F I L M a n d t h e P H O T O G R A P H I C P R O C E S S

FILM

composition
- scratch resistant layer, protects the soft gelatin emulsion
- emulsion, a gelatin layer containing light sensitive crystals
- acetate base, a plastic roll to hold the emulsion
- anti-halation coating, prevents reflections from reentering the film

light sensitive crystals
- silver halides, most typically silver bromide crystals
- silver ions, positively charged = missing one electron
- bromide ions, negatively charged = having one extra electron
- free silver ions, not connected to bromide ions
- additional impurities, to help bind free silver ions and electrons

PROCESS

latent image
- photons strike the film, freeing electrons from the bromide ions
- electrons merge with the free silver ions and impurities
- this forms 'sensitivity specks' that become visible
  - when the film is developed

development
- metallic silver is built up through time around the latent images sites

fixing
- with sodium thiosulfite removes the halides not struck by light

IMAGE REVERSAL

the negative
- a collection of silver specks on clear plastic film
- most dense where struck by the many photons
- least dense where few photons have struck
  - yielding an image that is lighter where the source image was dark and vice-versa,
    - i.e. **a negative image**

the positive
- a collection of silver specks on opaque white paper
- basically the same emulsion as on the film
  - light in an enlarger is projected through the negative
  - the negative acts as a mask allowing some light through
    - while blocking other parts of the light
  - the silver in the emulsion turns dark where struck by light
    - yielding an image that is the reverse,
    - i.e. **a positive image**
  - the white paper blends with the black of the silver
    - creating a wide range of gray tonalities

the EVOLUTION of FILM

It was not until the end of the nineteenth century that chemistry had progressed enough to make the projected light images of the camera obscura permanent. It had been noticed as early as the seventeenth century that certain chemicals change their composition when exposed to light. The trick was to stop the alteration at a certain point and make the new material insensitive to light.

Joseph Niépce created the first permanent photographic image in 1826 using bitumen, a kind of asphalt, dissolved in lavender oil. The bitumen struck by light hardened and the still soft, unexposed bitumen could be washed away with more lavender oil creating a crude image with a reasonable range of tonalities. Shortly thereafter, in both England and France, two separate processes were devised to produce a much more sophisticated product. In 1829 Louis Daguerre became a partner of Nipple and continued his work after his death in 1833.

Daguerre announced his new daguerreotype process on January 7, 1839 to the French Academy of Sciences. This process produced one-of-a-kind images on sliver plated copper sheet that had sharply defined details and within fifteen years as many as three million daguerreotypes per year were being produced in the United States alone.

Henry Fox Talbot announced a wholly independent solution to the same problem on January 25, just two weeks after Daguerre, to the Royal Institution of Great Britain. Although not the first to make the discovery, his process is actually the father of that which is used today. Talbot called his products calotypes, or "beautiful impressions". The basic complaint with this procedure was that although the images were reproducible, their paper base made them far less sharp than the daguerreotype.

Better chemical compounds continued to be developed including wet plate collodion process that Matthew Brady, the famous documenter of the Civil War used. This process required that an entire darkroom accompany the photographer. When collodion was coated on a glass plate a negative image was formed from which positive prints on albumen coated paper could be made . If the glass plate was backed with black material an ambrotype was created, which resembled a daguerreotype. Collodion coated onto a black plate produced a direct positive image called a tintype that was very inexpensive and became extremely popular for the average American.

In 1881 two new inventions revolutionized the photographic process. One was the development of a gelatin base in which to suspend the light sensitive silver salts. The second was the process of putting the emulsion onto rolls. George Eastman formed the Eastman Kodak company and developed a much simpler camera to hold these new rolls of film. In 1888 the Kodak camera was introduced, which came loaded with enough film for one hundred exposures. The camera was small enough to be hand held and the emulsion was fast enough to take exposures at 1/25th of a second. When all the film was exposed the camera was sent back to the factory. Finished prints were returned to the user along with the camera reloaded with new film. George Eastman and the Kodak camera put photography into the hands of everyone with the slogan, "You press the button, and we do the rest".

