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Learning Photography Course - 9. Film

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1. 1 What film is



Module eight ended by turning back to where photography began. So this module starts with the material itself, because everything a film camera does is in service of a strip of plastic about as thick as a sheet of paper.

That strip has two parts. The **base** is a clear, flexible support. On top of it sits the **emulsion**: a thin layer of gelatin holding millions of tiny crystals of silver halide. The gelatin is the same family of material as a jelly. The crystals are what matter.

A black-and-white film has, in effect, one working layer. A colour film stacks several. Broadly, one layer responds to blue light, one to green and one to red, with a filter layer in between to keep blue light out of the layers beneath. Each colour is recorded separately, in the same frame, at the same instant.

When light reaches a silver halide crystal, a few atoms of metallic silver form inside it. Nothing visible happens. The frame looks exactly as it did before you pressed the shutter. This is the **latent image**, the idea module one introduced, and here it is in its physical form: **a picture that exists only as a pattern of chemical change too small to see**.

Development is what makes it visible. The developer turns exposed crystals into black metallic silver, and it works fastest on the crystals that already carry those few atoms. Crystals that received more light turn dark sooner. The picture you see is simply a map of which crystals were struck.

That also explains grain. The crystals are not arranged on a grid. They are scattered at random, in different sizes, and after development each one becomes a small clump of silver. **Grain is that structure showing through**. It is not a fault laid over the image. It is what the image is made of.

2. 2 Speed, grain and character



On a digital camera, ISO is a setting you change between frames. **On film, ISO is a property of the film.** Load a roll of ISO four hundred and every frame on it is ISO four hundred until the roll is finished.

The number is measured, not chosen. For black-and-white negative film, the international standard, ISO six, finds the exposure that produces a density of **zero point one above base plus fog** - the faintest useful tone the film records - under a development that meets a defined contrast. The speed is calculated from that exposure. So an ISO number describes a film and a development together, which matters later in this module when we change the development on purpose.

Why does a faster film need less light? Mostly because its crystals are larger. A larger crystal is a bigger target for light, so it is more likely to form a latent image from a small exposure. The price is structure: larger crystals make coarser grain.

This is the point where film and digital part company. **Grain is not noise.** Digital noise is a measurement error, random variation added to a signal by the sensor and its electronics, and it grows as you amplify a weak signal. Grain is the image itself, built from particles of silver or clouds of dye. A grainy film is not measuring badly. It is building the picture from bigger pieces.

So on film, three things pull against each other: **speed, grain and sharpness**. A slow film gives fine grain and fine detail, and asks for more light. A fast film works in dim light, and shows its structure. There is no film that wins all three.

And two films with the same number on the box still look different. The shape of the grain, the way each responds to colour, how gently they handle bright highlights - these are decisions made by the people who designed the emulsion. That is what photographers mean by a film's **character**, and it is chemistry, not magic.

3. 3 Formats



Film is sold in sizes, and the size is called the **format**.

The one most people know is **thirty-five millimetre**, properly called one-three-five. The international standard for it, ISO one thousand and seven, describes a full frame of **twenty-four by thirty-six millimetres**, in cassettes of twelve, twenty, twenty-four or thirty-six exposures. The same standard also describes the **half-frame**: eighteen by twenty-four millimetres, half the area, twice the pictures on a roll. And that twenty-four by thirty-six frame is exactly what a full-frame digital sensor was sized to match. The digital world inherited its reference size from a film cassette.

Smaller still is **one-ten**, a pocket cartridge film with a frame much smaller than thirty-five millimetre, built for convenience rather than quality.

Larger formats begin with **roll film**: one-twenty, and its longer, now rare sibling two-twenty. There is no cassette; the film is wound onto a spool with a paper backing. Its formats have names like **six by four point five, six by six, six by seven, six by nine**, and the long panoramic **six by seventeen**. Those names are nominal, roughly in centimetres. The real picture area is a little smaller and varies with the camera.

Beyond roll film is **sheet film**: individual sheets loaded one at a time into holders, for large-format cameras. This is not only history. Kodak's current data sheet for Portra four hundred still lists it in thirty-five millimetre, one-twenty and **four by five inch sheets**.

What does the format change besides size? A larger negative needs less enlargement to reach the same print, so its grain is magnified less and its tones look smoother. For the same framing it needs a longer lens, which means less depth of field at the same aperture - the same arithmetic that applies to larger sensors. And it changes how you work. **A sheet of film costs enough that you think before every exposure.**

4. 4 Loading and shooting



A roll of film can be ruined before a single picture is taken, and almost always in the same two ways.

