- It’s History

This article enlarges upon the keynote address presented by Roland J. Zavada at the SMPTE Technical Conference in 1991. Zavada, who served several terms as SMPTE Engineering Vice-President, is now retired from Eastman Kodak Co., Rochester, N.Y.

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‘Managing’ the Moving Image

From an Engineering Point of View

By Roland J Zavada

Part 2: A Perspective on Perforations

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In Hubbard’s keynote speech, he identified the need for standards for the width, length, and thickness of film, as well as the form size and location of perforations, and charged that ‘for such standardization to be stable, it must be on a world basis.’

Perforations are those holes along the sides of the film that provide for the film’s transport and positioning. As holes, they essentially represent an absence in something, or possibly we could say they represent nothing. Therefore it gives me a great deal of pleasure to take a few moments to ensure that every member knows ‘something about nothing.’

The inconsistency of perforations was established when the Motion Picture Trust Co. sued Laemmle for infringement on one of its patent clauses concerning the use of perforated film to provide continuous film feed by means of a sprocket. Laemmle and his lawyers were given one day to produce evidence of prior use of perforations similar to those of sprocket holes on films. They were at a loss, from which there seemed to be no hope for recovery. Then, at the last moment, someone was inspired by the patented perforations on a roll of toilet paper. The argument was taken into court and upheld.

Notwithstanding the idiosyncrasies of patent law, in which toilet-paper perforation was recognized by the courts as comparable to film, perforations have played an important part in the Society’s history. Their use or abuse has repeatedly challenged the viability and effective application of film for motion-picture and/or television program production. Technology and quality are based on the concept that the film must interface with a mechanism in transport, position, and reposition.

The significance of Bell & Howell's work is apparent as we look to the dimensions proposed by Bell for the very first perforations the Society sought to standardize. It was not the rectangular perforation of Edison nor the round perforation used by some French companies, but rather was based upon Howell's effective punch and die for a perforator in which a piece of round drill stock 0.110 in. in diameter was ground with two flats, providing a perforation height of 0.073 in. That perforation remained with us unchanged for 74 years until modified in 1990 with the addition of small corner fillets for added strength.

The significance of that perforation is that it was used for the camera, the printing mechanism, and the projection mechanism. It was in the projector that its weakness was located. One of the problems facing the industry was that film had a high shrinkage coefficient and interfered with the sprocket teeth of intermittent movements that had worn down to sharp edges; the combination caused stresses and breaks along the perforation corners and caused the film to tear.

The Society's Film Perforations Committee undertook a study (this was the first directed study by an SMPE committee of which I am aware). This study consisted of having manufacturers run wear-and-tear tests on positive film made with the Bell & Howell standard perforation; a continental standard, probably the Pathe perforation with corner fillets; a Bell & Howell perforation modified with corner fillets; and a new rectangular perforation proposed by the Eastman Kodak Co. (Fig. 1) having corner fillets and 0.005-in. increase in height. These perforations were tested for length of life in projection as well as on various printing mechanisms. The results bore out the committee's anticipations. The Bell & Howell standard had the shortest life of 160 runs, the continental standard and the modified Bell & Howell were superior to it, and the new rectangular perforation, with more than 300 runs, was best of all.

In reviewing this history, we are fortunate in that the presentations by the standards committee were first offered as proposals and that we have a verbatim record of the discussions that followed. What we found was that many members of the committee desired to change the perforation's shape with fillets or a radius on the Bell & Howell or to accept a common-height rectangular perforation. Many members expressed concern or objected to the 0.005 increase in the height of the perforation, which Kodak believed and the subcommittee tests showed was necessary to accommodate for the shrinkage of film in its wrap around an intermittent drive sprocket and provide the longest projection life.

Jones of Eastman Kodak, as subcommittee chairman prevailed, stating that Kodak had already begun to supply more than half of its customers with positive films with the modified rectangular perforation. The reluctant acceptance of the committee's 1923 recommendation and a principal supplier's implementation was the first departure from a rigorous exclusive standard to a dual standard – in this case one perforation ‘for negative film’ and another ‘for positive film’. The framework was in place for 65 years of debate.

