# BLACK & WHITE DEVELOPERS PROCESSING AND TECHNIQUE

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# PROCESSING AND CHEMICALS

## Black & White Developers

We use developers every day, we have our favorites and our dislikes, we tend not to understand them and to use them incorrectly, oftentimes. There is an inclination to deify developers even though they are usually pretty straightforward chemical mixtures that can frequently be replaced by other products.

## CONSTITUENTS

Developing solutions have two or more of the following:

Reducing Agent (Developing Agent): A chemical that reduces silver halides to metallic silver, to be acceptable it must reduce exposed halides but not randomly reduce unexposed halides, at least not under normal circumstances of time and temperature. Eg. Elon, Hydroquinone, or Phenidone to name a few.

Activator: Chemicals that cause the reducing agents to function either catalytically or through an increase in pH which is the usual driver of the reaction. Eg. Sod. Hydroxide, Sod. Carbonate, or Sod. Sulfite. As a catalyst, occasionally Sod. Thiocyanate.

Anti-Oxidant: (and/or preservative): Chemical retarding oxidation or in some way retarding chemical spoilage. Eg. Sod. Sulfite, Citric Acid, or Sod. Bisulfite.

Restrainer or Anti-Foggant: A chemical that prevents or retards the random reduction of unexposed silver halides, usually required in highly active developers when they are fresh (in that use they are sometimes called developer starters.) Eg. Sod/Pot Bromide, Sod/Pot Iodide, Benzotriazole, or Citrazinic Acid. Citrazinic acid is used also to restrain the increase in contrast while overdeveloping to increase speed.

Buffer: Chemical added to change the pH of a developer or a great bulk of chemicals in a developer to prevent the easy change of pH. Eg. To change, Sod. Hydroxide, Sulfuric Acid, Sod. Bisulfite. For inertial use, Sod. Carbonate or Sod. Sulfite.

Sequestering Agent: A chemical that ties up unwanted chemicals in the water used as a developer diluent (especially calcium and aluminum compounds found in "hard" water.) Eg. Sod. Phosphate, Disodium Phosphate, Trisodium Phosphate, Sod. Hexameta Phosphate, QuadraFos, and Calgon.

Anti-Reticulator or Ant-Swelling Agent: A chemical that prevents the excessive swelling of gelatin. This is usually Sod. Sulfate and it can usually be safely added to any B/W or color developer at 5% or sometimes up to 10% although a developing time test may well have to be performed.

Solvent: A chemical that dissolves away part of the silver grain clumps for the purpose of reducing grain size and/or making available silver for auto physical development (D-76.) Eg. Sod Sulfite (at a density of at least 80 gms. per liter), Sod. Thiosulfite, Sod. Thiocyanate.

Hardener: A chemical that hardens the gelatin emulsion which has been softened by very high pH solutions and/or very high temperatures. Eg. Alum, Formaldehyde.

Wetting Agent: A chemical that reduces the surface tension of water for the purpose of promoting rapid soaking of solutions or preventing water spotting during drying. Eg. Photo Flo, Poly Phosphates and Anionic Surfactants.

Emulsifier: A chemical that promotes rapid soaking and prevents the rapid removal of a solution from an emulsion. Eg. Carbowax (Polyethylene Chloride.)

Desensitizer: A chemical that prevents fogging when examining the still developing film under relatively bright safelights. Eg. Pinakryptol Green, Pinakryptol Yellow.

Now that these constituents have been reviewed it should be pointed out that some highly complex formulae may have nearly all of these while one of the oldest and most highly useful, D-23, has only two, Elon and Sod. Sulfite.

## DEVELOPER TYPES

Following will be a listing and discussion of developer types and characteristics. A single developer may simultaneously be several types, whereas others may exhibit only one characteristic.

High Contrast: A developer that yields higher than normal contrast or average gradient. Normally used with high contrast films such as lithographic, shell burst, or sometimes infra-red. Eg. D-ll, D-19, or Kodalith.

Medium Contrast: Medium contrast developers normally used with general continuous tone films, between high and low contrast developers. Eg. D-76 or DK-50.

Low Contrast: A developer that yields a lower average gradient when used with general continuous tone films. Eg. D-23, D-25.

Compensating: A developer that gives proportionately greater development activity in the shadows than in the highlights.

Solvent or Fine Grain: A developer that dissolves away the sharp edges of silver grain clumps to reduce apparent granularity (also decreases sharpness.) Eg. D-76, UFG, Acufine, Microdol X.

Edge Effect: A developer that tends to produce darker lines around dark masses, lighter lines around light masses, increasing the apparent sharpness. When it is a desirable effect is called "edge effect", when it is undesirable it is called "Mackie Lines", while scientifically it is called "Eberhardt Effect." It is produced or enhanced by longer periods of stillness between agitation cycles. This technique reduces actual fine detail!

Split: A developer in two solutions wherein the developing agent (reducing agent) is combined with one or more preservatives (small quantity of Sod. Sulfite and Citric Acid) with no activator in solution A, while no developer but only activator is in solution B. It works by soaking developer into the gelatin emulsion where no development takes place, it is then gently inserted into the activator bath which allows the development to take place until the reducing agent is used up. This takes many times longer in the shadow areas than in the highlight area. The result is a tremendously compensating development and in normal scenes, a very flat negative ( Only non-split pyrocatechin reducing agent developer will yield greater compensation). Eg. Diafine and TEC. If the photographer prepares his own developer, D-76 can be split with great success.

Physical: In past periods of thick emulsions and low emulsion speed an improvement in density, contrast and granularity was needed. A developer was created with silver salts in solution. The nature of the solution permitted additional silver to be added to that which was reduced from the silver halides in the emulsion. The major problem was a 2 to 3 f stop loss in speed and the improvement was negligible relative to the speed loss. D-76 when used full strength will dissolve silver from the high density areas and re-deposit it in inverse proportion to exposure. This produces a full emulsion speed and if speed is tied to threshold or toe density in the photographers practice, a slight speed increase will be experienced.

Tanning: A tanning developer yields a relief image of such proportion in thick emulsions, that it can be used to transfer inks or dyes. Used in rotogravure printing production and dye transfer printing.

Stain: A rarely used method today. Several of the Pyro type developers yielded an ultra fine grain brown stain image in proportion to the silver image in the days of thick emulsions, high graininess, and low resolution. This improved the quality of the image and was a key to early research in chromogenic color formation (the dyes found in color films a few b/w film.)

