

A Primer on Film Technology, Formats, and Archival Holdings

Aimed at the collaborators and users of the Canadian Educational Sponsored and Industrial Film (CESIF) archive project, this primer outlines some basic facts pertaining to archival film holdings and the history of film technology. Commonly used abbreviations are also explained.

A definition of all underlined terms can be found in this primer.

Film bases and film gauges

Nitrate vs. safety film base

35mm films generally used a highly flammable nitrate film base up until the early 1950s. Nitrate film can burst into flames if a projector malfunctions and exposes a film frame to the light beam for a fraction of a second more than required. Once ignited, nitrate film burns rapidly and violently, and can keep burning underwater or without oxygen. As a result, early 20th century safety laws generally required 35mm film projectors to be installed in fireproof booths.

Non-flammable “Safety” bases using acetate or, later, polyester, were introduced in the 1910s, but initially mostly used for small gauge films (28mm, 16mm) intended for institutional or domestic use. The superior visual qualities of the nitrate film base, combined with the fact that it could withstand extensive use, largely explains the industry’s long-standing lack of interest for safer alternatives.

The safety concerns associated with nitrate films are further compounded by the instability of the nitrate film base, which could start decaying within a few decades of manufacture. Proper storing conditions can slow this decay, but not entirely prevent it. For these reasons, nitrate films can only be stored in specially-designed vaults located in remote locations. The Canadian vaults for nitrate films are located near Ottawa and managed by Library and Archives Canada.

While not prone to the same type of decay as nitrate films, the films printed on an acetate safety base tend to shrink over the years. Shrunken films will not run in standard projectors; they can only be viewed and transferred on specially-designed film apparatuses.

A film’s base can generally be identified by “NITRATE” or “SAFETY” markings along its edge.

35mm

- A 35mm-wide film developed in the 1880s for still photography, and used since the 1890s for motion picture photography.
- 35mm was the standard format for theatrical film distribution from the 1890s until the early 2010s.
- Up until the early 1950s, 35mm film generally used a highly flammable nitrate base, which made it unsuitable for institutional or domestic use.

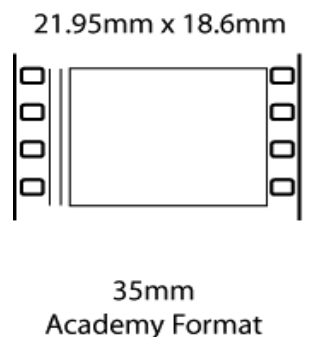


Figure: 35mm film with an Academy ratio frame and a soundtrack (on the left)
[source: whitecitycinema.com/2012/11/19/]

28mm (also known as “Pathé-Kok” and “Pathéscope”)

- An alternative to 35mm introduced by Pathé in 1912 in France and in 1914 in North America.
- 28mm used a safety film base, and was consequently suitable for projections in schools and other institutions.
- 28mm was gradually replaced by 16mm in the 1920s and 1930s.
- 28mm was extensively utilized by the Ontario Motion Picture Bureau for production and distribution from the late 1910s until the early 1930s.
- Preservation prints of many surviving titles available on the obsolete 28mm format were later struck on 35mm film by Library and Archives Canada.

16mm

- A small gauge format introduced by Eastman-Kodak in 1922 and still produced today.
- 16mm was first marketed as an amateur format for home movies, for the exhibition of 16mm prints of commercial films in the home, and for institutional (industrial, educational) use. It exclusively used non-flammable safety bases, such as acetate and polyester.
- 16mm was only available in reversal in the 1920s and early 1930s. Negative 16mm film was introduced in the 1930s when 16mm began to be used as a capture format for some professional productions.

Aspect ratios

The aspect ratio is the width to height ratio of each frame photographed on a strip of film. Multiple aspect ratios were used throughout film history.

