AVIPHOT BLACK & WHITE FILMS - SENZITIZATION AND MODULATION TRANSFER FUNCTION

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ABSTRACT:

The choice of the spectral sensitizers for AGFA aerial films is described. Compared with classical sensitization (long-wave limit about 700 nm) a sensitization up to 760 nm shows a dramatically improved quality in all parts of the image, where green vegetation is reproduced. The phenomenon can be explained by the results of the modulation transfer function measured with spectral band filters.

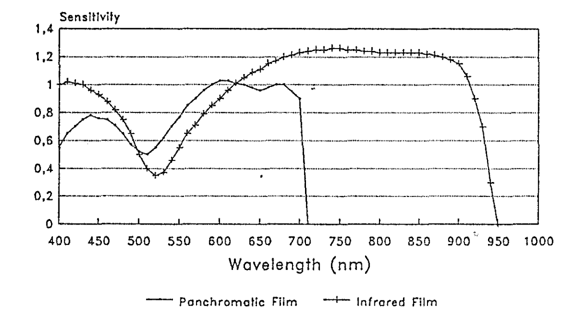
KEY WORDS: Accuracy, Film, IR, Image Quality, Resolution, Spectral

1. LONG WAVE LIMIT OF SENSITIZATION

When AGFA decided to create a new generation of black and white films for aerial photography, there were two different types of aerial negative films on the market, for as far as the optical sensitization was conerned: The classical panchromatic filmtype, with a long wave sensitization limit at approximately 700 nm and the infrared type, for wich the long-wave limit lies in the region of 900 to 950 nm.

Fig. 1 shows the spectral sensitivity of these two typical materials. Independent of the general speed of the emulsion, the graphs for the classical filmtype are always very similar.

Fig. 1
Spectral Sensitization



AGFA had the idea to combine the features of both classical types into a new film, aiming at a sensitization which would at least reach into the range of the infrared chlorophyll band, which we call the nearest infrared.

At that time, a lot of sensitizers were tried and - in the end - six of them were selected. To the the green and red sensitizers - used for the classical panchromatic filmtypes - the new sensitizers were added in order to expand the sensitization into the near infrared area. The long-wave maximum of the selected extra sensitizers is shown in table 1.

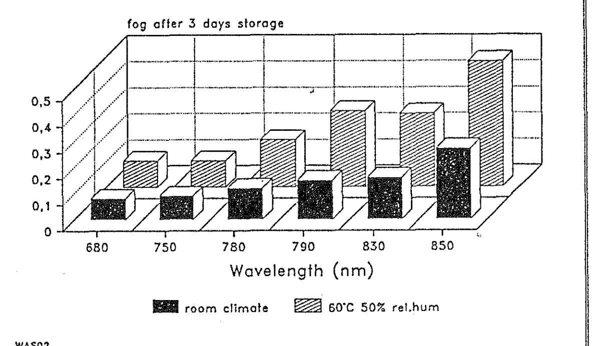
Table 1

Sensitizer code	Max. sensitivity
A	690 nm
B	750 nm
C	780 nm
D	790 nm
E	830 nm
F	850 nm

The long-wave limit of these sensitizations lies about 10 to 15 nm further into the infrared aerea.

An important feature of a photographic material is its stability when exposed to high temperatures and high humidity. Particularly for these features we see an interesting relation, as shown in figure 2.

Fig. 2
Different Types of Sensitizers



The fog level is a good indication for the stability of a photographic material. The figure distinctly shows that problems arise when the sensitization goes beyond 750 nm, where the fog level increases with increasing wavelength. Although this cannot be stated to be a law of nature, the phenomenon clearly showed up in the aerial photo-systems used in the AGFA labs.

So, sensitization "B" was chosen for the new family of films. The full line in figure 3 shows the result of that choice, namely the relation between sensitivity and wavelenght for that kind of sensitization. It led to a new maximum sensitiviy at 740 nm, with the long-wave sensitization limit at approximately 760 nm.

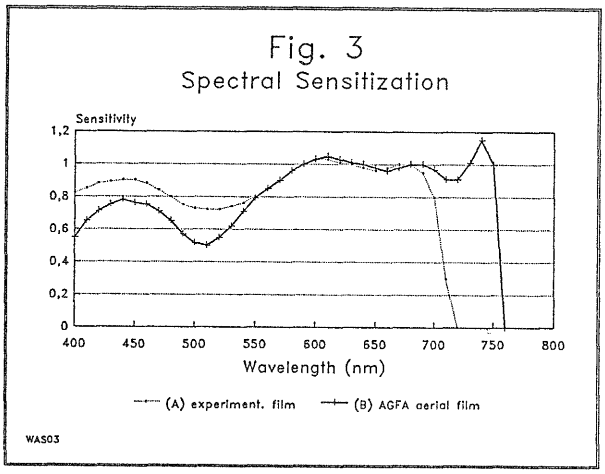


Fig. 3
Spectral Sensitization

That type of sensitization is now used in all AGFA's black and white aerial recording films, namely in AVIPHOT Pan 50, AVIPHOT Pan 150, AVIPHOT Pan 200 and AVIPHOT Pan 200 S.