Color; A developer that develops a silver image together with a dye image as a byproduct of that development (chromogenic formation.)

Panthermic A developer which can be successfully used over a wide range of temperatures with similar results by simply changing immersion times. The first famous product was Harvey"s 777, many others exist including D-76, HC110, UFG, and others.

High Temperature: (Sometimes called Tropical Developers) It is sometimes necessary to develop film at temperatures above 85 degrees Fahrenheit. There are some specially formulated solutions loaded with restrainers, sulfates, and formaldehyde to allow adequate developing times and prevent the emulsion from slipping away.

Dilute: Some highly dilute developers are used for high resolution, low contrast, edge effect, and/or extreme compensation.

Monobath: A solution that simultaneously develops and fixes the film. There are numerous technical problems but a solution designed for a single emulsion type can work very well. The requirement is that the fixer must be slow and developer fast. No commercial formula currently exists (Unibath was discontinued in the late 70's or early 80's), should the photographer need one, consult the Haist Monobath Manual, available in most large libraries.

Concentrated: A jellied developer designed for use in diffusion transfer or viscous layer development systems.

In addition to selecting the correct developer from the above descriptions, the user should agitate correctly. Initial agitation should be vigorous to dislodge air bells and promote rapid wetting. In general if developing times are five minutes or shorter you should agitate each 30 seconds. Longer than you should agitate once each minute unless a high resolution film and developer are used. If increased edge effect is desired, agitate gently once each 2 to 3 minutes (assuming that the developing times run over 8 to 10 minutes, a slight increase in immersion times may be required, due to the long times between agitation cycles.)

A Stop Bath of acetic acid should always be used following development. This will instantly stop development and condition the gelatin emulsion, slightly toughening and hardening it but not to the extent that it will interfere in any way with toning or other after baths. It has the further effect of preventing sulfurization of the fixing bath and dichroic sulfide staining of film and prints. Change stop bath frequently, it is inexpensive. It should be used at from 1 1/2 % to 5%. Tests have shown that within reason, strength has no adverse effect, provided adequate strength is used.

A Fixing Bath of a formulation recommended for use with your type of film or paper, removes unused silver salts, just don't over use it. Discard the fixing bath when the clearing time has more than doubled. Rapid fixer works faster lasts longer and costs less in the long run (even though it costs more initially.) Note that fixing bath (hypo) for paper is one half as concentrated as film fixer. The photographer should not use film strength fixer on paper, thinking that it is better. The fact is that it doesn't work as well, due to differences in the chemistry of the emulsions.

Hypo Clearing Agent is an after bath treatment discovered in the 1940's as a direct result of WWII. War ships could not support continuous washing of films and papers with fresh water (which had to be distilled from sea water). Orders were issued to wash photo films and papers in ocean water and briefly rinse is fresh water. As it turned out after examination, years later, those films and papers which were pre-washed in salt water were archivally superior to those washed solely in fresh water. It was determined that the salts in sea water rendered fixing bath and other chemicals much more soluble than they ordinarily were. Kodak and others scrambled to create solutions containing those salts known to produce the necessary effect. Other companies produced chemicals from organic solvents that also had the same effect. If small quantities of salt type agents were not entirely removed, no serious deterioration occurred. If, on the other hand, minute amounts of the organic solvent type hypo clearing agent are left in the emulsion, the effect is more harmful to the image than a bit of hypo. It is just as important to wash the clearing agent out of the emulsion as it is other chemicals.

Wetting Agents reduce the "surface tension" of this final bath, causing the water to run off the emulsion evenly and minimizing the tendency to "water spot". Water spots *are not removable after drying*. They consist of actual amorphous silver rings caused by the heavy silver grains which tumble from the soft areas on the margin of a water droplet wetted area into the still softer center droplet area. Wetting agents are of the detergent type or of the anionic surfactant type (the best but more expensive).

Mix wetting agent daily, it tends to support fungal and bacterial growth. Wetting agent is best mixed in distilled or de-ionized water, but do not, however, mix developers or other solutions in distilled or de-ionized water unless recommended by the manufacturer. Mixing solutions in these purer waters will significantly soften the emulsion causing it to "frill" (soften so much that small pieces of gelatin will erode and break off) sometimes taking part of the photograph along with it.

## PROCESSING FACTS

Developing: With almost no exception, developers are alkaline (bases). They are extremely time, temperature, and pH sensitive. The reactions are driven by temperature, pH, and sometimes by catalysts. Obviously, the length of time is equally important since this relates to the control of the duration of the reactions. Temperature control should be at held to + or - 1/2 degree F (+/- 1/4 degree C).

Stop Bath: also called "short stop", is not particularly time or temperature sensitive, and is carried out "to completion". If the material is exposed long enough to acidify it, for practical purposes no additional time will have any further effect. In general, we try to keep the temperature range +/- .5 degrees F (+/-2.5 degrees C).

Fixing Bath: frequently called "hypo" is also not particularly time or temperature sensitive, as long as it is immersed long enough, it too is a completion process. We should avoid extremely long immersion times because rarely some bleaching of the image will occur or occasionally difficult to remove chemical complexes will be produced. In general the usual +/- 5 degrees F for secondary or completion chemicals will still obtain.

Hypo Clearing Agent: A completion bath, relatively insensitive to time or temperature considerations, +/- 5 degrees F.

Wetting Agent: A completion bath, relatively insensitive to time or temperature considerations beyond one minute, +/- 5 degrees F.

Reticulation: The breaking of the emulsion into a peculiar pattern similar reptilian scaling. *This occurs secondary to extreme swelling of the emulsion caused by shock heating many degrees above normal* (not from chilling as is commonly thought!

Incipient Reticulation: Identical cause to reticulation above but much smaller pattern. It produces an effect that looks like excessive granularity.

Contamination: is the introduction of an unwanted chemical or substance into a solution. Photographic processes have a high tolerance to contamination in line or in order. For example, stop bath is expected to get a

small amount of developer in it. On the other hand, only a small amount of stop bath in the developer will adversely affect it.

