Preface

First the perfect picture - then the perfect processing.

Thanks to the massive investments of the film manufacturers, today's photographer has access to countless variations of film size and quality.

Highly sensitive emulsions have been created for the rendition of color nuances of the food photographer, the simulation of a mood setting for the advertising photographer, or the scientific documentation of research and medical technology. These films require consistent film processing with reproducible results. Often processing must occur immediately, day or night, and at any place in the world.

This manual is the result of practical experience and is meant for the working darkroom or lab. It is custom-tailored for all who process E-6 and are avowed to the JOBO rotation system, no matter whether they use Kodak, Fuji of Agfa films.

With this manual we publish our E-6 processing know-how accumulated over the years. An important part of the manual is the color test table. It is used with our error simulation, the color control system. Also, we offer the JOBO pH-correction kit as a supplement.

With these aids, professional results can be achieved at any time either in a fixed location or "on the road".

We gratefully acknowledge the cooperation of the corporations Kodak, Fuji, Agfa-Gevaert and Tetenal with the compilation of data.

Our best wishes "FOR YOUR BEST IMAGE".

Sincerely,

J.J. Bockemühl

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INTRODUCTION

1. Objective of this Manual

We have pursued three objectives with this manual. While they have general application, they are especially applicable to JOBO rotation processing. They are:

to make you aware of the main procedures used in preparing to process photographic material. Also we want to point out problems that may occur in actual practice while you prepare your work.

to provide users who are interested in close monitoring of their process with instructions and hints on how a process can be controlled using various aids.

finally, to provide a reference source for problem solving. This section includes a description of errors and possible suggestions for their correction.

We have attempted to relate as closely as possible to actual lab practice.
We have considered problems our customers have brought to our attention in the past.
Because of the complex interplay of the numerous and various factors that make a good process, it is obvious that no perfect solution can be found for every problem.

2. Organization of this Manual

This manual is divided into three major chapters, describing consecutively
1. **"Process preparation"**
2. **"Process control"**
3. **"Process errors and corrections"**

The individual subsections contain hints, rules and instructions in a brief and clearly organized arrangement.

In the introductory Chapter **"1. Process Preparation"**, we cover the principal procedures of running a process. Following these suggestions should help avoid potential sources of error as early as possible.

Chapter **"2. Process Control"**, is designed to enable even the user unfamiliar with the subject matter to enter the field with relative ease. Chemical process control is mentioned only marginally, since it is usually not important for the users of JOBO rotation processing.

The hints for troubleshooting in Chapter **"3. Process Errors and Corrections"**, are a compilation of common errors most often encountered in actual practice.
The correction possibilities offered should not be taken as absolute measures.

In the appendix you will find an alphabetical index and references to related literature. These sources deal in more depth with process handling and control. Also they deal with the various aspects of color photography and the materials used in it.
At the end of the manual are samples of various evaluation sheets that can be copied. You will need these sheets during process control to document your evaluation results.

1. PROCESS PREPARATION

1.1 Basic Prerequisites for E-6 Processing

1.1.1 General

The E-6 process is especially sensitive to processing errors for two reasons:

The large number of baths (6) allows more opportunity for errors to occur.

Errors such as slight color casts or density variations in the processed film cannot be compensated for later. This is different from the negative-positive process where correction can be made during the subsequent enlargement on photographic paper. Each error that originated during processing of the slide material affects the final photographic result; later correction possibilities do not exist.

It can easily be seen that the handling of the E-6 process requires even more care and cleanliness than any other common photographic process. To achieve reproducible processing results of consistently high quality, care must be taken. Before beginning with the actual processing operation, check the process handling prerequisites listed below and follow them.

1.1.2 Jobo Processors

Follow the information in the processor instruction manual when setting up and connecting the JOBO-Rotation processor.

Make sure that the connections for the water intake and drain are properly and securely attached.

The same applies to the connections of the supply hoses at the chemistry bottles. Tighten the bottle caps firmly since leaks in the compressed air supply system can lead to reduced filling quantities or even prevent the supply of chemistry solutions entirely.

To avoid formation of algae in the water bath, change the bath once a week. Drain the bath completely in case of a longer work interruption. In case of contamination or calcium deposits, use the special cleaning agent Processor-Clean 4181. (Please do not use other cleaning agents since chlorine and some other cleaning agents will destroy the unit).

Before the first operation, before and after longer shut downs, and in case chemicals in the processor have become spoiled, a cleaning program should be run to flush possible deposits or chemistry residues out of tanks and lines. To do this, fill all chemistry bottles completely with water and run the cleaning program once as described in the processor instruction manual.

If, despite all precautions, contamination of one or several baths occurs during actual operation, run the cleaning program three times. In this way the contaminants are removed and no adverse effects will occur when refilling with fresh chemicals.

It is not necessary to run a cleaning program at the end of a process. Flushing of the short common chemistry route is accomplished during the final rinse.

1.1.3 Preparation of the Chemistry Solutions

Use a separate preparation container for each bath required. Mark each container with a waterproof permanent marker.

Use a separate mixing rod for each preparation container.

If you are using the electrical mixer, JOBO-Chemix 4185, for the mixing of large chemistry batches, rinse the mixing rods with running warm water after each use!

Do not use unsuitable mixing rods. Simple straight rods are usually inadequate to assure sufficient mixing.

Mark the processor tanks and the chemistry overflow containers in the same way as the preparation containers. Use these only for the same chemical solutions.

Rinse the tanks and reels after each process run with running water and dry everything carefully before the next use. Water residue may cause swelling of the emulsion and cause uneven processing results.

Store prepared chemical solutions only in completely filled bottles or containers. All air should be squeezed out of partially filled plastic bottles or they must be covered with a heavy gas and then closed tightly (see 1.3.3).

Store the formulated concentrates and the prepared chemical solutions properly and use them within the specified time periods (see 1.3.5, 1.3.6 as well as 1.4.3).

Refer to section 1.3.6 regarding the shelf life of the prepared chemical solutions inside the processor.

Keep the work area for chemistry preparation and rinsing of tanks and reels clean to avoid cross-contamination of the baths (see 1.3.3).

1.2 Description of the E-6 Process

Following is a description of the action of the individual chemistry baths used in the E-6 process. In addition, a general overview of the effect of errors on the process results is provided. These are errors that can occur during preparation, dilution or storage of chemical solutions.

1.2.1 First Developer

In the first developer, the exposed silver-halide crystals contained in the red, green and blue-sensitive layers of the film (the so-called latent image) are reduced to metallic silver. A negative image of the original picture appears. The first developer is the most critical phase of the entire process. Even minute deviations from standard requirements cause clearly visible alterations of the final results.

Errors affect:

density (utilization of sensitivity)
contrast
maximum density (base darkening, fog)
minimum density (light areas, fogging)

1.2.2 First Rinse

The rinse between first developer and reversal bath stops the chemical action of the first developer. It also prevents carryover of the first developer into the reversal bath. Meticulous compliance with the specified rinse times and rinse temperatures is important.

Errors affect:

density (utilization of sensitivity)
shifts of color

1.2.3 Reversal Bath

The reversal bath contains a chemical agent serving as substitute for an intermediate light re-exposure. It facilitates developing of all silver-halide crystals that have remained unexposed when the picture was taken. No rinse should take place after the reversal bath. The reversal substance that has been carried over is needed for reversal during the color developer.

1.2.4 Color Developer

The silver salts remaining in the film after the first developer are reduced to metallic silver by the color developer. At the same time, through accumulation of the color couplers in the film layers, the final pigments of the slide develop. Here, the complementary colors cyan, magenta and yellow are formed in the layer with the corresponding red, green and blue sensitivity.

Errors affect:

contrast
maximum density
fogging
color balance
evenness of development

Dilution of color developer:

If the color developer is diluted, (e.g., through inaccurate preparation) the color density increases since particles that normally slow down color development become less active in a weak dilution. Only with much dilution (starting approximately with a threefold or fourfold quantity of water) does the pigment formation decrease. With too great a dilution there are not enough pigment-forming components to produce the correct pigment quantity in the specified time.

1.2.5 Conditioner Bath

In the conditioner bath the developed metallic silver is prepared for oxidation in the bleach bath. No rinse must take place between the conditioner bath and the subsequent bleach bath since the conditioner bath that has been carried over is needed for proper bleaching. Too high a concentration of this bath (+50% or more) can lead to the formation of a so-called leuco-cyan pigment. This is reflected in too low a maximum density for the cyan pigment, (i.e., the measured value 'red'.) This lack of cyan pigment results in red shadows.

1.2.6 Bleach Bath

In the bleach bath, the metallic silver formed in the first and color developers is transformed again to silver halide. Consequently, it can be completely removed from the film layers in the fixing bath.

Errors result in:

silver residues
low maximum density for red
yellow fogging (= minimum density for blue too high)

1.2.7 Fixing Bath

In the fixing bath the silver halides remaining in the film emulsion are converted into soluble silver compounds.
Most of these compounds remain in the fixing bath and can be reclaimed through various silver recovery procedures.

Errors result in:

yellow fogging (= minimum density for blue too high)
spot formation through silver halide residues becoming visible in the image sections with low density.

1.2.8 Final Rinse

The final rinse removes all developing substances that have remained in the emulsion. An insufficient final rinse reduces the life of the films; therefore, it is important to not fall below the specified rinse times.

1.2.9 Stabilizer Bath

The stabilizer bath improves the durability of the color pigments and, in addition, contains a wetting agent to safeguard faster and better drying. Since the films will not be rinsed again after stabilizing, this process must never be done in the processor. Remaining stabilizer bath residues would have a negative impact on the first developer during the next process run.

Errors Result in:

Over time a shift toward green in the finished transparency. This error does not occur immediately after processing but instead can take months or years to appear.

1.3 Directions for Preparation of Solution

1.3.1 General

The most important step before film processing is the proper preparation of the formulated chemistry. The specifications of the manufacturer are the primary guidelines. The quality of the slides, the stability of the developing process and the durability of the solutions depend largely on compliance with the preparation specifications. The cleanliness of the preparation vessels and storage tanks is of equal importance. (See also 1.1.3).

All vessels should be cleaned thoroughly in running warm water after each use so no chemistry residues remain.

The preparation vessels also should be rinsed thoroughly before each use. This removes dust that has settled on them. It also provides increased safeguards in case cleaning after previous use has been neglected.

The work area should have cold and warm water connections. Because of the inherent gases and fumes, it also should have adequate ventilation (approximately 10 to 20 air exchanges per hour).

When preparing the chemical solutions, the size of the graduates should be adequate for the solution quantity. The JOBO Mixing Kit # 7960 contains the ideal combination of graduates. This is of particular importance when partial preparation shall be started (see 1.3.4).

An overview of the terms you will encounter in relationship to chemistry preparation can be found under 1.4.2.

1.3.2 Warning for Handling Chemistry

The chemicals used with the E-6 process may pose minor or major health hazards when handled improperly. It is important to take special care when handling any of the solutions!

It is important that the safety regulations on the containers and in the instruction manuals be read before preparation and use of the solutions!

Photographic solutions may cause unpleasant skin irritations. Contact with clothing may cause permanent spots. It is advisable to wear protective gloves, goggles and a coat when preparing and pouring chemical solutions!

If skin, regardless of all precautions, comes into contact with an alkaline solution, immediately rinse the affected area thoroughly under running water.

If solution enters the eyes, flush the eyes immediately for an adequate time (at least 15 minutes) under running water. Consult a doctor at once!

If chemicals or solutions are swallowed, a physician should be consulted immediately! Since exact information about the ingested substances is necessary to treat the toxic symptoms, the concentrate container should be shown to the physician!

The tray (container) used for storage of the stabilizer bath should always be covered when not in use. This protects against contamination from dust particles and also helps to retain the toxic formalin vapors developed through evaporation. Be sure to provide adequate ventilation.

Unexposed and undeveloped films should not be stored in the same room together with the stabilizer bath. Formalin vapors may cause greenish discolorations (especially at the film edges)!

All chemicals should only be filled into vessels that are clearly marked and appropriate for this purpose. Chemicals should never be filled into vessels such as empty beverage bottles or other food containers. Make sure all vessels clearly indicate the nature of their contents!

If the smell of any photographic solution must be checked, smelling should only be done at the lid or other closure of the container. Vapors should be fanned toward the nose with the hand. Smelling directly with the nose at the container opening may cause severe chemical burns! Names of the active and (health) hazardous ingredients of the individual chemistry baths can be found under 1.4.1.

1.3.3 Basic Avoidance of Errors

Although the liquid concentrates used today simplify the preparation of chemicals, great care must still be taken because of the high strength of the concentration. Previous experience has shown that cross-contamination of the baths is one of the main causes for poor processing results. In addition, difficulties can occur with the actual process control.

Knowledge of the following simple chemical reactions of the individual baths is helpful. Taking these facts into account when preparing the chemical solutions will save you time. It also will save you cost because of lower chemistry waste.

The first developer is especially sensitive to contamination.

Even small traces of fixing or reversal bath in other solutions can lead to major deviations in processing results.

In case of the color developer, parts A and B should never be poured together in their original concentration. Immediate precipitation of particles occurs in this case.
When preparing the color developer, it is necessary to first provide water and then add parts A and B! Before adding the concentrate, be sure to follow manufacturer's recommendations regarding temperature of the preparation water and the quantity of water required.

Add the concentrates only after the air bubbles have disappeared from the preparation water. Add the concentrates and the amount of water necessary to obtain the total final volume carefully to avoid strong turbulence or splashing.

Stir evenly, carefully and not too long. Sufficient mixing of the baths must be assured by all means.

A proven practical approach consists of stirring the solution with a mixing rod in the graduate when preparing quantities up to one liter. The mixing rod should reach to the bottom of the vessel.

When preparing larger volumes, the chemistry should be mixed in the storage container using an electrical stirring device (e.g. Jobo Mix # 4185).

When pouring the prepared solutions into the processor tanks, air bubbles and strong turbulence can be avoided by pouring slowly.

The shelf life and effectiveness of first developer, color developer, reversal bath and conditioner bath diminish through oxidation. This oxidation cannot be entirely avoided, however, it can be reduced through appropriate measures.

To avoid premature oxidation and thus improve durability, it is recommended - especially when preparing larger quantities of stock solution - to fill the air space in the container with a heavy gas (e.g., Tetenal Protectan Spray). This heavy gas displaces the air, is non-toxic and easy to handle. Another method of reducing undesirable oxidation is the insertion of a floating lid into the stock container.

1.3.4 Partial Preparation of Solutions

Preparation of small amounts from bulk containers intended for the preparation of 20 to 100 liters present a very sensible way to save cost when processing large amounts of film. However, it also produces several risks. Because only small quantities of the concentrate are required, even small deviations from the required amount can create a problem. These minor variations have unproportionally greater effect when using the stronger concentrates than would occur with the smaller package size and hence weaker concentrates.

A decisive advantage of using larger chemical packages is the ability to purchase the individual parts separately. This allows you to reduce chemistry cost according to the method described under 1.7.3.

If it is not possible to assure one hundred percent compliance with the mixing guidelines, it is safer to use the smaller packages offered.

If you have decided to use partial preparations, the concentrate container must be shaken well several times before the concentrates are divided. It is important that the graduates used be of a suitable size (e.g., quantities of 50 ml should never be measured in a 1000 ml graduates.) The use of the JOBO Mixing Kit 1 # 7960 and 2 # 7961 have proven helpful for partial preparations. Also the electric mixer, Jobo Chemix # 4185, has been designed for use in mixing quantities of 5 to 20 liters.

A frequent source of error is the wrong calculation of the concentrate quantity required per liter of ready-to-use solution. To be safe, either recalculate several times or refer to the manuals of the chemistry manufacturers.

The concentrate quantities, once determined for the partial preparation, should either be noted on the stock containers or posted at the work area.

1.3.5 Storage Requirements of Concentrates

The storage temperature of the concentrate containers should be between + 5 and + 27° C (41 and 80 F°). In case of lower temperatures, precipitations or separations occur in the concentrates. Higher temperatures accelerate chemical reactions and lead to premature spoilage. If the concentrates are stored according to the specifications in the unopened original package, the durability is at least six months.