In 1925 an international congress on cinematography was held in Paris and delegates were sent from several nations. Here the English, French, and German delegations dominated the discussions and by 4 to 1 voted preference of the Pathe (continental standard) perforation, having almost the same height as the Kodak proposed perforation but based on a larger diameter than the Bell & Howell perforation shown in Fig. 1, thus wider. In this way they accepted the need for the modified perforation height that Kodak proposed but rejected the rectangular perforation.

At the next Film Perforation Committee meeting, the Society desired to accommodate the international congress and was faced with the reality of having its 35mm film standard designated with three different perforation hole types – the Bell & Howell for negative, and the Pathe and the Kodak rectangular for positive films. The discussion in the committee became rather heated, and there was a special objection from the Eastman Kodak representatives to accepting the Pathe perforation in Society documents.

Within the next two years one of these problems was solved in the best possible manner for a standards dilemma – one proposal was withdrawn. The Eastman Kodak Co. affiliated with Pathe, and Dr. Mees, the director of research, announced that the Pathe perforation would fade out of existence. Thus the standards committee adopted two perforation types, the Bell & Howell for negative, and the Kodak for positive. But our story does not end there.

The negative-positive difference in height of 0.005 in. made process photography using pin registration difficult. Many papers were presented trying to resolve the situation. In 1932 Dubray and Howell proposed a rectangular perforation comparable to the Eastman perforation, except that it had the same height as the Bell & Howell negative film of 0.073 in. (Fig. 1). The film dimensions committee challenged Dubray as to whether film shrinkage had improved; it had not, and the committee refused to adopt the perforation. Rather they took a bold approach and by 1933 considered the Kodak perforation as an exclusive SMPE Standard that was to be adopted universally for camera, printer, and projection use.

The International Standards Association (ISA) met in Budapest in 1936, and we had the opportunity to address the issue internationally. The USSR proposed, and the meeting adopted, a draft standard that all future film production should use the SMPE perforation. The U.S. delegates came back with an international acceptance for a universal single-standard perforation for all 35mm film based on the SMPE standard. In 1936 plans were made to change the pins in cameras and to switch the industry to the ‘SMPE standard perforation.’

If you think back for a moment you will recognize that world events were about to explode with other challenges and demands on technology. In addition, it was uncertain as to whether the U.S. delegates could commit the necessary domestic manufacturers to change. There was no trade cartel, and we have a ‘confederated industry’ free society. Our Society representatives had no power to implement the radical change that they endorsed; we needed to manage by influence.

A special Subcommittee on Perforation Standards was convened following the international agreement and reported its findings in the fall of 1937. The report is a learned dissertation on film and film positioning, valuable even today. Instead of endorsing the international agreement, the committee recommended that we not accept the universal SMPE standard perforation nationally, thus rejecting the international proposal. They proposed we adopt the Dubray-Howell proposal, which they had previously rejected in 1932. In April 1949 a third attempt was made by the Film Dimensions Committee to adopt the Dubray-Howell perforation as a single universal perforation.

‘If multiple standards can serve for seven decades, was the search for a single universal perforation real, or ideal?’

History tells us no change was made in the U.S. or in Europe because of the intervening events of the war. Our War Standards Committee re-established the standard Bell & Howell perforation until the end of the war period. However, almost a decade later when the clouds of war lifted, we were to find that the eastern European countries (recently the Soviet bloc) had adopted into their standards system the internationally proposed SMPE perforation for 'future use' as a universal single perforation for camera, printer, process photography, and projection. Film manufacturers selling to those countries were now faced with inventory and special-order problems.

Technical presentations continued trying to offset sprocket tooth shape and perforation height, challenging the wisdom of the early standards committee's decision to modify the perforation height in order to accommodate shrinkage of the film.

During 1947 and 1948 another thorough study of the question was carried out by the Film Dimensions Committee. In April 1949 a third attempt was made by the Film Dimensions Committee to adopt the Dubray-Howell perforation as a single universal perforation; this was published in the Journal for comment but not adopted.