MODERN FILM

BLACK & WHITE FILM

The black and white film that we use today is not unlike the early dry plate process. The new emulsions respond much more quickly to light, are much finer in texture, and are now applied to a flexible acetate base. Black and White film does not recognize color information, rendering only the brightness of objects using very small dots of metallic silver which appear black in color. These silver crystals are so small and uneven in texture that these photographic images are called "continuous tone". When placed on white paper, what appears to be a full range of grey intermediate tones is perceived.

COLOR FILM

In 1935 Kodak produced Kodachrome film that produced full color transparencies and introduced Kodacolor negative film in 1941. Both films consisted of three layers of silver based emulsion sandwiched together each sensitive to a particular band of frequencies, namely red, green and blue- the primary colors in additive color theory. Each band is developed as usual and then the silver is replaced with colored dyes to produce either color slides or negatives. The negatives in turn are used with enlargers that can control three colors of light, in this case cyan, magenta and yellow- the primary colors in subtractive light theory. These complementary colors are used to produce full color prints often called color coupler prints or simply C-prints. The newest color films employ a tabular grain structure which has now found its way into black and white film design.

Another process called Cibachrome, a direct positive print medium based on the destruction or removal of color dyes rather than the build up of them, actually creates a more stable and more sharp image than the chromogenic materials from Kodak. It is, however, more expensive and more dangerous than Kodak Ektaprint paper and chemicals.

POLAROID INSTANT COLOR

In 1962 Polaroid gave the world "instant" photographic imaging. The negative and positive photographic materials are packaged together and when the film is pulled from the camera after each exposure, the developing and reversal processes are initiated. When the materials are pulled apart in about one minute a finished positive image is had. This technology has since been surpassed with a more automatic process employed in the SX-70 camera and film, introduced in 1972.

CHROMOGENIC B&W FILM

With the loss of interest by the general public in photographs that are "merely" black and white, and the proliferation of quick processing shops, it has gotten increasingly more difficult to get black and white film processed. In response to this situation Ilford has created a chromogenic film called XP-1 which only contains the colors black and grey. It can be developed in standard C-41 color chemistry at a quick print store, and when printed as standard color film monochromatic prints with a slightly toned appearance are produced. This makes black and white photography as quick and convenient as color, if you do not mind having no control over what is happening in your 3½" x 5 inch prints, and do not mind paying as much as for color processing.

CHOOSING FILM

FILM SPEED

The choice of film to use in a particular situation is a balance of aesthetics and technology.

Technically, if you need to shoot at high shutter speeds to capture motion, or are merely shooting in low light, then you will probably use a **faster speed film**, e.g. ASA400 and above This will enable you to use faster shutter speeds without sacrificing all your depth of field. Just realize that you will get more noticeable grain in your photographs and they will not be as sharp or as detailed as if they had been shot with slower film.

If you are deliberately after a chunky, contrasty, graphic look, you will also select faster speed film and perhaps play with push processing the film by deliberately underexposing and then overdeveloping the film. Developing at higher temperatures can also help achieve this look.

see: Push and Pull Processing page, Alternative Films page

Aesthetically, if you are after more depth of field, you probably will want very fine detail to go with it. To get the detail you would use **slower speed film**, e.g. ASA125 and below and shoot at small apertures. This situation will cause you to lose a lot of light, however. To compensate for this you can put your camera on a tripod and shoot at a much slower shutter speed. In general slower films will give you the sharpest and most detailed negatives with a wide range of subtle tonal differences.

ASA400 speed film is considered to be 'general purpose', while ASA125 is for a bit finer grain and more detail. In the beginning of your photo experience it is good to use both types of film to see just how they affect the nature of your images. If after a while you find yourself gravitating toward one style or another, then you can begin to use one type of film more than another. Just make sure not to lock yourself into too narrow a style. Consistency is valuable, constipation is painful.

GRAIN SHAPE

For many years film emulsions have been made with a somewhat irregular round grain pattern. Recently, the Kodak T-Max and Ilford Delta black and white films have borrowed from color technology and now incorporate tabular grain. All the grains are the same shape, yielding greater sensitivity to light without a corresponding increase in size and therefore, noticeability. This regularity creates a somewhat undesirable pattern that necessitates the use of a diffusion enlarger to soften the edges.