Effects of low storage temperatures:

Concentrate	Effects
First developer, Color developer, part A, Conditioner bath, Bleach bath, Fixing bath	At temperatures between -18° and +4°C (0.4 and 39.2°F), these chemicals form a precipitation or they separate. After warming up to room temperature, it may become necessary to stir crystals that have formed back into the solution to once more obtain a homogenous concentrate. By adding water during the preparation process, all parts should dissolve again.
Color developer, part B	Above -18°C (0.4°F) neither precipitations nor separations occur.
Stabilizer bath	Below +4°C (39.2°F) solid precipitation may occur. This cannot be dissolved again in the solution. Caution: If precipitations (crystals) that have formed cannot be dissolved through heating (40°C [104°F]), the affected concentrate must not be used for the preparation of processing solution!

Caution: If precipitations (crystals) that have formed cannot be dissolved through heating (40°C - 104°F), the affected concentrate must not be used for the preparation of processing solution!

If you produce partial preparations from chemical bulk containers and therefore do not use the concentrates all at once, the following shelf lives for concentrates are recommended:

First developer, reversal bath, color developer:
4 weeks

Conditioner bath, bleach bath, fixing bath, stabilizer bath:
8 weeks

To reduce oxidation of the solutions in partially filled concentrate containers, it is recommended to fill the air space above the concentrate with a heavy gas (e.g., Tetenal Protectan Spray).

If the prepared chemicals are left in the processor, the shelf life is reduced to 1 week with the first three baths.

A possible procedure for partial preparations is shown below through the example of 5-liter preparations from a 20-liter batch:

1. Prepare the first 5 liter of processing solution.

2. Divide the remaining concentrate quantity into three parts and fill each third into smaller storage bottles of glass or PVC. Mark each bottle with filling date and contents.

3. Since the concentrates transferred in such a way can practically be stored with air exclusion - just as in the original containers - the shelf life of 6 months can maintained through this approach.

1.3.6 Shelf Life and Durability of Prepared Solutions

The shelf life of the prepared solutions in the storage containers depends on several factors. The most important ones are the storage temperature as well as the condition and fill level of the containers used. In addition, there can be differences between the chemicals of different manufacturers.

For the above-mentioned reasons it becomes obvious that general recommendations regarding shel life can only be made with great reservations. Therefore, we do not make any recommendations at this point and refer you to the manufacturer of the chemicals you are using. There you will receive much more reliable information - based on the description of your individual situation - than the scope of this manual would permit.

Shelf life of prepared solutions in a JOBO rotation processor:

First developer, reversal bath, color developer:
1 week (see 1.7.3)

Conditioner bath, bleach bath, fixing bath:
8 weeks (unused) (see 1.7.3)
4 weeks (used)

It is recommended to fill the air space in the processor tanks with a heavy gas if, for instance, the processor's temperature control continues over night or the unit is not used for several days.

1.4 Processing Directions

Because of the variety of possible combinations of film material and chemicals and individual variations from lab to lab, it is not possible to issue processing directions that apply universally. Therefore, the following data is of a general nature and should be considered as guidelines. The optimal requirements for the selected combination of film and chemistry must be determined in the individual lab. This is particularly true for the first developer time (see 1.4.4)

In case of serious problems please refer to the manufacturer of the film material or the chemistry you are using.

1.4.1 Effective Substances of Each Chemistry Bath

First developer:	Potassium hydroquinone monosulphonate
Reversal bath:	Tin dichloride, propionic acid
Color developer:	Part A: potassium hydroxide, potassium phosphate
	Part B: one p-phenylenediamine derivative
Conditioner bath:	$M^{I}_2SO_3$ sulphite, thioglycerol
Bleach bath:	Iron(III) salts
	Iron-EDTA-complex salt
	EDTA=ethylenediamine tetraacetic acid
Fixing bath:	$M^{I}_2S_2O_3$ thiosulphate, $M^{I}_2SO_3$ sulphite
Stabilizer bath:	Formaldehyde, wetting agent

1.4.2 Overview of Chemistry Designations

Concentrates: chemically active substances for the preparation of the different working solutions through mixing with water. Available in various quantities.

Replenishers or refill solution: stock solutions to be prepared from concentrates through dilution with water according to the preparation directions. These are not used with JOBO-rotation processing.

Working or processing solution: for the reversal and conditioner bath as well as for bleach and fixing bath, the working and the replenisher solutions are usually identical, i.e., the refill solution is ready for use with the processor.
As a rule for the two developers, an additional 5 ml starter solution must be added to the replenisher solution to make working solutions.
With JOBO rotation processing, you should prepare all stock solutions as working solutions, i.e., add the required starter quantities for the two developers to the storage tank.

Note:
Many smaller kits are designed for preparing only working solutions. These do not include directions for preparing replenisher solutions nor "Starter" to convert replenishment solutions to working solutions.

Hints:
With some preparations, starter solution must be added to the bleach bath replenisher before using it as working solution.

AGFA offers, especially for one-time rotation processing, the color developer "44 CD-Rotation" for preparation of a final volume of 5 liters.

Preparations (0.5 to 15 liter preparations) are always made up as working solutions.

Table of chemistry designations:

Processing bath	Abbreviation
First Developer	FD
Reversal Bath	REV
Color Developer	CD
Conditioner	COND
Bleach Bath	BL
Fixing Bath	FX
Bleach (Fixing) Bath	BX
Stabilizer	STAB

1.4.3 Appearance and Properties of Concentrates

The following table lists the normal appearance of the concentrates as well as changes in appearance and odor after prolonged storage. This will help in determining whether the particular concentrate can still be used.

Concentrate	Normal Appearance	Remarks
First Developer	Clear, light yellow to light brown. Faint smell.	Darkens with age. Do not use solution that has turned dark brown or opaque or has formed a strong precipitation.
First Developer-Starter	Clear liquid. Colorless to yellowish-reddish.	Darkens slightly with age, this does not affect usability.
Reversal Bath	Clear to slightly cloudy; colorless to light yellow. Development of odors.	Cloudiness is not unusual. Aging hardly affects appearance.
Color Developer Part A	Clear, slightly yellow. Faint, fish-like odor. High viscosity.	No change through aging. Good shelf life properties. No change through aging.
Color Developer Part B	Clear. Slightly yellow to slightly pink. Sulphur dioxide smell.	Dark violet or brown or opaque when oxidation protection is exhausted. The sharp smell disappears with strong oxidation. Careful when smelling!
Color Developer-Starter	Clear liquid. Colorless to yellowish-reddish.	Darkens somewhat when aging; this dooes not affect usability.
Conditioner Bath	Clear, colorless. Smells like organic sulfuric compounds.	No change through aging. The strong sulphur smell disappears with heavy oxidation.
Bleach Bath	Clear, dark red.	None.
Fixing Bath	Clear, colorless. Very faint ammonia smell.	Aging or intruding air may cause white, yellow sulphur precipitation.
Stabilizer Bath	Clear, colorless. Strong formalin smell.	Extrem cold may cause insoluble precipitation.

1.4.4 Processing Times

If you are using a Jobo Autolab processor, heed the following suggestions. Before beginning the process, make sure that all processing times have been programmed correctly and assigned to the corresponding process steps. For this purpose, you should step through all process times with the step button in "Set"-mode after programming to verify correct values and assignments!

In the following table we have compiled the processing times for the most common brands of process chemicals. These data should only be viewed as guidelines. The final photographic result depends largely on the combination of film and chemicals used.

Should you not reach satisfactory overall density results with the specified times, we recommend adjusting the process times following these principle rules:

Adjustment should take place solely by changing the first developer time. The times for all other processing steps should be complied with as indicated in the table.

If your slides frequently reveal too high a density, extend the first developer time, in 15 second increments, to a maximum time of 8:00 minutes. When the density is frequently too low the time can be shortened in 15 second increments down to 6:00 minutes.

Theoretically the density could be controlled through a temperature adjustment of the processing chemistry (a higher temperature leads to density reduction, a lower temperature to density increase). This method is not recommended. The temperature should be kept constant for the entire process run within ±0.3°C (0.54°F)!

When using chemistry of a manufacturer not listed in the table, usually almost identical processing times apply for E-6 compatible chemistries. If available, follow the directions of the manufacturer. If in doubt, start with a first developer time of 6:30 minutes and adjust this time, if necessary, following the above procedure.

If, in addition to the problems with the overall density, you also have problems with the color balance of your films, simple time control will not solve the problem. In such a case, please refer to sections 2.3.5 and 3.6 or 2.4.6 and 3.6.

Table of Processing Times:

Process chemistry	E-6	AP 44	3 Bath [1*]	Chrome-6 [1*]	Master Class Chrome-6
Chemistry Manufacturer	Kodak Fuji Hunt	Agfa	Tetenal	Phototech-nology	Phototech-nology
Temperature	38°C	38°C	38°C	38°C	38°C
Pre-warm	5:00	5:00	5:00	5:00	5:00
Pre-rinse	-	-	-	-	-
FD [2*]	6:30	6:30	6:30	6:30	6:00
Rinse	3:00	3:00	3:00	4:00	2:00
REV [3*]	2:00	2:00	-	-	2:00
Rinse	-	-	-	-	-
Intermediate exp.	-	-	-	-	-
CD	4:00 [8*]	6:00	6:00 [4*]	4:00 [8*]	4:00
Rinse	-	-	2:30	1:00	-
COND	2:00	2:00	-	-	2:00
Rinse	-	-	-	-	-
BL	6:00 [6*]	6:00	6:00 [5*]	10:00 [5*]	6:00
Rinse	-	-	-	-	-
FX	4:00	4:00	-	-	4:00
Rinse	4:00	4:00	4:00	4:00	4:00
STAB [7*]	1:00	1:00	1:00	1:00	1:00
Batch size:	2.5 l 3.8 l 5.0 l [2*] 13.2 l [6*] 20.0 l [6*]	5.0 l	5.0 l 15.0 l	0.6 l 1.7 l 5.0 l 15.0 l	5.0 l 15.0 l

Notes: _____

Remarks to above table:

1.* Three bath process; allows for considerable time savings compared to the six bath process. Because of the different properties of the process chemistry and the distinctive bath sequence, not all processing errors can be corrected on the basis of the error catalog shown in this brochure.

2.* For Fuji film materials, the following applies:
If, for instance, you expose a Fujichrome 100 with 21 DIN you must start with a first developing time of 7:00 minutes. You should overexpose Fuji material by 1/3 of an f-stop (max. 2/3) to be able to start also with a first developer time of 6:30 minutes.

3.* Both Kodak and Photo Technology suggest a 60 % solution of Reversal Bath in rotary processing. For this mixture you add only 60 % of the concentrate required for a given quantity of working solution. For example, to make 1 liter of Reversal Bath you would use 30 ml of concentrate to 970 ml of water.

4.* Reversal developer; the process of image reversal and the subsequent color development occur in a single process step.

5.* Bleach fixing bath (BX); silver bleaching and fixing occur in a single step; the conditioner bath can therefore be eliminated.

6.* When using Kodak E-6 chemistry (13.2 l and 20 l preparations and larger batches), 20 ml of starter solution per liter must be added to the bleach bath processing solution.

7.* Stabilize the films away from processor and reels, since absolutely no stabilizer bath residues must enter the processing operation.

8.* Both Kodak and Photo Technology suggest a reduced time of 4:00 minutes when using rotary processing.

1.5 Chemistry Amounts

1.5.1 General

The minimum chemistry quantities needed to achieve perfect and reproducible results are not the same for each bath. However, the drum fill quantity for all JOBO rotation processors is identical for all chemistry steps within one process run. For this reason the minimum quantities used must be determined by the step requiring the largest solution quantity.

Using quantities less than those listed in the table below may lead to sensitivity (density) and color deviations due to excessive exhaustion of the individual baths.

Duplicating films may require chemistry quantities above the data stated below. Please consult the film manufacturer for exact information.

Table of minimum chemistry quantities:

Film type	Number of films / ml											
	1	2	3	4	5	6	7	8	9	10	11	12
135-36	125	250	375	500	625	750	875	1000	1125	1250	1375	1500
120	110	220	330	440	550	660	770	880	990	1100	1210	1330
220	220	440	660	880	1000	1220	1460	-	-	-	-	-
9x12 cm	24	48	72	96	120	144	168	192	216	240	264	288
4x5"	33	66	99	132	165	198	231	264	297	330	363	396
13x18 cm/ 5x7"	57	114	171	228	285	342	-	-	-	-	-	-
18x24 cm	108	216	324	432	540	-	-	-	-	-	-	-
20x25 cm/ 8x10"	126	252	378	504	630	-	-	-	-	-	-	-

1.5.2 Film Formats

The following overview shows information about the various frame formats, their trade designations and surface areas as well as the required minimum chemistry quantities.

Frame Format	Designation	Surface Area	Chemistry
Cartridge Formats			
13x17 mm	110-20	73 cm²	27 ml
	110-24	122 cm²	28 ml
28x28 mm	126-12	165 cm²	38 ml
	126-24	297 cm²	97 ml
35-mm Formats			
24x36 mm	135-12	231 cm²	52 ml
	135-24	391 cm²	88 ml
	135-36	551 cm²	125 ml
24x36 mm perforated (35 mmx1 m)	410	325 cm²	74 ml
24x36 mm unperforated (35 mmx 1 m)	401/402/653/ 663/710	351 cm²	80 ml
Medium Format			
3x4 cm 4x4 cm 4x6 cm	127	269 cm²	60 ml
4,5x6 cm 6x6 cm 6x7 cm 6x9 cm	120/620 220	504 cm² 1020 cm²	114 ml 230 ml
6x6 cm perforated (70 mmx1 m)	475/488	675 cm²	152 ml
Sheet Film Formats			
6,5x9 cm		59 cm²	14 ml
9x12 cm		108 cm²	24 ml
13x18 cm		**234 cm²**	**53 ml**
18x24 cm		432 cm²	98 ml
4x5 inch.		129 cm²	30 ml
5x7 inch.		226 cm²	52 ml
8x10 inch.		516 cm²	116 ml
11x14 inch.		994 cm²	225 ml
20x24 inch.		3097 cm²	700 ml

1.6 "Push and Pull" - Processing

The term "push and pull processing" is a common name for the adaptation of processing times for films that have been either overexposed or underexposed.

"Push" processing: Films that have been underexposed (receiving too little light) must be processed longer with the first developer ("pushed") to show approximately the same densities as normally exposed films.

"Pull" processing: Films that have been overexposed (receiving too much light) must be processed shorter with the first developer ("pulled back") for their densities not to deviate significantly from those of normally exposed films.

1.6.1 General

Principally, any sensitivity increasing or decreasing process reduces the optimal quality of the processing results compared to processing in compliance with standard requirements. This approach, then, is a compromise. It should only be applied when the exposure conditions strongly call for it (e.g., when no film with the desired sensitivity is available) and quality losses can be tolerated.

Underexposed and subsequently overdeveloped films show a lower maximum density, reduced exposure margin, higher contrast, heavier graininess and a color deviation.

When underexposing by two to three f-stops, marked quality losses are unavoidable. Because of the lower maximum density and fogginess during the forced first developing step, the slides have a smoky, foggy appearance.

Overexposed and correspondingly underdeveloped films yield lower contrast, a lower color saturation and a color deviation.

The above-described characteristics of the film material with "push and pull" processing are of a general nature. Marked differences may occur in actual practice. Results will vary depending on the brand and speed of film used.
Therefore, in the absence of known values, test developments should be conducted with the emulsion employed to determine the optimal first developer time.

If you frequently rely on pushing films, you may want to use a film for your exposures that has been especially formulated for push processing (e.g., Ektachrome P 800/1600 Professional, Fujichrome P 1600 Prof D).

"Push and pull" processing and the films developed by those methods are not suitable for process control with sensitometric test strips made for the standard process. The error catalog at the end of this brochure and the corresponding suggestions for corrective measures have only limited validity for "pushed" or "pulled" films.

More information about the processing requirements of the Ektachrome P 800/1600 mentioned above can be obtained from Kodak. Special push test strips allowing sensitometric monitoring of this process also can be obtained from Kodak.

1.6.2 Adjustment of Processing Requirements

The following table provides approximate values for time adjustments for various abnormal exposure conditions.

