes not only the printer, but the equipment suppliers (i.e. lamps) and consumable suppliers (i.e. ink).

This white paper is put together as a primer for those interested in printing UV on traditional coldset presses, for those still in the learning curve stage and as a refresher for those actively engaged in this process. Many of the important basics, features and expectancies are highlighted. This short list was selected based on a compilation of first-hand experiences, lab work, interviews, and literature searches.

Ultra - Violet Curing Ink Basics

Ultra-violet light or UV light is the name for a region of wavelengths in the electromagnetic spectrum. It is a region of higher energy than the visible portion of sunlight. This is the same radiant energy region that causes skin to sunburn.

Electromagnetic Spectrum



This energy can be used to start a chemical reaction in specially formulated inks which leads to a solid or cured ink film. These inks are called UV inks.

Conventional ink components

Petroleum oils
Pigments
Resins
Additives

Conventional coldset web inks are petroleum oil based. They typically do not dry or cure and are just absorbed into an uncoated substrate.

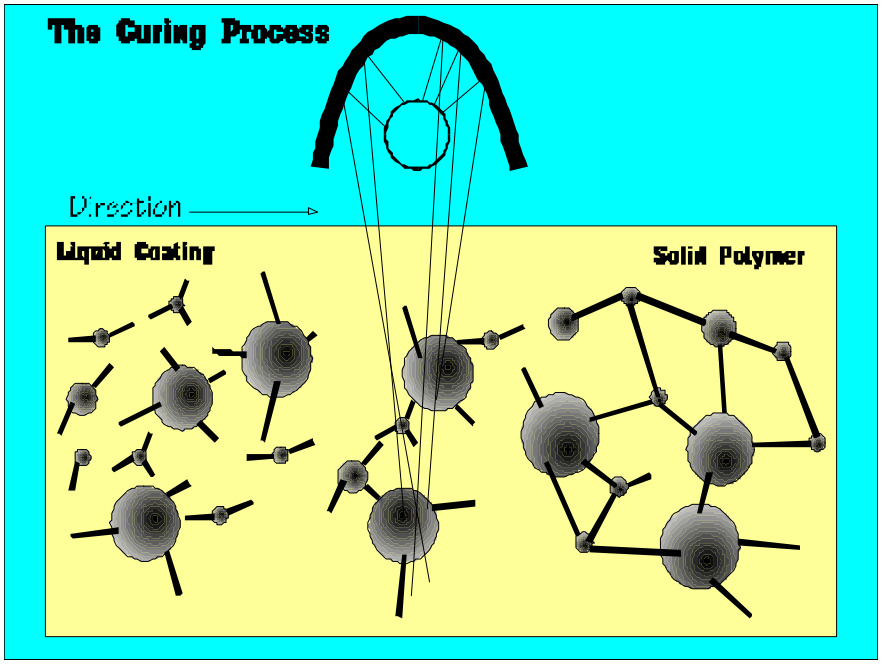
