Eastman
Duplicating Film

Its Properties and Uses

Eastman Kodak Company
Rochester, N. Y.

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The Properties and Uses of Eastman Duplicating Film

The making of duplicate motion picture negatives has hitherto presented great difficulties, and their use has usually been restricted to those occasions when the original negative was entirely unavailable. The unsatisfactory quality of duplicate negatives has been due to the use of unsuitable films for their preparation and to a lack of understanding of the conditions under which the best possible duplicates can be obtained. With a knowledge of these conditions and the introduction of Eastman Duplicating Film, the production of duplicate negatives is a simple matter, and prints can be made from them which are identical with those obtainable from the original negative.

A duplicate should be made of every valuable negative before it is printed, so that if the original becomes scratched in use or otherwise damaged, the duplicate will be available. Duplicate negatives can also be used to facilitate rapid foreign distribution, while in the case of loss by fire or deterioration in storage, the possession of a duplicate negative will save serious loss.

It is sometimes advantageous to duplicate a negative in order to improve it. Some negatives are very contrasty or very flat and are difficult to print. By the methods described in this pamphlet duplicates can he made from which better quality prints can be obtained than could be made from the faulty original.

A good duplicate negative should be capable of giving a print as similar as possible to that given by the original negative. It should reproduce the tones of the original accurately unless the contrast range has been modified deliberately in order to improve it. It should be as sharp as the original, while the increase in graininess should be negligible. It is quite possible to fulfill all these conditions by the use of Eastman Duplicating Film, which is coated with an emulsion especially adapted to the purpose.

The essential requirements in a printing material for the production of duplicates are sufficient latitude to reproduce correctly the greatest scale of tones likely to be met with in an original negative, extremely high resolving power, or ability to reproduce fine detail, and freedom from graininess. These three requirements were not combined in any film up to the present available on the market. Negative film, which has a great range of latitude, is manufactured essentially for the production of negatives in the camera, and in order to attain the necessary speed, the grain size of the negative film has to be greater than is desirable in an emulsion to be used for duplicating. Positive film, on the other hand, while it has a very fine grain, is made to give a contrast which makes it unsuitable for use in duplicating. In Eastman Duplicating Film are combined the small size of grain of positive film and the great latitude and low contrast necessary for a duplicating film, which are obtained by the incorporation of a yellow dye in the emulsion.

In addition to the latitude and high resolving power which this yellow dye confers upon the emulsion, it also limits the maximum contrast available on development. This is of great importance. When a film is developed to a degree very much lower than its maximum contrast, different tones are developed unevenly because the reaction products of the development restrain development.

Eberhard, a Danish astronomer, observed in 1912 that with low development a small exposed area surrounded by a larger area of less exposure develops with more density than similar small areas surrounded by areas having greater exposure. In the latter case the small inner areas develop to a less extent than they should. The halo effect surrounding images silhouetted against a light toned background, such as a gray sky, is really a modification of this effect, and is known as the "Mackie" line.

The explanation of the phenomenon is simple. In the first case, the developer acting on the small exposed area diffuses into the surrounding gelatin as it becomes exhausted, and fresh developer diffuses into the spot from all sides, thus accelerating development. If the small area has less exposure than its environment, the opposite conditions hold, development of the small area being actually restrained by the reaction products diffusing into it from all sides. Both defects are quite pronounced if development is stopped at an early stage. *When development is continued until the image has reached maximum contrast fresh developer has time to soak into the film from the outside and smooth over the irregularities.*

It is very necessary to avoid these defects in the duplicate process because they are cumulative. The original negative will show them to a slight extent. The positive will then accentuate this. The duplicate negative will accentuate it still further, and in the final print made from the duplicate negative, the defect will be very much worse than in a print from the original. It is the accumulation of these small errors due to development phenomena which give the "duped" appearance to prints made from duplicate negatives prepared on a positive emulsion. By the use the yellow dye in the Eastman Duplicating Film, its maximum contrast has been reduced to a point so close to that required for duplicating the original that the effects due to the restraining influence of the developer are made negligible.