FILM FORMATS

Moving to a larger film format, from 35mm to 2¼" for example, does not alter the grain. It merely gives you more surface to work with. Therefore a larger film format provides more detail just because it is larger; just as you can put more words on a larger piece of paper.

A larger negative needs to be blown up less than a smaller negative to reach the same print size. Therefore, an 8" x 10" print from a 2¼" negative has finer grain than a print from a 35mm negative because it is not enlarged as much.

F I L M : S p e e d & G r a i n

SPEED

Film speed is a rating of how quickly film emulsion responds to light. A somewhat arbitrary system of numbers is used to label the film speed in "stops" of light. Just as one *f*/stop on a lens lets in half or twice the light of the next stop, so does one stop of film speed represent either half or twice the sensitivity to light of a particular emulsion. In other words, film rated at ASA200 requires only half as much exposure as ASA100 film to produce negatives of the same density. Film is usually designated in one/third stops as follows:

25 32 40 50 64 80 100 125 160 200 250 320 400 500 640 800 1000 1280 1600

These numbers are usually preceded by the letters ASA, which denotes the American Standards Association, who came up with the numbers in the first place so a standard could be set between numerous film manufactures. People will refer to a specific film as ASA 125 film, and so on. The European community uses a different set of numbers but their relative placements on the chart are the same. That system is called DIN numbers.

In actuality the film speed listed on the label of the film is a recommended film speed rating. The manufacturer will also recommend several developers and starting point developing times for that film at that rated speed. You may vary from these recommendations by either rating the film at a different Exposure Index, and may accompany this by altering the developing time. see: Push and Pull Processing page. The results you get are not right or wrong, but different. Each alteration yields a different look. The easiest way to get a handle on what these different looks may be is to understand how film works and what the variables are.

GRAIN

Film emulsion is made up of a collection of silver bromide crystals. "Grain" is a name for the appearance of the structure of these crystals after the film has been developed. Fast speed films have larger grain, while slower speed films have smaller grain. Variations in grain size and structure have numerous repercussions.

Sensitivity - The larger the grain the more quickly the emulsion will respond to light. Larger crystals are more likely to be struck by photons of light, resulting in increased sensitivity. Conversely, smaller grain takes more time to respond to the same amount of light.

Resolution - The larger the grain, the fewer the number of silver crystals there are per unit area, resulting in lower resolution. This means faster film with larger grain will make images that are less sharp and have less detail. Slower film emulsions have grain that is much smaller and tighter yielding far more definition.

Appearance - The larger the grain, the more visible it will be, and the more textural an image will appear. Some people exploit this characteristic to create very grainy photographs which have a very graphic quality. Smaller grain better approximates a truly continuous tone image, and looks closer to the way our eyes perceive the world. Some photographers go to extremes to get as small and as tight a grain structure as possible, in search of the "perfect" image. These two extremes are merely a matter of differences in taste.

F I L M : C o n t r a s t

CONTRAST

The definition of contrast is the difference in tonality between the brightest highlight and the darkest shadow in an image. There are ten stops of difference in most films, ranging from totally clear to opaque black. These are sometimes called zones, to accompany the Zone System, a very exacting means of determining exposure and development for individually processed pieces of sheet film used in view cameras.

Higher contrast levels accompany faster emulsion speed and its inherently larger grain structure. However, contrast levels are more directly controlled by other factors.

Exposure - During short exposures only the top layer of silver bromide crystals in the emulsion are struck by photons of light. As more and more photons are allowed into the camera, crystals that are suspended further down in the gelatin get exposed. This creates a layering effect and the highlights build up and become very dense. Since the crystal in the shadow areas are so far apart, this layering does not have much visual impact in the clearer parts of the negative.

Development - Development is the process of building up metallic silver onto the crystals in the emulsion that have been struck by light. The longer a piece of film stays in the developer, the greater the amount of deposited silver. Since the crystals are much closer together in the highlight areas, the visual impact is much greater.