UV ink components

Oligomers
Monomers
Pigments
Photoinitiators
Additives

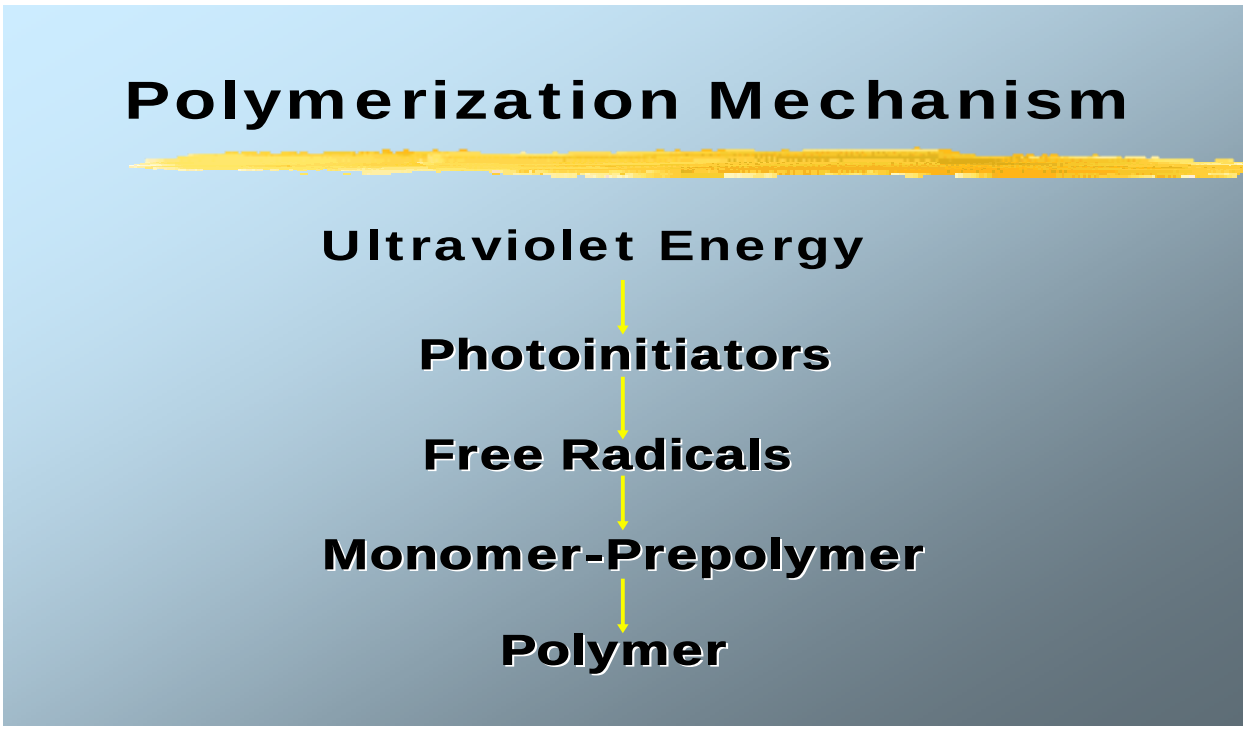
UV inks are acrylate based. They are highly reactive when in the presence of photoinitiators and exposure to ultra-violet light. This combination causes a polymerization reaction and a wet ink film will increase in viscosity until it solidifies or hardens. A completely solid film would be considered "cured."

UV Curing Process

A UV ink film is printed on a substrate and then passes under a UV lamp. The photoinitiators in the wet ink film are highly reactive when exposed to UV energy and generate free radicals. These free radicals then react with the oligomers and cause them to cross-link or polymerize so they very rapidly become solidified or cured.

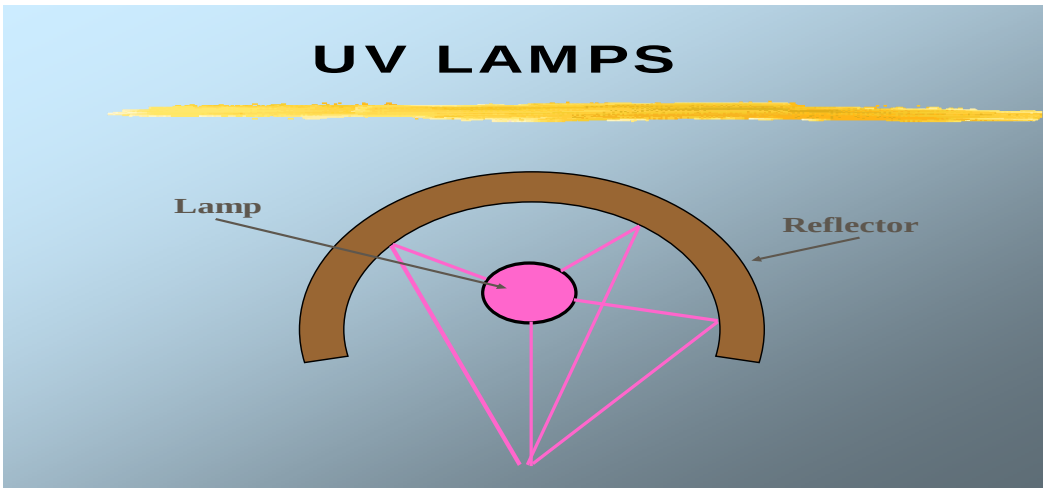


UV Curing Mechanism (or Method)



UV Lamps

Special lamps have been designed to generate ultra-violet energy. With the use of reflectors to focus the energy, these lamps can direct sufficient energy to a printed substrate to start the polymerization reaction. The amount of UV energy absorbed by the printed ink film will depend on the power of the lamps and the speed at which the printed substrate moves past the light.