Since the contrast available is dependent upon the yellow dye, it can be modified by the use of light filters in printing, and it is thus possible to control the contrast of duplicate negatives by the use of appropriate filters, as is described later. In addition the use of a filter increases the latitude and reduces the tendency for graininess. The dye washes out of the duplicating processing, leaving an image having the normal appearance.

The speed is about1/20th that of motion picture positive film, which necessitates a more powerful lamp in the printer. The film keeps wel1 and can be handled in the usual positive safelight (Wratten Series 0).

How to Use Eastman Duplicating Film

Duplicates on Eastman Duplicating Film may be made in the usual way without departing from the ordinary methods of exposure and development. The quality of these duplicates will be better than could be obtained on existing emulsions using similar technic.

Negatives may be divided into three general classes, according to whether they were correctly developed, under-developed, or over-developed. If the original negative was under-developed, a duplicate having higher contrast may be made by *fully* developing the master positive and the duplicate negative. In this type of duplicate, the development

defects are reduced to a minimum. If it is desired to make the duplicate of the same contrast as the original, the development time should be decreased some what. If the duplicate must be less contrasty than the original, the time of development must be shortened still more, but the development defects will be increased. Even so, the resulting duplicate will still be much better than the best duplicate that can be made with other existing emulsions because such emulsions are less suitable for duplicating work and are much more sensitive to development defects.

The Quality of the Master Positive and the Duplicate

No rigid rules can be given relative to obtaining the quality desired in the master positive and the duplicate, since this depends largely on the quality of the original negative. Certain general directions, however, may be given.

Ordinary projection prints are entirely unsuitable as master positives. The master positive should be made on Eastman Duplicating Film and should usually be of the same contrast as the original negative. This means that it should be softer than the usual projection print. It should reproduce every tone of the original whether this is desired in the final print or not. Timing of the negative for printing should therefore be full, so that *all* highlight detail is obtained in the master positive irrespective of the density of the shadows. In case eye timing is employed, the printing exposure is governed solely by the density of the highlights or densest portions of the negative, A slight density should be visible in the highlights or clear portions of the master positive when the image is examined with a pocket magnifier or placed on a white paper surface (see samples P-1, P-2, etc., page 17).

A simple method of comparing the contrast of the master positive and the original negative is to superimpose identical frames of each. If the two are entirely blotted out, it means that the contrast of the two images is exactly the same. If there is a *residual positive* image the master positive is slightly more contrasty than the original, whereas the reverse is true if there is a *residual negative* image.

If the original is quite flat, a master positive having increased contrast may be obtained by developing fully, but if developed too far there will be a tendency to accentuate graininess. The exposure for master positives from contrasty originals should not be so great as to over-expose the highlights, or it will not be possible to get highlight detail in the final print without blocking up the shadows. (samples, P-2 and P-4, page 17, made from the contrasty original show the quality desired)

The same general rules as stated for the master positive apply when printing the duplicate negative. The superposition test described previously is the best guide to use in printing the duplicate negative from the master positive to determine whether equal, more, or less contrast has been obtained.

An example showing the contrast increase obtained from a soft original is shown on page 17. (D-5).

Printers for Duplication Work

It is very important when making duplicates to clean the original negatives thoroughly with carbon tetrachloride. The printer used in making both the master positive and the duplicate should be carefully tested and equipped for this work. If possible, it is wise to set aside one or more machines for this particular purpose. They should be retested frequently and handled only by experienced operators.

Duplicates may be printed either by contact or by projection. If contact printers are used, it is very important to test the gate pressure plates for uniformity, since the definition of prints from duplicate negatives will be dependent on intimate and uniform contact in the printer. It is obvious enough that poor definition will result if the films are out of contact during printing, but it is not so obvious that lack of uniformity of contact can do any particular harm. To test the printer for non-uniformity of contact, make a print from a strip of evenly fogged and developed negative film. If the printer is in perfect adjustment, the print will have an even tint, whereas a patchiness resembling that caused by uneven development will be observed on inspection if there has been imperfect contact during printing.