Film Curves - The measurement of density in the shadow versus the highlight areas are known as film curves. These curves graphically indicate the significant amount of difference that both exposure and development have on both ends of the tonal scale.

Compression and Expansion - It is possible to measure the overall tonal range of the subject and express that range in terms of stops of light. One can then develop the negative so that the tonal range is compressed or expanded to fill the entire tonal range potential of that film. With this kind of control over tonality, exposures can be made for special effects and photographs with restricted tonal range. In addition, objects of a particular luminance can be "placed" in a specific tonal range on photo paper.

D E V E L O P I N G   F I L M

DEVELOPING FILM involves several chemicals; Developer, Fixer, Fixer Remover and Wetting Agent. The film is washed with water between each chemical step. All chemistry must be at the same temperature, between 68-75˚F / 20 - 24˚C.

Roll film onto reels in total darkness in the Film Loading Rooms or with a changing bag.
Place loaded reels into light-tight Film Developing Tank and close lid tightly.
Determine the amount of chemical solution you will need.
20 oz. for 2 reels of 35mm film in a Paterson tank
This is the volume of all other chemical solutions used during this process.
Fill a large beaker with the amount of water needed, at the desired temperature
This temperature should be between 68-75˚F / 20 - 24˚C.
All the other chemicals used should be the same temperature!

SPRINT 'STANDARD' FILM DEVELOPER
Developer is the chemical that converts all of the silver ions in the emulsion that have been struck by light into solid metallic crystals, called grain. It is mixed form a concentrate as a one-shot working solution. This is poured down the drain after use.

Dilute the proper amount of **Sprint 'Standard' Developer** concentrate with the water.
A 1:9 parts ratio is the standard for normal development.
for 20oz. this is 2 oz. Dev : 18 oz. Water / for 580 ml this is 58ml Dev : 522ml Water
Consult the Developer Time Chart above the sinks.
Determine the development time for the your film type at the temperature of your developer.
Consult the Time/Temperature Chart above the sinks.
Prewet the film with water of proper temperature for 30 seconds. Drain.
Develop for the determined amount of time.
Start timing as soon as you finish pouring the developer into the tank..
Agitate the tank with rocking motion for the first 30 seconds.
Then agitate the tank 5 seconds every 30 seconds.
proper and consistent agitation is extremely important !
Start pouring out Developer 15 seconds before developing time is up.
Stop the development by immediately filling tank with water at the same temperature.
Let it sit for 30 seconds.
Fill another beaker of the right amount of water at the right temperature.
Drain the tank

SPRINT 'SPEED' FIXER
Fixer is the chemical that make the change into metallic silver permanent (no longer light sensitive) and removes all of the silver ions that were not struck by light and therefore, not converted. There are bottles of Fixer already mixed into a working Solution. This solution can be used over and over, but the quality has to be checked each time after use.

Fix for 3½ minutes with agitation for the first 30 seconds.
Then agitate the tank 5 seconds every 30 seconds thereafter.
Check the Fix with Hypo-clear to see if it is still good.
add 2 drops of Hypo-Clear into the open tank of Fix.
White precipitate means the Fix is exhausted
Drain good Used Fix back into the Fix container. with a funnel
Suck Exhausted Fix into the Silver Recovery unit under the sink

FILM FINISHING

FIXER REMOVER

Sprint 'Archive' Fixer Remover is used to removed from the film emulsion. It removes all excess fix from the soft gelatin surface of the emulsion. Without this chemical the film would have to be washed for a very long time.

Rinse in Water for 30 seconds after Fixing

Fixer Remover for 2 minutes with agitation.

There is a small metal tank at the left end of the Developing Sinks that holds a solution of Sprint 'Archive' Fixer Remover mixed 1:9. If this is empty, more concentrate Sprint 'Archive' Fixer Remover can be found in the large chemical vats in the Darkroom, in the right-hand corner.

Mix 5 oz. Fixer Remover into 45 oz. water at the right temperature

Place the reels of film onto a metal rod and dunk into the Fixer Remover.

Agitate as usual, although this is now done by just moving the film in the tank.

Remove the reels from the Fixer Remover tank after 2 minutes

Place back into the tank, now full of clean water at the right temperature

Wash film for 5 minutes in the vertical Film Washing tube.

