Burning Characteristics of Safety vs. Nitrate Film

A REPRINT

By ALLEN L. COBB

SINCE 1950 all motion-picture film produced by the major U.S. and Canadian manufacturers for professional and amateur use has had a "safety" base of cellulose acetate or other material which burns slowly. Formerly, most film was made with a film base of cellulose nitrate. There still seems to be some confusion over the differences between these two types of film. Where "safety" film is used or stored exclusively, no special fire protection precautions are necessary. While the change to acetate base film has been an accomplished fact domestically for about six years, some cellulose film is still in circulation and some nitrate film will be in storage for years for archival purposes. The NFPA Standards for the Storage and Handling of Cellulose Nitrate Motion Picture Film (NFPA No. 40) should be followed to safeguard life and property where this nitrate base film is being stored or handled.

This article illustrates the difference in the ignition and burning characteristics of the two types of film. It should be understood that cellulose nitrate contains chemically combined oxygen, sufficient in amount so that this material can partially burn or decompose without the presence of air. The gases formed by such decomposition are both toxic and flammable and may be produced so rapidly as to create a hazard to life and dangerous pressures in enclosed spaces. While the actual heat of combustion of nitrate film measured in British Thermal Units per pound is 6,000 to 8,000 compared with 8,000 to 9,000 for wood, the rate of combustion is about fifteen times that of wood in the same form.

Cellulose acetate film, in contrast, burns relatively slowly — about the same speed as paper — and the combustion products of burning safety film are much less toxic than the gases of cellulose nitrate.

Loose-Film Burning Tests

At a series of tests, comparisons were made of the burning characteristics of nitrate and acetate films. Figure 1 shows the extent of a fire 15 sec after ignition of a pile of 1,000 ft of 35mm. nitrate motion-picture film which had been placed in a loose pile on the ground and ignited. The burning time was checked with a stopwatch at 38 sec. The nitrate film was completely consumed. Flames reached a

Reprinted by special permission of the National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., from the October 1956 *Quarterly* of the National Fire Protection Association, vol. 50, no. 2.

Fig. 1. Nitrate film 15 sec after ignition.

Fig. 2. Acetate film at height of fire.

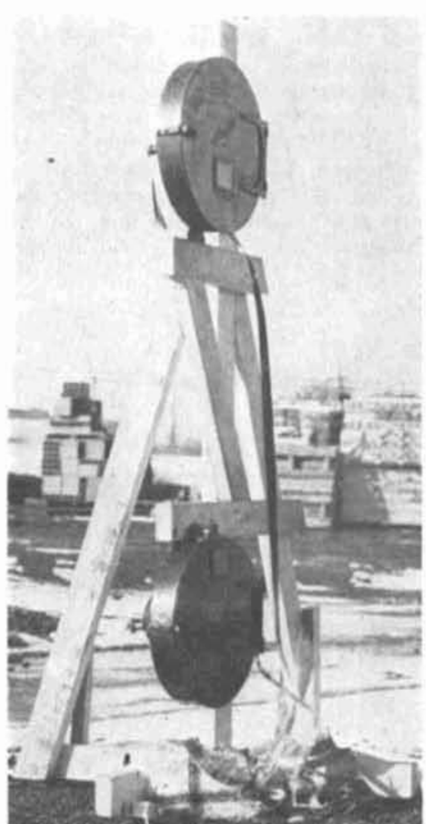

Fig. 3. Simulated fire at projection on acetate film.

Fig. 4. Nitrate film during same simulated situation as in Fig. 3.

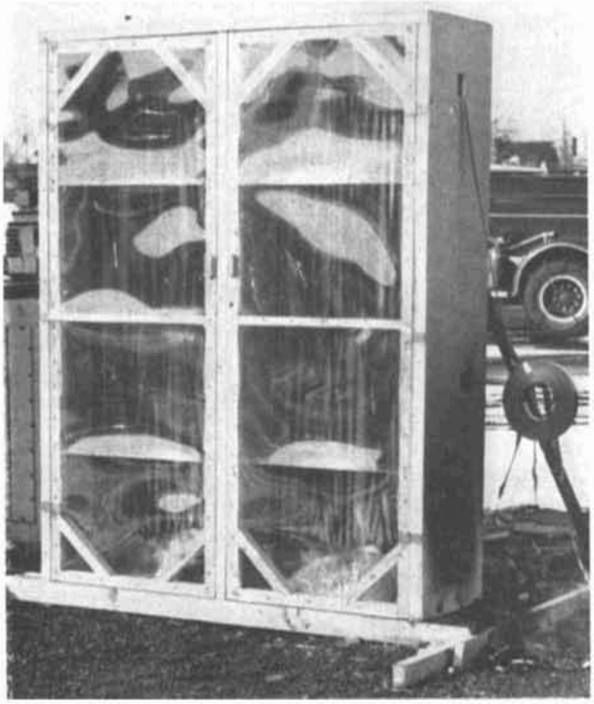

Fig. 5. Acetate film in mock 35mm process machine dryer — burnout time 170 sec.