With thirty-five millimetre, the risk is a leader that never caught. The camera advances, the counter moves, and the film stays in the cassette. So after loading, **watch the rewind knob turn as you wind on**. If it does not move, the film is not moving either. With one-twenty, the risk is light. The paper backing protects the film only while it is wound tight. Load and unload in shade, keep the roll tight as you take it out, and seal it straight away.

Metering on film brings a surprise: **negative and slide film want opposite instincts**.

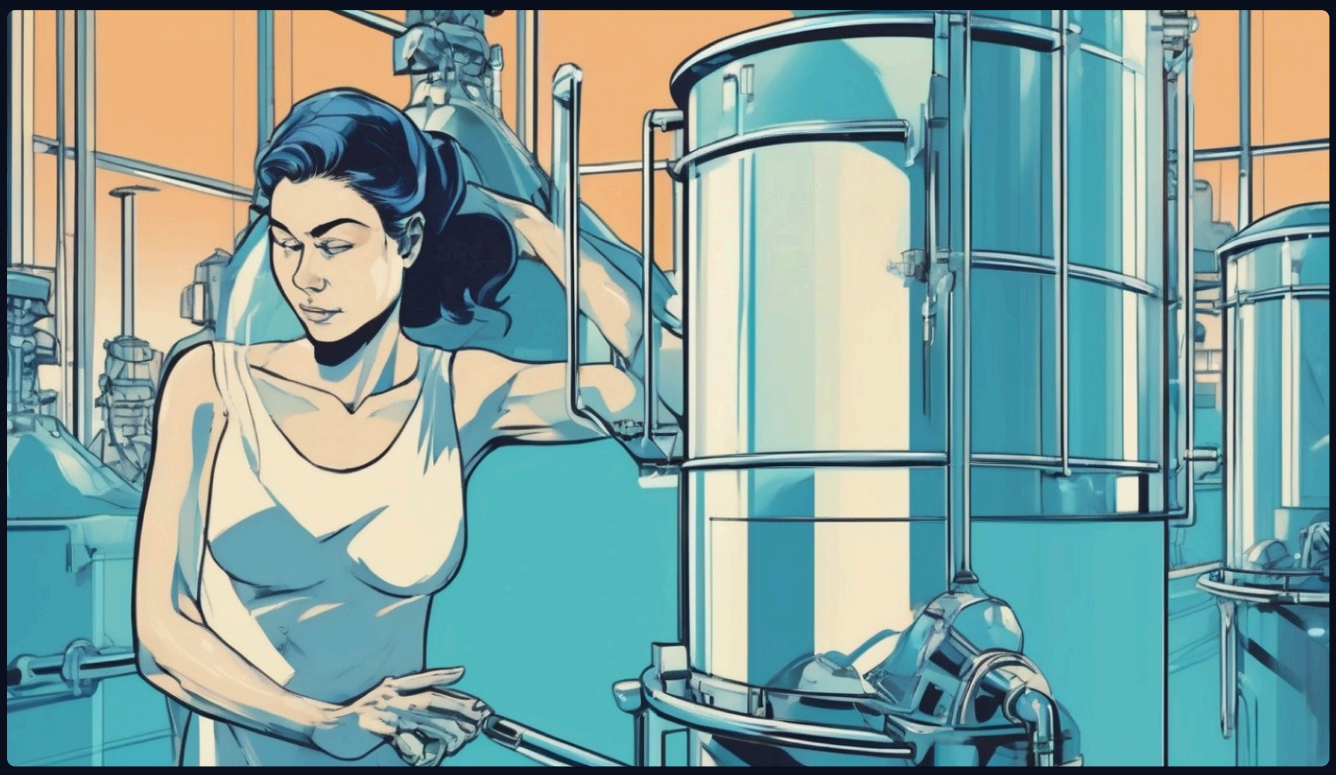
A negative is forgiving of too much light. The dense, over-exposed parts still hold detail that can be printed down. What it cannot recover is shadow that was never recorded. So with negative film, **expose for the shadows**, and when in doubt give it more light.