## B/W DEVELOPERS

D-76 by Eastman Kodak:

This is and has been, since its introduction shortly after the turn of the century (19th to 20th), the all round champion of B/W developers. This formula has been reproduced by many manufacturers under many different names due to its success. Since it has 100 grams per liter of sodium sulfite, it is a silver solvent developer (should be filtered occasionally). The chemical constituency is such that the silver is dissolved differentially in proportion to exposure/density and simultaneously redeposited in inverse proportion to exposure and density. The resultant effect is to increase shadow density and detail while reducing the tendency of the highlights to block up. This developer may be replenished with D76-R and used more or less forever (we are aware of a motion picture lab which used replenished D-76 for over 40 years without remixing). Replenishment is the ideal method of use for this and many other developers. A well used, properly replenished, developer is absolutely stable. First, the liquid dilutes some of the by products of development, then the level is replaced by the natural losses in film development, finally, the replenisher's very active ingredients are precisely balanced by the restrainers (by products of development) producing a solution which is insensitive to minor variations in time, temperature, and agitation.

D-76 diluted 1:1 is a very popular incarnation of the developer. When diluted the sulfite level falls to 50 grams per liter. Since 80gpl is required for silver solvency, it no longer functions as such and in fact is now a high resolution, compensating, "one shot" developer similar in many ways to Rodinal and TEC.

Warning! Do not use used/replenished D-76 as a 1:1 developer; its changed chemistry will result in developer failure.

RODINAL by Afga:

Rodinal is the oldest proprietary developer in use today, dating back into the 1800's. It can be used in dilutions from 1:25 to 1:50. In times past it was used in dilutions up to 1:150. This is the most popular of the

dilute, high resolution, compensating developers. For low and median speed films under normal to high detail situations it is a superb choice.

UFG by Ethol:

The best of the high energy fine grain developers, yielding legitimate speed increases to1 stop, excellent sharpness and granularity. As stable and long lasting as D-76 when replenished. Considerable silver solvency but no obvious loss of sharpness. Use only with medium and high speed films. Can be replenshed for very long periods of time but should be filtered occasionally. Only shortcoming is an extremely short immersion time (3 to 6 minutes, normally).

MICROPHEN by Ilford:

When used full strength and replenished, this is a remarkable high energy, fine grain developer. Legitimate speed increases of ½ to 1 stop while maintaining very fine grain. Particularly valuable in high speed films (400 to 1600) and with some significant value in medium speed films requiring a bit of speed increase and considerable enlargement. Can be replenished for very long periods of time but should be filtered occasionally. When diluted, this tends to be more like a compensating developer.

ACUFINE by Acufine Chemical (formerly Baumann Chemical):

Similar in many ways to UFG and Microphen with developing time about twice that of UFG and similar to Microphen. It too should be used full strength to take full advantage of its properties. Don't exceed the recommended replenishment, it should be discarded and remixed according to Dr. Baumann's schedule.

DK50 and DK60A by Kodak:

A superb general purpose developer intended primarily for sheet films but certainly very useable for roll films. Very clean working, adequate shadow detail, good sharpness. and good granularity. The DK50 developer may be diluted 1:1 for improved granularity, longer times, and more compensating effect. While the DK50 and DK60A are identical in use, the latter is replenishable and a DK60 R is available.

ETHOL 90, by Ethol:

A very rapid developing chemical which takes from 90 seconds to 3 minutes depending on film and temperature. Not the world's finest grain or sharpness, but highly acceptable for various rapid access applications.

DEKTOL by Kodak:

For rapid access in all sheet and roll films, Dektol paper developer may be used as a surprisingly good alternative. Be sure to test your film types before processing important work. Your starting technique will be Dektol 1:1 @ $70^{O}$ F for about 3 minutes, continuous gentle agitation.

AGITATION:

The purposes of developer agitation are several fold:

a: To wash away and dilute, the harmful by products of silver reduction which act as restrainers differentially, leading to mottle, bromide drag, adjacency effect, Mackie Lines, or other artifacts.

b: To present fresh, active chemicals to the surface of the emulsion.

c: To alter resolution, shadow detail, or create "edge effect".

Agitation Problems & Effects:

Theoretically, the ideal is continuous agitation. This however is unachievable except in "spray processing" and tray processing. The problem in all but spray techniques, is the production of hydraulic currents which are always regional, causing uneven agitation. *ALWAYS START WITH 10 - 15 SECONDS OF CONTINUOUS AGITATION!*

Spray Processing: This is most commonly encountered in motion picture processors. As the film is transported continuously through the system, developers and other chemicals are sprayed directly into the emulsion, at a $45^{o}$ angle, in opposition to film travel! Typically, the speed and placement are such that no more than 4 seconds elapses between spray jets, usually less. This technique results in the best, most controlled of all developing methodologies yielding eveness of +/- .005 to .01 (target density 1.00).

Tray Processing: A means of processing usually sheet films in which after manually immersing, wetting, and interleaving the film for 15 to 30 seconds, the tray is lifted and lowered from each side, continuously. About once per minute, the technician manually interleaves the film one or two cycles.
When done properly, the quality is excellent and the immersion time is reduced by 15% to 25%. Development eveness is at best +/- .03 to .06 for 4X5 and +/- .08 to .10 for 8X10 (target density 1.00).

Tank Processing: Sheets are placed in film hangers and immersed in a tank. While they vary in size from ½ gal. (2 L) to 5 gal (19L), the literature describes this as either large tank or deep tank. While the initial agitation of about 10 seconds must be vigorous, all subsequent agitation must be of the ASA type (lift and

drain from alternate corners for a total cycle length of 4 to 5 seconds), the quality level possible with this technique is +/- .06 to .08 (target density 1.00).

Small Metal Reel & Tank Processing: Typically these are small 35, 120, and 220 stainless steel systems commonly known by the original brand name, Nikor. These are capable of delivering high quality results when agitated properly. Only the Dobro method works well, the rotate and invert method which will deliver even processing at the +/- .03 to .04 level (target density of 1.00).

Small Plastic Reel & Tank Processing: Typically the primary representatives in the field today are the Patterson tanks and copies of these by other manufacturers. These are extremely convenient and well liked in the industry. In order to get acceptable eveness of development, agitation by rotation of reels works reasonably well provided it is not overdone and that the rotation is both clockwise and counterclockwise, equally. Quality levels are about +/- .06 to .08 for a target density of 1.00.

