Heat Damage To Prints: Part 2

We will consider the effects of radiant energy on film, heat damage, and how to determine whether you have a heat and problem and how to fix it.

Effect Of Radiant Energy
During projection, the film absorbs radiant energy. This energy causes a very rapid increase in the temperature of the thin emulsion layers when it is absorbed by the dyes or silver grains in the emulsion. The transparent film base absorbs a relatively small portion of the energy so it doesn't heat as quickly. The heat causes the emulsion to expand, displacing the center of the film frame away from the projection lens, which is called "negative drift."

As the radiant energy increases, the drift may vary from frame to frame. When the variation exceeds the depth of focus of the lens, the screen image loses sharpness (focus "flutter"). This is particularly apparent with the use of short focal length lenses. At even higher energy levels, moisture is driven out of the emulsion, causing it to shrink and the center of the frame to move toward the lens ("positive drift"). When some frames drift toward the lens and others drift away, the depth of focus is greatly exceeded, causing focus shifts. Film in this condition is nearly impossible to focus.

These focus effects depend upon several factors:

1. The moisture content of the film is influenced by how it was dried after processing, the drying effect of multiple projections, and the relative humidity in the booth. Kodak recommends maintaining a relative humidity of 50 to 60 percent in the booth.
2. The "core set" (winding) of the film is very important. Based upon Kodak studies, SMPTE Recommended Practice RP 39 calls for maintaining an emulsion-in winding to minimize focus drift problems. "Core set" is also influenced by the diameter of the core of the reel on which the film is wound. Film should always be wound on cores or reels with the largest practical hub diameter. This is why trailers wound on tiny cores often have severe focus flutter.
3. The design of the film gate (curved or straight) and the gate tension are important factors.
4. The density (darkness) of the film image contributes to the amount of energy absorbed by the film, with dark scenes showing more flutter than

light ones. This is the reason flutter is often more visible in the closing credits (white letters against a black background).

5. The amount of energy going through the film frame is the single strongest determinant of a stable image

Heat Damage

Excessive radiant energy can cause permanent damage to the print. Because silver grains absorb more infrared energy than dye images, black and white prints are especially sensitive to improper heat filtration. "Blistering" occurs when the energy level is so high that the emulsion heats to the point of bubbling away from the base. In extreme cases, the film actually chars.

With color prints, excessive radiant energy can cause the emulsion to heat to the point of the layers separating internally. This "emulsion void" first manifests itself onscreen as a frost-like crystalline (snowflake) pattern in darker areas of the scene. This is caused by the refraction of light at the internal separation. Looking at the print film itself, reflected light usually reveals opalescent spots in each frame, corresponding to the "hot spot" of the projector. Viewed from the emulsion side, these spots are often magenta or blue. Viewed from the base side, the spots are green or yellow. This is due to the void that occurs within the emulsion layers. The magenta layer is on top, cyan in the middle, and yellow at the base. Depending upon the film type and power level, this damage may occur within a few times of being projected.

"Dye migration" is another form of heat damage sometimes associated with emulsion voids. Multiple projections with excessive radiant energy can cause the dyes to spread out and move to adjacent areas of the image, causing colored fringes or halos around darker objects or people in the scene. Although current Kodak film stocks are resistant to "dye migration," theatres must maintain their vigilance to prevent heat problems. Certain features may be more sensitive to heat since silver is deliberately left in certain color prints when the cinematographer wishes to increase contrast and shadow density. This is a creative decision which can enhance the appearance of the film, but it can have an adverse effect on projection because of the added density and infrared absorption from the silver left in the print.

Do I Have A Heat Problem?

Good projectionists should watch for signs of heat problems. If obvious damage such as blistering, emulsion voids, or dye migration occurs, the cause must be diagnosed immediately. The first three questions to ask when troubleshooting a heat problem should be:

A. Is efficient heat filtration in place.
B. Is the lamp operating at the proper current.
C. Is the lamp focus adjusted to produce good uniformity without a hot spot.

If a projector causes heat damage despite being properly aligned, contact your theatre equipment dealer, the manufacturer, or a service engineer to explore more efficient heat filtration, the installation of a higher-gain screen, screen curvature, or other ways of optimizing screen light without film damage. Because heat-related damage often takes a few weeks to occur, make it a practice to carefully examine the print later in the run, logging and reporting any damage. Heat damage usually happens in the dark scenes first, since they absorb the most radiant energy. Dye fading caused by excessive ultraviolet energy usually results in the color balance of the print becoming more green, with the highlights turning slightly yellow, especially in the "hot spot" of the projector. If visible dye fading happens during the run, additional ultraviolet filtration may be needed between the lamphouse and aperture.

Addressing Heat-Related Focus Problems
Even if it doesn't produce film damage, high levels of radiant energy can still hurt image quality and audience satisfaction. Fuzzy pictures and poor focus uniformity are especially distracting on big screens where the high power levels and short focal length lenses needed to fill those screens often cause problems. Equipment selection (heat filtration, curved gates, focus stabilizers, modern lenses) play major roles in achieving sharp images on big screens. Don't forget the other factors that can be used to improve focus stability: relative humidity between 50 and 60 percent, emulsion-in winding, gate tension adjustment, and avoidance of small-hub reels and cores.

For more information, contact me at john.pytlak@kodak.com