Main Advantages of Printing UV Inks vs. Conventional Coldset Inks:

Virtually instant cure resulting in sharper images (less dot gain)

No marking, rub or set-off.

Ability to print on wider range of substrates from newsprint to supercalendared to coated papers.

Solvent free inks – virtually no VOC's – do not require additional emissions or permitting costs

Main Disadvantages of Printing UV Inks vs. Coldset Inks:

Significant capital investment

Less robust printing process – narrower water window

Ink Cost – high cost specialty acrylate raw materials used in UV inks

Ink Pumping Issues – chemical reactive barriers to pumping effectively and economically.

Safety concerns – possible skin irritation if not handled properly

Press Considerations

Press Speeds

A printed UV ink film must be exposed to sufficient UV energy for complete curing to occur. A printed UV ink film on a moving web traveling through a UV lamp housing will be exposed to UV energy. The amount of energy absorbed is dependent on the UV lamp intensity and the press speed. As the web speed increases, the amount of energy exposed to the printed film on the substrate decreases. This is called the dwell time and the amount of energy absorbed is called the dose. Curing speed will be dictated by web speed, lamp power and the reactivity of the inks. For faster press speeds, higher intensity lamps and highly reactive UV inks are required – both of which have costs associated with them.

UV Lamp

UV lamp suppliers can provide the necessary UV lamp equipment to meet the energy requirements for the desired press speeds. As press speed increases, the amount of energy required to cure the ink also increases. Therefore, lamp energy (or wattage) must be increased as press speed increases. The lamp intensity can be varied by press control systems that have been designed to do this automatically.

Inerting (or nitrogen blankets)

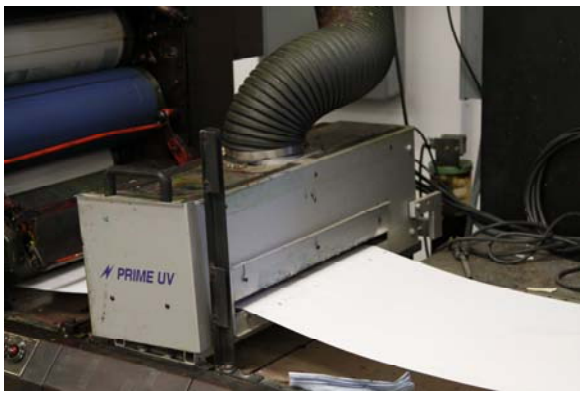
The presence of oxygen in the atmosphere hinders the UV ink curing process because it reacts with the free radicals formed during the UV curing process. Less of these free radicals will be available for the polymerization process and either increased lamp power and/or more of the expensive photoinitators will be required to overcome this free radical consumption - both of which have costs associated with them.

To make the UV curing process more efficient there are systems designed which displace the oxygen between the UV lamp and the substrate and replace it with nitrogen - often referred to as a nitrogen blanket. This is effective because nitrogen is not reactive or inert when exposed to the free radicals making more efficient use of the energy generated by the UV lamp and the subsequent free radical availability. This process is more commonly called inerting.

Of course, this increase efficiency will come at the expense of the increased equipment cost. The cost and benefits of using or not using this process can be discussed in more detail with the lamp equipment suppliers.

Lamp Housing Placement

Between printing units/couples (or inter-station curing)



This set-up creates the most desirable print product, but space between the units or couples on traditional coldset presses are usually not sufficient to install UV lamp equipment.

After 4 color printing units/couples (or wet trapping then curing)

Placing UV lamp equipment after printing the four color process is the most likely scenario for those with traditional coldset presses wishing to print UV. Typically, there is only enough space after the printing units or above a 4 color tower.

Both sides of the web (before touching any turner bars, idler rollers or angle bars)

The UV ink printed on paper must be exposed to the UV lamps before contacting any idler rollers or angle bars for it will smear the print and/or build-up causing further print defects in the non image areas.