Slide film is the reverse. The slide is the finished picture, and a highlight blown to clear film is simply gone. So with slide film, **expose for the highlights**, and when in doubt give it less. Kodak's data sheet for Ektachrome E one hundred gives its figures rounded to the nearest third of a stop, and advises a series of test exposures for critical work. That is a manufacturer telling you how little room there is.

Which is why **bracketing** matters on film in a way it rarely does now. You take the metered frame, then one a little brighter and one a little darker, and choose later. On slide film, brackets of a third or half a stop are normal. On negative film, a full stop apart is usually enough.

And keep notes. A digital file records its settings inside itself. **A negative records nothing but the picture.** A small notebook - frame number, aperture, shutter speed, what you intended - is the only way to learn from a roll after it comes back.

5. 5 Black-and-white processing



Black-and-white film is the one process most people can do at home, in a lightproof tank on a kitchen table, with the lights on once the film is inside.

There are four steps. **Developer** turns the latent image into silver. **Stop bath** halts development almost instantly. **Fixer** dissolves away the silver halide that was never exposed, so the film is no longer sensitive to light. And **wash** removes the fixer, so the negative lasts.

Real numbers make this concrete. Ilford's data sheet for HP5 Plus, dated November two thousand and eighteen, gives the following at twenty degrees, in a spiral tank. In ID-eleven developer, undiluted, at its rated speed of four hundred: **seven and a half minutes**. Stop bath: **ten seconds**. Rapid fixer: **two to five minutes**. Then Ilford's own wash: fill the tank, invert it five times and drain; refill, ten inversions; refill, twenty.

Agitation is written just as precisely. **Invert the tank four times during the first ten seconds, then four times again during the first ten seconds of each further minute.** Too little agitation and exhausted developer sits against the film; too much and the edges develop more than the middle.

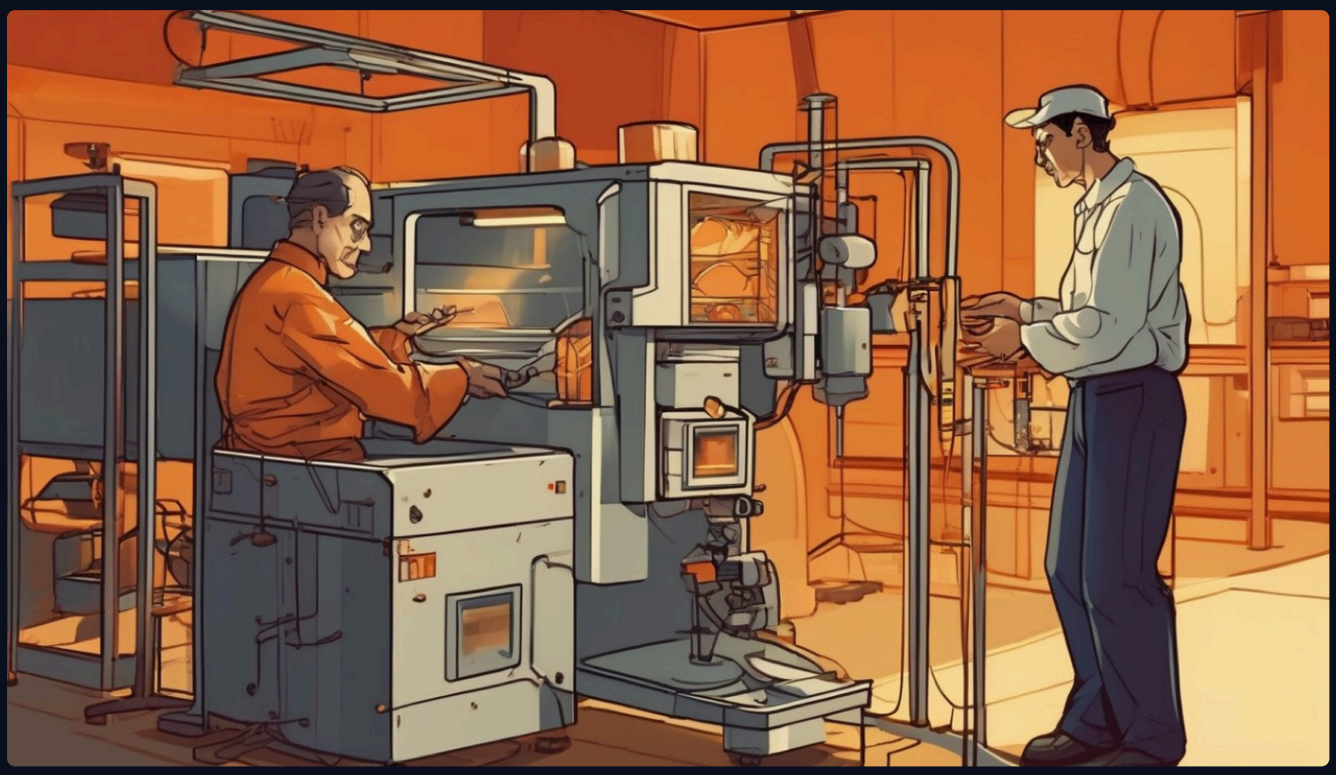
That is why time, temperature and agitation are **one relationship**, not three settings. Warmer developer works faster, so the time must shorten, and Ilford's sheet carries charts for exactly that. Change the agitation and the result changes too. A time on its own means nothing.

