Add before use:

Droxychrome or Activol X (or the equivalent quantity of a 20% solution)	6·5g
Water to	1000·0ml

One may also use as the colour developing agent diethyl para-phenylenediamine sulphate or hydrochloride (Activol 7 or 6) or even Genochrome or Activol No 1 may also be used at 5·0g/litre.

Bleach (pH:5·4±0·2)

Potassium ferricyanide	80·0g
Potassium bromide	20·0g
Disodium hydrogen orthophosphate ($12H_2O$)	26·7g
Sodium or potassium bisulphate	12·0g
Water to	1000·0ml

Fixer (pH:7·0±7·8)

Sodium thiosulphate (crystalline)	200·0g
Sodium sulphite (anhydrous)	10·0g
Water to	1000·0ml

Ammonium thiosulphate, 120g/litre, may be used to accelerate fixing, replacing the sodium salt.

* If 6-nitrobenzimidazole is available a 0·2% solution of the nitrate may be prepared by adding 1g to 500ml water previously acidified by the addition of 0·4ml nitric acid. The mixture should be shaken to dissolve the compound.

Procedure

		At 20°C	At 24°C
1	First developer	18-20min 20±0·5°C	13-14min 24±0·25°C
2	Rapid rinse	30sec 16-20°C	30sec 20-24°C
3	Stop bath	4min 18-20°C	3min 22-24°C
4	Wash	10min 16-20°C	7min 20-24°C
5	Re-exposure	500W at 3ft,	1min each side
6	Colour developer	14min 20±0·5°C	11min 24±0·25°C
7	Wash	20min 16-20°C	14min 20-24°C
8	Bleach	5min 18-20°C	4min 22-24°C
9	Wash	5min 16-20°C	4min 20-24°C
10	Fixer	5min 18-20°C	4min 22-24°C
11	Wash	10min 16-20°C	7min 20-24°C
12	Stabiliser and		
13	Wetting agent	1min 16-20°C	1min 20-24°C
14	Dry	Maximum 30°C	
	Total	96½min	70½min

Notes

A Recommended agitation is 30sec continuous then two periods of 5sec every minute.

B After Stage 5, the processing may be interrupted and the film dried, processing being completed later. In this case, washing should be prolonged to 5min, and the re-exposure to artificial light may be dispensed with. Once dry, the film should be kept in darkness to obviate any possibility of solarisation. If the intermediate drying procedure is followed it is *not* necessary to wet the film before proceeding to Stage 6.

Kodak Ektachrome films

The generic name for Kodak user-processable reversal materials is Ektachrome and all current materials of this type except two – Ektachrome Infrared and Photomicrography Color Film 2483 – are processed by **Process E-6.** These two exceptions continue to use the earlier **Process E-4,** which introduced for the first time the use of a chemical reversal bath to replace reversal by a second exposure. The reversal bath used in Process E-4, however, contains components which are toxic and require care in handling which may not be appropriate to some amateur circumstances. For that reason details are also given of the earlier **Process E-3** which employs a second light exposure to effect reversal. No materials directly designed for E-3 use are now manufactured by Kodak.

Ektachrome E-6

The Ektachrome E-6 process, like its predecessor the E-4 process, is intended for machine use and is usefully shorter, needing around 40min in the solutions. The shorter process time is achieved by raising the solution temperatures to 38°C. From the user's point of view the process has been improved in two directions; the somewhat aggressive preliminary hardener has been eliminated by hardening the film emulsion in manufacture and the highly toxic tertiary butylaminoborane used as a reversing agent in the colour developer has been replaced by the much less dangerous stannous chloride in a reversing bath which precedes the colour development stage.

Like the C-41 process for colour negative development the E-6 process uses separate bleach and fix stages but with the bleach action performed by a ferric-EDTA complex as is now common in bleach-fix solutions.

The processing schedule which follows and which uses the substitute formulations differs from the Kodak E-6 process in that the reversing bath is eliminated and a straightforward ferricyanide/thiosulphate bleach and fix routine is used. The use of a light source for the reversal exposure removes the need to make up one bath, which is, in any case, the subject of patent protection. Moreover, the Kodak reversing bath depends on a chelating agent which is not readily available except in industrial quantities.

The ferricyanide bleach bath is simpler to make up than one using the ferric-EDTA complex and is also somewhat lower in cost. In addition the use of ferricyanide removes the problem of leuco dye formation which is always present when the ferric-EDTA complex is used as a bleach. Unless a bleach or bleach-fix of the latter type is carefully controlled the amount of cyan dye generated is less than it should be and red densities are accordingly too low.

