

3 PROCESSING STEPS

Processing KODACHROME Film

Introduction

This section contains general information on films, chemicals, processing procedures, and process equipment used in Process K-14M. The methods and procedures described in this manual are presently recommended for processing KODACHROME Film. In some cases, even minor variations in these procedures and methods can cause significant degradation of film quality.

Film Structure

KODACHROME Films are reversal, subtractive color materials. When properly exposed and processed, they yield direct positive color images.

The illustration on page 3-4 is a cross section (not to scale) of KODACHROME Film that illustrates changes to the film during the process sequence. The transparent support (film base) has an antihalation backing layer called rem-jet. The rem-jet minimizes reflections of exposing light off the inner surface of the support, once it has passed through the film layers. These reflections cause "halo" images and loss of apparent sharpness in the processed films. The rem-jet backing is removed during the processing cycle.

The film base has a substratum (subbing layer) that provides adhesion of the light-sensitive emulsion layers to the film base. The subbing layer is followed by a red-sensitive emulsion, an interlayer, a green-sensitive emulsion, an interlayer, a yellow filter layer, a blue-sensitive emulsion, and finally, a protective gelatin overcoating. Although the red-sensitive layer is mainly sensitive to red light and the green-sensitive layer to green light, both of these emulsion layers are sensitive to blue light. The yellow filter layer absorbs the blue component of exposing light, preventing blue light exposure of the blue-green-sensitive and blue-red-sensitive emulsion layers.

Film Exposure

The best photographic results are obtained when the film is exposed as recommended in the film instructions. The processing laboratory must then have a well-controlled process to provide the customer with the best possible slide or transparency.

When the film is exposed, latent images are formed in each of the three emulsion layers. The blue-sensitive emulsion layer contains a record of the image created by the blue component of the exposing light; the green-sensitive layer contains the image formed by the green component; and finally, the red-sensitive layer contains the image formed by the red component of the exposing light. The records of the images are all formed simultaneously and are exactly superimposed.

Films

Use Process K-14M for the following 35 mm films:

| Name | Film Code | Letter Code |
|----------------------------------|-----------|-------------|
| KODACHROME 25 Film (Daylight) | 5073 | KM |
| KODACHROME 64 Professional Film | 5033 | PKR |
| KODACHROME 64 Film (Daylight) | 5032 | KR |
| KODACHROME 200 Professional Film | 5002 | PKL |
| KODACHROME 200 Film (Daylight) | 5001 | KL |

Processing Steps

Backing Removal Solution

The alkaline backing removal solution converts the rem-jet antihalation backing on the film base into a water-soluble form. This backing is removed in the backing removal wash.

Backing Removal Wash

This wash performs two functions:

1. It removes the backing removal solution from the film.
2. It completely removes the solubilized antihalation backing from the base by a combination of water action and mechanical buffing.

First Developer Solution

In the first developer solution, the exposed silver halide grains (latent images) are reduced to metallic silver by the action of Phenidone* and hydroquinone developers:



The resulting silver grains form three superimposed negative images of the original scene, one image in each of the red-, green-, and blue-sensitive emulsion layers. The remaining (unexposed and undeveloped) silver halide in the three emulsion layers constitutes the positive (reversal) images that are later converted to full-color images in the color-development phases of the process.

First Developer Wash

This wash stops the development and removes the first developer solution from the film.

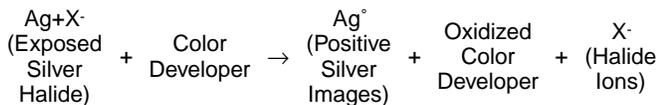
* Phenidone is a trademark of Ilford Limited.

Red Reexposure Printing Step

The red reexposure printing step completely exposes all of the remaining silver halide in the red-sensitive (bottom) emulsion layer so that the silver halide develops completely in the cyan developer solution. At the same time, exposure of any remaining silver halide in the blue- and green-sensitive layers must be avoided to prevent unwanted cyan dye development in these layers. This selective exposure is obtained by printing through the base side of the film, using a properly selected red glass filter in the light beam. The green- and blue-sensitive emulsion layers have no intentional sensitivity to red light and should therefore remain unaffected by the red-light exposure. However, some green-sensitive emulsion layers do have a slight, but significant, red sensitivity, and accurate control of the red printing intensity is necessary.

Cyan Developer Solution

In the cyan developer solution, a positive silver image is formed in the red-sensitive layer by the action of the color developing agent on the silver halide that was exposed during the red printing step.



Simultaneously, the resulting oxidized color developer combines with the cyan coupler to form a positive cyan dye image. This image is deposited only in the red-sensitive emulsion layer.



The simplified equations given above typify the development and coupling reactions that also take place in the yellow and magenta developer solutions. Actually, the reactions are more complex than indicated.

If any red-sensitive halide is left undeveloped, unwanted dyes will be produced in the red-sensitive layer during later color development stages.