Of course, loss of quality increases in relationship with growing deviation from the standard process.

The time adjustments recommended in the table affect only the first developer. The other processing steps remain unaffected. Chemical correction of the individual baths is not recommended.

A first developer time of less than 4:30 min. is not recommended since the developing results are usually uneven and difficult to reproduce.

Table for adjustment of processing requirements:

The information in the table is based on Kodak Ektachrome 100 film. The adjustment measures can be transferred analogously to all other films and sensitivities.

ISO	Exposure	First Developer	Time Adjustment	
30/800°	-3 f-stops	14:30 min.	+8:00 min.	
27/400°	-2 f-stops	12:00 min.	+5:30 min.	push
24/200°	-1 f-stop	8:30 min.	+2:00 min.	
21/100°	Standard	6:30 min.	0:00 min.	
18/50°	+1 f-stop	4:30 min	-2:00 min.	
15/25°	+2 f-stops	not recommended	* *	pull
12/12°	+3 f-stops	not recommended	* *	

1.7 "Replenishment" with the JOBO Rotation System

1.7.1 Principle of Replenishment

The chemical composition of the individual solutions changes during the developing process through accumulation of substances formed during processing (e.g., bromide accumulation in first developer, silver accumulation in fixing bath). If these chemicals are not replaced after use, these substances concentrate in the solutions. These concentrations cause deviation from the normal processing specifications.

For these reasons replenishment must be employed with continuously working processors. This means that the bath losses must be replaced through special replenishment solutions different in composition from the original bath. The first developer replenisher, for example, contains practically no bromide to compensate for the bromide generated during the first developer step. The bleach bath replenisher is slightly acid (pH-value approximately 0.5 lower than original bath) to compensate for the increase of the pH-value in the bleach bath through the carryover of developer and water.

1.7.2 Factors with JOBO Rotation Processing

Conventional replenishment is not reasonable for users of JOBO Rotation Processing for the following reasons:

1. A replenished process remains stable only under continuous load (i.e., the surface of at least one 135-36 must be processed per liter of developer per day.) (see 1.5.2).

2. The chemistry volume of Jobo users is usually too small for proper replenishment (5 liters per week). Therefore, when adding replenishers minute deviations from the correct quantities cause noticeable changes of the processing result.

3. With a replenished process, sensitometric monitoring with test strips is imperative. To accomplish this a color densitometer is also needed.

4. At least twice a day, sensitometric test strips must be processed and evaluated. The time investment is approximately 15 minutes for each evaluation.

1.7.3 Cost Savings

In spite of the above-mentioned reasons that oppose conventional replenishment, possibilities exist to save chemistry cost and thus increase the profitability of the JOBO Rotation Processor. Last, but not least, the rise of environmental awareness makes the need for more economical use of photographic chemicals an increasing issue. For example, in some areas of Germany the cost for the disposal of used chemistry has already exceeded the purchase cost of the new chemistry.

Below is a list of the approximate percentages of total cost based on the preparation of 1 liter of E-6 chemistry from a 20 liter kit.

Table of percentages of chemistry cost for 6-bath and 3-bath preparations:

	FD	REV	CD	COND	BL	FX	TOTAL
Portion (%)	14.0	4.0	19.0	8.0	49.0	6.0	100
		37.0 %			63.0 %		

The table shows that baths 1-3 represent approximately 1/3 of the total cost. They should not be used twice for reasons of processing quality. Also, conventional replenishment is not recommended. Therefore, there is no possibility to save chemistry cost with the first three steps of the process sequence. (In addition, baths 1-3 are utilized up to 90% during processing).

Conditioner bath, bleach bath and fixing bath - together responsible for almost 2/3 of the total cost - are strongly concentrated. They can safely be used twice without any kind of replenishment. This applies also to bleach-fix baths of the E-6 three-bath process.

Based on these considerations, the following approach to cost savings presents itself:

1. Always prepare only half of the conditioner, bleach and fixing baths in comparison with the quantities of chemistries 1-3.
Attention Jobo ATL Processor Users: Even with this approach, the processor tanks 1 to 6 must always be filled equally! (The same amount of chemistry in all bottles!)

2. At the next filling of the processor tanks, simply pour the conditioner, bleach and fixing baths in the reclaiming bottles back into the corresponding processor tanks. This method is especially easy with the ATL-3, since the automatic filling of the storage tanks allows the collection of the used conditioner, bleach and fixing baths directly into the 15 liter storage containers.
(Simply place the 15 liter storage container with the lid opened at the position of the collection container of the same bath).

3. The savings effect results from only preparing half of the conditioner, bleach and fixing bath (i.e., half the cost). Also only 9 and not 12 liters of chemistry must be disposed of after two complete process runs. This adds additional savings (i.e., 25% less). Another advantage is - compared with the complete preparation of all six baths - a savings in time can be realized with every other run. Also, since chemistry is reused, the chance of additional errors appearing when preparing chemistry is eliminated.

4. The savings with the method described above amounts to approximately 33% compared with the complete preparation of all baths for each process run. It also depends on the disposal cost for each liter of old chemistry.

5. The calculation is even more favorable when one keeps in mind that the higher silver portion in the fixing bath yields a correspondingly higher reimbursement at disposal if silver recovery is used.

2. PROCESS CONTROL

2.1 Process Control Aids

In this section we will give an overview of the aids that are available for the control of the process. Also we will determine their importance to process control of JOBO Rotation Processing.

The column "Remarks" gives you a brief description of the use of the aid and a partial reference to the sections where their use is explained in more detail.

Table of Aids:

Aid	Application	Type	Rating	Remarks
JOBO-Color Test Table	TableEvaluation of color, density and sensitivity	visual	recommenend	Establishing a reference standard, control exposures (see 2.3.3)/(see 2.3.5) (see 2.4.11)
		sensitometric	helpful	
	Evaluation of color exposures	visual	recommended	Normative light source of 5500 K (daylight) (see 2.4.3)
Densitometer	Density measurement of all colors	sensitometric	helpful	Measure with Status A for E-6 (see 2.4.3)
Test strip	Evaluation of color density and sensitivity	sensitometric	helpful	For ongoing process control, when changing emulsions and with preparation of each new bath (see 2.4)
pH-Meter	Measuring pH-value	chemical	not necessary	Only useful when fresh calibration solution is always available; relatively extensive procedure
Indicator (litmus) paper	Measuring pH-value	chemical	useless	too inaccurate
Hydrometer (Areometer)	Measuring of solution densities	chemical	not necessary	Solution densities do not change, since usually no evaporation occurs
Thermometer	Measuring of temperature	general	not necessary	To check possible malfunctioning of the built-in temperature sensors, use regular body temp. thermometer

2.2 Basics Process Control

2.2.1 General

The principle of process control is always the same regardless of the method used. The first step consists of developing a reference standard with correct process conditions. This standard serves as a reference point for all further comparisons during the process control. Process parameters that do not meet specifications are found by comparing individual test strips to the reference standard. Test strips that deviate from the reference standard point to possible process problems and suggest an action to correct the deviations.

Any type of process control, visual (see 2.3) or obtained by measurement methods (see 2.4),will only deliver reliable results when performed with great care and under the same conditions. Exact documentation of errors as well as process modifications made to correct these errors is very important.

Following we have compiled the most important principal rules for process control. These are explained in more depth in Chapters 2.3 and 2.4:

When an error has been detected, a "monitored control process" should be run. To do this a test should be run before any modifications are made to correct the problem. You should be present at the processor, during processing, to check whether the error has possibly been caused by irregularities in the program sequence. This process run serves as basis for all steps of the error correction.

Take time to visually analyze the error as precisely as possible. If you are using a densitometer make sure that the values are read exactly and the calculations performed correctly. In all cases, inaccuracies during error determination inevitably lead to wrong and thus ineffective corrective measures!

After you have determined the error, refer to the corresponding part in Chapter "3 Process Errors and Corrections", to find out which corrections are listed there.

Only one of the recommended process corrections should be performed in order to be able to assign the reaction precisely. The simultaneous application of several modifications is only recommended when explicitly stated!

Document each control process performed using the examples listed in 2.2.2.

Gradually and carefully (i.e., in such a manner that you can always reproduce the same results) you can compile your own catalog of errors. This "error correction list" will be valuable because it will take your particular conditions into account. This will enable you, in the future, to correct faulty processing results relatively quickly and without problems.

2.2.2 Documentation of Control Evaluations

Mark the film strip you have used for the "monitored control process" (the one without any process modification) with date and the letter "C".

Enter the error to be corrected at "1. Error occurred" into the evaluation sheet.

Perform one of the process modifications suggested in the error catalog. After making the modification, process a color test table exposure or a sensitometric control strip.

Enter the process change performed on the evaluation sheet at the heading "2. Modification of the general process sequence and evaluation of results." Mark the film strip with the date and the number "1" (again, don't forget the code number of the corresponding reference strip!).

Now analyze the process result thus obtained following the method described in 2.3 or 2.4. Note the insights gained on the evaluation sheet.

If the error has not been resolved after the first correction attempt, apply the next method suggested. Assign the number "2" to the control strip and document everything as before.

If you are unable to resolve the error with a maximum of three attempts following the corrective measures described, the best solution is to prepare all chemical solutions fresh. Follow the work methods described in the chapter "Process Preparation".

Once you are again in control of your process, archive all the test strips in negative sleeves. File these together with the evaluation sheets. Your personal error catalog will grow this way into a reference source of great value to you since you will already know from earlier experience how to correct a repeatedly occurring error.

If you are using the visual control method, comparison of actual control exposures with those archived will help your ability to determine color deviations. By this means your skill will increase.

When you encounter serious problems it is always advisable to notify the manufacturer of the film material and / or chemistry used.

Please do not be discouraged by the effort entailed in using process control. With the necessary sample forms and illustrated examples in the text, we have tried to make the entry into this type of work as simple as possible. We are certain that you will be able reach the desired objectives relatively quickly and with the least necessary effort when you follow the suggested methods.

2.3 Visual Process Control

2.3.1 Advantages over Measured Control

Visual process control (evaluating density and color shifts by eye) is influenced by subjective estimation of the errors. It does, however, offer several essential advantages over control with test strips and densitometer when conscientiously performed.

- Control with your own emulsion
- Control with your own studio lighting
- Control with the color characteristics of lens used to take the picture
- Simple handling without great time effort and with aids practically available in every photo lab.

Another advantage, not to be underestimated, is test strips and film material from the same manufacturer often reveal marked differences in their reaction to the same process deviations.

2.3.2 Required Aids

- JOBO Color Test Table
- E-6 Color Control Poster
- Light table/box with standard light of 5500 Kelvin (day light characteristic)
- Exposure of color test table onto the film material serving as reference standard, developed with normal density and free of color cast (see 2.3.5).
- Black cardboard
- Evaluation sheets for the recording of detected errors and process modifications performed to guarantee effective and repeatable monitoring of the process.

2.3.3 Arrangement of the Color Test Table and Meaning of Fields

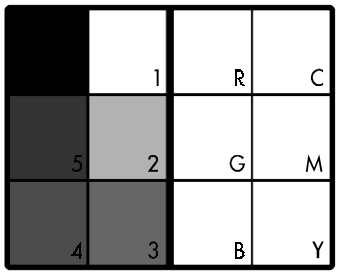
The following illustration of the JOBO Color Test Table indicates which fields should be used for evaluation and what conclusions these allow about the process condition.

To classify the color shifts that have occurred more accurately, compare your processing results with the examples shown on the E-6 Color Control Poster.

When you find a picture among the examples shown that is similar to your results or has, at least, a similar tendency, note the designation of this picture (e.g., 6A).

Now look under 3.3 or 3.4 for a possible error cause and its correction.

Illustration of the JOBO Color Test Table:



Meaning of the fields:

Greyfields:

1: for control of lights
2: for control of sensitivity and color
3 +4: for control of sensitivity
5: for control of color
6: for control of maximum density (base blackening)

Color fields:

This side of the table is for the evaluation of the general color characteristics of different films and emulsions (such as differences in color rendition between Agfa, Fuji and Kodak material). It also helps to determine the differences in color character as they can occur with emulsion change. These fields should not be consulted for the evaluation of the development process.

2.3.4 Standardization of Control Requirements

Visual evaluation is only valid when the conditions under which you produce the control exposures are identical from one batch to the next.
It is very important to produce the control test strips under identical conditions.
To aid in this be sure to heed the following points:

1. Always expose the entire format of the JOBO color test table.

2. Always use the same camera, lens and lighting (two identical light sources of equal output illuminating the object at an angle of 45°from the same distance). Pay particular attention that the color test table is evenly illuminated. Failure to do so will cause difficulties with later error evaluation.

3. Always keep the same exposure conditions. For this purpose, mark the distance between camera and color test table as well as the distance between table and light source (e.g., with tape or color marks on the floor).

4. After you have set up the exposure arrangement, produce enough pictures of the color test table to last for approximately 3 months. Store the films in the refrigerator at -18°C (0.4°F) protected against light and clearly marked (with date of exposure!).

5. For each control session, take the required quantity of film from the refrigerator and allow adjustment to room temperature for approximately 45 minutes. Proceed as described under 2.3.5.

2.3.5 Performing the Control

For the surrest results, please pay attention to the following hints and carry out the steps of the control performance in this sequence:

For visual inspection, it is theoretically best to take the control pictures on a sheet film format. A disadvantage of this type of control performance is its relatively high cost. We therefore describe the visual process control based on medium or 35-mm format. All information applies analogously, of course, even if you choose to work with sheet film.

When using medium or 35-mm format, establish some kind of a marks in your darkroom that can be felt and are approximately 30-35 cm (1 foot) apart. The edge of a table is ideal for this purpose. Now, for each process control cut a 30 cm (1 foot) strip of the exposed control film. Because of its general character, such a film strip allows for a much better evaluation than a relatively small individual slide.

When you are exposing the control test table using the 35-mm format, don't rewind the film completely after exposing the film. This allows you to store the exposed film in the cartridge and then pull it out gradually from the unopened cartridge as it is needed.

When using the medium format, after cutting the first control strip no further light protection is provided for the rest of the film. Store partially used roll films in an empty sheet film container. Place these in a nontransparent and airtight plastic container before putting the remaining film back into the refrigerator.

Wind the film strip for the control development two to three turns deep into the reel. This helps to prevent the film from slipping out during rotation processing. (The red duo-clip should be pressed into the reel winding to keep the test strip from moving toward the center core).

Once a particular format has been chosen for control it is best to continue using that format.

Establishing a reference standard (= lab-specific reference):

After you have prepared all baths fresh according to the directions, process a control strip. Start with a first developer time of 6:30 minutes and adjust the time in case of incorrect density (too light / too dark) following the methods described in 1.4.4.

Theoretically, this control strip (possibly after time adjustment) should not only show a correct density rendition but also an even color balance.

Unfortunately, this is not always the case in actual practice. Often correct density values can be reached through individual adjustment of the first developer time but in some cases the color balance is not neutral.

Should you encounter this situation in spite of proper chemistry preparation, please read section 3.6 and use the measures listed there to achieve an even color balance.

After you have performed all necessary time adjustments or color corrections and your reference standard now shows correct densities and neutral colors, archive the reference strip in a negative sleeve. A sleeve that is transparent on both sides is best for viewing and gives protection against dust, finger prints and mechanical damage. Note the film brand on the sleeve as well as the sensitivity and possibly the emulsion number.

In this way a reference value is obtained. This reference strip serves as a reference standard for the actual process control. It is used when conducting a visual comparison on the light table with all subsequent control processes.

Processing of the control strips:

A control process should be performed with each new chemistry preparation, each change of emulsion and whenever you suspect serious process deviations.

After processing is completed, place the control strip and the reference standard side by side on the light table.

Cover the open areas of light table with black cardboard so only the transparencies are illuminated. Visually evaluate the control strip and the reference standard looking for deviations in density and/or color shifts. (Only refer to the grey fields for evaluation!)

Take time to analyze the error as accurately as possible. From experience, the main difficulty with this is the correct determination of color shifts! The E-6 color poster will serve as an aid.

After determining the error that has occurred, if any, refer to chapter "3. Process Errors and Corrections".

Consider which of the process errors listed there is the most likely and perform the process correction suggested for its elimination.