Formulae

First Developer (pH:9·6±0·05)

Calgon	2·0g
Sodium sulphite (anhydrous)	25·0g
Potassium carbonate (anhydrous)	12·0g
Sodium bicarbonate	12·0g
Phenidone	0·4g
Hydroquinone	6·0g
Potassium bromide	3·0g
Sodium thiocyanate	2·5g
Sodium hydroxide	2·5g
Potassium iodide (0·1% solution)	15·0ml
Nitrobenzimidazole nitrate (0·2% solution)	50·0ml
Water to	1000·0ml

Stop Bath (pH:3·4-3·6)

Sodium acetate ($3H_2O$)	5·3g
Acetic acid (98-100% glacial)	30·0ml
Water to	1000·0ml

Colour Developer (pH:11·5±0·05)

Calgon	1·0g
Trisodium phosphate ($12H_2O$)	40·0g
Sodium hydroxide	3·0g
Sodium sulphite	4·5g
Potassium bromide	0·6g
Potassium iodide (0·1% solution)	30·0ml
Sodium thiocyanate	1·25g
Citrazinic acid	1·25g
CD-3	11·3g
Water to	1000·0ml

Bleach (pH:6·6-7·0)

Potassium ferricyanide	112·0g
Potassium bromide	12·0g
Disodium hydrogen orthophosphate ($12H_2O$)	62·0g
Monosodium dihydrogen orthophosphate (anhydrous)	15·6g
Sodium thiocyanate	10·0g
Water to	1000·0ml

Fixer (pH:6·9-7·0)

Sodium thiosulphate (crystalline)	160·0g
or ammonium thiosulphate (crystalline)	120·0g
Sodium sulphite (anhydrous)	10·0g
Monosodium dihydrogen orthophosphate (anhydrous)	10·0g
Water to	1000·0ml

Stabiliser

Formaldehyde (35-40% solution)	3·0ml
Wetting agent (10% solution)	10·0ml
Water to	1000·0ml

Procedure

1	First developer	6½min 38·0±0·3°C
2	Wash	1min 33-39°C
3	Wash	1min 33-39°C
4	Stop bath	2min 33-39°C
5	Re-exposure, No 2 Photoflood at 1ft	2 x 2min
6	Colour developer	6min 38±1°C
7	Stop bath	2min 33-39°C
8	Wash	1min 33-39°C
9	Wash	1min 33-39°C
10	Bleach	5min 33-39°C
11	Wash	1min 33-39°C
12	Fixer	5min 33-39°C
13	Wash, running water	6min 33-39°C
14	Stabiliser	1min 33-39°C
15	Dry	
	Total	42½min

Notes

A Recommended agitation is continuous for the first 15sec, then 5sec every half minute.

B If running water at 33-39°C is not available each of the 1min washes after the first development and the colour development stages can take the form of three changes of water, adjusted to this temperature, each of 20sec duration although the exact time is not critical.

C Reversal exposure can most efficiently be accomplished by see-sawing the film through a dish containing the first stop bath, front and back being exposed approximately equally. If the film is re-exposed in a transparent spiral this should be immersed in a white bowl containing the stop bath. About twice the recommended time should be given under these conditions.

D Although the new E-6 process films do not appear to use the familiar Kodak resin-protected couplers, complete transparency of the film is still reached only when it is perfectly dry.

E The two stop baths should be kept separate to avoid contamination.

F The time of treatment in the first developer should be increased in accordance with the use it has had. For 36-exposure 35mm films or 120 rollfilms processed in 500ml of solution the times should be as follows:

1-2 films	6½min
3-4 films	7min

G Keeping properties and working capacities:

Solution	Keeping time	Working capacity per litre		
		135-20	135-36	120
First developer	3 months	12	8	8
Colour developer without CD-3	6 weeks	12	8	8
Colour developer with CD-3	3 weeks	12	8	8
Bleach	6 months	12	8	8
Fixer	6 months	12	8	8
Stop bath	6 months	should be used fresh		
Stabiliser	6 months	should be used fresh		

H The colour balance of Ektachrome film processed with the E-6 process can be changed in the yellow-blue direction by altering the pH of the colour developer. Kodak recommend the use of either 5*N* sulphuric acid or sodium hydroxide added to the colour developer for this purpose. 1ml of 5*N* sulphuric acid per litre of working solution colour developer will *reduce* the yellow balance of the film by 0·05 units. 1ml of 5*N* sodium hydroxide solution per litre of working solution colour developer will *increase* the yellow balance of the film by 0·05 units. The 5*N* sulphuric acid can be made by adding 140ml of concentrated sulphuric acid to 750ml of water and making the solution up to 1 litre. **Caution – always add the concentrated sulphuric acid to the water.** The 5*N* sodium hydroxide solution is approximately 20%.

