"So talk to me about curing...."

Our editor took a thoughtful sip from his coffee mug, crossed his feet on the corner of his desk and settled back for what he was sure would be a long discourse. The topic was water-based inks and his subject — a long-time/big-time garment printer — was ever a source of accurate details on the ins-and-outs of the industry's art, science and business.

"Well, it's really very simple. What you need is 300° for three minutes."

After a short silence, the editor, feet now on the floor, attempted to draw him out: "That's fahrenheit, eh?"

"Yep."

This time, a more lengthy silence. "That's it?"

"Yep."

Afterward, envisioning a full story-spread containing that single statement and followed by several blank pages in the space allotted to the article.... Suddenly, a smile lit his face. He reached for the intercom, thinking: delegate.

Later, in his office, the associate editor cradled the receiver between shoulder and ear and punched in his long-distance code. The assignment: Three hundred for three. A straightforward standard to live by? Or can anything in this not-so-simple business be that easy? (Don't count on it, nagged the reporter in him.)

He greeted the party on the other end of the line, explained his assignment, then leaned forward in anticipation and put the question on the table, "300 for three. Good advice?"

"Well," the voice crackled. "Yes ... and no. It all depends...."

The associate editor leaned back and propped his feet up on the corner of his desk.

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Taken at face value, a three-minute cure at 300°F is a reasonable insurance policy for water-based textile prints. It certainly mirrors the realities of water-based ink chemistry.*

*Advice in this article is intended for those printing textile using water-based ink formulated with acrylic binder systems. Curing practices may vary for systems with urethane and other binders.
"One of the most frequent questions we get," says ink manufacturer Bob Ryan (Spectrachem Corp., Paterson, N.J.), "is, 'Will it work like plastisol?' Absolutely not." Printers accustomed to plastisol invariably assume ink to be ink... but not for long.

Savvy plastisol users have learned to save time in the cure by increasing dryer temperatures and belt speeds, making an art form of getting the ink film up to that 320°F cure threshold just before it exits the tunnel (not to mention seconds away from burning the shirt). But with water-based inks? Don't even think about it. Raising dryer temperatures does little to speed cure—but it does a lot to increase risk.

**Don't touch that dial**

In plastisols, the liquid or carrier component (plasticizer) is one of the active ingredients, and a fully participating component in the cured ink film. It is absorbed by PVC particles when heated and, at approximately 320°F, those swelled particles melt together into a solid mass. In water-based inks, the carrier (water) may account for up to 90 percent of the ink by weight, but does not become part of the finished ink. It must, instead, be removed. And that's where the problems begin.

"People overlook the fact that when you boil water, it will get to 212°F and stay there until it is entirely evaporated," says Steve Horton (Plast-O-Meric, Sussex, Wis.). "So as long as you have water in the ink film, you can have your oven set at 400°F, even 500°F, but (the ink temperature) won't get any higher than the boiling point of water—well below cure temperature." In the meantime, Horton warns, "you do, however, remove the small amount of water in the garment, and then you can start to scorch it." So the joker is that without sufficient time for the water to boil off, the ink's remaining ingredients have no opportunity to cure.

"Undercuring is one of the biggest problems out there," says Ryan, "and the Wal Mart of the world are raising their standards." Some retailers, in fact, are beginning to conduct their own crock and cure tests on water-based prints and many chains aggressively follow up on returns due to lack of washfastness.

"If the resins aren't completely set, they will continue to be, to some extent, water soluble," says Garry Edwards (QCM Ink Co., Kent, Wash.). "The consequences of that are"...
are significant because the print is headed (ultimately) for a washing machine. "The rub is, even under perfect curing conditions, some print erosion will take place at that first washing. "It's not practically possible," says Edwards, "to have zero erosion."

While Horton maintains printing integrity can be achieved very near that 100 percent mark — and suitable to most clients — it's by no means a cake walk.