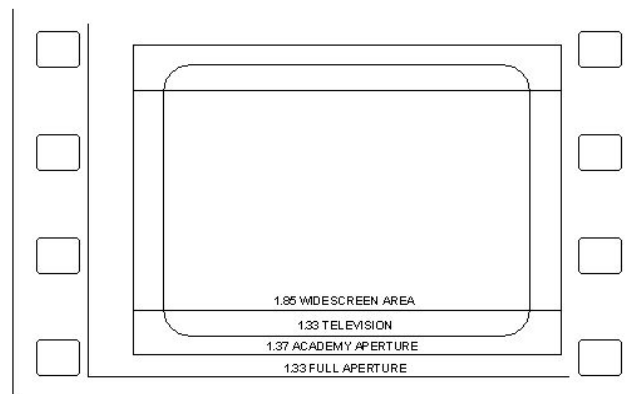


Figure: some frequently used aspect ratios
[source: www.cinematography.com]

Full-frame

During the silent era, each frame photographed on 35mm film would cover the whole area between four perforations on the left and four perforations on the right. The proportions of the resulting images would be 4 by 3, or 1.33.

Academy ratio

The addition of optical soundtracks to release prints in the sound era caused the width of each frame to be reduced. The addition of a blank space between frames eventually permitted the creation of a new standard, known as “Academy,” with an aspect ratio of 1.37 close to that of silent pictures (1.33).

Scope

Films with an aspect ratio wider than 1.37 gained in popularity in the 1950s, partly as an answer to television. Scope films used anamorphic processes such as Cinemascope relying on special lenses squeezing the image during filming and unsqueezing it during projection. Such anamorphic processes could produce images with aspect ratios as wide as 2.35 with 35mm film. Scope was mostly used for big-budget theatrical films. Still, a number of sponsored films, such as some titles produced for exhibition in world's fairs, relied on anamorphic processes. Another way to produce widescreen films (typically for films with an aspect ratio of 1.66 or 1.85) was to simply add more blank space between frames. Widescreen prints using this non-anamorphic process are often described as “flat” prints.

Super 16

A format permitting the image track to stretch from the perforation on the left of a 16mm film to the edge of the film on the right. Super 16 is purely a capture format; it uses the space reserved for the soundtrack on release prints to produce a wider image. Super 16 is designed to be digitized or blown up to widescreen 35mm for exhibition. No Super 16 projector was ever marketed.

Multi-screen

Films relying on the simultaneous operation of multiple projectors to produce extreme widescreen effect or create juxtapositions. In some instances, the multiple screens were not contiguous. Multi-screen installations films (including some educational, industrial and sponsored titles) were often featured at world's fairs.

Lengths, durations, and standard reel formats

A much valuable tool for calculating the duration of a reel of film (according to format, length, and frame rate) is available on Kodak's website: <http://www.motion.kodak.com/motion/Tools/Production/index.html>

35mm, silent era (1890s-late 1920s)

- Silent era cameras and projectors did not have a fixed speed or frame rate. Many were hand-cranked, and those fitted with an electric motor usually came with a rheostat permitting a wide range of speeds to be used. This permitted a creative use of speed in the silent era: shooting speed was typically slower than projection speed to add “spark” to the exhibited film, especially in comedies.
- Projection speed could also differ from one venue to another. A film could be photographed at roughly 16 frames per second (with variations between shots), and then screened at 18fps in one theatre and 20fps in another. Durations are consequently to be avoided in the description of films from this era; length (be it in reels, feet or meters) is to be preferred.
- A 16 frames per second frame rate was common in the 1910s. However, by the late 1920s frame rates generally varied between 20 and 28 frames per second. This inflation is attributed by some to a sort of competition between projectionists, who were sometimes instructed to project the film faster so that the theatre could cram an extra screening during its operating hours. The cameramen, aware of this practice, tried to compensate by increasing their shooting speed.
- The **duration** of a standard 1,000' reel of silent 35mm film can thus vary between 16 minutes 40 seconds (at 16fps) and 9 minutes 31 seconds (at 28fps).

- The **1,000 feet reel** of film became an industry standard around 1910. As a result, silent films were generally described as one-reelers (approximately 1,000'), two-reelers (approximately 2,000'), or multireel features (4-reel, 5-reel, 6-reel, etc.).