After the corrective action has been taken, another control process and subsequent evaluation must be performed. This will test whether the correction has achieved the desired result.

If this is the case, you may proceed with the processing of your slide films. If the process correction was not successful or even leads to other faulty results, you must check whether you have determined the initial error correctly!

If this is the case, perform the next modification listed in the error catalog and conduct the evaluation as before.

If you are not able to regulate the process - in spite of careful handling and correct error evaluation - after a maximum of three correction attempts, it is best to prepare all chemical solutions fresh. Before remixing clean all processor tanks and preparation vessels thoroughly. Also examine the general work method for potential error sources!

2.3.6 Hints for Visual Process Control

Visual process control can yield the desired success only when density deviations and/ or color shifts are evaluated accurately.

The main difficulty is correct evaluation of an existing color cast. Normally, this requires some experience. For example, wrongly evaluating a magenta cast to be a red cast can lead to wrong correction measures that will not only not correct the process error but worsen it.

If a densitometer is available, it is possible to use it to perform the process control. The advantages of this method were explained earlier. It is still possible to use the test table exposures for the film material you used but to conduct the density and color evaluation with the densitometer. The great advantage of this method is that error evaluation becomes independent from human subjectivity; especially of color shifts. If you are interested in this approach you will find more information in section 2.4.11.

2.4 Measured Process Control

2.4.1 Advantages over Visual Control

Process control with sensitometric control strips is the most reliable means of process monitoring and indispensable for continuously working processors with chemistry replenishment. Although these prerequisites are not present with JOBO rotation processing, there are several good reasons to conduct process control in this fashion:

Evaluation and interpretation errors can occur when using the visual method. These errors occur due to subjective evaluations of color or density. Using a densitometer is more accurate because all deviations are ascertained by measuring or mathematical calculation.

If the process must be monitored continuously (e.g., with consistently high film volume) and tendencies detected in a timely manner, measured process control is best. In this way, even small shifts in density or color often missed by the naked eye are detected.

If determination of optimal process conditions presents a serious problem, sensitometric control strips can help (see 2.4.6: "Determination of Reference Values").

2.4.2 Explanation of Terms

This section provides you with a brief overview of process control terms used throughout this brochure. This compilation will also be helpful when you have difficulties with terms appearing on the package inserts of the control strip manufacturers.

Action limit:
The point in process control at which action must be taken to bring the process back into control. At this point film processing may be continued.

Evaluation sheets:
Forms for noting process modifications and evaluation of control results as well as listing of all values obtained in connection with measured process control see 2.4.12).

Reference standard (lab-specific reference):
Reference point serving as basis for all measurements, calculations and evaluations of the individual process control. The reference standard takes, as far as possible, your particular lab-specific factors into account (see 2.3.5 and/or 2.4.6).

Code number:
Numerical designation of reference and control strips. Only the pertaining strips with the same code number may be used for process control.

Sensitivity control step (low density / LD):
Measuring step of a control strip allowing conclusions about the sensitivity utilization (speed) of the film material.

Color control step (high density / HD):
Measuring step of a control strip allowing conclusions about the color rendition of the film material.

Color spread (color balance):
Distance between the two color density values farthest apart on the sensitivity or the color control step (see 2.4.8).

Index value:
Density measuring result of a control step of a control strip.

Control limit:
The point in process control at which the process is "out of control". Action must be taken to bring the process back into control before processing may be continued.

Control strip:
Film strip exposed by the manufacturer and to be developed by the user in own lab; used for process control by referring to corresponding reference strip.

Control step:
Designated measuring field of a control strip (see 2.4.4).

Control value:
Difference between index and reference value. The condition of the process is evaluated based on the control values.

Correction range:

Range between action and control limits. If the control values are within this range the production may be continued, however, appropriate measures must be taken to prevent the exceeding of the control limits.

Correction value:

Correction of measured value for control steps of reference strip contingent upon emulsion and process.

Maximum density (Dmax):

Measuring step of the control strip allowing conclusions about the basic blackening reached by the film material.

Maximum spread:

Maximum of permissible difference between control values and reference values (see 2.4.10).

Minimum density (Dmin):

Measuring step of the control strip allowing conclusions about the fogging density of the film material.

Reference strip:

Film strip already exposed and developed by the manufacturer; serving a reference for the control strips with the same code number. Meaningful conclusions about the process evolve only when reference strips and film material of the same manufacturer is used.

Reference value:

Measuring value of a control step of a reference strip plus the corresponding correction values predetermined by the manufacturer.

2.4.3 Required Aids

Reference and control strips with same code number from manufacturer of film material employed.

Densitometer capable of handling colors with a density measuring range of at least D=4.0. Measuring takes place through filters R,G,B in status A (measuring of transmitted light). The concentration of the cyan pigment is measured with the red filter, the magenta pigment with the green filter and the yellow pigment with the blue filter.

The instructions of the densitometer must be observed and the calibration performed carefully. A zero adjustment is necessary before measuring of each new reference of control strip. Some densitometers available on the market have a process control function making work with continuous process control easier and simpler.

Evaluation sheets to record all measurements and calculations as well as errors detected and process modifications performed to guarantee effective and repeatable process monitoring.

2.4.4 Arrangement of Test Strips and Meaning of Fields

The appearance of the strips and the designation of the fields vary slightly between manufacturers. A feature all control strips have in common is the use of four fields for measurement evaluations. Test strips are available in different configurations. To monitor JOBO rotation processing, strips in 35-mm format (135) should be used.

Reference and control strips show the same arrangement and the respective fields have the same meaning.

Designation and meaning of fields:

Designation	Evaluation of
1 Minimum density (Dmin)	Fogging
3 Low density (LD)	Sensitivity
4 High density (HD)	Color rendition
5 Maximum density (Dmax)	Basic blackening

2.4.5 Handling of Reference and Control Strip

After measuring the reference strip with the densitometer, place it into its protective sleeve and store cool, dry and protected from light.

To avoid falsifications of the measuring results through finger prints, handle all strips only at the outer edges. Never write on front or back side of measuring fields.

Since the control strips have been pre-exposed by the manufacturer and thus contain a latent image, they must be stored in a freezer at -18°C (0.4°F) to maintain sensitometric stability.

When performing a control process, remove the necessary strip from the package in complete darkness, close the package and return it to the refrigerator.

Wait approximately 30 to 60 minutes before processing so the film can adjust to the room temperature.

Guide the control strip into the reel with the emulsion side toward the core of the reel. Wind the film two to three turns into the reel to avoid accidental dislodging during rotation processing.

2.4.6 Determination of Reference Values

Before measuring the reference strip the densitometer should be tested to be sure it works in filter status A (measuring of transmitted light) and has been perfectly calibrated or set to zero.

Next, measure the density values in the center of the four control steps.

Be sure to read the values for R,G,B in the proper sequence and transfer them to the evaluation sheet accordingly!

The correction values must be added to or subtracted from the values obtained for all steps. These values should be taken from the data sheet that is included with each control strip package.

At the end, enter the measured values of the reference strip and the corresponding correction values into the corresponding table. Use the following example determine the reference values by calculation.

Example for determination of reference value:

	Process E-6 Reference strips: Kodak Code number: 0133 Date: 8-31-1991	Densitometer-Filter Red	Green	Blue
		Densitometer readings		
D max	Measured value reference strip ± Correction values **= Reference values**	3,29 + 0,03 **3,32**	3,63 + 0,07 **3,70**	3,62 - 0,05 **3,57**
HD	Measured value reference strip ± Correction values **= Reference values**	2,05 + 0,02 **2,07**	2,03 + 0,03 **2,06**	1,99 + 0,01 **2,00**
LD	Measured value reference strip ± Correction values **= Reference values**	0,96 + 0,03 **0,99**	0,90 + 0,02 **0,92**	0,89 + 0,01 **0,90**
D min	Measured value reference strip ± Correction values **= Reference values**	+ 0,18 0,01 **0,19**	+ 0,19 0,01 **0,20**	+ 0,17 0,01 **0,18**

Establishing a Reference Standard (= reference):

After you have prepared all baths according to the instructions, process a control strip with the same code number as the reference strip you just measured. Start with a first developer time of 6:30 minutes.

Theoretically, the measured values of this control strip should agree exactly with the ones measured above. In actual practice, however, this is rarely the case. This is because the reference values do not take the individual lab- specific influencing factors such as type of processor, bath circulation, etc. into account.

You will, then, obtain measured values that deviate from the reference values in spite of the correct process condition. This can be accepted without hesitation as long as the difference to the reference values is not greater than the permissible processing tolerances (action limits) listed in section 2.4.10.

Exceeding the maximum densities or falling below the minimum densities is not significant and can be ignored.

If the measured values of the control strip are within the action limits, you can adopt the values of the corresponding reference strip as reference standard for all later control processes. These reflect your lab-specific conditions with sufficient accuracy. If, however, the values exceed the action or control limits, it is necessary to adjust the process.

To compensate for incorrect density (too thin / too dense), adjust the first developer times according the methods described in 1.4.4.

With adjustment to the first developer time it is usually possible to reach correct density values. However, the color balance may occasionally not be neutral.

Should you encounter this situation in spite of correct chemistry preparation, please refer to section 3.6 and initiate the measures listed there to reach an even color balance.

Corrective measures for density or color balance are sufficiently accurate when all values calculated after the adjustment are within the action limits. It is not necessary to continue making adjustments until values correspond exactly with those of the reference strip!

If adjustments were made because of your particular situation, note them on your evaluation sheet for reference determination.

2.4.7 Determination of Control Values

Normally, a control process should be performed after each new chemistry preparation, with each change of emulsion and whenever you suspect serious process deviations.

For this purpose, a control strip with the same code number as the reference strip is developed under the current process conditions.

Measure this strip after development with the same densitometer and in the same fashion as you did the reference strip. Again, be sure to read the value for R,G,B in the correct sequence and to transfer them to the evaluation sheet accordingly!

The values thus obtained represent the index values and are valid for the conditions under which your process is currently run.

To ascertain the control values, the difference between the index values and the reference values must now be generated. This happens again through notations into the table.

At the end, calculate the control values that will allow you to draw conclusions regarding the condition of your process (see 2.4.9).

Example for determination of control value:

	Process E-6 Reference strips: Kodak Densitometer-Filter			
	Code number: 0133	Red	Green	Blue
	Date: 8-31-1991	Densitometer readings		
D max	Measured value reference strip	3,33	3,65	3,63
	± Correction values	-3,32	-3,70	-3,57
	= Reference values	**+0,01**	**-0,05**	**+0,06**
HD	Measured value reference strip	2,09	2,10	1,97
	± Correction values	- 2,07	-2,06	-2,00
	= Reference values	**+0,02**	**+0,04**	**-0,03**
LD	Measured value reference strip	0,96	0,93	0,17
	± Correction values	-0,19	-0,20	-0,18
	= Reference values	**+0,02**	**0,00**	**-0,01**
D min	Measured value reference strip	0,21	0,20	0,17
	± Correction values	-0,19	-0,20	-0,18
	= Reference values	**+0,02**	**0,00**	**-0,01**

2.4.8 Calculation of Color Shift (Spread)

An existing deviation in color balance, unlike directly measured density deviations, cannot immediately be seen from the values obtained through the measurements. The necessary values, however, can easily be calculated from the existing data.

The control values obtained in the color control step (HD) and the sensitivity control step (LD) are the basis for this calculation.

The difference of red minus green (R-G) and blue minus green (B-G) are obtained for both steps by mathematical calculation.

Through this kind of calculation the control values for green are established to equal zero and thus become the reference point for the deviation (R-G) and (B-G).

Example for the calculation of color spread

Process E-6 Reference strip: Kodak				Code-Number: 0133	
	Control values			Color spread	
Date: 8-31-1992	Red	Green	Blue	R - G	B - G
Color control step (HD)	+0.02	+0.04	-0.03	-0.02	-0.07
Sensitivity control step (LD)	**-0.03**	**+0.01**	**+0.03**	**-0.04**	**+0.02**

Based on the above example, you now have calculated the values for the color spread (R-G) and (B-G) for the steps HD and LD.

To be able to state assumptions about the process condition in regard to color balance, it is necessary to form a color spread value for each step. Proceed with the calculations as follows:

1. In the Color Step (HD), R-G would be determined:
+0.02 - (+0.04) = +0.02 - 0.04 = -0.02
2. To calculate spread, use the formula (R-G) - (B-G) = Spread.
Substitute the values computed in step #1 above:
-0.02 - (-0.07) = -0.02 + 0.07 = 0.05 (Spread)

In our example, then, we have a spread of 0.05 in the Color (HD) step, and likewise a spread of 0.06 in the Sensitivity (LD) step. In all examples in sections 2.4.6 to 2.4.8 the values are within the action limits, (i.e., the process runs correctly and there is no reason to perform corrective measures.)

2.4.9 Evaluation of the Control Strips

You have now measured or calculated all values for the processed control strip necessary for the evaluation of the process condition. Proceed as follows for the evaluation of the strip:

First, compare the control values (density deviations) of the individual steps determined in 2.4.7 with the processing tolerances listed in 2.4.10.

Second, compare the values (color spreads) calculated according to 2.4.8 with the corresponding permissible tolerances in 2.4.10.

If all values are within the action limits, your process is running correctly and you can continue film processing without any changes.

If some or all values are within the range between action and control limits, you may continue film processing, however, you must realize that your process is running borderline within limits of the permissible tolerances.

If a few, several or even all the values are outside of the control limits, you must interrupt film processing. Refer to the appropriate section in the error catalog.

Consider which of the process errors listed there is the most likely and perform the process correction suggested for its elimination.

After process intervention, develop another control strip, measure it and perform the evaluation as described before to check whether the correction shows the desired result.

If this is the case, you may continue with processing your slide films. If the process correction does not show success or even leads to other faulty results, be sure to verify a second time whether you have determined the initial error correctly!

If this is the case, perform the next modification listed in the error catalog, develop another control strip and evaluate it as before.

If you are not able to regulate the process - in spite of careful handling and correct error evaluation - after a maximum of three correction attempts, it is best to prepare all chemical solutions fresh. Before remixing, clean all processor tanks and preparation vessels thoroughly. Also examine the general work method for potential error sources!

A visual evaluation of the sensitometric control strips through comparison on a light table with the corresponding reference strip may be performed only when no high correction values are given for the reference strip!

The objective and purpose of correction values is the determination of a neutral color rendition. The correction values usually differ between reference strip.
They are listed because even the film manufacturers are generally not able to reach a perfectly even color balance without these values.

2.4.10 Allowable Processing Tolerances

Following, the permissible processing tolerances are listed for the materials from Agfa, Fuji and Kodak.

Density deviations:

These are ascertained sensitometrically and directly through density measurements of the control strip.

Color spread:

A color spread exists when the density differences (test strip minus reference standard) of the three colors (RGB) are too great. To exclude visible color deviations, the greatest permissible distance between the two color densities farthest apart in the control steps for color rendition (high Density / HD) and sensitivity (Low Density / LD) must not exceed certain values.

Action limits:

	D max	HD	LD	D min	Spread HD	Spread LD
Agfa	-0.15	±0.12	±0.08	+0.03	±0.10	±0.06
Fuji	-0.15	±0.12	±0.08	+0.02	±0.10	±0.06
Kodak	-0.20	±0.12	±0.08	+0.03	±0.10	±0.06

Control limits:

	D max	HD	LD	D min	Spread HD	Spread LD
Agfa	-0.20	±0.15	±0.10	+0.05	±0.13	±0.08
Fuji	-0.20	±0.15	±0.10	+0.03	±0.13	±0.08
Kodak	-0.25	±0.15	±0.10	+0.05	±0.13	±0.08

2.4.11 Measured Evaluation based on the Color Test Table

If you prefer not to rely solely on visual error estimation and you have a densitometer available, it is possible to determine the process deviations exactly with densitometer measurements. This procedure is similar to using control strips from the film manufacturer but instead you use your own "home-made" control strips:

1. With the densitometer, measure the grey steps 1/3/5/6 of the reference standard (your lab-specific reference). Use the R,G,B filters in status A (measuring of transmitted light). The readings of these fields correspond to the fields to be measured on the sensitometric control strips (see 2.3.3 and 2.4.4).