2. PRACTICAL RESULTS

It is evident that theoretical work should be checked with practice. Let us therefore compare two filmtypes: Type B is AVIPHOT Pan 200, as it is being manufactured for several years now. Type A is an experimental type that will not be produced. Both types differ in the long-wave sensitization only, type A having a sensitization equivalent to code "A" in table 1. The dotted line in figure 3 shows the course of that spectral sensitivity.

Fig. 4a

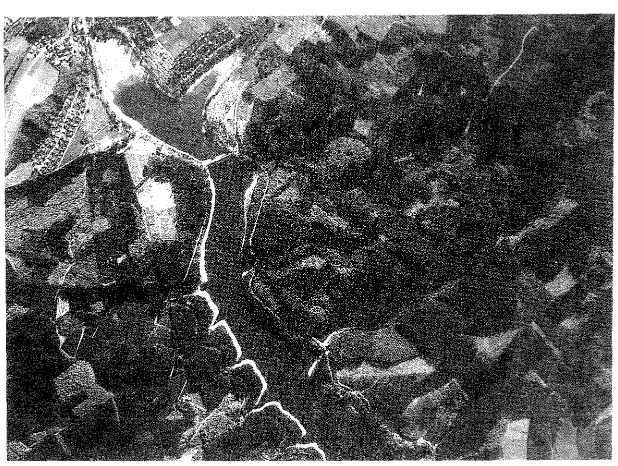
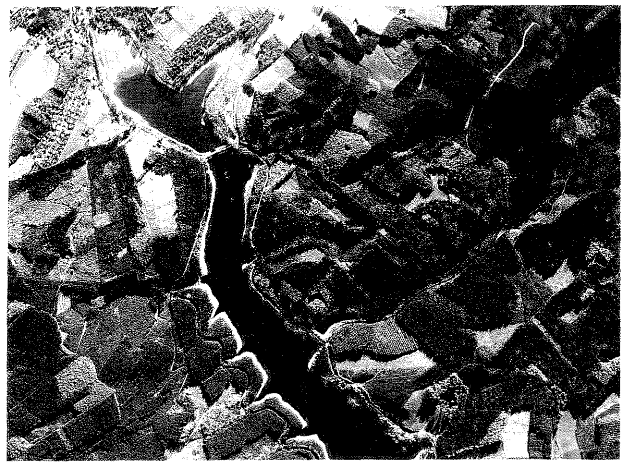


Fig. 4b



Very surprisingly, the small step into the near infrared region dramatically improves the quality of all parts of the image, where green vegetation is reproduced. Figure 4 compares two images of the same object, recorded with both filmtypes A and B. Figure 4b very clearly shows the excellent differentiation in all those parts of the image that contain green trees.
Of course, what you see here in these archives is only a copy of the actual aerial photographs: The original negatives reveal a much larger difference between the tow filmtypes.

3. EXPLANATION OF THE IMPROVEMENT

Locking at the extra information in the "green" parts of the image, one would conclude that either the resolution of filmtype B is much better or that its gradation is much higher. Yet, the two emulsions were developed to the same gradient, which was measured with white xenon light. The characteristic curves of the two films were also produced by exposure with filtered light, namely current green and red separation filters, and by a light cut-off filter, cutting off all wavelenths shorter than 715 nm.

Figure 5 shows the sensitometric curves: 5a for filmtype A, 5b for filmtype b respectively.