The best type of printer has a curved track and pressure plate with a small radius of curvature of about 1 ½ inches. The plate should be undercut over the picture area so that it presses only on the sides of the film over the perforations. This type of gate insures a very thin and uniform air separation between the two films and will eliminate any unevenness otherwise caused by buckling.

Printing Duplicating Film

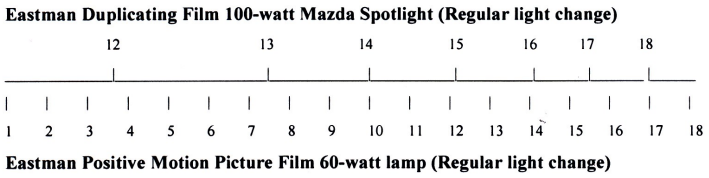
Because of the lower sensitiveness of Duplicating Film compared with positive film, it may be necessary to replace the usual printer lamp by a stronger one. This must be determined for the individual printer by experiment, but it has been found that the P25, 100-watt Mazda Spotlight (120-volt) gives ample illumination for printing average negatives at 16 to 24 feet per minute at the middle printer setting. With resistance controlled printers, it will be necessary with the stronger lamp either to retime the negative or to refer to a table giving the printer steps which with the 100-watt lamp on Duplicating Film correspond to the steps for the normal lamp with regular positive film, (see Table I). It is a simple matter to prepare a similar chart for any printer by making test prints throughout the entire range with the regular and 100-watt lamps.

Table I

Comparison of Light Intensities on a Resistance Control Printer

The chart gives equivalent exposures on Eastman Motion Picture Positive using a 60-watt lamp and on Eastman Duplicating Film using a 100-watt lamp.

The numbers indicate the resistance steps of the printer.



It is desirable whenever possible to use printers having a diaphragm light control, since the color of the light has a influence an the contrast of the print. Scenes printed at low voltage on a resistance controlled printer will tend to be slightly more contrasty than those printed at high voltage. With the range of contrast of modern studio negatives, however, this color effect is not serious and except in extreme cases may be disregarded.

When printing by projection the lens chosen should be one designed to work at unit magnification. Ordinary camera lenses are unsuitable because they are designed to focus sharply on objects at distance. The focusing of the printer lens must be very critical to avoid a loss of definition A clean lens is essential, as dirt marks will scatter the light and produce flatness in prints besides noticeably increasing graininess.

Contrast Control by Filters

Although Eastman Duplicating Film can be successfully used by the ordinary methods of exposure and development, the best results are obtained by giving complete development in all cases and securing any desired variation in contrast through the use of violet filters in the printer. The darker the filter used, the flatter will be the resultant master positive or duplicate negative. Inpractice it is found that a single or double thickness of Wratten Filter No. 39, Duplicating, will give all the control necessary.

The filter should be placed in the printer so that all the light reaching the film will pass through the filter. It is advisable not to place it too near the light source; this prevents over- heating and rapid fading of the violet filter. The filter will fade on prolonged use in the printer when it should be replaced.

With *full* development, one thickness of filter used for both master positive and duplicate negative ought to reproduce the contrast of the original negative. Ordinarily, then, most of the work will be done with one filter in position. (See samples D-1, D-2, and D-3 page 17.)

To make the duplicate of slightly greater contrast than the original no filter should be used when printing the master positive, but one filter should be used when printing the duplicate negative.

To make a duplicate of considerably greater contrast no filter should be used on either the master positive or duplicate. (Sample D-5.)

The use of two thicknesses of filter on the master positive and one thickness on the duplicate will give negative softer than the original, while the use of double thickness for both will result in a duplicate much softer than the original. (See sample D-4.)

The same rules previously given regarding the printing exposure and the quality of the master positive and duplicate, of course, apply with equal force when employing the filters. The violet filters regulate only the contrast of prints. The intensity of the printing light must of course be changed as usual in accordance with the density of the original being printed.

The filters do not lessen the photographic intensity of the light very much, and in general the effect of one thickness may be ignored. When double thickness is used, the printing light may be advanced one or two points, to compensate for the slight drop in printing power.