J If desired the separate bleach and fix baths can be replaced by a bleach-fix. The solution given for Ektacolor 74 and 78RC papers can be used with the quantity of EDTA NH_4Fe increased to 80g/l of working solution. The bleach-fix should be allowed to act for 10min and will give slightly lower red densities.

Ektachrome E-4

Special attention is drawn to the warnings as to the extremely noxious nature of some of the chemicals used in these formulae. Their use should not be attempted by workers unaccustomed to handling such chemicals. The Kodak E-4 process was designed *a priori* for the mechanised processing of Ektachrome materials (EX, EH, Reversal Print, Infrared Aero) with the exception of professional-type films (then processed by the E-3 method), but it may also be used for hand processing, provided scrupulous attention is paid to the times of treatment in the respective baths. These times were noticeably shortened in comparison with those of the E-2/E-3 procedures, but this very fact introduced greater risks for the amateur should he fail to observe them meticulously.

Process E-4 presented two departures from earlier processes.

1 Re-exposure before colour development was discontinued; reversal is effected by chemical fogging of the emulsion during colour development. This solution contains an organic chemical – TBAB (tertiary-butylaminoborane) – which enables all parts of the emulsion which have not been developed by the black-and-white first developer to react to the colour developer. TBAB is *very toxic* and must be handled with the greatest care to avoid contact with the skin and respiratory organs. It should be noted, however, that in the substitute formula for the colour developer this additive may be dispensed with, provided the film is re-exposed to light in the customary fashion; the colour characteristics of the film are practically unaffected. Chemical reversal with TBAB is also possible when working at 24°C (E-3) but only with Ektachrome EX, EH, and Infrared Aero.

2 To improve the mechanical resistance of emulsions destined for Process E-4 treatment at 29°C, it is necessary to treat them in a preliminary hardening bath containing, in addition to formaldehyde, 2,5-dimethoxytetrahydrofuran (DMTF), a liquid whose vapour is very aggressive in its action upon the respiratory system and eyes, and is very rapidly absorbed by the cutaneous tissues. It is therefore essential to avoid any contact with the liquid. Should the skin become contaminated with it, the affected part should be very thoroughly washed for 15min. Should the eyes exhibit symptoms of irritation a doctor should immediately be consulted. So far as formaldehyde is concerned, amateurs will already be familiar with its very active tanning and irritant properties, and we are confident that they will automatically take the utmost precautions.

Formulae

Pre-hardner (pH:4·9-5·0)

6-nitrobenzimidazole nitrate	0·03g
Sodium or potassium bisulphate	0·8g
Tetrahydro-2,5-dimethoxyfuran	5·0ml
Sodium sulphate (anhydrous)	136·0g
Formaldehyde (35-40% solution)	30·0ml
Potassium bromide	3·0g
Water to	1000·0ml

Neutraliser (pH:5·1-5·2)

Hydroxylamine sulphate	20·0g
Acetic acid, 100%	10·0ml
Sodium acetate ($3H_2O$)	24·0g
Potassium bromide	16·0g
Sodium sulphate (anhydrous)	25·0g
Potassium metabisulphate (crystalline)	5·0g
Sodium hydroxide	6·0g
Water to	1000·0ml

First developer (pH:10·1-10·3)

Calgon, sodium hexametaphosphate or tripolyphosphate	2·0g
Metol	6·0g
Sodium sulphite (anhydrous)	50·0g
Sodium carbonate (anhydrous)	30·0g
Hydroquinone	6·0g
Potassium bromide	2·0g
Sodium thiocyanate	1·3g
Sodium hydroxide (pellets)	2·0g
Potassium iodide (0·1% solution)	6·0ml
Water to	1000·0ml

Stop bath (pH:3·4-3·6)

Sodium acetate ($3H_2O$)	5·3g
Acetic acid (98-100% glacial)	30·0ml
Water to	1000·0ml

Colour developer (pH:11·80·2)