Several factors can, in fact, conspire to extend dry time. High pigment levels, for one: "Vivid colors are going to exact-

**W**ater-based inks cannot be spot-cleaned post-cure, and *resist* spot-cleaning pre-cure.

erbate the difficulties of curing," says Edwards. (See "Crock or Cure?" p. 120.)

Horton adds that retarder additives designed to prevent in-screen drying will tend to extend dry times as well.

And then there's discharge inks: "Discharge, classically speaking, is a steam-activated or wet process," says Charlie Leach (CHT North America, Lynchburg, Ohio). "Once the water disappears, the reaction doesn't take place. So in order to retain the water long enough for the action to take place, we and every manufacturer of discharge inks load the ink with a humectant to retain the water. This is why discharge drying has historically taken a long, long time." Too-efficient drying actually kills the reaction and results in dull colors.

And....

**Hobson's choice?**

At this point, those of you still nodding your heads in agreement probably haven't actually had to print much with water-based inks. But if you listen, you can hear those who have, shouting in chorus: So who's got three minutes?

"3:00 for three' is pretty realistic — if you can go out and buy a piece of equipment that will allow for a through-put time of three minutes and still maintain productivity," says Edwards. "Dollars will fix a lot of problems, but a lot of small- and mid-sized shops may not have that option."

Boxed in by market restraints — for instance, clients accustomed to paying 50 cents per print don't take kindly to paying extra to compensate for slower belt speeds or a second (or third!) pass through a dryer — most printers have been forced to find short cuts. "The whole (screen-print) culture is to run it through as fast as you can," says Edwards. "So in

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**On the Spot**

Unlike plastisols, water-based inks cannot be spot-cleaned post-cure and are extraordinarily resistant to it pre-cure as well.

According to CHT North America's Charlie Leach, water-based inks cure on something of a continuum. A print gains a certain amount of washfastness — and spot-clean resistance — almost immediately. "Even without heat, some color will remain if you just air dry it," says Leach. As a print dries completely and then is cured, the inks approach 100 percent washfastness (due to their essentially water-soluble nature), but become absolutely imperious to conventional spot-cleaning fluids.

Even limited success spot-cleaning water-based prints requires vigilant inspection and spotting immediately after removal from the press. "It's got to be instantaneous. Not only pre-cure, I mean pre-air-dry," Leach insists. "If it air-dries, nothing will take it out."
Over, under, around and through: Multi-level dryers, the belts of which increase retention time, effectively place as much as 30 feet of heat into 10 feet of floor space.

 practice, many ovens are running at times below the manufacturers’ recommendation.”

Under the gun, printers often compensate — or attempt to, anyway — chemically.

**Beating the clock**

Chemical cross-linkers are used both to insure maximum washfastness and, in the case of certain types which cross-link the binder without the aid of heat, to shorten oven-time requirements.

“A lot of big producers use both heat and a chemical cross-linker, even though the chemical cross-linkers are expensive,” says Leach. Most expensive are so-called “room cure” catalysts, which can cure the ink without any heat. Of this variety, Leach points out: “We’ve gotten some big producers that use it in everything they print because they don’t want to slow down production. All they have to do is get (the ink) dry enough to stack (the garments), then this goes ahead and cross-links it.”

A cross-linker, however, is no cure-all. “It’s actually only helpful once you reach the curing stage,” Leach explains. “When you have borderline cure — which lot of people have — adding cross-linker will increase the washfastness.” Unfortunately such does nothing to shorten the dry time, by far the lengthier portion of the process (See chart, p. 122.)