Roller Transport Processing: This is certainly the most convenient, albeit expensive, method for film and paper development. It is entirely adequate for paper but is somewhat less even for film and demanding of high levels of preventive maintenance. There is a great deal of mottling and extreme difficulty of maintaining cleanliness in these systems. Eveness of this system is +/- .15 to .20.

Mechanical Dip and Dunk: The most commonly used of all automatic film processors, varying in price from several thousand to several tens of thousands of dollars. The quality is very good, especially when combined with active recirculation and inert gas agitation. Eveness varies from +/- .05 at best up to +/- .15 at worst (target density 1.0).

## Deliberate Effects of Agitation Variations in Hand Processing

Fine Detail: For the finest detail the film should be agitated using an acceptable system, each 30 seconds. More than this will result in uneven processing, while less will reduce fine detail resolution, introduce mottle and possible other artifacts such as Mackie Lines.

Normal Use: The best compromise for most subjects is one agitation cycle each 60 seconds (1 minute). This permits adequate fine detail resolution while generating adequate shadow detail and speed.

Edge Effect (Eberhardt Effect): A result in which all light lines are surrounded by a lighter line and all dark lines are surrounded by a darker line. While this significantly decreases resolution, it increases the illusion of sharpness and improves the textural look of subjects. Most commonly used in "people photography" or certain exterior photographs. This effect is achieved through longer periods between agitation cycles, however the basic developing time must be at least 6 minutes.

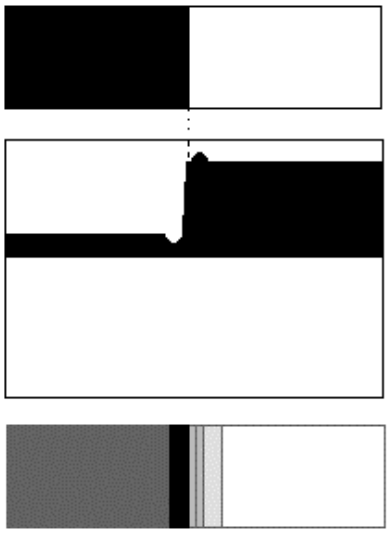
Moderate effect: Increase developing 10% and agitate once each 2 minutes.

Maximum effect: Increase developing time 15% and agitate once each 3 minutes.

Maximum Shadow Detail: Use either a split developer such as Diafine (which sometimes produces some edge effect) or water bath development (which rarely produces edge effect).

EBERHARDT EFFECT

This is an effect of reduced or absence of agitation resulting in a ripple effect in detail resolution. (See sketch). When Eberhardt is desirable, it is called "Edge Effect", when it is unwanted it is called by the English term, "Mackie Lines".



Above is a Diagram of Edge Effect

## DENSITOMETRIC CONSIDERATIONS FOR EVALUATION

.30 Density is the equivalent of 1 f stop. We study processing eveness at the level of 1.0 since it is a convenient density well within the acceptable tolerance of the value of upper median densities. Gray cards should be .70 net density, gross densities .75 to 1.00 or a bit more.

A most important film manufacturer stated that an acceptable commercial tolerance of variation based on this target criterion is +/- .20 (+/- 2/3 of an f stop!), approximately the performance of the roller transport processor which it manufactured. *My tests indicate that +/- .10 is the maximum reasonable tolerance for a high quality photographic film product.* The most perfect and most pristine target is +/- .02 but anything under +/- .10 is highly desirable.

The density variations will be influenced not only by agitation and transport systems but by the nature of the developer. High contrast developers increase this effect while low contrast developers decrease the variations. To be fair in my tests, I used the developer most appropriate for each system. In the graphic arts litho films and litho developers were used, in continuous tone sheet films, Tri-X Pan Professional in D-76 or DK-50 was used, while in roll films, good quality medium speed films such as Verichrome Pan, T-Max 100 or Delta 100 D 76 or Rodinal was used.

To understand film exposure and development get your copy of

## PRINTING AND EVALUATION

### B/W Printing

First:

Start with a #2 filter (or grade #2) in the system and select a section of the photograph which has the brightest highlights that you wish to record with detail.

Second: Select an intermediate aperture (based on your experience), with the lens stopped down at least two stops from its widest . With a heavy card, white side toward the light and black side toward the paper, make a series of convenient exposure steps (you can use a strip tester but I prefer just a card ) in bands across the most important areas in the first step. If, for example, you were to choose 10 seconds as convenient and made 5 exposures (moving the card a small amount each time) the resulting test strip would be, 10, 20, 30, 40, 50 seconds and should be adequate to run the gamut from too light to too dark.

Third: Examine the highlights for adequately perceptible detail. Find the exposure required and find a shadow at that exposure.

If the shadow has good detail, separation, and appropriate darkness, the contrast is correct.

If the shadows are too gray (light) the contrast isn't great enough and a higher number (2 1/2, 3 or higher) should be selected.

If, on the other hand, the shadows are too dark and lacking in detail or separation, a lower contrast filter or grade should be chosen.

Fourth: Make a print using the contrast chosen, carefully evaluate to determine whether or not any dodging or burning may be required to maintain a continuity of tones. Carefully evaluate, since most prints profit from a 50% "burn down". Take a large oval dodger and give the print an extra 50 % exposure while moving the dodger up and down, creating a constantly larger and smaller oval shadow. At its lowest point it should be shadowing the most important part of the print while at its highest only the corners should be exposed. Keep the dodger moving or else the manipulation will show! Look carefully at the lower portion of the photograph, most of these need at least an additional 50% burn on the lowest 20% to 25%. Psychologically, this makes the viewer mover comfortable with the bottom appearing "heavier" than the rest of the photograph.

Fifth: Make a print containing all of your corrections and give a final evaluation to your efforts. Check to see if any areas need to be burned or dodged further. If you encounter a stubborn highlight which resists adequate burning, give it as much as you can burning through a hole and then during the first 1 1/2 minutes of development, rub concentrated developer (undiluted) on the light spot with a "Q-Tip".

Important: Don't ever permit the exposure to be shorter than 8 seconds (due to the red afterglow)! If print manipulation is taking place, it is easier to get a smooth result with a base exposure of 15 to 30 seconds. It is equally important in custom printing for the development time to be 2 12 to 4 minutes, allowing time to accomplish any special applications and maintain quality.