35mm, sound era (1927- today)

- A frame rate of 24 frames per second became an industry-wide standard for sound films in the late 1920s.
- The duration of a standard 1,000' reel of sound 35mm film is therefore 11 minutes 6 seconds (though reels never were filled with *exactly* 1,000' of film).

16mm silent films (amateur and professional)

- 16mm cameras and projectors generally permitted shooting and projecting at both **18 frames per second** ("**Silent speed**") and **24 frames per second** ("**Sound speed**").
- Silent speed limited further uses of images, as footage shot at this speed would be significantly sped up if reused in sound productions, but permitted amateur filmmakers to produce longer films with the same amount of film stock.

16mm sound films

- 16mm sound productions and prints used the same standard frame rate as 35mm sound productions: **24 frames per second**.

16mm reels

- 16mm reels were never standardized the way 35mm reels were. Reel lengths varied between 100 feet (spools for use in amateur 16mm cameras) and 2000 feet (the largest reel size suitable for use on a portable sound projector).
- 400' reels were, however, commonly used for both shooting and exhibition. This reel size has the exact same duration (11 minutes 6 seconds) as a standard 1,000' 35mm reel at sound speed.
- 400' reels were also the largest reels that could be accommodated by silent 16mm projectors. Silent film prints were consequently often mounted on multiple 400' reels.

Core

Another way to store and distribute film: the film is wound on a simple plastic core instead of on a larger and heavier reel. A film on core can be mounted on a split-reel for exhibition.

- Archives generally prefer the use of cores to the use of metal or plastic reels.
- Editing tables such as those manufactured by Steenbeck are usually set up to work with films on cores, not reels.

Split-reel

A reel that can be unscrewed and opened ("split"), so as to permit a film on core to be mounted in it.

- "Split-reel" also referred to a standard 1,000 reel holding two different titles meant to be distributed as a pair in the 1910s.

Filmstrip

A strip of 35mm film holding a series of frames meant to be projected not as moving pictures, but as fixed images (i.e., as slides). These frames typically alternated between images and explanatory titles.

Associated Screen News, the National Film Board of Canada, and other Canadian producers of educational, sponsored and industrial films frequently produced filmstrips. Filmstrips, which often came with soundtracks (sometimes on 45rpm records) or written commentaries, permitted producers to exert

tighter control on exhibition, and thus on the message. Filmstrips were indeed harder to edit than presentations relying on autonomous slides.

- Archival holdings of 35mm filmstrips can generally be distinguished from 35mm moving pictures by their much shorter length.
- While deserving further investigation, the under-researched history of filmstrips is not covered by the Canadian educational, sponsored and industrial film archive project.

Emulsions and color processes

Negative film stock (NEG) / positive film stock (POS)

- Negative: a film holding a negative image from which a positive can be struck.
- Positive: a film holding a positive image.

The use of negative and positive film stocks was more expensive than the use of reversal film stocks, but permitted the production of multiple positive prints from a single negative. Reversal film stocks were not meant to be duplicated, as they would produce significantly degraded copies.

Reversal

An emulsion intended for shooting (i.e., to be used in cameras) that produces a positive image once developed. A reversal film exposed in a camera thus does not need to be transferred — as a negative would— before being exhibited. The use of reversal film was cheaper for amateurs, who did not need multiple prints of their work. The downside of this process is that while original reversal films can be of great visual quality, reversal emulsions tend to produce inferior copies. Furthermore, original reversal films could not be timed and color-corrected. As a result, reversal emulsions were rarely used for commercial film production. Kodachrome and Ektachrome were two widely used color reversal emulsions.