Calgon or sodium tripolymetaphosphate	2·0g
Trisodium phosphate ($12H_2O$)	40·0g
Sodium hydroxide (pellets)	5·0g
1,2-diaminoethane (hydrate)	3·8ml
or ethylenediamine sulphate (crystalline)	7·6g
Benzyl alcohol (35% solution*)	10·0ml
Tertiary butylaminoborane (TBAB)	0·1g
Citrazinic acid	1·3g
EDTA Na_4, EDTA tetrasodium salt	3·0g
Sodium sulphite (anhydrous)	5·0g
Potassium bromide	1·0g
Potassium iodide (0·1% solution)	20·0ml

Add before use:

Kodak CD3	11·3g
Water to	1000·0ml

*Benzyl alcohol, 35% solution

Benzyl alcohol	35·0ml
Diethylene glycol (digol)	45·0ml
Water	100·0ml

Bleach (also for E3) (pH:6·6-7·0)

Potassium ferricyanide	112·0g
Potassium bromide	24·0g
Disodium hydrogen orthophosphate ($12H_2O$)	62·0g
Monosodium dihydrogen orthophosphate (anhydrous)	15·6g
Sodium thiocyanate	10·0g
Water to	1000·0ml

Fixer (also for E3) (pH:4·5-4·9)

Ammonium thiosulphate (crystalline)	120·0g
Potassium metabisulphite (crystalline)	20·0g
Water to	1000·0ml

Stabiliser (also for E3)

Formaldehyde (35-40% solution)	3·0ml
Wetting agent (10% solution)	10·0ml
Water to	1000·0ml

Procedure

1	Preliminary hardener	3min 29·5±0·5°C
2	Neutraliser	1min 28-31°C
3	First developer	6min 29·5±0·25°C
4	First stop bath	2min 28-31°C
	Normal room lighting may be resumed	
5	Wash, running water	4min 27-32°C
6	Colour developer	9min 27-32°C
7	Second stop bath	3min 27-32°C
8	Wash, running water	3min 27-32°C
9	Bleach	5min 27-32°C
10	Fixer	6min 27-32°C
11	Wash, running water	6min 27-32°C
12	Stabiliser	1min 27-32°C
13	Dry	43°C max
	Total	47min

Notes

A Recommended agitation is continuous for the first 15sec, then 5sec every minute.

B Complete transparency of the film is reached only when it is perfectly dry. It should be noted that it is permissible to *dry off the film temporarily* after completion of Stage 5. The film should then be stored in diffused light or preferably in total darkness until processing is to be completed.

C The pre-hardener chemicals should be dissolved in water at 38-40°C with continuous agitation until solution is complete. At least 10min must be allowed to elapse before use to allow the DMFT to become transformed by hydrolysis into succinicaldehyde, a powerful gelatin tanning agent. The solution becomes effective only after this transformation is complete.

D Should it not be possible to obtain the commercial ethylene diamine (1,2-diaminoethane) hydrate (80% ethylene diamine) (beware of noxious fumes) for the colour developer, the sulphate, which is easier to handle, may be used. In this case, the pH-value may need to be adjusted by adding a few millilitres of a 10% solution of caustic soda. The TBAB, supplied by Kodak Limited in pellet form, should be crushed in a little water, using a glass rod or small pestle, then the remaining solution added. The TBAB can be dispensed with if the usual procedure of reversal by exposure to light is followed (see above). The developer in this form can then also be used for Process E-3.

E It should be emphasised that any contamination of one solution by another must absolutely be avoided. As the intermediate washes have been reduced to a strict minimum, all utensils employed in processing must be thoroughly cleansed and dried before used for a succeeding solution.

F The two stop baths should be kept separate to avoid contamination.

G Time of development in the first developer should be increased in accordance with the use it has had. For 20exp 35mm films, or approximately 0·37sq ft material per film, the times should be as follows:

1-4 films	6min
5-7 films	6min 15sec
8-10 films	6min 30sec
11-12 films	6min 50sec

H Prolonging or shortening the first development results in the following increases or decreases of effective emulsion speed with E-4 process films.

Effective emulsion speed (ASA)

Development Time (min)	Ektachrome-X	High Speed Ektachrome (Daylight)*	High Speed Ektachrome (Tungsten)**
$10\frac{1}{2}$	250	640	500
9	160	400	320
8	125	320	250
6(normal)	64	160	125
$4\frac{1}{4}$	32	80	64
3	16	40	32

Also applicable to the equivalent sheet films SO-371* and SO-375**
For critical work test exposures on the batch of film to be used are recommended. At extreme departures from normal development some slight corrective filtration may be necessary.