PRINT PROCESSING
INFORMATION SHEET

| RC, RP, or other water proofed paper | Process Time | Temperature $^{o}$ F |
|---|---|---|
| Ektaflow or Multigrade Developer 1:9 | 1 to 3 Minutes | 65 to 85 |
| Kodak Indicator Stop Bath | 5 to 60 Seconds | 60 to 100 |
| Rapid Fixer | 2 Minutes | 60 to 100 |
| Water Wash | 7 to 10 Minutes | 65 to 100 |
| Squeegee or Wipe With a Sponge | - - - | - - - |
| Dry | Forced Air As Necessary | Up to 110 or Slightly Higher |
| Ordinary Dye Spotting, Cold or Hot Mount | - - - | - - - |

**B/W Printing and Contrast Control**

CONTRAST: Literally, the difference between the light areas and the dark areas. The greater the contrast the fewer the steps of gray. The less the contrast, the greater the number of steps of gray. Normal contrast paper has a pure white and a pure black with a great number of steps in between.

When printing with too little contrast, there frequently is no true black and the gray steps are so subtle that separation is lost. In a ddition there is a general sense of grayness, weakness, and unreality.

When printing with too much contrast, there there is no detail in the blackened shadows, no detail in the chalky light areas, and very few (2 or 3) middle tones.

**Paper grade comparisons**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| World Standard | | 00 | 0 | 1 | **2** | 3 | 4 | 5 |
| US Standard | 0 | 1 | 2 | **3** | 4 | 5 | - | |

The world standard normal is #2 while the US standard is #3 except for some graded papers which retain their normalcy. The manufacturer won't tell you so you have to try them. Most Kodak papers use the new

US rating except for Elite which still uses the old method and P Max Art which is a full grade flatter than the new US standard. Most foreign made papers adhere to the international standard but a few use the new standard. It will take a years for all of this to straighten out.

**Variable contrast papers:** Both Defender (du Pont) and Ilford claim to be the inventors of variable contrast papers, it is unclear which did it in the late 1920's. In the early years up through the 1960's, du Pont Defender's Varigam was easily the world's best. For the next twenty five or so years the competition was about equal between Kadak and Ilford for the variable contrast business. In the late '80's and into the '90's Ilfords Multigrade seems to be the chosen product.

**How does it work?** Variable contrast papers are made up of a single layer containing a mixure of two emulsions. These are a very low contrast green sensitive emulsion and a very high contrast blue sensitive emulsion. By mixing yellow and magenta colors within a filter, any contrast may be made from 0 to slightly over 4. If using a low contrast paper developer such as Koday Selectol Soft, it is possible to have contrast from 000 to about 3, while more concentrated developers may permit the gain of about 1/2 a paper grade. The **modern "Poly" and "multi" filters** yield the same exposure from 0 to 3 1/2, 4 and 5 each require a 1 stop increase in exposure. When using a color head for filtration control, the exposure must be re-tested after each change in filtration.

## PAPER DEVELOPERS

### D/LPD

Kodak Dektol or Ethol LPD are the long time recognized champions of commercial paper developers, featuring very rich, cold tones with well separated middle tones. These are traditionally diluted 1:2, occasionally 1:1 for maximum contrast.

### SEL

Kodak Selectol is the favorite warm tone developer for warm tone portrait and premium papers. Its contrast is normal and it is used at a dilution of 1:1.

### SEL/S

Kodak Selectol Soft is a remarkable chemical, yielding beautiful warm tones in papers designed for that purpose. The delicacy of tone is very special. In conventional papers, especially the variable contrast commercial papers, a reduction of from 1 to 2 paper grades is possible in the event a very high contrast negative is encountered. Normally used at a dilution of 1:1.

### DS

The combining of Dektol (or LPD) with Selectol for special purposes. The dilution is : Dektol: 1 Part, Selectol: 1 Part, Water: 3 Parts.

## DSS

The combining of Dektol (or LPD) with Selectol Soft for special purposes. The dilution is: Dektol: 1 Part, Selectol Soft: 1 Part, Water: 3 Parts.

## PAPER/DEVELOPER COMBINATIONS

Any paper can be developed in, , Dektol, LPD, Multigrade, or Polymax.
There are reasons, however, for being more selective.
The following recommendations will be for other than
Polymax/Multigrade.

Cold Tone:
Any RC/RP or fiber base graded or variable contrast cold tone may be developed with fine results with D/LPD. In some instances papers featuring fine gradations such as Multigrade IV may produce significantly improved tone delicacy by the use of DS or DSS.

Warm Tone:
Any warm tone paper will normally yield more desirable tones when developed in SEL or occasionally SEL/S. If slightly less warmth is desired together with somewhat "stronger" shadows, DSS or DS may be selected. If only a bit of warmth is required but rather greater contrast and shadow density, D/LPD should be selected. Agfa's Insignia Fine Art paper is about the best of the above in general distribution.

In the case of AGFA's MCP (Multi Contrast Premium), a warm tone RC paper, which is 1/2 paper grade more contrasty than Multigrade and 1 or 1 1/2 grades contrastier than Kodak's traditional offerings, may profit from DSS to manage the contrast in some negatives, however, SEL is most often the best choice and SEL/S is sometimes a good choice.

Premium Papers:
Papers such as Ilford Gallery, Kodak Elite, Luminos and a couple of other pretty impressive products from Eastern Europe, for the most part, work best with DS or DSS. If more contrast is required, it may be achieved by using the D/LPD at 1:1 instead of the recommended 1:2. In general, two tray development (utilizing both low contrast and high contrast developers) doesn't work very well, and can always be equaled or exceeded by one of the above recommendations.