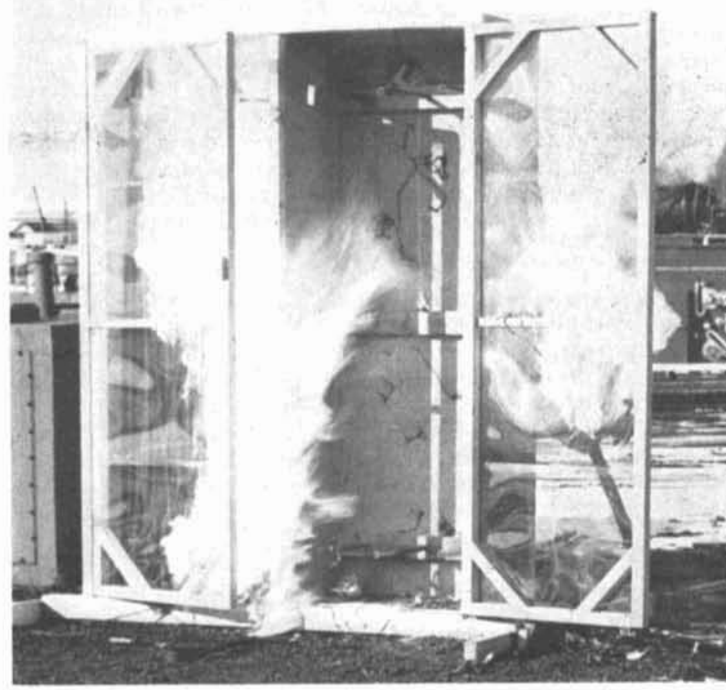

Fig. 6. Nitrate film in same test as in Fig. 5— burnout time 55 sec.

height of approximately 12 ft and gave off no visible fumes but did show some fly ash.

In a comparative test, 1,000 ft of 35mm. acetate motion-picture film was placed in a loose pile on the ground and ignited using a small wad of wood excelsior. Figure 2 shows the resulting fire at its height. The burning time was recorded at 218 sec. The safety film was not completely consumed and showed evidence around the edges of melting and curling. The flames of the safety film did not exceed two feet in height and gave off a black smoke.

About 1,000 ft of heavy craft paper, 35mm. wide, was placed in a loose pile under similar conditions. In this case, the burning time was checked as 124 sec. The flames were approximately two feet in height and considerable blue smoke and fly ash were observed.

About 1,000 ft of cotton fabric, 35mm. wide, was similarly ignited. Burning time was 155 sec; flames did not exceed two feet in height; very little fly ash was observed although there was some blue smoke.

Simulated Projector Fires

Two Simplex projector magazines were mounted on a frame in such a way as to simulate the mounting distance which could be found on a theater projector. Acetate "safety" film, a full 1,000-ft roll, was placed in the top magazine with a strip of film leading down to the lower magazine which contained part of a roll of acetate film. The lower magazine door was left open and film was placed in a disorderly pile beneath as might be found in a theater following a film break. This small pile of film was ignited with a wad of excelsior and it was observed from Fig. 3 that while much of the safety film on the ground was consumed, the flames did not carry up the streamers from the bottom magazine.

Figure 4 is the same test repeated but this time nitrate film was used in both the top and bottom magazines with the film streamers in approximately the same location. The loose nitrate film on the ground was set on fire and immediately the film in the lower magazine ignited and burned with considerable intensity. The streamers from the top magazine

Fig. 7. Extinguishing acetate film in test fire.

Fig. 8. Extinguishing nitrate film in same situation as in Fig. 7.

burned to the opening in the bottom of the magazine, setting off the roll in the top magazine which burned completely and with considerable intensity. It was observed that the intensity of the flames in both top and bottom magazines was sufficient to melt the white metal holders for the film rolls and to warp and bend the magazines.

Simulated Film Dryer Fires

Using a mock 35mm process machine dryer section constructed of two-by-fours with Transite sides, top, bottom, and back with center partitions and doors made of acetate sheeting for visibility, acetate film was threaded throughout the machine to a windup roll on the outside. Film was looped from the windup roll down to the ground as could occur from a nonattended windup. This material was ignited with a wad of excelsior and the film on the ground burned without carrying up to the windup roll as shown in Fig. 5. The burnout time was 170 sec.

