

# HOW PHOTOGRAPHIC FILM IS MADE

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*at the  
Eastman Kodak  
Company*

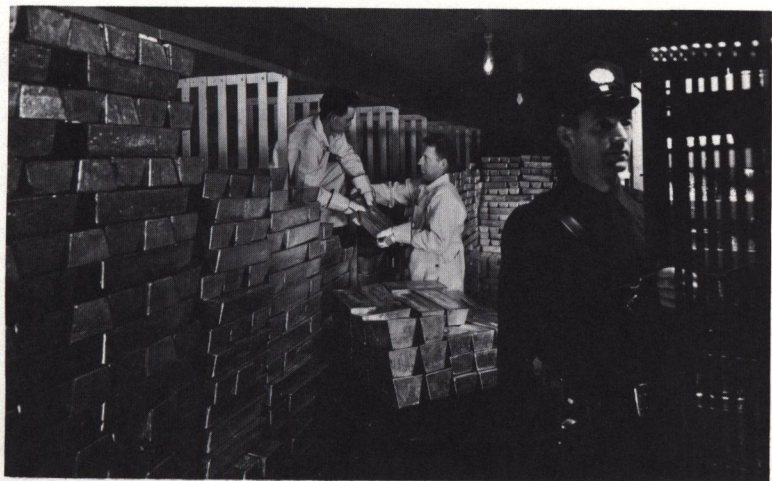


More and more people take pictures every year. Photography is the number one hobby in America. As photography has increased in popularity, so has the interest in how photographic film is made. To answer the questions of educators, students, visitors, and others, Kodak has prepared this description.

Raw materials from around the globe go into film. A partial list includes:

- Cotton linters — from the South
- Wood pulp — from the West Coast
- Silver — from Mexico and Canada
- Hide trimmings — from the United States and abroad
- Potassium bromide — from Great Lakes brine deposits

The two chief parts of photographic films are a base and an emulsion. The base is a transparent, flexible sheet, often cellulose acetate, on which the emulsion is coated. Years ago, only glass was used as a base; today, only very special applications still require glass plates. The use of a thin, flexible base permits film to be sold in rolls as well as sheets and thus makes motion pictures possible. The emulsion is a still thinner layer of gelatin in which light-sensitive ingredients have been suspended. It is the action of light, or certain other forms of radiant energy such as x-rays, upon the emulsion layer that is the basis of photography.



Silver ingots are stored in this vault at Kodak Park Works

Let's begin the story of film production by seeing how the base is made.

The process starts at Tennessee Eastman Company, Kingsport, Tennessee, a division of Eastman Kodak Company. Cellulose, the raw material for film base, reaches Tennessee Eastman in the form of cotton linters or wood pulp.

Because cleanliness is vital in film making, great care is taken in purifying the cellulose. If cotton linters are used, the impurities are removed with caustic soda, the linters are bleached, and then the clean cotton is dried. Wood pulp is also specially purified.

The next step is to treat the cellulose in acetic acid, acetic anhydride, and a catalyst such as sulfuric acid. Stainless steel mixers are used. The reaction produces a thick liquid which is stirred and heated until the desired end product, cellulose acetate, has just the right characteristics. This syrup-like liquid is next poured into water, and the cellulose acetate precipitates in the form of flakes, which then are washed and dried. These flakes are shipped in bales to Eastman Kodak Company's Kodak Park Works, Rochester, New York. There they are mixed with solvents to form a clear, honey-like liquid which is called "dope."

This dope is very carefully filtered to remove any dirt or undissolved material. It is also subjected to a partial vacuum to assist in the removal of suspended and dissolved air which might cause bubbles in the final product.

To form the plastic sheet, the dope must be coated out into a thin layer and the solvents must be removed. The first plastic film base was made in this way on long glasstop tables: When the solvent had evaporated the sheet was coated with emulsion; when dry the coated sheet was stripped from the table and rolled up. Today the glasstop tables have been replaced and the base casting part of the operation is accomplished continuously by piping the dope to machines containing highly polished coating wheels 18 feet in diameter and over 5 feet wide. A constant flow of dope is spread in a thin uniform layer on the turning wheel by means of a hopper. Since the film

must be uniform in thickness, this operation calls for extreme care. The standard thicknesses of film base run from  $3\frac{1}{4}$  to  $8\frac{1}{4}$  thousandths of an inch.