Subsequently, some of the technical issues that confronted early committee members changed significantly. The Society had standardized a modified 35mm sprocket during the war, and beginning in the early 1950s, manufacturers made a major change in film support to acetate safety support with significantly lower shrinkage coefficients. The need for the extra 0.005 in. in perforation height had disappeared. So is there more to the story?

In January 1951, W. F. Kelly and W. V. Wolfe of the Motion Picture Research Council (MPRC) were concerned that the adoption of safety film for two-color prints made it necessary to abandon the use of Bell & Howell perforations required for laboratory pin positioning because of the relative strength of nitrate versus acetate support. They provided extensive test results to back up their claim that there would be no commercial loss by going to the Dubray-Howell perforation. Further, they recommended that their board of directors propose this perforation as an American National Standard directly to ASA and gain the necessary industry support – without requiring the endorsement by the SMPE Film Dimensions Committee.

Later in that same year, W.G. Hill of Ansco reopened the issue of putting corner fillets in the original BH perforation and adopting it as the single standard for negative and positive films. Hill provided as much, if not more, supporting data than the Motion Picture Research Council. The records grew silent and the Dubray Howell/filleted Bell & Howell issue hung in the balance. Hill's proposal for corner fillets was not adopted; however, the Dubray-Howell perforation was added to the list of acceptable standard positive perforations. That was 40 years ago, and we can take a deep breath. But the story still doesn't end there!

As widescreen films began to appear as a response to the advent of television in the 1950s, new demands were being made on the picture area negative. A new, smaller, almost square-perforation 'CS' was introduced to provide sufficient additional film area for the CinemaScope anamorphic image and stereo sound tracks. Its height was the same as Bell & Howell and Dubray-Howell and its width 30% less. Sprockets were redesigned to accommodate the new and concurrently all other perforations with satisfactory life. Technically there were now several real options for the choice of a single universal perforation.

The International Standards Organization (ISO) met in Harrogate, England, in 1958. There, Czechoslovakia, the USSR, and France reopened the question of the 1936 proposal for the SMPE/KS universal perforation and approved a document statement that it should replace the others in the future. Concurrently, however, the potential of the new CS perforation becoming universal is proposed and seriously considered – as a universal perforation it fails, but the universal sprocket is standardized.

In addition to widescreen formats, optical blowups of conventional negative were being made to 70mm prints in increasing numbers. Now the BH perforation, instead of being driven on a single face on a continuous contact or step printer was being subjected to full pin positioning for multiple copies, as blowups were made to accommodate widescreen showcase theatrical applications. The perforation life was limited and often failed this new requirement.

Hill's work was recalled, and a little more than a decade ago the Film Technology Committee again addressed the question of placing fillets in the comers of the B&H & Howell perforations. However, because of possible interference with the fairly large radius fillets in camera pins, the proposal died in committee.

Finally the proposal for corner fillets or a radius for the Bell & Howell perforation was resurrected internally at Kodak in the late 1980s. Modern punch and die grinding technology has allowed a fillet so small as to eliminate the need for changes in camera and printer pins or sprockets and yet provides significant additional perforation strength. Internal trials resulted in a recommended change in product with sufficient market trade testing to ensure acceptance without problems. This new perforation proposal was reported on last year by Pylipow and is currently under review by the Film Technology Committee.

Now that we have a newer, stronger, Bell & Howell perforation we still remain faced with these perplexing questions:

- Was and is the 'Kodak Standard' KS perforation with the extra 0.005 in. in height really necessary after sprockets were redesigned in the late 1930s, sprocket diameter changed in the 1940s, and more significantly, after low-shrink acetate films were introduced in the early 1950s?