## OTHER CHEMICALS

Stop Baths:

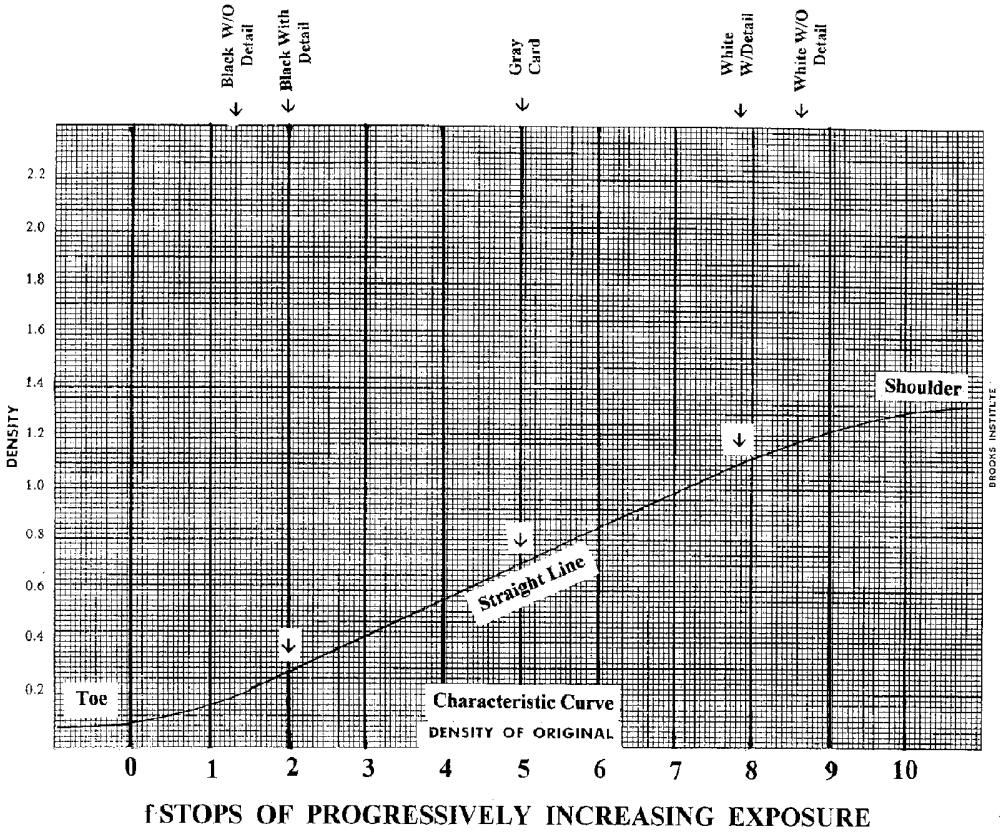
An acid bath which instantly stops development, conditions the gelatin emulsion, prevents sulfurization and other contamination of fixing baths. This is normally Acetic Acid @ 1% to 5% (usually closer to 1% 0r 2%). Sometimes an indicator dye will be placed in this solution to let the user know when the pH has risen to a near neutral state.
In some instances Citric acid may be used as a stop bath but it neutralizes too rapidly. In an emergency, a 1/2 to 1% Sod. Bisulfite solution may be used but this is not recommended due to a health hazard from excessive inhalation which can result in irritative pneumonia.

ACETIC ACID STOP BATH IS TO BE PREFERRED

Fixing Bath: Conventional or rapid fixers may be used but they should be mixed to the correct dilution. Regardless of advice to the contrary, do not use a "2 Bath" fixation method, this often results in sulfurization and the destruction of the image.

**THE CHARACTERISTIC CURVE**

H. Lynn Jones




**Normal Continuous Tone negative Average Gradient .49**
**All printable detail is carried in .80 of the straight line portion.**
**All printable tones are carried in 1.0 of the straight line portion.**
**This 1.00 of tonalities precisely matches the 1.0 Density Scale of World Standard #2 Paper or US Standard #3 Paper**

When film is given a series of progressively increasing exposures, the resulting densities when charted on a graph will appear as above. Notice that a considerable amount of exposure must be received before significant density increases occur, this is the *TOE* of the curve. Thereafter, exposure increases result in predictable and equal density increases, creating the so called, *STRAIGHT LINE* portion. When exposure increases beyond the straight line, there is progressively less increase in density creating the *SHOULDER* of the curve. Massive continuous increases in exposure beyond the shoulder of the curve may cause some density decrease producing partial reversal of the image, this is properly called *SOLARIZATION*. Herschel Effect and Clayden Effect both cause reduced density at the shoulder but for different reasons.

## B/W Printing Papers

The world international standard #2 (Normal contrast) paper was established many decades ago as the paper with characteristics which would yield a pure white, a pure black, and the maximum number of visually separable tones between those extremes. A reasonably good result may be obtained from contrasts 1 and 3 but with some losses in middle tone discrimination. Contrasts above and below 1 through 3 are for truly emergency use since significant losses in detail and tonalities always obtain.

## Important Definitions

BRIGHTNESS RANGE: The scale of tones in a scene, reported in density units, is called "Brightness Range".

DENSITY RANGE: The scale of tones in a negative, reported in density units, is called "Density Range".

DENSITY SCALE: The scale of tones which can be reproduced by a printing paper, reported in density units, is called "Density Scale".

| Designation | World Standard D.S. | A.N.S.I. D.S. |
|---|---|---|
| 5 | #5 = .40 | #5 = .60 |
| 4 | #4 = .60 | #4 = .80 |
| 3 | #3 = .80 | #3 = 1.00 |
| 2 World Standard | #2 = 1.00 | #2 = 1.20 |
| 1 | #1 = 1.20 | #1 = 1.40 |
| 0 | #0 =1.40 | #0 = 1.60 |
| 00 | #00 = 1.60 | #00 = 1.80 |
| 000 | #000 = 1.80 | #000 = 2.00 |

### Negative to Print Relationship

The exposure and development of a negative, when properly accomplished, should result in a total printing density range which matches the "Normal" printing paper, usually 1.00. This relationship determination goes back to the end of the 19th century. When most photographs were produced by contact printing, slightly different standards were used. When enlarging became the standard means of reproduction the current standards were adopted (approximately 1954).

The 1.00 Density Range to 1.00 Density Scale was selected by the ANSI predecessor ASA as the relationship that produced the greatest scale of tonality, yielding a pure black, a pure white, and the maximum of visually separable tones. Higher contrast papers would cause middle tone merging resulting in less scale while lower contrast papers would possibly create more middle tones but the reduced separation would make the differences harder to see.

It appears that the new ANSI standard is designed to conceal the fact that variable contrast papers cannot be made in contrasts much higher than D.S..60 (World Standard #4) and secondarily, films must be developed longer to match the lower contrast paper (higher Average Gradient) allowing a higher film speed to be claimed.