If the densities of the various scenes in the original do not differ greatly (not more than could be printed with four or five step changes on a resistance control printer) the entire negative may be printed at the same exposure setting provided the exposure is chosen so that the densest highlight of the densest scene will be printed correctly. The density of the scenes will, of course, differ in the master positive. If however the timing for the duplicate negative is based on the densest scene, the whole may again be printed at one setting, and the result will be a run of negatives having the same relative printing values as the original negative. This is assuming that the contrast of the original has been imitated, in other words, that one thickness of filter was used throughout the operations.

Note on Development

Various batches of Duplicating Film may vary somewhat in the time required for development, which must be full but not excessive. Development must consequently be controlled by inspection of the negative produced. It is correct when the duplicate negative obtained by one thickness of filter in each step of the process is equal in printing quality to the original. Duplicates made in this way will differ from the original only in requiring slightly more exposure when making prints for projection.

Processing Duplicating Film

Most uniform results in processing are obtained on continuous machines. If the film is processed on a reel, the film supports should be closely spaced to minimize bar markings. When the rack and tank method is used, the following agitation technic has been found effective in reducing development defects. After immersing the rack in the developer, it should be moved sideways and upwards for the first minute to impart a small horizontal and vertical agitation to the rack. Raise the rack entirely out of the tank once every minute until development is complete.

Developing solutions used for regular motion picture film are equally satisfactory for developing Duplicating Film. The following developer with complete development gives the desired maximum contrast on both the master positive and the duplicate negative:

Motion Picture Developer

(Formula D-16)

	Metric	Avoirdupois
Water (about 125°F.) (52°C.)	250cc	10 gal.
Elon …	0.3 gram	2 ozs.
Sodium Sulphite (E.k.Co.)	9.5 grams	16 ½ lbs.
Hydroquinone …	6.1 grams	2 ½ lbs.
Sodium Carbonate (E.k.Co.)	18.75 grams	8 lbs.
Potassium Bromide	0.9 gram	5 ¾ ozs.
Citric Acid	0.73 gram	5ozs.
Potassium Metabisulphite	5 grams	10 ozs
Cold water to make	1 liter	50 gal.

Full development with fresh developer is obtained in 7 minutes at 65° F.

After development the film should be rinsed for about 5 seconds in running water and immersed in the following fixing bath:

Acid Fixing Bath

(Formula F-2)

	Metric	Avoirdupois
Hypo	240 grams	100 lbs
Water to make	1 liter	50 gal.

When thoroughly dissolved add all of the following hardener solution:

Watcr …	32cc	200 ozs
Sodium Sulphite (E.K.Co	3.1 grams	20 ozs.
*Acetic Acid, 28% pure	20cc	120 ozs.
Powdered Potassium Alum	6.2 grams …	40 ozs.

*To make 28% Acetic acid from Glacial Acetic, dilute three parts of Glacial Acetic with eight parts of water.

The hardener components should be mixed in the above order following the directions given below for the stock hardener.

If a stock hardener solution is desired the following is recommended:

Stock Hardener Solution

(Formula F-2a)

	Metric	Avoirdupois
Water (about 125°F) (52°C.)	600 cc	30 gal.
Sodium Sulphite (E.K.Co.)	60 grams	25 lbs.
*Acetic Acid 28% pure	380 cc	8 ¾ gal.
Powdered Potassium Alum	120 grams	50 lbs
Cold water to make …	1 liter	50 gal.

To make 28% Acetic acid from Glacial Acetic, dilute three parts of Glacial Acetic with eight parts of water.

To make up the hardener dissolve the chemicals in water at about 125° F. in the order given above. When the sodium sulphite is completely dissolved, add the acetic acid. After the sulphite-acid solution is thoroughly mixed, add the potassium alum. Cool the hardener solution before using. For use add 2 ½ gallons of stock hardener to 50 gallons of the 25% hypo solution given in Formula F-2, (50 cc. hardener to 1 liter 25% hypo).