2. Perform the measurements three times for all fields and calculate the average values. Measure each field with all three measurements at the same point (as exactly as possible in the center of each step!).

3. This approach is absolutely necessary to receive reliable results. This is because uneven illumination of the color test table during exposure may cause markedly deviating densities between the center and the edges of the same field!

4. Write lab-specific reference values obtained on an evaluation sheet and archive it together with the film strip. In this manner you obtain measured and exact references to which you can refer for each subsequent evaluation of a control exposure.

5. With this approach it is possible to evaluate each developed control exposure according to the methods described in 2.4.7 through 2.4.9. It is then possible to make error determinations free from subjective visual estimation.

3. PROCESS ERRORS AND CORRECTIONS

3.1 Error Diagnosis

The tables for error diagnosis pictured below and the corrective suggestions will be helpful to you in the following situations:

1. You have difficulties handling densitometer and reference or control strips and performing measured process control (tables A through C).

2. Your films are too dark / too light or show varying densities / strong contrast deviations (points D through F).

3. You notice "extreme effects" when processing films such as no edge markings / no differentiation between light and shadow. Or you encounter deviations from one chemistry preparation to another (points G and H).

4. You have performed your control evaluation and the values exceed the control limits (tables 1 through 6). This part of the error catalog contains a detailed list of commonly occurring processing errors for materials from Agfa, Fuji and Kodak.

5. Although your processing results are fine in density and color, they show obvious physical effects and / or damages (tables 7 through 13).

3.2 Arrangement of Tables

Following is a guide for the easy handling of all error diagnosis tables as well as remarks about the information you can draw from these tables:

We assume that the majority of our readers will prefer visual process control. Therefore, the color test table has - in regard to density and color deviations - been shown and described in reference to the error.

The heading on the shaded background names the areas to be examined. Furthermore, it describes the manifestation of the error (e.g., contrast deviations / extreme effects / high maximum density / contamination on the film surface).

Within the frame of the detailed error catalog, the subject fields primarily relating to the evaluation are named in the heading.

The information given there is to be interpreted as follows:

(e.g.) "Dmax/6" calls for either
- the evaluation of sensitometric control strips based on field "Dmax",
- the evaluation of color test table exposures based on field "6".

The exact designations and meanings of the control strip fields are found in 2.4.4, those of the test table fields in 2.3.3.

In all tables, the lines marked (??) refer to the problem area and the related process parameter or error sources that need to be examined.

The lines marked (!!) offer clues how to gain control again of the corresponding process parameter or eliminate the error source.

3.3 General Diagnosis Tables

The clues to possible error sources in tables D through H are of general nature and apply to all film material. However, they may differ in their magnitude between manufacturers. The extent of the errors also depends on the processing chemicals used.

Overview of tables:

Problem area	Brief description	Refer to
Film altogether too dark	High overall density	Point D
Film too light overall or varying in density	Low or varying overall density	Point E
Contrast deviations	Density differences between lights and shadows too big / too small	Point F
Extreme effects	No edge markings / no differentiation between lights and shadows	Point G
Densitometer	Handling	Point A
Reference strips	Handling	Point B
Control strips	Handling	Point C
Deviation between preparations	Different processing results	Point H

Note: No examples exist on the E-6 color control poster for points A-G.

POINT A DENSITOMETER

Assure careful and cautious handling!

If you have found a process error upon evaluation of the measured values, be sure to repeat the measurement to rule out measuring errors. Should the first measurement then be confirmed, develop a second control strip without changing the process. Only then should you initiate necessary process modifications.

Also, pay attention to these items:

?? Wrong operation of densitometer
!! Comply with instruction manual

?? Did not consider warm-up time of densitometer
!! Begin measurements only after required time

?? Filter status
!! For E-6 processes, always measure with filters in status A (transmitted light)

?? Densitometer not properly set to zero
!! Perform a zero adjustment before turning on the unit and prior to the beginning of each measurement in order to establish a reference point

?? Densitometer filter faded
!! Replace filters from time to time (see instruction manual)

?? Color temperature of measuring lamp shifted
!! Replace lamp from time to time (see instruction manual)

?? Densitometer defective
!! Observe for unusual behavior and notify technical service, if necessary

Notify manufacturer of densitometer in case of serious problems!

POINT B REFERENCE STRIPS

If you have found a process error upon evaluation of the measurements, be sure to repeat the measurement to rule out measuring errors. Should the first measurement then be confirmed, develop a second control strip without changing the process. Only then should you initiate necessary process modifications.

Also, pay attention to these items:

1. Processing errors

?? Measuring errors
!! Measure in the center of the appropriate field
!! Measure in status A
!! Measure correct fields
!! Read densitometer readings correctly, pay attention to sequence of R,G,B-values
!! Repeat measurement for safety

?? Wrong reference strip used
!! Use only strips with same code number as control strips

?? Correction values confused or not taken into account
!! Verify and correct

?? Entered reference values incorrectly on evaluation sheet
!! Verify and correct

2. Physical damage

?? Wrong handling
!! Handle strips only at the edges to avoid fingerprints and scratches on the measuring fields

?? Wrong storage
!! Store in protective sleeves in dark and dry area

Notify film manufacturer in case of serious problems!

POINT C CONTROL STRIPS

If you have found a process error upon evaluation of the measurements, be sure to repeat the measurement to rule out measuring errors. Should the first measurement then be confirmed, develop a second control strip without changing the process. Only then should you initiate necessary process modifications.

Pay also attention to these items:

1. Processing errors

?? Measuring errors
!! Measure in the center of the appropriate field
!! Measure in status A
!! Measure correct fields
!! Read densitometer readings correctly, pay attention to sequence of R,G,B- values
!! Repeat measurement for safety

?? Wrong control strip used
!! Use only strips with same code number as reference strip

?? Entered reference values incorrectly on evaluation sheet
!! Verify and correct

?? Wrong handling
!! Handle strips only at the edges to avoid fingerprints and scratches on the measuring fields

?? Wrong storage
!! Store in refrigerator at -18°C (0.4°F); allow adjustment to room temperature before processing (approximately 30 to 60 minutes)

?? Stored too long
!! Do not use beyond expiration date

Notify film manufacturer in case of serious problems!

POINT D FILM TOO DARK OVERALL

Check all applicable problem areas regularly!

Overall density too high

1. Too dark overall

?? Too many films processed per liter of developer
!! Observe minimum chemistry quantities (see 1.5.2)

?? Pre-warm time too short
!! Verify and set to set-value (see 1.4.4)

?? Water bath level too low on a Jobo Processor
!! Set water level by turning level control so that drum / tank are just below point of floatation

?? First developer time too short or temperature too low
!! Verify and set to set-values (see 1.4.4)

?? First developer too strongly diluted, exhausted or oxidized
!! Drain and prepare fresh
!! Do not leave more than 1 week in processor tank (see 1.3.6)

?? Too much starter solution added to first developer or accidentally color developer starter added
!! Drain and prepare fresh

2. Overall or partially too dark (see also Point G, Points 2 and 3)

?? Did not use bleach and/or fixing bath, too strongly diluted, oxidized
!! Verify program, bath sequence and preparation method
!! Correct process sequence and, if necessary, drain bleach and/or fixing bath and prepare fresh
!! Do not use more than twice (see 1.7.3)
!! Do not leave more than 4 weeks in processor tank (see 1.3.6)

3. Too dark overall and red (sheet film)

?? Film exposed from wrong side
!! Position film properly in film holder (position touch mark of film to upper right when slide is pulled out downward)

POINT E FILM TOO LIGHT OVERALL OR VARYING IN DENSITY

Too light or varying overall density

1. Too light overall

?? Rinse temperature too high (above 41°C/106°F)
!! Verify and set to 38°C (100.6°F)

?? Film fogged by intruding light before processing
!! Do not use darkroom lighting; cover phosphorescent indicators and display lights; seal doors, windows, etc. against intruding light

?? First developer time too long or temperature too high
!! Verify and set to set-value (see 1.4.4)

?? First developer too concentrated or addition of starter overlooked when preparing processing solution
!! Drain and prepare fresh

?? First developer contaminated with color developer
!! Drain, clean tank thoroughly and prepare fresh

2. Too light overall and blue or cyan

?? First developer contaminated with fixing bath
!! Drain, clean tank thoroughly and prepare fresh

3. Variances

?? Irregularities of temperature
!! Check processor for disturbances of program sequence
!! Notify technical service if error cannot be found
!! Varying fill quantities (insufficient chemistry)

POINT F CONTRAST DEVIATIONS

Density differences between lights and shadows are too big or too small

1. High contrast / Great density differences

?? Color developer too strongly diluted
!! Prepare fresh and perform test development with test strips or test table exposures

?? Too much starter in first developer
!! Prepare new processing solution with correct starter quantity, use 20 ml graduate for preparation of starter

2. Low contrast / small density differences

?? Concentration of color developer too high
!! Prepare fresh and perform test development with test strips or test table exposures.

?? Not enough starter in first developer
!! Prepare fresh solution with correct starter quantity, use 20 ml graduate for preparation of starter

POINT G EXTREME EFFECTS

1. The films show absolutely no markings including edge markings.

?? Color developer: neglected to add Part B
!! Drain solution and prepare fresh
!! Check preparation method

2. The films are black throughout, no differentiation between lights and shadows can be recognized

?? Bleach bath: omitted
!! Verify programmed time and set to set-value (see 1.4.4)
!! Verify chemistry filling of processor tanks
!! Check bleach tank for tightness (leaks)

?? First and color developers confused or switched
!! Run cleaning program
!! Switch bottles

?? First developer: omitted
!! Bottle lid not tightened on Jobo Processor
!! Verify program

3. The films show a strongly increased overall density and lights and shadows appear contaminated on the surface

?? Fixing bath: omitted
!! Verify programmed time and set to set-value (see 1.4.4)
!! Verify chemistry filling of processor tanks
!! Check tank for tightness (leaks)

The process errors described in 2. and 3. can be corrected through processing the affected slide films with a complete second process run observing the times required for bleach or fixing bath!

POINT H DEVIATIONS BETWEEN CHEMISTRY PREPARATIONS AND/OR DEVIATIONS OF DENSITY

The films show varying processing results

1. Processor

!! For Jobo Processor users: Always assign same bottle and program numbers when programming
!! In case of down-times of more than one week, empty chemical solutions and run cleaning program (see 1.1.2)
!! Check containers and remove oxidized chemistry residues
!! Do not contaminate reels, tanks and processor with stabilizer

2. Preparation of pre-packaged chemistry

!! Use chemicals from the same manufacturer for entire process
!! Use the same storage tank for each chemical solution and rinse tank thoroughly after emptying and before refilling
!! Mix chemistry sufficiently
!! Do not exceed maximum storage time for prepared solutions (see 1.3.6)

3. Partial preparation

!! Always prepare same volume
!! Use suitable graduates (see 1.3.4)
!! Calculate the amount of concentrate required per liter of processing solution correctly (see 1.3.4)
!! Use separate preparation container as well as graduate, mixing rod and utensils for each chemical; clean thoroughly after use in running water
!! Pay attention to shelf-life of the concentrates (see 1.3.5)
!! Check storage area of concentrates (cool and dry, temperature from 5° to 27°C / 41° to 80°F)

3.4 Detailed Error Catalog

In this section you will find a detailed compilation of the processing errors occurring most often for materials from Agfa, Fuji and Kodak. This compilation we produced by creating the actual errors in a typical lab setting.

The tests leading to this compilation have been conducted using Kodak chemicals. When using chemicals other than Kodak's, slightly different results may occur. For this reason, all statements and assumptions made are only approximate. Absolute information cannot be given because of the many factors influencing the processing results.

If you are using E-6 three-bath chemicals, not all process errors can be corrected based on this error catalog because of the different characteristics of the process chemicals and different bath sequence. However, because this process consists of only FD, CD and BX, some possible errors that could occur during preparation are eliminated.

When following the modifications suggested in tables 1 through 6, never perform more than one modification before testing to see if the problem is resolved. (In a few instances two simultaneous modifications may be recommended by this book. In this case perform both modifications.)

Performing more than one modification without testing does not allow clear conclusions and may cause complete loss of control of the process!

If you encounter serious problems, please contact the film or chemistry manufacturer. These companies maintain Customer Service Departments.
These departments have broad experience with reactions of film materials or chemicals and can often help with your problems.

It is important to remember that for each problem or question, exact and repeatable documentation is needed. This documentation should include all detected errors as well as modifications performed for their correction. With this information the customer service department of the manufacturer is more likely to be able to help you.
It is better to make requests in writing with documentation and the processed samples attached.

Overview of tables

Problem area	Brief description	Refer to High
High maximum density	Black shadows	Table 1
Low maximum density	Blue low	Table 2A
	Red/green low	Table 2B
	Green low	Table 2C
	Red/blue low	Table 2D
	Red low	Table 2E
	Blue/green low	Table 2F
High utilization of sensitivity	Film too light overall	Table 3
Low utilization of sensitivity	Film too dark overall	Table 4
High minimum density	Overcast lights	Table 5
Color deviations	to blue	Table 6A
	to yellow	Table 6B
	to green	Table 6C
	to magenta	Table 6D
	to red	Table 6E
	to cyan	Table 6F
	to green/cyan	Table 6G
	to yellow/ green-cyan-magenta	Table 6H

TABLE 1 HIGH MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

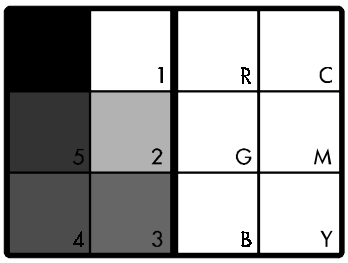
Control values for RED, GREEN and BLUE are markedly above the standard values.

Visual Evaluation:

No markings are present in the shadow sections of the slide or the slide shows no image.

Appearance of test table altogether too dark.

Fields 5 and 6 show a bluish discoloration.



Agfa / Fuji / Kodak

?? First developer: too much starter added
!! Drain solution and prepare fresh

?? First developer: time markedly too short or omitted
!! Verify programmed time and set to set-values

?? First developer or color developer: concentration too low
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer / color developer: reversed
!! Replace solutions and clean both tanks thoroughly
!! Check preparation and processing method

?? Color developer: too much part B added
!! Drain solution and prepare fresh
!! Check preparation method

?? Bleach bath or fixing bath: loss of chemical activity; bath was omitted
!! Verify temperature and programmed times and set to set-values
!! Do not use more than twice
!! Do not store prepared chemistry longer than 24 weeks, in the processor tanks no longer than 8 weeks
!! Check preparation method
!! Treat film(s) again in fresh solution(s); the error can usually be thus corrected

?? Film handling: no exposure or underexposed
!! Eliminate error in camera equipment used

Agfa / Fuji

?? Color developer: too much starter added
!! Drain solution and prepare fresh

Fuji / Kodak

?? Color developer: markedly too long
!! Verify programmed time and set to set-value

TABLE 2A LOW MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

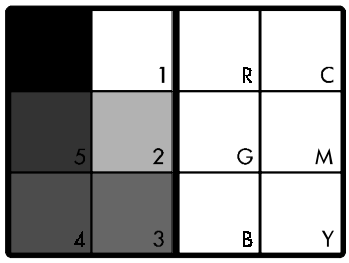
Control values for BLUE are below the control limit of -0.25 or below RED and GREEN; the latter are at approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a bluish tint.

Appearance of test table too light overall.

Fields 5 and 6 show a bluish discoloration.



Agfa / Kodak

?? Reversal bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method
!! For rotary processor users: Prepare reversal bath with 60% strength (for 1 liter solution use 30 ml concentrate + 970 ml water)

Agfa

?? First developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

Kodak

?? First developer, bleach bath or fixing bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: too much starter added
!! Drain solution and start fresh

TABLE 2B LOW MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

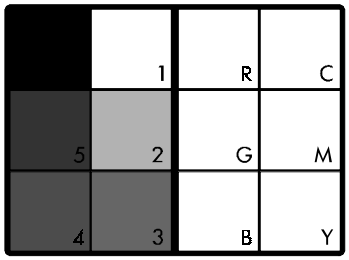
Control values for RED and GREEN are below the control limit of -0.25 or below BLUE; the values for RED and GREEN are approximately the same value.