# THE CHARACTERISTIC CURVE

## Background Information

The characteristic curve, sometimes called the H&D curve (after Hurter and Driffield, the English investigators who in 1890 first published data on sensitometry) is a line graph clearly showing the effect of equal increases in exposure at any tested level of development. It does not take any great skill to infer the films characteristics from the curve. The characteristic curve is part of the quality control of photography. The following are important to understand quality control.

*SENSITOMETRY: The science which treats of the reaction of photographic emulsions to exposure, development, and other procedures effecting changes in density, color, or contrast.*
*DENSITOMETRY: The science of the measurement of sensitometry's affect.*
*SENSITOMETER: Any device which exposes photographic emulsions in precise steps.*
*DENSITOMETER: Any device which reads or measures the density (light stopping or absorbing ability) of a sample, whether by reflection or transmission.*

Due to the numerically high variations in light stopping ability, a special system was adopted to chart, graph, and describe these variations. Following is the source of the methodologies which we use.

TRANSMITTANCE OR TRANSPARENCY: Expressed as a percentage of the original light sources penetrating the sample. This can be a clumsy figure with many decimals and many zeros, lending itself to errors in transcribing and in calculating.

OPACITY: The reciprocal of the transparency. If $1/10^{th}$ of the light is transmitted, the opacity is 10. Due to the fact that the opacity of higher deposits of light stopping photographic deposits can be in the 1,000's or These numbers tend to be difficult and clumsy to use.

DENSITY: The log of opacity, an easy progression to deal with and is an easy shorthand for extremely large or small numbers. This permits the construction of line graphs (characteristic curves) which exaggerate, graphically, the differences in such a way that we can know many things about the performance of a photographic emulsion at a glance.

| Transmission % | Transmission Decimal | Opacity | Density |
|---|---|---|---|
| 100% | 1.00 | 1.00 | 0.00 |
| 10% | .10 | 10 | 1.00 |
| 1% | .01 | 100 | 2.00 |
| .1% | .001 | 1,000 | 3.00 |
| .01% | .0001 | 10,000 | 4.00 |
| .001% | .00001 | 100,000 | 5.00 |

## METRICS

The Photography and Photographic Laboratory industries converted to METRIC MEASURE in 1954/55. In that 40 years, many of us have made few, if any, moves in that direction! If you don't think in met-

ricterms, you are our of step with the world! It should be the policy of our photographers to use metric measure, especially in the mixing of small quantities of chemicals. It isn't really possible to get truly accurate small measurements in fluid and dry ounces, which are in no way equivalent.

Metric, on the other hand, is an interchangeable system based on the meter which, until recently, was standardized as equal to 1/40,000,000 of the world's circumference.

One 1/100th of a meter, known as a centimeter, is the basis of uniform comparison as well as the basis for the measurement of distance. The millimeter is 1/1,000 of a meter (1/10th of a centimeter). The micron is one millionth of a meter while the millimicron or nanometer is one thousandth of one millionth of a meter (the unit of measurement of light waves).

The weight of one cubic centimeter of triple distilled water is the basis for the measurement of weights, known as one gram.

One cubic centimeter of triple distilled water is the basis for the measurement of volume.

There are 25.4mm (2.54cm) per inch.

There are 305mm or 30.5cm (304.8) per foot.

There are 39" to the meter (3" more than a yard).

Standard Focal Lengths

(approximate)

| | | |
|---|---|---|
| 50mm. . .2" | 210mm. . .8.25" | 400mm. . .16" |
| 75mm. . .3" | 240mm. . .9.5" | 500mm. . .20" |
| 90mm. . .3.625 | 250mm. . .10" | 600mm. . .24" |
| 100/105. . .4" | 300/305mm. . .12" | 1,000mm. . .40" |
| 135mm. . .5.25 | 355mm. . .14" | 2,000mm. . .80" |
| 150mm. . .6" | | |

Format Sizes

(approximate)

35mm. . .Standard DOUBLE FRAME 24X36mm (1"X1.5").

35mm. . .Standard SINGLE FRAME 18X24mm (.75"X1").

645. . .6X4.5cm, films127/120/220, 1.625”X2.25.

6X6. . .6X6cm, films 120/220, 2.25”sq.

6X7. . .6X7cm, film 120/220, 2.25”X2.75”.

6X8/6X9. . . 6X8.25cm, Film 120/220, 2.25”X3.25”.

Sheet Films:

4”X5”. . .3 62/64ths” X 4 62/64ths”, About 100mmX125mm.

5”X7”. . .4 62/64ths” X 6 62/64ths”, About 125mmX178mm.

8”X10”. . .7 62/64ths” X 9 62/64ths”, About 200mmX250mm.

Lab Metric Equivalents

**ml** and **cc** (milliliters and cubic centimeters) are the same volume

for our purposes (although scientifically slightly difference).

| Rough Equivalents | Precise Equivalents |
|---|---|
| Fluid Ounce=30ml | 29.5ml |
| Cup=250 | 236.5ml |
| Pint=500 | 473ml |
| Quart=1,000 (1 Liter) | 946ml |
| Gallon=4,000 (4 Liters) | 3,785ml |

Weight

Avoirdupois to Metric

1 lb = 453 gm

1 ounce = 28 gm

2.2 lbs = 1 Kilogram

2,200 lbs = 1 Metric Ton

1 troy ounce = 37.75 gm

Temperature

Fahrenheit vs Celsius (Centigrade)

Most of the photographic community avoids the Celsius scale due to its grossness, often requiring 2 decimals. In analytical labs, however, the Celsius scale is used due to it's energy interchangeability in chemical and analytical equations.

## HEALTH AND THE PHOTO LAB

ALWAYS USE PRINT TONGS to avoid direct contact with chemicals which may not be in your personal best interest or health.

ESPECIALLY if your are allergic, avoid contact with all photographic chemicals, dry or liquid. It is wise to use impermeable gloves. There are "rubber" or plastic gloves available, usually at supermarkets. Ordinarily, latex rubber (surgical) gloves are a bit too fragile for use in the lab

Many photo solutions such as developers are strongly alkaline, from about pH 8 to (in rare instances) about pH 12 (C 41 is up to pH 10). The human skin is acid with a pH in the area of 4 to 5. This acid state is called the "ACID MANTLE" and is essential to the skin's health. The washing away of the acid mantle or its destruction by basic chemicals renders the skin vulnerable to a number of undesirable conditions including the following considerations.