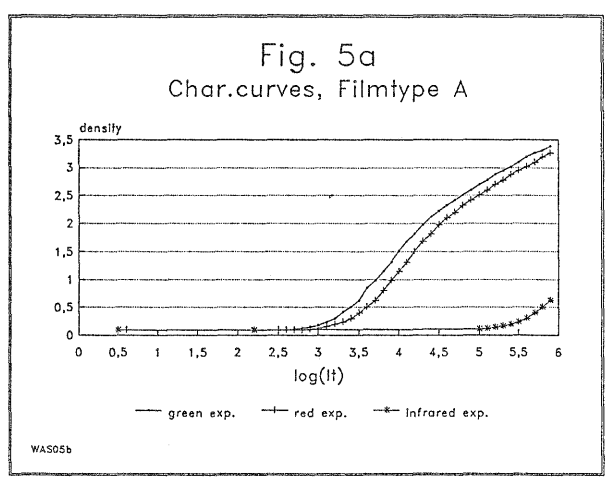
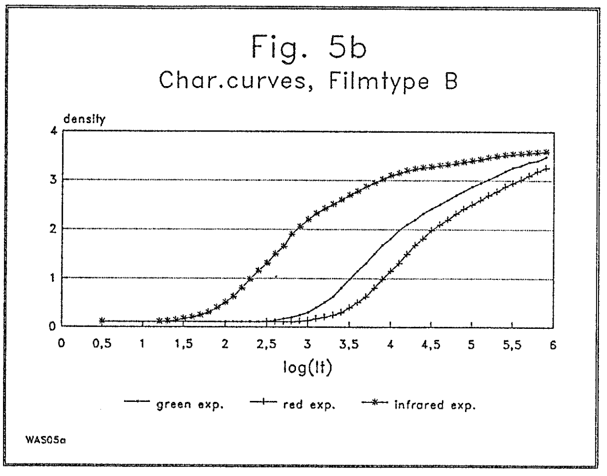
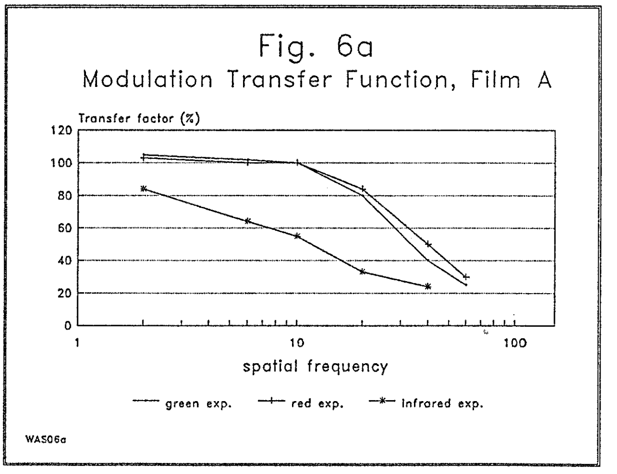


Fig. 5a
Char.curves, Filmtype A





The apparent difference in sensitivity is caused by the different transmittance of the filters. Yet, all curves show approximately the same gradation. Furthermore, the differences that were measured here are too small to explain that higher image content could be due to the gradation. Besides, the curve obtained by infrared exposure has the lowest gradation, particularly in the region of higher densities. It is evident that film A has a very low sensitivity behind the infrared filter. So, a higher gradation only in the green parts of the image cannot be the reason for the image improvement.

Let us look again at the possible initial conclusions: Could the resolution be responsible?

First, the resolution of a specific line pattern was measured. Table 2 shows exactly the same data for both materials.

Table 2

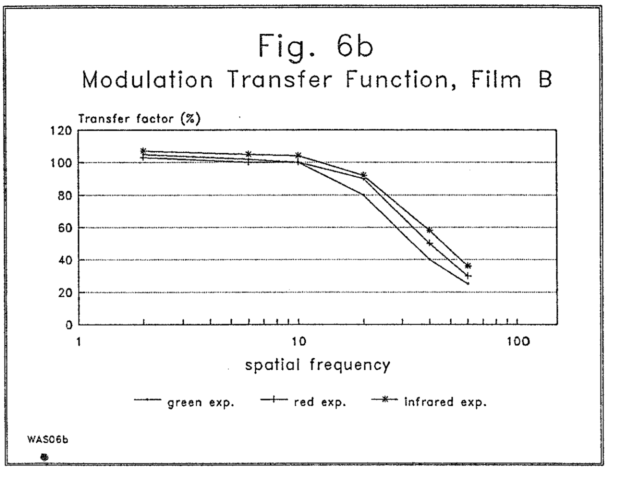
Filmtype	High contrast	Low contrast
A	130 l/mm	50 l/mm
B	130 l/mm	50 l/mm

So, the resolution is not the determining factor either, which makes us conclude that the effect is more sophisticated.

Looking then at the modulation transfer function (MTF) after exposure with white light, we measure no difference between the two filmtypes. So, no explanation can be found there.

Only the **measurement of the MTF with spectral band filters** gives us the explanation we are looking for.

To obtain the results shown in Figure 6, the same filter exposures were used as in the gradation experiment described above.



Judging the MTFs after exposure with green and red light, we see that they are very similar. Only the measurements of the MTFs for infrared exposure are different: For filmtype B, the infrared exposure gives a MTF that is slightly better than the green and red curves. The infrared curve for filmtype A, on the contrary, is very bad.

The explanation is simple: In order to get density 1.0 (needed to measure the MTF) the exposure required for filmtype A had to be approximately 100 times higher than for filmtype b.

4. CONCLUSIONS

It is customary to qualify a photographic material to be used for interpretation by its characteristic curves, by data concerning pattern resolution or by its MTF curve. But, as we see, there is more to it. If we are interested in the reproduction of distinct colors, it is even more important to know the MTF measured with light similar to the color involved. The high information rate in our filmtype B, sensitized into the nearest infrared, can only be explained by looking at the MTF in the near infrared area.

This theory proves to be correct when we look at the actual aerial photographs made on AGFA's AVIPHOT Pan films.