Pour the hardener slowly into the cold hypo solution while stirring the latter rapidly. If the hypo is not thoroughly dissolved before the hardener is added, a precipitate of sulphur is liable to form.

When using the rack and tank method, the rack should be agitated for 5 to 10 seconds after immersion in the fixing bath to insure even fixation. Sufficient fixing is obtained in 15 minutes in the above bath when fresh. When the time for clearing the film exceeds 10 minutes the fixing bath is exhausted and should be renewed.

Since the acid hardener tends to set the yellow dye in the film, washing should be very thorough. *Dye remaining in the film acts like a filter and will increase the printing time and make timing more difficult.* Washing with thorough agitation for 20 minutes will be ample to eliminate all the dye. An excellent arrangement is to wash in one tank for five minutes and transfer the rack to another independent tank.

These instructions apply for processing the duplicate negative as well as the master positive.

Fine Grain Developer for Original Negatives

The following developer has been found to give finer grained image on original negatives than any other commercially used negative developer. The formula is recommended especially for development of original negatives when duplicates are to be made, because the finer the grain of the original, the better will be the quality of the duplicate. There is no particular advantage to be gained in using this solution for development of the master positive and the duplicate, since Eastman Duplicating Film is a very fine grained emulsion. There is no objection, however, to using this developer for this purpose.

Fine Grain Negative Developer

(Formula D-76)

	Metric	Avoirdupois
Elon ….	2 grams	13 ¾ ozs
Sodium Sulphite	100 grams	40 lbs
Hydroquinone	5 grams	2 lbs
Borax	2 grams	13 ¾ ozs
Water to	1 liter	50 gals

Directions for Mixing: Owing to the high concentration of sulphite in this formula, it is somewhat difficult to dissolve all the chemicals unless directions are followed carefully.

First dissolve the Elon in a small volume of water (about 125° F.) and add the solution to the tank. Then dissolve approximately one-quarter of the sulphite separately in hot water (about 160° F.) and add the hydroquinone with stirring until completely dissolved. Now dissolve the remainder of the sulphite in hot water (about 160° F.), add the borax, pour the entire solution into the tank and dilute to the required volume with cold water.

Average time of development is 15 to 25 minutes at 65°F. The developer tank usually becomes coated with a white deposit of silver but this will do no harm.

EASTMAN KODAK COMPANY.

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NOTES

Wratten Filter No. 39, Duplicating, was used in all cases where a filter is mentioned.

In the first three master positives, P-I, P-2, and P-3 the quality is slightly softer than the usual projection print quality.