J This process is also suitable for use with Kodak Photomicrography Color Film PCF 2483 and Ektachrome Slide Duplicating Film 5038. In the latter case a first development of $4\frac{1}{2}$min is recommended.

Keeping properties and working capacities

Solution	Keeping time	Working capacity per litre			
		135-20	135-36	120	sq ft
Pre-hardener	4 weeks	12	7	8	430
Neutraliser	3 months	12	7	8	430
First developer	3 months	12	7	8	430
Colour developer:					
without CD3	6 weeks	—	—	—	—
with CD3	4 weeks	12	7	8	430
Stop baths	6 months	12	7	8	430
Bleach	6 months	18	10	12	650
Fixer	6 months	12	7	8	430
Stabiliser	6 months	should be used fresh			

Other manufacturers' materials compatible with the E-4 process

As a result of the worldwide dissemination of the Kodak Ektachrome E-4 process, many other manufacturers produced materials suitable for processing in E-4 solutions. Reference should be made to the tabulations of colour reversal films on pp 189-90. Particular care should be taken to distinguish between E-4 and E-6 process materials.

Ektachrome E-3

Formulae

First developer (pH:10·2-10·4)

Phenidone (or metol 6g)	0·5g
Hydroquinone	6·0g
Sodium carbonate (anhydrous)	40·0g
Sodium sulphite (anhydrous)	40·0g
Potassium bromide	2·0g
Sodium thiocyanate	2·0g
Potassium iodide (optional)	0·006g
Nitrobenzimidazole nitrate (0·2% solution) (optional)	15·0ml
Water to	1000·0ml

Hardener-stop bath (pH:3·52·2)

Chrome alum	30·0g
Water (cold) to	1000·0ml

Clearing bath (pH:4·60·2)

Potassium metabisulphite	20·0g
Hydroquinone (optional)	1·0g
Water to	1000·0ml

Bleach (same as for E-4)

Fixer (pH:4·70·2)

Sodium thiosulphate, crystalline	160·0g
or ammonium thiosulphate	120·0g
Potassium metabisulphite	20·0g
Water to	1000·0ml

Colour developer (pH:11·60·1)

Trisodium phosphate (crystalline, $12H_2O$)	40·0g
Caustic soda (pellets)	8·6g
Sodium sulphite (anhydrous)	5·0g
Benzyl alcohol	5·0ml
EDTA Na_4 (tetrasodium salt)	3·0g
Ethylenediamine sulphate	7·5g
Potassium iodide	0·01g
Citrazinic acid (2 6 dihydroxyisonicotinic acid)	1·3g
CD3	10·0ml
Water to	1000·0ml

Stabiliser

Formaldehyde (35-40% solution)	2·0ml
Wetting agents (10% solution)	10·0ml
Water to	1000·0ml

Procedure

1	First developer	10min 24±25°C
2	Rinse	$\frac{1}{2}$-1min 20-26°C
3	Hardener-stop bath	3-10min 20-26°C
	Normal room lighting may be resumed	
4	Wash, running water	3min 20-26°C
5	Re-exposure, No 2 photoflood at 1ft	2x$\frac{1}{2}$min
6	Colour developer	15min 20-26°C
7	Wash, running water	5min 20-26°C
8	Clear	5min 20-26°C
9	Rinse, running water	5min 20-26°C
10	Bleach	8min 20-26°C
11	Rinse, running water	1min 20-26°C
12	Fixer	4min 20-26°C
13	Wash, running water	8min 20-26°C
14	Stabiliser	1min 20-26°C
15	Dry	45°C max
	Total	65-72min

Notes

A Recommended agitation is 5sec every minute.

B After Stage 5, the processing may be interrupted and the film dried, processing being completed later. In this case, washing should be prolonged to 5min, and the re-exposure to artificial light may be dispensed with. Once dry, the film should be kept in darkness to obviate any possibility of solarisation. If the intermediate drying procedure is followed it is *not* necessary to wet the film before proceeding to Stage 6.

C The CD3 should be added to the colour developer just before use, as the complete solution does not keep well (at most 15 days in unused condition). A violet coloration will be observed, which disappears after an interval of a few hours and is of no significance. The CD3 may be added either in for form of a powder or a 20% solution.