Photographic film base emerging from a film coating machine

As the wheel turns, enough solvents evaporate from the dope to permit it to be separated from the wheel as a sheet before a full revolution is completed. More solvents are removed by circulating air around the continuous sheet as it moves over rollers. For easy handling, the base is rolled on cores in long rolls of from 1,500 to 3,000 feet in length. These are then ready to go to the sensitizing division where emulsion is coated on the base. But first, let's see how emulsions are made.\*

Light-sensitive ingredients of emulsions are generally silver salts. These salts and other elements that go to make a modern photographic emulsion are very carefully compounded from their basic raw materials. Kodak starts with silver bullion

*\*Estar polyester base is used in professional products where dimensional stability is of greater importance. At the present time this film base is made at Kodak Park for limited use in professional products, primarily for the graphic arts field.*



Silver ingots ready for dissolving



Crystals purified by redissolving in water



Final crystallization process

(99.97 percent pure) which comes in bars weighing about 75 pounds each. The bars are dissolved in nitric acid and the resulting clear liquid goes into storage tanks. From these tanks the solution is pumped slowly into crystallizers -- 1,000-gallon stainless steel tanks -- where it is constantly cooled and stirred. This stirring and the addition of some concentrated silver nitrate solution result in the formation and growth of silver nitrate crystals in the lower part of the tank. Soaking wet and resembling common table salt, the crystals then are drawn from the tank through a pipe and poured into perforated stainless steel baskets. The baskets are whirled so that most of the moisture in the crystals is carried off. Each basket contains 60 to 70 pounds of crystals, worth about \$600. Next, the crystals are redissolved in distilled water and go through another crystallizing step. After the wet crystals come from the crystallizer the second time and have been whirled until they are only damp, they are dumped into a rotary drying drum. At the other end of the revolving drum the dry crystals pour out.

Funneled into stainless steel barrels, each holding \$6,000 worth of the product, the dry silver nitrate is ready to be dissolved in warm water for use in emulsion making.

Also used in making the emulsion are potassium iodide, potassium bromide, and gelatin. The gelatin is made at Kodak Park and by the Eastman Gelatine Corporation at Peabody, Massachusetts, by chemically treating hide trimmings and bones in hundreds of tanks. The stock is then washed and its gelatin content is extracted with hot water. The resulting solution is thoroughly filtered. Next, the water is evaporated to leave a gelatin with characteristics more closely controlled than that used in foods. Careful selection and blending of the gelatin insures the uniformity of the product for use in film emulsions.

Because silver crystals are light-sensitive, the next series of steps is carried on in the dark. The blended gelatin is dissolved in pure, distilled water and then water solutions of potassium iodide and potassium bromide are carefully mixed with it. To this heated mixture is added silver nitrate solution and the desired light-sensitive silver iodide and silver bromide salts are precipitated as fine crystals. Because these crystals are held in suspension by the gelatin, the mixture is called an "emulsion." The average crystal size and the range of sizes in a given emulsion is important in establishing the characteristics of the film, such as speed, contrast, and fineness of grain.

The emulsion-making process is performed in silver-lined jacketed vessels fitted with agitators. Soluble salts formed during the reaction must be washed out of the emulsion. This is done by chilling it to a jelly, then shredding it and washing the spaghetti-like strands many times with cold water. Then the emulsion is melted, adjusted for the desired photographic and physical properties, and carefully tested.

The emulsion then is ready to be coated. It is piped to large machines where, in a continuous operation, rolls of base are unwound and the liquid emulsion is applied to one side. Such machines provide extremely close control of coating thickness uniformity. A dried layer of some emulsions is in the



**Combining ingredients for photographic emulsion**

order of six one-hundred-thousandths of an inch thick and is held to within about one-millionth of an inch in accuracy. Color products have several successive emulsion layers coated in this fashion — and remember, it is all done in the dark. After the film is coated, it is carried through a chilling box to set and harden the emulsion, through drying sections where it is brought to the correct relative humidity, and finally it is again wound in long wide rolls.