Place the reels of film onto a longer metal rod and put into the Washer

Turn on the water at the right amount of pressure

the Washer should fill and empty itself automatically

adjust the water pressure if it is not doing this

Do not add reels of film to a wash that is already in progress.

Otherwise the process has to start from the beginning.

FLIM WETTING AGENT

Photo-Flo is the Brand name of Wetting Agent. LFN is another brand that is sometimes used. It is the last liquid applied to the film. The makes the surface of the film wetter than water so it dries with no streaks or water marks.

Photo-Flo for 30 seconds. Drain but do not rinse off.

Place film back into the tank full of clean water at the right temperature

Add 2 drops of Kodak Photo-Flo to the tank (yellow label)

Gently rock the tank for 30 seconds

Pour the Photo-Flo down the drain when finished

Squeegee excess liquid from film with a film squeegee or wet fingers

A little Photo-Flo on the fingers will help

Grab the end of the film and lift up and off the reel

Don't let the other end touch the inside of the sink

Pull the film between 2 fingers to remove the excess Photo-Flo

Dry the film in the Film Dryer

Hang each roll of film by the leader end (black)

Get the wet film into the Film Dryer as quickly as possible.

This is when the film is most vulnerable to dust particles in the air.

Place a clip on the bottom end to weight it down.

Set the temperature dial to Level 4

Dry for about 12 minutes

The file will dry from the bottom up

FILM STORAGE

Cut into strips of 5 frames each when film is dry.
Do not leave your film out in the open for very long. Dust is your worst enemy.
- Start at the back end of the roll and then cut every 5 frames,
- Leave the leader on at the beginning of the roll for a five frame length strip.

Avoid having a strip with 3 negatives or less together.

Slide the film strips into plastic Negative Files using the light table.
- Insert the film with the emulsion side down and frame numbers in proper order.

Never touch the emulsion side of the film.
Negatives are fragile and will scratch easily.

Insert negative file into a plastic Negative Storage Binder.

Every time a satisfactory print is made, the exposure information should be written onto the back the the Contact Sheet of the negative used to make the print.

NEGATIVES : Exposure & Evaluation

EXPOSURE - Expose for the Shadows

The density of the negative in the shadow areas (thinnest) is controlled directly by exposure.

The most accurate method of determining exposure when shooting is to meter for the shadows and then underexpose by two stops.

Close the lens down or speed the shutter speed up, either of which will yield less light.

BIG NUMBERS yield small light / small numbers yield BIG LIGHT

DEVELOPMENT - Develop for the Highlights

The density of the negative in the highlight areas (densest) is controlled by development.

Because of this, the development times given are only recommended starting points which can be adjusted according to how and what you shoot.

The contrast in a negative is defined as the difference between the shadow and highlight densities. Longer developing times will make the highlights more saturated while changing the shadows only a little. This expands the contrast range.

Development, therefore, directly controls the contrast in negatives.

The amount of agitation can also alter the contrast range, more agitation yielding higher contrast, yet too much can cause streaking. This is why it is important to keep your agitation technique consistent.

EVALUATION

• Look at the thinnest shadow areas.

If there is enough information to render details in the shadows,
the negative is properly exposed.
If the film is too light or clear in the shadow areas,
the negative is underexposed - not enough light.
If the film is too dense or opaque in the shadow areas,
the negative is overexposed - too much light.
note: This will vary for each frame on a roll until you become consistent with technique

• Look at the densest highlight areas of a negative that is properly exposed (according to the shadows).

If there is enough information to render details in the highlights,
the negative is properly developed.
If the film is not dense enough in the highlight areas,
the negative is underdeveloped - not developed long enough.
If the film is too dense in the highlight areas,
the negative is overdeveloped - developed too long.

VARIATIONS

The longer film is developed, the larger each individual silver crystal becomes. This makes the grain structure more prominent and the photographs will appear more contrasty.

A similar effect is created by developing film at a higher temperature.

Conversely, if you deliberately overexpose you film, you can develop it for less time giving you finer grain yielding more detailed images.