Visual Evaluation:

The shadow sections of the slide appear to have a yellowish tint.

Appearance of test table too light overall.

Fields 5 and 6 show a yellowish discoloration.



Fuji / Kodak

?? First developer or reversal bath: time too long
!! Verify programmed time and set to set-value

Agfa

?? Color developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

Fuji

?? Color developer: time too long
!! Verify programmed time and set to set-value

?? Color developer or conditioner bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

Kodak

?? First developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with first developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: time too short
!! Verify programmed time and set to set-value

TABLE 2C LOW MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

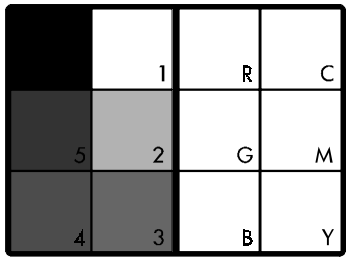
Control values for GREEN are below the control limit of -0.25 or below RED and BLUE; the latter are approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a greenish tint.

Appearance of test table too light overall.

Fields 5 and 6 show a greenish discoloration.



Agfa / Fuji / Kodak

?? Reversal bath: contamination with first developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: not enough or no starter added
!! Drain solution and prepare fresh

?? Color developer: contamination with stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath too strongly diluted, too old or used up
!! Drain solution and prepare fresh
!! Verify programming

Agfa

?? First developer: too long
!! Verify programmed time and set to set-value

?? Color developer or conditioner bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

Agfa / Fuji

?? First developer: contamination with reversal bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath or conditioner bath: time too short
!! Verify programmed time and set to set-value

Agfa / Fuji

?? Color developer: too much part A added
!! Drain solution and prepare fresh
!! Check preparation method

?? Bleach bath or fixing bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

Fuji

?? First developer: not enough or no starter added
!! Drain solution and prepare fresh

?? First developer or reversal bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method
!! Prepare reversal bath only with 60% strength (for 1 liter solution use 30 ml concentrate + 970 ml water)

?? First developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with first developer or bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: time too short, solution too old or too strongly diluted
!! Verify programming and, if necessary, drain solution and prepare fresh

TABLE 2D LOW MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

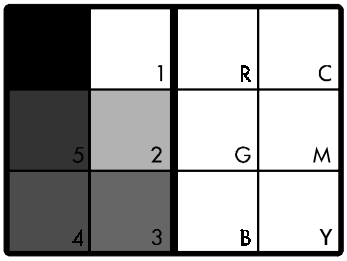
Control values for RED and BLUE are below the control limit of -0.25 or below GREEN; the values for RED and BLUE are approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a magenta-colored tint.

Appearance of test table altogether too light overall.

Fields 5 and 6 show a magenta-colored discoloration.



Kodak

?? Conditioner bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

TABLE 2E LOW MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

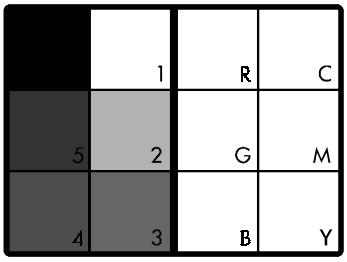
Control values for RED are below the control limit of -0.25 or below BLUE and GREEN; the latter are approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a reddish tint.

Appearance of test table too light overall.

Fields 5 and 6 show a reddish discoloration.



Agfa / Fuji / Kodak

?? First developer (three-bath): contamination with color developer
!! Drain solution and prepare fresh
!! Clean and dry reels and tanks thoroughly
!! When changing from three-bath to six-bath chemistry and vice versa, pay particular attention to cleanliness of chemistry preparation

Agfa

?? First developer: Contamination with color developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: time too short, solution too old or too strongly diluted
!! Verify programming and, if necessary, drain solution and prepare fresh

TABLE 2F LOW MAXIMUM DENSITY (D-max / 6)

Sensitometric measurement:

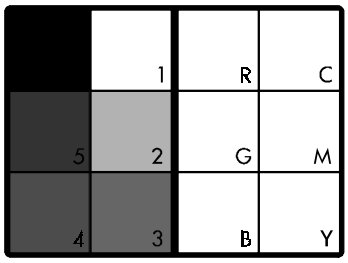
Control values for BLUE and GREEN are below the control limit of -0.25 or below RED; the values for BLUE and GREEN are approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a cyan-colored (blue-greenish) tint.

Appearance of test table too light overall.

Fields 5 and 6 show a cyan-colored (blue-greenish) discoloration.



Agfa / Fuji / Kodak

?? First developer: contamination with fixing bath
!! Drain solution and prepare fresh
!! Check preparation method

Agfa / Kodak

?? First developer: too little or no starter added
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer: contamination with stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method; do not bring reels into contact with stabilizer bath

Agfa

?? First developer: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath: time too long
!! Verify programmed time and set to set-value

Kodak

?? First developer: contamination with color developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath: time too short
!! Verify programmed time and set to set-value

?? Color developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method
!! Use separate preparation vessel for each chemical and rinse thoroughly before and after use

?? Color developer: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: too much part A added
!! Drain solution and prepare fresh
!! Check preparation method

TABLE 3 HIGH UTILIZATION OF SENSITIVITY (HD/3)

Sensitometric measurement:

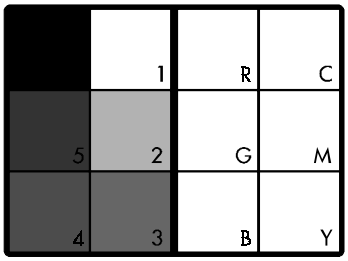
Control values for RED, GREEN and BLUE are below the control limit of -0.10.

Visual Evaluation:

The slide is too light overall.

Appearance of test table too light overall.

Fields 2 through 5 are clearly too light.



Agfa / Fuji / Kodak

?? First developer: too long
!! Verify programmed time and set to set-value

?? First developer: temperature too high
!! Verify temperature and set to set-value

?? First developer: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer: contamination with reversal bath, color developer, bleach bath or stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer or color developer: too little or no starter added
!! Drain solution and prepare fresh

?? First developer, reversal bath, color developer or conditioner bath: stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floatation lids no longer than one week and at the most at 25°C (77°F)

?? Reversal bath: time too long, extremely short or omitted
!! Verify programmed time and set to set-value

?? Reversal bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method
!! When using Kodak chemicals and a rotary processor, prepare reversal bath with 60% strength (for 1 liter solution use 30 ml concentrate + 970 ml water)

?? Color developer: concentration too high or too low
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contains too much part A or part B
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: time too short
!! Verify programmed time and set to set-value

?? Conditioner bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? Bleach bath: time too short
!! Verify programmed time and set to set-value

?? Bleach bath or fixing bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? No water rinses between First Developer and Reversal Bath
!! Verify programmed time and set to set-value

Agfa / Fuji

?? Reversal bath: contamination with first developer
!! Drain solution and prepare fresh
!! Check preparation method

Fuji / Kodak

?? Color developer: contamination with bleach bath or stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method

Agfa

?? Color developer: time too long
!! Verify programmed time and set to set-value

Fuji

?? Color developer: time too short
!! Verify programmed time and set to set-value

Kodak

?? Color developer: too much starter added
!! Drain solution and prepare fresh

TABLE 4 LOW UTILIZATION OF SENSITIVITY (LD/3)

Sensitometric measurement:

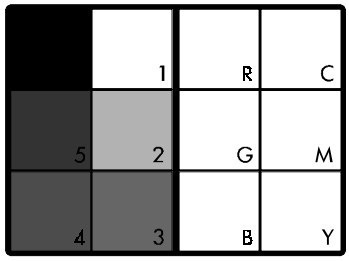
Control values for RED, GREEN and BLUE exceed the control limit of +0.10.

Visual Evaluation:

The slide is too dark overall.

Appearance of test table too dark overall.

Fields 2 through 5 are clearly too dark.



Agfa / Fuji / Kodak

?? First developer: time too short
!! Verify programmed time and set to set-value

?? First developer: temperature too low
!! Verify temperature and set to set-value

?? First developer: concentration too low
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer: too much starter added
!! Drain solution and prepare fresh

?? First developer: color developer starter accidentally added (marked loss of sensitivity, especially in blue)
!! Drain solution and prepare fresh

Agfa / Fuji

?? Color developer: too much starter added
!! Drain solution and prepare fresh

Agfa / Kodak

?? Agitation (rotation speed on rotary processors): too low
!! With a rotary processor always perform film processing bi-directionally at 75 rpm

Agfa

?? Color developer: contamination with first developer or fixing bath
!! Drain solution and prepare fresh
!! Check preparation method

TABLE 5 HIGH MINIMUM DENSITY (D-min / 1)

Sensitometric measurement:

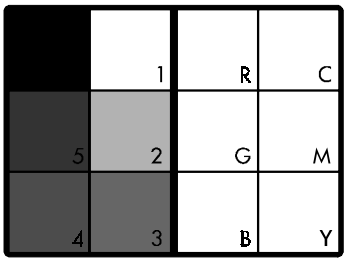
a) The control values for RED, GREEN and BLUE exceed the control limit of +0.05.
b) The control values for BLUE are above the control limit of +0.05.

Visual Evaluation:

A-The slide shows a dirty and subdued light rendition
B-The slide shows a dirty and subdued light rendition with additional yellow haze

Appearance of test table colors is neutral but the image is too dark overall.

In case a) field 1 is slightly or clearly too dark and appears dirty, in case b) it shows an additional yellow haze.



Agfa / Fuji / Kodak

?? First developer: concentration too low (case A)
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with first developer (case A) or fixing bath (case B)
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: time extremely short or omitted (case B)
!! Verify programmed time and set to set-value

?? Bleach bath or fixing bath: loss of activity or omission (case B)
!! Verify temperature and programmed time and set to set-value (at least 6:00 minutes)
!! Do not use more than twice; do not store prepared chemistry longer than 24 weeks
!! Check preparation method

Agfa / Fuji

?? Color developer: too much starter added (case B)
!! Drain solution and prepare fresh

?? Color developer: contamination with bleach fix (case A)
!! Drain solution and prepare fresh
!! Check preparation method

Agfa / Kodak

?? Agitation (rotation speed): too low (case B)
!! Always perform rotary film processing bi-directionally at 75 rpm

Agfa

?? First developer: too much starter added (case A)
!! Drain solution and prepare fresh

?? Color developer: contamination with stabilizer bath (case A)
!! Drain solution and prepare fresh
!! Check preparation method

Kodak

?? Reversal bath: contamination with first developer (case A)
!! Drain solution and prepare fresh
!! Check preparation method

TABLE 6A COLOR SHIFT (HD/5) TO BLUE

Sensitometric measurement:

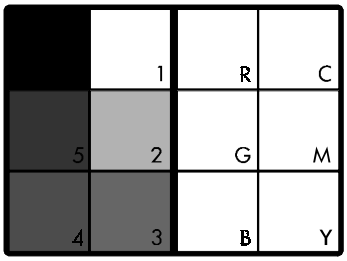
Control values for BLUE are below those for RED and GREEN; the latter have approximately the same level.

Visual Evaluation:

The entire slide has a bluish appearance.

Appearance of test table too blue overall.

This color cast is particularly obvious in fields 2 through 5.



Agfa / Kodak

?? First developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with first developer
!! Drain solution and prepare fresh

?? First developer, color developer or conditioner bath: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floatation lids. Store for no longer than one week and at not above 25°C (77°F)

?? Reversal bath, conditioner bath or bleach bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method
!! Prepare reversal bath at 60% strength (for 1 liter solution use 30 ml concentrate + 970 ml water)

?? Color developer: too much starter added
!! Drain solution and prepare fresh

?? Color developer-pH too low
!! Add sodium hydroxide solution *pH-UP 4802 to the color developer and adjust first developer time accordingly

*(pH-DOWN / pH-UP) (see also 3.6)

TABLE 6B COLOR SHIFT (HD/5) TO YELLOW

Sensitometric measurement:

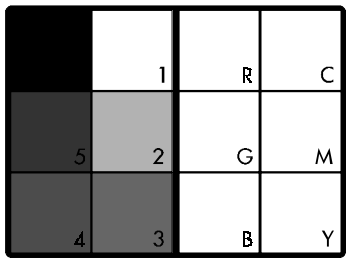
Control values for RED and GREEN are below those for BLUE; the values for RED and GREEN are approximately the same level.

Visual Evaluation:

The entire slide has a yellowish appearance.

Appearance of test table too yellow overall.

This color cast is particularly obvious in fields 2 through 5.



Agfa / Fuji / Kodak

?? Bleach bath: loss of activity or omission
!! Verify temperature and programmed time and set to set-value
!! Do not use more than twice
!! Do not store prepared chemicals for more than 8 weeks
!! Check preparation method

Agfa / Fuji

?? Color developer: too much starter added
!! Drain solution and prepare fresh

?? Color developer: time too short
!! Verify programmed time and set to set-value

?? Color developer: too much part B added
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: time extremely short or omitted
!! Verify programmed time and set to set-value

Agfa

?? Agitation (Rotation speed): too low
!! With rotary processors, may need to increase rotation speed

?? First developer: time too short
!! Verify programmed time and set to set-value

?? First developer or color developer: concentration to low
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method

Fuji

?? Reversal bath or color developer: time too long
!! Verify programmed time and set to set-value

?? Bleach bath: time too short
!! Verify programmed time and set to set-value

?? Fixing bath: loss of activity or omission
!! Verify temperature and programmed time and set to set-value
!! Do not use more than twice without de-silvering
!! Do not store prepared chemicals for more than 8 weeks
!! Check preparation method

Kodak

?? First developer: too much starter added
!! Drain solution and prepare fresh

?? Color developer: contamination with first developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer-pH too high
!! Add sulfuric acid *pH-DOWN 4801 to the color developer and adjust first developer time accordingly

*(pH-DOWN / pH-UP) (see also 3.6)

TABLE 6C COLOR SHIFT (HD/5) TO GREEN

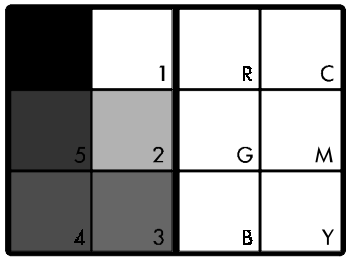
Sensitometric measurement:

Control values for GREEN are below those for RED and BLUE; the latter have approximately the same level.

Visual Evaluation:

The entire slide has a greenish appearance.

Appearance of test table too green overall.



This color cast is particularly obvious in fields 2 through 5.

Agfa / Fuji

?? First developer: contamination with reversal bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath: time too short, solution too strongly diluted or too old
!! Verify programmed time and set to set-value
!! Drain solution and prepare fresh

Agfa / Kodak

?? Color developer: not enough or no starter added
!! Drain solution and prepare fresh

?? Color developer: too much part A added
!! Drain solution and prepare fresh
!! Check preparation method

Fuji / Kodak

?? Agitation (rotation speed): too low
!! With rotary processors always perform film processing bi-directionally at 75 rpm

Agfa

?? Color developer: time too long
!! Verify programmed time and set to set-value

?? Color developer: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: pH too high
!! Add sulfuric acid *pH-DOWN 4801 and adjust first developer time

?? Bleach bath:concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

Fuji

?? First developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with first developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: pH too high
!! Add sulfuric acid *pH-DOWN 4801 and adjust first developer time

Kodak

?? First developer: time too long
!! Verify programmed time and set to set-value

?? Color developer: time too short
!! Verify programmed time and set to set-value

?? Color developer: contamination with fixing bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: time extremely short or omitted
!! Verify programmed time and set to set-value

?? Reversal bath: time too short, solution to strongly diluted or to old
!! Verify programming, if necessary, prepare solution fresh

*(pH-DOWN / pH-UP) (see also 3.6)

TABLE 6D COLOR SHIFT (HD/5) TO MAGENTA (PURPLE)

Sensitometric measurement:

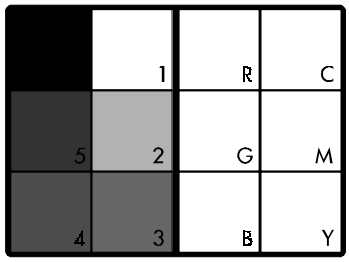
Control values for RED and BLUE are below those for GREEN; the values for RED and BLUE have approximately the same level.