Now the film — still in the dark — is ready for the final manufacturing steps. If it is motion-picture film, it must be cut to the proper length and width, perforated with accuracy so it will operate precisely in the camera and projector, and project a steady image on the screen. The rolls of film are then inspected, wrapped in light-proof paper envelopes, and packaged in sealed cans. The cans are stamped with the emulsion number and footage and placed either in wooden shipping cases or in fiber containers. If the film is sheet film, it must be cut to the proper size, notched with identifying code symbols, and packaged. In the case of roll film, the film is cut to proper width and wound, with backing paper having leaders and trailers for light protection, on spools. The spooled film is protected by a hermetically sealed foil wrap and then is packaged in the familiar yellow carton. Most film is dated on the outside of the box or carton.

After the film is packaged and dated, it is sent to air-conditioned store rooms to await shipment to Kodak sales divisions which, in turn, will forward it to photographic dealers.

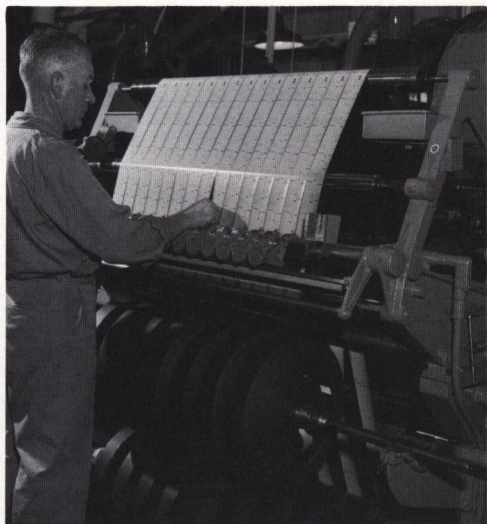
As the sensitivity of film is improved — and it is constantly being improved — it also becomes more sensitive to



temperature and humidity. Sealed cans or sealed metal foil provide desired protection from moisture. Many films also require storage at low temperatures and, at Kodak Park, all are stored in temperature-controlled rooms. Some special films are even refrigerated during shipment.\*

Almost all of Kodak's film boxes are made by the company. Strict quality control is necessary for the protection of sensitive photographic materials. Control is maintained by testing and manufacturing packaging materials "from the ground up." The package testing laboratory at Kodak Park is one of the most complete in industry. Each package is designed to withstand the hazards it is likely to meet in actual use. To determine the nature of these hazards, all handling operations are surveyed from the production line to the customer. Handling conditions are simulated in the laboratory by such devices as tumbling machines and special rooms where extreme degrees of temperature are maintained.

Most of the accessories used in the manufacture of film also are made within the company. For example: spools for roll film and amateur movie film; the backing paper on roll film; film-pack cases; cans for movie and motion-picture film; cores for motion-picture film. The company also prints most of its own labels.



Paper backing for Kodak roll film being slit to width

*\*For best results, photographic film should not be subjected to high temperatures -- for example, cameras and film should never be stored in the glove compartment or on the rear shelf of a car.*

Every room in which film is sensitized and handled must be kept at predetermined temperatures and humidities the year around to insure uniform quality. For this purpose, Kodak Park maintains a large refrigeration plant -- a network of air-conditioning equipment regulating humidity and temperature.



Amateur roll film packaging machine

The nature of the sensitized products manufactured at Kodak Park -- their susceptibility to impurities, dust, dirt, radio-activity, and atmospheric changes -- requires that they be manufactured and handled under exacting conditions imposed on few other products. Street sweepers and flushing trucks are used to keep Kodak Park's miles of paved streets clean. The air fed to many departments is washed and filtered. Cleaning squads go over walls and floors

with special vacuum cleaners -- and in many rooms their task is made easier because of specially constructed round corners in the rooms.

That's the story of film -- of one roll, or of the miles and miles which are turned out yearly at Kodak Park.

#### Kodak Park Works





Tennessee Eastman Company, Kingsport, Tennessee--produces plastics, man-made fibers and industrial chemicals, and materials for the manufacture of photographic film.

Eastman Gelatine Corporation, Peabody, Massachusetts--produces gelatin for use chiefly in photographic film and paper.



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