MACO EM/EMS Films

Electron Micrography Films

1 Characteristics and Application

MACO EM and EMS films are photographic materials optimised for scientific applications in electron micrography. Their particular advantages are:

- a high degree of flexibility,
- high speed,
- excellent signal-to-noise ratio (or ultra-fine grain), and
- optimum detail resolution.

The base material is mechanically, chemically, and dimensionally stable, robust polyester, which is practically untearable. Among other things, this ensures outstanding archival stability (expected life: 500 years).
Several users report that MACO EM and EMS films can be used to replace the well-established Agfa Scientia 23D56® Film as well as other common electron micrography films. As a rule, process adaptations, if any, will only be necessary to a limited degree.

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2 Available Formats

Size in cm	EM	EMS
6,5×9	yes	yes
7×7	yes	no
8,3×10,2	yes	yes
9×12	yes	yes

For better handling, the individual sheets of MACO EM and EMS Film are packaged with separating paper sheets. This reduces problems due to static charges (exposure through sparks) and ensures that sheets will not stick together when taken from the package.
Each sheet bears a notch, which is situated at the top right corner when looking at the emulsion side of the film.

3 Technical Data: Overview

Sensitisation	orthochromatic up to 695 nm
Speed	Nominal speed ISO 25/15° Effective speed and contrast can be varied according to the needs of the user by choosing the suitable developer and developing time.
Base material	Polyester, 175 µm, clear
Resolving power	In excess of 300 Lp/mm at nominal speed and a contrast of 1:1 000
Safelight	Red, 15 W, distance 1,2 m

4 Storage of Exposed and Unexposed Films

As with photographic materials, film should not be exposed to direct sunlight, intense heat, or high humidity.
For long-term storage, refrigeration is recommended. Before using film having been stored under refrigeration, allow the film to acclimatise to ambient temperature before removing the film from the package and exposing it to ambient air. If the film is considerably colder than the ambient air, humidity may condensate on the film.

5 Exposure, Speed, Contrast

5.1 *General*

Although electron micrographs are made on conventional photographic material, and, like with conventional photographic images, a positive print is made from the negative image, some important differences remain between the production of negatives using light and that using electrons:
In conventional photography, the latent image on the film is produced by photons (= light particles). For a silver halide crystal to become developable, it must usually be hit by 5 to 10 photons.
This is different in electron micrography. A single electron suffices to render up to 10 silver halide crystals developable. This difference is due to the different energies carried by a photon and an electron. While the typical photon in the visible-light range carries an energy of about 2 to 3 electron volts (eV), an electron in an electron microscope carries about 50 to 100 keV, i.e. 25000 to 35 000 times this energy. The film, accordingly, will behave differently:
While image noise – which is the pendant to grain in conventional photography – is essentially determined by the size of the silver halide crystals in conventional photography, it is

determined by statistical fluctuations of electron beam intensity in electron micrography. The actual image signal, i.e. the useful information, increases as a linear function of exposure. Image noise, on the other hand, increases as the square root of exposure. This gives rise to some conclusions with regard to the best possible image quality, or best possible signal-to-noise ratio:
If the required image density and contrast are achieved by prolonging development, the signal-to-noise ratio is not improved, noise being amplified by the same factor as the useful signal. However, statistical fluctuations, the cause of the noise signal, become less significant as the number of electrons increases. Increasing the number of electrons, or increasing the sampling rate, therefore, results in a decrease of image noise and an improvement of detail resolution.
A further factor of influence on the choice of exposure is the stability of the sample. Where the (in-)stability of the sample forbids extended exposure, reducing the device magnification (magnification of the microscope proper) and achieving the required magnification of the final print by optically enlarging the negative can be one way of improving image quality. Reducing the device magnification means that for the same exposure of the sample, more electrons are available for a unit of negative area. Consider, for example, a final magnification of 80, achieved, on the one hand, by using a device magnification of 80, and, on the other hand, by using a device magnification of 20 and optical enlarging of the negative by a factor of 4. Exposure may be as long as it takes in the case of a stable sample, and in that case, the first method would lead to optimum results. In the case of an unstable sample, allowing only limited exposure to electrons, however, a lower device magnification followed by optical enlarging, would yield better results.
This shows that films used for electron micrography must comply with different requirements than conventional photographic material. In particular, it must be possible to achieve similar values of density and contrast by pursuing different approaches (either weak exposure followed by energetic development or strong exposure followed by reduced development) determined according to the requirements of the sample.