Visual Evaluation:

The entire slide has a magenta-colored (purple) appearance.

Appearance of test table too purple (magenta-colored) overall.

This color cast is particularly obvious in fields 2 through 5.



Kodak

?? Color developer: time too long
!! Verify programmed time and set to set-value
!! Check preparation method

?? Color developer: concentration too low
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: pH too low
!! Add sodium hydroxide solution *pH-UP 4802 and adjust first developer time

?? Insufficient wash after first developer
!! Extend wash after first developer to 4 minutes

?? Insuddicient activity in bleach (bleach-fix with three-bath)
!! Aerate bleach or bleach fix before use
!! Drain solution and prepare fresh

*(pH-DOWN / pH-UP) (see also 3.6)

TABLE 6E COLOR SHIFT (HD/5) TO RED

Sensitometric measurement:

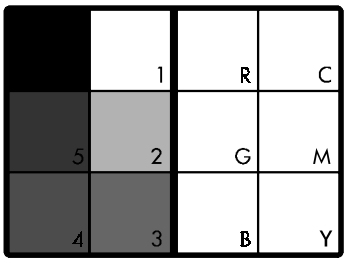
Control values for RED are below those for BLUE and GREEN; the latter have approximately the same level.

Visual Evaluation:

The entire slide has a reddish appearance.

Appearance of test table too red overall.

This color cast is particularly obvious in fields 2 through 5.



Agfa / Fuji

?? First developer: too much starter added
!! Drain solution and prepare fresh

?? Color developer: pH too low
!! Add sodium hydroxide solution *pH-UP 4802 and adjust first developer time

Agfa / Kodak

?? Fixing bath: loss of activity or omission
!! Verify temperature and programmed time and set to set-value
!! Do not use more than twice without de-silvering
!! Do not store prepared chemicals for more than 8 weeks
!! Check preparation method

Agfa

?? Color developer: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floating lids no longer than one week and at the most at 25°C (77°F)

*(pH-DOWN / pH-UP) (see also 3.6)

TABLE 6F COLOR SHIFT (HD/5) TO CYAN (BLUE-GREEN)

Sensitometric measurement:

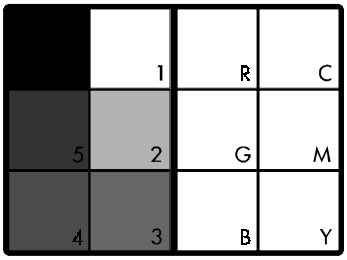
Control values for BLUE and GREEN are below those for RED; the values for BLUE and GREEN have approximately the same level.

Visual Evaluation:

The entire slide has a cyan-colored (blue-greenish) appearance.

Appearance of test table too blue-green (cyan-colored) overall.

This color cast is particularly obvious in fields 2 through 5.



Agfa / Fuji / Kodak

?? First developer: not enough or no starter added
!! Drain solution and prepare fresh

?? First developer: contamination with fixing bath
!! Drain solution and prepare fresh
!! Check preparation method

Agfa / Fuji

?? Reversal bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method
!! When using Kodak chemicals, prepare reversal bath with 60% strength (for 1 liter solution use 30 ml concentrate + 970 ml water)

?? Color developer: pH too high
!! Add sulfuric acid *pH-DOWN 4801 and adjust first developer time

Agfa / Kodak

?? First developer or fixing bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer: contamination with stabilizer bath
!! Drain solution and prepare fresh

?? Reversal bath: time too long
!! Verify programmed time and set to set-value

*(pH-DOWN /pH-UP) (see also 3.6)

Fuji / Kodak

?? First developer: concentration too low
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

Agfa

?? Reversal bath: contamination with first developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: time too short
!! Verify programmed time and set to set-value

Fuji
?? Color developer: not enough or no starter added
!! Drain solution and prepare fresh

Kodak
?? First developer: contamination with reversal bath, color developer or bleach bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath: time too short
!! Verify programmed time and set to set-value

?? Reversal bath: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floating lids no longer than one week

?? Color developer: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: too much part B added
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: contamination with stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Bleach bath: time too short
!! Verify programmed time and set to set-value

TABLE 6G COLOR SHIFT (HD,LD/5,3) HD/5: TO GREEN LD/3: TO CYAN

Sensitometric measurement:

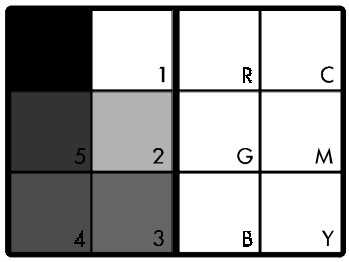
Control values in step HD (color control) for GREEN are below those for RED and BLUE; the latter have approximately the same level.

Control values in step LD (sensitivity control) for BLUE and GREEN are below those for RED; the values for BLUE and GREEN have approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a greenish tint; it appears cyan-colored (blue-greenish) in the light sections.

Appearance of test table merked by different tint in light and shadow section.



The fields 4 and 5 have a greenish tint; fields 2 and 3 appear cyan-colored (blue-greenish).

Agfa / Fuji

?? First developer: contamination with color developer
!! Drain solution and prepare fresh
!! Check preparation method

?? Reversal bath: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floating lids for no longer than one week

?? Color developer: pH too high
!! Add sulfuric acid *pH-DOWN 4801 and adjust first developer time

Agfa

?? First developer: too long
!! Verify programmed time and set to set-value

?? First developer: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floatation lids no longer than one week

*(pH-DOWN / pH-UP) (see also 3.6)

?? Conditioner bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

Fuji

?? First developer or color developer: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

?? First developer or color developer: contamination with stabilizer bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: too much part A added
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floating lids no lon ger than one week and at the most at 25°C (77°F)

?? Bleach bath or fixing bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

TABLE 6H COLOR SHIFT (HD,LD/5,3) HD/5: TO YELLOW LD/3:a) TO GREEN b) TO CYAN c) TO MAGENTA

Sensitometric measurement:

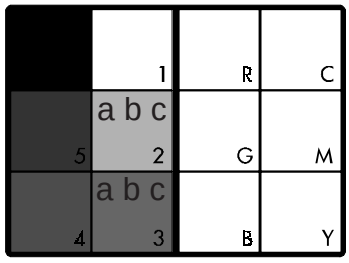
Control values in step HD (color control) for RED and GREEN are below those for BLUE; the values for RED and GREEN have approximately the same level.

Control values in step LD (sensitivity control):
a) for GREEN are below those for RED and BLUE; the latter have approximately the same level.
b) for BLUE and GREEN below those for RED; the values for BLUE and GREEN have approximately the same level.
c) for RED and BLUE below those for GREEN; the values for RED and BLUE have approximately the same level.

Visual Evaluation:

The shadow sections of the slide appear to have a yellowish tint; it appears A) greenish, B) cyan-colored (blue-greenish), C) magenta-colored in the light sections.

Appearance of test table marked by different tint in light and shadow section.



The fields 4 and 5 have a yellowish tint; fields 2 and 3 appear in case A) greenish, B) cyan-colored and C) magenta-colored.

Case A:

Agfa

?? Color developer: contamination with bleach bath or fixing bath
!! Drain solution and prepare fresh
!! Check preparation method

?? Conditioner bath: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floating lids no longer than one week

Fuji

?? Color developer: concentration too low
!! Drain solution and prepare fresh
!! Check preparation method

?? Color developer: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions no longer than one week only in completely filled bottles or tanks with floating lids

Case B:

Fuji

?? First developer: time too long
!! Verify programmed time and set to set-value

?? First developer: solution stored too long
!! Drain solution and prepare fresh
!! Check storage conditions
!! Store prepared solutions only in completely filled bottles or tanks with floating lids no longer than one week

?? Conditioner bath: concentration too high
!! Drain solution and prepare fresh
!! Check preparation method

Kodak

?? Conditioner bath: time too short
!! Verify programmed time and set to set-value

Case C:

Fuji

?? Color developer: contamination with fixing bath
!! Drain solution and prepare fresh
!! Check preparation method

3.5 Physical Condition of Film

Tables 7 through 13 give hints for troubleshooting problems due to physical damage to the film. Physical damage has occurred when the film shows correct color and density but other damage or problems are apparent,

To keep the likelihood of damage and contamination as small as possible, always handle the film with the utmost care.

Overview of tables:

Dirt on the film surface	Visible in transmitted / reflecting light	Table 7
Marbling / grain	Spotted slides	Table 8
Residues on film surface	Smudged film	Table 9
Scratches / wear	Lines / spots	Table 10
Emulsion defects	Stripes	Table 11
Handling of film	Kinks / stripes	Table 12
Spots / splashes	Film only partially properly developed	Table 13

TABLE 7 DIRT ON SURFACE OF FILM

Check all potential problem areas regularly!

1. Dirt in the solutions

!! Unfiltered used for preparation
!! Use floating lids with solution tanks

2. Dirt in the rinse cycles

?? Water filter dirty
!! Check and replace if necessary
!! Use water filter with a grid size of 5-25 micron

3. Dirt in stabilizer bath

!! Cover stabilizer bath when not in use
!! Use distilled or demineralized water for preparation
!! Empty container and clean, change bath once a week
!! Start fresh stabilizer bath

4. Dirt and chemistry residues in processor

!! If using a Jobo Processor, replace red sealing rings on lids of tanks and drums
!! Drain water bath once a week
!! Clean regularly with Jobo Processor-Clean (Jobo Part # 4181)

5. Dirt during drying process

?? Drying cabinet air filter dirty
!! Check, replace filter and/or clean drying cabinet
!! Keep walking distances to dryer short since dirt and dust settle on the wet film

TABLE 8 MARBLING / GRAIN

Slides appear spotted or sprinkled.

1. Silver residues (dirty appearance)

?? Verify program time of bleach bath
!! Set to set-value (see 1.4.4)
!! Prepare solution correctly
!! Do not use more than twice without replenishing (see 1.7.3)
!! Error can usually be eliminated through second bleaching; run complete E-6 process with the affected film for this purpose

2. Silver Halide residues (milky appearance)

?? Verify program time of bleach- and fixing baths
!! Set both to set-values (see 1.4.4)
!! Prepare solution correctly
!! Do not use more than twice without replenishing (see 1.7.3)
!! Error can usually be eliminated through second bleaching; run complete E-6 process with the affected film for this purpose

3. Sulfur precipitation in fixing bath (white dots)

?? Stored too long or too much air exposure
!! Prepare fixing bath fresh
!! Do not store more than 12 weeks, in processor tank no longer than 8 weeks

4. Rinse temperature

?? Rinse temperature too low
!! Verify and set to 38°C ±3° (100.4°F ±5.4°)

5. Emulsion defects

!! Notify film manufacturer and give number of emulsion
See table 11

TABLE 9 RESIDUES (SMUDGED FILM) ON FILM SURFACE

Smudges on film become visible in transmitted and reflected light.

1. Stabilizer bath

?? Used too long
!! Replace once a week

?? Concentration too high
!! Lower; add 6 ml formalin 37.5% to each liter of dilution water to maintain the color-stabilizing effect
!! Use of distilled or demineralized water may be helpful with preparation

2. Rinse water

!! Install water filter at processor intake when dirt is a problem

3. Foam separator

?? Tank foam separator accidentally added directly to a solution
!! Follow directions for foam separator
!! Use only liquid foam separator (e.g., Tetenal color foam separator)

TABLE 10 SCRATCHES / WEAR

Distinct colored or clear lines of spots without clear edges

1. Squeegee

?? Damaged or dirty
!! Check and use new squeegee blades

2. Film loader guide

?? Guide of loader defective
!! Check and use new guide

3. Back side of sheet film damaged

?? Check sheet film cassette (holder) for dirt particles; determine which cassette (holder) causes the damage
!! Clean cassette, discontinue use of defective cassette

?? Examine Jobo Expert-Drums for residues at inside of drum wall
!! Clean thoroughly, if necessary
!! Agitate films only one at a time in stabilizer bath or wetting agent
!! Fill Jobo Expert tube with water before removing sheet films
!! Don't pull sheet film out of Jobo Expert tube on one edge only but gently lift with both hands

TABLE 11 EMULSION DEFECTS

Kinks, holes, grooves, colored stripes and spots.

1. Stripes / Chemistry splashes

?? Filling quantity errors of drums / tanks
!! Verify and observe correct fill quantity

?? Reels and/or drums not completely dry before loading film
!! Rinse all parts used thoroughly after processing and dry together with film on the bottom of the drying cabinet

?? Water or chemicals have come in contact with film or drum prior to developing
!! Use separate work surfaces for chemistry preparation and film loading
!! Treat films with wetting agent and dry at 30°C (86°F) max.

2. Water spots

a) Deformed at perforation
b) Scratches (water splashes)
c) Water streaks

!! Dry reels and drums / tanks before loading
!! In case of hard supply water, prepare final baths with distilled or demineralized water
!! If using a rotary processor, do not use rotation speed of less than 50 rpm when using Agfa 35-mm film

3. Kinks

?? Film guide of sheet film cassette (holder) defective
!! Check and discontinue use of defective cassette (holder)
!! Always separate two halves of processing reels when removing films
!! Practice loading of films into cassettes (holders), reels, tanks with scrap material
!! Rotation speed possibly needs to be lowered when using film material with thin layer.

TABLE 12 HANDLING OF FILM

Light / dark crescent-shaped effects, stripes, hairlines.

1. Pressure exposure

?? Kinks through careless handling
!! Do not use force when removing films from cartridge or inserting into reel

2. Fogginess / haze

?? Darkroom light accidentally turned on or faded filter in infrared lamp
!! Do not use darkroom lamp; replace infrared filter or use lamp with low wattage

?? Phosphorescent indicators and display lights cause fogging or fogginess / haze of film
!! Examine darkroom for absolute darkness

?? Light penetration at door frame, window seal, etc.
!! Check for potential light intrusion areas and seal

3. Discharge of static electricity

?? Problem of film handling
!! If possible, all rooms should have a relative humidity of 45-65% and a temperature between 18° and 24°C (64° and 75°F)
!! Leave film in original package until ready to be used and store at recommended temperature.
!! Don't handle any materials more than necessary. Avoid quick and sudden movements that may cause friction.
!! Avoid too fast or too tight winding or unwinding of films
!! Keep all equipment clean and fully functional; keep work room and film handling area as dust free as possible

TABLE 13 ´SPOTS / SPLASHES

Film only partially properly developed.

1. Problems with filling quantity

?? Insufficient filling quantity programmed
!! Verify and observe minimum chemistry quantities (see 1.5.2)

?? Not enough chemistry in tanks
!! Always fill sufficient amount
!! Do not use Manual Overide feature to start process when remaining quantity of solution is too small for the next process run

?? Bottle caps not completely tight
!! Screw on tightly to avoid reduced filling quantities or even absence of chemistry pumping (1.1.2)

?? Wrong roller blocks used
!! Adjust according to size of drums / tanks used, following instruction manual

?? Processor not in level position
!! Level processor as described in instruction manual

?? When using Jobo ATL-3, possibly worked with rear bottles without refill and (-) not entered.
!! Follow directions of instruction manual

3.6 Influencing the Color Balance

Jobo provides a pH-Correction Kit (Jobo Part #4800). [Not available in all countries.] This set consists of a bottle with 10% sodium hydroxide solution (pH-UP #4802), a bottle with 10% sulfuric acid (pH-DOWN #4801) and a small graduate for measuring these solutions. These solutions are used to adjust the pH of the color developer to achieve neutral color results.

pH balance is achieved by adding the appropriate amounts of the solutions to the color developer chemistry. The color deviation observed determines whether sodium hydroxide solution (pH-UP 4802) or sulfuric acid (pH-DOWN 4801) must be added. The extent of the deviation determines the amount to be added.

Please read this chapter before using these solutions. It gives an understanding of the principles at work with this kind of process intervention. It also will give you an overview of how the color balance of the process can be controlled.

- To influence the color balance, use the two solutions from the pH- Correction Kit 4800 in their original concentration. Do not mix with other additives.

