PROCESSING RECOMMENDATIONS FOR ILFORD HOLOGRAPHIC FILM SP673

Introduction

As described in Technical Data Sheet 673/TD1 SP673 has been designed exclusively for use with a pulse ruby laser. This means that the emulsion has maximum sensitivity between 690-700nm and its reciprocity characteristics are such that it responds optimally to short bursts of high intensity irradiation. It was also designed for use with Ilford machine processing chemistry specifically intended to produce reflection holograms wavelength shifted to 580nm for maximum brightness. Ilford expertise is, therefore, particularly associated with this processing regime.

The film has also given exceptional results when dish processed to give master reflection holograms which are not wavelength shifted and, similarly, transmission holograms of unparalleled brightness and low noise have been produced. However, much of the credit for these results is due to the efforts and creativity of individuals external to the Company and so, at present, general processing guidelines only will be given but these will be subject to continued updating as a deeper understanding of this exceptional film is gained.

General Handling

Safelights

SP673 can be handled in green safelights. The Ilford green safelight filter GB-7 is particularly recommended as it gives maximum brightness in the region of minimum sensitivity of the film.

Water

All chemical solutions should be made with deionised or distilled water. Tap water must only be used for the final wash.

Stop bath

After using Ilford holographic developer 1 and before using a solvent bleach, the use of Ilford stop bath IN1 is recommended. This is necessary to prevent early exhaustion of the bleach bath.

Light stability

Phase holograms consisting of silver halide are inherently susceptible to photo-reduction. Amplitude holograms, where the fringes consist exclusively of metallic silver, are not. The light stability of phase holograms can be significantly improved by the use of a bath of potassium iodide. This should be employed after the hologram has been washed following the bleach bath. It will be noted that the use of the potassium iodide bath will impart a yellow stain to the hologram and some increase in scatter may be noticed.

The iodide bath can be made up as follows :

Dissolve 2.5g of standard laboratory grade potassium iodide in one litre of water

Method:

After bleaching and washing, immerse the film in the iodide bath at 30°C with continuous agitation. After two minutes, remove the film allowing excess liquid to drain off.

Drying

The use of film drying cabinet which blows warm air (preferably at 40°C) over vertically hung holograms is recommended. Holograms can be air dried at room temperature with care drying marks resulting in a change in image colour may be a problem in this case.

Processing guidelines

1. For reflection holograms wavelength shifted from 694nm to approximately 580nm.

Such a shift in replay wavelength can only be achieved if the thickness of the emulsion layer in the processed hologram is thinner than the same layer at exposure by the ratio $\frac{580}{694}$. This reduction in layer thickness can be achieved in one of two ways.

a) Preswelling : If the emulsion layer, at the time of exposure, has been artificially swollen, then a processing regime can be employed in which no silver is removed from the emulsion layer. The act of drying the hologram when the processing is complete will reduce the thickness and so bring about replay at a shorter wavelength. Experience shows that this approach yields the brightest holograms since maximum use is made of the original silver content of the emulsion layer. It has not been found practical for machine processing, however.

The following procedure is given as a starting point for further experimentation.

- Preswelling bath
  1% solution of triethanolamine in water. Soak for 1 minute, squeegee film and allow to partially dry. Expose in the usual way.

- Developer
  Ilford holographic developer or Phenisol Rep.

- Bleach

Ferric sodium EDTA - 100g
Potassium bromide - 10g
Water to 1 litre

Method

b) Shrinkage by silver removal.

This technique has been found most suited to machine processing and consists of development followed by solvent bleaching which converts the developed silver to a soluble silver salt which is then washed out of the layer. It is this removal of silver which causes the reduction in layer thickness which is, in turn, responsible for the shift in replay wavelength. It will now be seen that since the exact shift in wavelength is related to the mass of developed silver, a relationship must exist between wavelength shift and exposure and development times.

i.e. if a considerable wavelength shift is required then either a high exposure, or a long development time, or both, is called for. Also, long development times can be shortened by increasing the temperature of the developer solution.

Fortunately, the relationship between these variables has been the subject of exhaustive study and the following process has been found to be the most satisfactory:

- Developer - Ilford holographic developer or Ilford Phenisol Rep.

- Stop bath - Ilford IN1 (see p1)

- Solvent bleach - Ilford holographic solvent bleach.

Method:

It is important when evaluating new materials, chemistry or lighting, to optimise conditions by varying both the exposure time and the development time.

Use Ilford holographic developer diluted 1+4 at 30°C for time between 0.5 and 2 minutes. 1 minute is usually about right. Use Ilford Phenisol Rep diluted 1+9 at 20°C for 45 seconds to 90 seconds. Development times will vary with agitation during processing. We recommend continuous agitation.

Do not simply develop to a density that appears correct for other holographic materials.

Ilford solvent bleach should be diluted 1+4 at 30°C and used until the film is clear.

2. For master reflection holograms replaying at the wavelength of exposure (694nm.)

In processing for wavelength retention, the objective must be to ensure that the thickness of the emulsion layer after processing, is identical to that which it had at exposure. This is best achieved by exposing the dry film and processing in such a way that no silver is removed from the layer but is merely redistributed from the exposed areas to the unexposed areas, or vice versa.

This redistribution may take place during development or bleaching depending on the choice of chemistry employed. It is currently recommended that pyrogallol be used as developer[1], in which no redistribution takes place, and the process completed using a rehalogenating bleach. Published formulae exist for rehalogenating bleach baths based on Ferricyanide[2] or P-benzoquinone[3] and these give excellent results but cannot be recommended on grounds of safety in handling. A more satisfactory bleach bath, based on ferric sodium EDTA complex is :

Ferric sodium EDTA	100g
Potassium bromide	10g
Water to 1 litre	

This solution is effective, safe to use and stable. It should be used at 30°C until the film is clear.

Finally, it should be noted that SP673 shrinks by 10% by the simple act of wetting and drying but the use of the chemistry described above will compensate for this shrinkage.

1 A pyrogallol developer can be made as follows:

Part A - pyrogallol 6g
Ascorbic acid 6g
make up to 500ml

Part B - sodium carbonate 30g
make up to 500ml

Mix equal volumes of Part A and B immediately prior to developing and process for 1 to 3 minutes. Adjust exposure and development times for control of final image colour.

N.B. Once Parts A and B have been mixed the solution is unstable. It should be used immediately and discarded after use.

2. L. Jolly. J. Phot. Sci 31 143 1983

3. N.J. Phillips, et al. Phot. Sci. Eng. 24 120, 1980

3. Transmission Holograms

SP673 has been used to produce three types of transmission holograms:

laser transmission masters
white light (rainbow) transmission masters
diffraction gratings

All have exhibited high diffraction efficiencies (up to 95%) with very low scatter.

The traditional way of processing transmission holograms is:

Developer - Fix - Rehalogenate

This will produce a surface relief pattern on the hologram. The best results on SP673 have been achieved by ommission of the fix step. We therefore recommend the use of standard developers followed immediately by a rehalogenating bleach.

e.g. Developer: Holographic developer - Ilford
D19 - Kodak
Dokumol - Tetenal

Bleach: Ferric nitrate - 100g
Potassium bromide - 30g
Water to 1 litre

These chemicals have the advantage of being effective and non-toxic.