Cyan Developer Wash

This wash stops cyan development and removes the cyan developer solution from the film.

Blue Reexposure Printing Step

In this printing step, all the remaining silver halide in the blue-sensitive top emulsion layer is exposed so that the silver halide develops completely in the yellow developer solution. At the same time, exposure of the remaining silver halide in the green-sensitive layer (which is also blue-sensitive) must be avoided to prevent unwanted yellow dye development in the green-sensitive layer. This selective exposure is obtained by printing through the emulsion surface of the film, using a properly selected blue glass filter in the light beam. The yellow filter layer between the blue- and green-sensitive layers limits passage of blue light from the emulsion side. However, the filter layer does not protect the green-sensitive layer from any stray blue printing light that may strike the base of the film.

An optimum printing intensity for each printer should be established and then carefully controlled. Overprinting can result in unwanted exposure and subsequent yellow development of silver halide in the green-sensitive (magenta) layer. Underprinting leaves some of the silver halide in the yellow layer unexposed and subject to chemical exposure and development in the magenta developer. Either situation causes some degradation in quality.

The selected levels of reexposure for both the red and blue printing steps are based on the results of actual photographic tests including each of the film types that are processed. These printer settings are computer controlled. For anything other than a lamp failure, call Kodak for service. Processing film with an inoperative printer produces unacceptable customer film.

Yellow Developer Solution

In the yellow developer solution, a positive silver image is formed in the blue-sensitive layer by the action of the color developing agent on the silver halide that was exposed during the blue printing operation. Simultaneously, a positive yellow dye image is formed by the reaction between the oxidized color developing agent and the yellow coupler. See the section, "Cyan Developer Solution" on page 3-2 for the generic equations.

During the yellow development step, the blue-sensitive layer must be developed to completion while unwanted yellow development (fogging) of the green-sensitive layer is kept to a minimum. Any undeveloped silver halide in the blue-sensitive layer is developed in the magenta developer solution, causing magenta dye contamination in the yellow layer. Conversely, fogging of the green-sensitive layer during yellow development causes yellow dye contamination in the magenta layer and a significant reduction in the magenta dye yield. A normal Process K-14M yellow developer solution provides the required yellow and magenta separation.

Normally, all of the exposed silver halide in the red-sensitive layer would be developed in either the first or the cyan developer solution. If any exposed silver halide in this layer remains undeveloped after the cyan developer solution, it is developed in the yellow developer solution, and results in yellow dye contamination in the cyan layer.

Yellow Developer Wash

This wash stops the yellow development and removes the yellow developer solution from the film.

Magenta Developer Solution

At this stage in the processing sequence, only the green-sensitive layer should contain any unexposed silver halide. Therefore, selective reexposure is unnecessary. The reversal agent in the magenta developer solution nucleates (chemically reexposes) all the remaining silver halide.

During magenta development, a positive silver image is formed in the green-sensitive layer by the action of the color developing agent on the silver halide. Simultaneously, a positive magenta dye image is formed by the reaction of the oxidized color developing agent with the magenta coupler. See the section, "Cyan Developer Solution" on page 3-2.

Magenta development is somewhat less critical than cyan and yellow development, because if the preceding steps were properly carried out, no silver halide should remain in the red- and blue-sensitive layers. Therefore, no unwanted magenta dye development should occur. However, if any silver halide is present in the red- or blue-sensitive layers, it is nucleated and developed in the magenta developer solution, producing magenta dye contamination of the cyan or yellow dye image.

The silver halide in the green-sensitive layer is the most difficult to develop completely, and incomplete development results in an inadequate magenta dye image, especially in the maximum-density areas.

Magenta Developer Wash

This wash removes the magenta developer solution from the film. This is the most critical of all the wash steps because it is more difficult to remove the components of the magenta developer solution.

Conditioner

The conditioner prepares the metallic silver developed in the first and color developers for oxidation to silver halide in the bleach step. An oxidized conditioner solution is ineffective and may cause silver to be retained in processed film.

Bleach

The bleach converts the metallic silver back to silver halide; the silver halide is later removed in the fixer.

During bleaching, iron III is reduced to iron II. Iron II must be converted back to iron III by aeration so that satisfactory bleaching can continue. Aerate the bleach by bubbling air through it.

Inadequate aeration, underreplenishment, low temperature, and over-dilution of the bleach by conditioner can cause silver retention, which causes all densities to increase. The silver may be removed by bleaching and fixing the film again, if necessary.

Fixer

The fixer converts all of the silver halide into soluble silver compounds. Most of the silver compounds are removed in the fixer and can be recovered.

Underreplenishment, or fixer dilution, causes silver halide retention, increased blue density, or yellow D-min. The silver halide may be removed by bleaching and fixing the film again.

Final Wash

The final wash removes chemicals remaining in the film emulsion. Complete washing at this stage is important for image stability; any chemicals remaining in the film may deteriorate the image dyes.