Many of the chemicals used in photography are called "sensitizing" in nature. Particularly, when our skin has lost its acidity, it sometimes over reacts to sensitizing chemicals, after repeated exposure. The immune system goes wild and an incredibly severe allergic condition may result. The tissue breaks down into terrible open sores and the victim will probably never again be able to work around a photographic laboratory. An anaphylactic reaction is the worst of the allergic conditions possible and the victim may die if not treated immediately. This is an admittedly unusually uncommon situation but one which must be considered.

Prevention of these dire conditions is fairly simple, **AVOID CONTACT!** It is pretty hard to totally avoid contact with developers and impossible to avoid frequent hand washing. Periodically, the photographer should soak the hands in stop bath for a minute or two to re-acidify the skin and rinse in clear water. It is common for knowledgeable photographers to keep a large beaker or graduate filled with acetic acid solution at a 2% to 5% concentration (vinegar, a naturally occurring acetic acid, works well) in which to soak his/her hands. Frequent use of a moisturizing cream will prevent over drying and cracking of the skin. Pacquins Plus hand and body cream has been our favorite for many years (going back to our days as an operat-

ing room technician, scrubbing the hands with a stiff brush many times daily), Avoid creams having petrolatum or mineral oil, this doesn't moisturize, merely waterproofs the already damaged skin, in addition to putting greasy smudges on every thing touched.

The manufacturers provide data regarding the health hazards, toxicities, and other information. The Austin Community College Photo Technology Department maintains a file of these data entitled, Material Safety Data Sheets . . MSDS . . . and they are available to students and staff alike. If you darkroom is used by anybody other than you and your immediate family, for legal liability you should have a notebook, prominently marked "MSDS" in your darkroom.

## Terms

**pH** The measure of acidity/alkalinity, 7.0 is neutral, anything less is acid, while anything more is alkaline (also called basic).

**B.O.D. 5** The 5 day Biological Oxygen Demand. This is the oxygen consumption during biological degradation. Fish and other aquatic life require 5 to 7 mgm of oxygen per liter of water. Surface water normally contains 5 to 9 mgm of oxygen per liter of water at 70 $^{o}$ F, at higher temperatures water contains less oxygen. Dumping only 10 gallons of a solution containing a BOD or COD level of 600 could deplete the oxygen to the point where aquatic life could not live in from 1,200 to several thousand gallons of water.

**C.O.D.** The 2 hour oxygen consumption of a chemical (oxidation) as differentiated from BOD 5 above. Sadly, COD depletes the oxygen level of waterways 60 times faster than BOD 5 and the aquatic life won't even llive long enough to escape or to wait for the water to be diluted by currents!

**TSS/TDS** Total Suspended Solids or Total Dissolved Solids in a solution. While these are of concern in industrial health, they are seldom a problem in photography. The one exception is the minilab using "washerless" chemical systems, these must either be diluted or disposed of as hazardous waste under appropriate guidelines.

**FORMALDEHYDE** A water soluble colorless pungent gas, available in up to 37% liquid concentration, stabilized with a small quantity of methanol. In photography, formaldehyde is used to harden emulsions, stabilize color dyes, and as a preservative (it is a liquid "cold sterilizing" solution in the health sciences and will upon ample exposure, kill all known living organisms). While formaldehyde (also called formalin solution) is toxic in high concentrations (in photography it is normally used in a weak state, about .01%), if it is used according to PHS standards, it is relatively harmless unless one is allergic to it. Formaldehyde is biodegradable and not a danger to sewage disposal systems, except in huge quantities or high concentrations when it will kill the bacteria in primary sewage disposal systems. ***If a large quantity of the concentrate is spilled in the lab, it can be dangerous, however, it can be instantly altered chemically, to the point where it is odorless and non-toxic by pouring common sodium sulfite powder or solution on it.***

**HEAVY METALS** These are defined as metals having a specific gravity of 5.0 or more. Heavy metals include cadmium, chromium, cobalt, copper, gold, iron, lead, manganese, mercury, molybdenum, nickel, silver, and zinc.

**ZINC** Zinc is no longer found in photographic solutions, although it was an important stabilizing agent in color print processing during the fairly recent past. When it is now found, it is primarily as a result of traces being found rarely in certain photo sensitized products.

**IRON** Iron is commonly found as a tightly bound chemical in certain bleaches and bleach/fixes. It is of such nature that it never breaks down in normal photo uses and is therefore not a problem. In iron or steel plumbing, as a result of either new construction or repairs there may be liberated, small particles of iron or rust that may combine with chemical solutions and cause intractable staining of photographic products, but they are not a health hazard.

**SILVER** Silver is only present in solutions after being used. The silver is reduced from the silver salts in the photographic emulsions and is most commonly encountered as silver salt of the active ingredients of fixing bath or bleach fix. It will occasionally be encountered as colloidal silver or silver sludge in silver solvent developers. Such silver as is not reclaimed will work its way into secondary sewage disposal where it will be converted into silver sulfide and will be removed with other sludges. In modern photo labs, well in excess of 85% of silver reduced and liberated is reclaimed.

## AUTHOR AND SOURCES

H. Lynn Jones

**Born:** Springfield, IL, USA

**Military:** 9 years USN/USMC Hospital Corpsman, OR Tech, Medical Field Tech, X ray Tech, Medical Photographer, Independent Duty Qualified, Nuclear Warfare training and Nevada Test Site "Atomic" Bomb exercise.

**Schools:** ***Public schools,*** Illiopolis, IL , Springfield, IL (2X), Jerome, IL (2X), Boston, MA, Baltimore, MD, New Port, RI, Winter Harbor, ME, Southwest Harbor, ME (2X), Houston, TX.

***Adult education:*** Hospital Corps School, Operating Room Technique School, Medical Field Technique School (USMC Combat Medic), Medical Photography School, X ray Technician School. Special Training in various areas including Nuclear, Biologic, Chemical Warfare.

***College:*** BA, Brooks Institute of Photography,
Major: Advertising Illustration
Minor: Cinematography
Minor: Photo Lab Technology

***Casual:*** Hundreds of courses, classes, seminars, and workshops in photography, cinematography, videography, lab technology, business administration, advertising, public relations, consumer law, OSHA law, and various other subjects.

**Experience:** Over fifty years of experience in photography, writing, photo/optical design, manufacture, distribution, cinematography, advertising, public relations**.**