PROPERTIES OF SAFETY TOPOGRAPHIC AERO FILM[1]

EVER since the first development of acetate film which occurred some thirty years ago, there has been a constant endeavor to replace nitrate film with acetate film. At one time Mr. Eastman had actually taken the final steps to produce all film on acetate base but was forced to go back to nitrate base because of the poor physical properties and poor keeping qualities of the acetate support available at that time.

Since then, however, acetate has been gradually improved until in some types of film it has entirely replaced cellulose nitrate. The weaknesses of acetate in comparison with nitrate in the past have been:

1. Lower tensile strength.
2. Greater tendency toward brittleness under very dry conditions.
3. Greater absorptive power for water with its consequent increase in tendency to warp and distort.

Intensive study of variations in the methods of manufacture of the acetate and of the compositions of the solutions used for coating the film base has shown that a considerable degree of control can be obtained in regard to these three weaknesses so that, for certain purposes, film may be manufactured which is practically as good as nitrate. When amateur motion pictures came into vogue, it was absolutely necessary to avoid the fire hazard of nitrate film, and it was found that a cellulose acetate film could be produced which would have sufficient strength and toughness to withstand projections in the 16 mm. projectors. Film requirements for amateur projectors are less severe than for 35 mm. projectors.

The Bureau of Standards has recently shown that cellulose acetate is an extremely stable material and that photographic records kept on it, other things being equal, may be expected to last as well as records on the best rag paper, and there is a rapidly increasing tendency for librarians and others interested in the storage of valuable documents to make photographic records of these documents on acetate film in order to preserve them for posterity. This feature alone, aside from the costly storage vaults which are necessary for even short time storage of nitrate film, has made it extremely desirable to have available a topographic aero mapping film of the so-called safety or slow-burning type.

Now, the special requirements of Topographic Aero Film are:

1. That the shrinkage shall be as low as possible between the time of exposure and the time of printing.
2. That the shrinkage in the lengthwise and crosswise directions of the film shall be as nearly equal as possible.
3. That the change in dimensions with changes in atmospheric humidity shall be as low as possible.
4. That these changes in dimensions in the lengthwise and crosswise directions shall be as nearly equal as possible.

Of these four requirements, we believe that requirements 2 and 4 are of far greater importance than 1 and 3. For example, in most mapping operations prints are made by projection, and shrinkage or expansion of the film, provided it is uniform in all directions and in all parts of the film, can be compensated for.

[1] Paper delivered at the semi-annual meeting of the American Society of Photogrammetry in New York City on September 9, 1938 by Dr. E. K. Carver of the Eastman Kodak Company.

In order to understand the difficulties involved in the manufacture of aero film, it might be well to review briefly the methods generally used in film manufacture.

A heavy solution, about the consistency of molasses, of cellulose nitrate or cellulose acetate with suitable solvents together with a plasticizer, is spread on the surface of a large drum or wheel. This wheel slowly revolves while a current of hot air passes around it. The film base when stripped still contains a considerable portion of volatile solvent which can only be removed by subjecting the base to high temperatures for a considerable length of time. Since the production of base must, for economic reasons, be a continuous process, this secondary curing involves passing the film base continuously through a hot chamber over heated rolls, and it is this process which is especially damaging to the material for its subsequent use as Topographic Film. Two effects are produced. In the first place, strains are set up which gradually tend to relieve themselves, causing a shrinkage lengthwise and an expansion widthwise; in the second place, the micelles or particles of cellulose ester tend to become oriented in the lengthwise direction of the film base, producing a grain somewhat like the grain in wood or in paper. It is largely with the elimination of these two effects that the maker of Topographic Aero Film is concerned.

In order to determine the suitability of a given type of film for aero mapping, several tests have been devised which apparently give a satisfactory indication as to how well the film will behave in actual use.

The first of these tests is a Special Development Shrinkage Test which involves cutting strips of film both lengthwise and crosswise from the sheet, conditioning them to 50% R. H., processing, incubating at 125° F. for one week, reconditioning at 50% R. H., and measuring. This test measures both the amount of residual solvent and the residual strains left in the film. In actual practice, approximately four dozen strips are taken, half in one direction, and half in the other direction, from a wide strip of film in order to obtain accurate averages as well as deviations from the mean.

Another test, devised to measure the degree of uniaxialism or the freedom from orientation in the lengthwise direction of the particles of cellulose ester, has been called the Swell and Shrink Amplitude Test. In this test, pieces of film cut similarly to those for the Special Development Shrinkage Test are alternately wetted in water and dried in an oven, and the wet and dry dimensions taken. The difference between the wet and dry dimensions, expressed in percent, is called the Swell and Shrink Amplitude, and if this value is the same in the two directions, the film is essentially uniaxial.

A further test which gives results similar to the above is called the Humidity Amplitude Test, and is made in the same way except that the dry samples are brought to equilibrium with air at 20% R. H. and the wet samples are brought to equilibrium with the air at 80% R. H. and similar measurements taken.

The following table gives typical values for these three tests for ordinary nitrate aero film, Topographic Nitrate Aero Film, ordinary acetate film, and safety Topographic Aero Film. It will be observed that the new safety aero film suffers in comparison with the best Topographic Nitrate Aero Film only in one respect, viz., in the Special Development Shrinkage Test. Other tests run at room temperature indicate that this effect with safety aero film does not occur at room temperature and that, in ordinary use, we may expect the safety film to shrink no more than nitrate aero film.

The photographic properties of the film appear to be identical with the nitrate aero film. Some of the other properties, such as curl, stiffness, etc., are

slightly different from nitrate but, as far as can be told at present, offer no difficulties to the user.

	Regular Aero Nitrate	*Topographic Aero Nitrate*	*Ordinary Acetate*	*Safety Topographic Aero*
Special Development Shrinkage:				
Lengthwise	.15%	.11 %	.55%	.172%
Crosswise	.21	.135	.70	.200
Difference	.06	.025	.15	.028
Swell and Shrink Amplitude:				
Lengthwise	.50	.62	1.55	.55
Crosswise	.70	.64	1.75	.57
Difference	.20	.02	.20	.02
Humidity Amplitude:				
Lengthwise	.35	.38	.90	.38
Crosswise	.54	.40	1.05	.40
Difference	.19	.02	.15	.02

To summarize the situation, a new type of safety aero film base has been developed which shows no greater water susceptibility than nitrate aero film and which shows an equal degree of uniaxialism. These tests show that this new safety film should be exactly as good for aerial mapping as nitrate film.

In view of the great advantages, from the point of view of fire hazard, of long-time keeping of the photographic record, and of economy of storage vaults, we are very glad that we are now able to offer a safety aero film which we believe will satisfactorily fulfill the requirements of those who wish to use it.