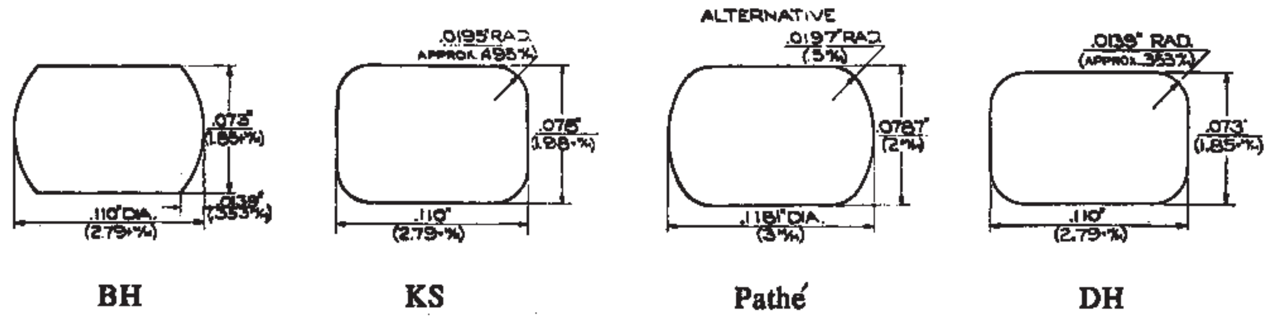

Figure 1. The perforation types that evolved are shown from left to right: Bell & Howell (BH), originally for negative and positive, and after 1926, negative only; the Kodak Standard (KS), which was also the SMPE Standard for positive films; the Pathé, which for two years was also the SMPE Alternate positive perforation; and the Dubray-Howell (DH) perforation proposed for positive and negative. Not shown are the BH modified with corner fillets or the CinemaScope (CS) perforation. (Originally appeared in J. SMPE, April 1932.)

- Should the Film Technology Committee address a new opportunity for a universal perforation at its next meeting? What lessons have we learned?
- If faced with a similar issue now, should consideration be first given to standardization of the hardware or the medium ?
- If a standard is developed to solve a problem, should it be withdrawn when the problem is solved even with significant commercial impact?
- If multiple standards can serve for seven decades was the search for a single universal perforation real, or ideal?

You see, in 'managing' the moving image, we did have something to say about nothing!

Lights – Camera – Fast Action

If we interpret a definition of standards as meaning consistency, this next little story is one of the most perplexing that I have found in my motion-picture engineering research. The issue is one of the velocity (in terms of frames per second) of the film when it is used to take and then to project images that faithfully reproduce a subject in motion.

Edison, in his early development, had proposed several approaches to frame frequency to approximate motion. In Edison's patent Caveat 1 it was 25/sec; in Caveat 2 it was 15 or 20 frames/sec; in Caveat 3 it was 15/sec; and after his visit to Europe, in Caveat 4 it was 10/sec. The 10 frames/sec also represented the approach taken by Friese-Green. However, in Edison's report to the Motion Picture Herald in 1890, the velocity was to be 8 to 20 frames/sec. We must recall that some of these early studies were based upon the use of a spark or flash lamp to provide the light for each individual frame as an option to intermittent film movement and a light-limiting shutter. It was Jenkins and Armat who subsequently developed the philosophy that for projection, the film should be at rest for a greater period of time to allow the maximum light through the print film compared to the time needed for the transport to the next successive frame. Their ideal was to be one-tenth of the time in darkness compared to nine-tenths under illumination.

During the period of 1896 to 1906. the film rate velocity of 16 frames/sec became the norm. This is reflected in the Society's first 1917 motion-picture standards as: 'A film movement of 60 feet per minute through motion picture mechanisms shall be considered as standard speed.' The film velocity of 60 ft/min as adopted translates to 16 frames/ sec for a 3/4 in. high image.

In the presentation, some audience participation took place, in order to better grasp the concept in the film velocity story. The camera and projector mechanisms of those days were hand-cranked. The gear ratio of the crank was set up as a 2:1 basis, that is, two turns of the crank per second would produce 16 frames/sec at the film velocity of 60 ft/min.

Here is the fascinating dialogue from our Transactions that took place in the SMPE standards committee meeting in 1925. (Remember a film velocity of 45 ft is 12 frames/sec, 60 ft is 16 frames/sec, 80 ft is 21.3 frames/sec.)

CHAIRMAN: At our last convention, we gave you a demonstration of projector speeds and recommended as a standard practice 80 ft/min with a maximum of 85 ft and a minimum 75 ft. We now suggest you give this your final approval.

