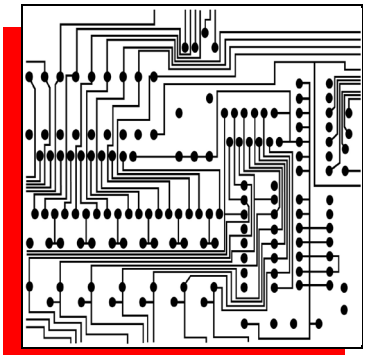
TECHNICAL DATA / **PRINTED CIRCUIT BOARD FILM**

Customer Guide to Plotting and Processing PCB Films



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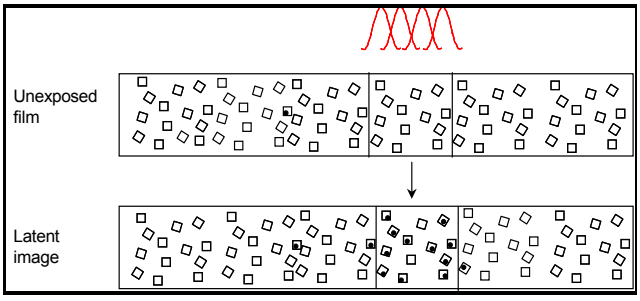
You have chosen to use Kodak film for your photoplotting needs. We believe that you have selected the best quality film available for your production. In this publication we want to help you get the very best results from our product.

We want to show you how the right film, correct exposure, good processing, together with sensible maintenance will produce consistent high quality results in terms of line width and line edge.

How Film Works

Let us begin by briefly examining how film works. When you expose your film in the plotter, the light energy from the laser interacts with the silver halide crystals suspended in the coated gelatin layers. Invisible changes occur to exposed silver halide crystals with the formation of the latent (hidden) image. Development, a chemical process, converts exposed silver halide grains into metallic silver: the latent image catalyses the reaction and the image becomes visible. The next step in the chemical process is fixation. The fixer stops development and removes the unexposed silver halide grains in non-image areas. Left within the film, these would eventually react with ambient light, turn into silver grains and make the film brown.



Following development and fixation are the important steps of washing to remove residual chemicals, and drying.

In a subsequent section more information will be provided on optimizing the processing of your films.

Precise Plotting

The important goal of this stage is to expose your film correctly so that with optimal processing, you obtain high quality phototools that give the correct line widths when used for imaging onto photoresist.

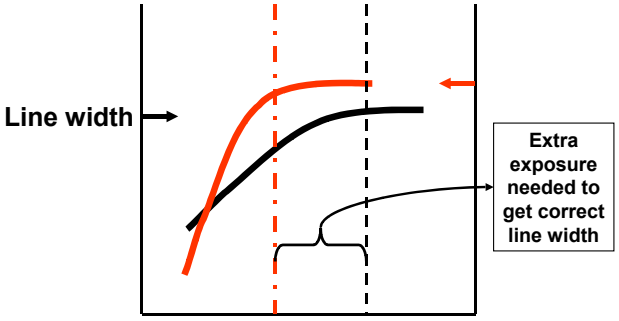
Before adjusting anything on the plotter, make sure that the processor is set up correctly for the film you are using. Look at the film technical data sheet for the required processing conditions. Dilute and mix the chemicals as directed, and set the time, temperature, and replenishment rates to recommended values.

Now you are ready to carry out an "exposure series." Some plotters enable you to do this very quickly, as you can run different exposure values on the one plot. Often you have already been running a film, so you can choose a relatively narrow range of exposure values, say +/-30% of the setting that you have been using. If you are changing plotter resolution or starting with a new film in a new plotter, a broader range of values will be needed for the first experiments.

Most plotter manufacturers also supply a test file with different line widths and patterns. There should also be a patch of maximum density so that you can check its value. Do the exposure with this file if possible, and process the film. Check the D-max with a densitometer. The value should be between 4.5 and 5.0. If you do not have a densitometer carry out the following procedure. Examine the pattern first with the naked eye and then using a 50x or preferably 100x lens. With the unaided eye you should be able to tell almost immediately if the initial selection of exposure values is in the right range. If the film is overexposed, it should be obvious on equal line and gap patterns (and particularly on narrower line widths below 30microns), that there has been "fill-in"; the lines have grown to fill the gaps. In the opposite case of underexposure, the smaller width line and gap patterns may not appear at all.

Evaluation and Process Control

One note of warning on D-max measurements: do not think that measuring maximum density alone is sufficient to establish the correct exposure value. In an ascending series of exposure values, you will almost certainly attain a suitable maximum density value before the correct line width (see graph: density=red, line width=black).



Once you have established that you are in roughly the right range, look at the patterns with the lens and measure the line widths if you can. Choose the exposure value where the line widths are closest to their intended values. If necessary, run another test with a narrower range of exposure values.

On some plotters, if you change the resolution you will also need to determine a new exposure value. As a rule of thumb, a higher resolution than the current one will require a lower exposure intensity, and vice versa for a lower resolution.