6 Processing

6.1 *Developers and Developing Times*

MACO EM and EMS films can be developed in all types of developers. Electron micrography films will preferably be developed in high-energy developers. We recommend LP-DOCUFINE HC and Kodak D-19, but also Ilford ID-11 and Kodak D-76.
The following developing times are for guidance, serving as starting values for your own optimisation. Due to the specifics of processing, the end user may have to adapt these values to meet specific needs.

Developer	Developing time [min]
LP-SUPERGRAIN 1+9	5
LP-DOCUFINE HC 1+7	4-5
Kodak D-19 1+2	4

6.2 *Stop Bath*

The stop bath primarily serves to neutralise any alkalinity retained by the film in order to prevent a loss of fixing-bath activity due to increasing pH values.
The following stop bath concentrates are recommended.

Stop Bath	Time [min]
LP-CITRIN 1+19	1
LP-CITRODUR 1+16	1
LP-ECOSTOP 1+7	1

Where a stop bath is *not* used, two intermediate washing cycles of 30 s each, at 20 ° C(68 ° F) and permanent agitation, are recommended to avoid the carryover of developer into the fixing bath.

6.3 *Fixing*

For fixing MACO EM and EMS films we recommend LP-FIX SUPRA at a dilution of 1+7 to 1+9. This is a modern high-performance fixing bath on the basis of ammonium thiosulphate. The necessary fixing time can be found by determining the clearing time (fixing time = twice the clearing time). Where clearing time is not determined, fixing for three minutes in fresh fixing bath at 20 ° C is recommended.

6.4 *Washing*

Ensure that the water-supply temperature is approximately 20 ° C. Washing for 5min in running water is then sufficient.

6.5 *Wetting Agent*

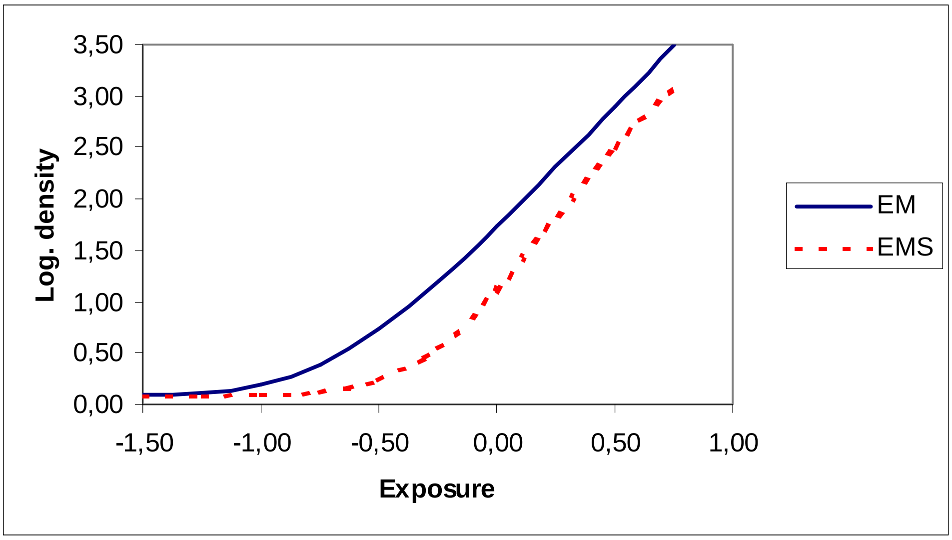
A final bath in demineralised, deionised, or distilled water (battery water) is recommended in order to avoid drying marks caused by water hardness and to reduce static charges. Static charges will cause the film to attract dust particles which will show as white spots on positive copies.
It is recommended to use LP-MASTERPROOF 1+200 to 1+100 for one minute, *without agitation.* (This will avoid the formation of foam, see below.)

Overdosing wetting agents must be avoided. Wetting-agent solutions can only be re-used if several films are processed in one session. Foam tends to stick to the film surface and will hardly run off. Therefore, avoid foam formation when preparing wetting-agent solutions by adding the water slowly.

6.6 *Drying*

Squeegeeing films is not advised as there is a great chance of scratching negatives. Following the wetting-agent treatment, try to shake off as much of the surface water as possible. Then hang the film to dry in a dust-free environment for several hours, e.g. over night.
When drying films in a drying cabinet, it is recommended *not* to activate the heating.
Drying using a hairdryer is *not* recommended, as, lacking a particle filter, hairdryers will tend to blow dust particles onto the wet, and still sticky surface of the film. Particles adhering to the film like that are difficult to remove without afflicting damage to the film.

7 Curves



Subject to changes.

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