Exhaust

Exhaust is necessary to remove the excess heat and small amounts ozone generated by the UV lamps. High energy lamps inside an enclosed housing will generate extremely high temperatures. Too high of a temperature and the paper could ignite and cause a fire. Therefore, exhaust fans are used to keep temperatures at a safe level when air is exchanged properly.

Also the ozone created from the mercury lamps will need to be exhausted into the atmosphere outside of the work area. Emitting ozone into the atmosphere is not a bad thing, but high ozone levels in an enclosed area can cause some health and safety issues – particularly respiratory concerns. This is why the EPA often uses the catch phrase **"good up high, bad nearby."**

UV Coldset Press Conversions

Ideally, the UV lamps will be placed directly above the last print couple on both sides of the web but, many times there is lack of space depending on the height of the ceiling, the distance between the last print couple and the first angle bars and/or the press configuration itself. Regardless, the UV lamps will need to be placed *after* the last print couple and *before* any roller bars.

Most printers in the States have dedicated units/towers for UV instead of switching back and forth between UV and conventional inks. The reason that many choose not to switch back and forth between chemistries is because it is a time consuming process. Still, some do it.

A complete conversion process would be as follows:

Converting from Conventional ink to UV ink

First, the conventional ink must be completely removed from the fountains, blankets and roller train. Residual conventional ink must be minimized to prevent contamination because it will not cure. If contamination occurs, then the printed UV copies could smear until all of the contaminated ink is used. The uncured printed inks could also transfer to the roller bars. This can transfer back to the printed copies even if the print is starting to cure before reaching that point. Thus, the conventional ink in the fountains must be emptied and wiped down to metal. The blankets and the entire ink roller train must be washed thoroughly with *conventional press wash*.

Next, the blankets and rubber rollers should be conditioned with UV roller compound prior to exposing to UV ink. UV roller compound is basically UV ink without the pigment. This compound will need to idle on the rollers for a period of time before thoroughly cleaning off with *UV press wash*. Typically, 15-20 minutes. This procedure will result in faster start-up and

improved print quality because it ensures a more complete removal of the conventional chemistry from the process and allows the rollers to equilibrate with the new chemistry.

Finally, the UV ink can be placed in the fountain.

It may also be necessary to switch the fountain solution for best print results.

Converting from UV ink to Conventional ink

First, the UV ink must be completely removed from the fountains, blankets and roller train. Residual UV ink must be minimized to prevent contamination with the conventional ink. If contamination occurs, it is possible that some of the UV ink will be mixed with the conventional ink and printed on newsprint or some other uncoated paper. The ink used in this coldset process does not dry - it is only absorbed into the paper. Thus, any residual UV ink compounds mixed in with the conventional ink and not exposed to the UV curing process could possibly cause skin irritation problems with certain highly sensitive people.

Thus, the UV ink fountains must be emptied and wiped down to metal. The blankets and the entire ink roller train must be washed thoroughly with *UV press wash*.

Next, the blankets and rubber rollers should be conditioned with conventional roller compound prior to exposing to conventional ink. Conventional roller compound is basically conventional ink without the pigment. This compound will need to idle on the rollers for a period of time before thoroughly cleaning off with *conventional press wash*. This procedure will result in faster start-up and improved print quality because it ensures a more complete removal of the UV chemistry from the process. It will also minimize any residual UV materials from getting into the printed substrate to be handled by the public.

Finally, the conventional ink can be placed in the fountain.

Again, it may also be necessary to switch the fountain solution for best print results.

Once printers consider this time consuming procedure or even go through the process several times they usually opt to dedicate the units to UV.

UV Rollers

A very important and often misunderstood problem is the proper rubber rollers (and blankets) to use with UV ink and press washes. The wrong combination can cause swelling or sometimes shrinking which could be a very costly mistake.

EPDM or **ethylene propylene diene monomer** based rubber rollers (and blankets) are designed for dedicated UV printing applications. They are designed to resist the aggressive UV chemicals and UV solvents usually resulting in the best print quality. The problem many coldset printers have with these types of rollers is that they are incompatible with conventional petroleum oil based printing inks and solvents – and even press lubricating oils. They can swell with just brief contact.