Once you are running production films, you will want to monitor your film exposure process. Many customers do a daily measurement of line width and plot charts. These can be used as a statistical process control, once control limits have been established. Remember to react only to trends in data and not minor excursions.

Perfect Processing

As explained above in "How Film Works," processing is a series of chemical reactions that reveal the latent image and stabilize it so that phototools can be safely archived. In Kodak's laboratories, film design is integrated with the processing chemicals to give optimal image quality. Although reasonable quality images may be obtained in other manufacturers' chemicals, the best results can only be guaranteed using Kodak film with Kodak chemicals.

Let's look at processing in a little more detail. The latent image produced during the plotter exposure needs to be converted into visible silver grains. The chemistry of development is complex, but the important features for our understanding are that the developer contains a developing agent (usually hydroquinone) together with other chemicals that restrain development. These latter are necessary to prevent "fog" formation, developed silver unrelated to light exposure.

Development

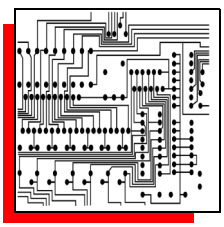
Development occurs most efficiently at a high pH (alkaline, around 10.5 in KODAK ACCUMAX Rapid Access Developer and Replenisher). During development, chemical by-products are produced which tend to reduce the pH, so the developer contains buffering chemicals that help maintain this high value.

In today's films there are other chemicals that enhance the development process to give very high contrast images with smooth line edge quality. Some manufacturers incorporate these chemicals in the film, while others divide them between the film and the developing solution. This is why films may not develop optimally in another manufacturer's chemicals.

It may be helpful to think about development in the context of chemical reactions. These reactions proceed most efficiently when the concentrations of the various components are optimal and other conditions, such as temperature and pH, are correct. We explained earlier that Kodak's film design and chemicals have been optimized with each other to give the best quality results; this is the basis for our processing recommendations.

Within the context of seeing development as a chemical process, replenishment is particularly important, as it serves to maintain developer concentration, remove unwanted by-products, keep the pH stable, and a number of other functions.

Some manufacturers distinguish between replenishment for developer use and oxidation, and call replenishment for the latter "anti-ox." But the same solution is being added, so when you are comparing different manufacturers' replenishment rates, remember to add both together and that will give the total budget for developer solution.



Fixation

Fixation is another chemical process and is necessary to stop the development reactions and obtain a stable image. In contrast to the developer, the fixer is quite acidic (pH between 5.1 and 5.5), which stops further development. Fixer also contains thiosulphate, which dissolves the unexposed silver halide out of the film. As the fixer is acid, it is important not to let it contaminate the developer.

Fixation also helps remove some dyes from the film.

Just like during development, fixer is consumed during the process, and materials washed out of the film build up in the fixer tank. Fixer replenishment helps to counteract these processes.

One of the factors that reduce the efficiency of the fixer is the build up of silver that forms complexes with the thiosulphate. At high levels of silver these complexes become unstable, and silver drops out of solution, forming a black sludge in the bottom of the fixer tank. If you are processing films with a low area of exposure, this problem could be particularly severe. It is also possible that silver/thiosulphate complexes could be carried over to the wash where they may break down, depositing silver in the wash tank with the possibility that silver particles may stick to the film. Such problems may be largely avoided by the use of a silver recovery process. This removes the silver from the fixer, preventing the formation of the unstable complexes. Over a few years such a unit will also save the customer money.

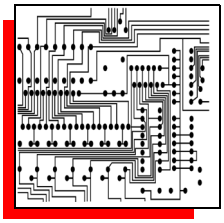
Washing and Drying the Film

Following adequate fixation, it is important to wash the film to remove residual processing chemicals and by-products.

Most customers use ambient temperature water. Heating the water improves the efficiency of the wash, but also encourages microbial growth. The latter is the major problem associated with the wash phase. But careful processor maintenance and judicious use of biocides will reduce the problem.

The water replenishment rate should be at least 1 litre per minute.

The chemical and wash phases are complete and all that remains is to dry the film. At this stage the most important factors are adequate drying of the film while maintaining good dimensional stability. Kodak PCB films have different gelatin content, and it is important to match the drying temperature to the particular film. In principle, single-sided films require a lower dryer temperature than double-sided ones. Drying efficiency and thus the set temperature will also be dependent on the ambient humidity. The configuration of the dryer and size of film being used will also influence the efficiency of drying. Ideally, drying should be slow at a moderate temperature. One advantage of the 45 second development time is that it allows ample drying time at moderate temperatures, lessening the risk of changing the film's size.



Processors

Most processors will give good results, but the features of some machines lead to more efficient processing.

Remember that processing comprises of chemical reactions between the film and the developing and fixing solutions. In a deep, narrow tank, the volume to surface area of the tank is greater than in a shallow tank. This means that there is relatively less oxidation of the developer at the surface and the developer tends to be more stable.

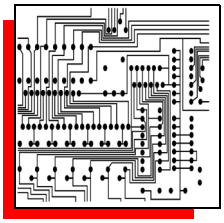
Another feature which will have a small influence is the number of "roller strikes"; the more there are, the more likely you are to obtain even development across large sheets.