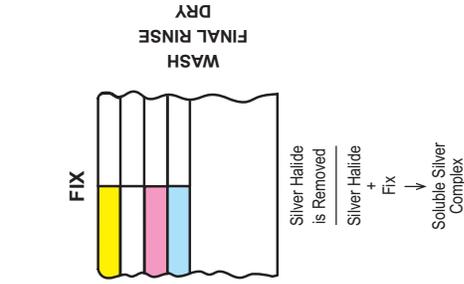
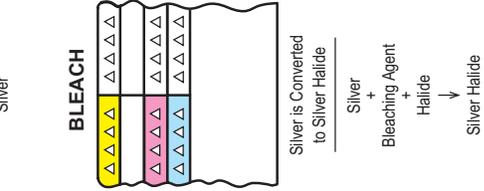
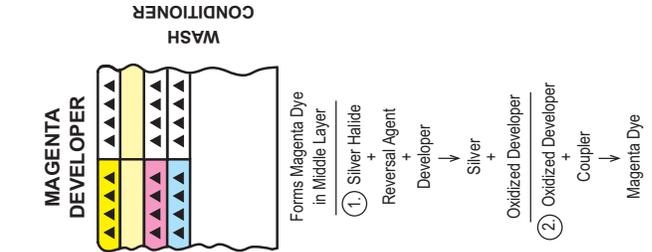
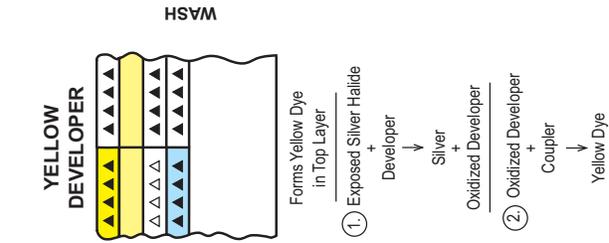
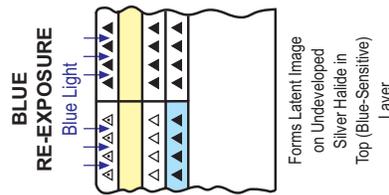
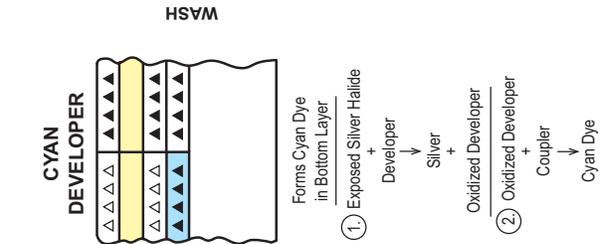
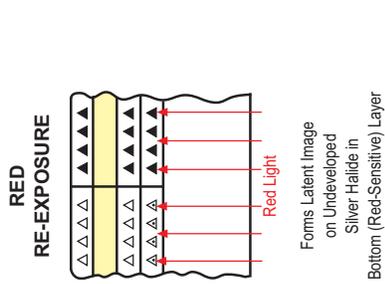
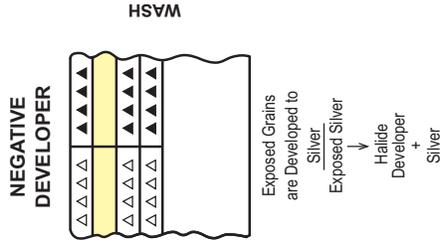
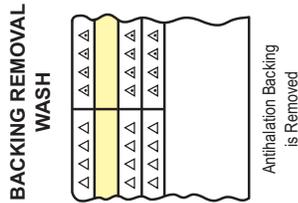
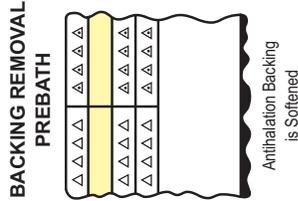
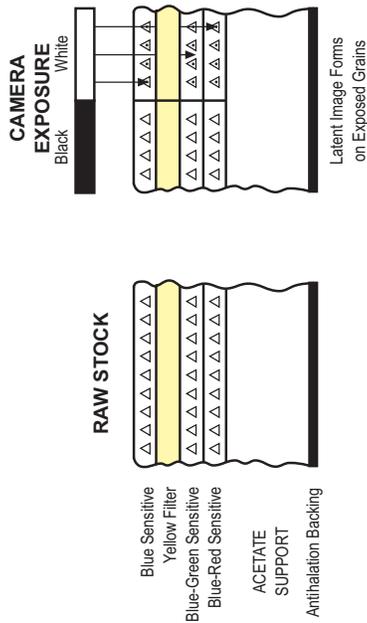
Final Rinse

The final rinse contains a wetting agent to reduce water spotting and provide uniform drying. To help prevent water spots and streaks, replace the final rinse solution daily.

Process Sequence



PROCESS SEQUENCE



WASH
FINAL RINSE
DRY