Kodachrome

A highly successful reversal color film introduced by Eastman-Kodak in 1935 and produced until 2009. Available in 16mm and 8mm, but not in 35mm (mostly because it did not produce good results when copied — a requirement for commercial productions). Still, Kodachrome was extensively used for travelogues, promotional films, educational films, industrial films, and sponsored films between the late 1930s and the early 1950s, which is when Eastmancolor negative film became available. Many films were shot in 16mm Kodachrome and blown up to 35mm for theatrical exhibition. Kodachrome is very stable: films tend to keep their vivid, saturated colors over the years (with the exception of the first generation of Kodachrome films produced between 1935 and 1938).

Eastmancolor

A color emulsion introduced in 16mm and 35mm by Eastman Kodak in the early 1950s. This negative/positive process was more suited to the production of multiple release prints than reversal color emulsions such as Kodachrome. A major issue of Eastmancolor prints is that they are prone to fading: they tend to lose much of their blue and green dyes, and consequently acquire a dominant red tint over the years.

Tinted

A monochromatic film with an added tint generally produced by dipping the film into a bath (though pre-tinted films bases were also available). The aim was to enhance effects or set the mood; for instance, a blue tint was frequently used to denote night scenes. Tints were commonly used in the silent era, but largely disappeared in the sound era as they interfered with optical sound tracks.

Sound and other physical properties

Optical sound track (OPT TRK)

The main sound recording system used in film production between the late 1920s and the 1950s involved photographing sound as a wave or as variable shades of grey on 35mm or, in some instances, 16mm film. Film production gradually switched to magnetic tape for sound recording between the 1950s and 1960s, but optical sound tracks remained widely used on release prints up until the 2000s. 35mm film was commonly used to record the sound of titles shot on 16mm film between the 1930s and the 1950s. For these films, the image capture format (16mm) is deemed to be the original production format.

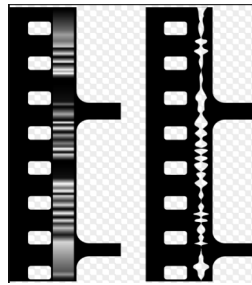


Figure: two types of optical sound tracks:
variable density (left) and variable area (right)
[source: <http://www.phonozoic.net/ostm1.html>]

Magnetic sound track (MAG TRK)

A sound track recorded on magnetic tape.

- **Production:** most tape recorders used for film production (such as the Nagra) since the 1950s relied on quarter inch tape.
- **Post-production (Editing and mixing):** the various sounds (dialogue, sound effects, foleys, room tones, music) recorded during production would typically be transferred to 16mm or 35mm perforated magnetic tape, which permitted the sound track to be easily synchronized with the image track, and then edited on an editing table such as a Steenbeck. Multiple tracks made up of pieces of magnetic tape alternating with leader (to isolate sounds during mixing) would be assembled and then mixed into one single continuous sound track at the end of the editing process.
- **Exhibition:** some prints featured magnetic sound tracks instead of optical sound tracks.

Composite (COMP)

A print featuring both a sound and an image track.

Silent (SIL)

A film devoid of a sound track, which could be a completed silent film, or production material for a sound film.

Leader

Opaque film not treated with emulsion.

- Used at the beginning (head) and end (tail) of reels to protect the actual film meant to be shown or used.
- Also used during postproduction on A and B rolls (to isolate shots) and sound tracks (to isolate sounds).

Perforations

Film relies on perforations to be driven through cameras, projectors, and other film apparatuses.

- The standard for 35mm film is four perforations on the left and right sides of each frame.

Single perf (16mm)

When 16mm film stock was introduced in 1923, it featured one perforation on both sides of each frame. The introduction of sound a few years later caused perforations on one side to be replaced by the sound track.

- A 16mm print featuring perforations on both sides can only be silent.
- A 16mm print featuring perforations on a single side can either be a silent or sound film, but can only be projected on a sound projector (as the second set of teeth on a silent projector would severely damage the sound track).



Figure: regular silent 16mm film

[source: <http://www.indietalk.com/showthread.php?t=20572>]



Figure: 16mm single perf sound film
[source: http://en.wikipedia.org/wiki/16_mm_film]

Edge codes

Codes printed on the edge of the various film stocks produced by Eastman Kodak, these are generally made up of two or three signs (circles, squares, crosses, etc.). Edge codes can be used to identify the year the film stock was produced.