After the acetate was removed from the machine dryer section, the machine was threaded with 35mm nitrate film in the same manner as the previous test. The nitrate film was ignited and in 55 sec the entire quantity of nitrate film was consumed. The fire burned from the loose pile on the ground up to and ignited the windup roll following the film strip from the machine to the roll and igniting the material looped inside the first section of the machine. It burned rapidly inside carrying through to the second section which burned almost immediately, and after the pressure built up inside the machine, the doors blew open and the heat was sufficient to melt some of the acetate on the doors. Figure 6 shows the extent of the fire a few seconds after ignition. It was interesting to note that the acetate material on the doors did not ignite and burn.

Extinguishment Tests

Approximately 40 lb of acetate film was placed in a loose pile inside an enclosure approximately eight feet wide with an open face. The acetate film was ignited and the fire allowed to burn for about two minutes. A fire fighter using a dry chemical extinguisher, as shown in Fig. 7, readily extinguished the burning film

Figure 8 shows another test fire with 40 lb of nitrate film substituted for the acetate. Here the fireman used a water spray nozzle to attempt extinguishment. The flames did not appear to diminish in intensity despite the application of water fog and when the fire was finally extinguished practically all the nitrate film in the center of the pile had been consumed.

Photographic Instrumentation at Project SMART

By DARRELL LASSITER
and WILLIAM KRUPP

Project SMART, Supersonic Military Air Research Track, is a 12,000-ft supersonic sled track designed and built for the Air Force. The track is located and operated to simulate pilot escape systems of high-speed aircraft. Photographic instrumentation of this site is described.

PROJECT SMART, Supersonic Military Air Research Track, was conceived and constructed for the primary purpose of testing and evaluating the extremely important problem of our "jet-age," pilot escape from supersonic aircraft.

The project is located in Southwestern Utah 16 miles west of Zion National Park and 160 miles northeast of Las Vegas, Nev.

The track is situated atop Hurricane Mesa, a table-top plateau, which is 3½ mi long and rises 1,500 ft above the valley of the Virgin River (Fig. 1).

One of the prime requisites for the selection of a site suitable for the study of this problem was that "in flight" conditions of escape, from ejection to final parachute deployment, could be simulated. Other tracks could not completely meet this requisite because as soon as the test object returned to track level the "in flight" conditions ceased. Free fall from aircraft does not lend itself to a precise predetermined flight path and metric instrumentation is difficult.

Project SMART meets the requirements of simulated "in flight" conditions. Test vehicles (Fig. 2), simulating aircraft cockpits, are propelled at supersonic speed along the 12,000-ft continuously welded, precisely aligned track. Test objects are ejected near the end of the track and the 1500-ft drop to the valley floor allows sufficient free fall for parachute deployment.

Instrumentation

Photographic instrumentation must provide three types of data: (1) trajectory information to determine whether the pilot does or does not clear the empennage of his airplane; (2) attitude and gyrational effects resulting from wind loading or other forces to ascertain whether the pilot has exceeded the limits of human tolerances as set by Aero Med; and (3) to gather "what happened" — event coverage.

Trajectory data, which are plotted in terms of space coordinates and time, are obtained with the Bowen CZR-1 Acceleration Camera. Seven of these cameras are used with one camera designated as the "master" camera for the purpose of phasing the picture-taking sequence to the other cameras designated as "slave" units. The strobo-units in the slave cameras are triggered by the synchronizing pip generator in the master camera. Manual computing methods are used, therefore synchronizing the picture-taking sequence eliminates the need for interpolation in the data reduction process.

Timing is supplied to the cameras from a Hewlett-Packard low-frequency generator located in the fire control building. A temperature controlled quartz crystal which generates 100,000 c/sec within an accuracy of 0.001% is used as the standard. This frequency is divided to produce sine waves of 10,000, 1,000, 100 and 10 c/sec. The 1,000- and 100-c signals are amplified separately and passed through signal level meters and attenuators to separate lines running to the camera stations. The two signals are amplified at the camera stations and are shaped into square pulses of approximately 33-μsec duration for the 1,000-c and 100-μsec duration for the 100-c signal. These two signals are then mixed together and are used to excite a common neon bulb in the camera. An image of the electrode is projected on the continuously

Presented on October 10, 1956, at the Society's Convention at Los Angeles by Darrell Lassiter and William Krupp (who read the paper), Coleman Engineering Co., P. O. Box 6, Hurricane, Utah.
(This paper was received on September 5, 1956.)