Additional features that are desirable in a good processor are filter units to keep the various solutions clean, recirculation pumps to aid mixing of replenishment with existing solutions, and level sensors.

There are other considerations when choosing a processor. How easy is it to clean? Are the racks easy to remove and the rollers accessible for wiping off? What are the control features for turning the machine off at night or over the weekend?

Five Keys to Successful Processing

1. **Correct chemical dilution.** You do not need to be extremely accurate about dilution – use the containers themselves and remember to keep count! If you are using a mixer, make sure the values are input correctly. Mix well to obtain an homogenous solution.
2. **Set the replenishment rates correctly.** For ACCUMAX Rapid Access Developer and Replenisher this is 350 mL/m^2 and 540 mL/m^2 for the fixer. You might think that you are saving money using lower rates, but the recommended values will ensure good and reproducible image quality over the lifetime of a developer batch. If you are processing less than 20 to 30 films a day (24" x 24"), you will need to add extra replenishment so that the total amount of developer exchanged in a week is one tank turnover (25 L). Adjusting the level of anti-ox does this.
3. **Set the development conditions correctly.** For most of our films development time should be 45 seconds at a temperature of 35°C (95°F). Slight deviations from these values will not affect the quality of processing, but lowering the temperature to, say 30°C (86°F), will seriously affect density and probably line width. Severely shortening the development time will also compromise image quality.
4. **Set the fixing and drying conditions correctly.** The fixing temperature should be between 32 and 35°C (90 and 95°F). Too low, and fixation may be inefficient; too high and losses due to evaporation will be excessive.
5. **Maintain the processor properly.** Racks should be cleaned once a week. Do not use abrasive materials, which might scratch the rollers. Filters should be changed when the chemicals are changed, or sooner if it is thought they are blocked. Some users may wish to use systems cleaner once a month or when the chemicals are changed.



Your Questions Answered

Q. Why does the developer go brown over time? Is it harming the process?

A. The most important component in the developer is the hydroquinone. This compound interacts with the oxygen in the air to produce a brown compound. Although it is unsightly, this does not affect the development process or stain the film. Sulphite in the developer helps prevent this oxidation.

Q. How important are time and temperature settings in development?

A. If you follow the manufacturer's recommendations, your processing quality should be consistent. If you suspect some fault with the processor, check the temperature of the different tanks and the time of film passage. Slight variations (5% or less) will not affect the quality of processing.

Q. What should I do if the film is not developing properly?

A. Check the dilution of the developer. Check that you are using the correct time and temperature settings. Make sure that the developer has not somehow been contaminated with fixer. Check that the replenishment and recirculation pumps are working.

Q. How often should I change the processing chemicals?

A. About every six weeks, depending on the use of the recommended replenishment rates. A low replenishment rate will either cause exhaustion or over-activity of the developer depending on the amount of film being used, but in both cases will lead to earlier exchange of the chemicals.

Q. Do I need to check the pH of the developer and fixer concentrates?

A. No, this is not necessary. This is rigorously checked at the factory using instruments that are maintained and calibrated according to international standards. Local measurement of pH in the concentrated solutions is very difficult and prone to serious error.

Q. Sometimes the film comes out with a blue or pink tint. What does this mean?

A. The films contain various dyes: sensitizing, anti-halation and safelight protection dyes. Normally these are decolorized and/or washed out in the developer and fixer. If the processed film has a colored tint it is most likely that there is something wrong with development. There are many possible reasons: pH too low, wrong dilution, exhausted, temperature too low, poor agitation, one or other of the replenishment and recirculation pumps faulty.

Q. My films have a milky appearance.

A. Most likely, fixation is not working properly. Check the dilution of the fixer; make sure that replenishment is at recommended levels; check function of the pumps; when was fixer last changed?

Q. How can I prevent drying marks on the back of my films?

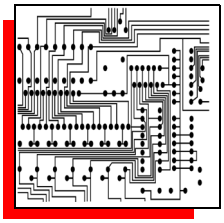
A. Check the alignment and condition of the squeegee rollers just prior to the dryer. If water is being recycled you might consider adding some detergent to improve film wetting. If the water is "hard," consider installing a water-softening unit.

Q. How can I stop bio-contamination of the water tank?

A. Every user occasionally encounters this problem. Good maintenance can help limit the occurrence and inconvenience of these episodes. One of the most effective procedures is to thoroughly clean the wash tank using a small amount of bleach, then rinse thoroughly and allow complete drying before refilling. If possible, fit filters to the water supply. Overnight and/or the weekend add some biocide to prevent growth in the standing water.

Q. How do I know that my process is in control?

A. If you have chosen the correct exposure value on the plotter to write your chosen line width, and the processor is operating at the recommended settings for time, temperature and replenishment, then processing quality should be maintained over the life of the developer (about five to six weeks).



NOTICE: The sensitometric curves and data in this publication represent product tested under the conditions of exposure and processing specified. They are representative of production coatings, and therefore do not apply directly to a particular box or roll of photographic material. They do not represent standards or specifications that must be met by Eastman Kodak Company. The company reserves the right to change and improve product characteristics at any time.

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