Developers come in families. A general-purpose developer such as ID-eleven balances grain, sharpness and speed. Others trade those qualities differently, for finer grain, for crisper edges, or for

more speed from the same film.

Which brings us to **push and pull**. Rate the film faster than its box speed, underexpose it, and develop longer to compensate. The same data sheet gives the real cost. **HP5 Plus rated at one thousand six hundred, two stops fast, needs fourteen minutes in ID-eleven**, against seven and a half. Almost double the time for two stops, with more contrast and more grain as the price. Pulling is the reverse: overexpose, develop less, and soften the contrast.

6. 6 C-41



Black-and-white development has a hundred right answers. **Colour negative has one.**

That process is called **C-41**, and it exists so that any colour negative film can go through any laboratory's machine and come out correctly. The film makers design their films around the process, not the other way round. The fixed recipe is the point.

Kodak publishes it in a document called Z-one-three-one. For sink-line and batch processing, the steps are **developer, bleach, wash, fixer, wash, stabiliser**, then drying. The developer turns exposed silver halide into silver and, at the same time, forms coloured dyes in each layer. The bleach converts that silver back into a form the fixer can remove. What is left is only dye.

The times are fixed. **Developer: three minutes fifteen seconds.** Bleach: six minutes thirty. Fixer: six minutes thirty. The washes are three minutes fifteen each, and the stabiliser a minute and a half. That is about twenty-four minutes in solution, in a process Kodak puts at about half an hour once every step drains.

Now look at the temperatures, because they are the real lesson. The developer must be held at **thirty-seven point eight degrees, plus or minus zero point one five of a degree**. Every step after it may be anywhere between **twenty-four and forty-one degrees**. One step is allowed less than a third of a degree of total variation; the others are allowed seventeen.

The reason is that **the developer is the only step that decides the colour**. It works in three layers at once, and each layer's dye forms at its own rate. Change the temperature and those rates change by

different amounts, so the balance between the three colours shifts. Nothing later can put it back. Kodak even notes that the temperature is the one to hold during development, not the one to start from - the tank cools once the film goes in.

Finally, the **orange mask**. Hold a colour negative up to the light and it is not just inverted, it is orange. That colour is deliberate. It is built into the film to help control contrast and correct shortcomings in the green- and red-sensitive layers when the negative is printed. The printer or scanner removes it. **It is a correction travelling with the film.**

7. 7 E-6



A slide is not a negative. It is a **positive image on the film itself**, the colours you see when you hold it to the light. Making one needs a longer, stranger process, and it is called **E-6**.

Kodak's document Z-one-one-nine sets out the sequence. **First developer**, which develops a black-and-white negative image in silver. A **reversal bath**, which prepares the silver halide that was not exposed. Then a **colour developer**, which develops that remaining halide and forms dyes where it does. A pre-bleach, a bleach and a fixer then remove every trace of silver, and what is left is a positive in dye. In short: the process makes a negative, throws it away, and keeps its opposite.

The first developer runs for **six minutes**, and Kodak's instruction is to hold that time to **five seconds and the temperature to zero point two of a degree**. The reversal bath, by comparison, may sit anywhere from twenty-four to thirty-nine point four degrees. The first developer is the strict one because it decides how much halide is left for everything that follows. **In E-6, the first developer is the exposure of the finished slide.**

Kodak shows this directly. To push Ektachrome E one hundred by one stop, you rate it at two hundred, and the first developer runs **eight minutes instead of six**. Nothing else in the process changes.