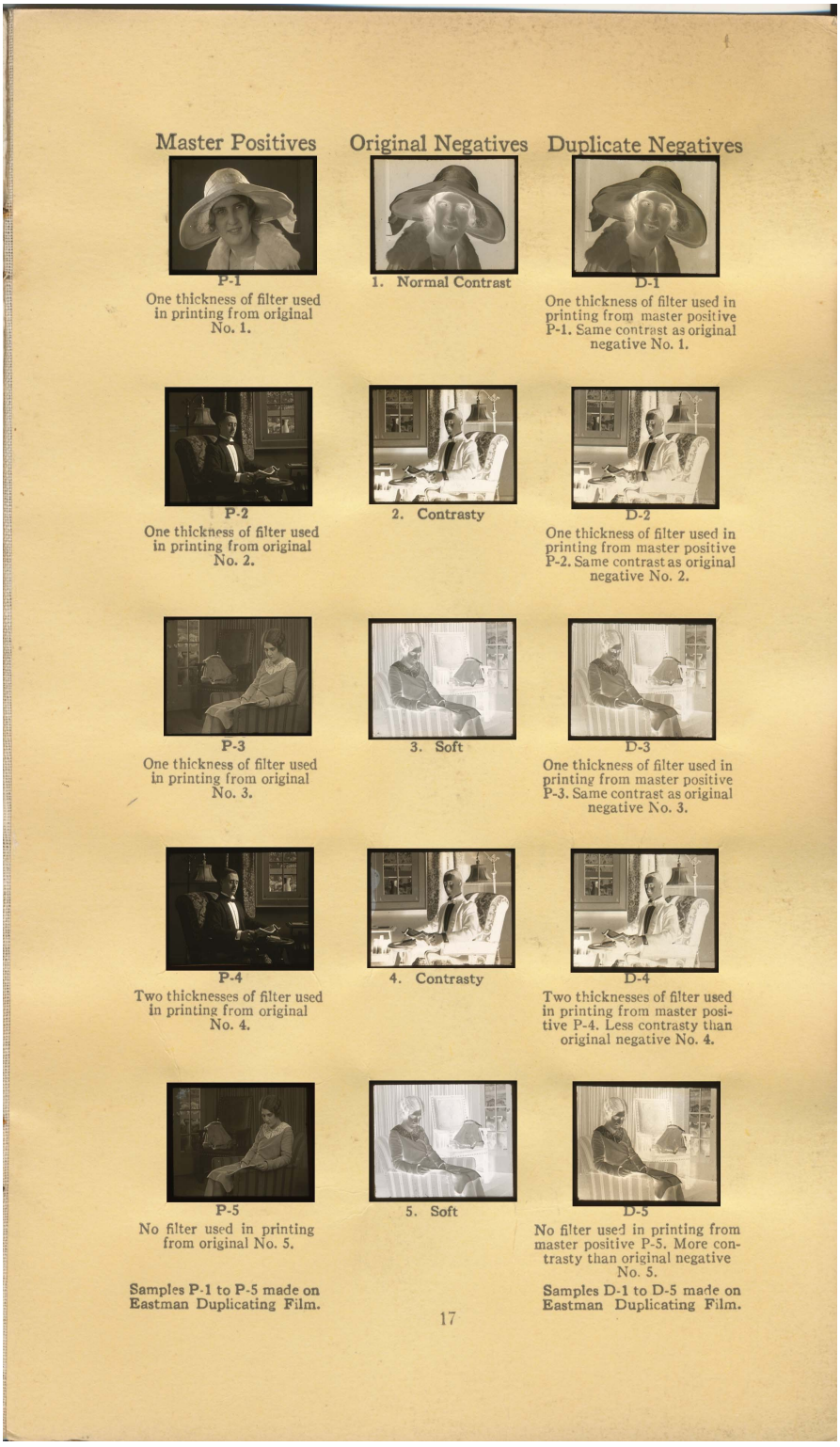
Highlights of master positives and shadows of duplicates should be slightly veiled as shown in all the samples.

Sample D-4 shows the maximum contrast reduction possible with filters. Sample D-5 shows the contrast increase possible with full development without filters. Intermediate variations are obtained by using one, two or three filters.

Four filter thicknesses (two in making the master positive and two in making the duplicate) give the maximum contrast correction.

All samples of master positives and duplicates were developed fully and for the same time, namely, 7 minutes at 65°F. using formula, D-16.

The filter tends to fade when exposed for long periods to the printer lamp. It should be examined frequently and replaced when necessary.



Master Positives	Original Negatives	Duplicate Negatives
P-1 One thickness of filter used in printing from original No. 1.	1. Normal Contrast	D-1 One thickness of filter used in printing from master positive P-1. Same contrast as original negative No. 1.
P-2 One thickness of filter used in printing from original No. 2.	2. Contrasty	D-2 One thickness of filter used in printing from master positive P-2. Same contrast as original negative No. 2.
P-3 One thickness of filter used in printing from original No. 3.	3. Soft	D-3 One thickness of filter used in printing from master positive P-3. Same contrast as original negative No. 3.
P-4 Two thicknesses of filter used in printing from original No. 4.	4. Contrasty	D-4 Two thicknesses of filter used in printing from master positive P-4. Less contrasty than original negative No. 4.
P-5 No filter used in printing from original No. 5.	5. Soft	D-5 No filter used in printing from master positive P-5. More contrasty than original negative No. 5.

Samples P-1 to P-5 made on Eastman Duplicating Film.

Samples D-1 to D-5 made on Eastman Duplicating Film.