As a result, many printers attack that problem by displacing water with something that evaporates faster. “They’re adding solvents,” says Edwards. And in that he sees an ultimate irony: in an attempt to make their water-based inks competitive with plastisols, printers may concoct an ink system (adopted in part out of environmental concern) that’s non-compliant with environmental regulations. “Unfortunately, some of the most effective solvents are the most deleterious,” Edwards explains. “They can ring environmental bells in several levels of regulatory enforcement.” (Such may also be the case, by the way, with some room-cure catalysts.) Inks that bear but trace amounts of solvents off the shelf, Edwards maintains, may contain up to 25 percent solvents by the time they go on the shirt and, at clean-up time, down the drain. Such practices have gone largely undetected, until recently. But, warns Edwards: “Waste-water enforcement is just starting to warm up.” For screen printers, in fact, effluent issues are likely to become the ‘90s environmental hot spot. (For more
information, see related stories, this issue, pages 130 and 146.)

**Beating the system**

Leach suggests a safer way to reduce water content is, simply, to use less ink: “Water-based inks, unless you thicken them, don’t tend to give you a surface deposit.” Instead, they soak into the fabric. Beyond a certain point, though, a heavier ink deposit may more deeply saturate shirt fibers but add little to print appearance.

Thus, maintains Leach, finer and finer meshes may be employed to lessen ink deposits, without a noticeable affect on the print: “It turns out with a transparent system — and that’s what water-base is, primarily — mesh becomes rather academic. And you can get by with a lot less dryer using 230 rather than 100 mesh.” He adds that minor variations can be adjusted by increasing pigment/binder content.

Surprisingly, Leach even recommends such practices for printers of dark substrates. “Even in the high-opacity systems,” he contends, “we can get beautiful white on a black garment through 156 and 178.”

**Crocking can be caused by a too-high pigment-to-binder ratio.**

“What’s the least I need?” There’s no easy answer to this.

Few printers are unaware these days that the convection oven (usually gas, since gas is far more efficient than electric) is considered the optimal — and by many, the only — way to dry/cure water-base inks because, the argument goes, such dryers heat and circulate massive volumes of air.

Yes, many infrared dryers now feature forced air, yet Horton says they, and (here’s a surprise) some highly touted gas dryers as well, lack one water-base essential. He says many dryer designers — based on the knowledge that plastisols typically contain little or no VOCs — sacrifice exhaust in favor of air-recirculation on the logic that it requires far less energy to keep reused air at optimum temperature than to heat up room air.

**Crock or Cure?**

The test print you just pulled from the dryer belt feels dry, but as you casually rub your hand over the print, you notice color on the tips of your fingers. You know you’ve got a problem, but it’s unwise to assume it’s undercure without further investigation. It may, in fact, be a crocking problem...

Crocking, or the dislodging of pigment from an ink’s binder by abrasion, can occur when the pigment-to-binder ratio is too great — simply, there isn’t enough binder to trap and hold the pigment in the ink. A simple test consists of taking the print to the washout sink and running a stiff water spray on it for a few moments. Observe the print: If color runs, but there is no degradation of the image itself, seek your solution in the ink department. If the print itself is eroding away, however, the place to start troubleshooting is your dryer.

Technical advice courtesy International Coatings Co. applications specialist Tim Johnson.
The critical difference between plastisol and water-based inks, dryer-wise, is the water: until it's gone, your ink is stuck at 212° — and won't cure no matter how long it's in the oven.

Which is great for curing plastisol, Horton says. But he insists that, with water-base, precisely the opposite is required. The dryer must remove water-laden air and replace it with fresh, dry air. "And that requires a large amount of exhaust and energy." And, you can bet, more money.

With anything less, though, Horton says there's a risk: "You can run the first few garments through, do a wash test, and things look dandy, but when your oven air is saturated, you're going to have failure."

Then, Ryan warns, even "300 for three" isn't protection enough. "You can have three minutes at three hundred degrees, but if that air is humid inside the chamber, you're still not going to get that ink dried."

**Theory and practice**

Okay, so our "300 for 3" maxim doesn't make water-based curing the breathtakingly simple procedure it might have been. While a good standard in theory, in practice (and ain't it always so?), it's a standard few can stand to live with. But that doesn't make it useless. Rather than the end of the discussion, perhaps it's best seen as a place to start.