That is also why a transparency has so little latitude. With a negative there is a second chance: the print or the scan can be made lighter or darker. **With a slide, the film you hold is the final image.** A highlight that went clear has nothing in it, and a shadow that went black cannot be lifted without showing its limits.

Which leaves **cross-processing**: putting a film through the process designed for a different one. Slide film processed in C-41 chemistry comes back as a negative, without an orange mask, usually with strong contrast and colours that shift in ways that are hard to predict. People do it for that look. It is worth being clear that **no manufacturer publishes data for it**, so every result is an experiment.

8. 8 The darkroom



A darkroom is not fully dark. Black-and-white printing paper is insensitive to certain colours of light, so the room is lit by a **safelight**, dim enough to work by and safe for the paper, within limits. Ilford's data sheet for its Multigrade resin-coated paper sets them: keep the paper at least **one point two metres** from the safelight, and do not leave it exposed to direct safelight for more than **four minutes**. Safe does not mean harmless forever.

The room has a geography, and it matters. A dry side, where the enlarger and the unexposed paper live. A wet side, where the trays sit in order: developer, stop, fixer, wash. Paper and chemistry should never meet by accident.

The **enlarger** is a projector pointing down. The negative sits in it, a lamp shines through, a lens focuses the image onto a baseboard, and the paper goes there. Before committing a whole sheet, you make a **test strip**: a strip of paper exposed in steps, covering a little more of it every few seconds, so one piece shows a range of exposures. Develop it, choose the step that looks right, and print at that time.

Contrast used to mean buying paper in fixed grades. **Multigrade paper** changes that. Its contrast is set by the colour of the light, using filters in the enlarger. Ilford's system uses **twelve filters, numbered double zero to five in half steps**, the lowest number giving the softest contrast. And Ilford notes that filters from double zero to three and a half typically need **the same exposure time**, so a test strip still holds when you change the contrast.

Then the hands come in. **Dodging** holds back light from part of the print, so it stays lighter. **Burning** gives extra light to one area, so it goes darker. A card with a hole in it, a piece of wire with a paper shape on the end, and a hand kept moving so no edge shows. This is the part no chart can teach.

Last, the paper. Resin-coated paper has its core sealed in plastic, so the chemistry never soaks in. Ilford gives it **thirty seconds in fixer and two minutes of washing**. Fibre-based paper absorbs the chemistry into the paper itself, and Ilford's optimum sequence for it is a minute's fix, **five minutes' wash, ten in a washing aid, and five more**. Longer and slower - and it is what Ilford itself recommends when long-term permanence comes first.

9. 9 Reciprocity failure, and why people came back



Exposure, as this course has used it from the start, is intensity multiplied by time: half the light for twice as long gives the same result. That is the **reciprocity law**, and at ordinary shutter speeds film obeys it.

In very long exposures, film stops obeying it. The crystals receive light so slowly that the first few silver atoms of a latent image can fall apart before more arrive. So a film left open for many seconds behaves as though it received less light than the meter says. That is **reciprocity failure**, and the fix is to expose for longer than the meter suggests.

Ilford publishes the correction as a formula. **The corrected time is the metered time raised to a power**, and each film has its own power. For HP5 Plus it is **one point three one**.

Here is Ilford's own worked example. A meter reads ten seconds. Ten, raised to the power one point three one, is **twenty point four seconds**, which Ilford rounds to **twenty**. So the film needs roughly twice what the meter said. And the gap grows with time: a metered hundred seconds becomes about seven minutes.

Ilford's data sheet for HP5 Plus says no adjustment is needed between half a second and a ten-thousandth of a second; its newer compensation guide draws the line at one second. Either way, below about a second, the law holds.

Every film has a different exponent because every emulsion is a different design. Ilford's own list runs from one point two five for Ortho Plus to one point four three for SFX. Colour films differ too.

Kodak says Portra four hundred needs no correction up to one second, while Ektachrome E one hundred needs none up to ten.

So why, with all of this to manage, did people come back to film? The honest case is not magic.

Against it: every frame costs money, in film and in processing. Nothing is visible until later. Mistakes are learned expensively. **For it**: a negative handles too much light gracefully. A limited number of frames makes you decide before you press the shutter. And a darkroom print is a physical object made by hand from a physical original.

None of that makes film better or worse than digital. **Film is a chemical process with a fixed response; digital is a measurement with an adjustable one.** Knowing how the first works makes you better at the second - and that is where the next module goes.

Sources and credits

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