MR. PORTER: Your committee has followed your instructions and investigated the question of camera speed. From the data we have been able to collect, it seems apparent that the best cameramen try to stick pretty close to a speed of 60 ft/min. In this connection the Committee was greatly aided by Mr. Earl Denison, who submitted stop-watch tests on a number of well-known cameramen shooting various types of pictures. The matter was taken up with the American Society of Cinematographers, who strongly recommend 60 ft/min.

From the data available, your Committee recommends (for the first time) as standard practice, a camera taking speed of 60 ft/min, with a minimum of 55 ft; and a maximum of 65 ft when normal action is desired in connection with the Society of Motion Picture Engineers' recommended practice of 80 ft/min projection speed.

DR. STORY: We have tentatively adopted a projection speed of 80 ft/min with a taking speed of 60 ft/min; I should like to know why we propose a taking speed which will give a distortion in action.

DR. MEES: I agree with Dr. Story in this. In working out the (16mm) Cine Kodak, we adopted a speed for taking and projecting (equivalent of 35mm) of 60 ft/min, and I have no doubt that it is an advantage for all regular practice. While I know that the theaters will project at 80 ft or even 100 ft/min and that the cameramen will take at 60 ft/min, I think the Society should not endorse this practice.

MR. KELLEY: This is a good recommendation. My experience is that a taking speed of 60 ft/min and a projecting speed of 80 ft/min do not produce an abnormal result. The cameramen are not machines and from watching many at work, I am of the opinion that most turn their cranks at a speed under 60 ft/min. We set up a camera having a meter attached giving the rates in pictures/sec for the chief cameraman on the Fairbanks lot and had him operate camera in making test shots. It was of great interest to us to note that the meter held steady at 12 pictures/sec (45 ft/min) on all takes. Standards will mean nothing unless cameras are fitted with tachometers.

DR. STORY: I would like to call your attention once more to the general matter of tolerances. As this reads, the standard taking speed is 60 ft/min with a minimum of 55 ft. As a matter of fact, the tolerance for normal action is zero; by no vote of this Society can it be made 5 ft more or less. In standards, there are no tolerances. They belong to recommended practices.

MR. EGELER: May I ask whether this standard of 80 ft for projection speed has been adopted as a final recommendation? I do not see how you can tie 60 ft/min taking speed and 80 ft/min projection speed together, and call them normal.

PRESIDENT JONES: Action has been suspended until the autumn meeting; it has not been finally adopted.

MR. CRABTREE: Will not the taking and projection speeds depend on the 'pep' of the actors? I have read of cases where the actors have been instructed to act more slowly or faster than normal, so that this factor would certainly enter into the question.

With regard to the relative speeds or taking and projection, I do not think it is necessary that they should be equal, because a projection speed of 60 ft/min certainly shows lag. We have decided unanimously that 80 ft/min gives the correct psychological effect when the picture is taken at 60 ft/min.

Subsequently, in the Transactions of March 1926, we find the report of the Standards and Nomenclature Committee under Camera Cranking Speed:

'Regarding camera speed we recommend as a recommended practice: a camera taking speed of 60 ft. per minute, with a minimum of 55 ft. and a maximum of 65 ft. when normal action is desired, in connection with the Society of Motion Picture Engineers' recommended practice of 80 ft. per minute projection speed.' (Motion passed to accept speeds recommended as above.)

In retrospect I found this approach to standardize a one-third increase in projection speed versus taking speed to be rather astounding. At last I understood why some of the early silent films had action that always appeared to be so fast-moving and jerky. Also very interesting was the fact that Dr. Mees of Kodak wanted consistency in taking and projection (at 16 frames/sec), while Crabtree, who worked for Mees, believed inconsistency (of 16 frames/see taking and 21.3 frames/sec projecting) was an acceptable approach! How do we 'manage' a taking and projection velocity in light of the psychological conditioning of early audiences to accept a 2: 1 discrepancy in taking and viewing?

As Hubbard said, 'Ideal standards involve searching investigations!' But our story doesn't end there.

Part three of this paper considers what happened when the Society got ready for another new technology – Sound.