EASTMAN KODAK DATE CODE CHART			DUPONT DATE CODE CHART		
1922	1942	1962	●■	1982	●■X
1923	1943	1963	●▲	1983	X▲X
1924	1944	1964	▲■	1984	▲■▲
1925	1945	1965	■●	1985	■●▲
1926	1946	1966	▲●	1986	▲●▲
1927	1947	1967	■▲	1987	■▲▲
1928	1948*	1968	++	1988	++▲
1929	1949	1969	+	1989	X+▲
1930	1950	1970	▲+	1990	▲+▲
1931	1951	1971	●+	1991	X+X
1932	1952	1972	■+	1992	■+▲
1933	1953	1973	+▲	1993	+▲▲
1934	1954	1974	+●	1994	+●▲
1935	1955	1975	+■	1995	+■▲
1936	1956	1976	●	1996	X●▲
1937	1957	1977	■	1997	X■▲
1938	1958	1978	▲	1998	X▲▲
1939	1959	1979	●●	1999	●X▲
1940	1960	1980	■■	2000	■■▲
1941	1961	1981	▲▲	2001	▲▲●
*1948 CAN BE EITHER ++ OR ●●●					
WHERE EASTMAN KODAK STOCK WAS MANUFACTURE					
S A F E T Y			- ROCHESTER		
S A F E T Y			- CANADA		
S A F E T Y			- ENGLAND		
S A F E T Y			- FRANCE		

Figure: Eastman Kodak edge code chart

Workflow and types of film holdings

Typical film workflow (before the arrival of digital technology)

Camera negative → edited into **A and B rolls** (following the editing of the work print) → used to produce **answer prints** (featuring the color-corrected content of the A and B rolls, optical effects, and the sound track) → the final answer print, when approved, is granted the status of **interpositive** → used to produce an **internegative** → used to produce **release prints**.

Camera negative

The original negative exposed during shooting. Generally edited on two rolls (A roll and B roll) after editing has been completed on a work print.

Work print

A positive print used during the editing process. It is made of positive footage produced from the unedited camera negative. Once the editing of the work print is deemed satisfactory and final, it is reproduced on the editing of the A/B rolls. The use of a work print permits the editing to be done on positive film, and spares the original negative from the extensive damage (dirt, scratches) generally incurred during the editing process.

A/B rolls

The camera negatives of professional film productions (35mm and 16mm) were generally edited on two rolls ("A" and "B"), with shots alternating with black leader on each roll: roll A: shot 1, leader, shot 3, leader, shot 5, etc.; roll B: shot 2, leader, shot 4, leader, shot 6, etc. This permitted splices to become invisible, as they would be made just outside of each shot's first and last frames. The use of A and B rolls also facilitated the production of optical effects such as dissolves and fades.

Answer print (ANS PRT)

A test print featuring the color-corrected content of the A and B rolls, optical effects, and the sound track.

Release print (REL PRT)

The end product of film production: a print meant to be exhibited, be it in a theatrical or nontheatrical context. The prints held by libraries and universities can generally be described as release prints. Release prints are not optimal for archiving purposes, as they are many generations removed from the camera negative, and tend to get scratched and dirty.

Dupe

Most frequently: the production of a dupe negative, and then of a dupe positive from a release print.

- Duplicates were frequently illegally produced bootleg copies.
- Archives also produce duplicates for preservation purposes when the only extant material is a release print.
- Duplicates tend to be of mediocre quality, as they are many generations removed from the original production material.

Access copy

An archival copy meant to be consulted rather than preserved. Access copies can be anything from 35mm prints intended for theatrical exhibition to VHS tapes or DVD-Rs designed to be viewed by researchers. Access copies are usually available in widely-used consumer formats such as VHS or DVD-R. The quality of access copies varies tremendously: some archives offer pristine 35mm prints, others cropped VHS tapes produced by videotaping an editing table's screen.