Theoretically, sodium hydroxide or sulfuric acid solutions with a higher or lower concentration are suitable. Kodak, for example, recommends the use of a 20% NaOH- or a 20% H2SO4-solution.

The amount of solution needed becomes smaller with a higher concentration. With high concentrations and small deviations, the amounts needed are so small it becomes difficult to measure them accurately. This will have a negative effect on reproducibility.

Use of 10% sodium hydroxide solution (pH-UP 4802) and sulfuric acid (pH- DOWN 4801) lowers the likelihood of wrong measurements. At the same time repeatability of results are assured.

- In their pure form, sodium hydroxide and sulfuric acid are very aggressive and dangerous substances. Even in the relatively small concentration of 10%, found in "pH-Up" and "ph-Down", they are not without hazardous. For your own safety, always follow the safety precautions on the packaging when handling these two chemicals.

3.6.1 Principle of Operation

- The principle is to change the alkalinity (=pH shift) of the color developer. The pH is lowered by adding acid (shift towards "acid"), or raised by adding an alkaline solution (shift toward "alkaline").

- Other acids are sometimes used for photographic purposes. Some common acids are acetic acid (CH_3COOH), or hydrochloric acid (HCl). Also, other alkaline solutions such as ammonia solution (NH_4OH) are used for photographic purposes. These acids and bases can cause a change of the alkalinity but should never be used to achieve an adjustment of the color balance. Doing so may completely ruin the color developer!

- Addition of sodium hydroxide solution (pH-UP 4802) or sulfuric acid (pH-DOWN 4801)causes color development to take place outside of the ideal pH. The density of the processed films decreases especially when adding larger amounts of the respective solution. To compensate for this effect, the first developer time must usually be extended (see 3.6.2).

- Unfortunately, it is not possible to correct all occurring color deviations through the addition of sodium hydroxide solution (pH-UP 4802) or sulfuric acid (pH-DOWN 4801).

The following principles apply:

1. Addition of sodium hydroxide solution (pH-UP 4802) shifts the color balance toward yellow (Kodak).

2. Addition of sulfuric acid (pH-DOWN 4801) (H_2SO_4)changes the color balance toward blue (Kodak).

3. Both solutions lower the color spread by approximately 0.02 densitometric units (density values) for each ml/liter of color developer.

4. If not used correctly, the spread may not be lowered but possibly even raised.

5. The following table is designed to give an overview of the direction of the color balance through the addition of sodium hydroxide solution (pH-UP 4802) or sulfuric acid (pH-DOWN 4801).

Hint: The E-6 Color Control Poster gives you information - in the lower right section - about the color deviation and the possible correction through pH-UP and pH-DOWN.

Table of color balance before/after addition of NaOH or H_2SO_4

Before addition of solution				**After addition of solution**					
Color-deviation		without addition to CD		Color	+7 ml NaOH per Liter CD		Color	+ 7 ml H_2SO_4 per Liter CD	
toward		R-G	B-G		R-G	B-G		R-G	B-G
1	**Blue (B)**	**0,00**	**-0,14**	**N**	**0,00**	**0,00**	B	0,00	-0,28
2	**Yellow (Y)**	**0,00**	**0,14**	Y	0,00	0,28	**N**	**0,00**	**0,00**
3	Green (G)	0,14	0,14	G/Y	0,14	0,28	C	0,14	0,00
4	Magenta (M)	-0,14	-0,14	R	-0,14	0,00	M/B	-0,14	-0,28
5	Red (R)	-0,14	0,00	R/Y	-0,14	0,14	M	-0,14	-0,14
6	Cyan(C)	0,14	0,00	G	0,14	0,14	C/B	0,14	-0,14

N = neutral color rendition

- The difference in color density (R-G) and (B-G) and the term "color spread" are explained in detail in section 2.4.8. The above value examples show the measured ideal situation for the corresponding color deviation listed.

- The designation G/Y, for instance, corresponds with a greenish-yellowish color rendition, R/Y with a reddish-yellowish one, etc.

- In the hypothetical ideal situation, only the blue-sensitive layer reacts to the addition of one of the two solutions [all values for (R-G) remain unaffected by the added solution].

Explanation of table:

- The correction of a color deviation works only in cases with the bold-print lines. By adding the appropriate amount of sodium hydroxide solution (pH-UP 4802), the shift is compensated for toward blue (1). By adding sulfuric acid (pH-DOWN 4801)the shift is compensated for toward yellow (2).

- With a shift toward "Cyan" (blue-green,6) the addition of sodium hydroxide solution (pH-UP 4802) causes a "color correction" toward "Green" (only the blue portion of the color is "taken out"). The addition of sulfuric acid (pH-DOWN 4801) causes a correction that increases the blue portion.

- Regardless of what color deviation occurs, the addition of sodium hydroxide reduces the blue portion of the deviation. The opposite occurs when adding sulfuric acid.

- In practical application the fact that only two of the possible color deviations can be corrected, is not as significant as it may initially appear.

3.6.2 Application of Solutions

There are two possible application areas for a process intervention through the addition of sodium hydroxide solution (pH-UP 4802) or sulfuric acid (pH-DOWN 4801) to the color developer:

A fresh chemistry preparation has been made.If necessary, the first developer time has been adjusted (see 2.3.5 or 2.4.6) with the help of a test table exposure (2.3) or a control strip (2.4). Although the density is correct, the color of the film has shifted toward blue or yellow, In addition the action limit (±0.10, see 2.4.10) of the spread has been exceeded for the color control step HD.

The addition of a solution has been suggested in the detailed error catalog in section 3.4 on tables 6A and 6B. The control limit (±0.13, see 2.4.10) of the spread has been exceeded for the color control step HD.

Example based on Kodak material !

1. Add 1 ml per liter of the required solution for each 0.02 units of detected color spread. Add sodium hydroxide solution (pH-UP 4802) for a shift toward blue. Add sulfuric acid (pH-DOWN 4801) for a shift toward yellow.

2. Shorten the first developer time by 5 seconds for each ml of pH-down (sulfuric acid) solution added. Do not exceed a maximum of -20 seconds when adding sulfuric acid. Extend the developer time by 5 seconds for each ml of pH-up (sodium hydroxide) solution added. Do not exceed a maximum of +20 seconds when adding sodium hydroxide.

3. Develop a control strip and evaluate the color and density:

a) If the color correction was not enough, increase the amount added. In this manner, establish the solution quantities that are optimal for your situation.

b) The color developer contains "buffer substances" to keep its pH at the same level. These insure that small additions of alkaline or acid solutions do not cause a pH-change. For this reason, the ratio between solution quantity added and pH-change (i.e. color correction or density loss) is not linear. Test the exact reactions for your individual setting.

c) The values listed at point 2 are approximations and must be optimized in practical application through control developments.

4. Note the proper solution quantities and time corrections to determine the best corrections for your lab.

Using visual control

1. When using visual control it is only possible to estimate color deviation, exact levels cannot be determined. When visual control shows a color shift, start by adding the following amounts of solution. Use sodium hydroxide solution (pH-UP # 4802) for a shift toward blue or sulfuric acid (pH-DOWN # 4801)for a shift toward yellow:

a) 2-4 ml per liter with small color deviations

b) 5-10 ml per liter with medium color deviations

c) 11-15 ml per liter with strong color deviations

2. Shorten the first developer time by 5 seconds for each ml of pH-down (sulfuric acid) solution added. Do not exceed a maximum of -20 seconds when adding sulfuric acid. Extend the developer time by 5 seconds for each ml of pH-up (sodium hydroxide) solution added. Do not exceed a maximum of +20 seconds when adding sodium hydroxide.

3. Develop a control strip and evaluate the color and density:

a) If the color correction was not enough, increase the amount added. In this manner, establish the solution quantities that are optimal for your situation.

b) The color developer contains "buffer substances" to keep its pH at the same level. These insure that small additions of alkaline or acid solutions do not cause a pH-change. For this reason, the ratio between solution quantity added and pH-change (i.e. color correction or density loss) is not linear. Test the exact reactions for your individual setting.

c) The values listed at point 2 are approximations and must be optimized in practical application through control developments.

4. Note the proper solution quantities and time corrections to determine the best corrections for your lab.

3.6.3 Application Examples

In actual practice "pure" color deviations toward blue or yellow (or other colors) occur rarely. The color deviation detected is usually a "mixed color".
Based on two examples of deviations toward blue or yellow taken from actual situations, we will explain in this section how these facts influence color correction and its chances for success.

When establishing an even color balance for the standard process, shifts toward blue or yellow pose the most common problem situations.

Problems with color renditions that are "too red" or "too magenta-colored" occur seldom with the balance of the process operation. If you should, nonetheless, encounter this situation, please consult the film or chemistry manufacturer.

Adding amounts of more than 15 ml of pH-UP or pH-DOWN to each liter of color developer is not recommended.

Film material of different manufacturers and sensitivities react differently to solution additions and the adjustment of the first developer time.
Consequently, the individual optimal values must be established through test developments.

When performing visual estimation of color deviation, two tasks face the user.
First it is necessary to determine the color of the shift. Second, after determining the color, the amount of deviation also must be estimated. Both aspects can be mastered with sufficient accuracy after some experience.

Example: Addition of pH-UP 4802 with Kodak material

Addition of sodium hydroxide solution (pH-UP 4802) shifts the color balance toward yellow (i.e., it must be performed when the color of the control strip is "too Blue".)

A typical example of a control notation that would require the addition of sodium hydroxide solution (pH-UP 4802) to the color developer could look like this:

For your current control strip you have measured density values for the color control step (HD) of
D=2.12 for Red
D=2.08 for Green
D=1.90 for Blue.

Referring to the reference values of example 2.4.6, we arrive at these control values:
+0.05 for Red
+0.02 for Green
-0.10 for Blue.

Based on these control values, the following color spread results: +0.03 for (R-G), -0.12 for (B-G) and a total spread of +0.15. The allowable tolerance of ±0.10 (±0.13, resp.) has been exceeded. The above value combination corresponds to a bluish color impression with a small cyan portion.

First, to correct this, add 6 ml sodium hydroxide solution (pH-UP 4802) for each liter color developer. Shorten the first developer time by 20 seconds.

The spread (B-G) is theoretically reduced from -0.12 to 0.00, the spread (R-G) with +0.13 remains unchanged. The total spread, then, is reduced from +0.15 to +0.03. Your film now shows an optically neutral color rendition. The deviation of -0.05 units toward "Cyan" is not longer noticeable. The rendition can be considered neutral.

Example: Addition of pH-DOWN 4801 with Kodak material

An addition of sulfuric acid (pH-DOWN 4801) shifts the color balance toward blue, (i.e., it must be performed when the color of the control strip is "too yellow".)

A typical example of a control notation that would require the addition of sulfuric acid (pH-DOWN 4801) could look like this:

For your current control strip you have measured density values for the color control step (HD) of
D=2.00 for Red
D=2.04 for Green
D=2.10 for Blue.

Referring to the reference values of example 2.4.6, we arrive at these control values:
-0.07 for Red
-0.02 for Green
+0.10 for Blue.

Based on these control values, the following color spread results: -0.05 for (R-G), +0.12 for (B-G) and a total spread of -0.17. The allowable tolerance of ±0.10 (±0.13, resp.) has been exceeded. The above value combination corresponds to a yellowish color impression with a small red portion.

First add 6 ml sulfuric acid (pH-DOWN 4801) for each liter color developer.
Extend the first developer time by 20 seconds.

The spread (B-G) is theoretically reduced from +0.12 to 0.00, the spread (R-G) with -0.05 remains unchanged. The total spread, then, is reduced from - 0.17 to -0.05. Your film now shows an optically neutral color rendition. The deviation of +0.03 units toward "Red" is no longer noticeable. The rendition can be considered neutral.

4. Appendix

4.1 Literature reference

If you are interested in more detailed process control information than provided in this manual or if you have special questions, the following brief literature list provides some suggestions. It is not complete but we have made a sincere effort to select publications from the wealth of material available. We believe these will meet the demands of most of our customers.

Kodak: Process Manual E-6 (Z-119)

- Data sheets of all Kodak color reversal material
- Overview of the Kodak E-6 chemicals including information on partial preparations.
- Process descriptions with processing tables for different types of processing equipment
- Error catalog for Kodak materials
- Sample evaluation forms

Agfa: Process Control Manual, Process AP-44

- Overview of Agfa AP-44 chemicals including information on partial preparations
- Process descriptions with processing tables for different types of processing equipment
- Process control with detailed description of control parameter and control handling
- Comprehensive information about chemical process control
- Sample evaluation forms

Fuji: Film Processing Manual, Process CR-56 (English)

- Overview of Fuji CR-56 chemicals with richly illustrated preparation directions (no information on partial preparations)
- Process description with very detailed presentation of the chemical reactions of the individual baths
- Process control with detailed description of control parameter and control handling
- Error catalog for Fuji materials
- Sample evaluation forms

Fuji: Educational text "The photographic quality control through use of control strips" (German)

- Basic treatment of sensitometry (=Science of sensitivity characteristics of photographic materials) as basis of quality control
- Directions for handling densitometer and control strips
- Sample evaluation forms

Fuji: Process Quality Control CR-56 (German)

- Basics of process control and its performance, color throughout with detailed examples

All film and chemistry manufacturers

- Must companies offer a special customer consultation service that will assist you with problem solving by phone.
- You can expect effective assistance by phone only when you are able to describe your problems in as much detail as possible.
- Of particular importance is an exact reproducible documentation of the problems that have occurred as well as of process intervention measures already taken to correct the problem!

Huber, Michael: Principles of Photography - Color Lab Applications
Publisher: Laterna Magica (Munich)

- Very practical with brief and precise demonstrations of basic terms of color photography including color science and sensitometry (=Science of sensitivity characteristics of photographic materials)
- Many color depictions and diagrams to illustrate the items discussed in the text; easy to understand even without prior training

Rainer Goetsch: Thesis, University Cologne
Photographic Engineering

4.2 Alphabetical Index

1. Error occurred

Date: _____ Code-Number: _____

Error analysis: _____

_____

_____

2. Modifications of the general process sequence and evaluation of the results

a) Date: _____ Code-Number: _____

Modification _____

_____

_____

Result: _____

_____

_____

b) Date: _____ Code-Number: _____

Modification: _____

_____

_____

Result: _____

_____

_____

Determination of Reference Values

Process E-6 Densitometer-Filter

Reference strip: _____

Code-Number: _____ RED GREEN BLUE

Date: _____ Densitometer reading

	Measured values reference strip	_____	_____	_____
	± Correction values	_____	_____	_____
D (max)				
	= Reference values	_____	_____	_____
	Measured values reference strip	_____	_____	_____
	± Correction values	_____	_____	_____
HD				
	= Reference values	_____	_____	_____
	Measured values reference strip	_____	_____	_____
	± Correction values	_____	_____	_____
LD				
	= Reference values	_____	_____	_____
	Measured values reference strip	_____	_____	_____
	± Correction values	_____	_____	_____
D (min)				
	= Reference values	_____	_____	_____

Determination of Control Values

	Index values			
	- Reference values			
D (max)				
	= Control values			
	Index values			
	- Reference values			
HD				
	= Control values			
	Index values			
	- Reference values			
LD				
	= Control values			
	Index values			
	- Reference values			
D (min)				
	= Control values Determination of Color Spread			

Determination of Color Spread

Process E-6

Reference strip: ____________ Code-Number: ____________

		Control values			Color spread	
		Red	Green	Blue	R-G	B-G
	Date: ____________					
Color Control Step (HD)		____	____	____	____	____
Sensitivity Control Step (LD)		____	____	____	____	____
	Date: ____________					
Color Control Step (HD)		____	____	____	____	____
Sensitivity Control Step (LD)		____	____	____	____	____
	Date: ____________					
Color Control Step (HD)		____	____	____	____	____
Sensitivity Control Step (LD)		____	____	____	____	____
	Date: ____________					
Color Control Step (HD)		____	____	____	____	____
Sensitivity Control Step (LD)		____	____	____	____	____

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We cannot, however, assume any liability for the accuracy of its content.
We always appreciate being made aware of errors.
Because of the constant advancement of film and chemistry, advice listed here for the correction of errors may lose its validity in the course of time.

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