Therefore, it is of particular importance not to contaminate these EPDM rollers with conventional petroleum oil based printing inks and solvents. This will always be difficult when both conventional and UV printing applications are being conducted in the same pressroom let alone the same press line. Thus, one mistaken application of conventional petroleum based ink and/or press wash could cause the EPDM rubber based rollers (and blankets) on the press to swell. This could possibly result in a need for them to be replaced - a very expensive mistake.

This is the reason why new coldset presses and conversions that will print UV have *vinyl nitrile (or nitrile)* rubber based rollers installed. These are sometimes referred to as hybrid rollers. These rubber rollers are compatible with both UV and conventional inks and solvents. This gives the printer the flexibility to switch back and forth between chemistries without the severe swelling and/or shrinking issues. This makes sense if there is any possible contamination between the two chemistries.

Please note that use of hybrid (vinyl nitrile or nitrile) rubber compounds still does not mean that the ink chemistries are compatible. They are not.

As outlined above, proper procedures and precautions must be taken to minimize contamination.

Consumables

As should always be the case, the printer should discuss their consumable selection with their supplier(s.) They should be able to recommend the best product(s) for their particular application/process.

UV Blankets

The same concepts apply to the rubber blankets as do for the rubber rollers. Many printers use blankets made specifically for either UV or coldset inks. Conventional (or butyl-n based rubber) blankets work best with conventional inks and UV (or EPDM based rubber) blankets work best with UV inks.

If deciding to use the UV only (EPDM) rubber blankets for optimal UV print results then, diligent care must be taken not to cross-contaminate them with conventional ink and press wash – or even press lubricating oils. It only takes one mistaken application to cause immediate swelling of the UV only blankets. This is the reason many UV coldset printers are using hybrid (vinyl nitrile or nitrile rubber based) blankets – to minimize the potential rubber swelling problems caused by cross-contamination of ink chemistries.

A good rule of thumb for any printing application would be to use the same rubber based material for both rollers and blankets.

UV Press Wash

UV press washes are specially designed to clean UV inks from blankets and rollers. These are much more aggressive solvents than conventional press washes because they have been modified to more effectively dissolve the very polar acrylates in UV inks. Therefore, it is possible that

these washes may be too aggressive for some rubber blankets and roller types. So, careful selection of press wash is needed to minimize these problems.

Off-line testing of press wash on the blankets and/or rollers is highly recommended before using on the press.

In addition, UV press washes are incompatible with the conventional (or *n-butyl* based) rubber rollers and blankets. These very aggressive UV solvents will severely swell these conventional rollers with minimal contact. Therefore,

UV press washes should be clearly marked for UV use only and kept a safe distance from any coldset presses or units using conventional (butly-n) rubbers.

UV Plates

UV plates are most desirable for this process. They are designed to hold up well to the aggressive UV wash up solvents. Although there are printers who do use the same plates as they do with their conventional coldset inks, this is not ideal because UV solvents can sometimes wipe the image right off the plate.

UV Fountain Solutions

As with coldset printing applications, a full gamut of fountain solutions are being utilized for UV coldset printing. The selection is based on the optimal results with any particular application.

Full acid

Mild Acid – most widely used fountain solution in the UV coldset application

Neutral

UV Inks

US Ink, a division of Sun Chemical, has specifically designed inks for UV coldset applications. There are inks available for most traditional coldset press conversions to UV. A sales representative will be able to direct you to the ideal product for your particular process or application.

UV Ink Handling and Pumping

There are handling and pumping issues to consider with UV ink that are different than those encountered with conventional ink. Most coldset presses have ink handling systems already in place. This would include a tank or container (tote or drum) an ink pump (piston, diaphragm, etc.) and piping leading to each fountain. These traditional ink handling systems typically will not work for UV inks. That does not mean a modified pumping system won't work for UV ink handling. Some of the issues, concerns and modification requirements are as follows:

Containers

UV ink in a properly filled and sealed container should have a shelf-life of at least 6 months. Longer shelf-life, up to 1 year, can be achieved if kept at ideal (temperature) conditions. This relatively short shelf-life expectancy is due to the fact that UV inks can start to polymerize *without* exposure to UV light. This can occur when the UV ink has little or no exposure to air (oxygen) and/or prolonged exposure to high temperatures. This is what is referred to as a *dark reaction* where the ink starts to polymerize and eventually becomes heavy and unusable. This dark reaction must be taken into account when deciding which ink container will be selected, where it is stored and how long.

A good practice is to follow the first-in, first-out (FIFO) rotation when consuming UV inks.

Returning empty containers to be re-filled with UV ink is not recommended because the ink could possibly be subjected to varying uncontrolled conditions – high temperatures and possibly light from an already opened container. Placing new ink into this container would create incomplete turn-over of ink and eventually lead to the above mentioned shelf life concerns.

One way disposable containers would be the ideal choice for minimizing contamination.

Pumps

Most conventional ink pumps are designed to move ink by high and low pressure differentials and the introduction of shear to promote flow. These designs are usually associated with both a vacuum (lack of air or oxygen) and heat (created by shearing). These are the two criteria that can hasten the dark reaction (or premature polymerization).

Seals

As mentioned previously, the rubber used for the seals in a pumping system would need to be specially selected to be resistant to UV inks. The same principles apply to the rubber seals as those for the rubber rollers and blankets.

Piping

The traditional carbon steel piping used with conventional inks is not recommended for pumping UV inks because trace amounts of iron and/or copper contaminants could initiate polymerization. Because of this potential, stainless steel piping is usually recommended for pumping UV inks.

Also, pipe diameter should be as large as possible and the distance from container/pump to press should be as short as possible to minimize pressure and shear requirements (heat).

In addition, a circulating loop system would continually shear the UV ink possibly creating a situation where the ink is under prolonged higher temperatures and increasing the possibility of a dark reaction. This scenario would be lessened with a dead-end system.

Basically, an ideal UV ink handling/pumping system would need to be a low pressure dead-end system with large diameter stainless steel piping of the shortest distance possible. Pump manufacturers and/or ink handling contractors should be able to guide the printer through the options best suited for their application.

Due to the greater expense associated with an additional ink handling system or the more expensive components required for pumping UV inks, many printers still handle their UV ink out of 3 ½ gallon kits or pails and place directly into the fountain by hand. This is why safe handling and hygiene practices are so important.

Safety and Handling

Material Safety Data Sheet (MSDS)

As with all inks and chemicals, a Material Safety Data Sheet (MSDS) will be available from their respective suppliers. These should be reviewed before receiving any chemicals you are not yet familiar with. They will warn of any material health and safety precautions. Then proper planning and training can be considered before receiving and handling these new materials.

General Safety Precautions for Handling UV inks

UV ink chemistry is different from conventional coldset ink chemistry and so are their respective safety and handling requirements. In the past, mis-handling UV inks oftentimes caused severe skin reactions or dermatitis. This is because many of the acrylate based chemicals selected for UV inks are much more aggressive than the petroleum based chemicals in conventional inks. Over time the careful selection of acrylate materials has minimized these problems. Even so, some people may still be over-sensitive to these chemicals. Therefore, it is imperative that proper handling procedures should be followed:

- Avoid contact
- Wear protective clothing
- Use gloves and barrier creams
- Wear eye protection
- Clean up spills immediately
- Dispose of wipes and rags properly
- Change contaminated clothing immediately
- Clean skin with soap and water
- Do not clean skin with solvents

Training

As with any new process, there will be a learning curve. Proper planning and training will help minimize this process and yield excellent results quicker. The equipment and consumable suppliers are always a good source of information. They can provide details of their first-hand experiences and even offer some training guidelines.

UV Coldset Expectations

Traditional coldset web printers can print UV inks successfully on coated web paper when the proper equipment, consumables and sufficient knowledge of the process is in place. Equipment and consumable suppliers can help with best selection of products for the printer's situation. Once knowledge of the UV printing process is understood, the coldset printer can achieve near heatset print quality and sometimes better.

The areas with the widest gaps between heatset and coldset UV are gloss and press speed. The heatset process has the distinct advantage of extreme heat and leveling – conditions that contribute to higher gloss. Also, heatset presses have been designed to print heatset ink and coldset presses have been designed to print coldset inks. Printing UV ink on a traditional coldset press at the press manufacturers top rated speeds have yet to be realized.